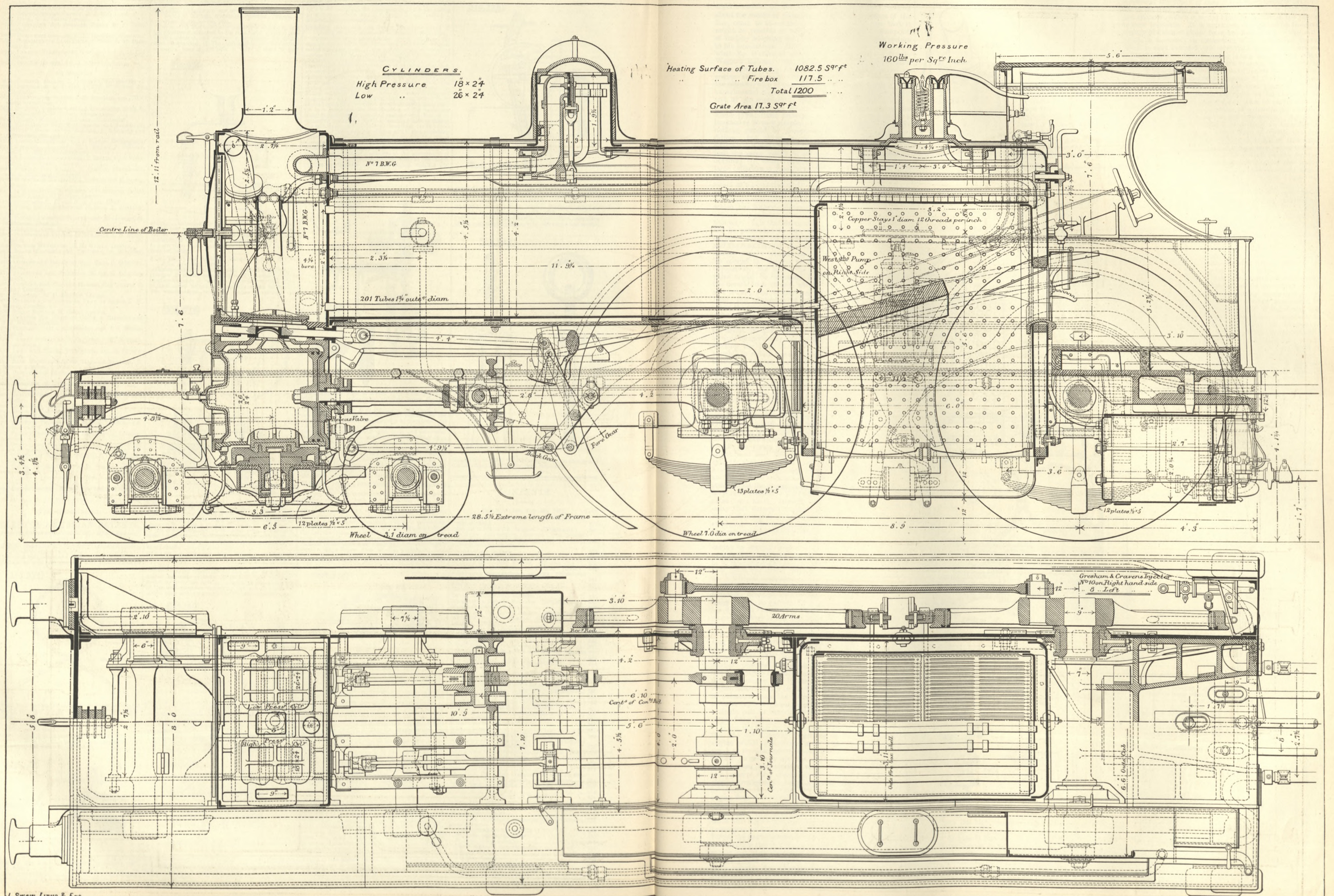
[SUPPLEMENT TO THE ENGINEER, MAY 15, 1885.]

COMPOUND LOCOMOTIVE, WITH PATENT STARTING GEAR, GREAT EASTERN RAILWAY.

MR. T. W. WORSDELL, M. INST. C.E., STRATFORD, ENGINEER.

(For description see page 377.)



J. SWAIN LITHO & ENG.

WORSDELL'S COMPOUND LOCOMOTIVES.

Mr. T. W. Worsdell, M. Inst. C.E., and locomotive superintendent of the Great Eastern Railway, casting about for means of reducing the working expenses of the line, came to the conclusion some months ago that it might be possible to effect a saving in the consumption of fuel by adopting the compound system of construction in his locomotives. Having fully acquainted himself with what Mr. Webb had effected on the London and North-Western Railway, and with the somewhat meagre data made available by continental practice, he designed an engine and brought the subject before the directors of the railway, who at once sanctioned the construction of an experimental engine. This engine we illustrate below and by our supplement this week. It will be seen at a glance that it is an entirely different engine from the Webb type. The principle involved in compounding a locomotive is very simple. Theoretically there is probably nothing gained by compounding under the given conditions; but there is, no doubt, a secondary saving effected, to which we shall refer further on. In other words, just the same result in an economical sense would be obtained by using sufficiently large cylinders to give the necessary power, and cutting off steam at a proportionately early part in the stroke. In practice, however, a difficulty is met with which has hitherto defeated all attempts at gaining economy in this way. It is that drivers cannot be persuaded to run their engines linked up sufficiently; and the result is that the boilers cannot supply steam enough. To compel the drivers to work expansively, the lap of the slide valve might be increased from the normal inch to, say, an inch and a-half, and in this way to limit the admission of steam when the engine is in full gear. As made ordinarily a locomotive can take steam when in full gear for about 90 per cent. of the stroke; by increasing the lap and altering the lead, it would be possible to reduce the maximum admission to less than 50 per cent. If, however, this were done, there would be four positions of the driving wheel in which no steam at all could get into the cylinders, and the engine could not be moved, either backwards or forwards. With an admission of a little more than 50 per cent., while one cylinder could not take steam to go ahead at all, the piston in the other might be so near the end of the cylinder that a locomotive with a heavy train could not start, and would have to be reversed in order to put the cranks in a more favourable position. This would cause so much trouble and delay that extreme amounts of lap on slide valves are never now employed. The compound system gets over the whole difficulty at once. Not only can the engine be started with the utmost facility, but the steam must be worked expansively, no matter how much the driver wishes to use it without expansion.

Mr. Worsdell, acting on this principle, failed to see that anything would be gained by the use of a third cylinder; to which, moreover, there is the objection that we have as yet little or no experience of the safety of running the, of necessity, very large piston at a very high velocity. Consequently, he made the smallest possible change in his standard engine for fast passenger traffic. It will be seen that the engine we illustrate differs from the normal engine almost solely in the fact that one cylinder is larger in diameter than the other; and in order to get this cylinder in, it has been necessary to substitute a bogie for a single pair of carrying wheels. We annex a full statement of the dimensions of the engine.

When the first engine was made and tried, it was found that the old difficulty turned up in another form. The engine would sometimes stop with the high-pressure crank at the dead point, when, of course, the engine would neither go one way nor the other. A pipe was fitted by which, when this happened, steam could be admitted to the low-pressure valve chest; but this was an inconvenient and clumsy arrangement, sometimes troublesome to work, and in practice the drivers always preferred to reverse the engine first if it would not start at once, and try to get away in that manner before resorting to the auxiliary valve. A good deal of time was lost in this way. Indeed, while the engine was making experimental trips without passengers, as much as three minutes have been expended before the engine could be got to go one way or the other. We mention this in order that the value of Mr. Worsdell's subsequent improvement may be more fully appreciated.

Seeing that the engine in its then condition was not quite suitable for regular traffic, Mr. Worsdell had the arrangement of auxiliary valve, which we illustrate by the accompanying detail engravings, fitted to the engine, and with the most complete success. The engine, indeed, starts away as freely and certainly as would an ordinary locomotive with but $\frac{1}{4}$in. lap. The construction of the auxiliary valve will be readily understood:—A is the high-pressure cylinder; C is the low-pressure cylinder; H is the steam pipe conveying steam direct from the boiler to the high-pressure cylinder; B is the exhaust pipe from the high-pressure cylinder to the chest of the low-pressure cylinder; D is the exhaust pipe from the low-pressure cylinder direct to the chimney; F is the starting valve for the low-pressure cylinder; G is an intercepting valve placed in the exhaust pipe between the high and low-pressure cylinders. Steam is admitted from the boiler in the usual manner direct to the high-pressure cylinder A. The exhaust steam from this cylinder passes through the pipe B to the chest of the low-pressure cylinder C. This pipe is enlarged and carried round the smoke-box to act as an intermediate receiver and superheater. The exhaust steam from the high-pressure cylinder after performing its duty in the low-pressure cylinder is then discharged through the pipe D into the chimney, or it can be used as a feed-water heater, or wholly or partially condensed by turning it into the water tanks of either the engine or the tender. The starting valve F is worked from the driver's side of the foot-plate, and is a small valve which admits steam direct from the boiler into the steam chest of the low-pressure cylinder, through the pipe B, and just below the intercepting valve G. This intercepting valve is also worked from the foot-plate, and is closed before the starting valve is opened; the object of closing this valve being to prevent the steam from the starting valve reaching the high-pressure cylinder, where it would block both sides of the piston in some positions. It is automatically opened on the first passage of exhaust steam from the high-pressure cylinder. Its use is necessary in connection with a starting valve, but it is only brought into operation when the crank on the high-pressure side of engine is in a bad starting point.

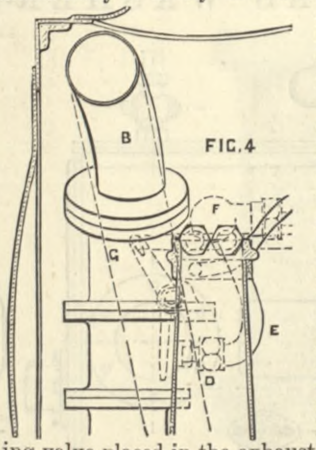
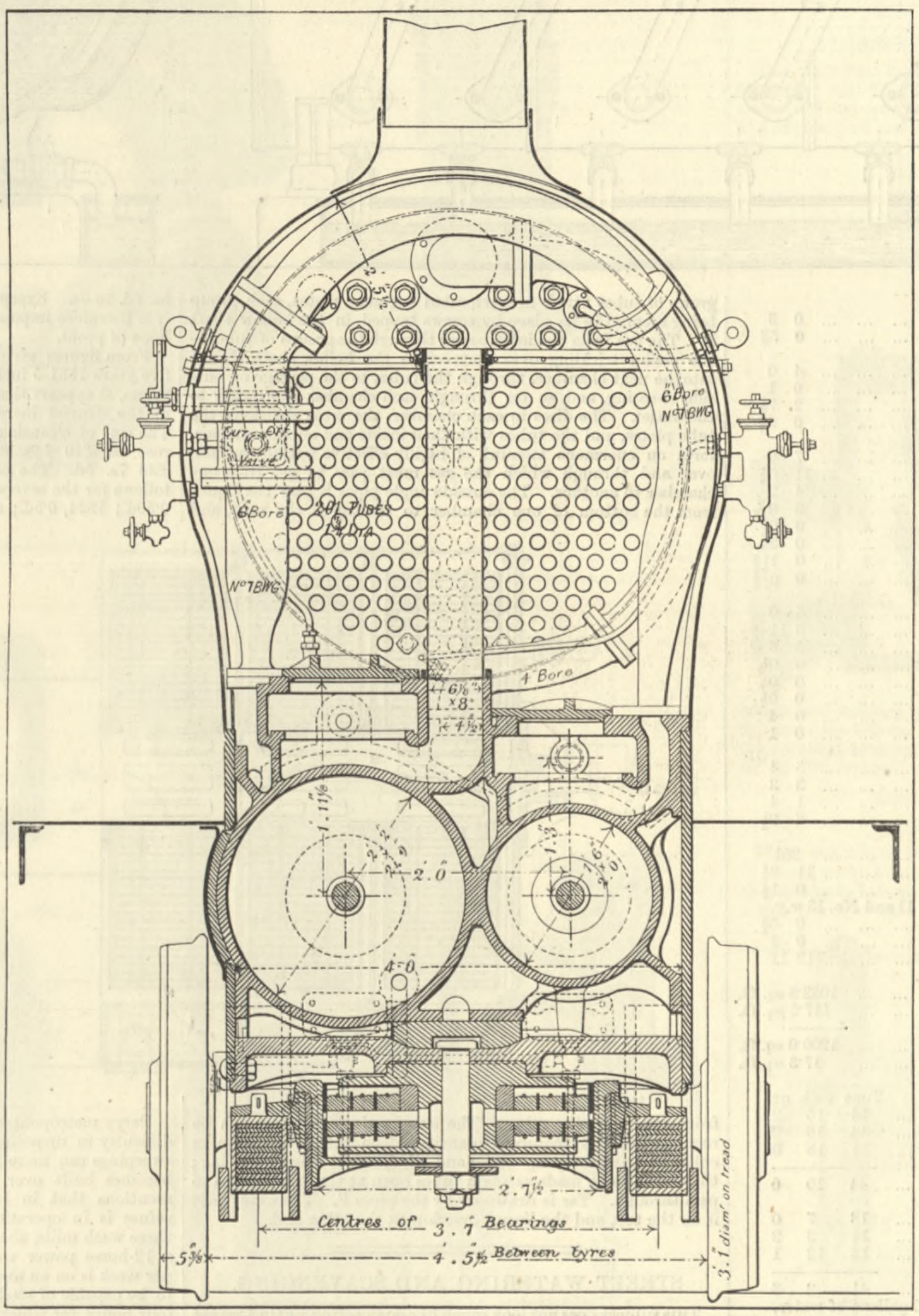


FIG. 4

We have stated that there are reasons apart from the working of the steam through two cylinders instead of one, which are very favourable to economy of fuel in the case of the compound engine. In the first place, the back pressure is much reduced, especially at high speeds, a matter of very great importance. This is partly due to there being only half the number of exhausts per minute, while the blast pipe retains its full dimensions. Again, it is well known that nothing is more fatal to economy of fuel than an exhaust so violent that it "pulls the fire about." In the compound engine no action of this kind takes place. The exhaust even with a very heavy train—and we have ridden on the engine with twenty coaches behind over part of the heavy Cambridge section of the line—is, to use a driver's words, "as soft as silk." The results obtained so far with this engine have been extremely satisfactory. The diagrams given by Joy's valve gear leave nothing to be desired, and the engine is exceedingly prompt and certain in getting away with a load—so good, indeed, has been its performance, both with heavy express and stopping trains, that ten engines of the same kind have been ordered, and are now nearly finished, while the others will in all probability immediately follow. As already announced in our pages, Mr. Worsdell will in a short time leave Stratford to take the post of locomotive superintendent of the North-Eastern Railway, and we beg to refer our readers interested in the subject for additional information to Messrs. Taite and Carlton, engineers, Queen Victoria-street.



CROSS SECTION OF COMPOUND ENGINE, GREAT EASTERN RAILWAY

The dimensions of the engine we illustrate are given in the following tabular statement:—

Principal Dimensions of G.E.R. Compound Engine.

	ft.	in.
Cylinders, high-pressure:—		
Diameter of cylinder	1	6
Stroke of piston ...	2	0
Length of ports... ...	0	$11\frac{3}{4}$
Width of steam ports	0	$1\frac{3}{4}$
Width of exhaust ports	0	$3\frac{1}{2}$
Distance apart of cylinders centre to centre	2	0
Distance, centre line of cylinder to valve face	1	1
Distance centres of valve spindles ...	2	0
Lap of slide valve ...	0	$1\frac{1}{8}$
Maximum travel of valve	0	5
Lead of slide valve ...	0	$0\frac{3}{16}$
Cylinders, low-pressure:—		
Diameter of cylinder	2	2
Stroke of piston ...	2	0
Length of ports ...	1	2
Width of steam port	0	2
Width of exhaust ports	0	$3\frac{1}{2}$
Centre line of cylinder to valve face ...	1	$5\frac{3}{4}$
Lap of slide valve ...	0	$1\frac{1}{8}$
Maximum travel of valve	0	5
Lead of slide valve ...	0	$0\frac{3}{16}$
Motion, Joy's patent:—		
Diameter of piston-rod	0	3
Length of slide blocks	1	3
Length of connecting-rod between centres	6	10
Length of radius rod	4	$9\frac{1}{4}$
Wheels and axles:—		
Diameter of driving wheel	7	0
Diameter of trailing wheel	7	0
Diameter of bogie wheel	3	1
Distance from centre of bogie to driving	10	9
Centres of bogie wheels	6	3
Centres of driving to trailing	8	9
Distance from driving to front of fire-box	2	0
Distance from centre of bogie to front buffer plate	4	$8\frac{1}{2}$
Distance from trailing to back buffer plate	4	3
Crank axle, steel:—		
Diameter at wheel seat	0	9
Diameter at bearings	0	$7\frac{1}{2}$
Diameter at the centre...	0	7
Distance between centres of bearings	3	10
Length of wheel seat	0	8
Length of bearing	0	9
Trailing axle, steel:—		
Diameter at wheel seat...	0	9
Diameter at bearings	0	$7\frac{1}{2}$
Diameter at centre	0	7
Length of wheel seat	0	8
Length of bearings...	0	9
Diameter of outside coupling pins	0	$4\frac{1}{4}$
Length of outside coupling pins...	0	4
Throw of outside coupling pins	0	12
Bogie axle, steel:—		
Diameter at wheel seat...	0	$7\frac{1}{2}$
Diameter at bearings	0	6
Diameter at centre	0	5
Length at wheel seat	0	7
Length at bearing	0	9
Centre to centre of bearings	3	7

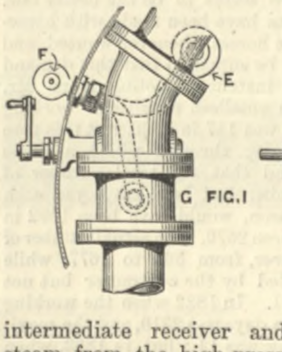


FIG. 1

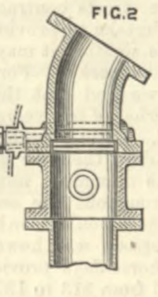


FIG. 2

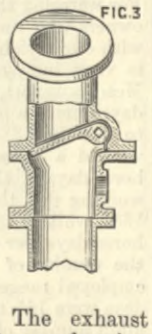
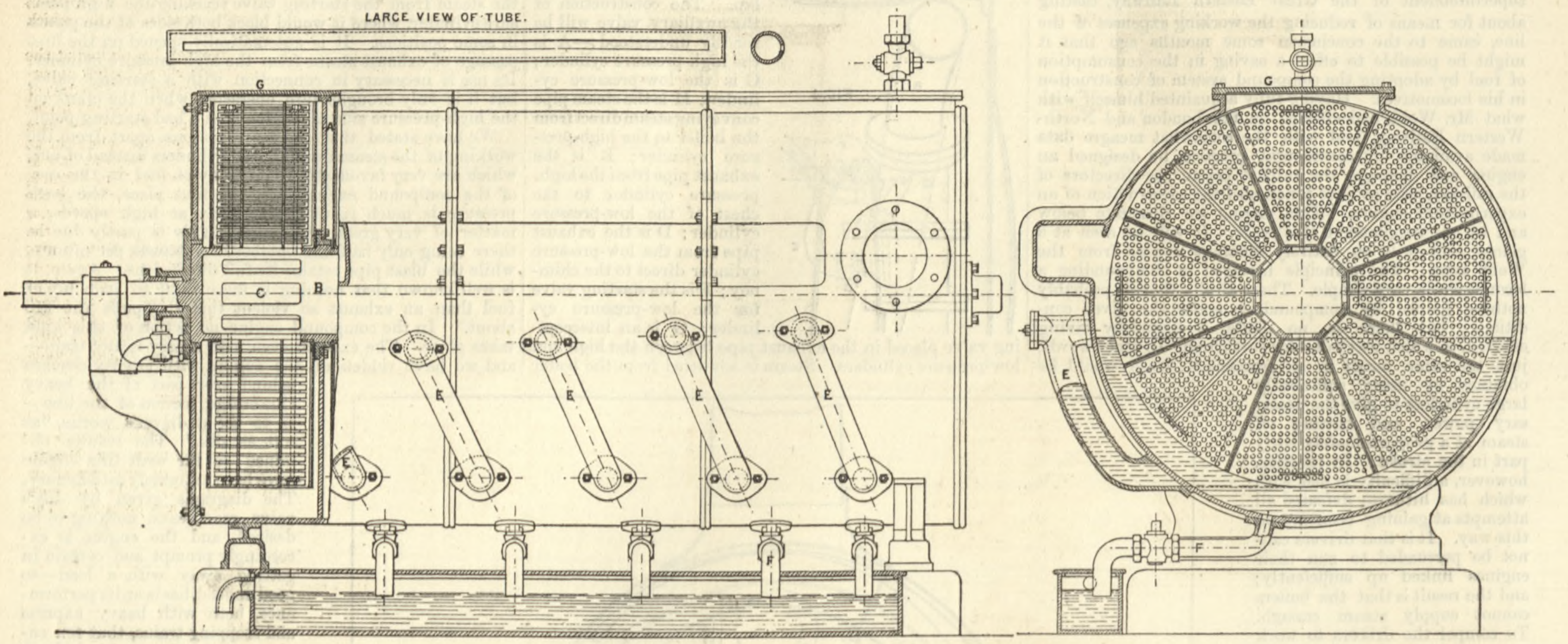


FIG. 3

WALLER'S PHOENIX GAS WASHER-SCRUBBER.



Bogie axle, steel:—		
Thickness of all tires on tread	0	3
Width of all tires on tread	0	5⅜
Frames, steel:—		
Distance apart of main frames	4	0
Thickness of frame	0	1
Distance apart of bogie frames	2	7½
Thickness of bogie frames	0	0¾
Boiler:—		
Centre of boiler from rails	7	6
Length of barrel	11	5¼
Diameter of boiler outside	4	2
Thickness of plates (steel)	0	0 7/16
Thickness of smoke-box tube plate	0	0¾
Lap of plates	0	2½
Pitch of rivets	0	1 13/16
Diameter of rivets	0	0 13/16
Fire-box shell, steel:—		
Length outside	6	0
Breadth outside at bottom	3	11
Depth below centre line of boiler	5	6
Thickness of front plates	0	0½
Thickness of back plates	0	0½
Thickness of side plates	0	0½
Distance of copper stays apart	0	4
Diameter of copper stays	0	1
Inside fire-box:—		
Length at the bottom inside	5	4
Breadth at the bottom inside	3	3
Top of box to inside of shell	1	4
Depth of box inside	6	2½
Tubes:—		
Number of tubes	201	
Length of tubes	11	9¼
Diameter outside	0	1¾
Thickness	No. 11 and No. 13 w.g.	
Diameter of exhaust nozzle	0	5¾
Height from top of top row of tubes	0	2
Height of chimney from rail	12	11
Heating surface:—		
Of tubes	1082·5 sq. ft.	
Of fire-box	117·5 sq. ft.	
Total	1200·0 sq. ft.	
Grate area	17·3 sq. ft.	

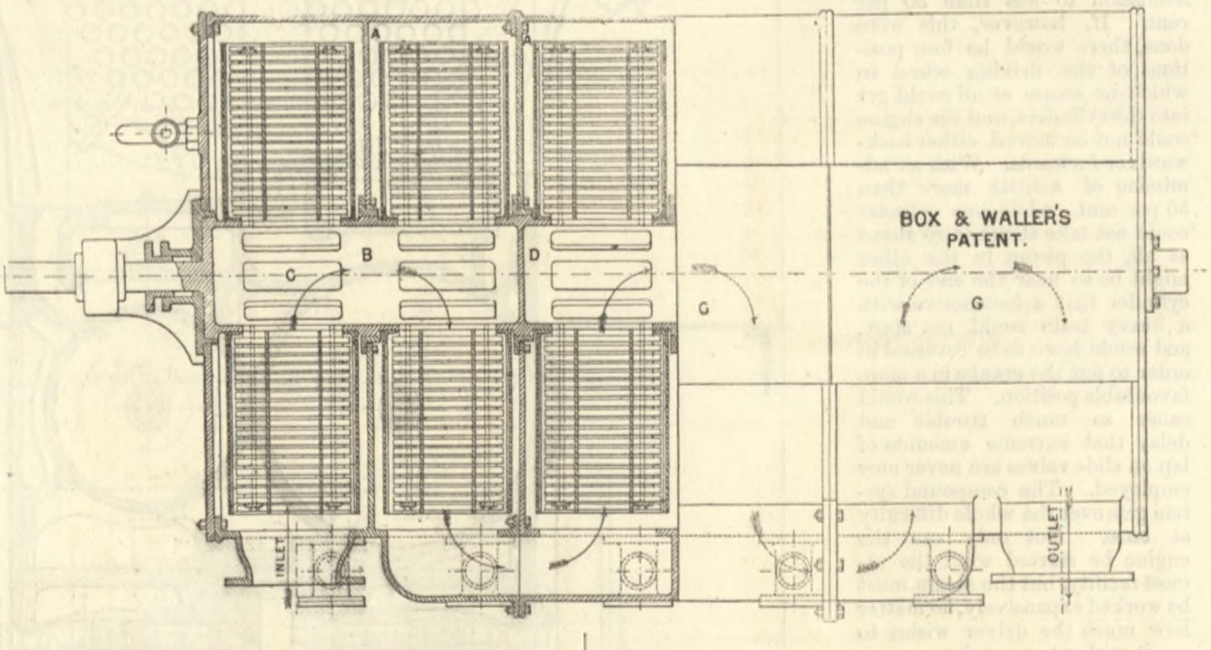
Weight of engine in working order:—	Tons	cwt.	qr.
Bogie wheels	14	15	2
Driving wheels	14	16	2
Trailing wheels	14	18	0
Total	44	10	0
Weight of engine empty:—			
Bogie wheels	13	7	0
Driving wheels	14	3	2
Trailing wheels	13	12	1
Total	41	2	3

The tender holds 5 tons of coal and 3200 gallons of water.

WALLER'S PHŒNIX WASHER-SCRUBBER.

THE accompanying engravings illustrate a new washer-scrubber for purifying gas and extracting the ammonia, as made by Messrs. G. Waller and Co., Phœnix Engineering Works, Holland-street, Southwark-street, S.E. The special advantages claimed are the following:—(1) The largest amount of wetted surface within the same space, with the additional advantage of numberless fine streams continuously trickling over the tubes, and in constant contact with the gas passing through. (2) All trace of ammonia is taken out before the gas reaches the outlet, leaving some chambers in reserve in case of emergency. (3) The liquor being passed from the bottom of each chamber to the next, the lightest is left on the top. (4) The pressure of the gas passing through is reduced to a minimum. (5) The certainty that no part will be stopped with tar, which hitherto has been a source of trouble. (6) The small amount of power required to work it in proportion to its efficiency. (7) The facility with which the working part can be examined, and if required the whole of the interior can be removed and refixed by unskilled labour in a very short time. (8) Convenience of fixing the connections at the side, away from the end covers and driving gear.

The casing consists of rings or cylinders of cast iron, with diaphragms A forming chambers, and having manholes G along the top or side. Through this casing, but above its centre, revolves a hollow shaft B, having diaphragms D corresponding with those in the casing; there are also long slots C for the gas to pass through. At each diaphragm D there is a bearing, in halves, which also serves as a gas check. On the shaft in each chamber are discs of sheet iron with cross divisions, making six, eight, or more pockets. Each pocket is filled with a nest or group of tubes fitted in perforated segment plates, each group being secured in its place by screws tapped in the hollow shaft B. The gas from the inlet passes through the groups of tubes—the steam trickling over them—into the hollow shaft, thence into the next chamber, through the tubes to the passage on outside of casing, and so on through each chamber alternately to the outlet. The discs in each chamber, the cross divisions, the tube plates, and the tubes with their inside and outside surface, form an enormous amount of highly effective wetted surface, over and through which the gas must pass to get from one chamber to another. The outside angle pipes E pass the liquor from the bottom of one chamber to the top of the next, and



from one end to the other. The supply of clean water can be regulated to any required quantity. The tubes, as shown in enlarged view, carry up water and discharge it when revolving; they can also be made as plain tubes open at the ends for gas to pass through. Tar is drawn off by the pipes F. The water inlet is on the top, and the liquor overflow at the other end.

STREET WATERING AND SCAVENGING.

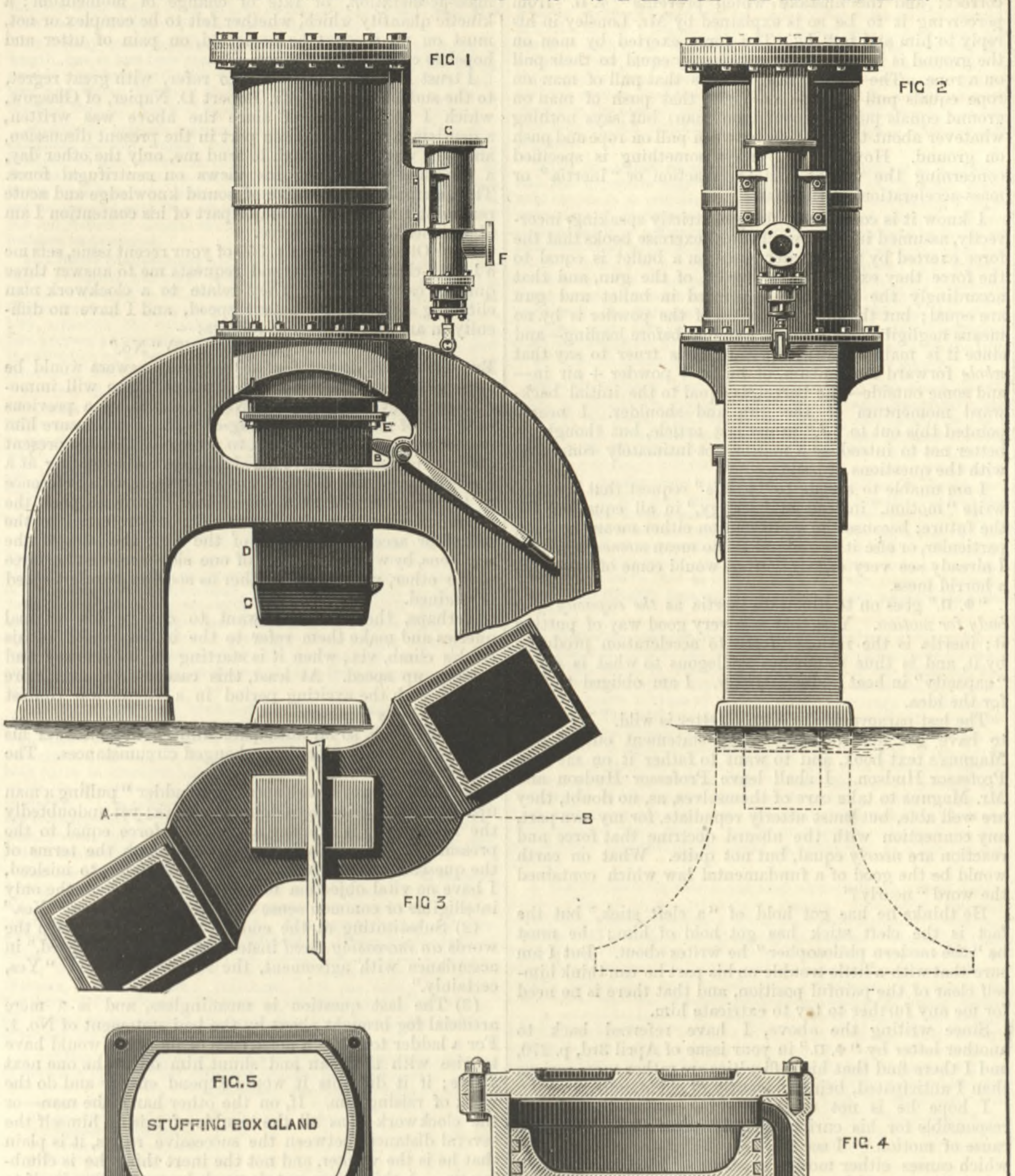
THIS subject does not look much like engineering, but in a report upon it to the Hornsey Local Government Board, Mr. T. de Courcy Meade, the engineer to the Board, gives a good deal of information which is of interest to engineers. The Board wanted to find out whether it would pay better to run its own horses or to contract for the use of horses and men as it has hitherto done. The medium course of contracting to some extent, and of hiring a few more seems to be the better one. For watering the streets contracts have been made with horse-owners who undertake to provide horses whenever wanted, and with our variable weather it may be supposed that this demand is very lumpy or jerky. For instance, quoting from Mr. Meade's report, we find that the smallest number of working days during a period of five years was 147 in 1883, but this rose to 178 in 1884. Calling each day through which a horse worked a horse-day, then we find that the total number of horse-days, if the maximum number had been employed each working day throughout the season, would have been 1992 in 1881, while in 1884 it would have been 2670. The actual number of horse-days per season was, however, from 865 to 1677, while the number of horse-days provided by the contractor but not employed ranged from 813 to 1371. In 1882 when the working days were 165, the number of horse-days was 2310, and the maximum number of horses on any day was 14; but in 1883, when the number of working days was 147, and the horse days only 2058, the maximum number of horses at work on any day was the same, namely fourteen. In 1884, with 178 working days and 2670 horse days, the horses employed on any day never exceeded fifteen. Besides providing for horses to be employed on whole days, the contractor had to provide for horses employed half and three-quarter days, and for this the contract price for providing horses, harness, and driver, whenever wanted, ranged from 9s. 6d. to 10s. per day, and for half days 5s. 6d. to 6s. Except to an owner of a large number of horses, it is therefore impossible to contract for this work with much hope of profit.

From figures giving the cost of street cleansing during the five years 1881-5 inclusive, the latter years based on contract prices, it appears that the number of miles of public roadway in the district increased during those years from 22 to 28·5. The cost of cleansing per mile was £34 10s. 9d. in 1881, but rose to £40 14s. 3d. in 1882, but in 1884 it again fell to £33 7s. 5d. The cost of cleansing per yard super. was as follows for the several years: 1881, 0·51d.; 1882, 0·61d.; 1883, 0·59d.; 1884, 0·5d.; and 1885 it is to be 0·53d.

Every metropolitan suburb seems to be experiencing growing difficulty in disposing of the slop from the streets. The dry sweepings can more readily be got rid of, but as the district becomes built over the difficulty will increase. Mr. Meade mentions that in Islington a process of washing the street refuse is in operation at the vestry's depôt, where there are three wash mills, about 20ft. in diameter, worked alternately by a 12-horse power engine. The quantity of slop, &c., washed per week is on an average about 600 yards. The mills are said to be capable of washing about 120 yards of slop per twenty-four hours, for which purpose about 36,000 gallons of water are required, and giving a residue of about 20 to 25 yards of clean sharp sand, suitable for building purposes. The skimmings and sludge are mixed with stable manure or dustbin refuse; the liquid result is passed through settling pits or tanks, from which a comparatively clear effluent is run off. Some of the sand is used for road-making, and the surplus sold at 3s. per yard. Formerly the slop was calculated to cost the vestry, on an average, about 1s. per yard for disposal; by the washing process the net loss is said to be about 2½d. per yard. From these facts it would appear that a satisfactory system of machinery for washing road scrapings with the smallest quantity of water would find employment for machine constructors and by vestries.

In dealing with the cost of removal of dust, Mr. Meade gives a number of figures of interest, and shows how much the destructor system of Manlove, Alliott, and Fryer, is coming into use. From the figures given it appears that the average cost per house per annum in the Hornsey district was, during the five years 1880-84 inclusive, 11·02d. The cost of dusting in the parish of St. Pancras for the year 1879-80 is stated to have been £6187 for the removal of 25,000 loads, or an average of 4s. 11d. per load. In the parish of St. Mary, Islington, the number of loads of dust dealt with during the year 1883-84 is given as 41,499, or an average of 3s. 7d. per load. The quantity of dust removed from the metropolitan districts is on an average about one load, or 2½ cubic yards, per house per annum. The present contract for Hornsey is 10·35d. per house per year. From various published reports it appears clear that not only are the refuse drying and burning furnaces a means of saving much trouble, but they save expense, while the clinker produced in the furnaces is cheaply reduced to the necessary fineness for making mortar.

DICK AND STEVENSON'S STEAM HAMMER.



THE accompanying engraving represents a type of steam hammer of which a series is being made by Messrs. Dick and Stevenson, of Airdrie. The hammer has been designed and patented by Mr. Graham Stevenson, of that firm, with the special view of securing greater rigidity for operation on steel ingots and steel use forgings, now increasingly replacing the older malleable product of this class. The design embraces several novel features which are clearly shown.

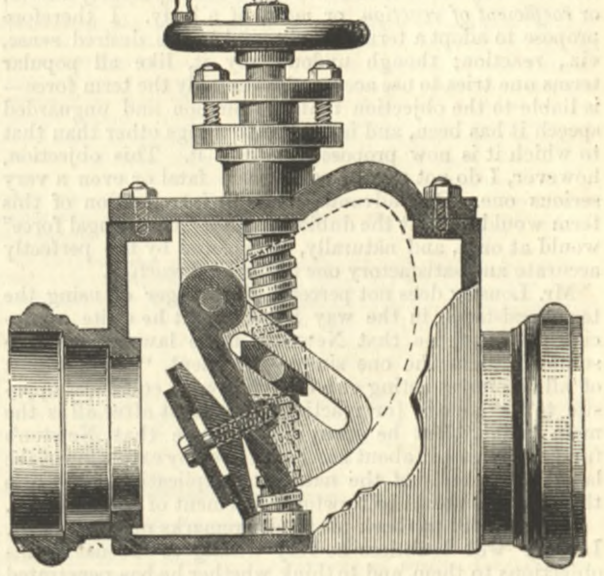
The ram or piston bar is a hollow steel casting, and in one piece with the piston, but in place of having an enlarged head for reception of hammer face piece as usual, its size in cross section is greater than that of the face piece itself, thus admitting of the latter being travelled up to, or even into the cylinder packing gland, a device which admits of considerable diminution in the height of the hammer, and secures steadiness of the ram by guides placed only sufficiently above the piece in process of hammering to afford freedom for its proper handling. It also provides for the insertion or withdrawal of the piston to or from its position through the cylinder without removal or disjointing any part except the top cylinder cover.

The anvil block and cylinder-supporting standards, the latter being preferably cast of steel, are in two castings, but being keyed together are rendered virtually of one mass, resting on one foundation, and opposing joint resistance to the ram blows. By this union of the two main members all chance of variation in relative position is entirely provided against, a point which will be appreciated by hammer users.

The illustration shows that the designer has aimed at the employment of few bolts, few joints, and generally few opportunities for slackness, flexibility, or derangement. The first of the type, a small sized hammer with three ton ram, was put under steam at the Crown Ironworks, Coatbridge—Messrs. William Tudhope and Sons—a few weeks ago, when its behaviour at work greatly pleased those concerned. The hammer face is oblong as usual, and the two annexed illustrations, Figs. 1 and 2, show the legs of standard placed in the lengthways plane of the hammer face and anvil block, but in hammers intended for use forgings, the legs are placed obliquely to the plane of the hammer, as represented by the plan A B, Fig. 3, in order to give more convenient access in applying sets or cresses to pieces submitted to hammering action. The engravings, Figs. 4, 5, 6, and 7, give the constructive information not to be gathered from the foregoing views, and show to what a simple thing the valve gear of a steam hammer has arrived, as compared with Nasmyth's gear of thirty years ago. The letters in the details refer to the same parts as those in the general views.

MESSENGER'S FULL WAY VALVE.

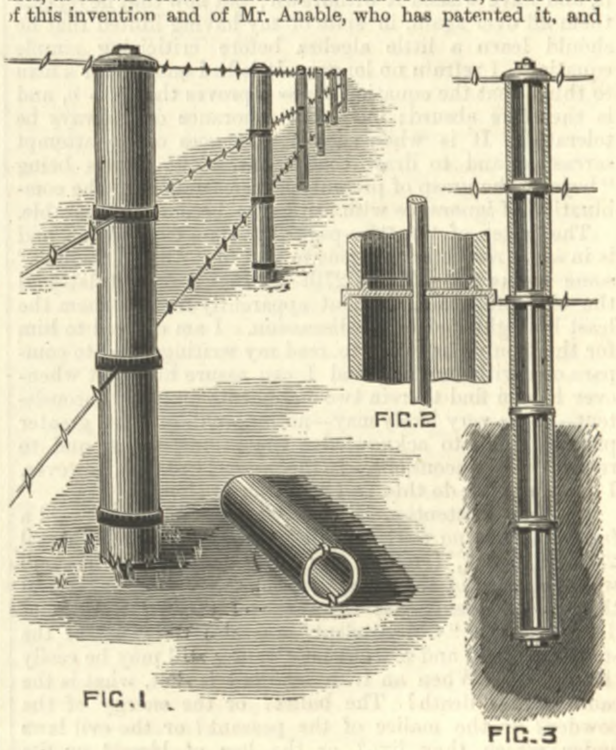
THE full way valve illustrated below is made by Messrs. Messenger and Co., Loughborough, for hot or cold water or steam. When open, it gives a free water way of the full bore of the pipe, and can be closed easily against any pressure. The



spindle and working parts are made of brass. By unscrewing four nuts the lid can be taken off, withdrawing the whole of the working parts, and a new rubber can be placed on the valve, and the lid replaced without disturbing the joints of the pipes.

DRAIN PIPE POSTS.

WHEN there is no wood left and iron posts are too costly or far off, then posts for some purposes may be made with drain tiles, as shown below. America, the land of timber, is the home of this invention and of Mr. Anable, who has patented it, and



who says it offers some advantages. He lives at Paw Paw, Mich. Fig. 1 shows the post in position holding its wires, Fig. 2 the detail of joining the sections, and Fig. 3 the interior of Fig. 1. They must be badly off for post stuff in the States.

ELECTRIC LIGHTING FOR THE ADMIRALTY.—The Admiralty last week placed orders for electric lighting gear for fifty-two ships, including twenty of the new sea-going torpedo boats; and they have selected the Willans engine—made by Messrs. Willans and Robinson, of Thames Ditton—for no less than thirty-two of these. The distribution of the orders is as follows:—Brush Company, twenty sea-going torpedo boats, Willans' engine; Brush Company, five ships, Willans' engine, three ships, Goodfellow and Matthews' engine; Siemens Bros. and Co., seventeen ships, Brotherhood and Goodfellow and Matthews' engine; Crampton and Co., seven ships, Willans' engine. With some already on order through Messrs. Crampton and Co., Messrs. Willans and Robinson have now nearly forty engines on hand for lighting her Majesty's ships.

NEWTON'S LAWS OF MOTION.

By Prof. OLIVER LODGE.

MY suggestion, that rate of change of momentum be called "reaction," scarcely meets with the full approval of either Mr. Napier or Mr. Lonsley—see your 24th April issue, p. 342. They agree, however, that a single name for this quantity would be useful, and while one suggests *inertia*, the other suggests *inertial reaction* or *inertial resistance*. "Inertial reaction" expresses the meaning exactly, but until some other kind of reaction than that due to inertia is discovered, the qualifying adjective seems unnecessary. "Inertial resistance" might do imperfectly well, except that its unwieldiness would cause the—in this case essential—qualifying adjective to be often dropped; with utterly confusing results, as I have endeavoured at some length to show. The word *inertia* alone is by no means bad for the purpose under consideration, and I was myself half tempted to suggest it; but there is the obvious objection that this word has been already applied to a part only of the thing to be denoted, viz., to the coefficient of acceleration in the full term *reaction, i.e.*, to the ratio of force to acceleration.

Strictly speaking, the word "inertia" for the whole thing, and the phrase *coefficient of inertia* for the constant known as mass, would have been very satisfactory, just as in electricity what is known as the *resistance* of a wire ought more properly to be called its *coefficient of resistance*:—its true resistance, or force with which it opposes a current, being proportional to the strength of the current flowing through it, and being equal to that strength multiplied by the coefficient already mentioned.

But the name "resistance," for the coefficient only, is too well established in Electricity for me to attempt to oust it; and similarly with the term *inertia* for the *coefficient of inertia*, or *coefficient of reaction*, or *mass*, of a body. I therefore propose to adopt a term already used in the desired sense, viz., reaction; though undoubtedly it, like all popular terms one tries to use accurately—notably the term force—is liable to the objection that in common and unguarded speech it has been, and is, applied to things other than that to which it is now proposed to limit it. This objection, however, I do not myself regard as a fatal or even a very serious one. One advantage of the introduction of this term would be that the dubious phrase "centrifugal force" would at once, and naturally, be replaced by the perfectly accurate and satisfactory one *centrifugal reaction*.

Mr. Lonsley does not perceive the danger of using the term resistance in the way he does, but he quite appreciates my doctrine that Newton's three laws may all be summed up in the one simple statement, "the resultant of all the forces acting on a body is always equal and opposite to its 'inertia' [or reaction];" and that after all is the main point. But he must not suppose that Newton's further statement about acceleration is any extension of the law; it is merely of the nature of explication, as also is the second sentence in Newton's statement of the third law.

With regard to Clerk Maxwell's remarks on inertia, Mr. Lonsley will doubtless be very willing to reconsider his objections to them, and to think whether he has penetrated to the proper depth for fully appreciating them. When he says that the non-destructibility of matter is its fundamental property, let him consider *how he knows* that the matter is not destroyed, and his acuteness will not fail to perceive the insight exhibited by Clerk Maxwell's remarks.

I refrained from expressing myself with reference to the letter of Mr. W. H. Longmore in my last article—April 24th—because I hoped that, even before his letter appeared in type, he would have been ashamed of the blunders in it, and have wished it withdrawn; but now that he repeats them all over again, in spite of my having hinted that he should learn a little algebra before criticising simple equations, I refrain no longer. It is bad enough for a man to think that the equation $3\ x = o$ proves that $3 = o$, and is therefore absurd; but mere ignorance can always be tolerated. It is when such a man goes on to attempt sarcasms, and to draw conclusions about things being "beyond the grasp of present mathematics," that the combination of ignorance with arrogance becomes unbearable.

The letter of "Φ. Π."—page 342—is a curious one, and is in some respects analogous to that of "An Old Student" some weeks ago—March 27th—in that it recapitulates all the old difficulties, without apparently feeling them the least bit lightened by the discussion. I am obliged to him for the trouble he takes to read my writings, and to compare one with another; and I can assure him that whenever he can find therein two statements mutually inconsistent—as he very likely may—nothing will give me greater pleasure than to acknowledge the inconsistency, and to recant the erroneous one. In the present instance, however, I am unable to do this, as I will shortly show.

His first contention is, that whereas in 1881 I said a force could do no work, yet in your recent issue of April 23rd, page 311, I told "An Old Student" that "his pull was the cause of the stone's motion." Well, so it is; and the "Old Student" was the cause of the pull. I do not deny that the "Old Student" was also the cause of the stone's motion; and more remote causes still may be easily thought of. When an Irish landlord is shot, what is the cause of his death? The bullet? or the energy of the powder? or the malice of the peasant? or the evil laws under which they live? or the loss of blood? or the clogging of the lungs? Which you like. As Mark Twain would say, "they are all the same price." The fact is the word "cause" is not much used in physics; but the word "work" is in a different category. *Work* and *Energy* have been carefully defined, and the definitions make us bound to admit that a thing which does work loses energy. Now when "An Old Student" pulls a stone, there can be no doubt that it is the "Old Student" who loses the energy, and who, accordingly, does the work. I should never, when speaking cautiously, say that his *force* did the work; because force is not an entity capable of possessing energy or losing it. It is a *body* which does work, and gives up some of its energy. One body loses energy, another body gains it; and work is the act of transfer between them. To all that I ever said on this subject I rigidly adhere, and am glad to find that "Φ. Π." does so likewise, because I regard it as very important.

Now about my "boots." I must reaffirm my tug-of-war statement, about R + R', as accurately and thoroughly correct; and the mistake which prevents "Φ. Π." from perceiving it to be so is explained by Mr. Lonsley in his reply to him and to "J." The force exerted by men on the ground is by no means necessarily equal to their pull on a rope. The "third law" asserts that pull of man on rope equals pull of rope on man; that push of man on ground equals push of ground on man; but says nothing whatever about the relation between pull on rope and push on ground. How can it, unless something is specified concerning the weight, and the reaction or "inertia" or mass-acceleration, of the man?

I know it is commonly, though, strictly speaking, incorrectly, assumed in most mechanical exercise books that the force exerted by the powder-gases on a bullet is equal to the force they exert on the breech of the gun, and that accordingly the momenta generated in bullet and gun are equal; but the inertia or mass of the powder is by no means negligible—it is easily weighed before loading—and since it is mainly thrown forward, it is truer to say that *whole* forward momentum, of bullet + powder + air in—and some outside—the barrel, is equal to the initial backward momentum of the gun and shoulder. I nearly pointed this out to "J." in my last article, but thought it better not to introduce a matter not intimately connected with the questions at issue.

I am unable to accede to "Φ. Π.'s" request that I would write "motion," instead of "energy," in all equations for the future; because the word motion either means nothing particular, or else it is understood to mean *momentum*; and I already see very clearly "what would come of it"—viz., a horrid mess.

"Φ. Π." goes on to illustrate inertia as *the capacity of a body for motion*. Yes, that is a very good way of putting it; inertia is the ratio of force to acceleration produced by it, and is thus somewhat analogous to what is called "capacity" in heat and electricity. I am obliged to him for the idea.

The last paragraph of "Φ. Π.'s" letter is wild. He seems to have got hold of some foggy statement out of Mr. Magnus's text book, and to want to father it on me and Professor Hudson. I shall leave Professor Hudson and Mr. Magnus to take care of themselves, as, no doubt, they are well able, but must utterly repudiate, for my own part, any connection with the absurd doctrine that force and reaction are *nearly* equal, but not quite. What on earth would be the good of a fundamental law which contained the word "nearly?"

He thinks he has got hold of "a cleft stick," but the fact is the cleft stick has got hold of him; he must be "the modern philosopher" he writes about. But I am sure that with a little trouble on his part he can think himself clear of the painful position, and that there is no need for me any further to try to extricate him.

Since writing the above, I have referred back to another letter by "Φ. Π." in your issue of April 3rd, p. 270, and I there find that his difficulties are rather more serious than I anticipated, being evidently of old standing.

I hope he is not under the impression that I am responsible for his curious doctrine that "force is not a cause of motion." I see no harm in *defining* force as that which causes either motion or strain or both, though such a definition would be confessedly imperfect.

He is evidently labouring under the delusion that forces, being always balanced, are incompetent to produce or destroy motion; whereas the truth is that whenever a body is being either accelerated or retarded, although the whole force may be rightly regarded as balanced, yet it is only so balanced *by reason of the particular amount of change of motion which is being caused;* this constitutes one of the terms in the system of balanced forces. "Φ. Π." speaks as if the resultant force acting on the body was zero, which is by no means the case. The forces in the whole system are balanced; the forces acting on the accelerated body are certainly not balanced.

His difficulty is exactly the same old difficulty over again, against which one has been tilting all the time—what I called *confusion No. 2* in my first article of March 20th—only the worst of it is that "Φ. Π." does not consider it a difficulty, but complacently regards himself as in possession of the true faith. It is sad, but it is necessary, to render him uncomfortable in his intrenched position lest he persuade others to come and join him in the same false shelter.

May I ask him to do me the favour to read my recent articles carefully through, not with the idea that he is agreeing with me, but with the object of finding out what I mean? I need hardly say that he is, of course, perfectly welcome to differ from me after that process if he chooses; but, though I should regret this, I had rather that he definitely differed from me than that he should promulgate his faith under the impression that it was in perfect agreement with my own.

Will it be any assistance if I return for one instant to the horse and cart illustration, taking as my text the concluding paragraph of "An Old Student's" letter on page 242, March 27th. I had said that if, when a horse started a cart, we asserted that the pull of the horse was no greater than the resistance experienced by the cart—the pull of the ground, &c.—we should talk nonsense; upon which "An Old Student" ejaculates, "Then Newton talked nonsense, for that is just what he said." That is where we differ; for, begging the "Old Student's" pardon, Newton said nothing of the kind. He said that the cart pulled back as much as the horse pulled forward; or that the total reaction of the cart, taking into account the acceleration being produced in it, as well as the resistance experienced by it, is exactly equal and opposite to the pull of the horse. So it is, but that is not the same thing as saying that the force resisting the cart's motion is equal to the force producing that motion, viz., the horse's pull. The true *reaction* of the cart, viz., that due to its inertia and acceleration together—"inertial reaction" as Mr. Napier proposes to call it—is not a resistance to its motion at all. It is not one of the forces acting on the cart. It is one of the forces acting on the *horse;* it is, in fact, just the force which the horse feels, over and above what the cart feels. It is a force exerted *by* the cart, not *on* it. Considered with reference to the cart, it is simply mass-acceleration, or rate of change of momentum: a kinetic quantity which, whether felt to be complex or not, must on no account be neglected, on pain of utter and hopeless confusion and error.

I trust I may be permitted to refer, with great regret, to the sudden death of Mr. Robert D. Napier, of Glasgow, which I have heard of since the above was written, a gentleman who has taken part in the present discussion, and who was good enough to send me, only the other day, a pamphlet embodying his views on centrifugal force. This pamphlet is indicative of sound knowledge and acute reasoning; and with the major part of his contention I am able unhesitatingly to agree.

"An Old Student," on p. 350 of your recent issue, sets me a ladder-climbing puzzle, and requests me to answer three queries categorically. They relate to a clockwork man climbing a rack at a constant speed, and I have no difficulty in answering them as follows:—

(1) "No." (2) "No." (3) "No."

But somehow I do not feel as if these answers would be very satisfactory to "An Old Student," who will immediately believe that answer No. 1 contradicts a previous assertion of mine respecting tug-of-war. I can assure him it does not, and must beg him to notice (*a*) that his present query expressly considers his clock-man as ascending at a uniform speed, and (*b*) that my statement, with reference to the winning side at a tug-of-war having to push the ground harder than the losing side, only referred to the initial or accelerated stages of the win; the sum of the reactions, by which the force of one side exceeds the force of the other, vanishes altogether as soon as constant speed is attained.

Perhaps, then, he will want to change his original queries and make them refer to the initial period of his clock's climb, viz., when it is starting on its journey and getting up speed. At least, this case corresponds more exactly with the exciting period in a tug-of-war contest of which he is thinking.

Let me, then, so far anticipate him as to re-answer his three questions under these changed circumstances. The answers are:—

(1) I should not myself speak of a ladder "pulling a man up," as if the ladder were doing the work; yet undoubtedly the ladder-rung is exerting an upward force equal to the pressure of the man's foot; and so, though the terms of the question are very unsatisfactory and liable to mislead, I have no vital objection to giving an answer to the only intelligible or common sense aspect of the question, "Yes."

(2) Substituting at the end of his second question the words *an increasing speed* instead of "a uniform speed," in accordance with agreement, the answer to it is, "Yes, certainly."

(3) The last question is meaningless, and is a mere artificial fog brought about by the bad statement of No. 1. For a ladder to act as a hoist, each of its rungs would have to rise with the man and shunt him on to the one next above; if it did this it would expend energy and do the work of raising him. If, on the other hand, the man—or the clockwork—has all the trouble of raising himself the several distances between the successive rungs, it is plain that he is the worker, and not the inert thing he is climbing up. A thing does not do work by permitting itself to be trampled on; it exerts force truly, but force and work are by no means the same thing.

(4) But I find there is a fourth question which I had overlooked, and it is in two or three parts. Do I believe in resistance? Yes, of course. In the popular sense? Yes, I suppose so, unless "the popular sense" is nonsense, which I have no reason whatever to believe. And is it identical with reaction? Good heavens, NO!! I have been writing these three articles to show that it isn't, and to explain that all the confusion arises by thinking that it is, or rather by not understanding the essential differences and relations between them.

Let me try once more to make this matter clearer. "Resistance" is a popular term, and means nothing more than the obvious drag which the most "popular sense" must perceive. "Reaction" is not a popular term at all, and does not exist in "the popular sense." It involves ideas of inertia and of change of velocity with time. It is zero in all uniform rectilinear motion. In curvilinear motion it goes by the name "centrifugal force." In quickening or slackening motion it is sometimes called "inertia," sometimes "force of inertia," sometimes, and most commonly, "resistance."

Why is it thus called resistance? A man pushes a railway truck on frictionless wheels and finds it resists him, so he naturally styles the thing which does so "resistance." Now so long as he is thinking of the resistance offered by the truck to *him*, he is quite right in so calling it:—it is the reaction of the truck which he feels as a resistance. To him, therefore, it is a resistance. But he has no means of ascertaining how the truck feels in the matter, and so he very soon begins to extend his sensations to the truck, and to think of its reaction as a resistance offered by the truck to *itself;* and thus gets into confusion and serious error. This is what causes him—if he be at all logical—to knock himself against the old puzzle—"if the truck resists its own motion, with whatever force I push it, how can it move?" How indeed! The idea of a truck resisting its own motion is absurd. It may resist other trucks, or a man, or a horse, or an engine, but not itself. To resist its motion something else must act on it; for instance, you can put a stone under its wheels, or burn the oil from its bearings, or jamb it between two pair of buffers. But a truck able to resist its own motion, *i.e.* to exert force on itself, would be a novelty. For such a truck a steam locomotive would be superfluous.

The whole of dynamics is involved in this matter. It is so completely the one fundamental law on which everything is based, that no one can possibly have a clear and sound knowledge of mechanics who does not understand it. It is, therefore, worth some trouble to settle, but I suppose the trouble is likely to be commensurate with the importance and magnitude of the result.

RAILWAY MATTERS.

THE chocolate paint now used for the engines on the Midland Railway lasts nearly twice as long as the green formerly used, and thus makes a saving of several thousand pounds per year.

THE many years-talked-of railway to Swanage, eleven miles in length, has at last been completed, thus connecting this interesting seaside neighbourhood with the London and South-Western Railway and Great Western Railway systems at Wareham. It is thought that the line will be opened for traffic on the 1st June.

INCREASED activity appears this week at one or two of the Birmingham railway wagon works, where orders have lately been received for iron underframes for certain of the Indian lines. In the building of carriages and wagons entire there is less doing than in the underframe departments. The decision of the Government not to proceed with the Suakim Berber Railway is likely to stay the completion of contracts into which some of the local carriage-builders had entered.

THE South Staffordshire and Birmingham District Steam Tramways Company has now twenty-three miles of line open. Its liabilities amount to £87,000, of which the largest part is owing to the contractors. The past year's working has proved unsatisfactory, although the earnings were £12,414. The directors therefore propose an increase of £50,000 in the company's capital, and the adoption of a revised scheme of working, which includes the removal of the offices from London to Birmingham.

DURING the year 1884 there were 523 servants of the railway companies or contractors killed and 2204 injured, against 543 and 2373 respectively in 1883. Among the various causes, too numerous to mention in detail, we find that 113 were killed and 153 injured while working on the permanent way or sidings; 149 killed and 238 injured while walking, crossing, or standing on the line on duty; 41 were killed and 119 injured by being caught between vehicles; 61 were killed and 20 injured while walking on the line to or from their work.

THE Select Committee of the House of Commons on the London Tramways Extension Bill gave their decision on Wednesday. They allowed the Bill to proceed in regard to the doubling of the lines in Junction-road, Fortess-road, and the extensions in Kentish Town, considering the preamble proved. The Chalk Farm-road line would be a good one, but considering the narrowness of the road and the impossibility of getting a proper margin between the tram-line and the kerbstone, they did not sanction that part of the scheme. They also sanctioned the line from Farringdon-street to King's-cross.

SURVEY reports have been furnished to the South Australian Government, by Mr. Graham Stewart and Mr. John M. Bagot, with regard to the proposed construction of a railway from Farina or Hergott's Springs as far as the Queensland Border; and they both agree in recommending that the line should run north-eastwards to Innamincka, and thence in a north-west direction to Birdsville. It is estimated that the proposed railway would meet the requirements of the trade of 90,000 square miles of territory, which, when fully developed, would carry ten million sheep, and yield a trade of 100,000 bales of wool annually.

THE decrease in railway receipts which has been noticeable during the first months of this year is not peculiar to this country. All the great French railway companies exhibit deficits in their receipts as compared with 1884. The aggregate loss for the six companies is about twelve millions of francs, nearly half of which is borne by the Lyons, the diminution on which is 12½ per cent.; the Orleans loses 12·33 per cent.; Eastern, 10·69 per cent.; Western, 7·76 per cent.; Northern, 6·99 per cent.; and the Southern, 5·62 per cent. There is no special reason for this falling off in the receipts beyond the depression in trade and the absence of foreign travellers.

A GENERAL classification of the accidents on American railways in March is made by the *Railroad Gazette*, as follows:—

	Collisions.	Derailments.	Other.	Total.
Defects of road	—	17	1	18
Defects of equipment	7	10	5	22
Negligence in operating	28	1	—	29
Unforeseen obstructions	1	1	1	3
Maliciously caused	—	1	—	1
Unexplained	—	13	—	13
Total	36	43	7	86

Negligence in operating is charged with 34 per cent. of all the accidents, defects of road with 21, and defects of equipment with 25½ per cent. A division according to classes of trains and accidents is as follows:—

Accidents:	Collisions.	Derailments.	Other.	Total.
To passenger trains	3	17	6	26
To a passenger and a freight	6	—	—	6
To freight trains	27	26	1	54
Total	36	43	7	86

THE Horseley Engineering Company, Tipton, have just completed a first portion of the contract secured by them from Messrs. John Cochrane and Sons, of London, for the ironwork to be used in the widening of the Charing-cross Bridge of the South-Eastern Railway Company. The widening will be accomplished by six spans, 154ft., and an extension of one side of the present fan end. Each of the openings, 154ft. span, consists of two main girders of wrought iron, to carry which additional cylinders of piers have been provided, and between which run two lines of rails. There is also an auxiliary girder of steel, which is to rest on existing piers and cylinders, to provide a third new line. The wrought iron main girders are each 164ft. long overall, the outer girder being 13ft. 6in. and the inner girder 13ft. 9in. deep over the angles. They are divided into fourteen equal bays between the bearings, each bay containing a double set of diagonals, crossing each other, which are connected to the top and bottom booms by turned steel pins. The booms are formed of plates, and consist of flanges 4ft. wide at the top boom and 3ft. wide at the bottom, and of four webs to each flange 24in. deep. The steel girders are each 164ft. long, and 13ft. 9in. deep between the angles. Each girder consists of fourteen double sets of diagonal bars, the upper and lower booms being further connected by vertical tie bars. The execution of the contract will occupy about twelve months. The total weight of iron and steel involved is some 4000 tons.

"HE JUMPED" is the title of the following from the *Detroit Free Press*:—"Yes," he answered, as he seemed to huddle himself up in a heap, "I've been there. That is, I've jumped from a railroad train running at a speed of forty-eight miles an hour, and I can't say as I want to repeat the experiment." "Where and When?" About thirty miles east of Chicago on the Michigan Central, three years ago." "What was the occasion?" "I was half drunk, and did it on a bet of 5dols. The bet was that I darn't walk out on the platform and take the jump without picking out my ground. As it happened, the ground was pretty clear, but 1,000,000 dols. wouldn't hire me to try it again." "How did you come out?" "Well, it's hard to describe the sensation. As I sprang from the step I seemed to fly. I sailed along in the air until my wings grew tired, and then I dropped down to see the country. I've got a good pair of eyes, but I didn't see much. I was too busy turning cart-wheels and hand-springs and somersaults. Sometimes I beat the professionals all hollow, and again I made a muss of it. It was my intention to skip all the mud puddles and avoid all the stumps, but you can't always have your way in this world. By-and-bye I rested my case; that is, I brought up in a fence corner, and waited for a first-class hospital to come along." "Much hurt?" "Might have been worse. Broke an arm, two ribs, and had over a hundred cuts and bruises, and it was seven weeks before I could walk a rod." "But you won the 5dols.?" "Y-e-s; but there is where I always grow sad. The stakeholder sent it back to me from the first town in the shape of a pine coffin, and it didn't fit my length into seven inches. I had to sell the confounded thing for a misfit at half price!"

NOTES AND MEMORANDA.

WRITING in an American journal, Mr. Coleman Sellers says: "If a bar of ordinary forged iron be planed up to measure 1in. square, and the bar be 1 English yard long, it will weigh 10 lb., and the tenth of such a bar will weigh 1 lb. more accurately than will the ordinary litre of water weigh 1 kilo. The English engineer, in these days of iron, knows when he uses shapes of iron, rolled of uniform section, that the tenth of their weight in pounds per yard gives him the area of the section, and this one admirable incident will long fix the desirability of the present unit of England and America."

WITH the object of producing manganese copper in a readier and less expensive way than at present, Mr. G. A. Dick melts pure copper in a crucible with ferro-manganese containing a large percentage of manganese, and in the presence of silicium. When pouring out into ordinary moulds, the manganese will be found to have combined with the copper, and the silicium with the iron, the latter forming a layer upon the manganese copper. The greater the amount of silicium present the more perfect is the separation, though even so small a quantity as 1 per cent. of silicium as compared with the manganese present suffices for the desired effect. In some cases the ferro-manganese contains in itself sufficient quantity of silicium to produce the necessary reaction upon the iron so as to set the manganese free to combine with the copper.

THE production of lead in Germany in 1868 was about 50,000 tons; by 1872 it had reached 60,000; next year it was 65,000; for the next two years, 70,000 each; in 1876, 75,000; in 1877, 80,000; in each of the two following years, 85,000; then it stood for two years at 90,000; then for two years at 95,000; and in 1884 it amounted to nearly 100,000 tons. This large increase took place in spite of a simultaneous increase in the production of Spain and the growth of the lead production of North America, during the period named, from almost nothing to 140,000 tons annually. More than one-fourth of the product of Germany is furnished by the Mechernich Company, and about one-sixth by the Stolberg Company. According to this report, the total product of the world in lead was about the same in 1884 as in the previous year, namely, between 450,000 and 500,000 tons, and nearer the latter amount than the former.

M. SOROLOFF, who continues his regular analyses of the water of the Neva, has come to the conclusion that the differences between the average monthly content of solid mixture in the water and the yearly average may be expressed by a curve whose characteristics are the opposite to those of the curve for the average monthly temperatures. The solid inorganic deposit remaining after the evaporation of a given amount of water is also inversely proportionate to the amount of organic matter contained by the water of the Neva. When comparing these curves for the Neva with that showing the amount of solid matter contained by the Thames—as given in the "Journal" of the London Chemical Society for 1880—it appears that both rivers give the same curves, notwithstanding the wide difference of their origins, which coincidence may lead to the supposition that the above might be considered as a law for the rivers.

A CORRESPONDENT asks a question respecting solution of india-rubber referred to in a previous impression. Concerning this the *Journal of Photography* says: First, pure rubber should be obtained—when vulcanised, it is perfectly insoluble. Secondly, pure solvents are necessary; chloroform containing a large excess of alcohol and water will fail to act even upon the purest rubber. Again, under the most satisfactory conditions, the action is very slow, and the amount of rubber capable of being taken up is proportionately very small. A small quantity of rubber should be placed in a bottle, and the liquid added, when it will gradually swell very considerably after the lapse of some time, and a mixture of the whole would be facilitated by stirring with a glass rod or a splinter of wood. The rapidity with which the rubber absorbs the solvent will depend upon its condition; but the action is never very quick, nor is it in any way analogous to the dissolution of a crystal. One cause of the failure of chloroform to act upon the caoutchouc may arise from the presence of alcohol in too great a proportion.

THE experiments on lubricants made by Professor Thurston show that under ordinary conditions of every-day practice the value for mechanism working under as light pressures as are met with in spinning frames, for example, different oils will give values varying from 0·10 to 0·25; under the usual pressures of heavy mill-shafting the figures range from 0·5 to 0·10; with pressures of greater intensity, such as are met in the steam engine and under railroad axle bearings, it often varies, using different lubricants, from about 0·01 up to 0·025, the first value being given by the best oils and the second by heavy greases. Under the exceptionally high pressures and at the speed of rubbing reached on the crank-pins of some steam engines—500 lb to 1000 lb. per square inch, 35 to 70 kgs. per sq. cm.—the coefficient may fall to one half the last given values. In endurance, the same variations are met with. The endurance decreases as pressures increase, and is twice as great with the best oils as with others of good reputation. The market prices of oil have no relations to these relations of quality. In some cases prices are made in the most arbitrary manner; as a rule, the price of a mineral or of a mixed oil is no guide to selection.

IN an interesting communication to *Nature*, Mr. Tenison-Woods points out that there are few countries of the world—except, perhaps, Eastern Australia—where coal is so extensively developed as in Borneo. Thick seams crop out in innumerable places on the coast and on the banks of the rivers. Some of the streams of North Borneo, he says, he has seen water-worn and rounded fragments of coal forming the entire shingle bed of the channel. In some places, again, there are outcrops with seams of good coal 26ft. thick. The coal formation is the one prevailing rock of the coast. It forms the principal outcrop about Sarawak. At Labuan, also, no other rock can be seen. Lining the banks of the Bruni River, he only saw picturesque hills of very old carboniferous shale. All the grand scenery of the entrance to the port of Gaya is made up of escarpment of coal rocks, and at Kirdat it is the same. In Eastern Australia and in Tasmania beds of coal of very different age lie close together, and according to Mr. Tenison-Woods it is the same in Borneo. Whether there is tertiary coal or not in the island he cannot say; but there is mesozoic coal and probably palæozoic coal, and coals like that of Newcastle in Australia, whose position hovers between the true palæozoic and the trias.

REFERRING to the construction of oil lamps in a lecture on "Accidental Explosions by Non-explosive Liquids," Sir F. A. Abel gave the following conclusions:—(1) It is desirable that the reservoir of the lamp should be of metal. It should have no opening or feeding place in the reservoir, nor should there be any opening or channel of communication to the reservoir at or near the burner, unless protected by fine wire gauze, or packed with wire, or unless it is of a diameter not exceeding 0·04in. (2) The wick used should be of soft texture and loosely plaited; it should fill the entire space of the wick-holder, and should not be so broad as to be compressed within the latter; it should always be thoroughly dried before the fire when required for use. The fresh wick or wicks should be but little longer than sufficient to reach to the bottom of the reservoir, and should never be immersed to a less depth than about one-third the total depth of the reservoir. (3) The reservoir or lamp should always be almost filled before use. (4) If it be desired to lower the flame of the lamp for a time, this should be carefully done, so as not to lower it beneath the metal-work deeper than is absolutely necessary. (5) When the lamp is to be extinguished, and it is not provided with an extinguishing arrangement, the flame should be lowered until there is only a flicker; the mouth should then be brought to a level with the top of the chimney, and a sharp puff of breath should be projected across the opening. The lamp should be on a firm support.

MISCELLANEA.

MESSRS. BAYLISS, JONES, AND BAYLISS notify their removal to premises at 139 and 141, Cannon-street.

MESSRS. LE GRAND AND SUTCLIFFE and Messrs. C. Isler and Co. have received further extensive orders for tube wells for the Soudan.

IN the notice in our last impression of a stern-wheel boat made by Messrs. Forrestt and Son, we omitted to say that the engines and paddle-wheels were made by Messrs. Jabez James and Co.

SPECIMENS of blue tracings, as they are commonly called, taken by means of sensitized paper, have been sent us by Mr. J. R. Gotz, of Buckingham-street, Adelphi. The specimens are remarkably clear heliographic reproductions of tracings in blue lines on white heliographic paper.

AN American contemporary, the *Steel Age*, says that steel rails cut up into lengths of a foot are being successfully melted in foundry cupolas by Mr. R. E. Masters, who has succeeded in producing some very fine castings at a rate of 5 lb. of steel to 1 lb. of fuel consumed.

THE Standing Orders Committee of the House of Commons have decided not to dispense with the standing orders in respect of the Tower Bridge Bill, which the Examiner had reported as not complying with orders. The Tower (Duplex) Bridge Bill, therefore, cannot be proceeded with this session.

THE experiments made at Vörösvar with the new five-barrel Nordenfelt mitrailleuse have, according to the *Times* Vienna correspondent, given the following results:—At 1000 yards range 26 per cent. of the shots took effect on a target two metres high. At 600 yards 70 per cent. of the shots struck. In the time firing 100 shots in twelve seconds and 480 in one minute were registered.

MR. SAMUEL ABBOTT, M.I.C.E., of High-street, Lincoln, civil engineer and surveyor, has been appointed chief resident engineer to the Buenos Ayres Great Southern Railway Company, and will leave England next month. Mr. Archibald R. Whitehead, who has been engaged with Mr. Abbott for several years on the engineering staff of the Great Northern Railway, and for some time past at Lincoln, will continue the practice at the same offices.

THE *Journal des Débats* says:—"The Chinese Government, abandoning old prejudices, is on the point of working its coal mines in a different way from that hitherto followed, by making use of European miners. It has, in fact, applied to the Belgian Company of Cockerill for the experienced workmen who are necessary to turn to account the mines already pointed out in various places. Thirty miners have accepted the advantageous offers made to them, and thirty more will follow. The Chinese, like the Japanese, learn easily what is taught them. They will know in a short time how to dig up the mineral, and then how to make use of the necessary machinery, and when they have acquired this knowledge they will try to dispense with the aid of Europeans."

IN the processes connected with dyeing and printing of cotton cloth it is frequently necessary to hang the fabric in loops from parallel rods for the purposes of exposure to steam, air, or ammonia. In order that the cloth should hold upon the rods without slipping or being strained, it is necessary to wind rope or strips of cloth around the rods, but this only mitigates the difficulty without accomplishing its removal, for the heat and corrosive action of the vapours rot any covering in a few weeks, and the first notice of any deterioration is generally the appearance of small pieces of roll covering among the cloth in process of finishing. Recently asbestos rope and asbestos cloth have been used for this purpose, and prove to be very durable. Larger ropes of this refractory material have been used for the transmission of power over places exposed to heat.

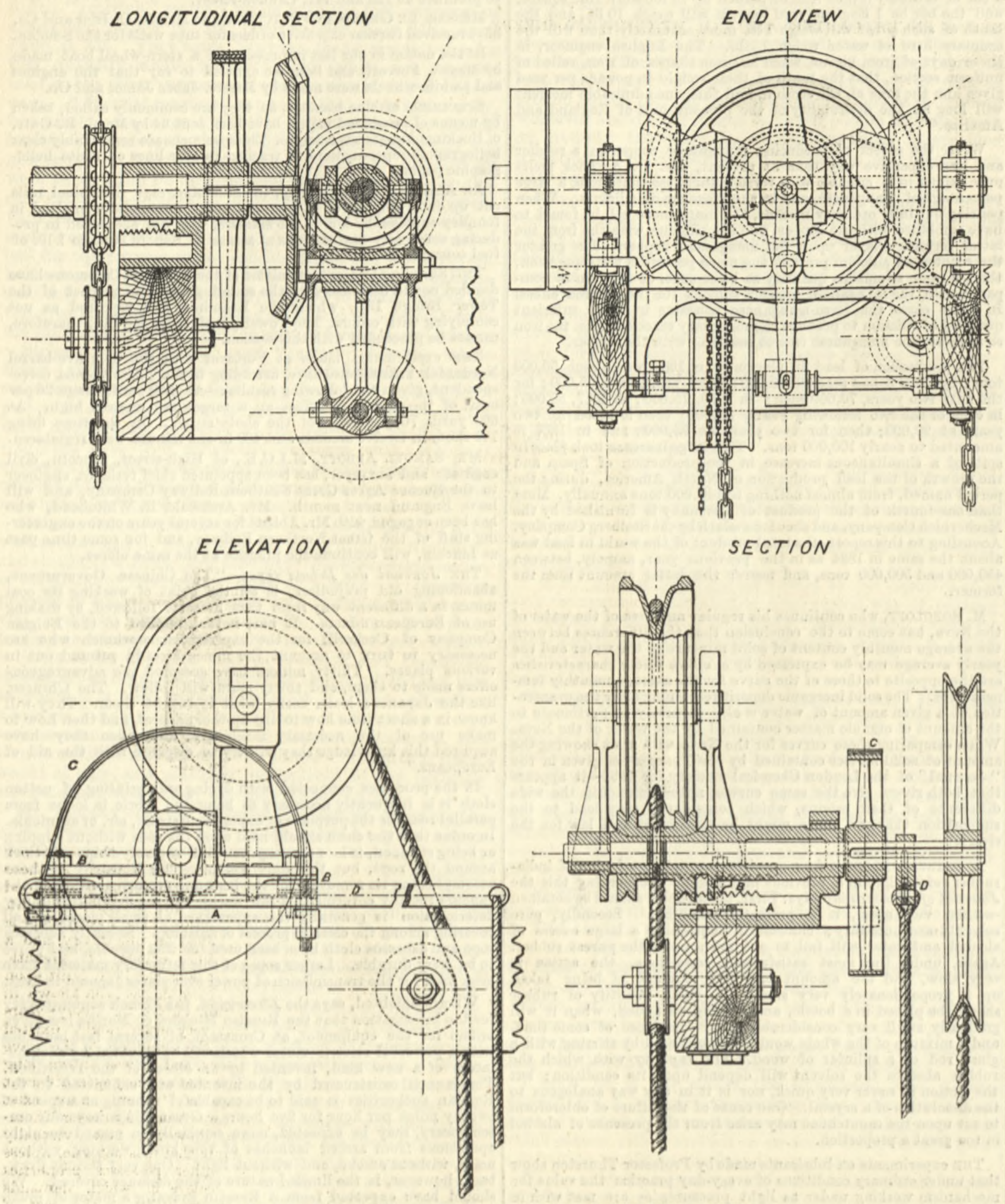
WE are indebted, says the *Electrician*, to a French contemporary for the information that the Russian Minister of Marine has given orders for the equipment, at Cronstadt, of several fast launches with a powerful electric motor which will be actuated by accumulators of a new kind, invented by an officer of the Ivéritinoff. The launch constructed by the inventor and submitted to the Russian authorities is said to be capable of running at a speed of twenty miles per hour for five hours. Great things, says our contemporary, may be expected, more especially in regard to night operations from armed launches of this kind, working without noise, without smoke, and without light. One very serious drawback, however, is the limited nature of the distance covered. We should have expected from a Russian inventor a motor of much more extended capabilities. One hundred miles per hour for a week would have been better and more characteristic of the nation.

ALTHOUGH it is popularly supposed that Australia has few rivers, they are very numerous, and several of those on the New South Wales coast enjoy a large and rapidly increasing trade. For instance, the shipping returns of the Richmond River trade for the year 1884 show that 13,929,047ft., besides 4849 logs, 478 boards, and 2341 pieces of cedar, pine, hardwood, and other timbers, were exported; also 3273 tons of sugar, and 23,148 bags of maize. The other principal exports were 832 bags of oysters, 816 bags of bones and horns, 173 coops of poultry, 351 cases of eggs, 612 head of live-stock. By Sydney steamers the exports were 126 casks of tallow, 8066 hides, 2695 casks of molasses, 80 bags of arrowroot, 60 bags of potatoes, 156 kegs of butter, and 5344 packages of various kinds of cargo. During the same period 540 trips in and out were made by steamers and sailing vessels, and the total number of passengers who travelled by the Richmond River steamers was 4691. The Richmond River district is settled principally by small farmers, who appear to be a most industrious and prosperous class.

SPEAKING about dust explosions, says the *Milling World*, a case from Germany is worthy of notice. A sack of flour, falling down stairs, opened and scattered the contents in a cloud through the lower room, where a burning gas flame set fire to the dust, causing an explosion which lifted a part of the roof of the mill and broke almost all the windows. There can be no doubt that the majority of dust explosions are, like mine disasters, due to open lights, and as this danger can be practically avoided by the use of the incandescent electric lights, there really seems to be no valid reason why it should not be introduced more generally, as those establishments which have used it express themselves in its favour. No matter how carefully other lights are guarded, an absolute safety, as long as the globes are intact, is offered only by the incandescent lamps, where the atmosphere or the dust has no access whatever to the flame. The above instance teaches also how little is necessary to start an explosion in the cleanest mill so long as open lights are used; how much greater must the danger be in establishments where the air is constantly charged with dust, and where cleanliness is looked upon as of minor importance!

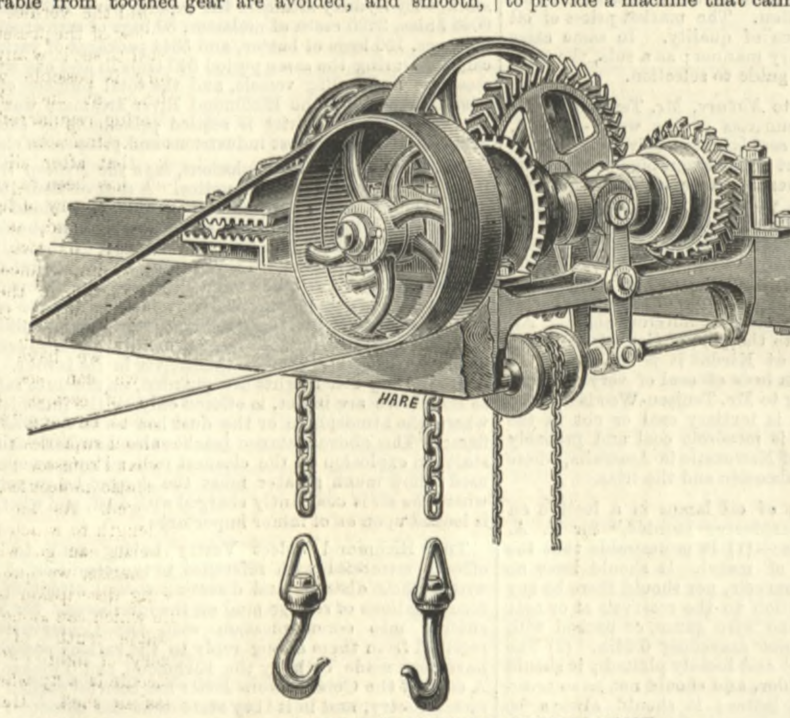
THE Richmond Select Vestry having sent to the Home-office a memorial with reference to the condition of the Thames within their district, and directing special attention to the vast accumulations of sewage mud on the foreshores. Sir W. Harcourt entered into communication with the Conservators, and has received from them a long reply to the various complaints which have been made both by the Richmond and Twickenham people. A copy of the Conservators' letter has been forwarded to the Richmond Vestry, and in it they state that the character of the mud complained of, and the fact that it was brought up the river by the floods during spring tides, prove that it was derived from the same source as the extensive mud deposits which exist in the lower reaches—namely, the sewage of the metropolis, and the reason that this sewage matter was enabled to reach so far up the river is to be found in the fact that the long-continued drought had diminished the volume of the land water to such an extent that it was unable to resist the impulse of the polluted tidal stream. It is the opinion of the Conservators that this nuisance will continue to exist in a greater or less degree until a radical change is effected in the disposal of the metropolitan sewage, and they cannot accept the responsibility for a state of things the origin of which is beyond their control.

INVENTIONS EXHIBITION—ATTWOOD'S HOISTS AND LIFTS.



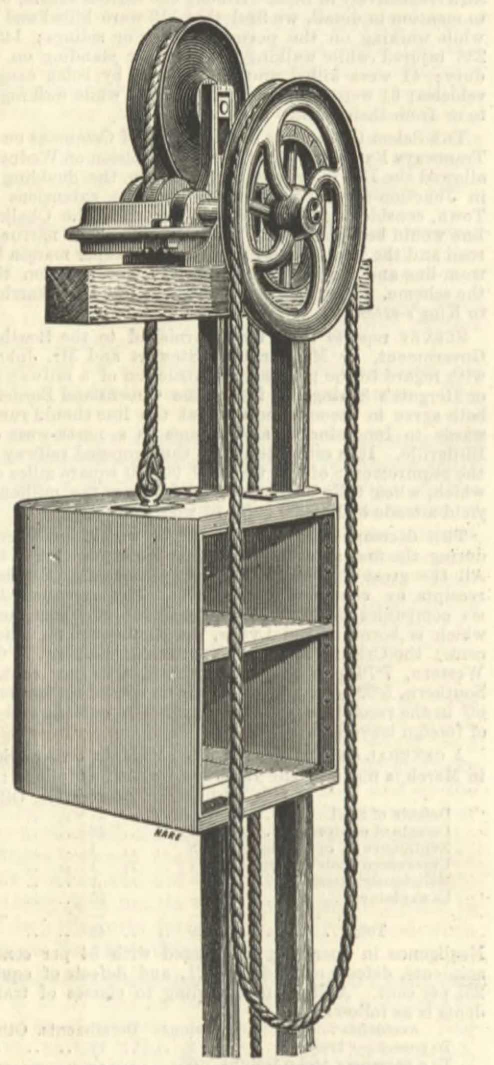
DETAILS OF POWER AND HAND SELF-SUSTAINING LIFTS.

MESSRS. A. ATWOOD AND CO., of Ulverston, show in the Inventions Exhibition their self-sustaining hand power lifts of different sizes. The gearing of these lifts is fitted with an ordinary brake wheel, which is automatically thrown out of gear by the act of pulling the hand rope, without the use of any clutches, pawls, or similar devices, and the arrangement is such that the brake friction is always proportioned to the load. A neat adaptation of friction gearing is also employed, by which some of the risks inseparable from toothed gear are avoided, and smooth,



SELF-SUSTAINING POWER HOIST.

easy motion obtained. Messrs. Attwood also exhibit a working model of a direct-acting hydraulic balance lift, in which the weight of the cage and ram is balanced by an internal ram, thus avoiding the use of overhead gear, balance weights, or chains. The front of their stand is closed in by their revolving and expanding grilles, designed to take the place of revolving or other shutters by protecting the windows or doors without interfering with the view of the goods, &c., exposed inside. Messrs. Attwood and Co. have received instructions from the Committee to fit three of their revolving shutters, worked by balance motion, in front of the steam boilers in the main building. Referring to our engravings of the hoist it may be remarked that it requires considerable experience to lower a loaded cage safely by brakes, especially if the operator is some distance above the floor to which the cage is being lowered. Great strains are often introduced by a too sudden application of the brake, besides which they frequently have to be handled by all sorts of inexperienced persons; and it becomes of the greatest importance to provide a machine that cannot be injured, or damage its contents, by carelessness or mismanagement. In the self-sustaining lift the hand brake is dispensed with, and an automatic brake or some form of clutch provided, which locks the gearing immediately the endless hand rope is let go. So long as it is pulled, at either side, the automatic brake or clutch is kept out of gear by the act of pulling. The method of accomplishing this, adopted by Messrs. Attwood and Co., as illustrated by the accompanying engravings, has the merit of simplicity, an ordinary brake wheel and leather-faced strap being used; and there is no complication of clutches or any difficult or fine adjustment required. The entire gearing, except the base plate A and brake strap C attached to it, is balanced on two fulcra B B, allowing of a very slight rocking motion sufficient to relieve or lock the brake wheel and its strap, which latter is fixed round the upper half only of the wheel. The fulcra are adjustable to vary the leverage, and so allow of the required brake friction being regulated when the lift is first fixed. The act of pulling down the hand rope thus tilts the gearing forward sufficiently to relieve the brake wheel from its strap, and on letting go it is again immediately checked, the weight of cage, loaded or unloaded, being always sufficient to keep the brake wheel up to its strap when the hand rope is let go. The amount of brake friction is always in direct proportion to the weight raised. The engravings show the same principle applied to a power hoist gearing. In this gear the hand rope wheel is replaced by a bevel wheel, which is driven at either side by bevel pinions, thrown into gear by a double-ended cone clutch, operated by the starting chain, which, as usual, runs the entire height of the lift, and is provided with the usual automatic stops to throw the clutches out o' gear at top and bottom of the lift. Other advantages claimed for this form of lift gearing are its compact self-contained form, easy fixing, and non-liability to derangement, being independent of shrinkages or warping of timber supports or settlement in the building. This construction of gearing supplies, also, an important means of preventing overloading, as the cage, if much overloaded, instead



SELF-SUSTAINING HAND POWER LIFT.

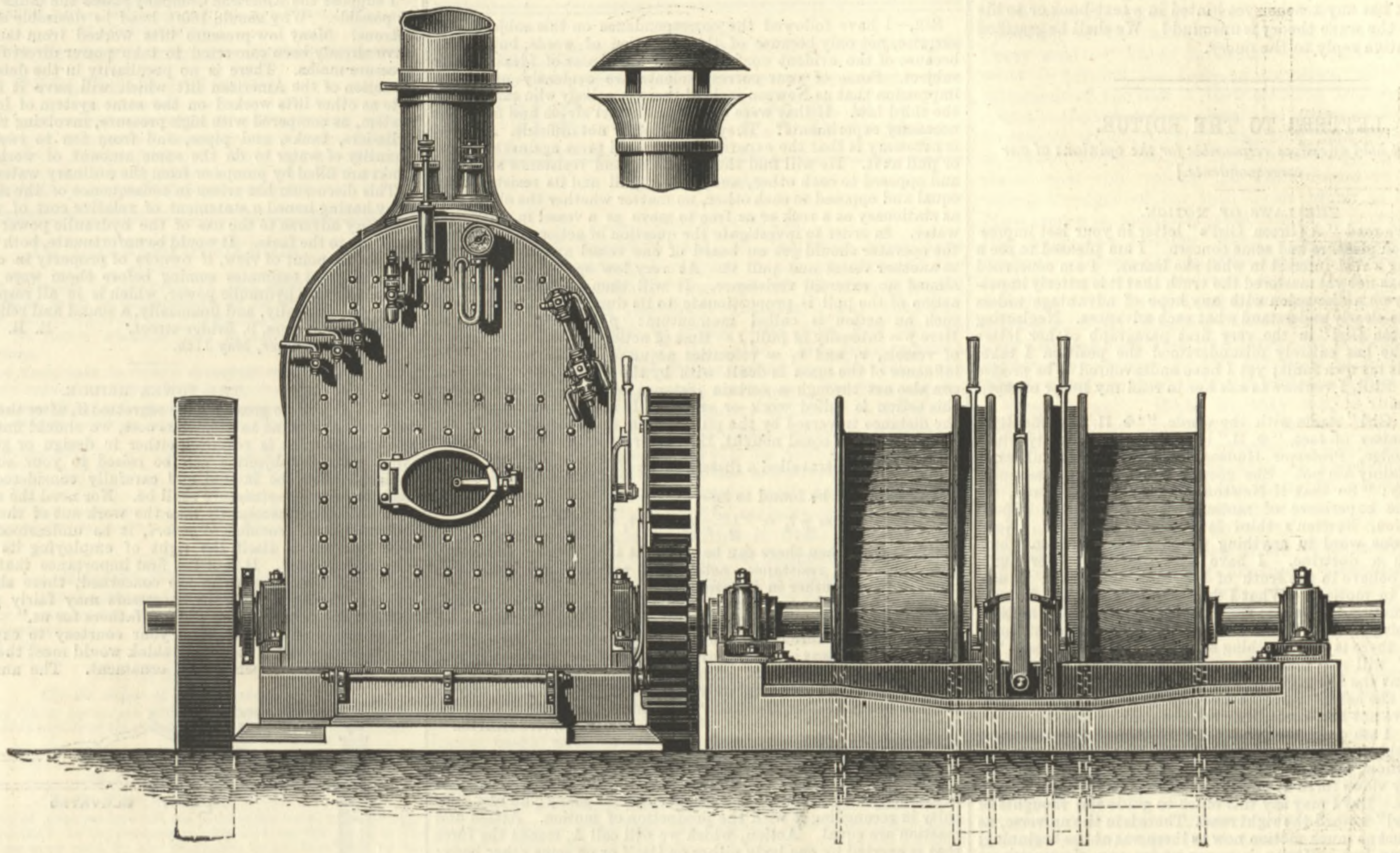
of running down, becomes difficult to move either up or down. An objection has been raised in a few instances to self-sustained lifts, because the empty or loaded cage has to be pulled down by using the hand rope hand-over-hand in the same way as it is raised, though, of course, with far less exertion; whereas with the old hand brake the cage can, if sufficiently loaded, be lowered by brake. This is, of course, a workman's objection, but the element of safety is undoubtedly of far greater importance in most cases than a little extra labour, though in practice this extra labour is reduced to a minimum by adjusting the balance of the cage. There are, however, cases where the risk is either very small or the goods such as cannot easily be damaged, where a hand brake can be employed, and for these Messrs. Attwood and Co. provide a simple lever D and cord, which may be used or not, as found desirable. The effect of pulling the cord is the same as pulling the hand rope, thus relieving the brake so long as it is pulled. If there is found any risk in using it, the cord can be removed in a few minutes, and the lift is complete without it, and free from any chance of accident.

NAVAL ENGINEER APPOINTMENTS.—The following appointments have been made at the Admiralty:—John Baillie, engineer, to the Indus, additional, for the Stormcock; Robert C. Moon, engineer, to the Woodcock; Albert Mastell, engineer, to the Magnet; Chief Engineer George H. Weeks, to the Asia, additional; Assistant Engineer William H. Adams, to the Pembroke, additional.

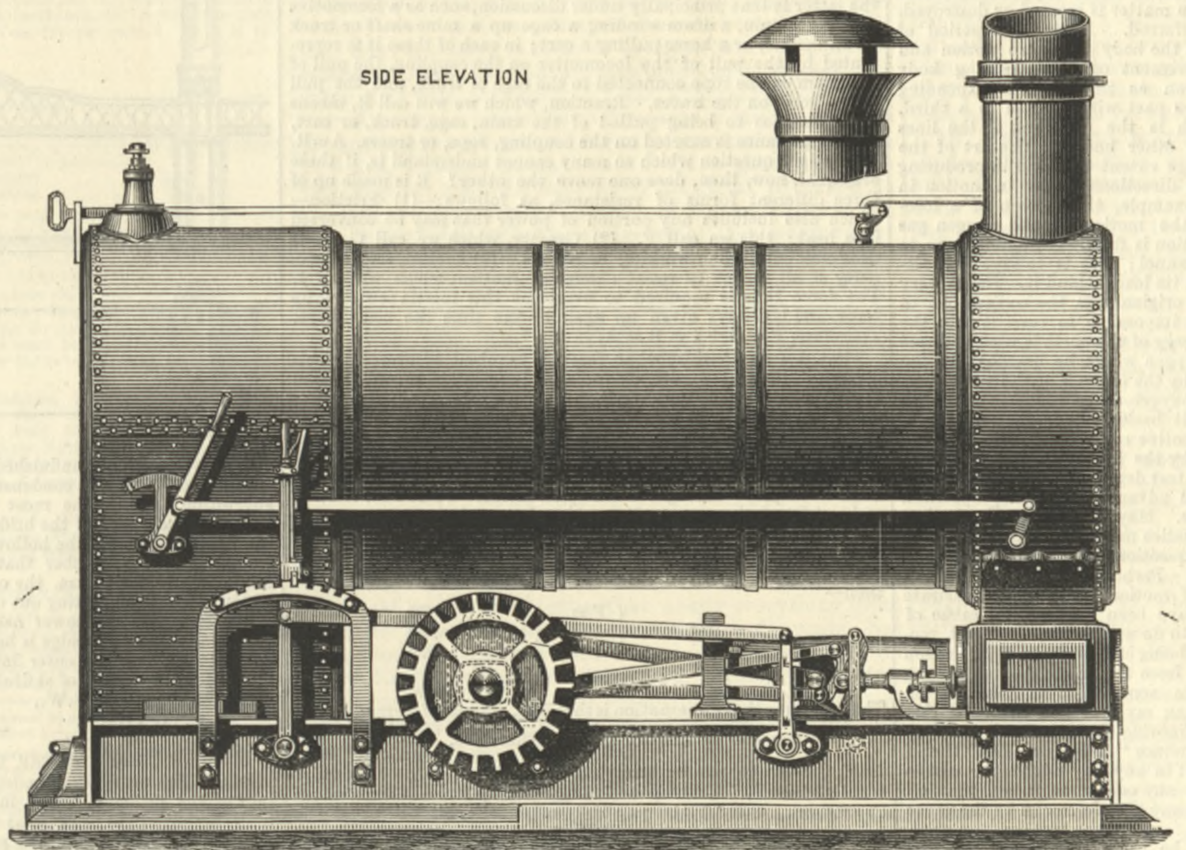
A FIVE TON SMOKE-FOG.—Firth College, Sheffield, was crowded last Monday to hear a lecture on the career and inventions of the late Sir Charles William Siemens, by Mr. W. Lant Carpenter, B.A., B.Sc., and F.C.S., manager of the School of Submarine Telegraphy and Electrical Engineering, London. Dr. Siemens was an intimate friend of the lecturer, who dealt with his subject in a most interesting and exhaustive manner. One point was of special importance to the people Mr. Carpenter was addressing—the general doctrine of the conservation of energy, or, to put it concisely and localise it—smoke prevention. Siemens, he said, speedily perceived that steam and other engines did not give nearly the quantity of mechanical work for the heat expended on them, and that led him to the principle now known as regeneration, which he had applied to steam engines, and finally to furnaces and the consumption of fuel generally. He did not stop there, but looked forward to the adoption of gaseous fuel as the remedy for the smoke-fogs of great towns. Siemens held that the more people could be induced to adopt gas as fuel, both for warming and cooking in their houses, and to do what the best manufacturers now did, the more would they lessen the smoke-fogs. On the same calculation as had been made for London, the solid unburnt fuel which hangs daily over Sheffield in the air probably amounted, the lecturer said, to five tons.

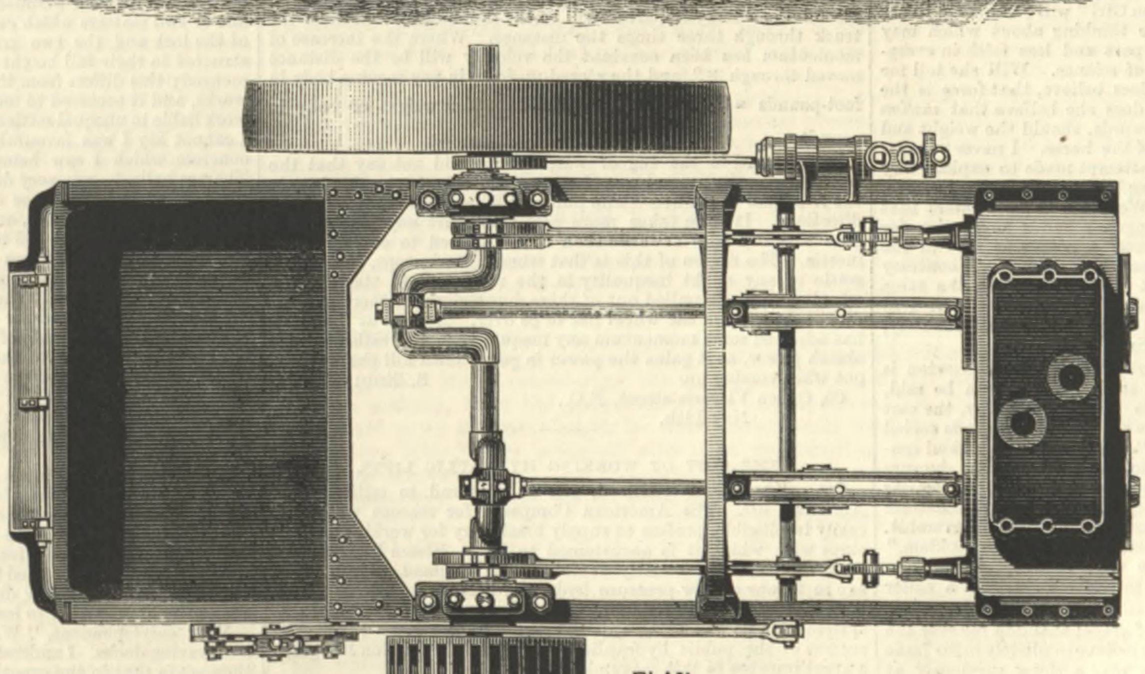
PORTABLE WINDING MACHINERY.

MESSRS. SPENCER, CARTER, AND CO., HITCHIN, ENGINEERS.



SIDE ELEVATION





PLAN

THE accompanying engravings show a semi-fixed winding engine, manufactured by Messrs. Spencer, Carter, and Co., engineers, Hitchin. The engine and boiler are self-contained, upon a wrought iron bedplate, the winding gear fixed on one side of the engine and driven by spur gear from the crank shaft. There are two steam cylinders, each 10in. bore, and having a stroke of 16in. The piston-rods are of mild steel. The crosshead is of crucible cast steel with slide blocks cast on top and bottom to work between slide bars of channel or trough section with oil wells at each end. The slide valves are worked by link motion reversing gear, the reversing link being of steel, and all joints case-hardened, and pins of steel. The fly-wheel is 6ft. in diameter. The boiler has a fire-box of Lowmoor iron plates, the saddle plate, arch plate, and barrel being made of Staffordshire plates. The engine and boiler are mounted on an iron bed-plate, the sides of which are formed of strong wrought iron channel iron rivetted together by a cross frame, and strengthened at the corners by wrought iron gusset plates. The steam cylinders are bolted to the channel iron sides at one end of the bed. The front end is formed of a cast iron ash-pan front, while the space between, from the cross frame to the front, forms the ash-pan. The winding gear is driven by shrouded spur gearing. The winding drums are 5ft. in diameter by 1ft. 6in. wide, the cheeks being bolted together at the boss and rim fitted with turned and bored gun-metal bushes furnished with oil tubes; they are lagged with oak 2½in. thick. They are capable of revolving loosely on the drum shaft, or may be driven separately by a sliding clutch placed between them, sliding on a steel feather sunk in the shaft, and actuated by a lever. Each drum is provided with a double-action brake.

A SCIENTIFIC MISTAKE.

IT has been ere now urged against teachers of science that they never let their pupils know anything of their own uncertainties or doubts. They repeat the *rôle* of the priests of Isis; and having laid down a law, they adhere to it. This assertion is, however, not quite true, for there are adventurous spirits who do not hesitate to speak their minds, and that very freely. A remarkable and instructive example of this is supplied by a comment from the pen of Professor G. Forbes on a lecture by Sir Wm. Thomson on "Molecular Physics. We may, perhaps, here stop to explain that for many years the wave theory of light has been taught, according to which, among other things, the colours of light are due to the varying lengths of waves in the ether, of almost inconceivable minuteness, and the recurrence of which is counted by many thousands per second. The impact of these waves on the retina is supposed to cause the sensation of light. The action of the spectroscope is explained on this theory, and a scientific edifice of gigantic dimensions has been built upon it. Now, it has been known in certain circles for many years that very grave doubts existed as to the soundness of the wave theory, and it was shown long since that as many as six different kinds of "ether" must exist if it was true. Professor Thomson, however, now virtually admits that it is not true, unless the ether possesses properties to believe in which demands more credulity on the part of the student than is likely to be found in any civilised community. Professor Forbes, recently writing in *Nature*, pens the following remarkable sentence:—"The desperate condition of the wave theory is shown by the words penned by Lord Rayleigh before he knew of Stokes' experiments—p. 272—'Should the verdict go against the view of the present paper, it is hard to see how any consistent theory is possible which shall embrace at once the laws of scattering, regular reflection, and double refraction.' It appears, then, that after all the labour which has been expended upon the wave theory of light, it fails absolutely, and, as it seems, hopelessly, in two points of primary importance. One is the extinction of the ray polarised by reflection; the other is double refraction. In other matters we have difficulties, but we can see a possible means of escape. Here there see as to be none." Sir William Thomson supposes the existence of what Professor Forbes terms gyrostatic molecules, crude, and improved. As an example of the length to which the mathematician can go when put on his mettle, we quote the following description of the molecule which can alone permit the possible truth of the wave theory of light:—"The crude molecule is a fly-wheel inside a massless shell. Here there is no gyrostatic action opposing a motion of translation, but only opposing a motion of rotation. This is the molecule which was stated to give the wrong kind of variation of magneto-optic rotation with variation of wave-length. The improved gyrostatic molecule consists of two fly-wheels on one axis. But the axis is cut in two in the middle between them, and the parts fitted together by a ball and cylinder joint. The other ends of the half axes are supported in ball-and-socket joints in the massless shell. So far as rota tion of the shell is concerned, this acts like one gyrostat, the axis always remaining in one line. But if the shell be frictionless, the ether can only give translational movement to it, and the double gyrostat produces a gyrostatic effect when the molecule is accelerated in any direction except along the axis." Now, we would ask has any teacher yet hinted in a text-book or to his scholars that the wave theory is unsound? We shall be gratified by an affirmative reply to the query.

LETTERS TO THE EDITOR.

[*We do not hold ourselves responsible for the opinions of our correspondents.*]

THE LAWS OF MOTION.

SIR,—I have read "A Girton Girl's" letter in your last impression with much pleasure and some concern. I am pleased to see a student taking a real interest in what she learns. I am concerned because she has not yet mastered the truth that it is utterly impossible to carry on a discussion with any hope of advantage unless the disputants clearly understand what each advances. Neglecting this, "A Girton Girl" in the very first paragraph of her letter shows that she has entirely misunderstood the position I take. Perhaps this is my own fault; yet I have endeavoured to be precise and explicit. Still, I venture to ask her to read my letter of April 3rd once more.

"A Girton Girl" starts with the words, "'Φ. Π.'s' difficulty." Now, as a matter of fact, "Φ. Π." is not in any difficulty whatever. Dr. Lodge, Professor Hudson, &c., are in difficulties, I think. I certainly am not. She goes on and defines my assumed difficulty thus: "So that if Newton's third law were true, we could have no experience of motion, but as we have experience of motion, Newton's third law cannot be true." Now, there is not one word in anything which I have written which supports such a doctrine. I have said over and over again that I firmly believe in the truth of Newton's third law. I also firmly believe in motion. What I do *not* believe is that force is the cause of motion. I believe that motion is the cause of motion, and that nothing else is. I believe that motion is a cause of force. I believe that there is no such thing as an unbalanced force. "A Girton Girl" will see that this confession of faith turns aside every argument she has urged against me.

"If then," she asks, "force be not the cause of motion, what is?" These are not her words, they are the drift of her argument. Precisely so. I am endeavouring, and have been endeavouring for years, to get this question answered. As for myself, I venture to think that I know, but I do not think that the time has yet come for setting my views forth at length. I have quite enough on my hands as it is. But I may say this much to guide the thoughts of "A Girton Girl" toward the right road. There is in the universe, as we know it, just as much motion now as there was at the beginning; no more and no less. Motion is never under any circumstances created or destroyed any more than matter is created or destroyed. Motion is communicated or transferred. During the period of transfer, a stress is set up between the body giving up motion and the body accepting it. The movement of the receiving body is always in the same direction as that of the expending body. When two or more bodies part with motion to a third, the third moves in a line which is the resultant of the lines and quantities of motion of the other bodies. The art of the engineer is—unconsciously to a large extent—exerted in producing from matter in motion in various directions matter in motion in the direction he requires. For example, the motion of a locomotive engine is derived from the motion of the oxygen gas supplied to the furnace. This motion is finally gathered up, so to speak, and directed all into one channel; that is to say, the locomotive careers across country with its load behind it. But a very large portion indeed of the motion originally in the oxygen cannot be used in this way because it is impossible to turn it into the proper direction. The nervous energy of the horse is used to direct the motion obtained from the oxygen which he breathes, to the drawing of the cart; and the horse by the exercise of the mysterious power Will is able to direct this oxygen-derived motion either to pull the cart forward or to push it backwards. The link motion and the reversing gear of the locomotive are the equivalent of the mechanism of reversal possessed by the horse, the nature of the action of which no one in the faintest degree comprehends. I do not think that in all this I have advanced a single proposition which is opposed to known facts. May I express a hope that "A Girton Girl" will do me the justice not to consider these few sentences as a full and complete exposition of the faith that is in me concerning the cause of motion. Perhaps it would be as well to say here that I regard "cause of motion" as a very inaccurate sentence, because, whatever may have been the original cause of motion eons ago, we have nothing to do with it now—at least, motion is never caused in the sense of being created now. The motion of the cart, for example, is derived from the motion of something else, and that in its turn from something else, and so on *ad infinitum*. There is an old Indian saying which bears on this point, "A fly cannot buzz without moving the universe."

I hope I have said enough to convince "A Girton Girl" that I am in no difficulty at all. I am not in any way puzzled, except to understand how it is possible for any one to maintain that all forces are balanced, and next to assert that force can be the cause of motion.

And now, being old enough to be the father of any "Girton Girl," perhaps this particular "Girton Girl" will permit me to ask her one or two questions, the mere thinking about which may induce more self-reliance on her own part and less faith in everything that is taught her in the name of science. Will she tell me why she believes, as she evidently does believe, that force is the cause of motion? and secondly, why does she believe that *motion* can balance a *force*? Why, in other words, should the weight and motion of the cart balance the pull of the horse. I never yet saw in print, or heard, any satisfactory attempt made to explain why motion should balance force. Nothing but force can balance force. Motion and force are incongruous. We might as well assert that by putting knowledge of a dead language and a reputation for accuracy into one scale, we could balance a pound of lead in the opposite scale. "A Girton Girl's" reasons for holding a contrary opinion I shall watch for with great interest. I held the same opinion long after I was her age, and I boldly confess that I so held it because I was taught that it was a fact. Unfortunately, too many scientific beliefs rest on no firmer foundation.

Finally, I can assure "A Girton Girl" that Sir Isaac Newton is perfectly clear and explicit. He says as plainly as it can be said, that just as much as the horse pulls the cart one way, the cart pulls the horse the other way. Here are his precise words copied from page 16 of my edition of the "Principia":—"Actioni contrarium semper et æqualem esse reactionem, sive corporum duorum actiones in se mutuo semper esse æquales et in partes contrarias dirige." That is his enunciation of the third law; and to illustrate his meaning he goes on:—"Si equus lapidem funi allegatum trahit, retrahitur etiam et equus (ut ita dicam) æqualiter in lapidem." "A Girton Girl" will not want me to translate this for her. When Newton used the word pull, he meant pull just as a sailor means it.

If "A Girton Girl" will take heart of grace; abandon for ever the notion that force is the cause of motion; believe implicitly in Sir Isaac Newton; hold that there is no reason why a thing previously at rest now moves save the motion of something else; substitute for energy the word motion, and write "the conservation of motion" the "waste of motion," &c., I can promise her that molecular science, the world in which we live—nay, the very universe itself—the phenomena around us, all will possess for her new and untold charms. In this view, and in this alone, lies the key to the mysteries which crowd around us on every side. The door to them can never be opened by men who, teaching youth, maintain such an impossible thesis as "Forces cannot exist unbalanced, but force is the cause of motion." "Φ. Π."

London, May 11th.

SIR,—I have followed the correspondence on this subject with surprise, not only because of the confusion of words, but chiefly because of the evident confusion and vagueness of ideas on this subject. Some of your correspondents are evidently under the impression that as Newton is dead there is nobody who can explain the third law. If that were so, why not start afresh and make the necessary experiments? They are certainly not difficult. All that is necessary is that the experimenter should press against an object or pull at it. He will find that pressure and resistance are equal and opposed to each other, and that a pull and its resistance are equal and opposed to each other, no matter whether the objects are as stationary as a rock or as free to move as a vessel in stationary water. In order to investigate the question of action and reaction, the operator should get on board of one vessel and attach a rope to another vessel and pull it. At very low speeds there will be almost no external resistance. It will then be found that the action of the pull is proportionate to its duration. The result of such an action is called momentum: $p\ t = m_1\ v_1 = m_2\ v_2$. Here p = intensity of pull, t = time of action, m_1 and m_2 = masses of vessels, v_1 and v_2 = velocities acquired by the vessels. The influence of the mass is dealt with by the other laws. The pull can also act through a certain distance of space. The result of this action is called work or energy. It is also proportionate to the distance traversed by the pull. If in the above example the initial velocities equal nought, then after an interval of time t, one vessel will have travelled a distance $l^1 = \frac{p\ t^2}{2\ m_1}$, $l_2 = \frac{p\ t^2}{2\ m_2}$.

The work will be found to be—

$$w_1 = p\ l_1 = \frac{m_1\ v^2}{2},\ w_2 = p\ l_2 = \frac{m_2\ v^2}{2}.$$

If this is true, then there can be no doubt that pressure and resistance, pull and resistance, action and reaction, are equal and opposed to each other in direction.

Your correspondent, "Girton Girl," reminds me of a conversation I had on this subject with a very accomplished lady, who even ventured to read through Kant and Schopenhauer. Her contention was that it was not necessary to take off an overcoat or put aside any weight which one might be carrying while being weighed. Her argument, which completely silenced me, was, "Then why do the 'bus companies require that 'all children except infants in arms must be paid for?'" C. E. STROMEYER.

London, May 11th.

SIR,—The principle of Newton's third law seems to me so exceedingly simple that it is a wonder how so many find any difficulty in reconciling it with the production of motion. Action and reaction are equal. Action, which we will call A, means the force that is exerted by one body either on itself or on some other body; the latter is that principally under discussion, such as a locomotive drawing a train, a drum winding a cage up a mine shaft or truck up an incline, or a horse pulling a cart; in each of these it is represented by the pull of the locomotive on the coupling, the pull of the drum on the rope connected to the cage or truck, and the pull of the horse on the traces. Reaction, which we will call R, means the resistance to being pulled of the train, cage, truck, or cart, which resistance is exerted on the coupling, rope, or traces. A = R.

Now, the question which so many cannot understand is, if these are equal, how, then, does one move the other? R is made up of three different forms of resistance, as follows:—(1) Friction—which also includes any portion of power that may be converted into heat; this we call F. (2) Gravity, which we call G; this does not exist when working on a level. (3) Inertia, or the property of all bodies to resist change of motion, which we call I. The force that is required to overcome this inertia is stored-up force, and is always given up again by the time the body stops. Therefore, F + G + I = R = A.

First, let us consider what force is required to overcome this inertia. To pull a weight through 16·09445ft. in one second requires a pull equal to that weight, as this is the force of gravity, and a pull of 1 lb., therefore, during one second absorbs 16·09445 foot-pounds of energy, and this amount is stored up to be given out at future time. It is also, I think, clear that 1 lb. will pull 16·09445 lb. through 1ft., and in this we have a basis of calculation. Take the case of winding a truck up an incline—I will omit friction and weight of the rope, as it would only complicate matters—say the incline is 1 in 8, the truck weighs 1 ton or 2240 lb, and the strain on the rope 1000 and the frictional resistance 50 lb. to the ton—this generally increases with the speed, but if we reckon it constant—then—

$$A = 1000\ R = \begin{cases} F = & 50 \\ G = & \frac{1}{8} \times 2240 = 280 \\ I = & 670 \end{cases}$$

$$\overline{1000}$$

The only force that gives motion is the 670lb., and as before mentioned, 1lb. will move 16·09445 through 1ft.; therefore, $\frac{670 \times 16{\cdot}09445}{2240}$ = 4·814, the distance moved through in one second, and 670 × 16·09445 = 4·814 × 2240 = 10,783 foot-pounds of stored-up force at the end of one second. Now, if the power is taken off, this will cause the truck to run up the incline $\frac{10{,}783}{50 + 280}$, or 32ft. During the next second the energy imparted will be the same, but it will draw the truck through three times the distance. Where the increase of momentum has been constant the velocity will be the distance moved through × 2, and the stored-up force in any moving body in foot-pounds = $\frac{\text{velocity in feet per second}}{2}$ × weight of body in pounds.

With regard to the tug of war, Newton did not say that the resistance on the ground was the same, and it is not, as this is only the frictional resistance. The pull on the rope is the same in both directions. It often takes more power to start anything than it does to move it afterwards than that required to overcome the inertia. The reason of this is that when a truck stops, the wheels settle in any slight inequality in the rails, and in starting the wheels have to be pulled out of these depressions, or there may be dirt or dust which the wheel has to go over. As soon as the truck has acquired some momentum any inequality in the rails does not absorb power, as it gains the power in going down hill that it gives out when coming up. S. EDDINGTON.

60, Queen Victoria-street, E.C.,
May 14th.

THE COST OF WORKING HYDRAULIC LIFTS.

SIR,—I have not criticised, nor do I intend to criticise, the American lift. The American Company, for reasons which are easily intelligible, prefers to supply machinery for working at pressures with which it is accustomed to deal. Steam lifts for passenger use were practically abandoned in England twenty years ago in favour of low-pressure hydraulic lifts worked from tanks. When America began to advocate low-pressure lifts the use of this system with us was being superseded by high-pressure lifts. The success of the public hydraulic power supply in London has given a great impetus to this movement.

I take it from the American Company's letter that it was about six years ago that Messrs. Otis Bros., their New York corresponding house, issued a circular stating that they were at last convinced that hydraulic lifts were as good, if not better, than steam lifts. It would be interesting to watch the future development of their opinion. Six years is not a very long experience. I could show the American Company many high-pressure lifts which have been at work in London for about fourteen years, which, I believe, have never undergone material repair or stoppage. Sir Wm. Armstrong, the founder of the high-pressure system could no doubt furnish instances extending over thirty years.

I suppose the American Company places the tanks it uses as high as possible. Why should 160ft. head be desirable and 1600ft. disastrous? Many low-pressure lifts worked from tanks in London have already been converted to take power direct from the high-pressure mains. There is no peculiarity in the details of the construction of the American lift which will save it from the same fate as other lifts worked on the same system of low-pressure—a system, as compared with high-pressure, involving the use of large cylinders, tanks, and pipes, and from ten to twenty times the quantity of water to do the same amount of work, whether the tanks are filled by pumps or from the ordinary water mains.

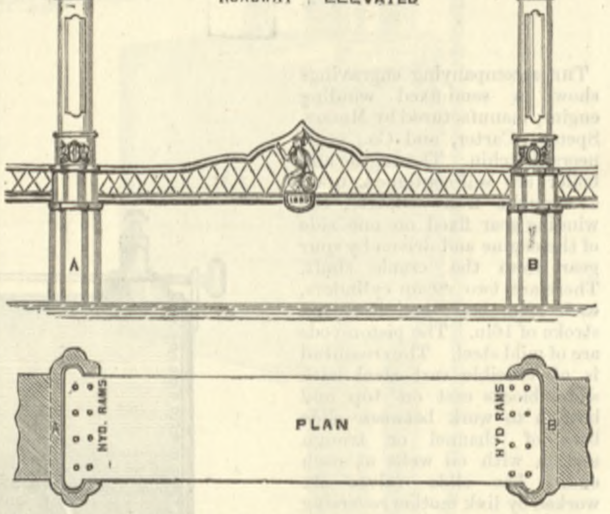
This discussion has arisen in consequence of the American Company having issued a statement of relative cost of working which was very adverse to the use of the hydraulic power and was quite contrary to the facts. It would be unfortunate, both from a private and public point of view, if owners of property in consequence of such incorrect estimates coming before them were to regard unfavourably the hydraulic power, which is in all respects, mechanically, economically, and financially, a sound and reliable system.

Palace-chambers, 9, Bridge-street, E. B. ELLINGTON.
Westminster, May 11th.

THE TOWER BRIDGE.

SIR,—It will be greatly to be regretted if, after the Tower Bridge has been erected at an enormous cost, we should find too late it is not exactly what is required, either in design or general utility. No reasonable objection can be raised to your suggestion that designs should be invited and carefully considered, before it is decided what the structure shall be. Nor need the carrying out of such a proposal necessarily take the work out of the hands of the City Engineer, provided, *à priori*, it be understood the Corporation reserves to itself the right of employing its own officers, wholly or in part. It is of the first importance that, where costly and permanent structures are concerned, there should be such wisdom displayed that our successors may fairly point to them with pride and say, "This did our fathers for us."

I am tempted to trespass on your courtesy to explain my idea of a bridge, which I venture to think would meet the requirements of convenience, expense, and ornament. The annexed sketch,



although rough and unfinished, as is also my description, will convey more than any condensed form of words I could use. My suggestion is that the most convenient and rapid method of elevating the centre of the bridge would be by a series of hydraulic rams working within the hollow piers A B. Of these rams there should be such a number that only half would be necessary for raising the bridge centre. the others being reserved for use in case of the first-named getting out of order or needing repair.

Of the hydraulic power needed, and of the amount of power recovered when the bridge is being lowered, as well as other details, it is not necessary to enter into here, for are they not matters rather for the display of skilful engineering?

204, Brixton-road, S.W., W. DAVEY BENNETT.
May 11th.

DEEP WATER DOCKS AT TILBURY.

SIR,—Like your correspondent "W. X. Y.," I think that drawings of the principal works in connection with this magnificent undertaking would be of great value to many engineers. I visited the works recently, and was struck with their extent and difficulties. With your permission, I should like to draw attention to one or two matters which came under my notice. In the execution of the lock and the two graving docks, the side walls were constructed to their full height before the inverts or cills were commenced; this differs from the usual method of constructing such works, and it occurred to me that the course followed renders the work liable to unequal settlement, and consequently risk of leakages. I cannot say I was favourably impressed with the quality of the concrete which I saw being executed. Some of the material—Thames ballast—was very dirty; it was being mixed by hand, and was only turned over once dry and once wet. The proportion, I believe, is usually 10 to 1, and the dock walls below water-line are faced with a thin coat of 3 to 1 concrete. I have frequently seen perfectly satisfactory faces on concrete walls for harbours and docks obtained by the ordinary concrete used in the wall, the proportion being 7 to 1. The face batter of the dock walls—1 in 20, I believe—is much steeper than usual, and is a departure in the right direction. The side of an ocean steamer's hull is battered in the opposite direction to the face of the wall, so that before the bilge catches the face of the wall the rail is closer to coping when the batter is small. Seeing the excavation in the middle of the dock standing in some parts with an almost vertical face, I could not understand why the sloped sides of basin were being made so flat as 6 to 1.

The general arrangement of the works appears to be very well designed, the distribution of quays and water space being apparently well considered. The steamship City of Rome could swing easily in the main dock, and then be berthed in either of the three branch docks. Another notable feature is that in each of the branch docks the import trade is confined to one side and the export to the other, so that after a vessel has discharged cargo she has simply to haul across the branch dock to load outwards.

Your correspondent, "W. X. Y.," refers to the position of the two graving docks. I understand one reason for placing them where they are is that in the event of an accident occurring to the lock, or any repairs being required to the gates, &c., the lock can be pumped out, and the graving docks used as substitutes. Another advantage in having them where they are, is that vessels can be received from either the tidal basin or the dock. Altogether these works are of great interest to engineers connected with dock works.

May 12th. FORTH.

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G. B. S. (Frodsham).—*Write to the Secretary, Cannon-street Hotel.*

B. M. AND CO.—*Messrs. Johnson and Mathey, Hatton-garden, supply platinum stills.*

B. A. T.—*The arrangement for overhead cranes which you show is quite satisfactory. We presume that you have calculated the strains and settled the dimensions you have adopted accordingly.*

ERRATUM.—*The paper "On Petroleum as a Fuel," an abstract of which appeared in our last impression, p. 351, was read before the University College Engineering Society, and not before the King's College Engineering Society, as stated.*

MILROY'S EXCAVATOR.

(*To the Editor of The Engineer.*)

SIR,—Can any of your readers furnish me with names of the makers of Milroy's excavators? G. L. C.

London, May 12th.

HARTZ METAL.

(*To the Editor of The Engineer.*)

SIR,—Can any reader favour me with the address of the agent in this country for Hartz's anti-friction metal? LUBRICANT.

May 13th.

TRADE PROFITS.

(*To the Editor of The Engineer.*)

SIR,—Will any of your readers tell me what is the usual trade practice in estimating profits? Is the percentage estimated on the gross or the net profit; on the sum paid by the purchaser, or on that paid by the seller? For example, a portable engine costs me, say, £200, including all charges of every kind—rent, taxes, gas, insurance, &c. I sell it for £300. What is my profit? Is it 50 per cent. or 33⅓ per cent.? What is the custom of trade in this respect? X. Y.

Southwark, May 13th.

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MEETINGS NEXT WEEK.

THE INSTITUTION OF CIVIL ENGINEERS.—Tuesday, May 19th, at 8 p.m.: Ordinary meeting. Paper to be discussed, "The Signalling of the London and North-Western Railway," by Mr. A. M. Thompson, Assoc. M. Inst. C.E. Papers to be read, time permitting: (1) "On the Theory of the Indicator and the Errors in Indicator Diagrams," by Professor Osborne Reynolds, F.R.S., M. Inst. C.E. (2) "Experiments on the Steam Engine Indicator," by Mr. A. W. Brightmore, B.Sc., Stud. Inst. C.E. The President's *conversazione* will be held, by permission of the Executive Council, in the International Inventions Exhibition, South Kensington, on Friday, June 5th, from 9 to 12 p.m.

ENGINEERING SOCIETY, KING'S COLLEGE, LONDON.—Thursday, May 21st, at 4 p.m.: Paper to be read by Mr. Bouton "On the Construction of Locomotives."

CLEVELAND INSTITUTION OF ENGINEERS.—Monday, May 18th, at 8 p.m.: Elections since last meeting. Discussion "On Telpher Lines, or the Transport of Goods on Aerial Tramways with the Aid of Electricity," being paper read at the last meeting by Professor Fleeming Jenkin, LL.D., F.R.S., Edinburgh, who will be present and take part in the discussion. Paper "On Modern Practice in Slide Valves," by Mr. Tom Westgarth, Middlesbrough. Paper "On the Manipulation of Heavy Forgings," by Mr. T. Putnam, Darlington.

CHEMICAL SOCIETY.—Thursday, May 21st, at 8 p.m.: "Calorimetric Method for Determining Small Quantities of Iron," by Mr. Andrew Thomson, M.A., B.Sc. "On Some Compounds of Calcium and Sulphur," by Mr. V. S. Veley.

ROYAL METEOROLOGICAL SOCIETY.—Wednesday, May 20th, at 7 p.m., the following papers will be read:—"The Temperature Zones of the Earth in Connection with its Biological Conditions," by Dr. W. Köppen, Hon. Mem. R. Met. Soc. "Velocities of Winds and their Measurement," by Lieut.-Colonel H. S. Knight, F.R. Met. Soc., F.R.A.S. "Note on Mr. C. Harding's Paper on Wind Velocities," by Dr. W. Köppen, Hon. Mem. R. Met. Soc. "Note on a Peculiar Form of Auroral Cloud Seen in Northamptonshire, March 1st, 1885," by Rev. James Davis.

SOCIETY OF ARTS.—Monday, May 18th, at 8 p.m.: Cantor Lectures. "The Manufacture of Toilet Soaps," by Mr. C. R. Alder Wright, D.Sc., F.R.S., F.C.S. Lecture III.—Manufacture of spirit-made transparent soaps—machinery and appliances employed in the preparation of bars and tablets—cutting and shaping—squirting, cold and hot—stamping and drying—valuation of toilet soaps by chemical analysis—constituents often admixed, objectionable and otherwise—discussions of analytical methods for the determination of free alkali, and recent researches thereon—hydrolysis of soaps in contact with water—classification of toilet soaps in accordance with the results of chemical analysis—analysis of various British and continental soaps, and discussions of their general characters—qualities requisite in soaps intended for delicate complexions and tender skins. Tuesday, May 19th, at 8 p.m.: Foreign and Colonial Section. "New Britain and the Adjacent Islands," by Mr. Wilfred Powell. Sir Francis Dillon Bell, K.C.M.G., will preside. Wednesday, May 20th, at 8 p.m.: Twenty-second ordinary meeting. "The American Oil and Gas-fields," by Professor James Dewar, M.A., F.R.S.

DEATH.

On the 8th nst., at Glasgow, Mr. ROBERT D. NAPIER, of Messrs. Napier Brothers, Hyde Park-street.

THE ENGINEER.

MAY 15, 1885.

DR. PERCY'S ADDRESS.

SIR HENRY BESSEMER said, on Thursday week, that Dr. Percy's presidential address to the members of the Iron and Steel Institute "was one of the most splendid ever delivered from the chair which Dr. Percy occupied," and we are disposed to think that this was not an exaggerated estimate of its value. We have given a tolerably full abstract of it in another page, but we make no apology for referring again to it here. Dr. Percy spoke as a man possessing that authority which knowledge confers; and he succeeded in no ordinary degree in combining sound science with practice, while he indicated in precise language the nature of some of the more recondite problems which surround the metallurgist and demand solution. Nothing in the address, perhaps, deserves more admiration than the manner in which it deals with technical education. Dr. Percy is very far indeed from thinking that technical education can work the miracles which some would have us believe it is capable of accomplishing. There can, of course, be no manner of doubt that technical education, like all education, is a good thing; but it is not a good thing in the abstract. A man need not necessarily either be more moral, or better off pecuniarily, because he is very highly educated, than he would have been if he had never been educated at all; and a great deal of most useful work is done by men who are entirely destitute of technical education, and who would be in no sense or way the better of it. Dr. Percy defines technical education as special instruction adapted to special artificers in addition to what they can acquire in the ordinary practice of their respective arts. "Of the advantage of such instruction to many of our artificers there cannot, I presume, be two opinions. But, on the other hand, I contend that there is a large number of artisans who will not be rendered more competent by instruction of that kind. In support of this contention let me adduce file-cutters by way of example, and others whose sole industrial work is the performance of one and the same mechanical operation. It would, I think, puzzle some of those gentlemen who talk so glibly and profusely about technical education to suggest an improvement in that of the file-cutter. Let him be saturated with knowledge of all the mysteries of iron and steel, and he certainly would not in consequence become a more skilful artificer, any more than would a sculptor by being informed that the marble on which he operates is composed of carbonic acid and lime. Nevertheless, if our file-cutters and others desire special scientific instruction in iron and steel-craft, no one can reasonably object to their having it." This seems to us to be very good and sound common sense. We may push Dr. Percy's argument a little further, and ask those who blindly advocate technical education as the greatest possible benefit that can be bestowed on what are known by a curious figure of speech as the "working classes"—as though lawyers, physicians, soldiers, engineers, never did any work—to point out the results which have been achieved in this country by the spread of technical education within the last twenty years. It should never be forgotten that nearly everything great that has been initiated—in engineering, at all events—has been brought about by men whose technical education, in the South Kensingtonian sense of the word, was simply miserable. It is even doubtful at this moment if any man of pure science has accomplished anything of moment which proved of great use to the human race. We are indebted for the steam engine in all its forms to unlettered men. The telephone, the electric light, the telegraph, to say nothing of the great mass of our manufacturing and metallurgical operations, have all been originated by men of no technical education at all, in the modern sense of the word; and while we admit that certain men who possess special knowledge have applied that with success to certain processes, we hold that not only are such cases exceptional, but that men who did not possess this knowledge have done yet more remarkable things. The Bessemer process, for example, was devised by Mr. Bessemer when he knew nothing of any moment concerning iron and steel. He knew that cast iron had the carbon burned out of it by passing oxygen through it—that was all; and it occurred to him that this might be done by blowing air through the molten metal. The history of his failures and successes need not be written here. Messrs. Gilchrist, Thomas, Snelus, and Riley devised the basic process of steel making, no doubt, as a result of profound chemical knowledge. But the invention of the puddling furnace was a greater work, considering the then state of the art of iron making, than the invention of the basic process. We could go on at great length to show how much has been done long before technical education was heard of, and how comparatively little has been done since; but it is not necessary. To the end of time the few must direct the operations of the many, and so long as the few have a sufficient store of knowledge they will control the manufacturing power of a nation, and represent its skill and mental capacity. Technical education is a useful and good thing if properly directed; but the tendency in the present day is to exalt it far above the position it ought to hold in the national estimation; and to pin our faith on it as a means of restoring the trade prosperity of Great Britain is to be betrayed into a great folly. Like most things, technical education has its value. Let us follow Dr. Percy's advice and not over-estimate that value.

Leaving social problems, Dr. Percy dealt at length with those presented in abundance by the behaviour of the metals used in the arts. Some of these are very curious and interesting. Thus, for example, iron and steel, no doubt have their strength greatly increased by cold rolling. It is a remarkable fact that the metal thus condensed has a less specific gravity than the metal not so treated. Speaking of the molecular changes brought about, Dr. Percy said:—"These molecules are bound together by what is termed the force of cohesion, which is a mere statement of the fact of their sticking together; but how comes it that that force should be increased by mechanical treatment which, *à priori*, might be supposed would tend in greater or less degree to produce disaggregation? It is stated that cold rolling has been found to increase the tensile strength of bar iron by as much as 50 per cent. How comes it, moreover, that less force is required to tear the molecules asunder when it is concussive and not gradual? Those are questions which furnish substantial food for reflection, but will not, I fancy, admit of easy solution." Dr. Percy might have gone further, and called attention to Mr. Hughes' experiments, according to which every molecule of iron in a large bar is capable of being revolved on its axis by the influence of a small magnet. Magnetically, indeed, a bar of soft iron is not so stable as a rope of sand. What, we may ask, is the reason that molecule clings to molecule? Is not this clinging the result of a force entirely external to the molecule? These and many other questions such as these make no small claim on the attention of the thoughtful metallurgist.

While dealing with questions concerning the strength of iron and steel, it may be worth while to digress for a moment to direct attention to Mr. Wicksteed's remarkable improvement in testing machines, described and illustrated in our last impression. Now, for the first time, the metal tested records its own behaviour. It is worthy of note that the strength of a bar of tough steel depends much more on its power of resisting compression than appears at first sight to be the case. It must be remembered that when we are speaking of the breaking strai of such and such a metal being, say, 30 tons on the square inch, we are saying what is, in one sense, not the fact. The real strength of such a metal is probably considerably over 40 tons per square inch section of contracted area. As the strain is applied, the bar, after a time, begins to become smaller and smaller in some part of its length; and one of the reasons why hard bars have a greater apparent tensile strength than soft bars is that they resist the strain tending to cause a reduction of diameter. Thus very soft and very hard bars will sometimes be found to be almost identical in strength, if the fractured area is used as the divisor—a circumstance to which not nearly sufficient attention has yet been paid.

Dr. Percy seems to possess a special instinct which guides him in putting before his hearers subjects which will give them matter for thought, or statements of facts likely to interest them. Referring at some length to the injury supposed to be done by often heating iron to a welding heat, he cited Colonel Dyer's experiments made at Woolwich Gun Factories, which proved that iron might be heated four times to a welding heat, and kept at that temperature for three hours each time, without injuring it in the smallest degree. The special object of these experiments was to ascertain if the internal portion of the large gun forgings would be likely to be injured by repeated re-heatings to a welding heat, though well hammered each time on the exterior. So much is being heard just now of hydraulic forging machinery, that we see with much pleasure that Dr. Percy has given credit where credit is due, as shown by the following passage:—"The forging of iron and steel by hydraulic pressure was first introduced and practised many years ago by Mr. Haswell, who at that time and till recently carried on engineering works at Vienna. He had been a pupil of Sir William Fairbairn, as the latter himself informed me. There were beautiful drawings of Mr. Haswell's hydraulic forge hammer, as it was called, in the Austrian department of the International Exhibition in London in 1862, and carefully executed engravings of it in the catalogue of articles sent to the Exhibition by the Austrian Society of State Railways. The hammer was patented in this country." No doubt many engineers who visited the Vienna Exhibition in 1873 had opportunities afforded them of seeing the Haswell press at work at the locomotive shops of the Stadts Bahn, of which Mr. Haswell was then, and for many years subsequently, manager. They might have seen a railway wheel, spokes, rim, and boss, all welded together in about fifteen seconds; and axle-boxes and cross-heads for locomotives, of wrought iron, made at the rate of about thirty an hour, so true that not much more than one-eighth of an inch had to be planed off. The machine is not really a hammer, but a squeezer, capable of putting on a strain of about 1500 tons. A billet of white hot iron is thrown into a mould, the top die is brought down on it, and in less than five seconds the soft iron has filled every cranny of the mould, and a complete crosshead, axle-box, &c., is ready to be turned out of it. We have reproduced elsewhere much of what Dr. Percy had to say concerning Whitworth compressed steel, from which we gather that Dr. Percy holds it to be an excellent material, but not because it is compressed; the compression, in fact, in no way affects the density or the soundness of the material. If a change is really worked in the metal at all it is one of texture, but Dr. Percy did not indicate in any way the nature of this change.

It was not probable that a man of Dr. Percy's attainments would pass over in silence the work of the chemist. But he spoke of chemists with the same straightforward common sense that marked all his utterances. The natural shrewdness of the man, no amount of scientific training has been able to obliterate. Science is never to him good merely of itself. It is only good as it is useful. The bald accumulation of facts he treats almost with disdain. It is not many years, he pointed out, since we had to grope about to discover an analysis of iron ore or of pig iron, whereas now we are actually overwhelmed with such analyses. We are deluged with percentages of carbon, graphitic or combined, of silicon and manganese, of sulphur and phosphorus. We are bewildered by this vast accumulation of material, like the traveller in the mazes of a primeval American forest. What is now wanted is the man to reduce it to law and order, to evolve from it principles for our sure guidance. But the problem is so intricate and complex that no common brain can solve it, and there are yet dozens of questions connected with iron and steel of which we know next to nothing. Who, for example, can tell us what are the physical properties of pure iron after fusion? Who has an accurate knowledge of the properties, chemical as well as physical, of compounds of pure iron and pure silicon in various proportions? Who can give us certain information as to the modes of existence of manganese, silicon, and phosphorus when present together in pig iron? Who can state positively and explain satisfactorily the *modus operandi* of manganese in the various processes in which it is used by iron and steel manufacturers? These are not questions of pure science. There is not one of them the answer to which may not be of the very greatest importance to the iron and steel trade of this country. Take, for example, the relations of phosphorus to pig iron. It is believed that at one stage in a Bessemer blow, nearly the whole of the phosphorus goes out of the iron into the slag, but that as the process is continued, it is reabsorbed by the iron. It has been proposed that the slag should be drawn off at the proper time, and the blow then continued. This is, we understand, one feature of the Clapp-Griffith process, about which a good deal is being heard. It will be seen at a glance that a thorough knowledge of the relations of sulphur, iron, and phosphorus are of the most vital importance to the iron maker. We cannot think that Dr. Percy attached too much weight to the necessity which now exists for condensing and reducing to form the information which has been collected. It is with the more pleasure we receive the announcement that he is about presently to bring out a new edition of his well-known treatise on iron and steel. The first edition was written twenty-one years ago, and so much has been effected since, that a new edition has become almost a necessity.

ENGINEERS IN THE NAVY.

A GENERAL sketch of the engineering department of the Royal Navy may not be out of place at a time when the engineers of the mercantile marine may be invited to offer the country their services, as stated by Sir Thomas Brassey's speech on the Navy Estimates. The engineers of the Navy have had a considerable amount of trouble and neglect to go through before they obtained for their class anything approaching a fair recognition. It is not so many years since instead of the device of the crown and anchor there was a raised side elevation of the old-fashioned side lever engine on the uniform button. In those days engineers in the Navy were neither fish, flesh, or fowl, or anybody's children; in fact, they were worse off than are the engine-room artificers of the present day, and their position is bad enough. However, when it became apparent to their Lordships of the Admiralty—impede the progress of steam as they would—that the days of "'bout ship" were, for all practical purposes, at an end, it was determined, though they did and do stick to their royal yards and topgallant masts, it is said "as a gymnasium for the maintenance of the health of the crew," that unless they trained their own engineers they would be at the mercy of the profession, as they are now in regard to the medical branch. A system of entering boys, to be trained as engineers afloat, was introduced; but it was soon found that they could not train efficient engineers on board ship. The boys were then transferred to the dockyards, where they were passed through the various workshops. This was the beginning of what came to be called or known as the "engineer student's system." This class was entered at the dockyards from among the sons of the dockyard artisans, warrant and petty officers of the Navy and marines, and from Greenwich School. They served for five or seven years; received 8s. per week the first year, increasing to 24s. per week in the last year of their apprenticeship. During the time they were employed in the dockyards they were required to attend school two afternoons and three evenings a week, books, stationery, &c., being found. They went through the engine-fitting, pattern-making, boiler-making, smithing, and moulding shops. When they had finished their time they were examined, and, if they passed, received appointments as acting assistant engineers in the Navy. The first two or three who headed the list at the examinations were selected for study at the School of Science and Art, South Kensington, where they spent a couple of terms, receiving their pay as acting assistant engineers, after which they entered the Navy, and were eligible for appointments in the dockyards and at the Admiralty. Some of them are the present chief engineers and chief assistants at the dockyards, as are also the engineer instructors at the Greenwich College.

When Greenwich College was established, instead of the few best of the students being sent to South Kensington, the whole of them, as they obtained their appointments as acting assistant engineers, were sent to Greenwich College, and the two best of each batch were allowed to remain two terms longer, and, as before, became eligible for home appointments; also their promotion to be chief engineers was certain after ten or thirteen years' service, independent of the seniority list. Therefore it will be seen, from the time and money spent on the training of naval engineers, they ought to be efficient. The old school of engineers, who may be said to have made the Navy for engineers what it is, are nearly all retired; so that for the most part all the officers now serving in the Navy entered and were trained under the engineer student system. Of the engineers who joined the Navy in 1878 from the mercantile marine there are only twelve left, and being entered as engineers for temporary service, they were not entitled to the same prospects as their brethren on the permanent list. Having nothing to look forward to, the greater part of them resigned their appointments. About six years ago another change was instituted. H.M.S. Marlborough, an old-fashioned wooden ship, was fitted up at Portsmouth Dockyard as a training school for engineer students. She is in reality the home of the students while they are in the dockyards; before this they lived outside, now they can only leave the yard by permission, and being always in uniform, they cannot pass the gates without it. At the same time that the Marlborough scheme came into operation, advertisements appeared in the leading papers of the large towns, where they began to hold yearly examinations, and in proportion as these advantages become known, so the boys came from all parts of the kingdom.

The rank of engineers in the Navy at the present time is: assistant engineer, engineer, chief engineer, inspector of machinery, and chief inspector; their respective relative rank is sub-lieutenant, lieutenant, commander, and captain. In large men-of-war, to which the mercantile marine engineer would probably be appointed on joining the Navy, no person under the rank of lieutenant is entitled to a cabin. As an engineer does not rank with a lieutenant until he has been eight years in service, he would, on joining his ship, find instead of a cabin a hammock to sleep in, and a sea chest of the regulation size and shape for his gear. Portmanteaus, and luggage of that description have no place in a man-of-war, and would, figuratively speaking, be more often found in the "scran bag" than where they were left. This "scran bag" is a sort of lost luggage office. If any private property is found about the ship, or gear that is not in its proper place, it all goes into the "scran bag." A fine of a piece of soap, for washing paint work, is inflicted on the man who claims his gear. There is only one part of a ship which a junior officer can reasonably call his own, and that is that portion of the deck which is covered by his chest, for, being of fair size and extra strong make, it is rather too heavy to be lightly knocked about; consequently it is generally to be found where it was left. Besides the hammock and chest, the engineers have a bath-room and a mess berth; the mess berth is the living room, so to speak.

The expenses of joining the Navy for a short period of service would be roughly about £12. This would comprise one suit of uniform and a sea chest, with a few odds and ends; and the cost of living, with necessary expenses for other matters, not including wine, would average about £4 per month. About seventeen years ago a class called "engine-room artificers" was introduced; but their numbers were small until a few years since, when they were rapidly increased, and the number of engineers reduced. This class generally perform the duties of the junior engineers of the watch at sea, and in harbour they work in the engine and boiler-rooms at their respective trades—engine fitting and turning, boiler making, smithing, and copper-smithing. In the large ships there will be generally from six to a dozen artificers, and about the same number of leading stokers, many of whom, as well as stokers, have the rating of stoker mechanic, and are what may be called handy men.

Before we close this sketch, a few words on the term "rank with but after." For instance, an engineer of the Royal Naval Reserve ranks with but after his respective ranks in the Navy. If he should be sent to serve in a ship where there is an assistant engineer, and they should be both in the same watch; and if the assistant is promoted, he becomes senior of the watch, and the senior of course becomes the junior of the watch he had charge of, and the same in all other matters.

THE WORK OF THE METROPOLITAN BOARD.

THE Metropolitan Board is an institution which has unquestionably rendered much valuable service to the metropolis. During its period of action improvements have been effected which would have been impossible had the old disjointed system of local government, previously existing in London, been perpetuated. A few days ago the annual report, in which the doings of the Board are recorded, once more made its appearance. In it there is a recognition of the fact that in the opinion of some people there is need for a great and sweeping change in respect to the manner in which London is governed. "The year 1884," says the report, "opened with a general expectation that it might possibly be the last in which the local affairs of the metropolis would continue to be managed upon the system established by the Metropolis Management Act of 1855." But the London Government Bill brought forward by the Home Secretary was destined to be withdrawn before arriving at a second reading, and we are told "it would be difficult for any one to foretell the time at which it may be possible for ministers again to come before Parliament with a proposal to deal with the subject." A curious hint is given as to the mode in which the London Government Bill was prepared. The Metropolitan Board can properly claim the benefit of experience in the administration of the affairs which concern London as a whole. Hence the Board may be assumed to be familiar both with the merits and defects of the present system. Yet, it is intimated, somewhat indirectly, but yet with sufficient clearness, that in preparing a scheme of local reform for the metropolis, Sir W. Harcourt held himself wholly aloof from the Metropolitan Board, and sought neither information nor advice at its hands. Such an attitude can only be interpreted as one of antagonism, or, we might say, actual hostility. The Home Secretary appears to have a greater affection for the Corporation of the City, or even for the Vestries and District Boards, than he has for the central authority at Spring Gardens. On the other hand, the Metropolitan Board announces itself as "certainly not antagonistic to reform," and consequently "has ever held its knowledge and experience at the service of any minister desirous to inform himself of the conditions of the case, with a view to effecting improvements." Apparently, Sir W. Harcourt was not so desirous, but trusted to his own inspiration, aided by the Municipal Reform League. Now we have a promise from the Metropolitan Board that, whether in conjunction with the Home Secretary or not, "it will at the proper time be prepared to propound its own views of the direction in which reform should proceed." There is too much reason to apprehend that Sir W. Harcourt's Bill would place the local affairs of the metropolis at the mercy of Government officials, despite the professed intention to give the whole of London the benefit of genuine municipal rule. Unquestionably there is a splendid domain to be occupied, and power of no ordinary sort to be wielded. London deserves the best form of government that can possibly be given to it, and the ideal may very readily exceed the reality. The Metropolitan Board is a prosaic body, but it has done some wonderful works. What might be accomplished by a more potent body is a matter of speculation. Perhaps London might not have streets more magnificent than those which have been created or are being produced by the present authority. There is a splendid embankment on either side of the Thames, and it must be acknowledged that the main drainage works are admirable specimens of engineering. There is something more to be done with the sewage, and the Metropolitan Board does not shrink from undertaking the enormous enterprise of purifying the huge volume of liquid discharged at the main drainage outfalls. We suppose there is nothing that London wants, such as a municipal body can be expected to supply, which the Metropolitan Board would not take in hand. Its duties already are exceedingly multifarious, and it might be suggested that if reform is wanted, it is more in the direction of the vestries than the central board.

Considerations as to the government of London connect themselves inevitably with the actual work of the Metropolitan Board, and with its plans and projects relative to undertakings lying in the future. The water supply is a case in point. Cabinets, Royal Commissions, and Committees of Parliament have from time to time declared that the water supply of London ought to be in the hands of a public representative authority. The Metropolitan Board stands ready to undertake the duty. It covets the possession of the water supply; but the present Home Secretary considers that the Board is not properly representative of the metropolis, and ought not to be entrusted with so important a charge. Hence the new municipality is to come first, and the water supply is to be dealt with afterwards. As the new governing body is evidently a long way off, so a change in the administration of the water supply is decidedly remote. There is no help for it, except to make the best of the present state of things. But the water supply is a growing interest, and the longer the transaction is deferred the greater will be the cost when the undertakings have to be bought up. In the meantime the water companies are treated roughly by the Government, and are looked upon with disfavour by the Metropolitan Board. The daily press is generally ready to find fault, either with the supply, or with the price that is charged for it. On the whole there is something like war declared against the London water companies, and in no respect do they seem capable of giving satisfaction. The only streak of light consists in the sensible and impartial reports addressed monthly to the Local Government Board by Sir Francis Bolton, the official water examiner appointed under the Metropolis Water Act of 1871. In the annual report of the Metropolitan Board there is no recognition of Sir Francis Bolton, and hence we have but a partial view of what the companies are doing. For instance, it would seem as if the Chelsea Company was taking no steps for the introduction of the constant supply, whereas, at the commencement of 1884, Sir F. Bolton reported that this company was giving a constant supply to 3550 houses, and last March the number had risen to 4316. The object of the Board is to be in a position to take the reins, and hence it has, for the second time, brought in a Bill seeking power "to prepare a scheme" either for purchasing the present supply or introducing another. The chance of carrying such a Bill, in the teeth of opposition from Sir W. Harcourt and the water companies, is extremely doubtful. Should the Metropolitan Board ever get possession of the water supply of London, we fear that the task will be found rather heavier than the Board will be well able to manage. Concerning the gas supply, the Board has a better tale to tell than in respect to the water. We referred some time ago to the defective lighting power of the gas, as tested by the officers of the Board at places where the official testing stations failed to exercise their protective influence. The subject is dealt with in the annual report, which states that in consequence of the representations made to the gas referees by the Board, two additional testing stations have been established. But something more than this has been done. A portable photometer has been set on foot, and the results obtained with this perambulatory apparatus serve to show that "there are parts of London the inhabitants of which do not always get their gas of the quality which it was thought had been secured to them by Act of Parliament." How true this is may be inferred from the further statement that the gas is "frequently" found to be inferior in lighting power to the prescribed standard, and sometimes by as much as one candle. But as the travelling photometer is an extra-legal instrument, these observed deficiencies cannot be made the basis of legal proceedings, and the companies escape all forfeiture and penalty. The Metropolitan Board, being assured of the accuracy of the observations, wrote to the Board of Trade, suggesting that statutory authority should be obtained for this mode of testing; but the law remains unaltered, and these occasional photometrical tests simply serve the purpose of giving the Board information, which is communicated from time to time to the gas referees. It cannot be tolerated that matters shall remain in this state. The companies might be warned that unless they supplied gas of proper lighting power in all parts of their district, they would have to bear the cost of new stations in those localities where the portable photometer showed the quality of the gas to be defective.

At the date of the annual report the Metropolitan Board had only just received the second and final report of the Royal Commission with reference to the drainage outfalls. Hence the Board was not in a position to place on record any observations respecting the opinions expressed by the Commissioners, or with regard to the conclusions arrived at. The deodorising operations carried out during the hot weather are briefly described; and it is stated that the experiments previously commenced were subsequently resumed, to ascertain the best method of purifying the sewage at the outfalls. The subject is now more fully developed; and proceedings are in progress for deodorising the sewage in the coming summer, as also for proving on a large scale the value of the precipitating process devised by the Board's chemist. It is evidently hoped that all necessity for carrying the sewage down to the estuary of the Thames will be avoided; and we may expect every effort will be made to prove that land filtration can be dispensed with. The disposal of the sludge is a formidable part of the affair, and how this is to be effected is not yet decided. More than one mode is contemplated, and experience is requisite before the best method can be determined. The Royal Commissioners said: "The solid matter deposited as sludge can be applied to the raising of low-lying lands, or burnt, or dug into land, or carried away to sea." But the partial drying of the sludge, before it can be called "solid matter," will tax the ingenuity of the Board's officers, in addition to the final question of its removal. The treatment of the London sewage is an arduous problem, only mitigated by the fact that the effluent need not be purified up to the point which would be required if it flowed into a river associated with a drinking supply and entirely free from the admixture of sea-water. Another question affecting the Thames is that of preventing the occasional overflow of the river. The Board seems to have been successful in carrying out its piecemeal process for the prevention of this evil. Passing on to other topics, we observe that after some years of apparent success, the electric light has vanished from the Victoria Embankment, and gas is now employed. One way and the other, rather more than £1000 was expended on the lighting of the Victoria Embankment last year, while £200 was the cost of the water used on the roadway and in the ornamental grounds. The new street from Tottenham Court-road to Charing-cross is now fairly in hand, as also the thoroughfare from Oxford-street to Piccadilly-circus. The provision of workmen's dwellings has been the obstacle in the way of constructing these streets, and an alteration of the law had to be effected before substantial progress could be made. The Artisans' Dwellings Act of 1875 has been another difficulty with the Metropolitan Board, two amending Acts being found requisite to make this statute a really practical measure. Twenty schemes in all have been proceeded with by the Board under the Act. Bridges form another important element in the Board's operations, and immense benefit has accrued from the general abolition of tolls in connection with these structures. Discouraged in all their previous efforts, the Board has refrained this session from proposing any scheme of trans-Thames communication below London Bridge, except by means of free steam ferries, leaving to the Corporation the more ambitious task of making a bridge—an undertaking for which the civic authorities have prepared a scheme which is not of the most promising order. Parks, commons, and open spaces are possessed by the Board to the extent of 1835 acres, and London still cries out for "more." The Fire Brigade leads up to a "burning question" in the shape of funds, the revenue at the disposal of the Board for the protection of the metropolis against the great destroyer of cities being obviously inadequate. Perhaps there will be a panic some day, and then the question will be settled in haste. Tramways, cattle diseases, dairies, cowsheds and milk stores, slaughter-houses and noxious trades, the regulation of the trade in explosive substances, the law with regard to petroleum, the protection of infant life, the general supervision of streets and buildings, and the enforcement of certain conditions with respect to music-halls and theatres, are matters comprehended in the duties of the Metropolitan Board. This hardworking body has a debt of £24,000,000, against which are assets reducing the net debt to £16,000,000, and the burden on the rates for the present year is rather more than 7¼d., supplemented by the coal and wine duties. There is plenty to be done, and much to be spent, by a Board comprising less than fifty members.

SLIDING SCALES IN THE COAL TRADE.

WHILST in the Yorkshire coal trade there is a long and a costly struggle in progress taking the shape of an endeavour on the part of the coalowners to obtain a reduction in the rate of the wages paid to the miners in their employ, it is noticeable that without cost and without a struggle the rate of wages in the Durham coal trade has been reduced. It is true that on the one hand the reduction claimed in South Yorkshire is 10 per cent., and that in the county of Durham the sliding scale shows a reduction at the rate of 1¼ per cent. only, yet that is merely one reduction during the currency of the sliding scale. On the whole, the scale this time has worked in favour of the employers, and naturally so, because the needs of the trade have been in the direction of a reduction of the cost of production. Thus, in the northern coalfield we have—for Northumberland is under a similar scale, and the recent results have been similar—a reduction in the rate of wages that goes slowly but surely on as the selling price of the coal makes it needful; whilst on the other, in the Yorkshire coalfield, we have had the spectacle of the employers paying a rate of wages above that they could afford, according to their own statement, until in the end the needs of the times resulted in a demand that has brought about the strike that is still in progress, and that must have been very costly to both classes. This is a proof of how well fitted the sliding scale system is to settle questions of rise or fall in the rates of wages. In the Durham coal trade a basis was settled upon about six years ago, and that basis has been slightly altered since, so that the bargain was merely the determination of the rate of wages to prices, and the mechanical scale then decided on has adjusted prices automatically. When the strike has ceased, it may be that influences will be at work that will alter prices and relationship of wages; and if this prove to be the case, there will arise the need for a settlement that will be contended for, and that will also be costly, if the same arbitrament be sought. It is well, therefore, if the attention of the coalowners and miners of Yorkshire can be turned now to the method of cheaply settling labour disputes by applying a constant basis to the fluctuating prices of coal.

ROBERT D. NAPIER.

MR. ROBERT D. NAPIER, senior partner of the firm of Messrs. Napier Brothers, mechanical engineers, Glasgow, died somewhat suddenly on the 8th instant. That his illness was of short duration is shown by the fact that a letter from his pen, written on the 2nd May, appeared in our issue of last week. He was a son of Mr. David Napier, the founder of the great shipbuilding and engineering firm of that name, and although his business relations have been for many years entirely distinct from those of Messrs. Robert Napier and Sons, he inherited much of the mechanical ingenuity of his father. It is hardly necessary to recall, even at this comparatively distant time since his death, the valuable services rendered by David Napier in the initial promotion of steam navigation. These services are well-known to our shipbuilders and marine engineers. Mr. David Napier constructed the engines for the Rob Roy of 90 tons, this being the first steamer that plied between the Clyde and Belfast. Her engines were 30-horse power. In 1819 he also placed engines of the same capacity in the Talbot, built for him by Messrs. Wood, of Port Glasgow; she was 150 tons, and provided steam accommodation between Dublin and Holyhead. From 1820 onwards the family were intimately connected for a long time with almost every development of the marine engine, and the effects of their work did not even cease after the great improvements of Charles Randolph and John Elder. The steeple marine engine was the invention of David Napier, who placed one in the steamer Clyde, in 1836. It is interesting to recall these facts, because during a great part of the active life of David Napier, his son, who has now passed away, was intimately associated with him in all his works. The year after they fitted the steeple engine into the Clyde—viz., in 1837—Mr. David Napier, with his sons, Robert D. Napier and Frank Napier, left the engineering business in Glasgow, and proceeded to London, where they established works at Millwall, and for a series of years they turned out steamers which in those days were regarded as performing great feats of speed. Robert D. Napier subsequently went to New South Wales, where he took charge of the operations for the dredging of Sydney harbour. It was while so employed that the idea occurred to him which he matured into the "self-holding brake"—the mechanical invention by which his name is most widely known. Some fifteen years ago he returned to his native city, and in conjunction with his brother, the late John D. Napier, he started the firm of Napier Brothers, adapting the "self-holding brake" to ships' windlasses and other machines, the manufacture of which has since been carried on by the firm.

In February, 1871, Mr. Robert D. Napier read an interesting paper before the Institution of Engineers and Shipbuilders in Scotland, on "An arrangement for Transmitting Power from one Machine to another through a Differential Friction Brake." He explained that the brake was made self-holding, or approximately so, according to what might be considered the most suitable for the kind of machine or the sort of work to be done. The first application he proposed of the invention was in the form of an arrangement for dispensing with counter-shafting in machine shops. He also proposed to apply the differential brake to the driving of rolling mills, more particularly to reversing rolling mills, and this has been extensively done. There have been numerous other applications of the invention to which it is unnecessary to allude.

The subject of our sketch interested himself deeply with mechanical and physical problems, and had not his time been so much engrossed with the details of his business, the results of his studies and experiments might have been more generally known. On many occasions, however, Mr. Napier contributed letters and papers to this and other scientific journals. He was the author of an investigation into the laws attending the flow of steam—a work which has been translated into German by Professor Fliequer, of Zurich. He read a paper to the Institution of Engineers and Shipbuilders in Glasgow, in March, 1879, on the "Flow of Water through Orifices," the contribution being a description of experiments to ascertain the hydraulic pressure in or near an orifice in the side of a cistern during the free outflow of water. He began by laying it down that, "if water is being discharged through an orifice in the side of a cistern, and if the depth of the orifice be small in proportion to the head of the water above it, then every particle of the water approaching the orifice must be subjected to continuously decreasing pressures from the adjoining particles." The question to be determined was, what was the pressure in any given position in relation to the orifice? And Mr. Napier detailed a series of interesting experiments he had made to attain this object. He came to the conclusion that the problem of inventing a pressure-gauge of very minute size, which shall move along with the stream, and enable us to observe at any instant, not only the pressure, but the position at which that pressure exists, must seem so difficult that it must be given up as hopeless. This, he said, would throw us back upon the only other alternative—that is to say, to arrange a pressure-gauge which we can apply at any point in the stream at right angles to its direction, and which will interfere very little with its velocity. This was the problem which Mr. Napier succeeded, to a great extent, in solving, and his method of doing so is detailed in the paper to which allusion has been made.

From such studies and experiments as these Mr. Napier's mind naturally introduced itself to a contemplation of the laws of motion, and it was upon this very subject that he wrote the letter which appeared in our issue of Friday last.

Mr. Napier was sixty-four years of age. He was most unobtrusive in his habits, and highly esteemed by all to whom he was known.

EXAMINATION FOR LOCAL SURVEYORS AND INSPECTORS OF NUISANCES.—The Sanitary Institute of Great Britain will hold its next examination for local surveyors and inspectors of nuisances on Thursday and Friday, June 4th and 5th, at the Parkes Museum, 74A, Margaret-street, W.

TELEPHONE AND TELEGRAPH WIRES.—The report of the Select Committee on Telephone and Telegraph Wires was issued yesterday. It is entirely in favour of the development of telephonic and telegraphic communication, and, so far from suggesting restrictions in the use of overhead wires, it proposes that legal facilities should be given for their extension. The Postmaster-General and his licensees, the committee think, should have power, after giving notice, and unless objection deemed by a county-court judge to be reasonable should be made, to erect any telegraphic line along roads. It is further represented that power should be given, with the consent of occupiers, but without that of a lessee or owner, to make attachments to private property—such consent, however, to be limited to the occupier's term. There should be no right on the part of owners or occupiers to prohibit the passing of wires over property; but such wires must be removed if the premises are to be raised, or some other good cause is shown. Mr. George Russell, the chairman of the committee, in his draft report, proposed to prohibit overhead cables, and to give power to local authorities to insist, when more than ten wires were carried along one line, that they should be taken underground; but the committee rejected these proposals.

THE PROTECTIVE POWER OF ARMOUR PLATES AS PROVED IN ACTUAL WARFARE.

IN view of the protest so ably put forward by Sir E. J. Reed and other well-known naval authorities, against the system adopted by the Admiralty of leaving a large portion of the hulls of our modern ironclads wholly unprotected by armour, a brief summary of the resistance to shot afforded by armour protection in the ironclad actions which have been fought up to the present time, may be of interest. We purpose in this article to refer to those engagements only in which ironclads have been opposed to armoured and unarmoured ships of war, and shall reserve the subject of "Ironclads *versus* Forts" for a future occasion, omitting in both cases the actions fought during the war between the Northern and Southern States of America, as both the armour and ordnance employed by the contending parties was of too makeshift a character to be of lasting importance.

In their resolve to denude the ends of our modern ironclads of all armour protection, the Admiralty appear to have been governed by the opinion that thin armour plating is worthless. Theoretically this assumption is correct, and the various experiments at Portsmouth, Shoeburyness, Gâvre, Kummersdorf, Amager, Kolpino, Steinfeld, Muggiano, &c., apparently give this theory a practical backing, which, however, is completely overthrown by the experiences of actual warfare, as will presently be shown. It is, of course, desirable that the heavy guns, &c., of our ironclads should be provided with the thickest possible armour protection, provided that the efficiency of the vessels as fighting machines is not thereby impaired. The question naturally arises: "Are the unarmoured portions of our latest ironclads so constructed that, if riddled by shell from even the worst gun at present afloat, no detriment will ensue to the steering qualities of the vessels?" The answer to this question is obvious to those who are acquainted with H.M.S. Colossus and her sisters.

The Battle of Lissa, fought in July, 1866, by the Austrian and Italian fleets, under the respective commands of Rear-Admiral Tegetthoff and Admiral Persano, affords the first instance of a modern ironclad engagement—modern in so far as both parties were in possession of *bonâ fide* ironclads and of rifled ordnance. The Austrian ironclads engaged at Lissa were all armoured along the entire extent of their water-lines, the plating ranging from 2½in. to 5in. in thickness. The aggregate armament of the seven armour-plated ships consisted of 173 guns, seventy-four of which were 6in. rifled cast iron Wahrendorf breech-loading guns, and the remainder 48-pounder smooth bores. The Italian ironclad fleet numbered twelve vessels, four of which were but imperfectly protected at the ends, viz., the Re di Portugallo, Re d'Italia, Varese, and Palestro. The total number of guns was 248, all rifled, ranging in calibre from the 6½in. Cavalli breech-loader to the 9in. Armstrong muzzle-loader. It is unnecessary to dwell further on the events of this battle than to refer to the damage by shot sustained by the respective fleets. The official Austrian report says:—"The resistance of the ironclads was not generally put to a very severe test. With the exception of the Habsburg and Don Juan, none of the armour-clads exhibited shot marks with impressions nearly approaching those produced on trial by 48-pounder cast iron shot with a charge of 14 lb. of powder, at a range of one cable. The greater portion of the projectiles struck obliquely, and a single coating of paint generally sufficed to render the shot marks invisible. Several shots struck the Habsburg below the armour-belt, bulging and cracking, but not perforating the wooden hull. The Don Juan exhibits the most important shot marks, three in number, produced by 300 lb. shot, two of which, with a penetration of about 4in., are on a level with the ports, whilst the third is forward, just below the water-line, having penetrated to the extent of nearly 4½in. The formation of these marks shows that they were caused by 9in. rifled shot. The armour-plating stood remarkably well, not a single crack being visible on the surface. . . . The only remaining shot mark of consequence is one produced by a 7in. steel projectile, which perforated the thin armour of the Ferdinand Max in a slanting direction, and remained embedded in the backing." The above extract of the official report refers only to the effects of the Italian fire on the armoured portions of the Austrian ironclads, and it will be observed that even the 300 lb. Armstrong shot failed to perforate the 4½in. armour, although this projectile is supposed to be capable of penetrating 8in. of iron armour at a range of 500 yards.

Referring to the Battle of Lissa, the *Times* of August 31st, 1866, observes that the Austrian projectiles had very little effect on the Italian armour-plates, owing chiefly to the light calibre of their guns. This does not, however, agree with the Austrian report, which says that the great loss in killed and wounded sustained by the Italian fleet was chiefly due to the fact that the Austrian projectiles "struck the edges of the plates near the ports, sending a hailstorm of fragments into the interior of the vessels. No such splintering occurred with the Austrian plates." It should be observed that the Italian naval authorities, then as now, were in favour of hard and brittle armour-plates of French manufacture, whilst the Austrians followed the Sheffield system of tough armour. Early in the battle the Italian ironclad, Re d'Italia, was disabled in her steering gear—which was unprotected by armour—and in this condition she was rammed and sunk by the Austrian flagship, the Ferdinand Max. The loss of the Palestro was due to a similar cause; and the Austrian ironclad Drache was, in consequence of her superior manœuvring qualities, able to pour broadside after broadside of shot and shell into her unarmoured stern, until she caught fire and blew up.

The next engagement between ironclads did not occur until October 11th, 1873, when an action was fought off Cartagena, between the squadron of the insurgent chief Contreras and the Spanish Government vessels under Admiral Lobo. Contreras' flagship was the ironclad Numancia, 7305 tons, 5in. armour, eight 10in. and eight 7in. Armstrong guns; whilst the chief vessel of Admiral

Lobos squadron was the Vitoria, 7250 tons, 5½in. armour, eight 9in. and three 8in. Armstrong guns. The remaining vessels which participated in the engagement need not be enumerated, as their performances have no connection with the subject under consideration. The chief interest of the action centres in a short duel between the Vitoria and Numancia, which ended, however, by mutual consent when affairs began to assume a serious aspect. This occurred when, according to the Spanish report, "a shell from the Vitoria killed seven men on board the Numancia, including M. Moya, Vice-President of the Junta of Cartagena, and wounded eighteen others. This shell penetrated the unarmoured portion of the vessel on the port side, exploded on the quarterdeck, knocked away the wheel and the head of the aft capstan, and seriously damaged the mainmast at a height of 8ft. above the deck. One portion of the shell shivered the mainyard, whilst another fragment entered the battery through the after hatch, and destroyed an iron deck beam on the port side." In this action the armoured portions of the Vitoria and Numancia were struck eight and fourteen times respectively by heavy shot, but no serious damage was done, as the projectiles failed to pierce the plates.

The engagement between her Majesty's unarmoured cruisers Shah and Amethyst and the rebel Peruvian ironclad Huascar, on May 29th, 1877, off the Port of Pacocha, affords further proof of the protective power of thin armour-plating. The armaments of the respective vessels were composed as follows:—Shah, two 9in., sixteen 7in., and eight 64-pounder muzzle-loading guns; Amethyst, fourteen 64-pounder shell guns; Huascar, two 9in. muzzle-loading, and two 40-pounder and one 12-pounder breech-loading Armstrong guns. The armour-plating of the Huascar varied in thickness from 5½in. at the turret ports to 2in. at the bow and stern. The following is an extract from the official Peruvian report of the damage sustained by the Huascar during the above action:—"The hull: A 300 lb. projectile, passing through the armour-plating—3½in. in thickness—near the side light of the second sleeping cabin, starboard side, exploded, and destroyed the bulkhead, injured the tube of the cabin pump, &c., besides killing one and wounding three men. Another projectile, of the same calibre, first striking the same side of the ship and making an indenture of 3in. in the armour-plating. . . . . . Another, of 150 lb., striking the same side, injured the armour-plating about 1in. in front of the foremast and 16in. above the deck. Another shot grazed the forecastle without causing damage. Another, of 150 lb., penetrated the armour, port side, to the extent of 2in. . . . . Another of 300 lb. struck the ironwork of the stern, and, passing to starboard, exploded, doing considerable destruction and wounding a sergeant of marines. . . . . Turret: A 300 lb. projectile made a 3in. indent 3ft. from the left embrasure. . . . . Different kinds of projectiles and fragments of shells destroyed the irons which served for holding the sacks, as also the wooden base on which they rested. . . . ." Nearly a hundred projectiles struck the vessel, principally about the upper works, funnel, masts, boats, &c., all of which were destroyed or seriously damaged; but the 64-pounder shells were useless against even the thinnest portion of the Huascar's armour.

The engagement in July, 1877, between the Russian auxiliary cruiser Vesta and the Turkish armoured gunboat Feth-i-Bulend, may be dismissed without further comment, for although the former vessel was badly mauled, the latter received only one shot through the funnel, and another through the main stay.

Much more serious, however, were the injuries sustained by the Peruvian ironclad Huascar in her celebrated action with the Chilian ironclads, Almirante Cochrane and Blanco Encalada, off Punta Angamos on October 8th, 1879. The Cochrane and Blanco Encalada mounted six 9in. muzzle-loading Armstrong guns each, and were protected by armour varying in thickness from 4½in. to 9in., exclusive of an inner skin of 1½in. As these vessels were built from the designs of Sir E. J. Reed, they were, of course, well protected in all vital parts by armour-plating. The force of the Peruvian vessel has already been given. At 9.27 a.m. the Cochrane opened fire on the Huascar at a range of about 200 yards, and continued to engage at close quarters for forty minutes, when the Blanco Encalada came up and joined in the action. The commander of the Cochrane, Captain Latorre, aware of the superior manœuvring qualities of his ship, as well as of the weak points in the design of his antagonist, kept in the wake of the Huascar, directing his fire chiefly against her unarmoured stern and other vulnerable portions of her hull. In the course of the fight the hull, turret, &c., of the Huascar were struck twenty times by heavy shot, ten of which perforated the armour, whilst five glanced off. The remainder of the shots took effect in the unprotected portions of the hull, principally in the stern, destroying the steering gear and rendering the vessel unmanageable. The 5½in. turret armour was pierced twice, the 4in. armour once, the 3in. armour four times, the 2in. armour twice, and the 2in. armour once. The projectiles which perforated the turret armour and partially disabled the guns were fired by the Cochrane at a range of only about twelve yards. A few minutes later the Blanco Encalada came up, and passing within twenty-five yards of the Huascar's stern, discharged a raking broadside into her, which killed or wounded many of her crew. The only damage sustained by the Cochrane was caused by two shells which penetrated the unarmoured portion of her hull on the starboard quarter above the water-line armour, and wounded ten men, whilst the Blanco Encalada received no injury whatever. Notwithstanding the terrible battering sustained by the Peruvian vessel, her engines at the close of the engagement were in perfect working order, thanks to the protection afforded them by the water-line armour. This circumstance alone is of sufficient importance to justify the demand for the utmost possible protection in our new ironclads. Had the steering gear been equally well protected, the Huascar might perhaps have effected her escape, or have succeeded in ramming the Cochrane during the first stage of the action, in which case her superior speed would have enabled her to outdistance the Blanco Encalada. Unfortunately, however, her steering gear was shot away three times, so that she was unmanageable during the greater part of the action. Another fact worth attention is that no less than 50 per cent. of the projectiles which struck the armour-plating glanced off, though in some instances the plates were only 2½in. in thickness, whilst every shell which hit the unarmoured parts of the hull penetrated into the interior of the vessel, where it exploded. The armour plates of the Huascar appear to have been of a very good quality, for though several were pierced by the heavy Chilian projectiles, not one was "wrecked," as was the case with many of the brittle French plates on the Italian vessels at Lissa.

In conclusion, the chief lessons as regards armour taught by the foregoing ironclad engagements may be briefly summarised as follows:—(1) The details of construction, and consequently the weak points of every ironclad, are known to the enemy. (2) The want of strongly armoured transverse bulkheads led to the destruction of the Palestro at Lissa, and in a great degree to the surrender of the Huascar at Punta Angamos. (3) Armour of the thinnest kind in use affords a considerable amount of protection against oblique fire, and if penetrated has a tendency to localise the effect of the explosion of the shell.

It must, of course, be borne in mind that all the vessels referred to above were armoured with either hammered or rolled iron plates, the best of which are about 30 per cent. inferior in resisting power to the modern compound armour, as now employed in the British, German, Russian, and most other navies. It may be observed that the maximum thickness of armour has, for the present at least, been reached in the case of H.M.S. Inflexible, viz., 24in., and there is now a tendency among English and French naval architects to reduce the maximum thickness to about 18in., as demonstrated by the latest designs. There is, however, a great difference in the manner in which the weight so saved has been utilised in the respective navies, for whilst we devote the same chiefly to various arrangements and fittings of secondary importance, the French have strengthened their bulkhead and water-line armour.

At present the ends of our partially protected armour-clads are, in a sense, at the mercy of even the worst naval gun afloat, viz., the British 64-pounder. Considering the enormous size of these vessels, exceeding in some cases 10,000 tons, it is hardly an exorbitant demand to insist on the introduction of a few hundred additional tons of armour along the water-line, and at other vital parts.

NAVAL ARCHITECTURE AT THE INTERNATIONAL INVENTIONS EXHIBITION.

SEEING that the position occupied by Great Britain among other countries of the world depends in a very large measure upon the supremacy of its Navies, and that immense strides in advance have been made during the last quarter of a century, both in regard to the application of steam as a means of propulsion of vessels, the use of iron and then steel as a material for construction, and the attainment of high speeds with ships of enormous size—it might have been expected that the exhibits in Group 7, which is devoted to naval architecture, would have proved among the most interesting and instructive in the Exhibition. We fear, however, this is not likely to be the case; for though in some respects the models and the matters which have been gathered together are in the highest degree representative, and indicate very completely the progress that has been made in certain departments during the last five-and-twenty years, it must be confessed that, on the whole, the Exhibition is incomplete, many branches being entirely omitted, while, with a few notable exceptions, most of our leading manufacturing firms are conspicuous by their absence. To some extent this may be accounted for by the fact that marine engines, as well as much of the other machinery which is directly and indirectly connected with shipping, are to be found in other groups. Apart from this, moreover, and taking the term "naval architecture" as merely including matters relating to the construction of a vessel itself, exclusive of machinery, we think it is to be regretted that more attention has not been given to the exhibition of details. Had this been done, such improvements as have been made would have been more readily appreciated, and a means would have been afforded for forming a comparison between the several systems of construction that are adopted in the various shipbuilding centres.

The building assigned to this department is known as the Queen's Gate Annexe, occupied last year by Belgium; but only a small portion is devoted to naval architecture, the remainder being occupied with carriages and wagons, and with cycles. The Lords Commissioners of the Admiralty, from whom much might reasonably have been expected, have done very little. They have merely sent a few models of war vessels built between the years 1868 and 1874. None of the more modern ironclads or cruisers are to be found. On the other hand, some private builders are very well represented so far as models go. The progress of Channel mail steamers since the year 1840, and of screw mail steamers since 1852, is very fairly shown by Messrs. Laird Bros., Birkenhead, who have also sent models of some of the earlier iron steam vessels. Sir W. G. Armstrong, Mitchell, and Co., Newcastle-on-Tyne, are large exhibitors. A set of half models of the Staunch type of gunboat, originally designed by Mr. G. W. Rendel, then a partner in the firm, but now a Civil Lord of the Admiralty, shows the development in this class of vessel. The Staunch, built in 1867, had a displacement of 160 tons, a speed of 7½ knots, and was armed with one 12½-ton 9in. muzzle-loading gun. Then followed the Dutch gunboats Ever and Hydra, in 1871, with 170 tons displacement, and 8 knots speed; the Mastiff and Bloodhound built for H.M. Government in the same year, with 290 tons displacement and 8½ knots speed; and finally the series of eleven gunboats for the Chinese Government, commencing with the Alpha and Beta in 1876, each with 320 tons displacement, and armed with one 11in. 26½-ton muzzle-loading gun, worked and loaded by hydraulic power, and ending with the Iota, Kappa, and Lambda, in 1881, each with a displacement of 440 tons, and armed with one 11in. 35-ton muzzle-loading gun, worked and loaded by hydraulic power, two 12-pounder breech-loading guns, and two Gatlings. A beautifully-made full model of the Chilian cruiser Esmeralda is shown, as well as a set of three photographs, one of which was taken instantaneously while the cruiser was at sea, steaming at the rate of over 18 knots an hour. A full illustrated description of this remarkable vessel recently appeared in THE ENGINEER, and will no doubt be fresh in the minds of many of our readers. There is also a half model of a second-class torpedo cruiser now building at Elswick, with a displacement of 2100 tons, and 18½ to 19 knots speed. The armament is to consist of six 6-ton breech-loading guns, nine 6-pounder rapid fire guns of the Elswick pattern, and six rapid fire Gatlings. Many other full and half models have been sent by the same firm, some of which are of considerable interest. Of these we may mention the twin-screw cable steamer Faraday, of 9000 tons displacement, built in 1874, having the bow and stern precisely of the same form, so that when desired the cable may be hauled back on board without turning the ship, and running the great risk of breakage; the cable steamer Hooper, also of 9000 tons displacement, which was launched in the short space of 100 working days from the time the keel was laid, and was entirely finished in seven months from the date of order; and the twin screw steamship Pouyer Quertier, which is employed in the repair of Atlantic cables. Coming to a smaller class of vessels, we notice full models of three steamboats, at present being constructed for the River Thames Steamboat Company, for an improved service between Battersea and Greenwich. The cabins of these vessels will be light and airy, and the hulls will be well sub-divided by watertight bulkheads, so that travellers on the river may at last look forward to having some better accommodation than that afforded by the miserable boats now in use. There is also a half model of the Nile steamer, Safia, of 150 tons displacement, built in 1862. It will be remembered that this was the last steamer abandoned by Sir Charles Wilson at Gubat, after his unsuccessful attempt to relieve General Gordon at Khartoum. Another model of interest is that of a floating dock, built in 1877 for the Dutch Government for service in connection with the harbour works in Java. It was constructed for docking dredgers and hopper barges, and is entirely made up of horizontal and vertical cylinders of boiler plate. The dock was erected and tried in this country, and then taken to pieces and shipped to Java, where it was put together with bolts without the employment of skilled labour. Finally, we may draw attention to the models of a set of vessels built for service in the Caspian, Azoff, and Black Seas, for the carriage of petroleum in bulk, and fitted with powerful pumping appliances for loading and discharging, as well as with apparatus for burning petroleum as fuel for generating steam.

The Thames Ironworks and Shipbuilding Company, Blackwall, shows models of the Warrior and Benbow, these being the earliest and latest ironclads built by this firm for the British Navy. The Benbow is 330ft. long, 68ft. 6in. beam, and 37ft. deep, the displacement 10,000 tons, and the indicated horse-power 9000, for a speed of 16 knots. The armament will consist of two 110-ton and ten 6-ton guns, besides twenty-six smaller pieces, and the armour is 18in. and 14in. thick.

Messrs. Samuda Brothers, Poplar, exhibit two interesting models—the Riachuelo, a Brazilian armour-clad turret ship of 6000 tons displacement, with a speed of 16⅔ knots, and an armament of four 9in. 20-ton, six 5½-ton, and fifteen machine guns; and the Mary Beatrice, a steel paddle steamer for the Folkestone-Boulogne service, which it is claimed is the fastest vessel of her class, having attained a speed of 19 knots.

Adding to the foregoing the name of the Barrow Shipbuilding Company, which has sent a series of half models, we have practically exhausted all that need be said in relation to the exhibits of the builders of large vessels. As to those of a smaller character, such as torpedo boats and launches, much less need be said; for, with the exception of Messrs. Yarrow and Co., Poplar, who show models of the stern-wheel steamers Lotus and Waterlily, which rendered such useful service in the Nile Expedition, and of four sea-going torpedo boats for the Brazilian Government, and of Messrs. Simpson and Dennison, South Devon, who, among other things, have sent a well-finished steam launch, 24ft. long, fitted with Kingdon's patent compound surface-condensing engine and natural draught boiler, little of a practical nature is to be seen.

The usual run of "inventions" are present in considerable force, and there may be seen models of steamers designed to attain express railway speed at sea, of improved torpedo boats, rudders, propellers, life-boats, buoys, anchors, detaching apparatus for boats, and a host of other matters of greater or less utility.

Among the exhibits relating to constructive details, that of Messrs. Jessop and Sons, Sheffield, is by far the most important. As is well known, Messrs. Jessop have long advocated the use of cast steel for stern frames and solid rudders as a substitute for wrought iron, the absence of all welds and the superior strength of the material rendering it extremely suitable for the purpose. Excellent samples of these are shown, together with a large collection of propeller blades, crank shafts—solid and built up—connecting rods, and flexible shaft couplings.

Messrs. Cochran and Co., Birkenhead, show a new patented watertight bunker door, worked by a screw from the deck or any convenient position. The door has a knife edge on the bottom, which enables it to cut through the coal as it descends, so avoiding the trouble of cleaning the slides and clearing away the coal.

The other exhibits are mostly of a trivial nature, many having very little connection to naval architecture. As before stated, we fear this portion of the Exhibition will prove a disappointment, the more so as it is a branch which in former Exhibitions was made very attractive.

In this connection reference should be made to a case exhibited by Messrs. John Kirkaldy and Son, showing the gradual development of barnacles as they grow on ships' bottoms, some remarkable specimens being exhibited in connection with a display of Kirkaldy's anti-fouling composition for steel and iron ships, and exfoliating enamel for sailing ships, a composition which has for a long time been successfully used by the White Star, Inman, Guion, and other steamship lines.

THE IRON AND STEEL INSTITUTE.

THE sixteenth annual meeting of the Iron and Steel Institute began on Wednesday morning, the 6th inst., in the hall of the Institution of Civil Engineers, 25, Great George-street. Sir Bernhard Samuelson occupied the chair in the first instance, and after the usual routine business had been disposed of, he introduced Dr. Percy, who took the chair and delivered an inaugural address, which was far too long for reproduction here. The number of subjects with which Dr. Percy dealt was vast. He began by announcing the welcome fact that he has in preparation a new edition of his well-known treatise on iron and steel. He then went on to consider the influence of technical education. He next dealt with the changes said to take place in the texture of malleable iron and steel. He stated that so recently as February last it was announced that Mr. John Collett, State Geologist of Indiana, had found that the malleable bar iron used in the construction of several railway bridges in America, and which, it is asserted, was of the best quality, had acquired a crystalline structure, and in some places to such an extent as to threaten disaster at any time. The alleged change of structure was attributed to the continued and repeated vibration caused by the passage of heavy trains. It is an old and still prevalent opinion amongst engineers, that malleable iron may by long exposure to vibratory or concussive action—as, for example, under such conditions as he had just mentioned—acquire what it did not previously possess, namely, a crystalline structure. Now he ventured to question the correctness of that opinion. There may be conclusive evidence in support of it; but, if so, it has escaped his attention, though he has long been in quest of it. What has been demonstrated is, that malleable iron, by exposure to vibratory or concussive action, becomes harder and more easily frangible, so that a blow which before such exposure would not break a bar of iron, might easily break it afterwards. But when even the most fibrous iron is broken with extreme rapidity, as it may be by the impact of a cannon shot, as he had often seen, its fracture is always crystalline, and as distinctly and largely so as that of similar iron broken by a sledge hammer after having been subjected to the necessary degree of vibratory or concussive action. It may possibly be suggested that a crystalline structure may be instantaneously developed in the one case as well as slowly in the other, just as a supersaturated solution of sulphate of soda may be instantaneously changed into a crystalline mass by a touch, and an ordinary hot saturated solution of the same salt gradually changed into a crystalline mass by slow cooling. It should, however, be observed that the crystals formed under these two conditions differ widely in character from each other. When rapidly produced they are small and confused, and, in the opposite case, large and well defined. But this, as far as his experience goes, does not occur when iron is fractured instantaneously by a cannon shot, and comparatively slowly by a sledge hammer. In directing the attention of the members of the Institute to the alleged development of crystalline structure in iron, under the conditions previously stated, he entertained the hope that it may be made the subject of further investigation, and shown conclusively to be either true or erroneous. Dr. Percy next proceeded to consider the effect of cold rolling on iron and steel, dwelling on the curious fact that although the metal so treated has its tensile strength greatly increased, and is rendered much harder, its specific gravity is diminished. Here, he pointed out, is a puzzle not to be easily solved.

Concerning the fatigue of metals, he referred to the physical change which some metals and alloys have been observed to undergo spontaneously while at rest, and under ordinary atmospheric conditions. Thus, chains which have been used to support chandeliers, or even the much lighter gaseliers, have suddenly snapped, and have not been found, on the most careful inspection afterwards, to present the slightest external indication of change.

Speaking at some length concerning "burnt iron"—a material but too well known to all smiths—he pointed out that no really satisfactory explanation of what takes place when iron is "burnt" has yet been advanced. With respect to the chemical changes which have been alleged to occur in the "burning" of iron, he expressed his own opinion, which is, that the experimental evidence hitherto published on the subject cannot be regarded as conclusive. It is for this reason that he had ventured to bring it before the meeting, in the hope that it may attract attention from some of the many skilful chemical analysts at our iron and steel works, and induce them to attempt the solution of it. The point which he would particularly suggest for their investigation is the alleged absorption of oxygen by iron at a high temperature, with, of course, the formation of oxide, and its solution in, or diffusion through, the mass. Here, obviously, there could be no case of occlusion of oxygen, unless the temperature were high enough to cause the dissociation of oxide of iron. The effervescence, following the addition of spiegeleisen to molten decarburised pig iron has been adduced as proof of the existence of oxygen in some state or other in the metallic bath; and experiments on the small scale have seemed to indicate that molten malleable iron may, like molten copper, dissolve some of its own oxide. But what is now wanted is conclusive evidence on such interesting points—evidence founded on the sure basis of accurate observation and careful experiment. Some persons may, however, possibly ask, to what useful practical results is the investigation of such questions likely to lead? The answer is, that many an apparently sterile fact in science has been unexpectedly found to admit of practical application, with the result of benefitting the world and enriching not the man who discovered the fact, but the man who was fortunate enough to apply it. Who can tell that it may not so happen with respect to the investigation of "burnt iron?" though he must confess that it seems very improbable.

He dealt at considerable length with the compression of fluid steel. Long ago he had seen copper, and even flint-glass, subjected to similar treatment, the pressure, however, being much less than—indeed, not comparable with—that applied to steel. In the case of copper, it was done with a view to impart greater soundness and compactness to what may be called, for lack of a better expression, the texture of the metal, and thereby to render it more suitable for rolls used in calico printing; and in the case of glass, which it was vainly hoped might be substituted for copper in the manufacture of such rolls, it was done with a view to get rid of air bubbles. Sir Joseph Whitworth was the first to produce cast steel as an article of commerce, which, during solidification and subsequent cooling, had been subjected to intense compression—if, indeed, he were not the first to propose and adopt this process. Such steel is designated by Sir Joseph "fluid compressed steel," and is now generally known by that name. The idea of thus compressing steel originated in the notion that the formation of blow-holes, due to bubbles of gas in the molten metal, might be thereby prevented; and further, that the steel would be rendered specifically heavier, and, as a consequence, more compact in texture. Now, there is only one way, it appeared to him, in which compression could possibly act in causing these bubbles of gas to disappear, and that is by inducing their absorption or occlusion by the molten metal, just as in the really analogous case of applying pressure to water from which bubbles of carbonic acid gas are escaping. But notwithstanding that our knowledge of the subject of occlusion has been much extended during the last few years, he doubted whether it is sufficient to justify a positive opinion on the absorption or occlusion by molten steel of the gas of which these bubbles consist. That the bubbles should be extruded by compression from liquid steel is incomprehensible, because pressure on a liquid acts equally in all directions, and consequently the position of a bubble of gas in liquid steel would not be changed by compression. That intense compression will greatly reduce the size of the bubbles, and may, therefore, be advantageous, there can be no doubt; but that it should completely destroy them, except occlusion come into play, is inconceivable. It has been supposed that the specific gravity of steel solidified under compression is greater than that of the same steel cast in the usual manner, not under compression, and free from blow-holes. But this supposition is erroneous, as the results of experiments, which he submitted, demonstrated. Some years ago he had the opportunity of testing its correctness under exceptionally favourable conditions. He determined the specific gravity of the bottom, middle, and top of an ingot of compressed steel, and of the middle and bottom of an ingot of the same steel not compressed, and found it to be practically the same throughout. The mean specific gravity was 7·8438, and the extremes were 7·8483 and 7·8387, the difference being 0·0096. He had the satisfaction of adding that the specific gravity of portions of the same pieces of steel which he examined was determined by one of the ablest of our living chemists, with these results: mean specific gravity 7·841, the extremes being 7·845 and 7·840, showing a difference of 0·005. He next referred to some novel process of tempering steel, which was communicated to the French Academy of Sciences. It is stated to consist in heating an ingot or bar of steel to redness, enclosing it in a box which it exactly fills, and then subjecting it to enormous pressure, even 15 tons to the square inch, which is continued until it has become cold. Steel so treated is said to be very highly tempered, and suitable for magnets. This steel, it is asserted, is now being used in the manufacture of telephones, and makes excellent and very fine tools. The compression, it is alleged, may be so regulated as to impart any required degree of temper to the steel. How far what is claimed for this steel may be correct it must be left to steel manufacturers to determine; but this certainly cannot be claimed for the process of making it, namely, any great novelty, as in the Whitworth process, in operation so long previously, the ingot of steel was allowed to cool after solidification, for some time at least, under precisely the same conditions. There is one effect—and it would not surprise him if it should prove to be the most important effect—which the compression of liquid steel during solidification may produce, that is, of so modifying the texture of the metal as to increase its tenacity and ductility, qualities which the Whitworth steel possesses in a very high degree, as shown by trials of the severest kind. Dr. Percy dealt at much length with the chemical changes supposed to be brought about in compressed steel, quoting largely from Sir F. Abel's conclusions, which may be thus summarised:—Firstly, in hardened steel the mode of existence of the carbon is mainly, but might be wholly, the same as in molten steel. He found it to contain only a small and variable proportion of a definite carbide of iron of the formula Fe^3C—*i.e.*, composed of 93·33 per cent. of iron and 6·67 per cent. of carbon—which, to use his own words, he thinks is "probably due to the unavoidable and variable extent of imperfection, or want of suddenness, of the hardening operation; so that, in some slight and variable degree, the change due to annealing takes place prior to the fixing of the carbon by the hardening process." Secondly, in annealed steel the carbon exists entirely, or nearly so, as carbide of iron of the formula Fe^3C, which is equably diffused through what is designated "the mass of metallic iron." Thirdly, in tempered steel the carbon exists partly in the state in which it exists in hardened steel, and partly in the state of carbide of iron. The formation of this carbon is thus explained by Sir F. Abel, and to prevent the possibility of misrepresentation, he—Dr. Percy—gave his explanation in his own words. "The maintenance," he writes, "of hardened steel in a moderately heated state causes a gradual separation—within the mass—of the carbide molecules, the extent of which is regulated by the degree of heating, so that the metal gradually approaches in character to the annealed condition; but, even in the best result obtained with blue-tempered steel, that approach, as indicated by the proportion of separated carbide, is not more than about half-way towards the condition of annealed steel. The carbide separated by chemical treatment from blue and straw-tempered steel has the same composition as that obtained from annealed steel."

Dr. Percy concluded a most able address with a disquisition on the policy of Government manufacturing for itself such things as guns and armour-plates, in which he leaned altogether to the policy of employing private enterprise, which was, he held, capable of giving us the very highest results.

A vote of thanks was moved by Sir H. Bessemer and carried unanimously.

At the adjourned meeting in the afternoon the Bessemer medal was presented, through Mr. Bell, to Mr. Akerman, of Stockholm.

Mr. I. L. Bell then read a paper

ON THE BLAST FURNACE VALUE OF COKE FROM WHICH THE PRODUCTS OF DISTILLATION FROM THE COAL USED IN ITS MANUFACTURE HAVE BEEN COLLECTED.

This paper turned on the influence likely to be exercised on the quality of coke by the utilisation of the bye-products. It dealt at great length with the chemistry of the coke, but the essence of the whole paper may be said to be in its concluding paragraph, which runs:—"In conclusion, I would say a few words on the question which in the end must determine the adoption or rejection of the closed Simon-Carvès oven, viz., its value in a purely commercial sense. So far as the coke is concerned, there is an undoubted economy in obtaining a much better yield from coal than can be had in the open oven, and when the product is to be applied to almost any purpose except that of smelting iron, I do not see any reason why a ton of it should not go as far as a similar weight produced in the beehive oven. As a matter of fact, I have the authority of my friends, Sir J. W. Pease and Co., for asserting that among ironfounders the Simon-Carvès coke is even preferred to any other for the mere melting of iron in the cupola. The composition of the Bearpark coal, as determined by analysis in the Clarence laboratory, is as follows:—

Carbon, of which 66·21 was fixed	79·45
Hydrogen	4·81
Oxygen and nitrogen	6·96
Sulphur	1·69
Ash	5·96
Water	1·13
	100·00

Thus it will be seen that there is no reason why such coal as that in question should not be capable of affording, as I am informed it does, 75 per cent. of coke containing 2·35 per cent. of water. On this computation, 25 cwt.—the quantity consumed to produce a ton of No. 3 pig iron—represents 33·33 cwt. of coal. If, on the other hand, 22½ cwt. of coke made in the beehive oven suffice to produce the ton of metal, the quantity of raw coal required to make this weight of coke, at a yield of 63 per cent., is 35·71 cwt. This would indicate that a large portion of the coal saved in the oven is lost when the coke comes to be used in the blast furnace. If this view be correct, then the iron smelter can afford to pay very little more for 25 cwt. of Simon-Carvès coke delivered at his works than he is accustomed to pay for 22½ cwt. of coke burnt in the beehive oven. In other words, the extra yield of coke from the coal, after paying for extra carriage, will bring but little profit to the coke burner. The value of the Simon-Carvès oven is now left dependent on the profit afforded by the bye-products. This, I am informed on good authority, at the present moment is about 1s. 3d. per ton of coal coked, from which has to be deducted 10d., the cost, according to Mr. Dixon, of labour, &c., in distilling and condensing the tar and ammonia. He gives about 470 tons as the weight of coal capable of being coked per annum by each oven, which at 5d. per ton leaves a gross profit of nearly £10 per oven. Its cost, including the apparatus for collecting the tar and ammonia, is £100 to £120 in excess of that of the ordinary beehive oven. From the profit just named a deduction will have to be made for interest, redemption of capital, and the greater wear and tear attending the use of a more complicated piece of apparatus. It must be borne in mind that the experiments described in the present paper have reference exclusively to coke made from Durham coal, and to which its language is exclusively directed. It is quite possible, and this is borne out by the information I have received in France, that the Simon-Carvès oven is capable, not perhaps of making coke which can resist the action of carbonic acid as well as Durham coke made in the beehive oven, but of producing an article as good in this respect as can be made from the French coal when treated in the ordinary open oven."

Sir Bernhard Samuelson, who opened the discussion, said that the facts given by Mr. Bell spoke for themselves, and the inference drawn from them was that the coke made at the Bearpark Colliery by the Simon-Carvès process was inferior in smelting power owing to its being more readily acted upon by carbonic acid. With respect to the facts there could be no question, because no one was more capable of observing facts or more critical in controlling them than Mr. Bell. His inferences also he was not prepared to dispute; but supposing them to be justified by facts, the only question to his mind was whether other facts might not also have been present which he had omitted to note, and which might partially account for the additional consumption of coke which no doubt had taken place during his experiments. The result of experiments he had made himself was that with the Simon-Carvès coke the produce of iron per week from a furnace was about 20 tons less than when ordinary coke was used; but on the whole, he held that the result of a three-weeks' trial was not unsatisfactory, as with pipe stoves and a blast temperature of 1000 deg. they used 22·07 cwt. of coke per ton, and the average quality was 2·75, which he held to be very fair work.

Mr. Cochrane spoke at some length on the chemistry of the subject, concluding that the Simon-Carvès process would give 72 per cent. of coke; the ordinary plant in the North of England might be assumed to give 60 per cent.; he had got 66 per cent., and in the month of April he actually realised 67 per cent. Hence it should not be taken for granted that there was no improvement possible in the beehive oven, or that it was impossible to obtain equally valuable coke without sacrificing one-sixth of the total fuel in the coke.

Mr. Williams, Mr. Simon of Manchester, and many other gentlemen took part in the discussion, which occupied the whole of the afternoon. In the evening Dr. Sorby read a paper on

THE MICROSCOPICAL STRUCTURE OF IRON AND STEEL.

The microscopical study of fractured surfaces is unsatisfactory, not only on account of the optical difficulties, but because a fracture shows the line of weakness between the crystals, and not their internal structure. All his results are based on the examination of flat sections. These should be finished by grinding with Water of Ayr stone, and polished so as not to alter the true structure of the extreme surface. Anything approaching to a burnished surface or polished scratches is fatal to good results. In general, after having been polished with the finest rouge and water, so as to show few or no scratches, the surface was acted on by very dilute nitric acid, and repeatedly examined in a small trough of water, until it was found that the acid had properly developed the structure. In some cases it is, however, best to polish with dry rouge on parchment, and not to use acid. Thin glass covers were afterwards mounted over the surface with Canada balsam. Some of his preparations have kept perfectly well for above twenty years, but others have deteriorated considerably. Objects thus prepared must be examined by means of two special kinds of surface illumination, viz., first, the side parabolic reflector, now common, but he believed originally made for this purpose, which gives oblique light, and, secondly, a small silver reflector covering half the object glass, which throws the light directly down on the object, and from this it is reflected back through the other half of the lens. With the oblique illumination a polished surface looks black, but with the direct illumination it looks bright and metallic. A truly black substance appears black in both cases. A magnifying power of about sixty linear is most generally suitable, but the sections will bear a higher power perfectly well.

The author described at considerable length the results which he had obtained. It would, however, be practically impossible to make what he said intelligible in the absence of the specimens. The whole may be summarised thus:—The various kinds of iron and steel are seen to be varying mixtures of six or seven substances, having very different properties, viz.: (1) Free iron; (2) a pearly compound with carbon; (3) an intensely hard compound, probably with more carbon; (4) a residual, probably variable, substance; (5) graphite; (6) possibly crystallised silicon; (7) slag, including fused iron oxide. It is quite probable that the individual character of some of these constituents may be modified by the presence of small quantities of sulphur, phosphorus, or other impurities, or the manner in which they separate out from one another changed thereby. This question would require special investigation. The author's chief aim now was to show that the various kinds of iron and steel are usually varying complex mixtures of two, three, four, and sometimes of even five different substances which can be distinctly recognised with the microscope. Except in a few very special cases, iron and steel are therefore not analogous to simple minerals, but to complex rocks. Such being the case, the microscopical examination of properly prepared sections throws much light on the causes of their varying properties. Very much still remains to be learned about the details. What he had done so far was little more than to show how such an inquiry could be carried out, and to describe some of the most conspicuous structures met with in ordinary varieties of the metals. The sections of iron and steel examined were prepared above twenty years ago. The general conclusions then derived from their study were described, and the microscopical photographs taken directly from the preparations were exhibited at the meeting of the British Association at Bath in 1864.

The discussion was opened by Mr. Bauermann, who said he most heartily agreed with what might be called the moral of the paper, that iron and steel were highly heterogeneous substances. They were aggregate masses of various substances and minerals, and therefore it was wrong to talk as though there was such a thing as iron having some indefeasible sort of structure. The subject was complicated by the re-forming produced by the cooling of the external surface. A great deal was what was called columnar structure, the planes of cooling being set up perpendicularly to the cooling surfaces. In reality very little was known about the crystalline form of iron, but judging indirectly from such sections as those of meteorolites, it was a structure compatible with the cubic system. But he thought some other method of taking down iron, so to speak, was wanted, and instead of working upon polished surfaces, to have fractured surfaces obtained by a very sudden rupture. In that way perhaps they might be more likely to get at something more of the nature of the solid form. In all these cases of polished surfaces they were only dealing with indirect evidence. It really appeared as though the difficulty was something of this kind. Supposing they knew nothing whatever about the properties of quartz, and had to deduce them only from polished slabs, not transparent, of millstone grit, or coarse or fine grained sandstone, he thought they would have a very peculiar idea of what quartz was. They had to trust a good deal to the imagination in interpreting the very beautiful sections that Dr. Sorby had shown them.

After a few words from Mr. Riley and Mr. Stromeyer, the discussion dropped, and a vote of thanks was passed to the author, and the meeting adjourned until Thursday morning, the 7th inst.

ABSTRACT OF RESULTS OF EXPERIMENTS ON RIVETTED JOINTS, WITH THEIR APPLICATION TO PRACTICAL WORK.*

By PROFESSOR ALEXANDER B. W. KENNEDY.

THE experiments, of which the following is an abstract, consist of fourteen series, and cover in all 290 experiments, 64 on perforated —punched and drilled—plates, 97 on actual joints, 44 on the tenacity of the plates used in the joints, 33 on the tenacity and shearing resistance of the rivet steel used in the joints, and the rest on various other matters connected with them. All the joints in the whole series were supposed to be made of the same material, a soft steel or ingot iron, supplied from the Landore-Siemens Steel Works; and that all the rivets were made from rivet steel supplied from the same works.

Having summarised the experiments themselves, the author proceeds to summarise the conclusions which it appears safe to draw from them, to examine the proportions of joint which they appear to indicate as the best, and to mention the points on which further information is now being obtained. In accordance with the plan pursued in the rest of this abstract, this will be done in the briefest possible manner, without discussing the points at length as they occur. In most cases a much more detailed treatment of them will be found in the various reports of the rivetting committee, of which this is only an abstract. It will be remembered, and may be again stated here once for all, to avoid repetition, that the conclusions given below all refer to joints made in soft steel plate with steel rivets, that the holes were all drilled, and that the plates were in their natural state—unannealed. Further it should be said that all dimensions, thicknesses of plate, &c., were measured by the most accurate means available; and that in every case the rivet or shearing area has been assumed to be that of the holes, not the nominal—or real—area of the rivets themselves. Also in every case the strength of the metal in the joint has been compared with that of strips cut from the same plates, and not merely with nominally similar material. It is thought that, if these points had always been attended to, many of the discrepancies in published rivetted joint experiments would never have appeared.

(1) The metal between the rivet holes has a considerably greater tensile resistance per square inch than the unperforated metal. This excess tenacity amounted to more than 20 per cent.—both in ⅜in. and ¾in. plates—when the pitch of the rivet was about 1·9 diameters. In other cases ⅜in. plate gave an excess of 15 per cent. at fracture with a pitch of 2 diameters, of 10 per cent. with a pitch of 3·6 diameters, and of 6·6 per cent. with a pitch of 3·9 diameters; and ¾in. plate gave 7·8 per cent. excess with a pitch of 2·8 diameters.

(2) The shearing resistance of the rivet steel is a matter upon which, as has been pointed out, further experiment is required. It may be taken as established that the resistance per square inch in double shear is as great as that in single shear, so that allowance need not be made for the two shearing planes not being equally stressed. In single-rivetted joints, however, the bending of the plates will put considerable tensile stress in the rivets; and this may diminish their apparent shearing resistance. In single-rivetted joints it may be taken that about 22 tons per square inch is the shearing resistance of rivet steel,† when the pressure on the rivets does not exceed about 40 tons per square inch. In double-rivetted joints, with rivets of about ¾in. diameter, most of the experiments gave about 24 tons per square inch as the shearing resistance, but the joints in Series XIII. went at 22 tons. In Series XIII. the larger rivets also went at a low load; but in the other double-rivetted joints, with larger rivets, these latter remained unbroken at a stress of 22 tons per square inch.

(3) The size of the rivet heads and ends play a most important part in the strength of the joints—at any rate in the case of single-rivetted joints. An increase of about one-third in the weight of the rivets—all this increase, of course, going to the heads and ends —was found to add about 8½ per cent. to the resistance of the joint, the rivets remaining unbroken at 22 tons per square inch, instead of shearing at a little over 20 tons.‡ The additional strength is, no doubt, due to the prevention of so great tensile stress in the rivets through distortion of the plates.

(4) The strength of a joint made across a plate is equal to that of one made in the usual direction. (Both this conclusion and the last preceding are stated as the result of a very limited number of experiments; but there seems no reason to doubt their general truth.)

(5) The intensity of bearing pressure on the rivets exercises, with joints proportioned in the ordinary way, a very important influence on their strength. So long as it does not much exceed 40 tons per square inch—measured on the projected area of the rivets—it does not seem to affect their strength; but pressures of 50 to 55 tons per square inch seem to cause the rivets to shear in most cases at stresses varying from 16 to 18 tons per square inch. This conclusion is based on the experiments of Series X., in which the margin was made equal to the diameter of the drilled hole. For ordinary joints, which are to be made equally strong in plate and in rivets, the bearing pressure should therefore probably not exceed 42 or 43 tons per square inch. For double-rivetted butt joints, perhaps, as will be noted later, a larger pressure may be allowed, as the shearing stress may probably not exceed 16 or 18 tons per square inch when the plate tears. But in this case it would probably be wise to increase the margin.

(6) A margin—or net distance from outside of holes to edge of plate—equal to the diameter of the drilled hole has been found sufficient in all cases hitherto tried.

(7) To attain the maximum strength of a joint, the breadth of lap must be such as to prevent it from breaking zigzag. Such a method of fracture must inevitably be accompanied by unequal stresses in the plate straight between the rivet holes, and by consequent diminution of strength. It has been found that the net metal measured zigzag should be from 30 to 35 per cent. in excess of that measured straight across, in order to ensure a straight fracture. This corresponds to a diagonal pitch of $\frac{2}{3}p + \frac{d}{3}$, if p be the straight pitch and d the diameter of the rivet hole. To find the proper breadth of lap for a double-rivetted joint, it is probably best to proceed by first setting this pitch off, and then finding from it the longitudinal pitch or distance between the centres of the lines of rivets.

(8) Visible slip or "give" occurs always in a rivetted joint at a point very much below its breaking load, and by no means proportional to that load. A careful collation of all the results obtained in measuring the slip indicates pretty clearly that it depends upon the number and size of the rivets in the joint, rather than anything else, and that it is tolerably constant for a given size of rivet in a given type of joint. The loads per rivet at which a joint will commence to slip visibly are approximately as follows:—

Rivet diameter.	Type of joint.	Rivetting.	Slipping load per rivet.
¾in.	Single rivetted	Hand	2·5 tons
,,	Double rivetted	,,	3·0 to 3·5 tons
,,	,, ,,	Machine	7 tons
1in.	Single rivetted	Hand	3·2 tons
,,	Double rivetted	,,	4·3 tons
,,	,, ,,	Machine	8 to 10 tons

To find the probable load at which a joint of any breadth will commence to slip, it is only necessary to multiply the number of rivets in the given breadth by the proper figure taken from the last column of the table above. It will be understood that the above figures are not given as exact; but they represent very well the results of the experiments in all series from VIII. to XIII., except Series X., in which the average—for 1in. rivets—was much lower than that given above. In this series, however, the proportions of the joints was intentionally somewhat abnormal; and it is, perhaps, not to be expected that in this respect their results should agree with those of the other experiments. This result as to the slipping of a joint, although, perhaps, unexpected, is not contrary to what ought to have been expected. For experiments show that, long before stresses are reached which could visibly stretch the plates of a joint, there will be quite measurable shear of the rivet. The visible slip, therefore, will consist almost wholly of this shear, the magnitude of which will depend primarily on the number and size of the rivets in the joint. Anything that will hold the plates up better together, such as hydraulic pressure on the rivets, might be expected to diminish this shear or delay its commencement—exactly as seems to have happened. The following table gives the results of experiments on this matter which were made along with those given in the Committee's first Report, but which have not previously been published in the "Proceedings" of the Institution. The experiments are on 1in. turned pins of rivet steel, tested in the single-shear apparatus already described. Of course, the shear would commence later, and be at first smaller in extent, when the pin was replaced by an actual rivet, and when the plates were thus forcibly held together, instead of being quite free to slide, except as far as held from motion by the resistance to shear.

Shearing stress in lbs. per square inch.	Test Nos. 343	344	345	346	347	348
	Amount of shear in inches.					
0	0·0	0·0	0·0	0·0	0·0	0·0
6,365	·010	·013	·016	·022	·055	·021
12,730	·022	·028	·030	·034	·066	·032
19,100	·034	·040	·042	·048	·078	·043
25,460	·055	·060	·060	·071	·091	·062
28,320	·066	—	—	—	—	—
31,830	·080	·086	·082	·091	·113	·183
35,010	·093	—	—	—	—	—
38,190	·113	·113	·108	·114	·140	·108
41,380	·141	—	—	—	—	—
44,550	·168	·152	·142	·170	·171	·155
47,740	·200	—	—	—	—	—
50,910	·242	·200	·196	·248	·238	·222
54,110	—	—	—	—	—	—
Breaking load per sq. inch, lbs.	54,110	54,930	55,240	52,830	56,670	53,530
Breaking load per sq. inch, tons	24·15	24·52	24·66	23·59	25·29	23·90

(9) The value of machine-rivetting, as compared with hand-rivetting, in cases where sound hand-rivetting is possible, lies mainly, if not entirely, in the fact that it doubles the load at which the slip of a joint commences. This conclusion is subject to modification by future experiments with the use of higher pressures in closing the rivet, which may probably still further raise the slipping load, so that the advantage of machine-rivetting may quite possibly be even greater than it is here assumed to be; but there is no indication that it is likely to affect the ultimate strength of the joint. The question of *friction* in the joint, which has not been specially experimented on by the committee, no doubt comes in in the same way. The friction induced by the rivet will affect the point at which slip commences, but can hardly have much, if any, relation to the breaking load. It is thought that the load at which visible slip commences is probably proportional to the load at which leakage would begin in a boiler. Looked at this way, it will be seen that the great value of hydraulic rivetting appears to lie rather in the increased security and stiffness it gives at ordinary working loads than in any actual raising of the breaking load. From a practical point of view the former is probably the more, and not the less, important function. Further experiments are now in progress to test the effect of higher closing pressures on the rivet than were used in Series XII. and XIII., the results of which, it is hoped, will allow more definite conclusions to be arrived at in respect to the comparative merits of hydraulic and hand rivetting.

(10) The experiments point to very simple rules for the proportioning of joints of maximum strength, which will be mentioned before any other joints are discussed. Assuming that a bearing pressure of 43 tons per square inch may be allowed on the rivet, and that the excess tenacity of the plate is 10 per cent. of its original strength,* the following short table gives the values of the ratios of diameter d of the hole to thickness t of plate $\left(\frac{d}{t}\right)$ and of pitch p to diameter of hole $\left(\frac{p}{d}\right)$, in joints of maximum strength in ⅜in. plate:—

Original tenacity of plate. Tons per sq. inch.	Shearing resistance of rivets. Tons per sq. inch.	Ratio $\frac{d}{t}$	Ratio $\frac{p}{d}$	Ratio $\frac{\text{Plate area}}{\text{Rivet area}}$
30	22	2·48	2·30	0·667
28	22	2·48	2·40	0·785
30	24	2·28	2·27	0·713
28	24	2·28	2·36	0·690

Summed up and rounded off, this means that the diameter of the hole—not the diameter of the rivet cold—should be two and a-third times the thickness of the plate, and the pitch of the rivets two and three-eighth times the diameter of the holes.† In mean also it makes the plate area 71 per cent. of the rivet area. If a smaller rivet be used than that here specified, the joint will not be of uniform and therefore not of maximum strength; but with any other size of rivet the best result will be got by use of the pitch obtained frum the formula formerly cited,

$$p = a\frac{d^2}{t} + d$$

where, as before, d is the diameter of the hole. The value of the constant a in this equation is as follows:—

For 30-ton plate and 22-ton rivets, a = 0·524
,, 28 ,, 22 ,, ,, 0·558
,, 30 ,, 24 ,, ,, 0·570
,, 28 ,, 24 ,, ,, 0·606

or in the mean, the pitch $p = 0{\cdot}56\frac{d^2}{t} + d$.

It should be noticed that with too small rivets this gives pitches often considerably smaller in proportion than two and three-eighths times the diameter. For double-rivetted lap joints a similar calculation to that given above, but with a somewhat smaller allowance for excess tenacity on account of the large distance between the rivet-holes, shows that for joints of maximum strength the ratio of diameter to thickness should remain precisely as in single-rivetted joints; while the ratio of pitch to diameter of hole should be 3·64 for 30-ton plates and 22 or 24-ton rivets, and 3·82 for 28-ton plates with the same rivets. Here, still more than in the former case, it is likely that the prescribed size of rivet may often be inconveniently large. In this case the diameter of rivet should be taken as large as possible; and the strongest joint for a

* Abstract of paper read before the Institution of Mechanical Engineers.

† In one pair of single-rivetted joints only a shearing resistance of over 24 tons per square inch was reached; in none of the other did it exceed 22·5 tons.

‡ See "Proceedings," 1881, pp. 713-714.

* The excess strength is taken lower than the average result of the experiments, because it is probable enough that the steel used had more than the average softness.

† The small difference here from the constants formerly given is due to the assumption, now quite justified, of a somewhat greater bearing pressure than was then allowed.

given thickness of plate and diameter of hole can then be obtained by using the pitch given by the equation

$$p = a\frac{d^2}{t} + d,$$

where the values of the constant a for different strengths of plate and rivet may be taken as follows:—

Table of Proportion of Double-rivetted Lap Joints, in which

$$p = a\frac{d^2}{t} + d.$$

Thickness of plate.	Original tenacity of plate. Tons per sq. in.	Shearing resistance of rivets. Tons per sq. in.	Value of constant a.
⅝in.	30	24	1·15
,,	28	24	1·22
,,	30	22	1·05
,,	28	22	1·12
⅞in.	30	24	1·17
,,	28	24	1·25
,,	30	22	1·07
,,	28	22	1·14

Practically we may say that, having assumed the rivet diameter as large as possible, we can fix the pitch as follows, for any thickness of plate from ⅝in. to ⅞in.:—

For 30-ton plate and 24-ton rivets } $p = 1·16\frac{d^2}{t} + d$
,, 28 ,, 22 ,, }
,, 30 ,, 22 ,, $p = 1·06\frac{d^2}{t} + d$
,, 28 ,, 24 ,, $p = 1·24\frac{d^2}{t} + d$

In double-rivetted butt joints it is impossible to develope the full shearing resistance of the joint without getting excessive bearing pressure, because the shearing area is doubled without increasing the area on which the pressure acts. In the writer's last report it was shown that, considering only the plate resistance and the bearing pressure, and taking this latter as 45 tons per square inch, the best pitch would be about four times the diameter of the hole. It appears justifiable, however, to apply here the results of Series X., and take corresponding constants. Thus we may probably say with some certainty that a pressure of from 45 to 50 tons per square inch on the rivets will cause shearing to take place at from 16 to 18 tons per square inch. Working out the equations as before, but allowing excess strength of only 5 per cent. on account of the large pitch, we find that the proportions of double-rivetted butt joints of maximum strength under given conditions are those of the following table:—

Original tenacity of plate. Tons per sq. in.	Shearing resistance of rivets. Tons per sq. in.	Bearing pressure. Tons per sq. in.	Ratio $\frac{d}{t}$	Ratio $\frac{p}{d}$
30	16	45	1·80	3·85
28	16	45	1·80	4·06
30	18	48	1·70	4·03
28	18	48	1·70	4·27
30	16	50	2·00	4·20
28	16	50	2·00	4·42

Practically, therefore, it may be said that we get a double-rivetted butt joint of maximum strength by making the diameter of hole about 1·8 times the thickness of the plate, and making the pitch 4·1 times the diameter of the hole. These are very nearly the proportions which were used for the ⅝in. joints in Series XI. to XIII.; for the ⅞in. joints the diameter of the rivet was, as with the lap joint, less than that indicated by theory. In thick plates, where it is thought impossible or inconvenient to make the rivet-holes so large as 1·8 times the thickness, the best pitch for any assumed diameter of rivet cannot be found by the method formerly used; for here we have not a given maximum shearing stress to work to, but rather the shearing stress which in a given joint causes a given maximum pressure on the rivets. The best ratio of pitch to diameter of hole in double-rivetted butt joints of maximum strength for any assumed diameter of hole d is therefore the same as that given in the last table, or in mean, 4·1.

(11) All the experiments hitherto made have necessarily connected themselves with the question of strength, and the proportions just given belong to joints of maximum strength. But in a boiler the one part of the joint, the plate, is much more affected by time than the other part, the rivets. It is therefore not unreasonable to estimate the percentage by which the plates might be weakened by corrosion, &c., before the boiler would be unfit for use at its proper steam pressure, and to add correspondingly to the plate area. Probably the best thing to do in this case is to proportion the joint not for the actual thickness of plate, but for a nominal thickness less than the actual by the assumed percentage. In this case the joint will be approximately one of uniform strength by the time it has reached its final workable condition; up to which time the joint as a whole will not really have been weakened, the corrosion only gradually bringing the strength of the plates down to that of the rivets. Thus, suppose a single-rivetted lap joint in ⅜in.-plate is in question, and it is considered that corrosion will make this equal to only ¼in. plate before the boiler pressure has to be lowered. The rivet should then be proportioned as if the plate had a thickness of 0·5in., which would give for 30-ton plate and 22-ton rivets (see Table, preceding column) a diameter of hole of 1·24in. Assume this as too large to be convenient, and take the diameter of hole as 1in. Then from the Table, preceding column, the pitch will be

$$p = \frac{0·524}{0·5} + 1 = 2·05\text{in.}$$

The ratio of plate to rivet area to start with will be 0·835, which means of course that the plate is in excess; but the ratio will diminish until it reaches 0·667, when the strength of the plate has become equivalent to that of one only ¼in. thick, as was required. The efficiency of the joint would be 45 per cent., whereas the best efficiency of a joint in ⅜in. plate with 1in. holes (p = 1·84in.) would be 50 per cent., and the best possible efficiency of a single-rivetted lap joint in ⅜in. plate under the given condition of strength would be about 62 per cent. It is hardly necessary to point out how strongly these figures indicate the necessity of using as large rivets as possible, and of taking every possible means to reduce the allowance necessary for corrosion. For a boiler such as has just been discussed is absolutely no stronger than one of ¼in. plate throughout, if only the thickness of the latter could be kept unreduced at the joints.

(12) There are now in hand for the Rivetting Committee further experiments on double-rivetted joints of the general types already tested, in ⅜in., ⅝in., and 1in. plate, designed specially to throw light upon the questions of hydraulic and hand-rivetting, high and low-pressure hydraulic-rivetting, and the practical value of exceptionally large rivets. They will also give further information as to the slip of joints, and other points already discussed; and may further, it is hoped, be made use of to throw some light on rather more obscure problems—such as those raised recently by Mr. Milton at the Institution of Naval Architects—connected with the stress in the metal of the plate in the neighbourhood of the joint.

Although this paper is an unofficial abstract of the result of experiments only, and not an official summary of the whole work of the Rivetting Committee, the author may be allowed to call attention, in conclusion, to other memoirs, not reports on experiments, which have been prepared in connection with the work of the committee. Of these the earliest, and by far the most important, is the admirable summary of the published results obtained up to the time when the committee commenced work, by Professor W. Cawthorne Unwin, and published in the "Proceedings" for 1881, pp. 301–368. This paper, along with many valuable suggestions made by its author at the time, formed really the foundation of the whole work of the committee. The table compiled by Mr. Ralph H. Tweddell, showing rules of practice used by manufacturers for rivetted joints in iron, published in the "Proceedings" for 1881, pp. 293–299, has proved very instructive. In addition to this, Mr. Tweddell has contributed some remarks on hydraulic rivetting to the last report of the committee just issued to members; and Mr. W. Silver Hall has added in the same place a collation of Mr. C. H. Moberly's experiments and a few others, with those of the committee.

LAUNCHES AND TRIAL TRIPS.

THE Italian protected cruiser, Giovanni Bausan, which has been built by Sir W. G. Armstrong, Mitchell, and Co., for the Italian Government, made her official trial on Saturday last, off the mouth of the Tyne, and was in all respects successful. The vessel, which is under the command of H.R.H. the Duke of Genoa, proceeded to sea, having on board her own officers and crew. The machinery was under the charge of Mr. Foley, manager of Messrs. R. and W. Hawthorn; and immediately the visitors arrived on board, the engines were put out at full speed, the boilers working under forced draught, and the vessel then proceeded to make a series of runs, lasting continuously without easing for six hours, some of the runs showing a speed of over 18 knots, and the average for the entire six hours was over 17½ knots. The engines worked during the whole time with the most perfect smoothness and regularity, and the boilers supplied abundance of steam without the least indication of priming or anything to mar the entire success of the trial, which was of the most exhaustive character. The forced draught was obtained from four powerful fans, and an incidental effect of their operation was to keep both the stokeholds and engine-room extremely cool. It is to be observed that the duration of the trial under forced draught was over six hours, which is probably about double the time that any vessel has previously been run under similar conditions, the time now stipulated for ships building for the British Admiralty being four hours. On the completion of the trial the vessel returned to the Tyne, and as she already has her gun and torpedo armament fitted, it only remains for her to take on board her final stores, fill up with coal, and probably some time next week will proceed to her destination.

THE PHYSICAL SOCIETY.

AT the meeting of this Society on April 25th, Professor Guthrie, president, in the chair, the following papers were read:—"On the Theory of Illumination in a Fog," by Lord Rayleigh. The paper dealt with certain theoretical results based upon the assumption that the medium in which the fog was formed and the substance composing the fog itself were perfectly transparent. The effect of such a fog surrounding a source of radiation would be to diminish the radiation, and in the case of a supply of energy from without, as with the carbon filament of an incandescent lamp, the temperature of the source would be increased by the fog. A spherical envelope of such a fog surrounding the lamp, and sufficiently thick to be impervious, would act as a perfectly reflecting surface. A problem closely related to the above, and which is easily worked out, is that of light incident normally upon a pile of glass plates. If m be the number of such plates and ρ the fraction of incident light reflected by one plate, $\phi(m)$ the light reflected, and $\psi(m)$ that transmitted by a pile of m plates, we have

$$\frac{\phi(m)}{2m\rho} = \frac{1}{1 + (2m-1)\rho} = \frac{\psi(m)}{1-\rho}.$$

If the transmitted light be allowed to fall upon another pile consisting of n plates, we have an infinite amount of reflection between the plates, and as the final result, if A denotes the radiation in the original direction and B that in the opposite,

$$A = \frac{2n\rho + 1 - \rho}{2(m+n)} \quad B = \frac{2n\rho}{2(m+n)\rho + 1}.$$

If m and n are large, we have $A = B = \frac{n}{m+n}$, which shows that by increasing n we can make the radiation between the plates as much as if the first pile did not exist, whatever the number of plates in it.

"On a Monochromatic Telescope," by Lord Rayleigh. This is a modification of Maxwell's colour-box. In this instrument, as is well known, light passes through a slit in the focus of a collimimating lens; it traverses in succession this lens, a prism, and another lens, by which it is brought to a focus upon a plane surface, in which is a movable slit; the eye being placed behind, which receives light approximately monochromatic. If in addition a lens be placed just behind the first slit, so as to bring some distant object into focus at a convenient distance from the eye, this object will be seen by the light that would enter the eye in the simple colour-box. The author suggested the use of this instrument to compare lights of different colours, and hinted at the possibility of choosing some colour towards the middle of the spectrum, at which lights might be compared for practical purposes.

"On the Self-regulation of the Compound Dynamo," by Professor A. W. Rücker. If ϕ represents the current or electro-motive force in the external circuit of either form of compound dynamo, it is given by means of an equation of the form

$$\phi = \frac{P}{A+x} - \frac{Q}{B+x},$$

where A, B, P, and Q are quantities which are different in different cases, but are always independent of the external resistance, and x is the conductivity or the resistance of the external circuit, according as ϕ represents the electro-motive force or current. The constant A in all cases depends only on the resistance of the various parts of the machine.

If μ and m are respectively the largest and smallest values of x between which self-regulation is aimed at, then $\mu - m$ may be called the range of x. That value of x which corresponds to the resistance most frequently used may be called the usual value of x, and indicated by ξ.

The maximum efficiency η of the machine is connected with A and ξ by the relations

$A = \xi(1+\eta)/(1-\eta)$ if ϕ be the external E.M.F.,
$A = \xi(1-\eta)/(1+\eta)$ if ϕ be the external current.

It can easily be shown that the function ϕ has two critical values, and that the value of x corresponding to one of these is necessarily negative, unless one of the inducing spirals is wound so as to diminish the magnetisation.

Various cases are considered corresponding to different relations among the magnitudes of the constants A, B, P, and Q. The following indications of the method of treatment may suffice:—If $A/B < | < \sqrt{P}/\sqrt{Q}$, ϕ is positive for all positive values of x, and the critical value of ϕ occurs for a negative value of x; so that ϕ diminishes as x increases. Hence, if we write

$$\frac{P}{A+m} - \frac{Q}{B+m} = \phi_1,$$

we must have

$$\frac{P}{A+\mu} - \frac{Q}{B+\mu} = \frac{\phi_1}{1+q},$$

where q is a positive quantity, which will be less as the self-regulation is more perfect. These equations give

$$P = \frac{\phi_1}{1+q} \cdot \frac{\mu - m - q(B+m)}{(A-B)(\mu-m)}(A+\mu)(A+m)$$

$$Q = \frac{\phi_1}{1+q} \cdot \frac{\mu - m - q(A+m)}{(A-B)(\mu-m)}(B+\mu)(B+m).$$

Now, since $A - B$ is negative, we must, if P and Q are positive, have $q > (\mu - m)/(A+m)$, and *a fortiori*,

$q > (\mu - m)/(B+m)$.

By similar methods inferior limits to q are found in other cases, and it is thus shown that for given values of u and m the limit is lower as A is larger. It has, however, been proved above that if the maximum efficiency of the machine is high, A will be large or small, according as it is taken from an expression that gives the external electro-motive force or the external current. Hence it is more difficult to combine high efficiency with good self-regulation if an approximately constant external current is desired, than if an approximately constant external electro-motive force is aimed at. The equations do not lead to any simple rules for the relations which should hold between the various parts of compound dynamos, but if some of the constants are taken as given, the values which must be assigned to the others can be calculated if a given efficiency for the usual value of x, and a given deviation from perfect self-regulation between given values of x, are to be attained.

"On the Determination of the Heat Capacity of a Thermometer," by Mr. J. W. Clarke. The method consists in the estimation of the masses of the mercury and glass of the thermometer immersed, by weighing the instrument in air and in water, and again in water when immersed to the extent usual in the thermal experiment. The specific gravity of the glass and mercury being known, the absolute masses immersed can be readily calculated, and consequently their thermal capacity.

A photometer which enabled a comparison to be made between the light of a lamp emitted at any angle and a standard, was exhibited by Mr. Dibdin, and the action explained by Mr. Livingstone, who stated that the maximum amount of illumination took place at an angle of 45 deg.

A MEETING of this Society was held on May 9th in the Physics Theatre of Clifton College, Bristol, in consequence of an invitation from the British Naturalist Society—Professor Guthrie, president, in the chair. Messrs. E. Cleminshaw, E. F. Herrom, and A. L. Selby were elected members of the Society. The following communications were read:—

"On Evaporation and Dissociation," by Professor W. Ramsay and Dr. S. Young. The authors gave the results of a series of investigations undertaken with the view of determining how far the passage of a liquid into a gas resembled the dissociation of a chemical compound. For this purpose the relation between the pressure and temperature of several dissociating substances—such as ammoniac carbonate, chloral hydrate, and phthalic acid—had been examined. The authors hope shortly to publish the full details of these experiments, and the conclusions arrived at.

"On a Model Illustrating the Propagation of the Electro-magnetic Wave," by Dr. S. P. Thompson. The model consists of two sets of beads. Each set is composed of a number of beads fixed to the extremities of wires, and by a suitable mechanical contrivance each executes an approximately harmonic motion at right angles to the wires and the mean plane of the set. The phase of each bead differing by a certain small amount from the succeeding, the whole represents a wave propagation. The two sets are coloured differently, and are so placed that their harmonic motions are executed at right angles about the same axis, which represents the direction of propagation of an electro-magnetic disturbance, one wave being the electro-static and the other the electro-magnetic displacement.

"On a Self-recording Stress and Strain Indicator," by Professor H. S. H. Shaw. This instrument was designed for one of Wicksteed's 50-ton single lever machines, lately erected in the engineering laboratory of University College, Bristol, and has been found very simple and effective. In this testing machine the stress is applied by moving a mass of one ton along a lever. This mass is connected by a cord with a vertical cylinder upon the indicator. This cylinder carries a paper wound round it, and turns upon its axis as the mass is moved towards the end of the lever. A pencil capable of a vertical motion bears against this, and thus horizontal distances upon the paper are measures of stress. The strain is measured by the vertical motion of the pencil, the position of which is controlled by a wire attached to the rim of a wheel above, upon the same axis of which are other smaller wheels, any one of which can be connected to a fine wire which is carried horizontally to the upper end of the test piece, passing over a pulley fixed to it, and is fixed to the lower end. Any extension of the test piece can be multiplied at pleasure on the diagram by attaching the wire to a larger or smaller wheel.

"Note on the so-called Silent Discharge of Ozone Generators," by Mr. W. A. Shenstone. Mr. Shenstone had arranged some apparatus by which this could be viewed. It seemed to have the characteristics of the Brush discharge.

CIVIL AND MECHANICAL ENGINEERS' SOCIETY.—The annual dinner of this Society was held at the Holborn Restaurant on Thursday evening, the 7th inst. The chair was occupied by the President, Mr. Thomas Cole and a large number of members and visitors were present. The usual loyal toasts having been duly honoured, Mr. R. H. Willcocks, LL.B., proposed "Success to the Society." The President responded to this toast, and in the course of his remarks spoke of the usefulness of the Society and the practical benefit which had been derived from it by many of the members, and said that he hoped that the large increase in numbers which had taken place during the last year or two would be steadily maintained.

SOCIETY OF ENGINEERS.—At a meeting of the Society of Engineers, held on Monday evening, May 4th, at the Town Hall, Caxton-street, Westminster, Mr. Charles Gandon, president, in the chair, a paper was read by Mr. W. Newby Colam on "Cable Tramways." The author, on introducing the subject of his paper, alluded to the number of years that vehicles had been propelled by wire cable, and explained that the novelty in the cable system of tramways was the invention which had enabled a cable to be used as a transmitter of power to tramcars in such a manner that they can be drawn through crowded streets without interfering with the ordinary traffic. The author then gave an account of the history of the invention and its application to the first cable tramway, which was constructed up Clay-street Hill, San Francisco, in 1873. The great mechanical and financial success in this first line induced other tramway companies, at that time using various motors, to convert their lines to the cable, with the result that there are now over forty miles working most successfully in that city. The lines in San Francisco are more or less very steep, in places being as severe as one in five; but the introduction of the system in 1882 into Chicago, which city is practically on a dead level, has demonstrated its great advantages under such circumstances, and in climates subject to extreme variations of temperature and heavy falls of snow. Over twenty miles of cable track is now in operation in that city, and during the very severe weather of last winter the cables were the only uninterrupted means of locomotion. It was shown that two lines have been working successfully in New Zealand for some years; that twenty-seven miles of line have been commenced in Melbourne, and also another in Sydney, Australia. Lines are in course of construction in Philadelphia and other American cities. The New York authorities have just sanctioned the laying of seventy-two miles of cable line in that crowded city. The remainder of the paper was devoted to describing the construction of the Highgate Cable Tramway, to which the author is engineer. This line has been working most successfully since May, 1884, during which time 600,000 people have been carried up and down grades as steep as 1 in 11. It was argued by the author that the cable system had proved itself possessed of a great many advantages over all other tramway motors—more particularly that no space in the street is occupied by the motor, whereas considerable space is taken up by horses or engines; and also in its power to accommodate sudden and great rushes of traffic, as no other system can possibly do, thus being the best caterer to the public, with a minimum obstruction to them, important points which cannot fail to claim public support.

AMERICAN NOTES.

(*From our own Correspondent.*)

NEW YORK, May 2nd.

THE iron and steel manufacturers will probably have to wait for another season before they will profit by the demand which railway construction creates for material. The recent returns show that construction is being pushed forward very slowly; that profits as compared to four years ago are not much in excess of 25 per cent. of what they were then, despite the heavy increasing tonnage; that a great deal of railway property is passing into the hands of receivers, and that investors in railway securities are backward. During 1884 thirty-seven roads, operating 11,000 miles of line, representing 715,000,000 dols. in stocks and bonds, passed into the hands of receivers. At this rate over 1,100,000,000 dols. of American railway property will fall into the hands of receivers. Last year there were over 10,000 commercial failures, representing liabilities of 250,000,000 dols., and it is estimated that at the present rate of progress the failures will exceed this number by 1000 this year, and the liabilities exceed last year's by about 25,000,000 dols. During the first quarter of this year thirty co-operations passed into the hands of receivers. The profits for the quarter of the roads paying dividends were 1,000,000 dols. The transporting capacity of the roads running eastward from Chicago foot up 4,400,000 tons annually. This capacity has never been utilised, the highest figures being 3,150,000 tons. If the traffic requirements increase, there will be urgent action for additional railway construction. A great deal of railway mileage throughout the country is profitless. It is estimated that there are some ten to twelve thousand miles of projected road waiting for increasing traffic demand. There is an abundance of capital ready for employment. There are at present 53,000,000 dols. of idle capital in New York city, and a large volume in Boston and Philadelphia, but it refuses to accept present risks. Rail-makers, it is said, are negotiating with buyers to furnish rails at 25 dols. and 25.50 dols. Offers of this character have been made, at least, and have not yet been refused. The production of pig iron throughout the country is slowly improving, and, as far as record shows, without any accumulation of stocks at furnaces. The general business of the country is not improving, and ranges from 25 to 30 per cent. below the volume at the corresponding period of last year. Values are from 10 to 15 per cent. lower, and competition seems to have about reached its limits, leaving manufacturers in a position where they cannot invite further purchases by greater concessions. At the same time, there is a spirit of hopefulness in all manufacturing channels. The smaller trades are busier. The machine shops, tool shops, agricultural works, and engine works are all increasing their orders, while the locomotive works are not. The shipyards are doing a little repairing. A few of the large car works are busy, but the greater number are running with about one-half their usual force. The manufacturers in iron anticipate trouble with their workmen, and will endeavour to arrange a compromise during May. The coal trade throughout the Eastern States is not active. Large consumers, particularly steamship and railway companies, are declining to place their usual heavy orders at this season, in view of the possibility of heavy orders for anthracite coals, either by internal dissensions in the anthracite combination, or by the competition of bituminous coals from Pennsylvania, Maryland, and West Virginia.

THE IRON, COAL, AND GENERAL TRADES OF BIRMINGHAM, WOLVERHAMPTON, AND OTHER DISTRICTS.

(*From our own Correspondent.*)

THE somewhat better tone noticeable in last week's markets was stronger in Birmingham this—Thursday—afternoon. The preservation of peace is regarded as sure to encourage merchant buying, and ironmasters were to-day less disposed to accept former minimum prices. At present, however, the demand has not much increased, and short work continues.

Orders for high-class branded iron for engineering and dockyard purposes have been fairly good recently, and the local consumption of nail and tube strip and braziers' sheets is well maintained. But sales of sheets for galvanising are not buoyant, and prices in this department are proportionately lower than in any other branch. Singles for galvanising are £6 15s. upwards, and doubles £7 upwards. Lattens are £1 per ton additional. Merchant singles are £6 5s. to £6 10s. and on, according to quality. Some makers of best thin sheets for stamping purposes quoted to-day for sheets of 20 w.g. £10 10s. per ton; best qualities, £11; double best, £12; treble best, £13; and semi-charcoal, £14, all cold rolled and close annealed.

Sheets in the galvanised state were not in large call, though some firms keep quite active. Certain makers of best qualities quoted galvanised roofing sheets, of 20 g., £12 per ton; best for working-up purposes, £18; double best, £19; and charcoal qualities, £21 per ton.

Prices of bars, hoops, strips, and other merchant iron are not quotably stronger on the week. Earl Dudley's make remains at £8 2s. 6d. per ton, and other marked bars at £7 10s. to £7. Most business continues to be done in the qualities ranging from £6 10s. down to £5 5s. Common hoops are £5 10s. upwards, and tube strip is as low as £5 5s.—a figure which ironmasters have but seldom before accepted for some years past.

Pig iron consumers are overbought, and new business is very tame. The demand for all-mine sorts and for hematites is militated against by the increased local consumption of steel in the shape of billets, blooms, and sheets. All-mines are changing hands at 53s. 9d. to 55s., though occasionally 57s. 6d. is obtained by best hot blast sorts. Hematites are 54s. to 55s. delivered from over districts. South Yorkshire pigs are 51s. 3d. delivered at works; Lincolnshires, 42s. 6d. to 44s. delivered to stations; and Derbyshires, 40s. to 41s.; Staffordshire pigs smelted mainly from Northampton ores, 39s. to 40s.; and common pigs, 35s. down to 33s.

Cokes are moving off quietly at 23s. for Durham foundry sorts delivered here, and 21s. for forge sorts. South Yorkshire cokes are 15s. delivered, and South Wales, 14s. Hematite ores are in quiet request at 18s. per ton. Northampton ores are being despatched to South Wales in large quantities at 8s. per ton delivered in the principality.

The inquiries in the market by the Secretary of State for India for cast iron plate sleepers and fastenings, and those by the East India Railway Company for Bessemer steel switches, cast steel crossings, and locomotive springs, are viewed here with satisfaction.

The officials of the Iron Trade Wages Board find themselves unable, I am informed, to recognise the claim which has just been made by the Millmen's Association that the Board should consider the new system of reduced payments which has of late been introduced into some of the sheet mills. Only a portion of the members of the Millmen's Association contribute to the support of the Wages Board. In cases, however, of alterations at works which do contribute to the Board, the sub-committee are prepared to attempt a pacific solution if the men consider themselves aggrieved.

Manufacturers here are trying to get the maximum of obtainable business out of the Inventions Exhibition. Some fifty firms from Birmingham have contributed exhibits, and there is also a fair sprinkling of goods from other district towns, more especially Coventry, which sends a profusion of cycles.

The refusal of the Birmingham Town Council to join in a scheme for the purchase by the corporate bodies in this district of the Grand Junction Canal has not been allowed to crush it out. It was desired that the canal should be so improved, by the expenditure of £1,000,000, as to allow of steamers of 120 tons burden travelling between Birmingham and London. The Committee of the South Staffordshire Railway and Canal Freighters' Association suggest that Mr. Henry J. Marten, C.E., of London and Wolverhampton, should make a survey of the route and report, at a cost of £500. A considerable part of this sum has already been subscribed.

By the decease of the Earl of Dudley, South Staffordshire loses its most powerful coal and iron master. His lordship's great mineral areas in Staffordshire and Worcestershire comprised, besides valuable ironstone deposits, the seams known as the celebrated "Ten yard thick coal." His lordship was the owner of the Round Oak Ironworks, near Dudley, the brands of the Round Oak and L. W. being known throughout the world. As a maker of pig iron at Tipton and Brierley Hill, his lordship was equally famous.

NOTES FROM LANCASHIRE.

(*From our own Correspondent.*)

Manchester.—There is still an absence of any indication of improvement in the iron trade of this district, either as regards prices or demand. For pig iron there is a continued complete stagnation in the demand, with makers in some cases showing a disposition to come below the prices for which they have been holding of late. In manufactured iron here and there a little more activity is reported, but business, taking it all through, is still very slow, and no better prices are obtainable.

The Manchester 'Change meeting on Tuesday brought forward very little business. There were one or two moderate enquiries for pig iron in the market, but buyers seem only prepared to place out orders either at prices under those which sellers are willing to accept, or for longer forward delivery than makers care to entertain, and except where one or two sellers are prepared to come in with cheap brands at extremely low figures, the actual business done is very small. In forge pig iron there is a little giving way on the prices to which the leading makers have recently been adhering. Local makers would now be willing to entertain offers at under 40s., and good district brands are to be got without difficulty at 39s., and one or two brands at as low as 38s., less 2½, delivered equal to Manchester. Foundry qualities are without material change. For good Lancashire brands makers hold firmly to 40s., less 2½, delivered equal to Manchester as their minimum figure, and district brands are still quoted by the leading makers at 40s. 6d. to 41s., with one or two cheap brands to be got at 39s., less 2½, delivered here.

For manufactured iron prices remain on the low basis of £5 7s. 6d. for good qualities of Lancashire and North Staffordshire bars, £5 17s. 6d. for hoops, and £6 17s. 6d. to £7 per ton for sheets delivered into the Manchester district, and there is not much actual pressure to sell at anything below these figures. Most of the makers are supplied with work sufficient to keep them moderately well employed, but orders come forward very slowly, and shipping, which does not seem to have yet recovered from the check given to it by the recent warlike complications abroad, is generally dull. There is, however, more inquiry in the market, and the tendency of trade is in the direction of improvement.

The chief feature to notice in the engineering trade is the decided slackening off in the activity which has for some time past characterised the locomotive building branch of industry; the leading firms in this district are still kept fully employed on the work they have in hand, but this is running off, with very few orders coming forward to replace it. Machinists are still tolerably well employed, and tool makers in most cases are kept moderately well supplied with orders, but generally a continued tendency towards slackness is reported.

The condition of employment as reflected through the reports of the Trades' Union societies connected with the engineering industries continues only indifferent, and the various branch returns show no improvement in the condition of trade. The Secretary of the Ironfounders' Society, in summing up the reports as to the condition of trade, regrets to announce that there is neither any visible improvement nor any indications at present of any change for the better. The number of members returned as out of employment is slightly on the increase, and out of a total membership of 12,375, there are no less than 1259 in receipt of out-of-work support. With very few exceptions the reports as to the condition of trade are either moderate or bad, and the following large industrial centres give a fair indication of the state of trade generally:—London, bad; Manchester, Leeds, Hull, Middlesbrough, Bolton, and Wigan, also bad; Barrow, Birmingham, and Newcastle, very bad; Oldham, short time; and Sheffield and Warrington, moderate. The Secretary of the Steam Engine Makers' Society is able to report a decrease in the number of unemployed, which from an average of 4½ per cent. of the members in receipt of out-of-work support, as shown in the returns for March, has this month dropped down to 2½ per cent. This, however, has been due almost entirely to the recent increased demand for men in the Government establishments at Woolwich, Portsmouth, and Chatham, and does not indicate any actual improvement in trade generally, the secretary being compelled to admit that unless the branch statements as a whole reported more hopeful prospects in the separate districts than they had done for some months past, it was feared the more favourable condition of employment would not be maintained. The miners' strike in South Yorkshire was affecting their members injuriously, owing to the stoppage of collieries; whilst at two ironworks in the locality notices of reductions had been given which might lead to a further cessation of work. The reports as to the state of trade throughout the country are still only moderate, with a slight improvement in some ship-building centres. In the Manchester and Salford districts the members are being kept fairly employed. In Bolton, Oldham, and Rochdale trade continues good, and at Preston and Wigan, which for some time past have been bad, a slight improvement is being reported.

Messrs. Kendal and Gent, of Manchester, have just completed for the Antwerp Exhibition a combined slotting and milling machine, which has been specially designed with the object of meeting the requirements of heavy engineering work, in which massive wrought iron portions such as cranks, &c., which have frequently to be milled in some parts and slotted in others, and it is so constructed that it can be readily changed from one operation to the other, whilst the combination for both purposes does not in the least interfere with the perfect action of the machine for either. The general outline of the machine is that of a powerful slotting tool, but the ram is so constructed as to carry a strong spindle, with special driving for milling. The ram is provided with quick return motion by means of elliptic wheels, thus entirely obviating the large element of friction in machines as ordinarily constructed with the sliding-block and lever, and it is also counterbalanced. It is so arranged that one driving serves for either milling or slotting. The tables are specially constructed for giving great solidity; all the movements and feed motions are controlled from one side of the machine, and the workman is enabled to change instantly from milling to slotting as required. The machine is constructed to admit objects 7ft. in diameter, and is provided with 15in. milling cutters. Complete it weighs from twelve to thirteen tons, and the whole of the mechanical arrangements are so accurately adjusted that, notwithstanding the very heavy gearing required, the machine is practically noiseless in its working

A trial of a new pumping engine, constructed by Messrs. F. Pearn and Co., of Manchester, was made on Saturday at the Hurst Mills, Ashton-under-Lyne. The engine is one of Messrs. Pearns' long-stroke double-ram Manchester pumping engines, having two 7in. rams, two 10in. steam cylinders, 14in. stroke, with a normal speed of 65 strokes per minute, and delivering 14,770 gallons per hour. The engine is of the vertical type, and self-contained, with a very simple arrangement of working parts throughout. Although the trial was carried out under the somewhat unfavourable condition of a strong, gusty wind, it was throughout very satisfactory, and the following results were obtained:—With a boiler pressure of about 90 lb. and a speed of 106 on the engine, a pressure of 125 lb. was obtained through five $\frac{5}{8}$in. jets; at a speed of 120, a pressure of 100 lb. through four $\frac{3}{4}$in. jets; and at a speed of 72, a pressure of 170 lb. through two $\frac{3}{4}$in. jets and one 1in. jet. One $\frac{3}{4}$in. jet and one 1in. jet, at a speed of 68, giving a pressure of 210 lb., were played over the building, which is 150ft. high; whilst with a speed of 92 and 150 lb. pressure, a jet through a $1\frac{1}{4}$in. nozzle was carried about 40ft. over the tower.

In the coal trade the usual summer quietening down in the demand is making itself felt, but for the time of the year there is still a fairly good demand for the medium qualities of house-fire coals. Common round coals still move off very slowly for iron-making and steam purposes, and are a drug in the market. Engine classes of fuel are also only in indifferent demand. Although the giving way in price in the Manchester district at the commencement of the month has not been followed by any actually announced reduction in other districts, it has provoked a good deal of pressure on the part of buyers for concessions, which has had to be met by some giving way in quoted rates, and prices may be said to be easier. At the pit mouth they average 8s. 6d. for best coals, 7s. seconds, 5s. to 5s. 6d. common coal, 4s. 6d. to 4s. 9d. burgy, 3s. 9d. to 4s. best slack, and 2s. 9d. to 3s. inferior sorts.

Shipping is dull, and 6s. 9d. to 7s. per ton represent the average figures quoted for steam coals delivered at the high-level, Liverpool, or the Garston Docks.

Barrow.—The hematite pig iron trade of the north-west of England remains in a very quiet, inactive state, and it is noticeable that the orders now being booked are not likely in any way to improve the prospects of makers generally. On the contrary, it is evident that sales do not more than represent the actual production of the works, so that stocks, which are still very large, do not decline. A better feeling, I am assured, is likely to arise in business circles, owing to the cessation to some extent of political difficulties. The orders in hand, however, do not represent any very large amount of forward deliveries, and there is not likely to be any improvement in this direction so long as confidence is so shaken that buyers will not purchase pig iron when prices are as low as 43s. 6d. per ton for mixed Bessemer parcels, and so long as large stocks are held in the district and the output of the furnaces restricted as at present. Of course, it would not be policy to increase the output and augment stocks in face of so limited a sale, but some justification for the belief that prices have reached their lowest point is surely to be found in the fact that with stocks very large and the output very much restricted makers will not, indeed cannot, sell at lower values. Steel makers are not busy in any of their departments. The rail mills are not working regular time; the merchant mills are badly supplied with orders; tin bars are not in as large request as usually is the case; special mild and hard steel for a variety of purposes are not now ordered so freely, and steel plates and steel sleepers are not produced on anything like the scale as the capacity of production would justify. It is probable there will be a great development in steel plate rolling in this district. A Siemens furnace is being started at the Barrow Iron and Steel works, where Mr. David Evans, of the Rhymney Works, has taken the general management in place of Mr. W. S. Davy, resigned. Marine engineering shops are very busy. Shipbuilders have not booked any new orders.

THE SHEFFIELD DISTRICT.

(*From our own Correspondent.*)

THE Yorkshire miners have held another conference at Barnsley, and this time they have decided to make the coalowners an offer of arbitration. While passing resolutions re-affirming their determination to resist the reduction of 10 per cent., the conference instructed their secretary to write to the coalowners' secretaries asking "if the men are willing, are the coalowners willing, to submit the question to arbitration, and if they will meet a deputation to discuss the same at an early date." Of the result of this application no sanguine hopes can be entertained, for it is coupled with another resolution asking the coalowners to consider a scheme for a sliding scale for the regulation of wages in future. This scheme is the one the colliery proprietors had before them several months ago, the second clause of which is fatal to its adoption. This clause provides that "the present rate of wages" is to be the minimum, whereas the coalowners insist that the minimum shall be the present rate of wages less the 10 per cent. It is, in fact, the whole bone of contention, and it is a sheer waste of time to ask the coalowners to accept what they have already, and so recently, decided to reject. There seems no reason why the men themselves should not settle the question by ballot. At the Barnsley Conference the delegates numbered over 100, and were stated to represent 40,000 miners; but there is no getting over the fact that a large body of the men—the moderate portion—are usually silent when these delegates are selected, and any one who suggests a settlement on other than "no surrender" lines, runs the risk of being treated like a pariah. A ballot, honestly conducted, would soon settle the strike of Yorkshire miners. The Kiveton Park and West Kiveton miners have taken the matter into their own hands by resuming work on Wednesday morning. As the Union officials would not advise them to go out *en masse*, they have gone in *en masse*.

South Yorkshire collieries are feeling the pinch of the dispute in their business by rail and water to Hull. The quantity sent last month was 80,416 tons, a falling off to the extent of 29,352 tons when compared with the corresponding period of last year, and a decline of 20,644 tons on the month of March. Eleven collieries—notably Denaby Main, where the war of exhaustion is still proceeding—sent nearly 33,000 tons less last month than in April, 1884. Denaby Main showed a decline of about 12,800, and Shireoaks of 6700 tons. On the other hand, considerable increases were shown by Edmund's Main, Kilnhurst, Kiveton Park, Roundwood, Thrybergh Hall, Wath Main, and Strafford Main. The West Riding pits seem to have suffered most severely, four firms (Allerton Main, Frystone, Whitwood, and Wheldale) sending nearly 21,000 tons less than in April 1884. New collieries are getting a share of the work, and thus business drifts about in the course of a great struggle. The export trade, singularly enough, increased largely in April—44,336 tons, an increase of 10,433 tons. California, the United States, Belgium, and Canada (who had no English coal from Hull in April, 1884) took last month 1671, 2576, 2541, and 1719 tons respectively, while Germany had 8390 tons, as compared with 6454 tons for the corresponding period last year. Russia took 3368, an increase of 1068 tons; Denmark increased by 1000 tons; Italy, by 2068; while our coaling stations at Malta and Gibraltar had 722 and 610 tons respectively, against *nil* in April, 1884. These figures account for the improvement in the export trade. Stocks at the collieries are now seriously diminished, and next month's return will be much attenuated so far as the Yorkshire collieries are concerned.

The Board of Trade returns for April tell the same disappointing story of falling markets all over the world. The result disclosed for last month is the most discouraging for many years. Imports show an increase of £3,547,402, the total value being £33,321,190, against £29,773,788 in April, 1884; but the exports amounted to only £16,394,212—a decrease of £2,355,301. Though the decrease is spread over all classes of goods, it affects with special force the industries of this district. Hardware and cutlery for April of 1883-84-85 show diminishing values of £294,863, £264,889, and £219,871; iron and steel, £2,359,778, £2,138,319, and £1,863,371. In hardware and cutlery the decline is over 17 per cent. Every market shows a decrease, except Russia, where the advance is only £3. British North America has dropped from £17,992 to £11,124; British East Indies, from £29,942 to £20,564; Australasia, from £47,705 to £44,818; British Possessions in South Africa, from £4248 to £3226; and the United States from £25,692 to £18,100, the latter figure being just about one-half the value sent in April, 1883. The shipments of unwrought steel in April of the last three years were £118,822, £101,225, and £85,812. France in these periods took values amounting to £9938, £8366, and £8662; the United States, £47,955, £33,908, and £15,327. Though the lessened income is due, in part, to fall in prices, there is also a heavy drop in quantities. The total shipments of iron and steel were only 264,400 tons last month, against 305,949 tons last year, and 338,459 in April, 1883. In rails and railway iron there was an increase in quantity of under 2000 tons, but the increase in value was over £24,000; prices are evidently higher in this branch than last year.

On Saturday the Manchester, Sheffield, and Lincolnshire fast train from Sheffield at 4.20 p.m. for London proceeded safely until between the Shireoaks and Worksop stations, when the driver perceived something amiss with the running gear of his engine. He slowed his train and came to a stand near the Cateford-road bridge, 300 yards from Worksop station. The engine was examined, and one of the crank axles was found to have given way. The engine was shunted into a siding and the train taken on to Retford by a pilot.

THE NORTH OF ENGLAND.

(*From our own Correspondent.*)

BUSINESS was almost as stagnant as ever at the Cleveland iron market, held at Middlesbrough on Tuesday last. Merchants have again reduced their prices, and consumers, as a matter of course, hold off until they can be satisfied that the bottom has been reached. For prompt delivery of No. 3 g.m.b. merchants now accept 33s. per ton, and for delivery over the next three months they ask 33s. 3d. to 33s. 6d. per ton. Makers are selling very little iron just now; for No. 3 they quote 33s. 9d. to 34s.

Forge iron is in steady demand, and the price is firm. The usual quotation is 33s. per ton, and it is not often that it can be had for less. It is several years since forge iron and No. 3 g.m.b. were sold at the same price.

The stock of Cleveland pig iron in Messrs. Connal and Co.'s store at Middlesbrough has decreased 580 tons during the past week, the quantity held on Tuesday last being 50,242 tons.

Shipments have not improved as might have been expected. The quantity of pig iron shipped this month up to Monday last was only 22,671 tons, as against 23,203 tons in the corresponding period of last month, and 25,639 tons in May last year.

Finished iron makers have now less cause of complaint than they had. A fair number of orders are being given out, and at prices which are 5s. per ton higher than at the beginning of the year. Favourable specifications of ship-plates can be placed at about £5 per ton, but 2s. 6d. more has to be paid for small lots. Angles are £4 12s. 6d. to £4 15s., and bars about £5, all free on trucks at makers' works, usual terms.

Messrs. Jones Brothers, of Middlesbrough, are about to start a new sheet mill for gauges thinner than any yet made in the district.

The value of goods, exclusive of coal and coke, exported from Middlesbrough during April amounted to £172,483, being a decrease of £21,093 when compared with April, 1884. The value of the exports from Newcastle was £190,515, or £58,905 less than in April last year.

The North-Eastern Railway Company is building twenty new express passenger engines at Gateshead and Darlington shops. The weight of each engine will be 42 tons, and of the tender attached, 28 tons. The cost will be £2000 each. A trial of the first engine has been made, when, it is said, a speed of 80 miles per hour was attained.

The freight market continues in a variable and uncertain condition. In some directions a decided rise has taken place, but in others the old low rates still prevail. One favourable sign continues, however, namely, that the number of vessels laid up in northern ports is steadily diminishing. At this time last year there were sixty-three vessels in the Tyne without any employment whatever. Later on in the year the number had risen to a hundred and ten. Now forty-five only remain ready for work, but without finding it. Nor do the above figures represent a fixed quantity. Every day the tiers in Shields harbour and other anchorages grow thinner and thinner, and shipbuilding will no doubt soon receive renewed attention. The number of new vessels on the stocks in the Tyne is at present forty-five, and thirty-four are lying at the adjacent wharves undergoing completion. The Government orders are scarcely yet in full progress, but in a short time they will add materially to the generally increasing activity.

The Moor Ironworks at Stockton have just been turned over to a limited company, entitled the Moor Iron and Steel Company.

Mr. J. E. Stead, the well-known analyst of Middlesbrough, whose name is so closely identified with the development of the basic process, is at present in Servia. It is understood that his visit there has for its object to inspect and report upon the value of certain metalliferous mines.

NOTES FROM SCOTLAND.

(*From our own Correspondent.*)

THERE was a slight upward movement in the warrant market in the early part of the week in consequence of a scarcity of warrants; but the amount of business done has not been very large. It was expected that the past week's shipments would be very small, but they turned out a good average. From Canada the inquiry has been good; but the requirements of the United States are far too easily met, and the continental demand is also disappointing. The consumption of pigs at home is fair, but the preference given by founders to the cheaper Cleveland pigs reduces the amount of Scotch pig going into use. The past week's shipments were 10,779 tons, against 11,491 tons in the preceding week and 11,925 tons in the corresponding week of 1884. About 400 tons were added in the course of the week to the stock in Messrs. Connal and Co.'s Glasgow stores.

Business was done on Friday in the warrant market at 42s. cash. There was less doing on Monday, when the figures were 41s. 9d. to 41s. 10d. cash. On Tuesday business took place at 41s. 9½d. to 41s. 10½d. The market was idle on Wednesday at 41s. 10d. To-day—Thursday—there was some animation, with quotations up to 42s., closing at 41s. 10½d.

The market values of makers' iron do not exhibit much variation. Free on board at Glasgow, Gartsherrie, No. 1, is quoted at 50s. 6d.; No. 3, 46s.; Coltness, 52s. and 49s. 6d.; Langloan, 52s. and 49s. 6d.; Summerlee, 50s. 6d. and 46s.; Calder, 52s. and 46s.; Carnbroe, 48s. and 45s. 6d.; Clyde, 46s. 9d. and 42s. 6d.; Monkland, 42s. and 40s.; Quarter, 41s. 9d. and 39s. 6d.; Govan, at Broomielaw, 42s. and 40s. 3d.; Shotts, at Leith, 50s. 6d. and 50s.; Carron, at Grangemouth, 52s. 6d. and 47s.; Kinneil, at Bo'ness, 44s. and 43s.; Glengarnock, at Ardrossan, 47s. 6d. and 42s.; Eglinton, 42s. 3d. and 39s. 6d.; Dalmellington, 46s. and 42s.

The steel trade is very active, and ship plates are now quoted at £7 7s. 6d. a ton.

Several important shipbuilding contracts have been arranged with Clyde shipbuilders, and these will have considerable influence upon the trade, which is yet, however, far from being fully employed.

The past week's shipments of iron manufactures from Glasgow embraced locomotives to the value of £15,000 for Adelaide, and £9600 worth to Bombay; machinery, £6500; sewing machines, £2750; a stern-wheel paddle steamer worth £7000 for Manilla; steel goods, £5000; and general iron manufactures, £29,000, the latter including iron wagons valued at £10,800 for Bombay.

The coal trade is active in a majority of the mining districts. In the West of Scotland the shipping export gives large employment at the collieries, and a positive assurance of peace with Russia would have a beneficial effect. Shipowners are yet doubtful as to the propriety of chartering their vessels for the Baltic trade, although in a number of cases whatever risk there is has been undertaken. During the week 20,619 tons were shipped at Glasgow, 2264 at Greenock, 1965 at Irvine, 6540 at Ayr, 9508 at Troon, and 10,423 at Grangemouth. The inquiry for steam coals is brisk, but there is, of course, a diminution in the orders for household sorts. Important gas coal contracts are now in course of arrangement. The condition of the coal trade in Fife has undergone some improvement, although it is not as yet in a satisfactory state. The minimum rates quoted, f.o.b., at Burntisland, are 6s. 3d. to 6s. 9d. per ton.

The Ayrshire miners in the Kilmarnock district have approached their employers by delegates, asking them to restore the 6d. a day taken off the wages at the time of the last reduction. At a meeting of delegates it has been reported that the masters declined to comply with this request. It was also reported at the same meeting that all the men in the district are now working the restricted eight hours a day.

Following the declaration of a dividend of 25 per cent., the directors of the Broxburn Oil Company have issued their annual report, which states that the company have acquired a right to a missive of lease, for thirty-eight years, of a shale field 2650 acres in extent, on the Hopetoun estate, adjoining the company's present mineral field. Boring operations have commenced, and from the outcrop of shale at various places it is expected that the field will be of great value to the company in the future.

WALES & ADJOINING COUNTIES.

(*From our own Correspondent.*)

THE general interest of the district has been centred this week upon the strange action of the House of Lords Committee in their treatment of the Bute and Taff Amalgamation Bill. The preamble of the Bill was granted on condition of the Barry Dock and Railway having running powers over the Taff system! This could not be entertained, and the progress of the Bill was at once abandoned.

The coal trade, especially in best steam, has been very active of late. From Cardiff alone the total for last week was over 180,000 tons, and a little more spurt will see the long-desired figure of 200,000 tons gained. As a consequence of this the leading collieries have been in full drive, and promise to continue for some time. I am glad to see Admiralty orders being placed more freely. During the last few days the Dowlais Company secured some, and the Glamorgan Coal Company and Powell Duffryn have been equally fortunate. Small steam and large steam are very firm in price, and it is evident that the market rate is going up. House coal has improved in some valleys, but there is no change in price. Coke, except in the Rhondda, is in little demand. Prospects of the Monmouthshire coke ovens are not improved.

I have not much encouraging news for the iron and steel trades. A little "hand-to-mouth" business is being done at most of the works, and a few rails and bars are turned out, but nothing of any consequence. Rails for Montreal are being shipped off more expeditiously, and it is expected that now the Russian difficulty is passing away that we shall have a few good orders in that direction.

During last week three good cargoes of "accumulations" of rails left Newport, Mon., for Canada. They amounted to 6060 tons. Iron clearances from Cardiff have fallen off to almost nothing, and little has been done of late in Swansea iron shipments. Fortunately, Swansea is getting busier in its coal and fuel traffic, and contracts ahead are being made with some degree of freedom. In tin-plate there is a good deal being done, and the month's transactions contrast very favourably with those of the previous one. Last month the shipments to the United States amounted to 7783 as against 4306 tons for the previous month. The demand, makers say, is very good, but prices are too low, and for the principal kind there is really no benefit in making them.

The ruling price for ordinary cokes is 13s. 3d. Some brands will realise as much as 13s. 6d. or even 13s. 9d., but I have heard of 13s. being offered and accepted, though this is an exceptionally low figure. Buyers, however, are very persistent, and, it is notorious, are aiming to get plates for even less than 13s. Best steel plates, Siemens quality, have been placed as high as 14s. 6d. Wasters, which are sought after, fetch 12s. 6d.

In the Rhondda Valley this week trade has been somewhat interfered with by political movements. Mr. Broadhurst, M.P., Sir H. Vivian, Bart., and others attended in the effort to carry a labour representative for the House of Commons. I am glad to hear that the experiments of the Mines Accidents Commission with the safety lamp are nearly complete, and will soon be made public. It promises to be a very satisfactory inquiry.

The Taff Vale Railway have secured their No. 1 and No. 2 Bill.

THE PATENT JOURNAL.

Condensed from the Journal of the Commissioners of Patents.

*** *It has come to our notice that some applicants of the Patent-office Sales Department, for Patent Specifications, have caused much unnecessary trouble and annoyance, both to themselves and to the Patent-office Officials, by giving the number of the page of* THE ENGINEER *at which the Specification they require is referred to, instead of giving the proper number of the Specification. The mistake has been made by looking at* THE ENGINEER *Index, and giving the numbers there found, which only refer to the pages, in place of turning to those pages and finding the number of the Specification.*

Applications for Letters Patent.

*** When patents have been "communicated," the name and address of the communicating party are printed in italics.

5th May, 1885.

5497. Cooking Ranges, J. Akeroyd, Bradford.
5498. Stretchers for Trousers, J. Cadbury and J. G. Rollason, Birmingham.
5499. Water Motors, W. Freakley, Longport.
5500. Position Indicator for Musical Instruments, M. Hearn, Manchester.
5501. Illuminated Clocks, J. M. Crawford, Paris.
5502. Preventing Accidents Arising from Horses Shying, R. Ashton, Manchester.
5503. Manufacturing Shirt Bodies, &c., J. H. Kenyon, Manchester.
5504. Winding Upon Doubling Frame Spindles, B. A. Dobson and E. Gillow, Bolton.
5505. Sewing Machines, J. Holroyd, Manchester.
5506. Water-closet Seats, R. R Heap, Manchester.
5507. Watch Protectors, A. S. Cartwright, Birmingham.
5508. High-pressure Safety Valve, J. B. Stubbs, Manchester.
5509. Power and Fuel Economiser, F. J. Common, Sunderland.
5510. Treatment of Valuble Products from Metallic Ores, E. Bramwell and J. W. Kynaston, Liverpool.
5511. Spring Closing Tongs, G. and C. Ball, Birmingham.
5512. Applying Waterproof Material to Pile, B. Hallett and T. F. Wiley, London.
5513. Resistance and Speed Meter, F. Caws, London.
5514. Using Liquid Hydro-carbons, B. H. Thwaite, Cheshire, and J. Pedder, Lancashire.
5515. Pointing Stone and Lead Pencils, H. Roberts, Clynnog.
5516. Wheels of Vehicles, W. J. Brewer, London.
5517. Lubricating the Axles of Wheels, G. W. Leach, London.
5518. Slide Valves, J. H. Proctor, London.
5519. Gas Regulators, H. N. Bickerton, London.
5520. Plant Food or Fertilisers, W. S. Pierce, London.
5521. Check Valves, H. S. Hayward and R. McDowell, London.
5522. Hat Curling Machines, H. J. Allison.—(*G. Yule, United States.*)
5523. Photographing by Artificial Light, E. Himly, London.
5524. Water Filters, E. Johnson, London.
5525. Fastening for the Metallic Hoops of Buckets, G. Hill, London.
5526. Covers for Dishes, R. E. Keen, London.
5527. Holders for Photographic Films, A. J. Boult.—(*G. Eastman and W. H. Walker, United States.*)
5528. Fastenings for the Permanent Way of Railways, H. Bankart, London.
5529. Combination Cabinets, W. Riches, London.
5530. Social Attachments for Bicycles, J. A. Kirk, London.
5531. Protecting the Fold-over Ends of Flat Wire Ropes, W. Tillett, London.
5532. Curtain Hook, A. Pyke, London.
5533. Two-wheeled Vehicles, M. J. Rowley, C. A. Wheeler, and W. G. Hobill, London.
5534. Yielding Coupling for Rotating Shafts, G. B. Goodfellow and R. Matthews, London.
5535. Corset Busks, W. Fairweather.—(*G. Brockhaus, Germany.*)
5536. Cooking and Heating Stoves, J. F. Allan and J. Ramsay, Glasgow.
5537. Bow Saws, G. Halbach, Glasgow.
5538. Lithographic Stones, &c., P. Walker, Glasgow.
5539. Trimming the Brims of Hats, J. Bigelow, London.
5540. Light or Cover for Forcing Pits, W. A. Raglan, London.
5541. Steam Generators and Engines, H. J. Haddan.—(*A. Daussin, Belgium.*)
5542. Steam and Water Gauges, H. J. Haddan.—(*J. L. Nelson, A. F. Landerholm, and J. Lang, U.S.*)
5543. Hubs, H. J. Haddan. (*J. Maris, United States.*)
5544. Combined Tent and Raft, W. Jackson, London.
5545. Opening and Shutting Carriage Folding Heads, G. N. Hooper and W. Hooper, London.
5546. Recording Telegraphs, G. G. N. Hagborg.—(*O. A. Ericsson, Sweden.*)
5547. Telegraph Cables, &c., R. M. Lowne, London.
5548. Delivering Cards, Circulars, &c., J. Harrington, London.
5549. Aerostats, L. Capazza, London.
5550. Drawing, &c., Hemp, &c., A. V. Newton.—(*J. Good, U.S.*)
5551. Electric Arc Lamps, M. H. Hurrell, London.
5552. Safety Apparatus for Condensers for Engines, H. E. Newton.—(*C. C. Worthington, U.S.*)
5553. Treatment of Alkaline Silicates, &c., W. R. Lake.—(*The Bonsilate Company, U.S.*)
5554. Nail-forming Mechanism, W. R. Lake.—(*F. F. Raymond, U.S.*)
5555. Folding and Adjustable Bench, J. Jones, London.
5556. Window Frames and Sashes, A. M. Clark.—(*G. B. Jones, U.S.*)

6th May, 1885.

5557. Automatic Lubricators, A. M. Clark.—(*C. Couse, U.S.*)
5558. Box for Concertinas, H. Hayward, Wolverhampton.
5559. Ventilating India-rubber Waterproof Garments, P. Cruickshank, Edinburgh.
5560. Raising, &c., Shuttle-boxes of Looms, C. Bedford, Halifax.
5561. Gas Motor Engines, C. H. Andrew, Manchester.
5562. Steam Washers for Clothes, &c., J. Winnard and W. Dewhurst, Manchester.
5563. Prevention of Accidents by Overwinding, F. Turner, Durham.
5564. Registering Consumption of Gas, W. P. Thomson.—(*J. Wybauw, Belgium.*)
5565. Bakers' Ovens, D. Sawyer, Liverpool.
5566. Picking Motion of Looms for Weaving, W. Greenwood and A. Hartley, Manchester.
5567. Grounding, &c., Hides and Skins, J. E. Dixon, London.
5568. Pavement and Facing Blocks, H. G. Fiske, London.
5569. Perambulator Wheels, G. Parsons, London.
5570. Ornamental Turning and Facing, G. W. Budd, London.
5571. Securing Stoppers in Bottles, G. Robinson, London.
5572. Machine Belting, J. Moxon, London.
5573. Ring Spinning, &c., Frames, R. T. Gillibrand, London.
5574. Velocipedes, W. Hillman, W. H. Herbert, and G. B. Cooper, London.
5575. Frames for Anchor, Cabin, &c., Lamps, H. Markham and A. Rotherham, London.
5576. Vegetable Pulp, T. F. Veasey, London.
5577. Iron Welded Hinges, J. T. B. Bennett, Birmingham.
5578. Graduating the Opening and Closing of the Swell Shutters for Organs, J. R. Cafferata, Liverpool.
5579. Fire-proof Hearths, &c., A. Diss and H. Goodey, London.
5580. Breech-loading Fire-arms, W. Eley, Chiswick.
5581. Raising, &c., Boats, A. Fowler, London.
5582. Tea Chests, A. Linberry, London.
5583. Indicating Mechanism, N. F. Harrison and J. W. Coughtrey, London.
5584. Controlling the Movements of Lock Bolts, F. B. Aspinall, London.
5585. Sizing Paper, &c., C. Weygang, London.
5586. Facilitating Manual Exercise by Row-boat Action, J. Perry.—(*J. M. Laflin, United States.*)
5587. Measuring Electricity, L. B. Miller, London.
5588. Ruling Machines, H. J. Haddan.—(*M. L. Metzger and A. Cooper, United States.*)
5589. Combination Milk Measure and Tester, S. Musgrave, London.
5590. Corsets, S. Royle, London.
5591. Bicycles, J. R. Turnbull, London.
5592. Tanks for Electrical Purposes, D. A. Davis, London.
5593. Dress Fastenings, W. H. Cooper, London.
5594. Eyeletting Presses, H. L. Wilson, London.
5595. Internal Screw Stopper, W. G. Walker London.
5596. Making Files, A. Blain, St. Pierre les Calais, France.
5597. Making Infusions of Tea, &c., S. C. Davidson, London.
5598. Applying the Tractive Power of Horses to Produce Rotary Motion, J. E. Wallis, London.
5599. Combustion of Hydrocarbons, P. Tarbutt, London.
5600. Hot-pressing Woven Fabrics, C. D. Abel.—(*Messrs. Rudolph and Kühne, Germany.*)
5601. Generating Electricity, C. A. Parsons, London.
5602. Steam Pumps, T. H. Williams, London.
5603. Mounting Machine, &c., Guns, T. H. Williams, London.
5604. Gloves, C. Mays and W. P. Pepys, London.
5605. Holders for Flowers, &c., G. Gibbons, London.
5606. Caps for Gas, &c., Chimneys, A. M. Clark.—(*P. Cootes and A. Vervin, France.*)
5607. Copying Apparatus, G. F. Redfern.—(*E. Levesque, France.*)
5608. Preventing Smut in Grain, G. F. Redfern.—(*F. M. Davoine, Oran.*)
5609. Winding Coils of Thread, &c., A. Dewhurst, London.
5610. Softening of Vegetable Parchment, H. H. Leigh.—(*C. Eichhorn and T. Mohr, Germany.*)
5611. Preventing Fraud by Money-takers, &c., J. Withers, London.
5612. Vertical Boilers, J. R. Robson, London.
5613. Stocks employed in Manufacturing Leather, B. Preston, London.
5614. Disconnecting Gear for Power Looms, P. Jensen.—(*J. von den Berg, Germany.*)
5615. Roadway, E. van Putten, London.
5616. Weighing Machines, H. H. Lake.—(*C. Schrember and Sons, Austria.*)
5617. Pessaries for the Treatment of Mal-positions of the Uterus, G. E. Harrison, London.

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5618. Cone Driving Mechanism for Slubbing and Roving Frames, G. Young, Manchester.
5619. Railway Couplings, R. Stone, Bristol.
5620. Utilising Certain Residuals obtained in the Manufacture of Copper and Alkali, C. Wigg, Liverpool.
5621. Fastenings for Bracelets, &c., G. Anscombe, Birmingham.
5622. Bottles, W. Tapp, Bristol.
5623. Combined Shelling and Grinding Machines, W. P. Thompson.—(*Messieurs Aebi and Muehlethaler, Switzerland.*)
5624. Presses for Cutting Out Leather, T. B. Barker and J. A. Ewins, Birmingham.
5625. Spool or Pirn Winding Machines, J. B. and W. Whiteley, Halifax.
5626. Compound Lining for Boilers, &c., J. Makin, Manchester.
5627. Transmitting Currents in Electric Tramways, M. H. Smith, Manchester.
5628. Railway Rugs, R. Ashworth, Manchester.
5629. Preparing Stones and Printing Surfaces, A. H. Seggie, Edinburgh.
5630. Tuyeres of Bessemer Converters, J. T. King.—(*H. W. Oliver, jun., and J. P. Witherow, U.S.*)
5631. Blast Apparatus for Bessemer Converters, J. T. King.—(*H. W. Oliver, jun., and J. P. Witherow, United States.*)
5632. Stationary Converters with Movable Bottoms, J. T. King.—(*H. W. Oliver, jun., and J. P. Witherow, United States.*)
5633. Lining Baths, A. Armitage, London.
5634. Frames for Sewing Machines, H. Fridt and H. Müller, Paris.
5635. Ventilating, &c., Valve, M. Wallace, London.
5636. Door Check, S. Coombs, London.
5637. Ball Casters, B. J. Saunders, Brighton.
5638. Converting Oils into Gaseous Fuel, &c., F. Lennard, London.
5639. Adjusting Door Knobs, R. Hodges and F. J. H. Lilley, London.
5640. Metallic Bedsteads, &c., E. Lawson and R. G. Hodgetts, London.
5641. Roller Castors for Furniture, W. Izon, Birmingham.
5642. Extracting Copper, Nickel, Cobalt, Silver, or Gold from their Ores, L. A. Groth.—(*C. G. Dahlerus, France.*)
5643. Wire Gauze Dish Covers, &c., G. F. James, London.
5644. Movable Bottom Grates, T. J. Constantine, London.
5645. Producing Heat and Cold, Charles Marquis de Montgrand, London.
5646. Making Steel and Iron, &c., C. Scheibler, London.
5647. Aerating Liquors, G. Barker, London.
5648. Facilitating the Correct Reading of Weights on Dials, W. Simpson, London.
5649. Altering the Throw of Excentrics, W. H. Tozer, London.
5650. Cork-drawing Apparatus, C. Walker, London.
5651. Safety Bicycles, J. de L. Watson and Trigwell, Watson, and Co., London.
5652. Cord Holder for Grain Binders, G. F. Redfern.—(*B. E. Huntley, United States.*)
5653. Fuel Supports for Stoves, &c., E. R. Weston, London.
5654. Distilling Apparatus, H. J. Haddan.—(*A. Liedbeck, Sweden.*)
5655. Boots, S. Pitt.—(*H. Corrick, New Zealand.*)
5656. Fasteners for Doors of Railway Carriages, C. A. McEvoy, London.
5657. Lighting Signal Lanterns by Electricity, J. E. H. Gordon, London.
5658. Wire Spring Mattresses, J. R. Collier and D. S. Musgrave, London.
5659. Breech-loading Rifles, H. E. Newton.—(*K. Gercke, London.*)
5660. Furniture for Lavatories, &c., A. W. L. Reddie.—(*J. B. French, United States.*)

5661. WARMING HOUSES, &c., J. Horne, London.
5662. CARTRIDGE CASES, G. Kynoch, London.
5663. TREATING SEMI-LIQUID SUBSTANCES, E. Langen, London.
5664. CHOCOLATE, H. Ramognino, London.
5665. HEATING APPARATUS, L. Wesp, London.
5666. QUILLS for ARTIFICIAL FLOWERS, &c., E. Golonya and F. Rath, London.

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5667. UNITING WOVEN and other FABRICS, T. T. Pulman, Accrington.
5668. SPRING CUTLERY, C. H. Wood, Sheffield.
5669. ANNEALING POTS, T. Timothy, Briton Ferry.
5670. LOOMS for WEAVING, W. Thompson, Halifax.
5671. METALLIC THERMOMETERS with DIALS, W. H. Gauntlett, Middlesbrough-on-Tees.
5672. SPINDLES for SPINNING and TWISTING FIBRES, W. Walker and A. Binns, Halifax.
5673. OVERHUNG AUTOMATIC or HAND-CLOSING FLAP, F. Cormyn, Woodstock.
5674. HAWKING MACHINES for INDIGO DYEING, J. Coulter, Halifax.
5675. TOOL for CUTTING KEY-WAYS in WHEELS, J. H. Kidd, Manchester.
5676. VELOCIPEDE, &c., SADDLES, W. J. Lancaster, Birmingham.
5677. PORTABLE STANDS for PHOTOGRAPHIC CAMERA WORK, W. J. Lancaster, Birmingham.
5678. WATCH or CLOCK GLASS, R. E. Ellis, London.
5679. PORTABLE ELECTRIC LAMPS, J. C. Merryweather and C. J. W. Jakeman, Greenwich.
5680. SPEED GOVERNORS, W. H. Northcott, London.
5681. WASHING MACHINES, J. Chapman, London.
5682. A LAWN TENNIS MARKER, F. J. Berry, jun., London.
5683. AUTOMATIC FEATHERING PADDLE-WHEEL, F. J. Candy, London.
5684. GLAZING and FIXING SHEETS of GLASS, T. W. Helliwell, Halifax.
5685. RINGS or RIMS for FURNITURE CASTORS, J. E. Beaver and W. G. Ward, London.
5686. TRICYCLES, J. W. Hancock, London.
5687. MULTIPLE CYLINDER ENGINES, R. C. Parsons, London.
5688. BULLET SHIELD or MANTLET, E. S. Copeman, London.
5689. REGULATING the HEALDS in LOOMS for WEAVING, R. Ecroyd and J. Bentley, London.
5690. COUPLING APPARATUS, A. W. L. Reddie.—(*The Compagnie des Appareils Automatiques pour Accrocher et Décrocher les Wagons de Chemins de fer, France.*)
5691. LAWN TENNIS BALL, C. H. Gray, London.
5692. MINERAL known as CANNEL or CANNEL COAL, T. W. Dance, London.
5693. KEYLESS WATCHES, A. Browne.—(*The Society Industriel of Montier, Grandval, Switzerland.*)
5694. MEMORANDUM TABLETS, W. R. Lake.—(*H. T. G. Batny, France.*)
5695. MILITARY or other BRACES, A. Hart, London.
5696. PESTLE and MORTAR, J. W. Cousins, London.
5697. SAFETY CUT-OUTS for ELECTRIC LIGHTING, A. W. Brewtnall, Thelwall, and M. W. W. Mackie, London.
5698. SYRINGING the LEAVES of PLANTS, J. A. Drake and R. Muirhead, London.
5699. PIANOFORTE ACTIONS, A. Craig, Belfast.
5700. REAPING and MOWING MACHINES, T. S. Bissot, Glasgow.
5701. DECORATING SURFACES such as WALLS, &c., W. R. Davis, London.
5702. COATING METAL PLATES with TIN, D. Edwards, R. Lewis, and P. Jones, London.
5703. COUPLINGS for SHAFTING, W. Pitt, London.
5704. FOUNDRY LADLES and CRUCIBLES, G A. Goodwin and W. F. How, London.
5705. FIRE-ESCAPES, A. J. Blew, London.

9th May, 1885.

5706. TREATING SALT, A. Collingridge.—(*V. Cornet and A. Jones, France.*)
5707. SHIPPING and STOWING COAL, &c., T. H. Peate, Manchester.
5708. SHIPPING and TRANSFERRING COAL, &c., T. H. Peate, Manchester.
5709. VARYING the SPEED of BOBBINS of ROVING, &c., FRAMES, S. Tweedale, Halifax.
5710. DOBBIES of LOOMS for WEAVING, F. W. Jepson, Halifax.
5711. KETTLES, &c., G. H. Millichamp, Birmingham.
5712. DOMESTIC WASHING MACHINES, F. Helm, Padiham.
5713. METALLIC BINS or CHESTS, H. W. Tomlinson, Birmingham.
5714. TORPEDO BOATS, &c., W. Welch, Portsmouth.
5715. PUMPING ENGINES, J. C. Merryweather and C. J. W. Jakeman, London.
5716. FASTENINGS of BROOCHES, &c., R. Bateman, Birmingham.
5717. COMBINATION FORK and SPOON, M. Roberts, London.
5718. GRIDIRONS, J. Edmonds, Aston.
5719. BREECH-LOADING RIFLES, W. P. Thompson.—(*K. Gercke, Germany.*)
5720. ELECTRO-MAGNETS, M. Immisch, London.
5721. WASHING MACHINES, G. Whalley, Keighley.
5722. INDICATING the TIME VEHICLES are OCCUPIED, &c., J. Bisset, Glasgow.
5723. INDOOR GARDEN BASKET, A. Gray, London.
5724. PROTECTING VESSELS AGAINST TORPEDOES, A. C. Koerner, Paris.
5725. PHOTOGRAPHIC FILM HOLDERS, A. J. Boult.—(*G. Eastman and W. H. Walker, United States.*)
5726. WHEELS, DRUMS, and PULLEYS, J. S. Fairfax, London.
5727. SHEET METAL CASH BOXES, A. Bratt, London.
5728. COOLING AIR in MINES, TUNNELS, &c., E. Capitaine, London.
5729. GRINDING and POLISHING SHEET METAL, F. Räuber, London.
5730. LAWN TENNIS, &c., BATS, A. J. Altman, London.
5731. DRILLING MACHINES, T. G. Elliott, London.
5732. DISPLAYING ADVERTISEMENTS, &c., W. H. Beck.—(*L. Jost, France.*)
5733. DECORATING POTTERY, &c., J. and G. Jobson, London.
5734. PADS for HORSES' FEET, R. J. Forster, London.
5735. GUN CARRIAGES or MOUNTINGS, T. Nordenfelt, London.
5736. GAS REGULATING BURNERS, H. J. Haddan.—(*W. M. Jackson, United States.*)
5737. TYPE-WRITERS, P. M. Justice.—(*T. Hall, United States.*)
5738. REGULATING the SUPPLY of GAS, J. McLennan, London.
5739. PISTON PACKING, H. Kühne, London.
5740. TORPEDO BOATS, T. H. Williams, London.
5741. BOOTS and SHOES, J. Stevenson, Glasgow.
5742. FILTER, J. Howie, Glasgow.
5743. NUT LOCK, A. E. Gilbert, Glasgow.
5744. WATER-HEATING APPARATUS, J. Keith, Glasgow.
5745. FINISHING FABRICS, G. H. Nussey and W. B. Leachman, London.
5746. SUBMARINE SHIPS and VESSELS, K. Degener, London.
5747. FURNACES, L. Roberts and H. Tomkins, London.
5748. SOCKS, H. Barrance, London.
5749. GRAIN GERMINATING CHAMBERS, J. T. Gough, London.
5750. DRYING GRAIN, J. T. Gough, London.
5751. WINDING PAPER, J. J. Milford, London.
5752. SCRATCH BRUSHES, C. E. Day, jun., London.
5753. AUTOMATICALLY PUMPING BILGE WATER from VESSELS, A. M. Clark.—(*E. Dunn, United States.*)
5754. ORDNANCE and PROJECTILES, &c., T. R. Bayliss, London.
5755. WIRE ROPES and CABLES, W. H. and T. Laidler, London.
5756. CONDUCTING METALLURGICAL or CHEMICAL PROCESSES, J. S. Williams, Riverton, U S.

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5757. ELECTRICAL APPLIANCES, F. D'A. Goold, Manchester.
5758. CASING for TELEGRAPH, &c., WIRES, H. O. Adams, Birmingham.
5759. CONVERTIBLE COAL and GAS COOKING RANGES, G. G. Brodie and J. D. Prior, Birchfield.
5760. FERRULES or TIPS for UMBRELLAS, &c., W. Fearnley, Darwen.
5761. STEERING BATH CHAIRS, &c., R. J. Urquhart, Chorlton-cum-Hardy.
5762. KNEADING MACHINES, P. Fazakerley, Liverpool.
5763. VENTILATORS, P. M. Walker, Halifax.
5764. SIGHT FEED LUBRICATORS, B. Ronald and J. M'Robie, Glasgow.
5765. SELF-ADJUSTING SIGHT for SMALL-ARMS, &c., F. Silas.—(*A. Prüsker, Austria.*)
5766. ROLLER MILLING MACHINERY, &c., W. Burness, London.
5767. FIRE-GRATES, G. G. Campbell, London.
5768. STEAM BOILER JACKETS, &c., E. S. T. Kennedy, London.
5769. ORNAMENTAL TURNING and SHAPING, G. W. Budd, London.
5770. LAVATORIES, J. Shanks, Glasgow.
5771. DISINFECTING and DRYING APPARATUS, A. B. Reck, Copenhagen.
5772. AUTOMATICALLY REGULATING the ELECTRO-MOTIVE FORCE of an ELECTRIC CURRENT, B. M. Drake and J. M. Gorham, London.
5773. WATER WASTE PREVENTER, H. Yull and J. Thomson, London.
5774. WATER-SLIDE GAS CHANDELIERS, S. T. Booth, London.
5775. LAMPS, S. A. Johnson, London.
5776. WEIGHING MACHINES, A. J. Boult.—(*E. Bacas, Spain.*)
5777. TEACHING SEWING, A. J. Boult.—(*M. Paillot, France.*)
5778. CHAIRS, E. P. Alexander, Anerley.
5779. WICKET-KEEPING GLOVES, H. R. Lamb, London.
5780. PROTECTING the UPPER PORTION of the BODY from INCLEMENT WEATHER, W. G. Honey, London.
5781. NOTATION SLIP for FINGER BOARD of STRINGED INSTRUMENTS, J. Burton.
5782. PRINTING TEXTILE FIBRES, O. Imray.—(*The Farbwerke vormals Meister, Lucius, and Brüning, Germany.*)
5783. LAEVULIC ACID, O. Imray.—(*The Farbwerke vormals Meister, Lucius, and Brüning, Germany.*)
5784. GAZOGENES and SYPHONS, A. W. L. Reddie.—(*J. Seidl, Hungary.*)
5785. GOVERNING APPARATUS for ENGINES, J. G. Joicey and M. Watson, London.
5786. AUTOMATIC EXPANSION VALVE GEARING for COLLIERY, &c., ENGINES, D. Greig and F. J. Anson, London.
5787. STEAM ENGINES, E. Ciotti, London.
5788. STOPPING RUNAWAY HORSES, B. J. B. Mills.—(*G. Rua and C. Passamonte, Italy.*)
5789. HORSESHOES, E. Edwards.—(*F. Dejean, Belgium.*)
5790. A WINDOW CLEANER'S SAFETY, C. B. Dowling, London.

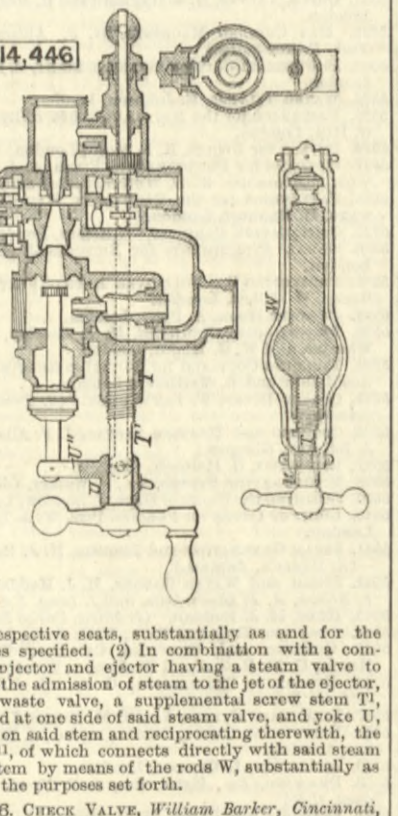
SELECTED AMERICAN PATENTS.

(From the United States' Patent Office Official Gazette.)

314,446. COMBINED INJECTOR AND EJECTOR. *Thomas J. Hart, Detroit, Mich.—Filed June 4th, 1884.*

Claim.—(1) In a combined ejector and injector provided with a valve for the admission of steam to the steam nozzle of the ejector, and with an overflow or waste valve, the stem of both said valves projecting through the walls of the device, one at either end thereof, said valves being on the same vertical plane, but each arranged on one side of the centre of the other, as shown, the threaded projection T, integral with the casing, in combination with the threaded stem T¹, yoke U, and rods W, constructed and arranged substantially as described, by means of which said steam and waste valves are connected and simultaneously operated in opposite directions as relates to

314,446

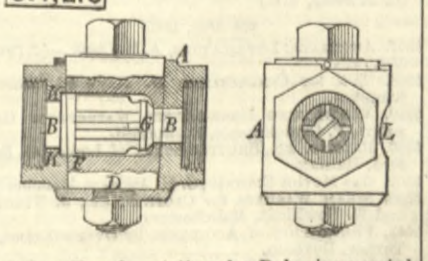


their respective seats, substantially as and for the purposes specified. (2) In combination with a combined injector and ejector having a steam valve to control the admission of steam to the jet of the ejector, and a waste valve, a supplemental screw stem T¹, arranged at one side of said steam valve, and yoke U, sleeved on said stem and reciprocating therewith, the arm, U¹, of which connects directly with said steam valve stem by means of the rods W, substantially as and for the purposes set forth.

314,216. CHECK VALVE, *William Barker, Cincinnati, Ohio.—Filed October 15th, 1884.*

Claim.—(1) The combination, in a check valve, of a casing or shell having a suitable passage and an opening at one side, and a rotating plug having a seated port containing a valve that closes against said seat, for the purpose described. (2) The combination, in a check valve, of the pierced shell A B L, having a

314,216

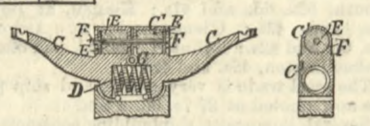


counterbore K, and a rotating plug D, having a seated port E F, that contains a suitable valve, as G, closing against said seat, for the purpose described. (3) A check valve having a turning member provided with a valved port, which port is normally in line with the channel of the valve casing or shell, but can be shifted out of line with said channel and brought into communication with an opening in said casing, in order that said valve may be reground without removing it bodily, substantially as herein described.

314,245. CAR SPRING, *John T. Herschell, Evansville, Ind.—Filed January 20th, 1885.*

Claim.—(1) A car spring consisting of two arms or parts, the adjacent ends of which are provided with hollow upper portions containing springs, and connected to each other from the ends of said springs, and the lower adjacent portions of which have a spring interposed between them, and a pivot bolt or fulcrum interposed between said adjacent ends of the arms between the said upper and lower springs, substantially as set forth. (2) A car spring consisting of two

314,245

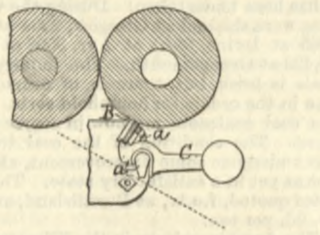


arms having hollow adjacent upper portions, springs in said hollow portions, and a bolt running through and connecting said springs, a pivot bolt or fulcrum interposed between the ends of the arms, and a spring interposed between the lower adjacent portions of said arms, substantially as set forth. (3) The combination, in a car spring, of the arms or parts C, having open-ended hollow adjacent upper portions C¹, the rubber springs E, inserted in said hollow portions, the followers E¹ on the outer ends of said rubber springs, the bolt F, passing through said springs and hollow portions and connecting said followers, the pivot bolt or fulcrum G, interposed between the ends of said arms, and the spring D, interposed between the ends of the arms below said fulcrum, substantially as set forth.

314,278. SCRAPER FOR ROLLER MILLS, *Jesse Warrington, Indianapolis, Ind.—Filed August 30th, 1884.*

Claim.—The combination, with the grinding rolls of a roller mill, of a scraper consisting of the scraper blade B, slides *a* therefor, fulcrums *a*¹, and levers C,

314,278

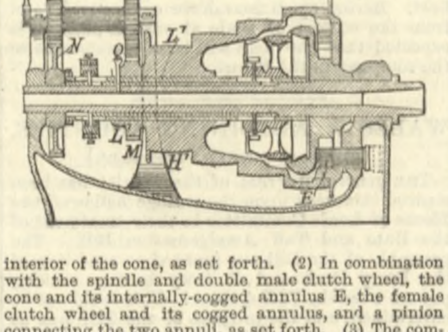


extended across and supported by said fulcrums, the inner ends of which pass under and support said scraper blade, and the outer ends of which are weighted, said several parts being arranged and operating substantially as shown and specified.

314,433. LATHE, *Edward S. Cobb, Terre Haute, Ind.—Filed March 15th, 1884.*

Claim.—(1) A cone having an internal friction or clutch surface, in combination with the spindle, a sliding male clutch wheel carried by the spindle, and a female clutch wheel, also carried by the spindle, and gearing connecting the female clutch wheel with the

314,433

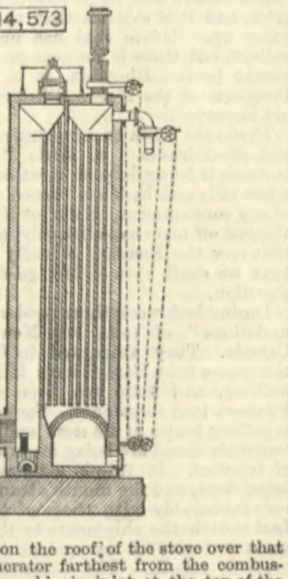


interior of the cone, as set forth. (2) In combination with the spindle and double male clutch wheel, the cone and its internally-cogged annulus E, the female clutch wheel and its cogged annulus, and a pinion connecting the two annuli, as set forth. (3) The combination, with the cone clutch mechanism and spindle, of sleeves H¹ and L¹, pinions M and P², gear wheels N and P¹, and pin Q, as set forth.

314,573. HOT BLAST STOVE, *Frederick W. Gordon, Allegheny, Pa.—Filed July 5th, 1884.*

Claim.—In a hot blast stove, the combination of a vertical shell, a combustion chamber wall reaching from the base of a stove to near its top, a hot blast outlet and gas inlet at the foot of the combustion chamber, a separating wall reaching from the roof of the stove to near the base of the stove, regenerator walls upon either one of the sides of said separating

314,573

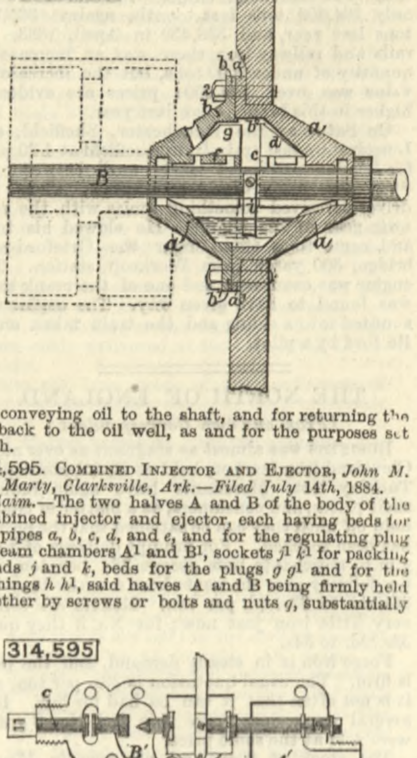


wall, a chimney upon the roof of the stove over that portion of the regenerator farthest from the combustion chamber, and a cold air inlet at the top of the stove over that portion of the regenerator farthest from the combustion chamber.

314,475. BEARING FOR SHAFTING, *Joseph A. Powers and Clinton M. Ball, Troy, N.Y.—Filed February 16th, 1885.*

Claim.—(1) The bearing for shafting, composed of the hollow shells *a b*, having uniting flanges *a*¹ *b*² *b*³, integral bearing tubes *c f*, partitions *d g*, the oil holes, channels, and chambers, in combination with a frame A, and bolts 2, the shaft B, and a fin or paddle *i* upon the same, substantially as and for the purposes set forth. (2) In a bearing for shafting, the combination, with the shaft B and fin or paddle *i* upon the same, and a support for the bearing, of the hollow bearings shells *a b*, the bearing tubes *c f*, the inclined partitions *d g*, and openings for introducing oil within the shells,

314,475

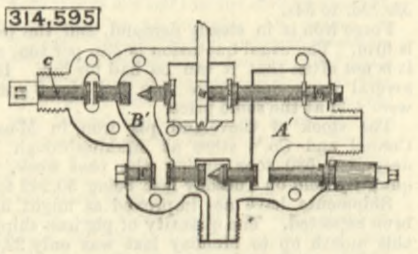


for conveying oil to the shaft, and for returning the oil back to the oil well, as and for the purposes set forth.

314,595. COMBINED INJECTOR AND EJECTOR, *John M. Marty, Clarksville, Ark.—Filed July 14th, 1884.*

Claim.—The two halves A and B of the body of the combined injector and ejector, each having beds for the pipes *a*, *b*, *c*, *d*, and *e*, and for the regulating plug *f*, steam chambers A¹ and B¹, sockets *j*¹ *k*¹ for packing glands *j* and *k*, beds for the plugs *g g*¹ and for the bushings *h h*¹, said halves A and B being firmly held together by screws or bolts and nuts *g*, substantially

314,595

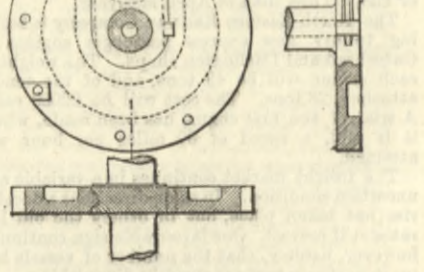


as described. In combination with the combined ejector and injector, having the two halves A and B, steam chests A¹ and B¹, self-stopping overflows *o* and *p*, and ground sockets *b*² *c*², with tubes *b*, *c*, *d* and *e*, having ground shoulders *b*¹ *c*¹, fitting into said ground sockets *b*² *c*², substantially as shown and described.

314,788. METHOD OF SECURING PULLEYS OR CRANK DISCS TO SHAFTS, *William A. Bole, Pittsburgh, Pa.—Filed December 16th, 1884.*

Claim.—The improvement in the method of securing crank discs, pulleys, &c., to shafts, which consists in first fitting a wedging key in a longitudinal recess in the periphery of the shaft or of a crank arm thereon,

314,788



then casting the disc or pulley upon and continuously around the shaft and key, and finally driving the key to a tight bearing, after the solidification and contraction of the casting, upon the member which it permanently incloses, substantially as set forth.

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