EXPRESS COMPOUND PASSENGER ENGINE, WITH SINGLE DRIVING WHEELS, NORTH-EASTERN RAILWAY.—WORSDELL AND V. BORRIES' SYSTEM.

IN our issue of January 3rd we mentioned that Mr. T. W. Worsdell had built five compound engines, with cylinders 20in. and 28in. in diameter and 24in. stroke, with single driving wheels, 7ft. 7¼in. in diameter, and we stated that at some future period we should be able to give more particulars. We now, through the courtesy of Mr. T. W. Worsdell, locomotive superintendent of the North-Eastern Railway, have pleasure in placing before our readers illustrations of these handsome and powerful locomotives, the latest development of the compound system, specially designed to work the ever-increasing East Coast traffic, which at the present time is one of the fastest and heaviest in this country, and no doubt will, with the opening of the Forth Bridge, be further augmented. The extra accommodation required for the convenience and comfort of the travelling public brings with it also additional weight to be drawn per passenger carried.

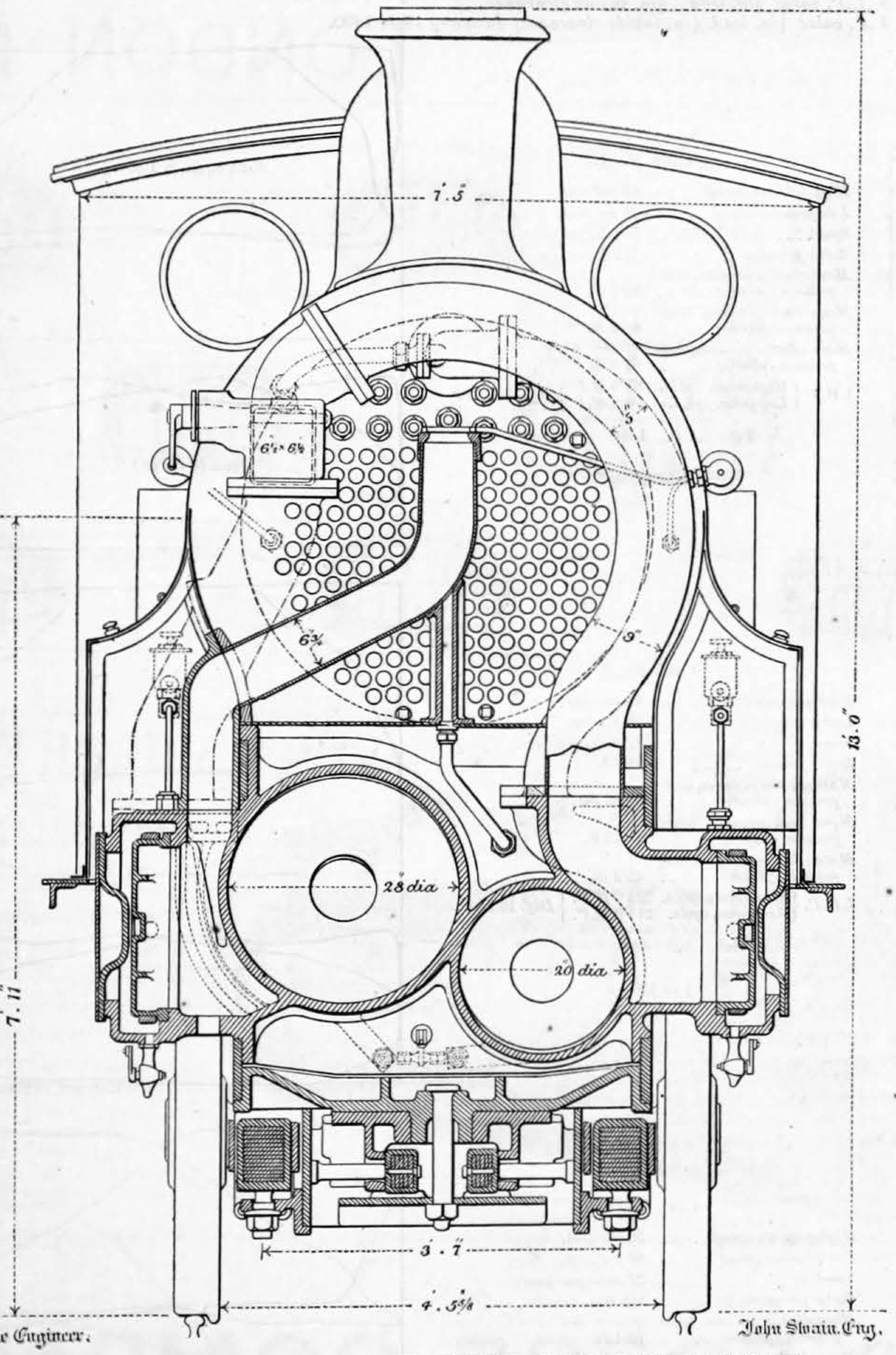
The distance from Newcastle to Edinburgh is about 125 miles, and these engines have to run their trains through the whole distance without a stop. The tender carries 3940 gallons, or nearly 18 tons of water. This is, we believe, a greater quantity than has ever before been carried in a tender, and under the most unfavourable circumstances is amply sufficient for this long run with a heavy train; and this is also further secured by the fact that, as the engines are working compound, the saving in water as well as in fuel is from 18 to 20 per cent. as compared with the non-compound engines on the same service. As a matter of fact the consumption of all the compound passenger engines working the same relative trains with the non-compound engines averaged, during twelve months, a net saving of 22 per cent. of coal per 150 tons train per mile.

In designing these engines the greatest consideration has been given to all the working details, so that the long distance can be run at the high speeds required, with as little extra need for attention on the part of the men in charge as possible, and every facility has been provided for their ready control. The personal comfort of the enginemen has also been attended to, so that they can perform the duties that devolve upon them under the most favourable circumstances. The first of these engines, No. 1517, was put to work in October last, and this, with the other three—the fifth will be exhibited at the forthcoming Exhibition in Edinburgh—has been working the fast passenger traffic between Newcastle and Edinburgh regularly, the number of vehicles varying from ten to twenty-two, in either case these engines have no difficulty in running within time.

On one occasion a trial was made between Newcastle and Berwick with a train of thirty-two empty carriages, the distance being sixty-seven miles, and the total weight of train 270 tons; the time was seventy-eight minutes, or three minutes less than that of the Scotch express, and with the heaviest loads it is quite unnecessary to provide an assisting engine, an important consideration in the economical working of a railway.

The consumption of coal is indeed much lower than anticipated. At the end of October, No. 1517 engine averaged 26·4 lb. of coal per mile, which must be considered splendid work, considering the service it is engaged on. These engines steam well and run exceedingly steady. With a special train of eighteen six-wheeled carriages a speed of about ninety miles per hour, the highest on record by several miles, was obtained, and at that speed there was not the slightest inconvenience in moving about on the foot-plate or front end of the engine. Diagrams were taken on this trip which we hope to illustrate in a future number. We give below examples of diagrams taken at various speeds, and combined by Mr. Worsdell. One set it will be noticed was taken at a speed of eighty-six miles per hour on the level. The speed was carefully measured by stop-watch and mile posts, the quarter mile posts being frequently registered during the trip, the shortest time was just over ten seconds per quarter mile. The highest indicated horse-power was obtained at this speed, viz., 1068; the weight of the train, including engine and tender, was 310·6 tons.

Last week we gave a longitudinal section and plan; this week we give an end view; and a general elevation on almost the same scale as that to which our illustration of Mr. Webb's compound engine, Marchioness of Stafford, was drawn.[1] There are many novelties in connection with Mr. Worsdell's engines which our illustrations fully explain; particular notice should be taken as to the way in which the 20in. and 28in. cylinders are got between the narrow-spaced frames, as they are placed on the same centre lines as all the engines that Mr. Worsdell has constructed for the last nine years, whether compound or non-compound, and thus all the crank centres and valve motions are the same. Mr. Worsdell informs us that he is now building several more of these large engines. It should be stated that the boilers have been constructed and tested to carry a working pressure of 200 lb. per square inch, but it has not been required to exceed 175 lb., at which pressure they are now working. Following this will be found a table of the leading dimensions and particulars of these engines:—



COMPOUND LOCOMOTIVE, NORTH-EASTERN RAILWAY, SECTION THROUGH CYLINDERS.

Particulars of Compound Express Passenger Engine, with a Single Pair of Driving Wheels (7ft. 7¼in. diameter) Worsdell and Von Borries' System.

	ft.	in.
Cylinder (high-pressure)—		
Diameter of cylinder	1	8
Stroke of piston	2	0
Length of ports	1	5
Width of steam ports	0	1¾
,, exhaust ports	0	3½
Distance from centre line of cylinder to valve face	1	9
Lap of slide valve	0	1¼
Maximum travel of valve	0	4½
Lead of slide valve	0	0 1/16
Inside clearance of valve	0	0⅛
Distance apart of cylinders centre to centre	2	0
,, ,, slide spindles ,, ,,	5	10½
Cylinder (low-pressure)—		
Diameter of cylinder	2	4
Stroke of piston	2	0
Length of ports	1	8
Width of steam ports	0	2
,, exhaust ports	0	3½
Centre line of cylinder to valve face	1	9
Lap of slide valve	0	1½
Maximum travel of valve	0	5¼
Lead of slide valve	0	0 1/16
Inside clearance of valve	0	0⅛
Motion—		
Diameter of piston rods	0	3½
Length of slide blocks	1	3
,, connecting rods between centres	6	1
Diameter of rocking shaft	0	4
Wheels (cast steel)—		
Diameter on tread, bogie	3	7¼
,, ,, driving	7	7¼
,, ,, trailing	4	7¼
Thickness of tires on tread	0	3
Width of tires	0	5½
Crank axle (steel, circular web)—		
Diameter at wheel seats	0	9
,, bearings	0	8
,, centre	0	7¾
Distance between centres of bearings	3	10
Length of wheel seats	0	7 1/16
,, bearings	0	9
Diameter of crank bearings	0	8¼
Length ,, ,,	0	5
Distance between centres of cranks	2	0
Bogie axle (steel)—		
Diameter at wheel seats	0	7½
,, bearings	0	6
,, centre	0	5¾
Length of wheel seats	0	7¼
,, bearings	0	9
Distance between centres of bearings	3	7
Trailing axle (steel)—		
Diameter at wheel seats	0	8½
,, bearings	0	7
,, centre	0	6¾
Length of wheel seats	0	7½
,, bearings	0	11
Distance between centres of bearings	3	8
Frames (steel)—		
From centre of bogie to front buffer beam	5	9
Centres of bogie wheels	6	6
From centre of bogie to centre of driving wheels	10	0
,, ,, driving ,, ,, trailing ,,	8	8
,, ,, trailing to back end of frame	4	3
Distance apart of frames	4	0
Thickness of frame	0	1
Distance apart of bogie frames	2	8
Thickness of bogie frames	0	0¾
Boiler (steel)—		
Height of centre of barrel from rails	7	11
Length of barrel	10	7
Diameter of barrel outside	4	3
Thickness of plates	0	0 9/16
,, smoke-box tube plate	0	0¾
Pitch of rivets	0	1 13/16
Diameter of rivets	0	0⅝
Fire-box shell (steel)—		
Length outside	7	0
Breadth outside at bottom	3	11
Depth below centre line of boiler, front	5	6
,, ,, ,, back	4	6
Thickness of throat plate	0	0⅝
,, sides and top plate	0	0½
,, back plate	0	0⅝
Pitch of copper stays	0	4
Diameter of copper stays	0	1
Roof stays, cast steel girder section.		
Inside fire-box (copper)—		
Length of fire-box—inside at bottom	6	3½
Breadth ,, ,,	3	2¼
Top of box to inside of shell	1	3½
Depth of box inside, front	6	3½
,, ,, back	5	3½
Tubes (brass)—		
Number of tubes, 203.		
Length between tube plates	10	11½
Diameter outside	0	1¾
Thickness, No. 11 and No. 13 B.W.G.		
Height of chimney from rail	13	0
Heating surface—		
Tubes	1016 sq. ft.	
Fire-box	123 ,,	
Total	1139 ,,	
Grate area	20·7 ,,	
Working pressure	175 lb. per sq. in.	

	Tons	cwt.	qrs.
Weight of engine (empty)—			
Bogie wheels	15	12	0
Driving ,,	16	0	0
Trailing ,,	12	11	0
Total weight	44	3	0
Weight of engine (full)—			
Bogie wheels	15	18	2
Driving ,,	17	15	0
Trailing ,,	13	0	0
Total weight	46	13	2

Tender.

	ft.	in.
Wheel base—		
From front buffer beam to centre of leading wheels	4	2
,, centre of leading ,, middle ,,	6	4
,, ,, middle ,, trailing ,,	6	4
,, ,, trailing wheels to back buffer beam	4	5
Wheels—		
Diameter of wheels on tread	3	9¼
Thickness of tires	0	3
Axles—		
Diameter of bearings	0	5
Length ,,	0	10
Diameter of wheel seats	0	6¾
Length ,, ,,	0	7½
Distance between centres of bearings	6	10

[1] See THE ENGINEER for December 21st, 1888.

Frames—		
Distance between inside frames	4 1	
Thickness of inside frames	0 0¼	
Distance between outside frames	6 2¾	
Thickness of outside frames	0 0⅝	
Capacity of tank	3940 galls.	
Coal space	4 tons	
Weight of tender (empty)—	Tons cwt. qrs.	
On leading wheels	6 8 1	
On middle "	6 18 2	
On trailing "	5 19 1	
Total	19 6 0	
Weight of tender (full)—	Tons cwt. qrs.	
On leading wheels	13 4 0	
On middle "	12 6 0	
On trailing "	14 11 0	
Total weight	40 1 0	

The success of compound locomotives on the Worsdell and Von Borries' system will be best understood by simply stating that in the last few years about 600 have been built and put to work, and the demand for them is steadily on the increase. Numerous attempts are now being made to produce compound locomotives of a similar design.

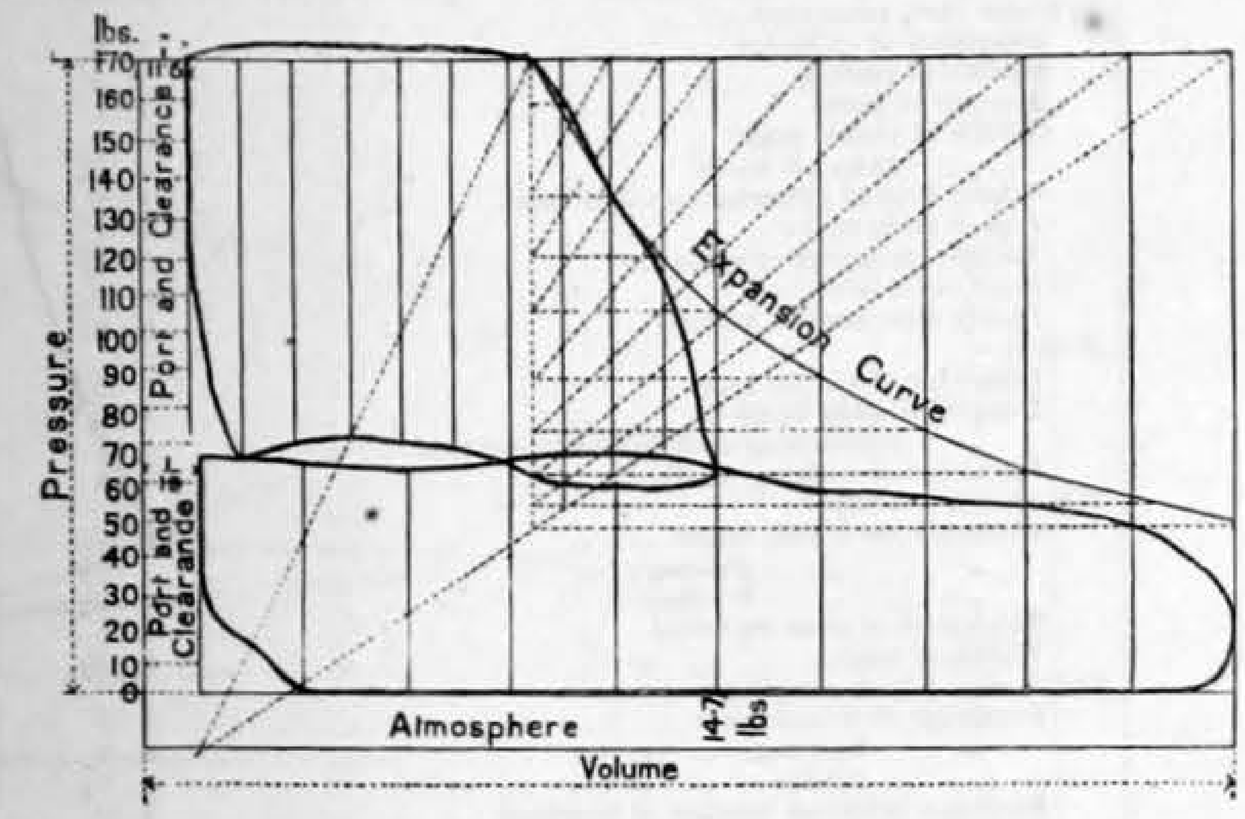
Mr. Worsdell has done a great deal to develope the compound locomotive. From the first he has adhered to the two-cylinder principle, in order to keep the machine as simple as possible, Joy's valve gear facilitating matters very materially. While locomotive superintendent of the Great Eastern Railway he designed the first compound passenger engine on this principle, with cylinders 18in. and 26in. diameter respectively, with 24in. stroke and coupled driving wheels 7ft. in diameter, and having run this for a considerable time built ten others to exactly the same dimensions, there being no alteration in any particular. Since going to the North-Eastern Railway he built the first compound passenger engine on very similar lines and dimensions, but with an improvement in the intercepting valves and in the main valves of the cylinders, making all ports larger, and in these alterations finding a greater economy. Then he extended the number of goods engines, and has built a large number of six-wheeled coupled goods locomotives with tenders, and also tank engines. Both types have been illustrated in our pages,[2] keeping exactly the same dimensions of cylinders, so that at the present time he has on the North-Eastern line, working and under construction, 32 compound passenger engines and 162 compound six-wheeled coupled goods engines, with tenders and tank engines.

[2] See THE ENGINEER, January 14th, and February 25th, 1887, and October 26th, 1888.

COMPOUND EXPRESS ENGINE, No. 1518.—(WORSDELL AND V. BORRIES' SYSTEM.)

Working special trains between Newcastle and Berwick. Total weight of Engine, Tender, and Train, 310 *tons* 6 *cwt. High-pressure cylinder,* 20*in. dia.; Low-pressure cylinder,* 28*in.; stroke,* 24*in. Driving wheels (single),* 7*ft.* 7¼*in. diameter.*

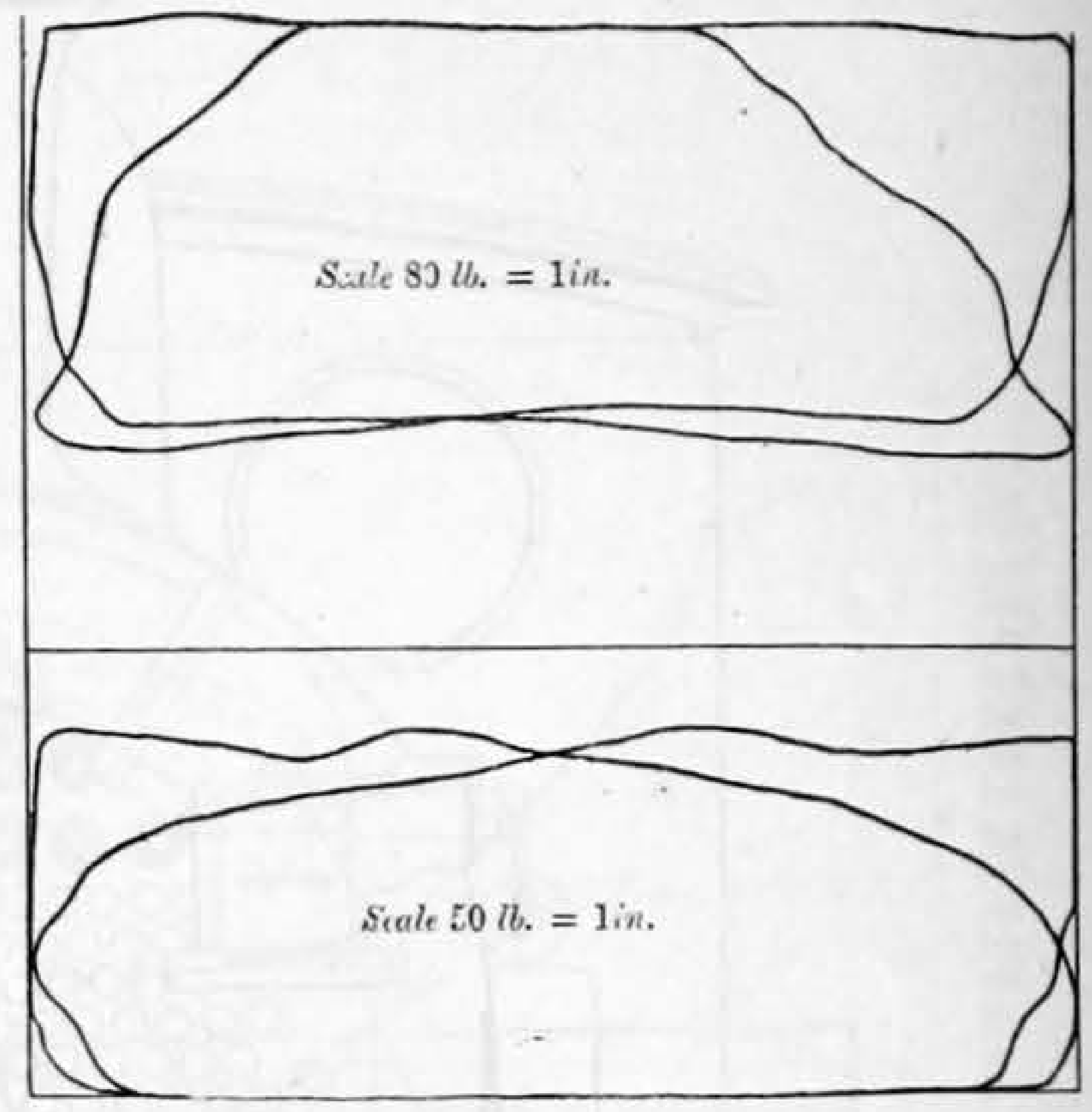
Cards 1, 3, 4, *and* 5, *H.P. valve* ¼*in. lead,* 3/16*in. inside clearance* } *January* 20*th*, 1890.
Cards 1, 3, 4, *and* 5, *L.P. valve* ⅛*in. lead,* ¼*in. inside clearance* }
Cards 2, 6, *and* 7, *L.P. valve* ¼*in. lead,* ¼*in. inside clearance, January* 10*th*, 1890.

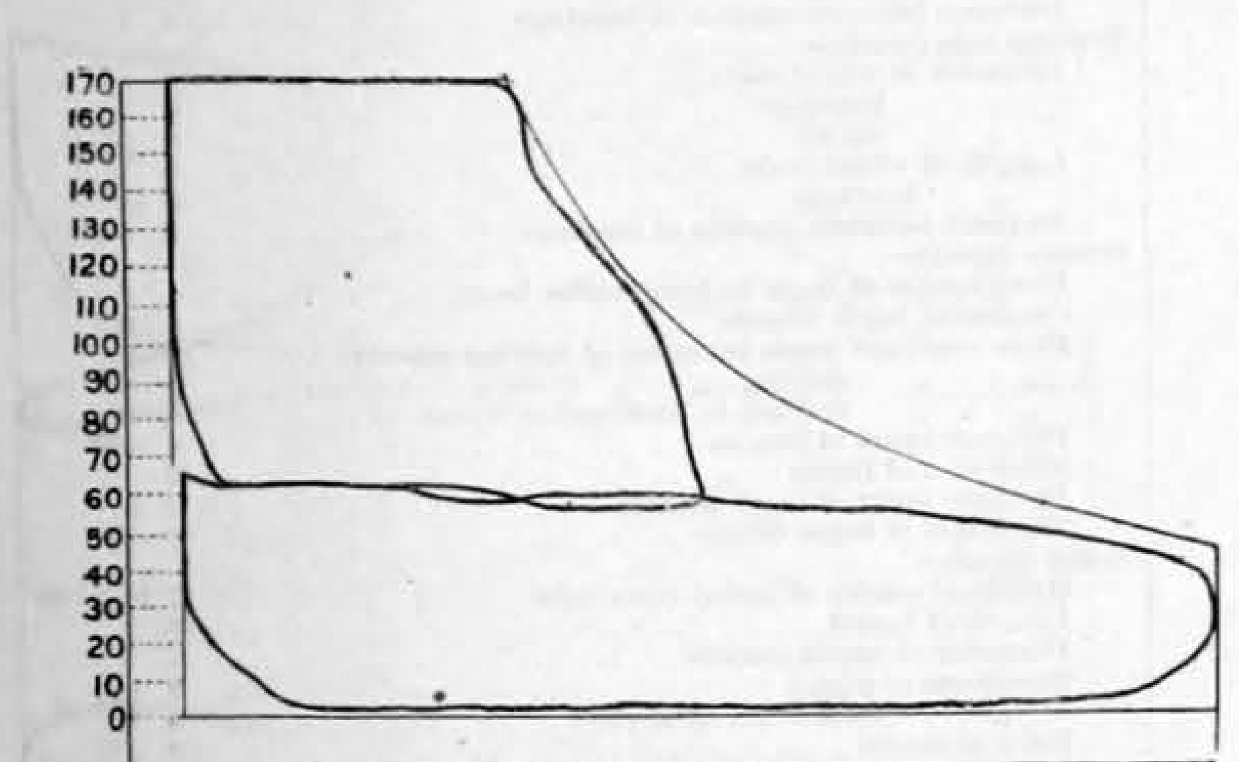


CARD No. 1.

High-pressure cut-off	63 *per cent.*
Low pressure cut-off	78 *per cent.*
Speed	5 *miles per hour.*
Boiler pressure	175 *lb.*
Mean effective pressure, high-pressure cylinder	92·7 *lb.*
Mean back pressure, high-pressure cylinder	62·5 *lb.*
Mean effective pressure, low-pressure cylinder	51·5 *lb.*
I.H.P. { *High-press. cylin.*	65·0 *H.P.* } *Diff.* 5·8 *H.P.*
I.H.P. { *Low-press. cylin.*	70·8 *H.P.* }
Total	135·8

1 *in* 190 *up.*

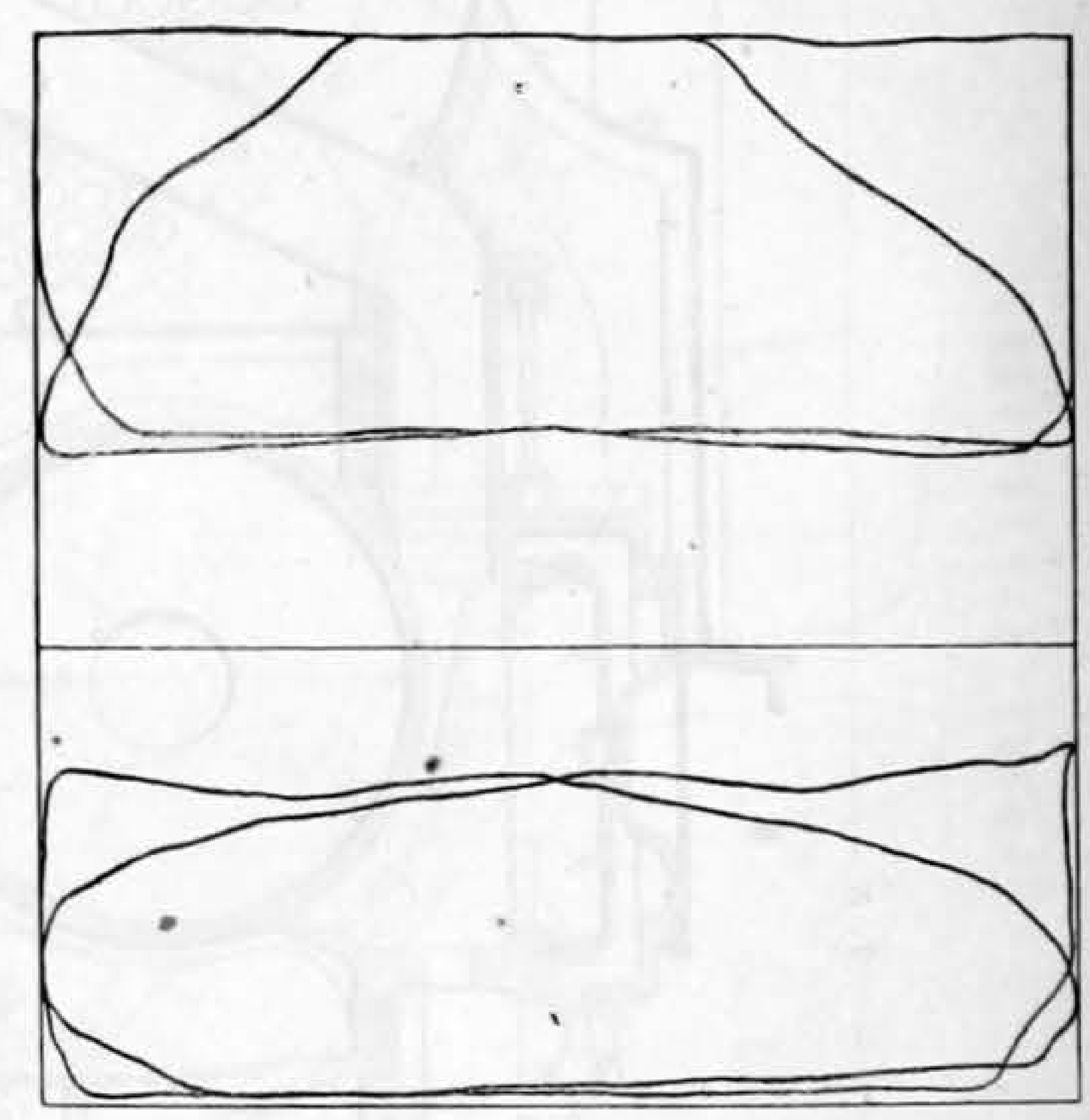


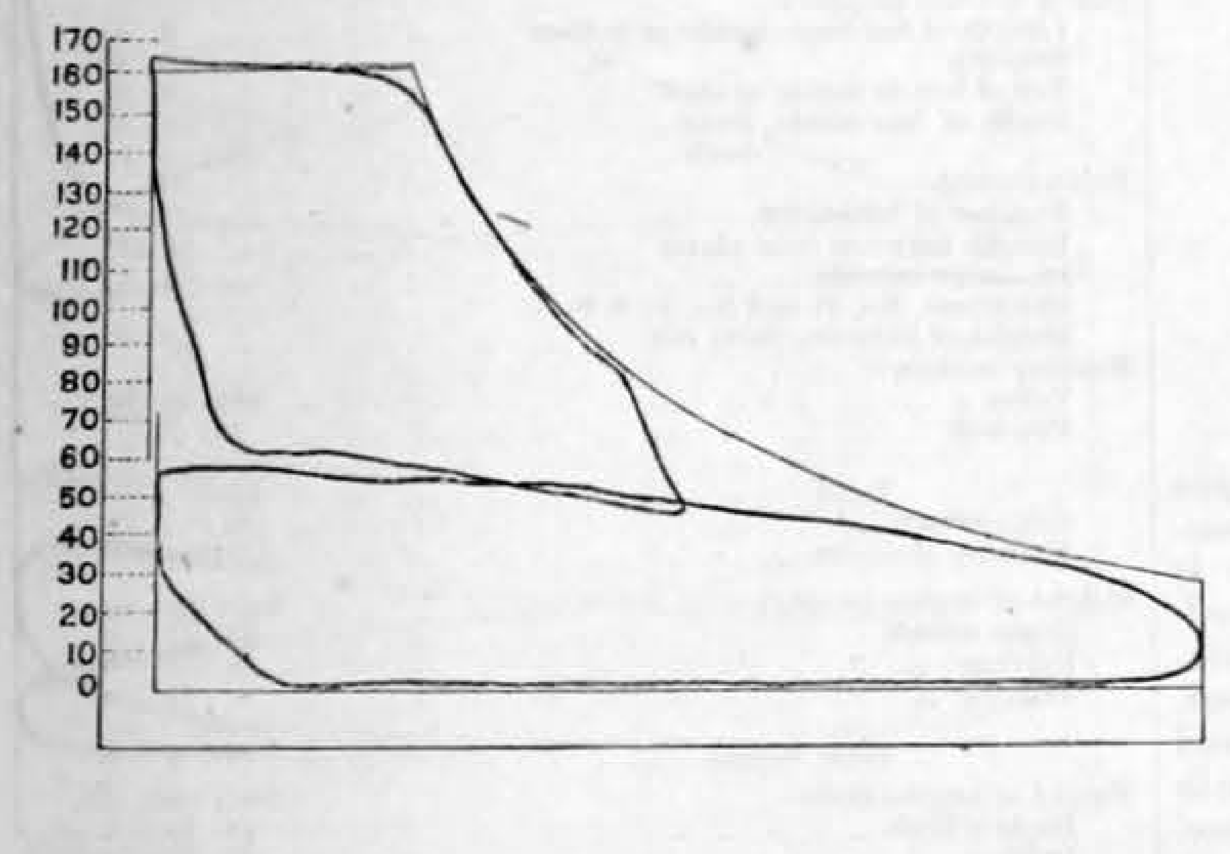


CARD No. 2.

High-pressure cut-off	63 *per cent.*
Low-pressure cut-off	78 *per cent.*
Speed	17 *miles per hour.*
Boiler pressure	180 *lb.*
Mean effective pressure, high-pressure cylinder	94·25 *lb.*
Mean back pressure, high-pressure cylinder	56·75 *lb.*
Mean effective pressure, low-pressure cylinder	45·9 *lb.*
I.H.P. { *High-press. cylin.*	224·0 *H.P.* } *Diff.* 10 *H.P.*
I.H.P. { *Low-press. cylin.*	214·0 *H.P.* }
Total	438

1 *in* 170 *up.*

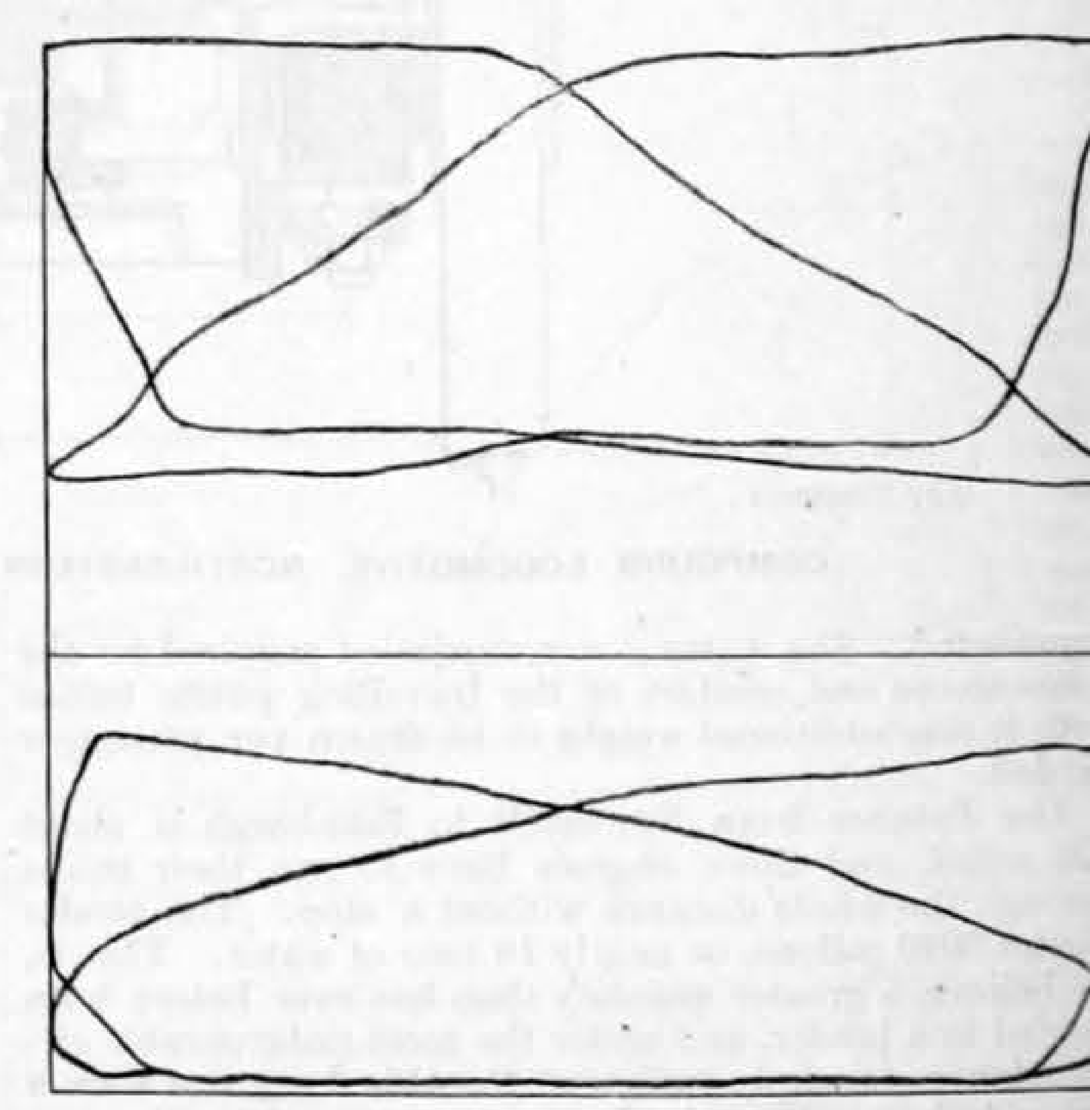




CARD No. 3.

High-pressure cut-off	50 *per cent.*
Low-pressure cut-off	68 *per cent.*
Speed	23 *miles per hour.*
Boiler pressure	175 *lb.*
Mean effective pressure, high-pressure cylinder	72·4 *lb.*
Mean back pressure, high-pressure cylinder	60·75 *lb.*
Mean effective pressure, low-pressure cylinder	42·0 *lb.*
I.H.P. { *High-press. cylin.*	233·0 *H.P.* } *Diff.* 32·0 *H.P.*
I.H.P. { *Low-press. cylin.*	265·0 *H.P.* }
Total	498

1 *in* 200 *up.*



REVOLVING CYLINDER ENGINES.

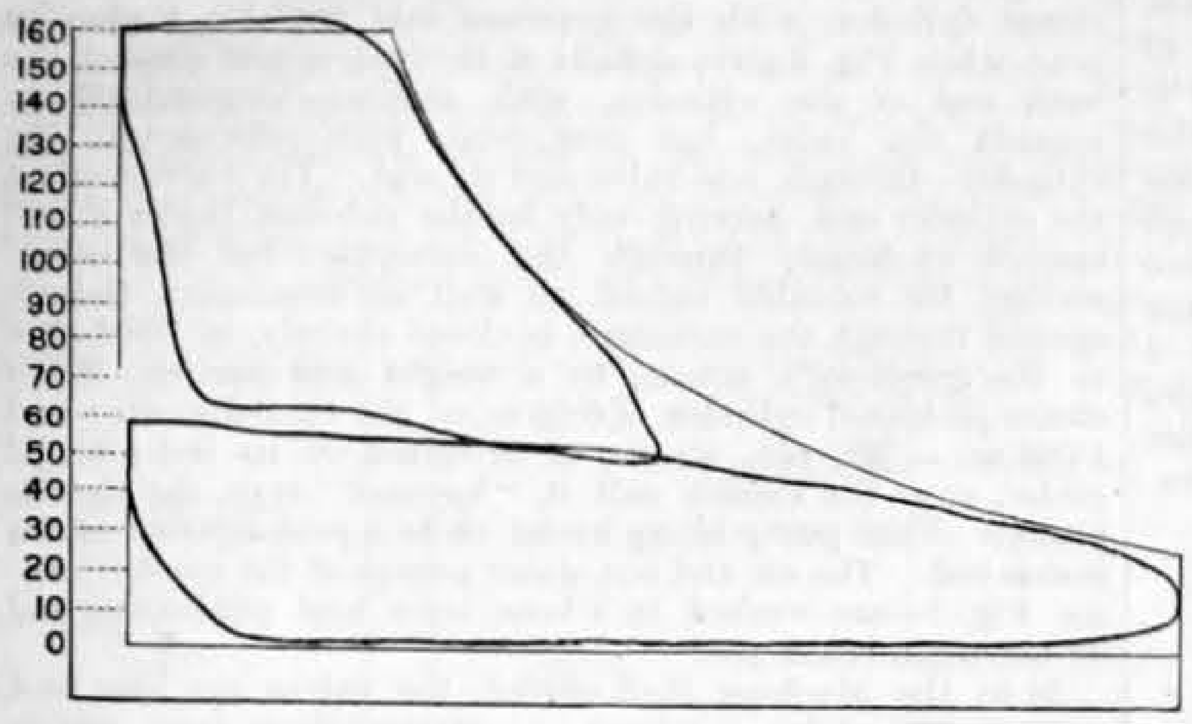
No. I.

ROTARY MECHANISM.

THE mechanism of a direct-acting engine consists of a piston reciprocating in a cylinder secured to a fixed frame, a crank shaft revolving in bearings arranged in the fixed frame, and a connecting-rod jointed to a crank pin on the shaft and to a pin formed in the piston or piston-rod. During a complete revolution of the crank shaft in its bearings, the crank pin makes a complete revolution in that end of the connecting-rod to which it is jointed, and the other two joints, the piston in the cylinder and the pin in the tail-end of the connecting-rod, reciprocate through a limited stroke and a limited angle respectively. This disposition of mechanism always seems to be indirect on account of introducing a reciprocating piston, when the motion of a revolving shaft is the object to be attained. Many efforts are continuously made to obtain direct action, but none seem to effectually attain their object. Amongst a crowd of efforts of various characters, one principal seems to be attaining an increasing popularity; on it are constructed what may be termed revolving cylinder engines.

Two shafts or frames are arranged, which revolve around two parallel axes a little apart, and are coupled together by a piece which reciprocates respectively to each; generally one of the reciprocations is rectilinear and the other angular. Though very different in appearance, yet these engines bear a close analogy to the ordinary fixed cylinder engine. In fact, the complete cycle is the same as in that engine, but its order relatively to the fixed frame altered. If, instead of

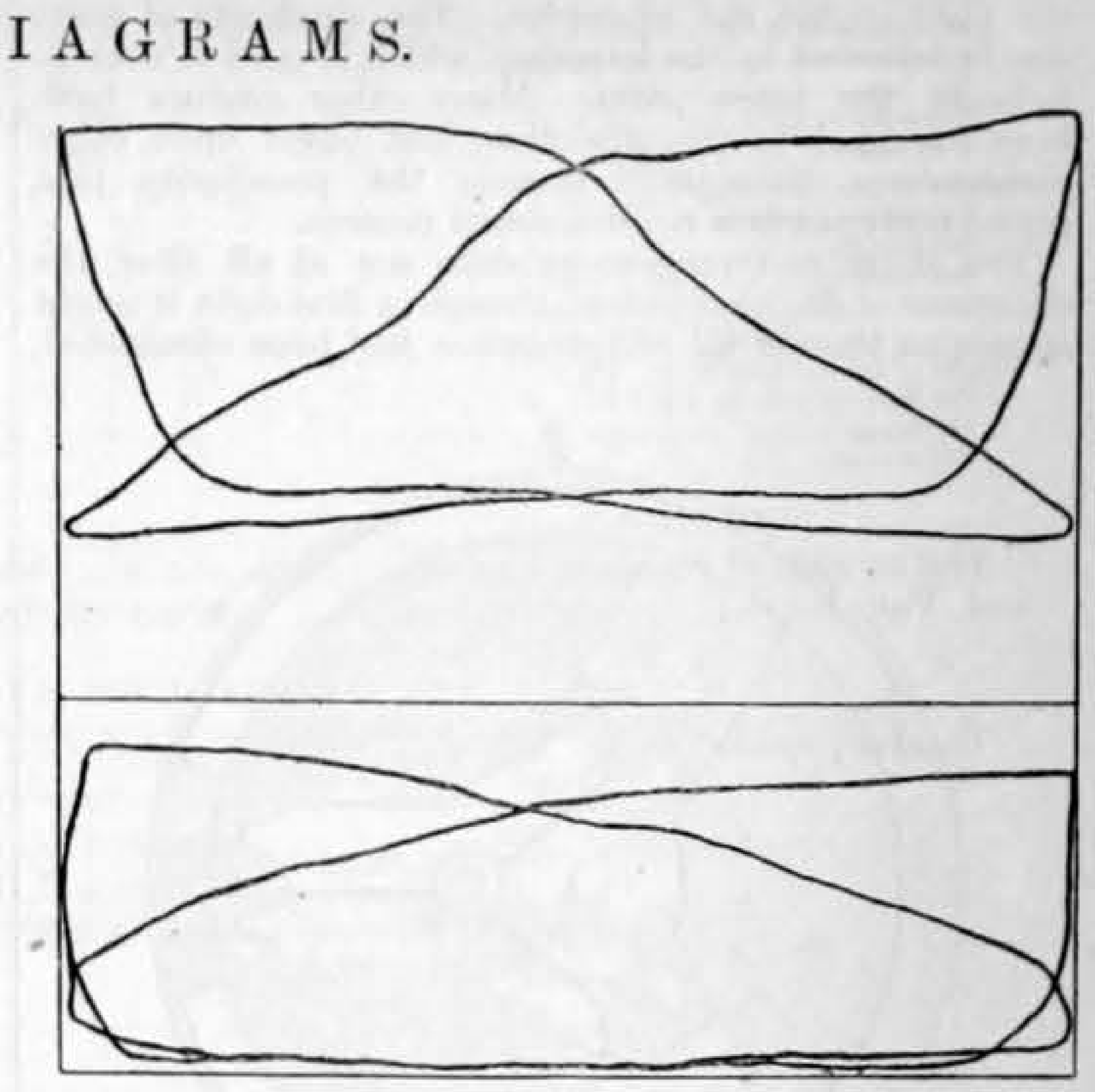
COMPOUND EXPRESS ENGINE, DIAGRAMS.

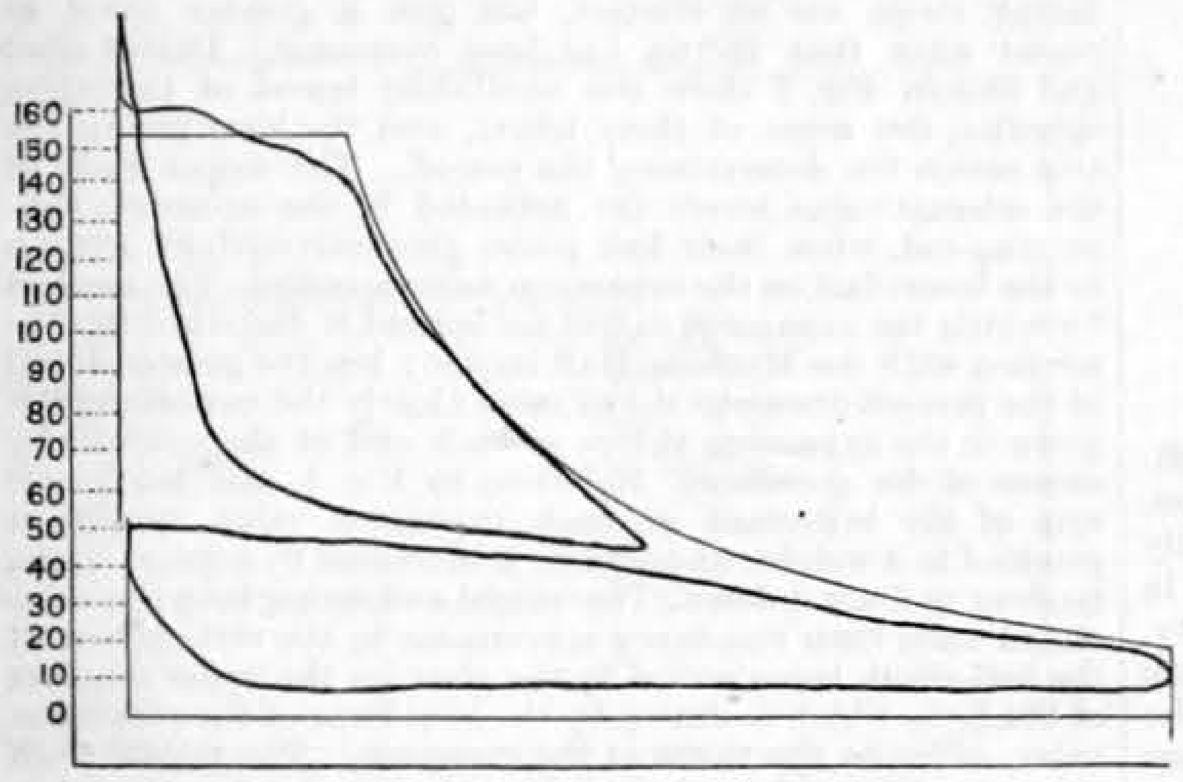


CARD No. 4.

High-pressure cut-off ... ... 50 *per cent.*
Low-pressure cut-off ... ... 68 *per cent.*
Speed ... ... 30 *miles per hour.*
Boiler pressure ... ... 175 *lb.*
Mean effective pressure, high-pressure cylinder ... ... 69·3 *lb.*
Mean back pressure, high-pressure cylinder ... ... 62·25 *lb.*
Mean effective pressure, low-pressure cylinder ... ... 41·0 *lb.*
I.H.P. { *High press. cylin.* 291·5 *H.P.* / *Low-press. cylin.* 338·1 *H.P.* } *Diff.* 46·6 *H.P.*
Total ... ... 629·6

1 *in* 461 *up.*

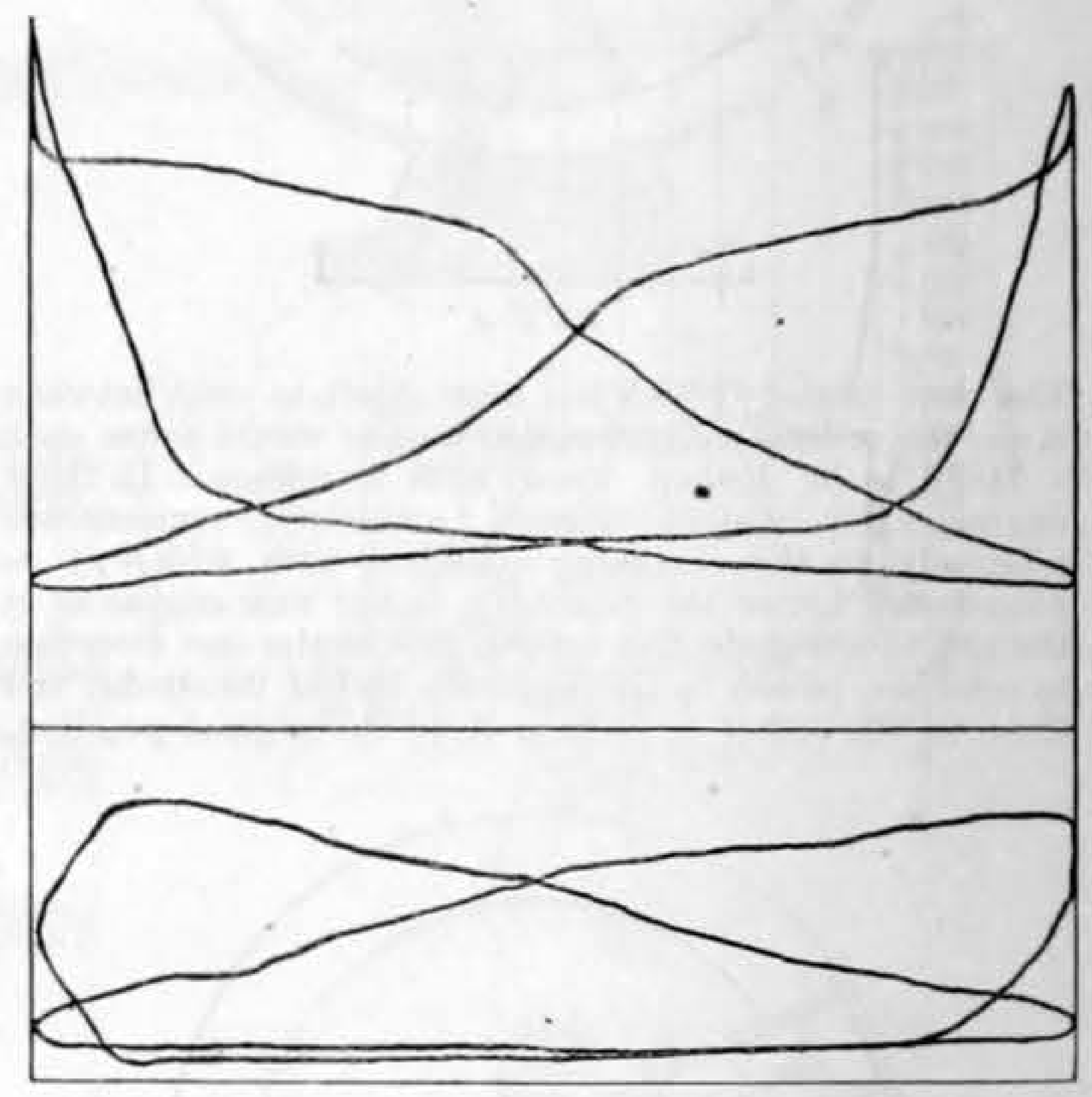


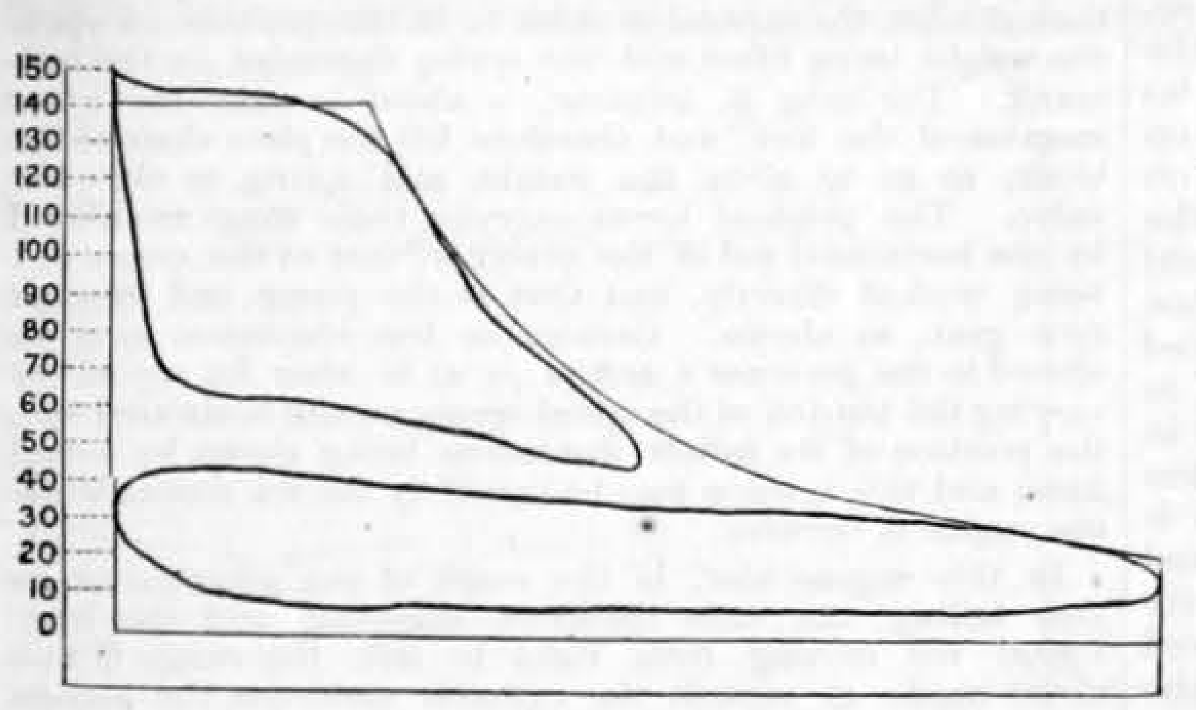


CARD No. 5.

High-pressure cut-off ... ... — *per cent.*
Low-pressure cut-off ... ... 62·5 *per cent.*
Speed ... ... 50 *miles per hour.*
Boiler pressure ... ... 180 *lb.*
Mean effective pressure, high-pressure cylinder ... ... 46 *lb.*
Mean back pressure, high-pressure cylinder ... ... 59·6 *lb.*
Mean effective pressure, low-pressure cylinder ... ... 24·75 *lb.*
I.H.P. { *High-press. cylin.* 322 *H.P.* / *Low-press. cylin.* 339·8 *H.P.* } *Diff.* 17·8 *H.P.*
Total ... ... 661·8

1 *in* 275 *up.*

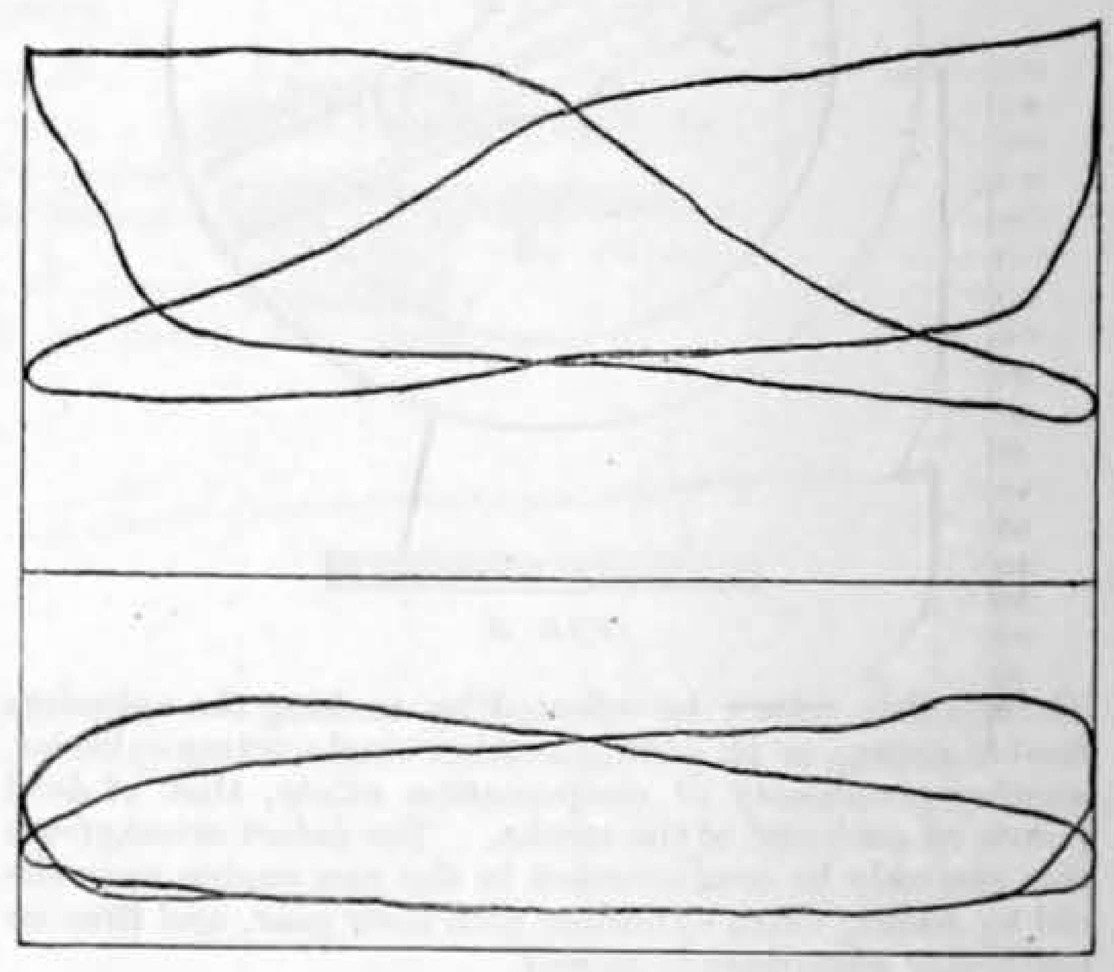


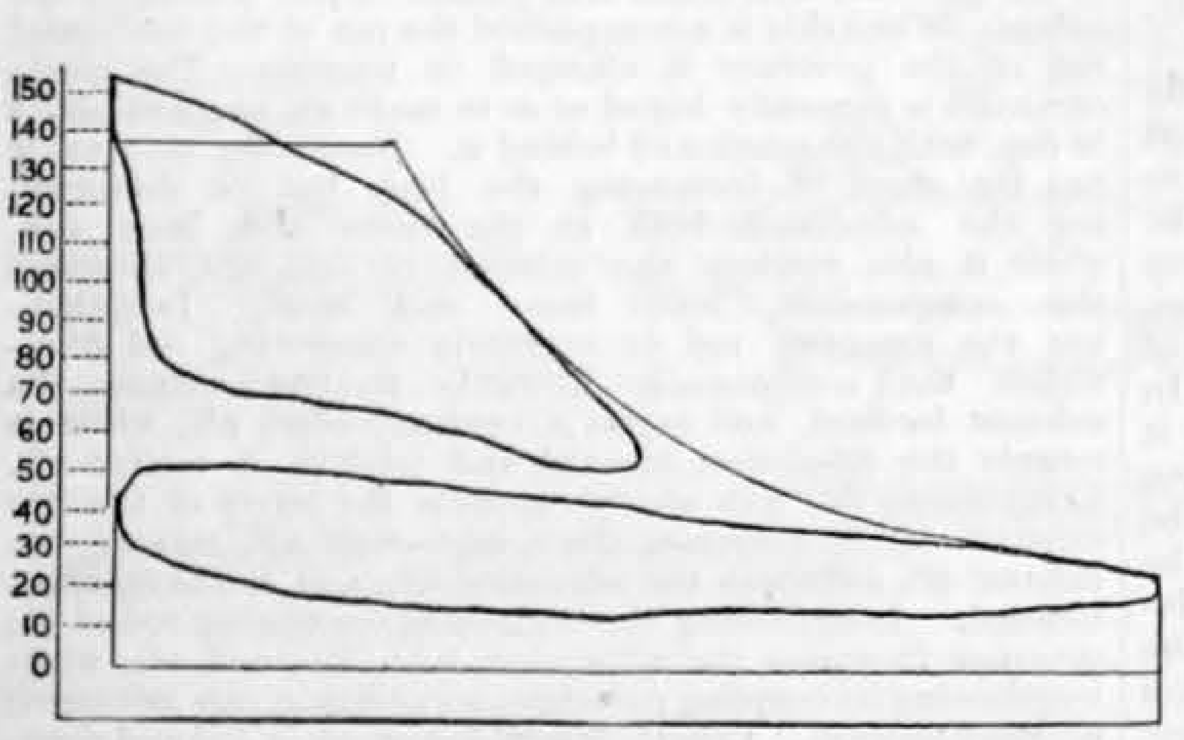


CARD No. 6.

High-pressure cut-off ... ... 47 *per cent.*
Low-pressure cut-off ... ... 67 *per cent.*
Speed ... ... 75 *miles per hour.*
Boiler pressure ... ... 175 *lb.*
Mean effective pressure, high-pressure cylinder ... ... 52 *lb.*
Mean back pressure, high-pressure cylinder ... ... 62 *lb.*
Mean effective pressure, low-pressure cylinder ... ... 24 *lb.*
I.H.P. { *High-press. cylin.* 546·7 *H.P.* / *Low-press. cylin.* 494·7 *H.P.* } *Diff.* 52 *H.P.*
Total ... ... 1041·4

Level.

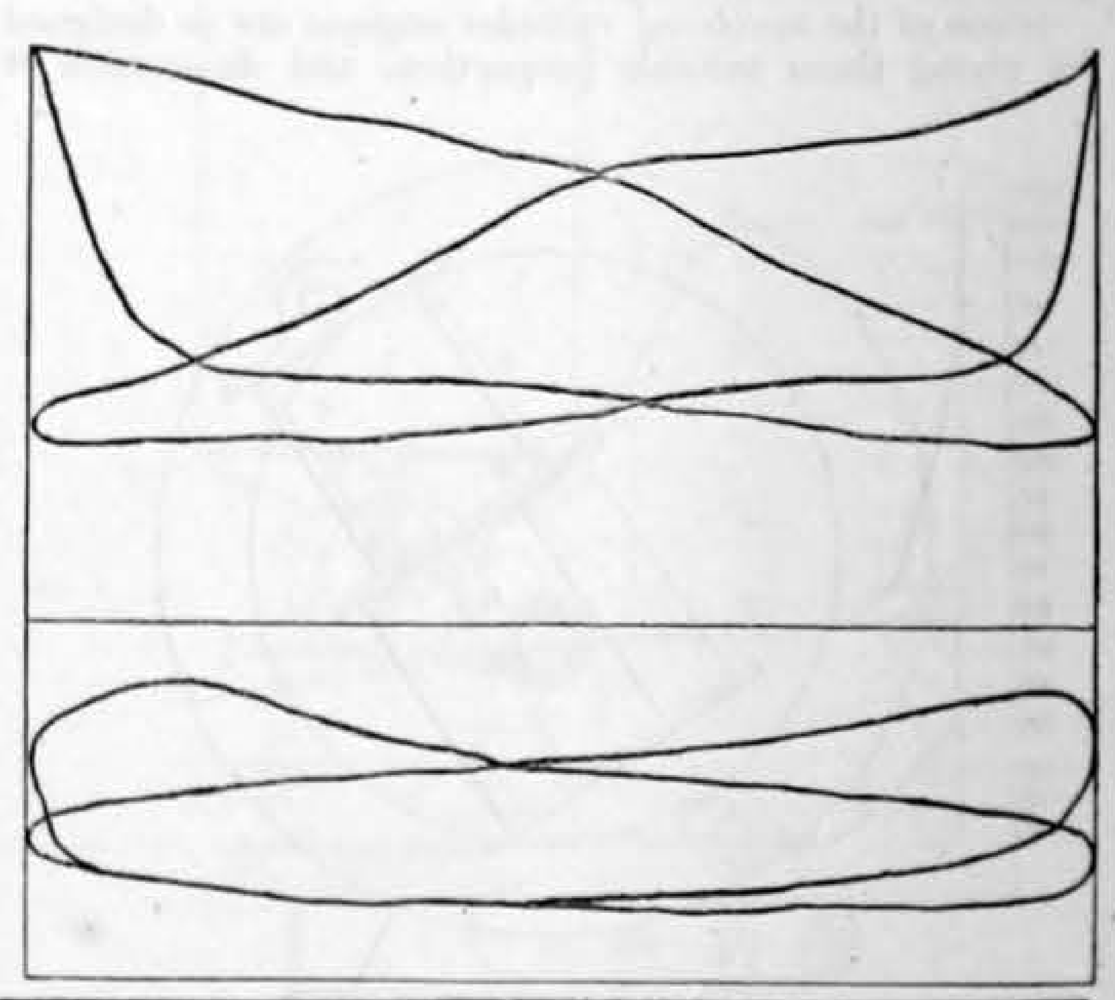




CARD No. 7.

High-pressure cut-off ... ... 53 *per cent.*
Low-pressure cut-off ... ... 70 *per cent.*
Speed ... ... 86 *miles per hour.*
Boiler pressure ... ... 170 *lb.*
Mean effective pressure, high-pressure cylinder ... ... 45·68 *lb.*
Mean back pressure, high-pressure cylinder ... ... 63·4 *lb.*
Mean effective pressure, low-pressure cylinder ... ... 21·92 *lb.*
I.H.P. { *High-press. cylin.* 550·6 *H.P.* / *Low-press. cylin.* 518 *H.P.* } *Diff.* 32·6 *H.P.*
Total ... ... 1068·6

Level.



arranging that the link or frame which holds the cylinder and main bearings be fixed, we arrange that the crank arm or frame which contains the two revolving pairs shall be fixed, then we come at the pattern that forms the subject of this article. Supposing this to be done, we have that which was the fixed frame making a complete revolution relatively to the now fixed crank arm, and that which was the connecting-rod making also a complete revolution to the crank arm. These two revolving pieces are coupled together by a piston or reciprocating piece, which moves backwards and forwards in a straight line relatively to the one, and backwards and forwards through a limited angle relatively to the other.

Some such constructions may be readily understood by referring to the accompanying sketches. Fig. 3 is an engine brought out some time ago by Mr. Mills, and consists of a cylinder frame A revolving round an axis, and holding two cylinders symmetrically placed as shown. The pistons of these cylinders are connected by piston-rods to a common crosshead, the centre of the crosshead being jointed to a pin fixed to a circular frame revolving about a centre B. In this instance the cylinders revolve absolutely about the centre A, and the pistons approximately about the centre B. They would revolve absolutely about that centre if the crosshead were rigidly attached to the frame B and they were shaped with a spherical surface where they pair with the cylinder, and thus accommodate themselves to the various obliquities imposed upon them. Fig. 4 is an example invented long ago by Mr. Ward, and is on the same principle. This engine has one cylinder, whose axis is placed so that it directly radiates from the centre, round which it revolves. Another engine is of a very similar character, devised by Mr. Benham, and differing but little from it, except that as many as eight cylinders are constructed in the cylinder frame, these radiating directly away from the centre of revolution. The above arrangements are sometimes varied by radiating the cylinders towards the centre of the cylinder frame, instead of outwards. It requires no explanation to see that the main features of such mechanism are precisely of the same character. Figs. 1 and 2, the Morey engine and the Cary engine, are examples. The similarity of parts can be followed by the lettering, which is used in each to indicate the same parts. Many other engines have been invented in this direction, and based upon other mechanisms, though all possess the peculiarity that piston and cylinders revolve round centres.

The above re-arrangement does not at all alter the character of the mechanism, though at first sight it might appear as though all reciprocation had been eliminated.

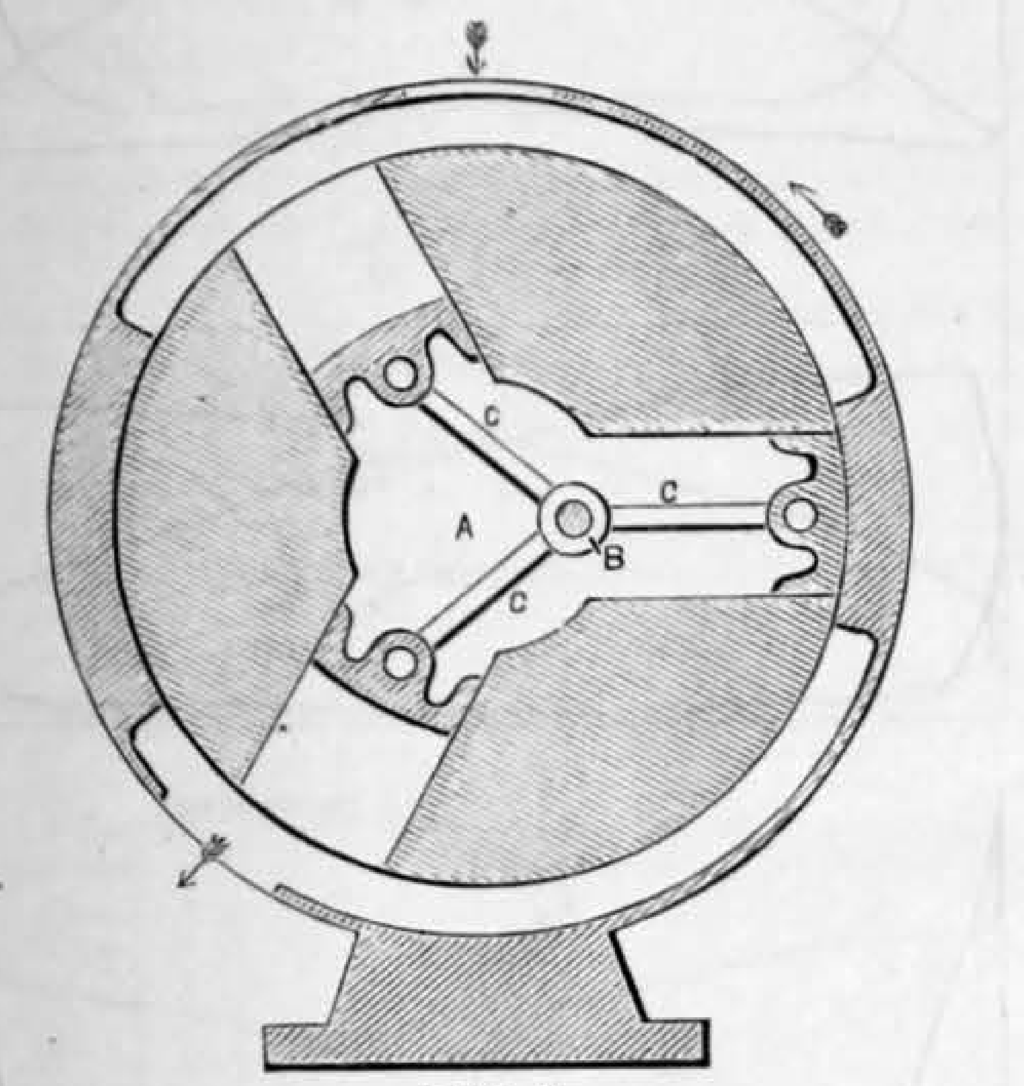


FIG I

The close analogy which has been shown to exist between it and the ordinary direct-acting engine would cause such a claim to be looked upon with suspicion. In these engines the piston, though revolving, reciprocates relatively to the revolving cylinders with which it is paired, and hence the necessity, in the new engine as in the old, to alternate the action, first in the one direction to send the piston to the opposite end of its stroke, and then in the other to return it to its original position.

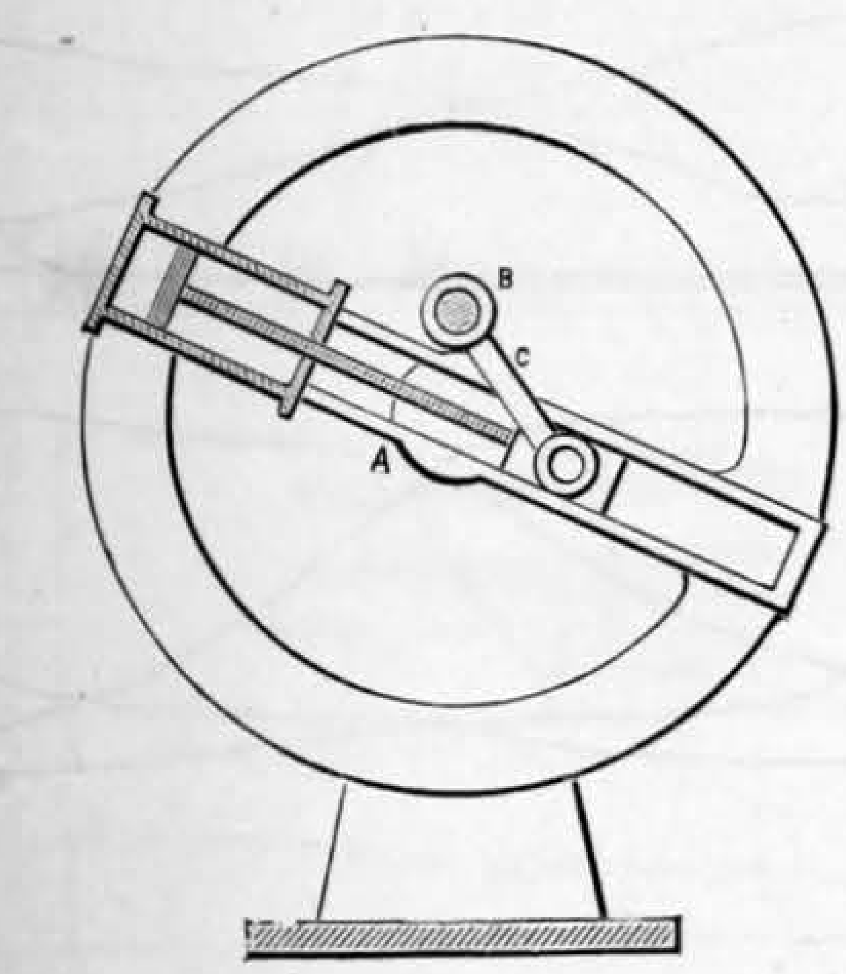


FIG. 2

Though this return be effected by making the cylinders double-acting, or by adding another single-acting cylinder, another peculiarity of reciprocation exists, that of dead points at each end of the stroke. The defect arising from this can only be counteracted in the new engine as in the old by adding extra cylinders with their gear, and thus no particular advantage is gained.

Some of the revolving cylinder engines are so designed by giving them suitable proportions and disposition of

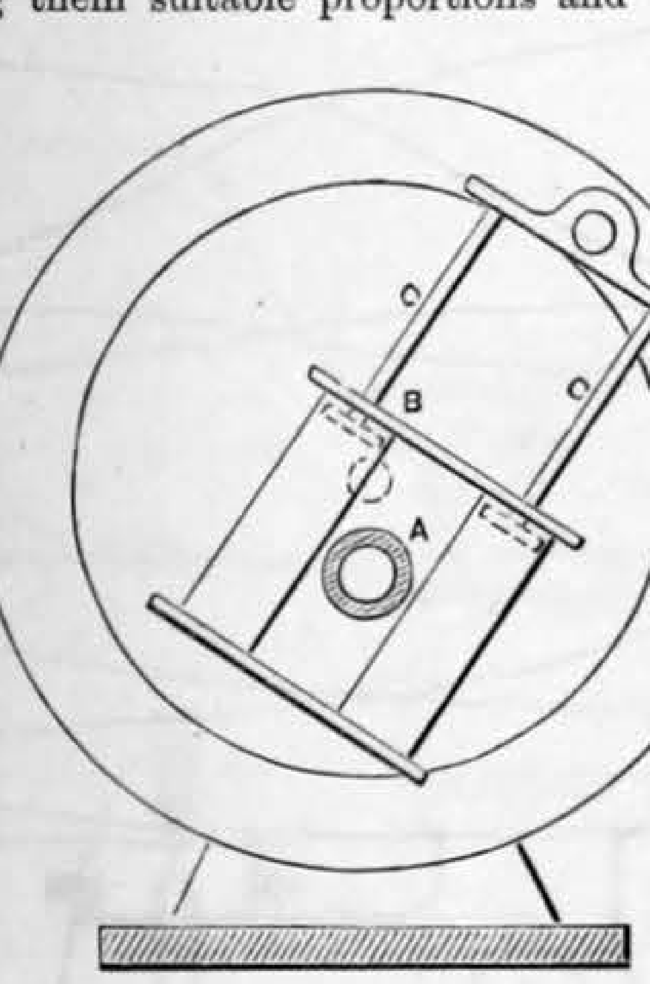


FIG.3

parts, that it would appear that a third peculiarity of reciprocation is done away with, that of absorbing power to overcome the inertia of the reciprocating parts. This, considered from a point of view of wasting power, is no defect, for that power which the reciprocating piece may absorb during the first part of its movement, or during the time its velocity is being accelerated relatively to the piece to which it is paired, is restored again during the latter part of its travel, or while its speed is correspondingly retarded relatively to the cylinder in which it works. The evil that this action does produce is, that it throws a recoil in the opposite direction to the force acting upon it, and this being communicated to the fixed frame, causes it to be unsteady, or at least to subject it to vibration.

As it has been shown that altering the disposition of the engine mechanism with respect to the earth does not obviate the necessity of counteracting the main essential features of reciprocating, that is, returning the reciprocating piece to its original position and the existence of dead points, so it may be shown that this evil of recoil is not alleviated. Take any one of these engines, say the Cary engine; here the cylinders revolve round one common centre and the pistons round another, each having an absolute revolving motion, but a relative reciprocation. That is to say, with respect to the fixed frame holding the two main centres, these pistons have a revolving movement, but with respect to the cylinders a rectilinear reciprocation, and with respect to the other frame or excentric frame, an angular reciprocation. Con-

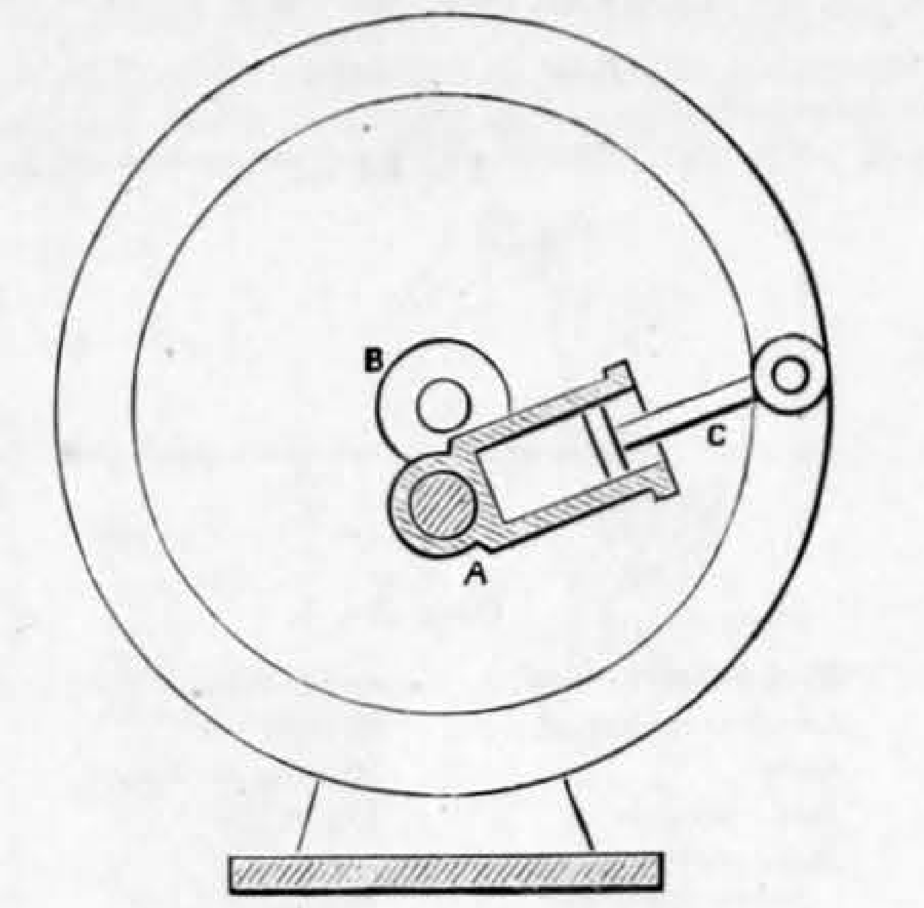


FIG.4

sidering only one cylinder and its fittings, which is sufficient to eliminate all the characteristics of reciprocation, if, as is asserted, no reciprocation exists, it will hardly be disputed that the piston, relatively to the cylinder in which the steam acts, moves with a varying velocity. There is no difficulty in seeing that it will vary from zero at one end of its stroke to zero at the other end, the intermediate variations depending upon the proportions of the engine. It will vary, in reference to the cylinder, exactly in the same way as the piston of an ordinary engine, whose length of crank is equal to the distance between the centres of the improved type, and whose length of connecting-rod equals the distance between the centre of excentric frame and centre of pin on this frame, to which the piston or its rod is jointed. This being so, if we consider the action when the steam enters the cylinder, and is starting the piston off from one end of its stroke, we shall see that the steam pressure acting on the piston will not be fully communicated to the pin on excentric or wheel frame, but will be diminished by the amount required to start the piston off at its original acceleration. This is not modified by the fact that cylinder and wheel frame are revolving round fixed centres. The action of a force in setting a body in motion is determined only by the movement produced in the direction in which the force acts. Though the piston goes round in a circle the force keeps up with it, and is always acting in the direction of the piston's motion; and hence has some of it absorbed when the velocity of piston is increased in that direction, and is restored again when decreased. The result is therefore, at the moment under consideration, that there are two forces acting on the fixed frame through the centres—one equal to the steam force acting at the back of the cylinder, the other a smaller quantity, depending upon the rate at which the piston is accelerated. Thus the fixed frame, at this instant, is under the action of the difference of these forces, and hence will tend to move, or, if secured firmly, to vibrate.

Such engines may, however, be balanced, but exactly in the same way as ordinary fixed cylinder engines; that is, by adding extra cylinders with their gearing, and so arranging them that the irregularities of the one may be counteracted by those of the others. There would seem to be no way of avoiding the evils of reciprocation, whether return stroke, dead points, or recoil; but all of these may have their evil tendency counteracted. In some of the examples quoted, as for instance, Riggs, it cannot be disputed that they do run with exceeding smoothness, even though the cylinders may not be arranged to produce perfect balance. This may be accounted for by considering that the weights of the revolving parts are great in comparison with the weight of the reciprocating parts, and thus the evils of reciprocation are deadened, or smothered over. Given, however, a perfectly-balanced fixed cylinder engine; or, given an imperfectly-balanced fixed cylinder engine, with a substantial fly-wheel, the result should be as satisfactory.

WHEELOCK PUMPING ENGINE FOR EIFFEL TOWER LIFTS.

In a former issue[1] we described and illustrated the Wheelock motor in the Machine Hall of the Paris Exhibition; and we now reproduce, on page 189, the working drawings of the pumping engines, with valves and gear on the same system, that were erected in the South pillar of the Eiffel Tower, for raising water to the second platform, for working the Roux and Otis lifts in all four pillars. The height to which the water was raised is 120 metres = 393ft.; and each of the two Wheelock engines, condensing but not compound, with double-acting Girard pumps, raised 50 litres = 11 gal., or 80 litres = 17½ gal. per second, according as the engine made 22½ or 36 revolutions. As a rule, one engine and pump was found sufficient, it being only necessary to run the two together on days when the influx of visitors to the tower was considerably above the average. The consumption of dry steam did not exceed 11·6 kilos., or 26 lb., per horse-power per hour, measured in water raised.

[1] See THE ENGINEER of February 7th, 1890, pp. 114 and 118.

Fig. 1 of the illustrations shows a side elevation of the steam cylinder, with the governor and variable expansion gear, while Fig. 2 gives details of the valves and gear at the back end of the cylinder, with section—longitudinal as regards the valve, but transverse with reference to the cylinder—through one valve and its seat. The valve nearest the cylinder end, serving only for the exhaust, is closed and opened uniformly through the excentric; but the other, serving for variable cut-off as well as admission, though opened through the excentric, is closed sharply, in obedience to the governor's action, by a weight and spring. Each steam-jacketted cylinder, of 0·65 m. = 2ft. 1⅝in. diameter and 1·066 m. = 3ft. 6in. stroke, is mounted on its bed-plate of girder, or as the French call it, "bayonet" type, the double plunger of the pump being keyed on to a prolongation of the piston-rod. The air and hot-water pumps of the condenser—see Fig. 3—are worked by a bent lever and connecting rod off the main crank pin.

As in the Machine Hall engine, the valves are long and narrow grid slides, working on corresponding faces which form nearly cylindrical plugs, cut away to receive the slides, and driven in tight. All the four valves of a cylinder with their seats may be replaced in a quarter of an hour. Thanks to the very narrow facing strips on both valve and face, the surface in contact is so slight that friction is reduced to a minimum, while the valves are almost balanced. The slides—see Fig. 2—are driven by short curved levers and links, so arranged that they act at the greatest advantage for overcoming the inertia when the facing strips are in contact, but give a greater speed of travel after that inertia has been overcome. Dotted lines and arcs in Fig. 2 show the oscillating travel of the valve spindles, the arms of their levers, and the lever giving the trip action for determining the cut-off. The upper ends of the exhaust valve levers are actuated by the excentric connecting-rod, while their fork pivots give intermittent motion to the levers fast on the expansion valve spindles. The method by which the expansion valves are opened is described in connection with the Machine Hall engine; but the greater detail of the present drawings shows more clearly the cut-off motion given to the expansion valves at each end of the cylinder by means of the governor. Referring to Fig. 1, the horizontal arm of the bell-crank on each expansion valve spindle is pivotted to a weight, whose force is increased by a spiral spring tending to draw it down. The weight and spring keep the valve closed until their resistance is overcome by the vertical arm of the bell-crank being pulled by the plate on the upper member of the fork, which is drawn by the bent lever of the admission valve, owing to the throw of the excentric. The release from this action, permitting the weight and spring to close the valve, is effected by the snug B—that is to say, the outside one at each end of the cylinder—on the socket of the short lever, which is loose on and pendent from each expansion valve spindle. In Fig. 1 the valve at the pump end of the cylinder, or left side of the figure, is shown closed with the weight down and the spring compressed, while at the other, or crank end of the cylinder, the expansion valve is in the position of open, the weight being lifted and the spring distended by the bell-crank. The snug B, however, is about to raise the lower member of the fork, and therefore lift the plate clear of the block, so as to allow the weight and spring to close the valve. The pendent levers carrying these snugs are moved by the horizontal rod of the governor, that at the crank end being worked directly, and that at the pump end through spur gear, as shown. Greater or less resistance may be offered to the governor's action so as to alter its *régime* by varying the tension of the spiral spring on the horizontal rod, the position of its fullest distension being shown by dotted lines; and this tension may be varied by the set screws while the engine is running.

In this engine also, in the event of the governor or its gear failing, the balls therefore dropping and the horizontal rod moving from right to left, the snugs O O—those inside as regards the cylinder ends—on the sockets of the pendent levers, come into permanent contact with the lower arms of the forks and prevent the opening of the valves, and therefore any further admission of steam. This occurs at least when the stop is in the position P, shown by the full lines; but not, while stopping the engine, in the position P^1, shown by dotted lines. The slot in the lower or vertical arm of the governor bell-crank is to permit of the setting of the valves. When this is accomplished the pin of the horizontal rod of the governor is clamped in position. The single excentric is generally keyed so as to make an angle of about 55 deg. with the crank and behind it. Increasing this angle has the effect of increasing the lead, but of diminishing the admission both at the front and back end, while it also renders the exhaust earlier, but increases the compression, both front and back. Lengthening the excentric rod or excentric connecting rod diminishes the compression forward, renders earlier the exhaust forward, and exerts a contrary effect aft, while it retards the admission forward and renders it earlier aft. Lengthening the rod which connects the levers of the two exhaust valves increases the compression aft, retards the exhaust aft, advances the admission aft, and exerts no effect forward. Lengthening the horizontal connecting-rod of the governor increases the admission both fore and aft, while lengthening its coupling rod increases admission aft, but exerts no effect forward. Lengthening the connecting-rod and correspondingly shortening the coupling rod, on the contrary, increases the admission forward and exerts no effect aft. Finally, lengthening the exhaust valve links retards the exhaust and increases the compression, the port being less uncovered, while lengthening the admission valve links retards the admission, the port being less uncovered, and no change taking place in the detent.

The stop valve, in the middle of the cylinder's length, has a conical seat, and is opened and closed by a screw at the end of its spindle, kept tight by the pressure of steam against its collar, and turned by a star wheel, as seen in Fig. 1.

The Girard double-acting pump, shown by Fig. 4, is 0·29 m. = 11⅜in. in diameter. The two barrels, cast with wide bases, and each with its suction and delivery valve boxes, are bolted together. The valves are faced with leather and weighted by laminar springs. The delivery chamber is surmounted by a sheet steel air vessel of 1000 litres = 220 gallons capacity. As this drawing is only for the Girard pumps, the Wheelock valves are not shown on the steam cylinder.

The pumping engine on the left bank of the Seine, for the

WHEELOCK ENGINE, WITH GIRARD PUMPS, FOR EIFFEL TOWER LIFTS.

A. DE QUILLACQ, ANZIN, FRANCE, ENGINEER.

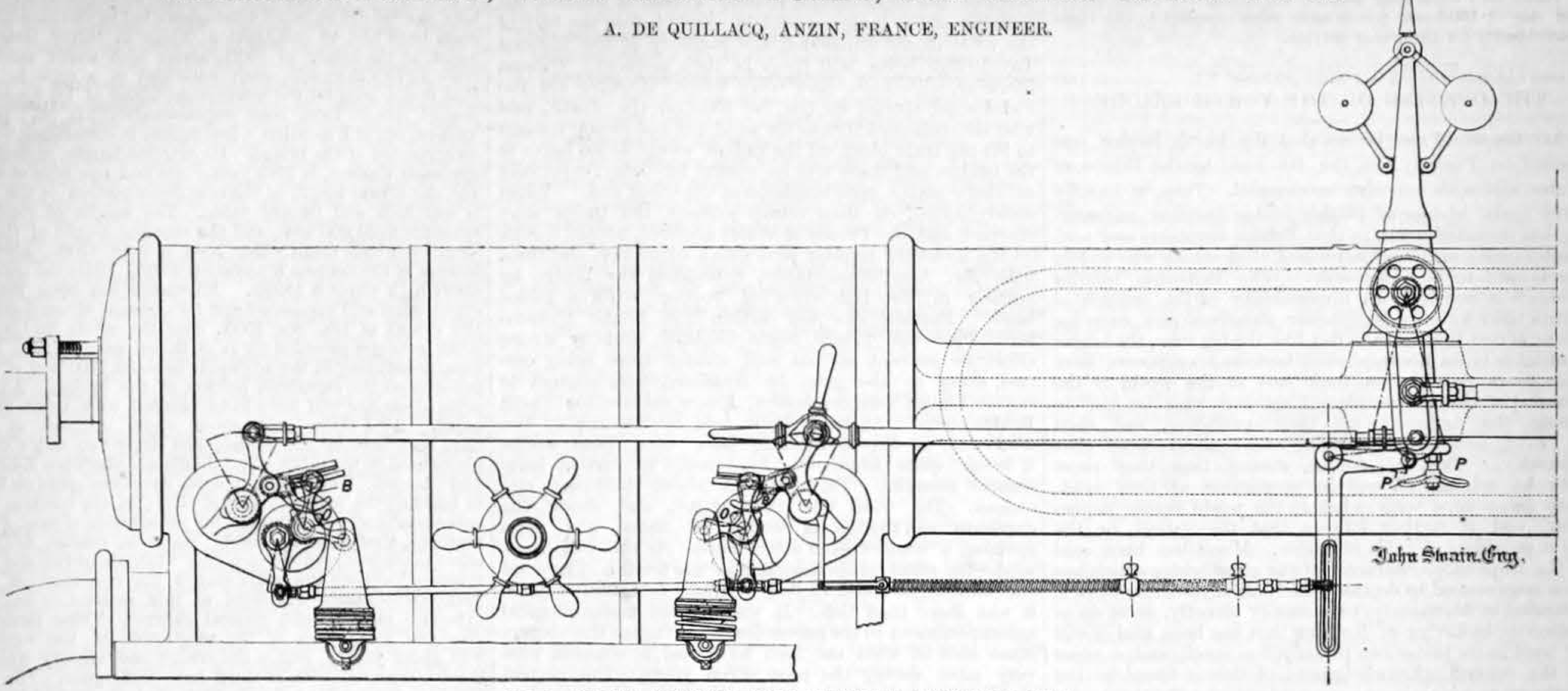


Fig. 1 — STEAM CYLINDER WITH VARIABLE EXPANSION GEAR.

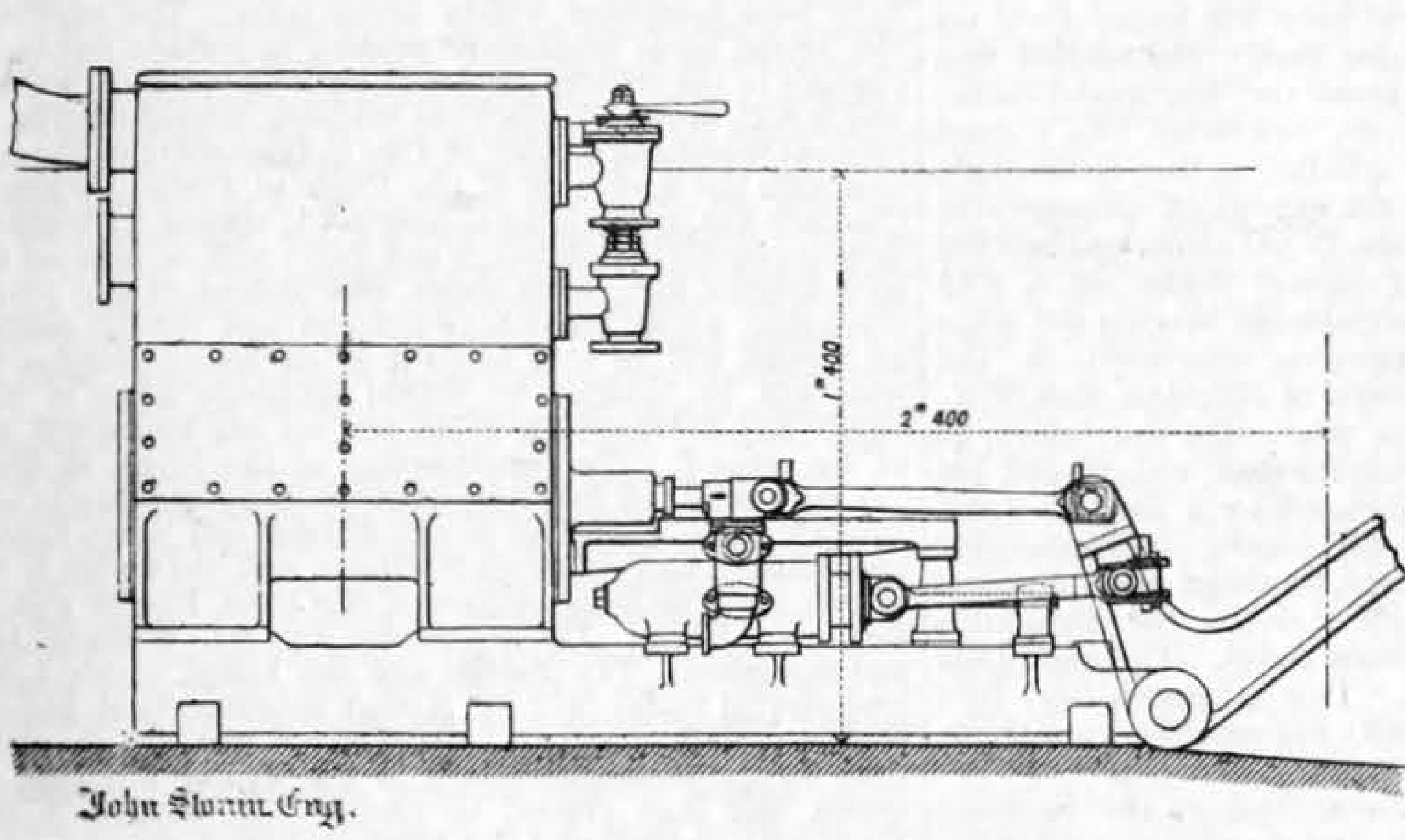


Fig. 3 — CONDENSER WITH AIR AND HOT WATER PUMPS.

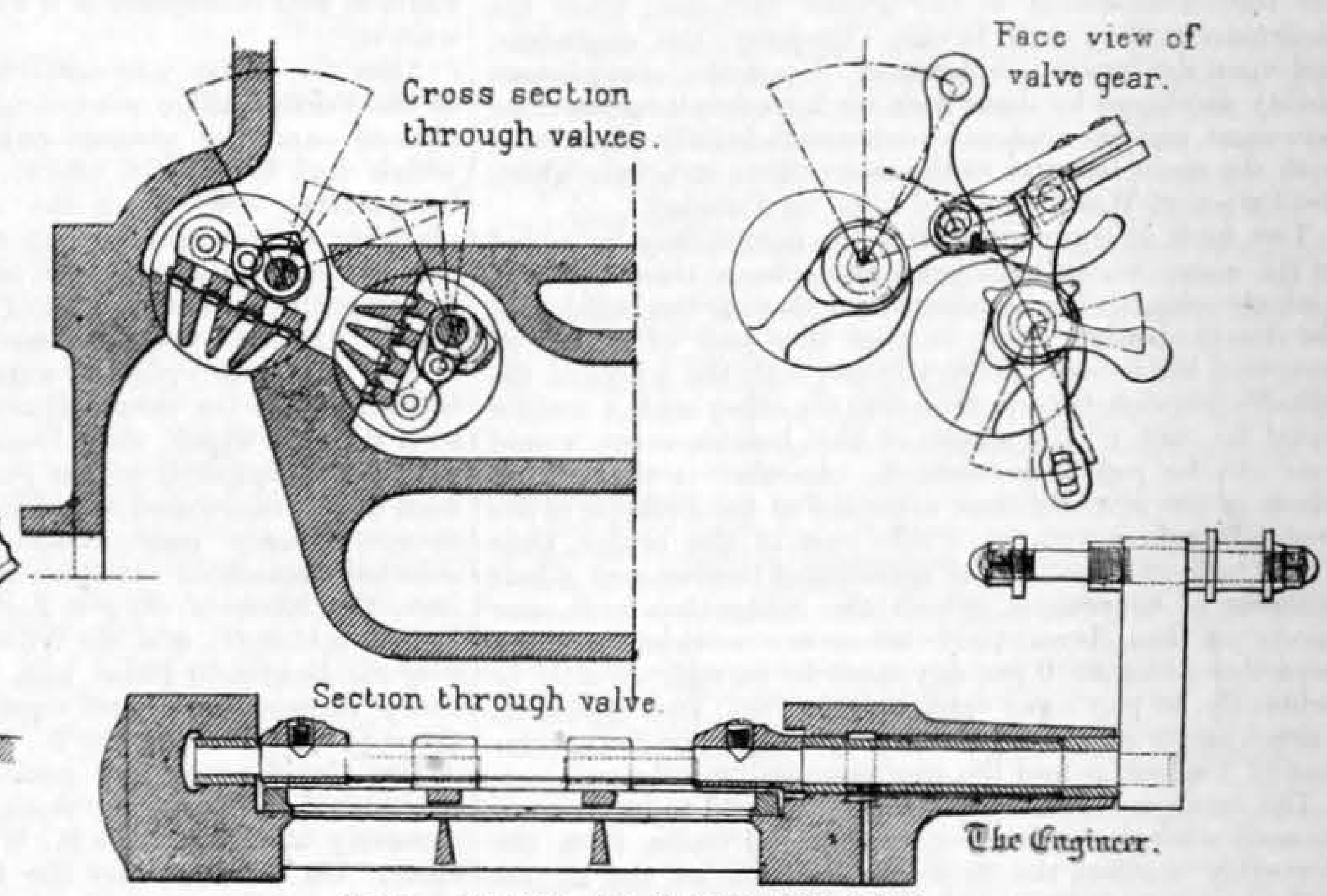


Fig. 2 DETAILS OF VALVE AND GEAR.

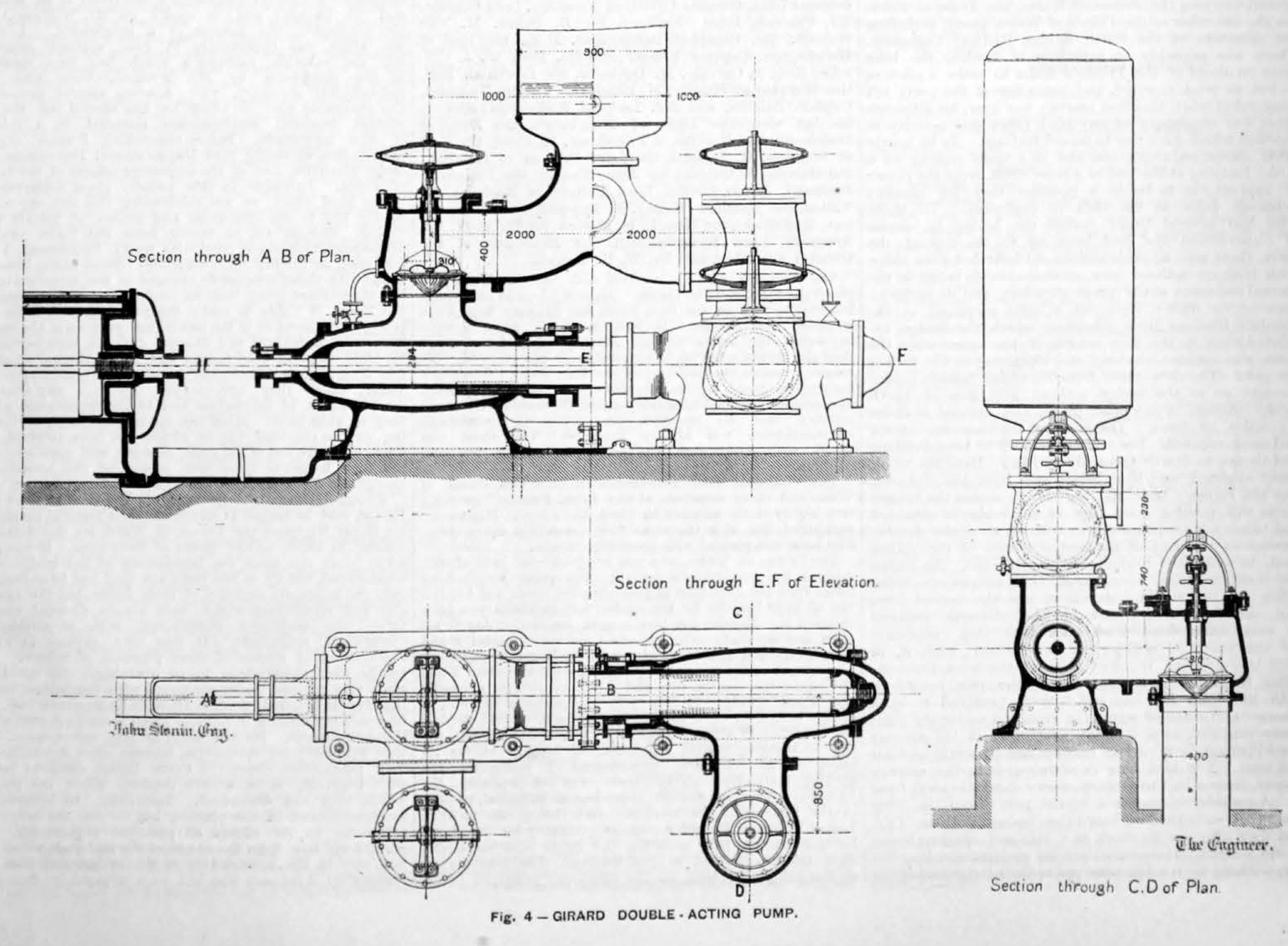


Fig. 4 — GIRARD DOUBLE-ACTING PUMP.

motors in the Machine Hall, similar to the above, raised 220 litres = 48 gallons of water per second to a height of 49 m. = 160ft. 9in., while four similar engines of 400-horse power and one of 150-horse power have been supplied to the Paris Municipality for the water service.

THE OPENING OF THE FORTH BRIDGE.

ALL the world now knows that the Forth Bridge was opened on Tuesday last, the 4th inst., by the Prince of Wales, and with imposing ceremonial. Thus, in exactly forty years' history of British bridge building engineering has repeated itself, in that British engineers and contractors have again accomplished that which was widely proclaimed to be impossible. The Britannia tubular bridge was not less an impossibility in the opinion of critics than was the far-grander structure now carrying trains across the Forth. But like the big tube, the bigger cantilever is an accomplished fact, and engineers have once more proved that their part in the world is the removal of the impossible. Engineers may be said to create the necessity for their existence, and then to exist and provide living for others from that necessity. This, of course, means that they must ever be originators, and in proportion as they originate must cope with what to the world seems impossible, and it further follows that they must be the great providers of fields of labour. Much has been said of the stupendous character of the great bridge which has now commenced to do that which all engineering work is intended to do, namely, earn money directly, or to do so indirectly by saving it. Nothing that has been said or will be said in its praise can praise it too much, and a proof of the general acknowledgment of this is found in the distinctions which have been conferred by the Queen, on the recommendation of the Prime Minister, upon the chairman of the Forth Bridge Company, the engineers, and upon the leading contractor. Upon the conspicuous ability displayed by these men we have dwelt on previous occasions, and our readers have been made fully acquainted with the main features of the marvellous structure which the Prince of Wales declared open on Tuesday.

Two facts in connection with the bridge may be added to the many which have been given from time to time, with the object of conveying some idea of the bigness of the Forth Bridge. One is that if a pair of scales be imagined big enough to carry in one scale the whole of the metallic superstructure, then into the other scale a weight equal to that of the whole of the British army would have to be put to balance it. Another is that if the whole of the working time occupied in the building of the bridge be taken, and the whole cost of the bridge, then it will be found that in the spending of the two and a-half millions of sovereigns, which the bridge has cost, one sovereign has been paid for every working minute. Something like £350 per day must be earned, directly or indirectly, to pay 5 per cent. on this cost, and, of course, a much larger sum to pay that rate of interest on the greater cost of the bridge and the new connecting railways.

The ceremonies of Tuesday may be said to have commenced with the starting of two special trains from the Waverley Station, the first carrying one of the largest gatherings of railway men or leaders in cognate affairs that has perhaps ever been brought together, and the second carrying the Prince of Wales, the Duke of Edinburgh, and other of the Prince of Wales' party, including the directors of the Forth Bridge Railway Company. There was probably no intention in sending the long train on ahead of the Prince's train, to make a pilot of it, but as pilot it acted, and not a few of the party felt some relief when this first journey was over, for although there was no danger of any kind, there was novelty of position which gave rise to mixed feelings. To be nearly 160ft. above an angry sea, and in a train resting on a girder hanging at the end of a lever 680ft. from the points of support, is to be in a position that for comfort demands faith in the skill of engineers. To those who had several times visited the bridge in course of construction and had been up to the top of the piers, there was no such excitement left; but even those with faith crystallised into an unshakeable belief in the eternal residence of the great structure and its performance of its duties, were not a little surprised at the absolute freedom from vibration which the bridge exhibited even in the very centres of the spans when the train was rocking, shaking, and clattering in the fury of the gale. The first train from Waverley Station passed straight on to the bridge without any stop at Forth Bridge Station, or any other place, and crossed at about six miles an hour. The wind at the time was strong and some rain fell. The train continued to Inverkeithing and thence to North Queensferry Pier. Here the whole party alighted, and from below and from the distance, saw the Prince's train moving slowly across the bridge. From this point a good view of the bridge is obtained, and to see a train passing over is to get an ocular demonstration of the fact of the insignificance of the rolling loads to which the bridge will be subjected. An engine and train of saloons is comparatively a microscopic thing when on the mighty structure, and the veriest tyro can see how vast must be the strength required to carry the dead load, and that that necessary for the train is nothing in comparison with it, or with the strength required to meet the wind pressure. After the Prince's train reached the pier his party, with Sir John Fowler and others, entered a small steamer and steamed round the piers and under the great spans, and saw, as well as the roughness of the estuary would permit, how various parts of the structure look far and near. The best view is, perhaps, from the estuary shores, from a half to three-quarters of a mile away from it. A considerable number of the party from the other train then embarked on board the steamer William Muir, and they also saw as much as a gale and blinding spray would permit. However, they did not remain long on the seething waters, but returned to their trains and again over the bridge. This time another experience was obtained, for the wind had risen, and was blowing a gale. Some of the more careful visitors wondered whether the crossing of the bridge would be made before the fury of the wind abated somewhat, the memory of the ill-fated Tay Bridge being still fresh in their memory. Others, however, who knew how very much stronger are the awful wind storms on the Tay than on the Forth, and who also reasoned that as the wind was not strong enough to lift the train clean off the rails it would do no harm to the bridge, said there was no reason for delay, especially as there was a good luncheon at the other end. When nearly across, on their return journey, the trains were stopped, and the Prince of Wales alighted, turned a cock on the hydraulic rivetter pipe with a silver key, and thus, with Mr. Arrol's assistance, completed the bridge by putting in the last rivet of copper with a gilded head. Further on—just within the South Queensferry Pier—the Prince again alighted, and by strong effort to prevent his hat and himself from being carried away by the gale, he remained long enough to say—"Ladies and gentlemen, I now declare the Forth Bridge open." At least, he is said by the one or two who were to his leeward to have used these words, it being quite impossible to remain for further ceremonial remarks. This was at about half-past one o'clock. The wind was very gusty, and shook the carriages as though it would lift them, and upon opening a window even a few inches on the weather—west—the effect inside the carriage was terrific. The wind was blowing at about 15 lb. per square foot, but at times it was more than this. It was a meet meteorological accompaniment to the proceedings, for it gave the visitors some idea of what the men have had to contend with very often during the past seven years. The perfect steadiness of the bridge under the gale also helped to confirm that confidence in it which is felt by all connected with it.

After the bridge was declared open the trains drew up at the Forth Bridge works—now partly dismantled and cleared—and the visitors entered the big model-room, which had been very effectively converted into a great banquetting hall. Over the middle of the chairman's platform there was a magnificent canopy of crimson and gold plush, surmounted with the Royal arms, and bearing underneath the motto of the Prince of Wales on a gold scroll. On the walls there were shields bearing the arms of the different railway companies interested in the bridge, and of the principal towns of England and Scotland through which their lines pass. On the tables, it may be mentioned, a four-paged *menu* was placed for each guest, illustrated and decorated in a most tasteful manner, every page containing some appropriately-selected quotation. It contained, amongst other engravings, the likeness of Sir John Fowler, Sir Benjamin Baker, K.C.M.G., and Sir William Arrol. The quotation over Sir Benjamin Baker was, "Thy judgment fair, lays every project well," and equally appropriate were those given to Sir John and Sir W. Arrol.

The Royal party and guests arrived at the banquet hall shortly before two o'clock, and were received by the company standing. Sir M. W. Thompson occupied the chair. On his right were the Prince of Wales, the Earl of Rosebery, Prince George of Wales, the Duke of Fife, Mr. John Dent, Lord Provost Boyd, Herr Mehrtens, General Ellis, General Lyttelton Annesley, Lord Colville, Mr. Calcraft, Herr Krueger, Sir B. Baker, M. Van Hasselt, Mr. Campbell-Bannerman, M.P., the Earl of Haddington, Captain Vander Meulen, Hon. W. J. Colville, Hon. A. Colville, M. Ogekelin, Sir Lowthian Bell, the Marquis of Huntly, M. Eiffel, Sir Charles Tennant, Captain Zelenoi, and Mr. Leopold Rothschild; and on his left were the Duke of Edinburgh, the Duke of Buccleuch, the Marquis of Tweeddale, M. Picot, the Earl of Wemyss, M. Tasafini, the Lord Provost of Glasgow, the Marquis de Guigne, Sir John Fowler, the Bishop of Lichfield, Baron Reillie, Lord Balfour of Burleigh, M. Vallon, Sir Matthew Ridley, M. Doppler, Sir W. Thomson, M. d'Oissel, the Hon. R. H. Dutton, Sir W. Arrol, Mr. Armitage, Lord Kingsborough, the Moderator of the General Assembly, and Dr. W. H. Russell.

The Chairman, who was received with loud applause, proposed the toast of "The Queen." He said he could carry back his recollection to the time when her Majesty the Queen ascended the Throne. It had been his great fortune to watch the career of her Majesty, and he observed that she always acted up to the duties of her position. No matter whether the Ministry of the time was a Liberal or a Tory Government, her Majesty was always up to the occasion and acquitted herself admirably as the Sovereign of a great country, and her decision, given often in momentous circumstances, was always respected. The toast was drunk with enthusiasm, the band playing the National Anthem.

The Chairman then gave the toast of "The Prince of Wales and other members of the Royal Family," speaking very highly of the manner in which their Royal Highnesses performed the high functions which devolved upon them. The toast was pledged with great enthusiasm.

The Prince of Wales, who was received with loud cheers, said: I feel very grateful for the kind words which have fallen from the chairman in proposing the toast, and I thank you all most heartily for the cordial way in which you have received it. The day has been a most interesting day to all of us, and especially so to me, and I feel very grateful that I have been asked to take part in so interesting and important a ceremony as the one at which we have all assisted. I had the advantage, nearly five and a-half years ago, of seeing the Forth Bridge at its very commencement, and I always looked forward to the day when I should witness its successful accomplishment. I may, perhaps, say that in opening bridges I am an old hand. At the request of the Canadian Government, I performed the opening ceremony thirty years ago of opening the Victoria Bridge over the St. Lawrence at Montreal, putting in the last rivet, the total of rivets being one million. To-day I have performed a similar ceremony for the Forth Bridge, but on this occasion the rivets number nearly eight millions instead of one million. The construction of the bridge has been on the cantilever principle, which has been known to the Chinese for ages, and specimens of it may be seen likewise in Japan, Tibet, and the North-West Provinces of India. Work of this description has hitherto been carried out on small dimensions, but in this case the engineers have had to construct a bridge in thirty fathoms of water, at the height of 150ft. above high water mark, and crossing two channels, each one-third of a mile in width. Had it not been for the intervening island of Inchgarvie the project would have been impracticable. It may perhaps interest you if I mention a few figures in connection with the construction of the bridge. Its extreme length, including the approach viaduct, is 2765 yards, one and one-fifth of a mile, and the actual length of the cantilever portion of the bridge is one mile and twenty yards. The weight of steel in it amounts to 51,000 tons, and the extreme height of the steel structure above mean water level is over 370ft., above the bottom of the deepest foundation 452ft., while the rail level above high water is 156½ft. Allowance has been made for contraction and expansion and for changes of temperature to the extent of 1in. per 100ft. over the whole bridge. The wind pressure provided for is 56 lb. on each square foot of area, amounting in the aggregate to about 7700 tons of lateral pressure on the cantilever portion of the bridge. About 25 acres of surface will have to be painted with three coats of paint. As I have said, about eight millions of rivets have been used in the bridge, and forty-two miles of bent plates used in the tubes, about the distance between Edinburgh and Glasgow. Two million pounds have been spent on the site in building the foundations and piers; in the erection of the superstructure; on labour in the preparation of steel, granite, masonry, timber, and concrete; on tools, cranes, drills, and other machines required as plant; while about two and a-half millions has been the entire cost of the structure, of which £800,000 — nearly one-third of this amount — has been expended on plant and general charges. These figures will give you some idea of the magnitude of the work, and will assist you to realise the labour and anxiety which all those connected with it must have undergone. The works were commenced in April, 1883, and it is highly to the credit of everyone engaged in the operation that a structure so stupendous and so exceptional in its character should have been completed within seven years. The opening of the bridge must necessarily produce important results and changes in the railway service of the east coast of Scotland, and it will, above all, place the valuable manufacturing and mineral producing district of Fife in immediate communication with the south side of the Firth of Forth. When the Glenfarg line, now nearly completed, is opened for traffic the distance between Edinburgh and Perth will be reduced from sixty-nine to forty-seven miles, and instead of the journey occupying, as at present, two hours and twenty minutes, an express will be able to do it in an hour. Dundee likewise will be brought to within fifty-nine miles of Edinburgh, and Aberdeen 130 miles, and no sea ferries will have to be crossed. The construction of the bridge is due to the enterprise of four important railway companies — (1) North British—the bridge is in its district—(2) North-Eastern, (3) Midland, and (4) Great Northern, and the design is that of two most eminent engineers, Sir John Fowler and Mr. Benjamin Baker. The contractor was Mr. William Arrol, and the present Tay Bridge and the bridge which I have inaugurated to-day will be lasting monuments of his skill, resources, and energy. I have much pleasure in stating that on the recommendation of the Prime Minister, the Queen has been pleased to create Mr. Matthew William Thompson, chairman of the Forth Bridge Company, and of the Midland Railway Company; and Sir John Fowler, engineer-in-chief of the Forth Bridge, baronets of the United Kingdom. The Queen has also created, or intends to create, Mr. Benjamin Baker—Sir John Fowler's colleague—a Knight Commander of the Order of St. Michael and St. George; and to confer on Mr. William Arrol, the contractor, the honour of a knighthood. I must not allow this opportunity to pass without mentioning the valuable assistance which has been rendered to the companies by Mr. Wieland, their able and indefatigable secretary, who deserves special praise for the admirable way in which he has carried out the important financial arrangements essential in a scheme of such magnitude. Before concluding, I must express my pleasure at seeing here Major-General Hutchinson and Major Marindin, two of the inspecting officers of the Board of Trade. Although in this country great undertakings of the kind which we are celebrating this day are wisely wholly left to the enterprise and genius of private individuals without aid or favour from the State, yet, in connection with these particular works, Parliament, I am informed, for the first time associated officers of the Board of Trade with those practically engaged in the construction of this magnificent bridge from its commencement, by requiring the Board of Trade to make quarterly reports to be laid before Parliament as to the nature and progress of the works. This most important and delicate duty has been performed by Major-General Hutchinson and Major Marindin; and I now congratulate them on the completion of their responsible duties, which they have carried out in a way that redounds credit to themselves and to the department which they so ably serve. Allow me again, gentlemen, in thanking you for the kind way in which you have received this toast, to assure you of the great pleasure and gratification it has been to me to have been present on this occasion to inaugurate this great success of the skill of engineering."

Sir John Fowler, in acknowledging the toast of the Forth Bridge, said he begged to return his most grateful thanks to his Royal Highness the Prince of Wales for the flattering manner in which he had spoken of their work. It was now seven years ago since the foundations of the bridge were commenced, but up to two years ago they had to endure not only the legitimate anxieties of their duties, but the attacks and evil predictions which were always directed against those who undertook engineering work of novelty or exceptional magnitude. It was very curious to watch the manner of retreat of these prophets of failure. The results had proved them to be mistaken. He could tell some very curious stories connected with the bridge, but on that day he felt that he could afford to be magnanimous, and he would say nothing ill-natured about them—not even about the astronomers. He was sorry for the astronomers, and they were sorry for themselves, because since the failure of their predictions about the Forth Bridge cautious people were beginning to be a little doubtful about the planets which they had discovered. Personally, he believed in astronomy, and in the planets, but he did not believe in astronomy in its effects on practical engineering. He pointed out how, from the nature of the materials which had been used in the construction of the bridge, and from the nationality of the men who had been engaged in that construction, the bridge possessed an international character. But besides strength and solidity, the æsthetic considerations could not altogether be ignored. He confessed that this gave him a little concern at first, for he read rather strongly-worded lectures, and altogether they seemed to be likely to get into hot water. Fortunately, the Edinburgh Royal Society of Arts conceived the idea of settling this matter in a very summary fashion. Accordingly they called to their help two famous artistic authorities—Mr. William Morris, famous for his power of attack on the bridge; and Mr. Benjamin Baker, famous for defending it. The result, he believed, was that Mr. Baker and the bridge were entirely victorious; and as this society never allowed any appeal, the æsthetic question was settled forever. They had two materials in the Forth Bridge—granite and steel. They would agree with him that in Scottish granite connected together with English cement they had durability and union of parts for at least a thousand years, and with the permission of the Chairman and their Royal Highnesses he would postpone any further consideration of that question until that period had expired. In regard to steel it might be deteriorated or decayed from two causes—vibration and oxidisation. Vibration could only produce injurious action when the maximum strain to which it would be habitually exposed by use approached one-half of its ultimate strength, but as the Forth Bridge could never have as much as one-half of the strain of the ultimate strength, he thought they might dismiss vibration as a source of injury. With regard to oxidisation, that meant gross neglect by those who were in charge; it meant that the painting was so neglected that air had access to the steel, and he would not do those who had charge of this important work the injustice of supposing that such a contingency was possible. He wished that time permitted to mention the names of the contractors and the able assistants who had done such good work, but he must content himself with mentioning Mr. Phillips, who had been resident engineer—a man of great experience from the first; Mr. Arrol, who had shown such conspicuous ability and originality, and his excellent secretary, Mr. Biggart. And now, the last but not the least, he claimed for the foremen and thousands of workmen who had been engaged on the Forth Bridge the highest praise for their skill and their bravery. In that hall where they were now assembled the drawings of the engineers were drawn out to the full size, and from those drawings moulds were made; they were taken down to the shops where by hundreds of skilful men, with admirable machines, many of them designed by Mr. Arrol specially for the work, the steel was drilled, made ready, and put together very carefully. It was put together with the greatest exactitude, then taken down again, and carried to the site of the bridge. For several years, often in very inclement weather and at an elevation of one, two, three, and four hundred feet above the water of the Forth, those brave men worked, and never knowingly scamped a rivet."

Sir W. Arrol also responded in a few well chosen words.

Sir Benjamin Baker was then most vociferously called for by the audience, and although his name had not been on the list, the call was so unanimous and spontaneous that the Prince through Lord Colville asked Sir B. Baker to reply.

Sir Benjamin Baker said he was there as a visitor. He considerd that personally and practically his connection with the Forth Bridge was over when his very severe friends General Hutchinson and Major Marindin expressed their unqualified satisfaction with the work they had visited. Being a visitor, and not being on the toast list, and also being extremely surprised at the honour which had been accorded him, he need hardly say that he was not quite prepared to make a speech. But of course it was perfectly easy after one had finished a somewhat difficult undertaking—it was pleasant to receive approbation. The approbation which the engineer valued most, he thought, was that of his own conscience, when he had done the best he could for the job. He could answer for his colleague Mr. Stewart, and his friend Mr. Biggart, and the whole staff of engineers, that they had the approbation of their own consciences, that every man had done the best that he could. Next to that, perhaps, was the approbation of their brother engineers, for they were best able to appreciate the kind of difficulties that they had to deal with. He was not altogether sorry that the elements had been such as they had been that day, because it would give them some idea of those difficulties which they had to overcome. And, last, they wished the approbation of the general public, and they had some evidence that that also had been achieved. Of course they had had dark days during the construction of the bridge, and during these dark days they tried not to be—and he thought they had succeeded—in not being unduly oppressed. On this, the brightest day in the history of the bridge, when His Royal Highness had done them the favour, which they so much appreciated, of being present, he might say on behalf of the engineers that they were not unduly elated, and that the flattering remarks which had fallen on them would not turn their heads. He hoped they would understand that they did not less heartily thank them for the extreme kindness and cordiality with which they had received the toast of the engineers, directors, and contractors, and he might say the workmen, of the Forth Bridge.

Mr. John Dent Dent then proposed the guests.

The Earl of Rosebery returned thanks.

Herr Mehrtens, of the Prussian Railway Department, also replied for himself and in the name of his companions from Saxony, Austria, and Hungary.

M. Picot, on behalf of the railway engineers of France, also replied in a speech in which he eulogised the bridge and its engineers and contractors.

The Marquis of Tweeddale proposed "The commercial interests of Scotland."

The Lord Provost of Edinburgh and the Lord Provost of Glasgow acknowledged the toast.

The Prince of Wales arose and stated amid cheers that he had received a telegram from the Queen and from the Princess of Wales. Both took the greatest interest in the undertaking, and both wished success to the Forth Bridge.

The proceedings, which had throughout been of the most agreeable nature, then terminated. The Prince and the Royal party then drove off to Dalmeny, and were loudly cheered.

During the banquet the band of the Cameron Highlanders played a selection of music, and the pipers of the regiment marched round the hall, their inspiriting strains being apparently greatly relished by the foreign guests, who were enthusiastic in their applause. After each toast the band played an appropriate air.

The French railways were very fully represented, as will be seen from the following list of names:—

Chemin de fer Paris et Lyons: Messieurs Mallet, President du Conseil d'Administration; Noblemaire, Directeur de la Compagnie; R. Picard, Chef de l'Exploitation; Henry, Ingénieur-en-chef du Materiel et de la Traction; and Denis, Ingénieur-en-chef de la Voie.

Chemin de fer Paris et Orleans: Messieurs Juigne (Marquis de) Administrateur de la Compagnie; Heurteau, Directeur de la Compagnie; Rougier, Directeur des Travaux; and Salacroup, Ingénieur-in-chef, adjoint a l'Ingénieur-en-chef du Materiel et de la Traction.

Chemin de fer du Midi: Messieurs Ancoc, Vice-president du Conseil d'Administration; Picot (Georges), Administrateur de la Compagnie; d'Elchthal (Eugene), Administrateur de la Compagnie; and Blage, Directeur de la Compagnie.

Chemin de fer de l'Ouest: Messieur Desbriere, Administrateur de la Compagnie; Blount (Henry), Administrateur de la Compagnie; Marin, Directeur de la Compagnie; Morliere, Ingénieur-in-chef de l'Entretien et de la Surveillance de la Voie; Foulon, Ingénieur, Secretaire de la Direction.

Chemin de fer du Nord: Messieurs Hottinguer, Administrateur de la Compagnie; Pièron, Ingénieur-en-chef adjoint à l'Ingénieur-en-chef du service Actif; Sauvage, Ingénieur principal de l'atelier des machines; and Aguellet, Ingénieur-en-chef des services centraux des Etudes du Matériel des voies et des bâtiments.

Chemin de fer de l'Est: Messieurs Imécourt (Marquis d'), Administrateur de la Compagnie; Reille (Baron Victor), Administrateur de la Compagnie; Barabant, Director de la Compagnie; A. Picard, Chef de l'Exploitation adjoint; and Gerhardt, Ingénieur de la Traction.

M. Alfred Sire, agent in England of the Northern of France, and M. T. Visinet, the representative of the Western Railway of France in this country.

Altogether there were nearly six hundred present at the ceremonies, and thousands of people collected at North and at South Queensferry to witness the proceedings. It was, in fact, a general holiday, and in spite of the very inclement weather every spot of vantage ground supported a sightseer.

The representatives of the French railways who were present on the occasion of the opening of the Forth Bridge were entertained, on Wednesday evening, at a banquet given by the chairman and directors of the London, Chatham, and Dover Railway, in the marble salon of the Grand Hotel, Trafalgar-square. The chair was occupied by Mr. J. S. Forbes, who made all arrangements in connection with the trains by which these gentlemen travelled from France and in this country, supported on his right by the French ambassador.

It is generally well known that the Forth Bridge, as part of an ordinary local or even ordinarily placed main line, could not pay. It is, however, through the important connections which it and its railways will enable the combined guaranteeing railways to make, that it will pay, and more especially since it is fully expected that the further amalgamation of the North British and Glasgow and South-Western will be effected; and thus, with the Western lines, including the new Helensburgh and Fort William Railway, which we illustrated and described in our last impression, a grand and far-reaching net-work will be controlled by the guaranteeing companies. The monopoly of the Caledonian will be broken, and the Western Highlands will become much more accessible.

Some of the visitors on Tuesday remained long enough at Forth Bridge Station to see the starting of the first goods train for Dunfermline. The bridge was opened for traffic on Wednesday, but there are several branch lines involved in the general scheme. On the Fifeshire side is the North Queensferry and Inverkeithing Railway, a length of about two miles; and on the south side there is a length of three-quarters of a mile to connect the bridge with the junction at Dalmeny. There is also the Winchburgh and Dalmeny line, four miles and a-half, to connect with the main line between Edinburgh and Glasgow. Another line runs from Inverkeithing along the shore for some distance to Burntisland. The Glenfarg line strikes due north between Loch Leven and Perth.

Referring again to the four-page menu already mentioned, it should be noted that under the words "All reap at last the actions they have sown," the names are given of many who have been actively associated with the building of the bridge, either on the staff of the engineers or of the contractors. The names thus given are those which follow:—Tancred, Phillips, Falkiner, Bakewell, Biggart, Westhofen, Hunter, Lilljiqvist, Aitken, Neville, Middleton, Main, Law, Gray, Wood, Stewart, Cooper, Meik, Schluter, Scott, Moir, Carey, Bourke, Symons, Tuit, Fitzmaurice, Blackburn, Harris, Campbell, Mayor, Webster, Chalmers, Knowles, Martin.

THE INSTITUTION OF CIVIL ENGINEERS.

RAILWAY BRIDGES.

AT the fourteenth ordinary meeting of the session, on Tuesday, March 4th, Mr. Berkley, vice president, in the chair, three papers were read on railway bridges:—

I. THE HAWKESBURY BRIDGE, NEW SOUTH WALES, by Mr. C. O. Burge, M. Inst. C.E.

The railway system of New South Wales had hitherto consisted of two separate divisions—the one starting from Sydney and branching thence in a westerly, southerly, and south-westerly direction, while the other originated at Newcastle, on the sea coast, about 100 miles north of Sydney, and communicated with the northern part of the Colony and with Queensland. The Hawkesbury Bridge was situated upon the connecting link of railway which was designed to unite these two systems. It crossed the main channel of the Hawkesbury between Long Island and Mullet Head, at a point where the channel had a width of about 2800ft., and a maximum depth of 77ft., while its bed consisted of a deposit of mud extending to a depth varying from 60ft. to 170ft. below high-water mark, and overlying the sand. For the construction of this difficult work the colonial Government invited tenders, accompanied by competitive designs, and took steps to make the competition world-wide. A committee, consisting of Mr. W. H. Barlow, past president Institution of Civil Engineers, Mr. G. Berkley, vice-president Institution of Civil Engineers, and Captain Douglas Galton, R.E., Assoc. Inst. C.E., was appointed to adjudicate on the tenders; and when the report of this committee had been supplemented by others from Sir John Fowler, past president Institution of Civil Engineers, and Mr. John Whitton, M. Inst. C.E., Engineer-in-Chief for Railways, New South Wales, it was finally decided to accept the tender of the Union Bridge Company, of New York, who undertook to complete the bridge within two years and a-half, for the sum of £327,000. The accepted design consisted of seven spans of 415ft. from centre to centre of the piers, the foundations being carried down in steel caissons filled with concrete, while the upper portions of the piers and the whole of the abutments were of masonry. The girders were formed of built steel compression members, and solid steel eye-bar tension-rods, all the connections being made by steel pins. The cross girders and rail bearers were of rivetted steel plate. The two main girders of each span were 410ft. long from end pin to end pin, and 58ft. deep at the centre, and were placed 28ft. apart from centre to centre, the bridge carrying two lines of railway. In the execution of the foundations it was found very difficult to sink the caissons in a truly vertical position through the great depth of mud that had to be penetrated before the sand could be reached. The tendency of the caisson to assume an inclined position, and to draw away from its true place during the process of sinking, gave rise to a great deal of trouble and delay, and in some cases could not be entirely overcome; and the author was of opinion that this difficulty was in great measure due to the form in which the caissons were constructed. In plan, the caisson formed a rectangle with rounded ends, its length, transversely to the bridge, being 48ft., while its outside width was 20ft. The outer shell of the caisson, having this contour, formed a vertical prism for the greater portion of its height; but in the lowest 20ft., the walls were splayed 2ft. outwards at the base by inclining them at a batter of 1 in 10 at the sides, and also at the rounded ends. Each caisson contained three circular dredging wells, 8ft. in diameter, placed along its axis at distances of 14ft. from centre to centre, the wells being splayed outward at the base in conical form, so as to meet the outer shell, and to come to a cutting edge at the periphery of the caisson, and also between the wells. The lower part of the caisson was built on shore, and, being temporarily fitted with a false bottom, was floated out and sunk to the bed of the river. The space between the wells and the outer skin was then loaded with concrete, and the caisson was sunk through the mud by dredging the material from the bottom of the three wells. If the caisson showed any tendency to cant transversely to the bridge, it could be righted by dredging one or the other of the wells in advance of the remainder; but when it canted transversely to the axis of the caisson, the central position of the well precluded the use of any such means of righting it. It was also believed that the splayed form given to the base of the caisson enhanced the tendency to cant over, as the sinking of the splayed shoe would leave around the walls of the upper portion an empty space, which would afterwards become filled up in an irregular manner, depending upon the consistency of the mud. For the work of erecting the main girders, a pontoon was constructed of sufficient size and stability to carry a complete span of the superstructure elevated above the deck upon staging high enough to command the piers, whose summit was 40ft. above high-water, the range of tide being 7ft. At a convenient point on the shore a gridiron was built at a distance of about half a mile from the bridge, and on this gridiron the pontoon was scuttled and allowed to remain, while the steelwork of a complete span was put together upon the top of the elevated staging above the deck. For the voyage of this craft out to the bridge a favourable conjunction of tide and weather was selected, and the scuttling valves of the pontoon having been closed at low-water, the vessel floated off the gridiron at the rise of the tide, and was warped out to the bridge by 6in. hawsers worked by steam windlasses, the operation being facilitated by the assistance of steam-tugs and by the flow of the tide. At the top of the tide, the pontoon was in place between the piers, the ends of the main girders being then a few inches above the bearings on the piers, and the vessel, being moored in this position, was allowed to fall with the ebbing tide until it left the girders supported upon the piers. In some cases the process was hastened by partially scuttling the pontoon. The author described the numerous vicissitudes of the voyage, which was repeated in similar manner for each span, and also the endeavours that were made to correct or to remedy the canting of the caissons. It was worthy of remark that although the successful tender was made by an American firm, yet the whole of the steel and ironwork was provided and manufactured in the United Kingdom, excepting only the swelled heads of the eye-bars.

(To be continued.)

SOCIETY OF ENGINEERS.

THE APPLICATION OF WATER PRESSURE TO MACHINE TOOLS AND APPLIANCES.

AT a meeting of the Society of Engineers, held at the Town Hall, Westminster, on Monday evening, March 3rd, Mr. Henry Adams, President, in the chair, a paper was read by Mr. Ralph Hart Tweddell, M. Inst. C.E., on "The Application of Water Pressure to Machine Tools and Appliances."

The author referred to his previous paper read before the Society in 1877, and to the greatly extended adoption of his system of hydraulic machines and appliances during this interval. He gave figures showing the continually increasing power and size of this class of machines during the quarter of a century which has elapsed since he first introduced them, and very closely analysed the relative advantages of hydraulic, pneumatic, and electric transmission of power, considered in their special relation to working machine tools and the appliances in connection with taking the work to and from them.

The author, having emphasised the fact that the conditions to be fulfilled in the designing of a "complete system" of machine tools are very different from those affecting a "single machine," proceeded to point out the great number of conditions to be fulfilled by any motive power when applied to working machines varying greatly in their individual character and requirements. Dividing the subject of the relative merits of these three motive powers into (1) the convenient storage of the power, (2) economy and facility in distributing the same over large areas, (3) simplicity in its application to machine tools and the appliances required to take them to and from their work, (4) adaptability to perform work of the lightest and heaviest description, the author stated that, while electricity and air fulfil some of these conditions, they do not fulfil those of the most importance in connection with the class of work under discussion. On the other hand, hydraulic pressure not only fulfils all of the above conditions, but it is especially applicable to the working of machine tools and the appliances for lifting and transporting the materials operated upon by them. The author then referred to various improvements effected by himself and others in hydraulic machines now required to meet the altered conditions of rivetting, flanging, drilling, &c., in order to make sound work in the heavy boilers now used with high steam pressure.

The author then proceeded to describe the rivetting up of large bridges *in situ*, and referred to the first bridge so constructed namely, the Primrose-street Bridge, in London, which was rivetted up on the author's system in 1873. After alluding to many other bridges, the author pointed out the absolute necessity of a largely extended use of labour-saving appliances in workshops, such as cranes, lifts, capstans, &c., which are necessary, not only on account of the greatly increased weight of the work now machined, but also to keep all classes of machine tools in more continuous work. In conclusion, he pointed out that hydraulic pressure was as suitable for working these appliances as for working the machine tools themselves.

RECONSTRUCTION OF THE NEWARK DYKE BRIDGE, GREAT NORTHERN RAILWAY.

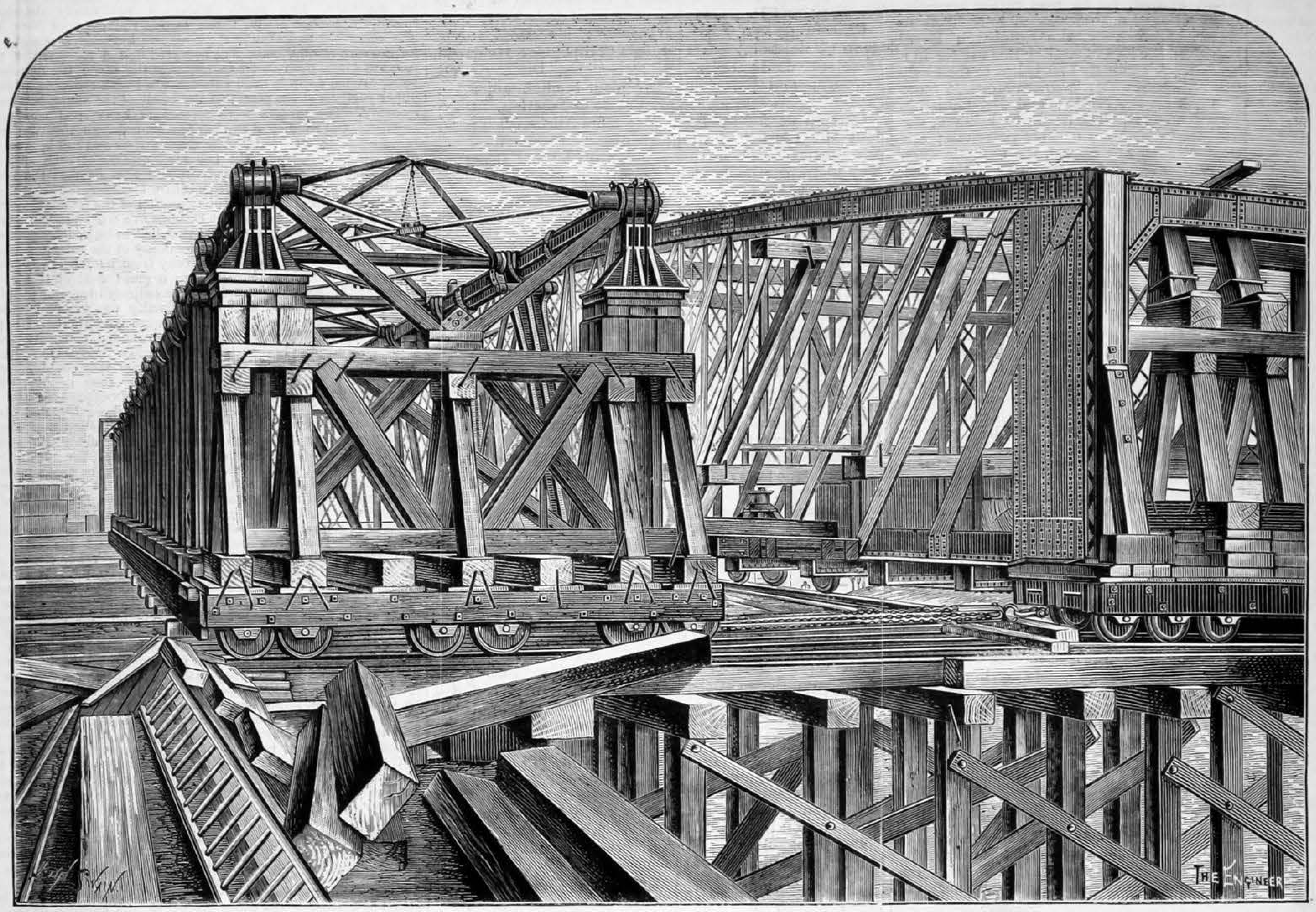


Fig. 7—REMOVAL OF OLD STRUCTURE, EASTERN HALF.

THE NEWARK DYKE BRIDGE.

IN THE ENGINEER issue of the 21st February a short notice was given of this bridge, together with an illustration showing the new bridge in the process of being placed in position. Before proceeding further with the description of the new structure, it may be interesting to state a few facts in relation to the old one concerning the kind of structure, and why it was thought necessary to replace it.

The old bridge was of the form known as the "Warren" truss, and was the largest span of its kind in this country, it being 259ft. from centre to centre of its bearings. There were two single bridges, one for the down and one for the up line. The trusses were composed of cast and wrought iron, cast iron being used for the top or compression member and the diagonals, the normal state of which was compression, and wrought iron being used in the bottom or tension member and in the diagonals that were subject to tension only. The top member consisted of a cast iron tube, varying in diameter from 13½in. at the ends to 18in. at the centre. The diagonal struts were cast with a jaw at the top-end to embrace the tube, and tapered towards the bottom tie. The bottom tie consisted of a series of links 9in. wide and enlarged at the ends to 16½in., to allow a connecting pin 5½in. in diameter to pass through, the diagonal ties being exactly like the bottom tie. The bottom tie graduated from fourteen links at the centre to four at the ends. The diagonal ties graduated from two at the centre to four at the ends, the thickness varying from ¾in. to 1in. Fig. 1 gives an end view of the original bridges. The main trusses were on the whole well constructed, the iron being of the very best quality and workmanship. The wind bracing at top and bottom was hardly in keeping with the main trusses, being badly designed and loosely fitted.

The cause of the bridge wearing so badly was the manner in which the road was carried by the main trusses, cross timbers 8in. deep being placed across from truss to truss, and resting directly on the bottom tie, so that when the timber deflected during the passage of the trains all the pressure came upon the inner links, and as the links were fourteen in number at the centre, the leverage tending to cause rupture of the inner diagonals was considerable.

The bridge was erected in 1849 and 1850, and was calculated to take a maximum moving load of one ton per foot run. The load was, at the time the bridge was erected, thought to cover any possible increase that might occur in the rolling stock of the future. This of course was a pardonable error, when we find that the "monster" locomotive of the period, the Lord of the Isles on the Great Western Railway, only weighed about 60 tons with tender included. The express locomotives and also the heavy goods on the Great Northern system, now weigh nearly 78 tons; engine being 42 and tender 36 tons. This heavy increase in the weight of the rolling stock of the company was a serious thing for the old structure, and in 1879 Mr. Johnson gave instructions for the thorough overhauling of all the parts. It was then found that in consequence of the defect in the method of carrying the flooring, the inner links of the diagonals in the centre of bridge had elongated about $\frac{1}{16}$ of an inch, thereby putting all the stress on to the outer links. The method of laying the floor was then altered, and arranged in such a manner that all the members did their share of the work that was required of them. In 1888, fresh signs of weakness occurred, and as they were beyond the possibility of a remedy Mr. Johnson decided on a reconstruction, and with that end in view instructed his assistant, Mr. E. Duncan, to prepare designs for a new steel structure. Upon this design, the directors invited tenders for the execution of the works, and in November of that year accepted one sent in by Messrs. Andrew Handyside of the Britannia Ironworks, Derby. The work has taken rather longer than was contemplated, but the causes of the delay did not rest with the contractors, both steel and timber being difficult to obtain.

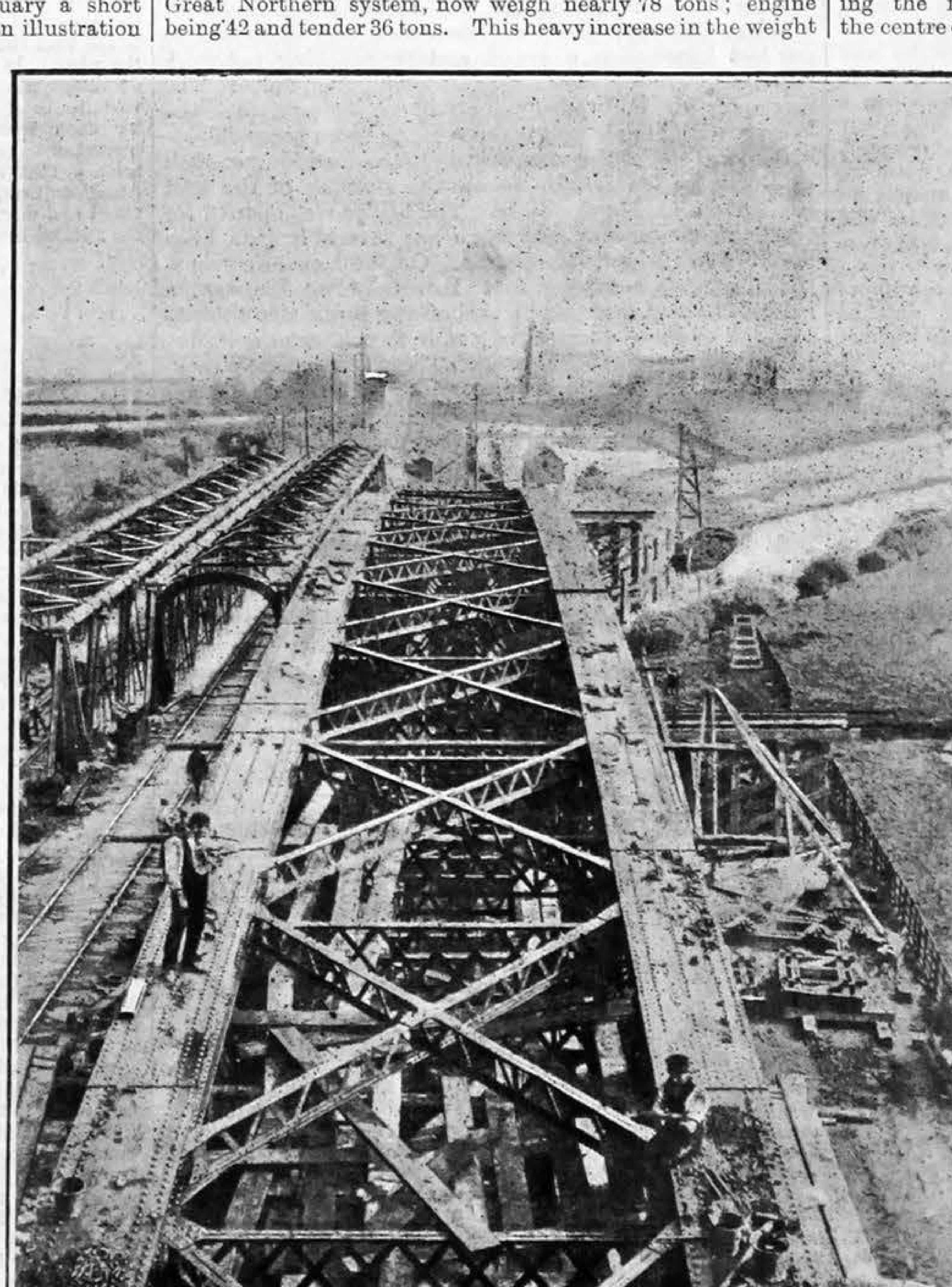


Fig. 2—BIRD'S-EYE VIEW OF NEW BRIDGE DURING CONSTRUCTION, WESTERN HALF.

The design of the new bridge is of the class of truss known as the "Whipple-Murphy" type, and it is made entirely of steel, the steel used being made by the basic process. Upwards of 400 tests were made during manufacture at the Staffordshire Steel and Ingot Iron Co.'s works, near Wolverhampton, and also by Mr. David Kirkaldy, the tests in all cases showing a remarkable uniformity. The company's specification stated a minimum of 28 tons, and maximum of 32 tons per square inch of area of specimen before straining; and the average breaking strain was about 29¼ tons, with about a variation of a little less than 1 ton per square inch more or less.

As the new bridge could not be constructed *in situ*, a staging had to be formed about 600ft. long, and parallel with the old one; in order to do which piles varying from 30ft. to 38ft. in length had to be driven by the side of the embankment and across the river. The piles were driven five abreast, two outer ones 5ft. apart carrying longitudinals, the full width of the stage being 33ft. Upon this stage the girders were constructed between two lines of rails—see Figs. 2 and 3—upon which twenty-four trolleys were placed, twelve on each side, each trolley having an hydraulic jack in the centre. These trolleys were divided into four sections, and connected up; struts and ties were then fixed on the top of each jack. Each section of jacks was connected by a pipe passing along the length of that section, a connection being made with all the six jacks. These pipes were fed from four small pressure pumps, one placed in each section. By this means the pressure was applied simultaneously in all four sections, and the whole bridge lifted and carried by the twenty-four jacks, the whole bridge was then moved forward upon the trolleys

RE-CONSTRUCTION OF THE NEWARK DYKE BRIDGE, GREAT NORTHERN RAILWAY.

MR. RICHARD JOHNSON, M. INST. C.E., ENGINEER; MESSRS. ANDREW HANDYSIDE AND CO., DERBY, CONTRACTORS.

(*For description see page* 192.)

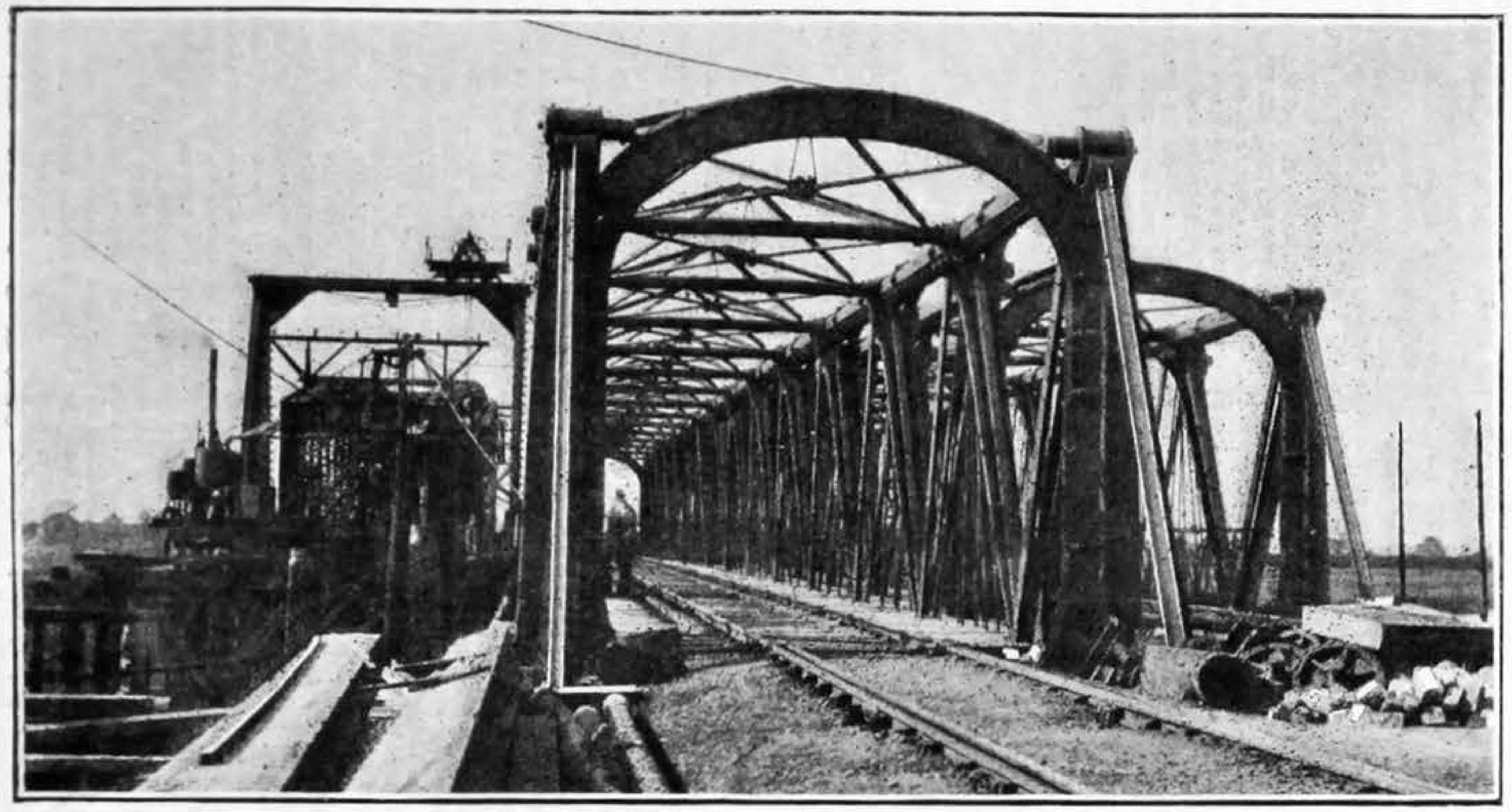


Fig. 1—GENERAL VIEW OF OLD STRUCTURE BEFORE DEMOLITION.

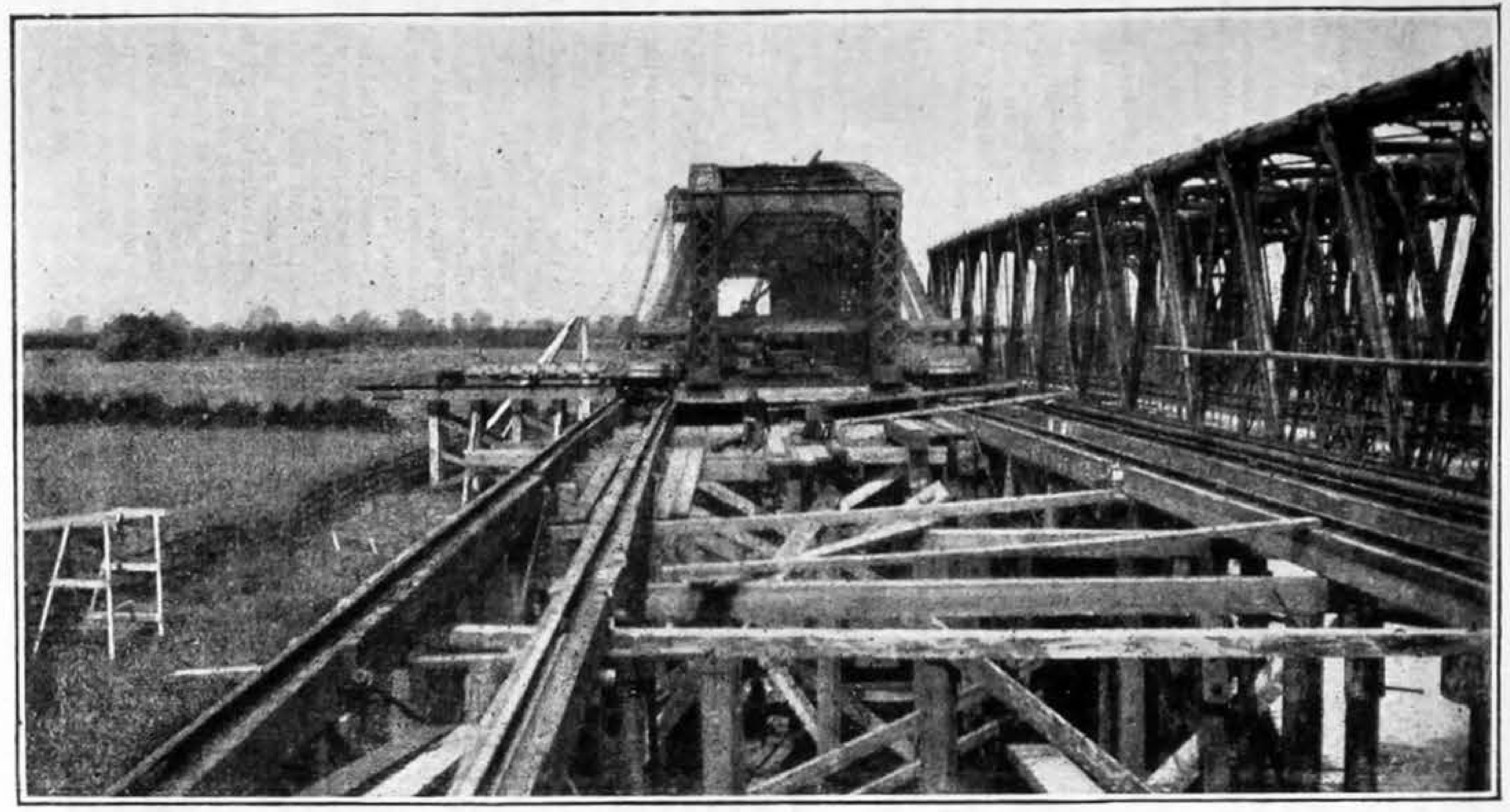


Fig. 3—NEW BRIDGE PLACED ON TROLLIES READY FOR MOVING FORWARD.

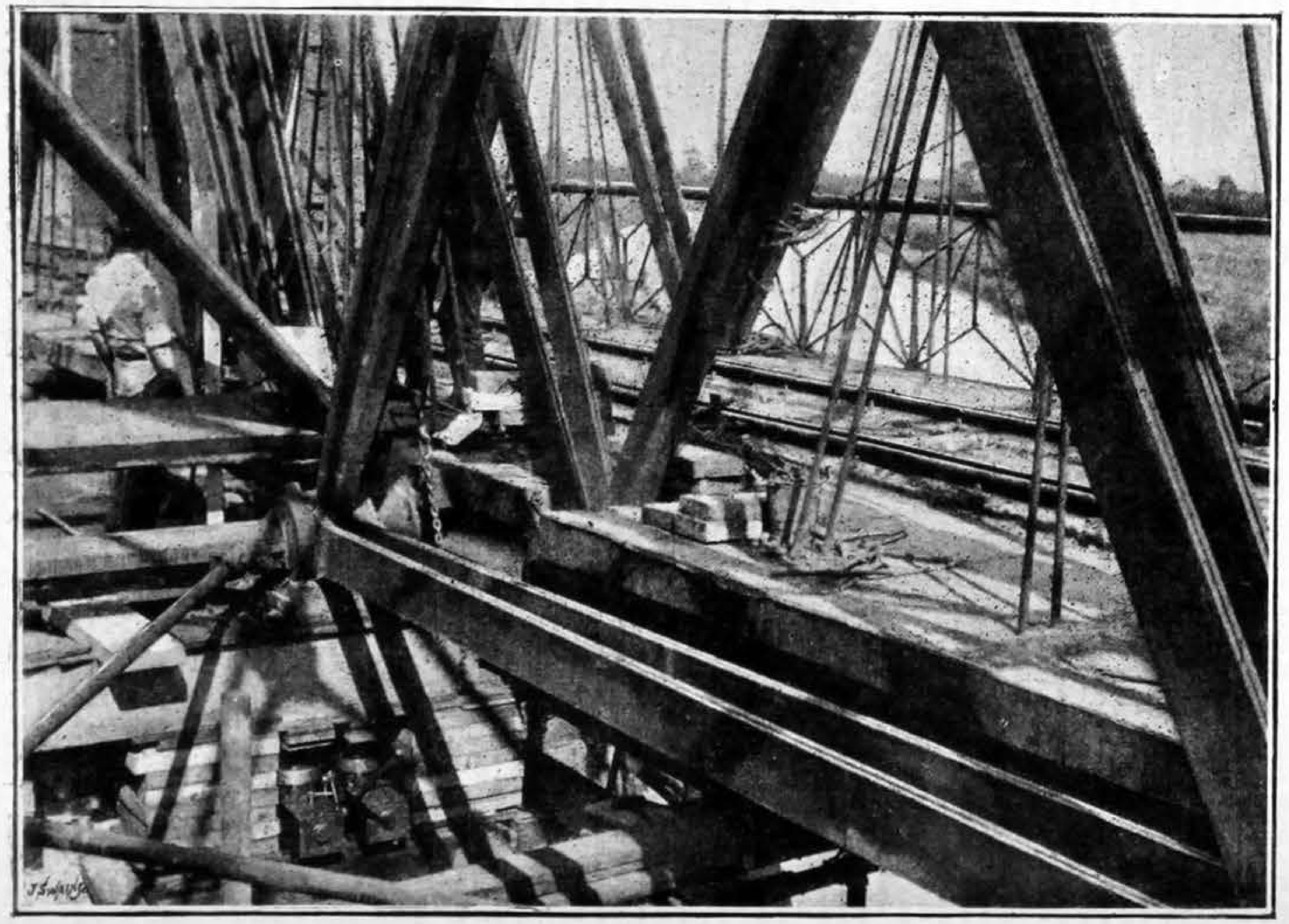


Fig. 5—OPERATION OF LIFTING THE OLD BRIDGE OFF THE CAST IRON END FRAMES.

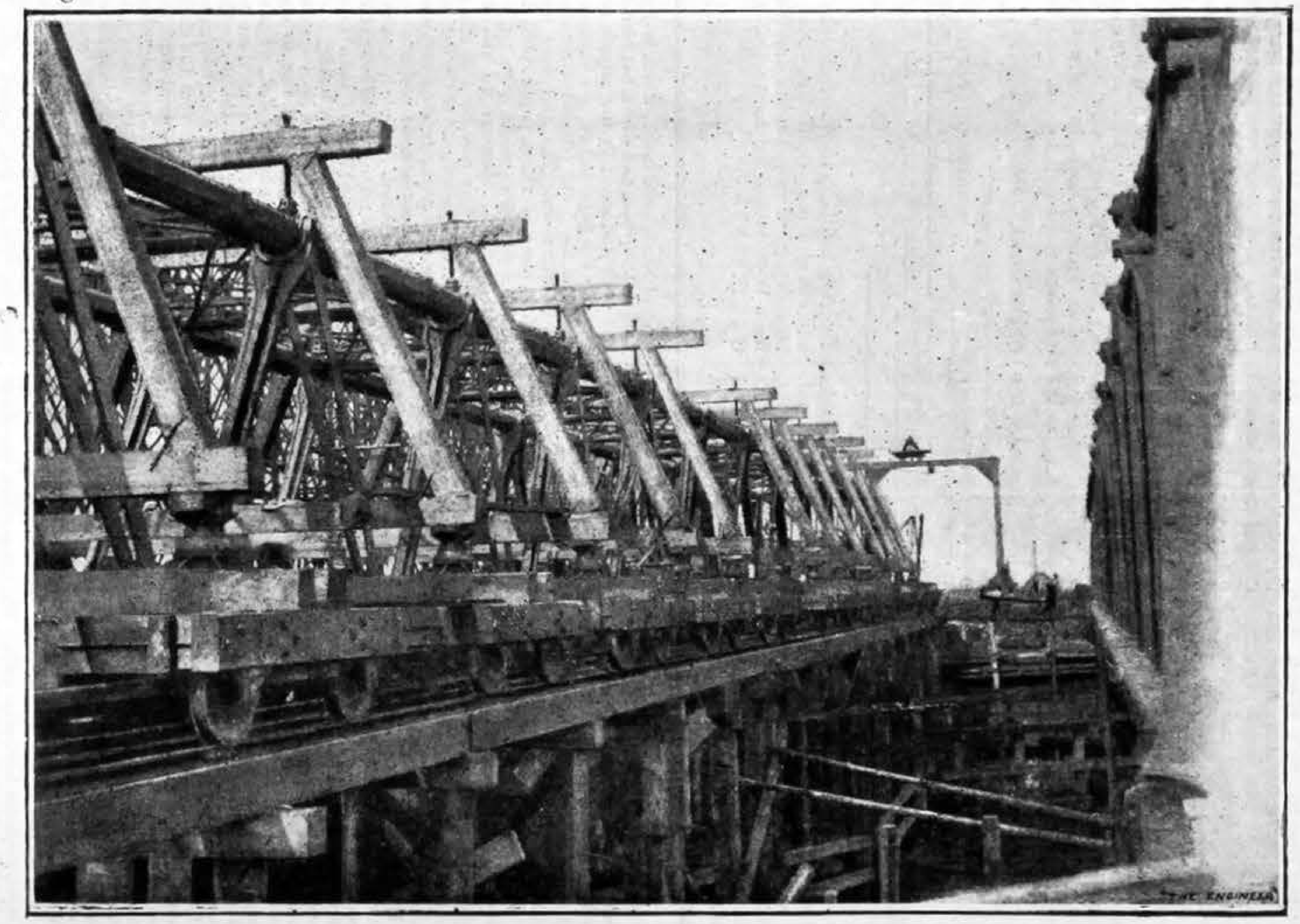


Fig. 6—REMOVAL OF OLD STRUCTURE WESTERN HALF.

as shown by our illustration in our issue of February 21st last, and when the centre of the new bridge was directly in line with the centre of the old one, two large trolleys, each running on twenty-two wheels, were placed under the ends, and the twenty-four jacks lowered until the bridge rested on the large trolleys at the ends. The twenty-four small trolleys were then disconnected and pushed back to where the bridge was built up.

The next operation was to get the old bridge off the cast iron frames; a part of this work is shown in Fig. 5, where two jacks, each capable of lifting a hundred tons, can be seen placed under the end strut. Four of these were used, two to each truss. The bridge was then lifted 3in. and the cast iron frames removed, and the lifting proceeded with until it was 20in. above its old position. A timber back and connected up in a similar manner to that done with the new bridge; but as the old bridge was much lower than the new one, and in order to save cutting the timbers, the cross struts were placed on the top, and the bridge suspended with forty-eight 1¼in. wrought iron bolts, as shown on Fig. 6. The bridge was then drawn away, and placed on the blocks occupied by the new girders during their construction. The new bridge was then hauled across into its final position, the end trolleys removed, and the bridge lowered, first on to the fixed bearing, as shown by Fig. 8, and then on to the roller bearings, as shown by Fig. 9.

The total weight of the new bridge, together with the flooring and permanent way, is 430 tons, and the old one 320 tons. In both cases, in order to save time, the permanent way was fixed and moved with the bridges. The following

DIAGRAM OF OPERATIONS.

trolley, as shown in Fig. 7, was then fixed, and the jacks moved to the other end and the same operation carried out. When both ends were lifted and securely fixed to the trolleys, the bridge was hauled out sideways, as shown by Fig. 7. As soon as it was placed on the stage between the two lines of rails, the trolley carrying the hydraulic jacks were pushed diagram will help to illustrate the transposition of the new and old girders respectively:—No. 1, new bridge built at A, on completion moved to B and on to C; No. 2, old moved from D to B and on to A; No. 3, new bridge moved from C to D.

(To be continued.)

THE BEHAVIOUR OF STEEL.[1]

In compliance with the suggestions below, the following questions were raised for discussion:—

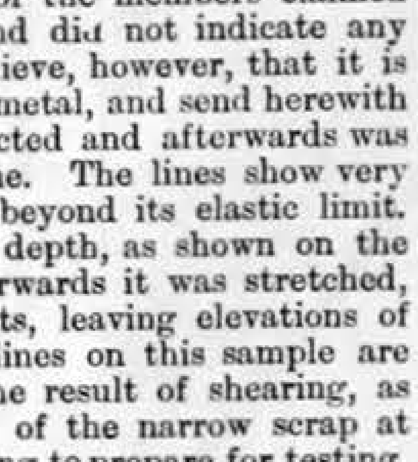
What experiences and phenomena can you describe as to the conduct of steels under the conditions in which you were using them? How much allowance is wise in shrinkage fits with steel? What is the best form of cross section to adopt for steel castings of a complicated nature, in order to secure solidity and freedom from shrinkage cracks? How often must the skin of steel be removed in grinding true gauges, &c., before change of form ceases?

Mr. H. D. Hibbard: In discussing Topic No. 66, I would like to call the attention of the members to the importance of giving as far as possible the history of the steel under consideration. To those not engaged in its manufacture, steel is steel, but not necessarily so to those engaged in the business. Unless the history of its manufacture is known, much of the other information about it is useless. Even with the chemical analysis known, which is essential, the great variations in physical properties due to different methods of manufacture and subsequent treatment, may account for any anomalies, and, unless these are known, the mysterious element of the symposium will not be kept at a minimum. As no two plants are alike, no two methods alike, and no two men alike, the most complete description of the steel would include the name of the firm, and the man who made the steel. Then would follow the subsequent manipulation to put the steel in shape for use. Even then the mishaps it has met with from bad workmanship will never be known.

Mr. Wm. Kent: The lowest tensile strength I have ever found in steel was 42,000 lb. per square inch. It was American open-hearth steel, made for horseshoe nails. The composition was about C 0·10, P 0·012, Mn 0·20, Si 0·02. It was necessary to keep the phosphorus extremely low to secure the low tensile strength and great ductility desired. Some three years ago I procured thirteen samples of watch springs, and tested them for tensile strength in a crude apparatus, in which a strong spring balance was used to indicate the strain. The springs included a Jurgensen mainspring, an English, a Waltham, a Waterbury, and several other springs of various sizes and different tempers. The tensile strength of the whole lot of thirteen varied between the limits of 300,000 lb. and 375,000 lb. per square inch, a much less variation than might be expected, considering the variety of sizes, tempers, and sources from which they were obtained. The samples exhibited in connection with this paragraph are trusses for torsion balances, with spring steel wires stretched upon them, and have been under test for some months past in the factory of the Springer Torsion Balance Company. The longest of the three wires on the double truss has been twisted through an angle of 45 deg., that is, 22½ deg. each side of its normal position, 7,100,000 times. The two shorter wires on the single trusses have been twisted through an angle of 16 deg., 2,200,000 times. These wires were stretched originally to the notes C sharp and D above the staff respectively. After they had been twisted 1,000,000 times each, the tone was tried again, and one of the wires appeared to have a tone half a semitone higher, and the other was about half a semitone lower than when the test was begun—possibly a mistake in the original tuning. After they had been twisted 2,000,000 times each, the tone was found to be the same as it was after 1,000,000 twists.

Mr. Levi K. Fuller: In 1885, I had occasion to make a series of dies and punches for the Estey Organ Company, to be used in punching sheet brass for reeds, both block and tongue, for use in their organs. The steel was No. 4, Sanderson Brothers Steel Company, Syracuse, N.Y. The bar was cut into various sizes in a planer, heated in a charcoal fire, and annealed in wood ashes. They were then planed to various sizes and thicknesses, ranging from $\frac{1}{16}$ × 1 × 3 to ½ × 3 × 3. These were heated to a bright red, in accordance with the instructions printed upon the label on the bar of steel, hardened in water and ground without the temper being drawn in the least. They were then subjected to grinding in an emery grinder to the proper sizes. They were ground on a frame but not confined, remaining loose so as to allow the steel to move, if there were any tendency in that direction. As the skin was removed upon one side, the surface was slightly concaved, and they had to be turned over and ground upon opposite sides five times before they ceased changing their form. The various blocks were planed ·010 thicker than the finished size to allow for grinding. They were ground ·0001 in. alternately on each side, receiving a total of five grindings upon each side, reducing the total thickness ·010 in., as above stated. After they had been ground a few hours, they began to crack, and nearly every one was ruined by reason of this tendency. In some cases they would break into a dozen pieces. I had communication with Sanderson Brothers Steel Company, and they attributed the fact to overheating; but the description "a bright red" had been strictly followed, and had been none too high for similar steel for a like use. Samples of this were sent to Sanderson Brothers and tempered by them, and the temper slightly drawn, but it was not sufficiently hard to do the work. We then resorted to steel No. 5, same make, which had precisely the same treatment as first described, and which has resulted in no case in breakage. The work performed by the sample returned to us by the Sandersons was the punching of five thousand reeds without re-grinding, while the No. 5 will punch twenty thousand, and with some thicknesses even more. The dies were perfectly square, and were set with a piece of tissue paper ·0005 in thickness between them, cutting a perfectly smooth edge.

Mr. Chas. L. Huston: In the discussion at the Nashville meeting as to the significance of the peculiar carved lines which appear in the disturbance of the surface scale of steel boiler plates, caused by the strains of shearing, some of the members claimed that it was only a scale disturbance, and did not indicate any injury to the metal. I have reason to believe, however, that it is an indication of injury to the body of the metal, and send herewith a piece of plate, which had been so affected and afterwards was stretched and broken in a testing machine. The lines show very plainly that the metal had been strained beyond its elastic limit. not only upon the surface, but to some depth, as shown on the edges of the test piece, so that, when afterwards it was stretched, it did not so readily yield at these points, leaving elevations of slight extent upon the surface. The lines on this sample are not so much the peculiar curved ones, the result of shearing, as they are those resulting from the curling of the narrow scrap at the shears and the subsequent straightening to prepare for testing. I have observed, as also have many other workers of steel, that metal of some degree of ductility, when subjected to strains, will sometimes crack like glass, showing no evidence of ductility at the point of fracture. I noticed, some five years ago, one striking case of a ⅝ plate of American-made basic steel, which was sent to a locomotive works to try its flanging qualities. It was flanged into a locomotive throat sheet, the edges being first turned down, and then the concave end worked out. The next morning a crack appeared at the opposite end A, which had not been heated at all, and had had the roughness of shearing removed by planing. This crack continued to extend for a week or ten days, until it reached the whole way across to the part that had been heated. This, of course, was due to the contracting strain at the flanged end, and the sides of the crack showed little or no evidences of having reduced or stretched at the fracture. I had a test piece taken from one side of the crack—as at B—and prepared, so that when pulled it had the crystalline face of the crack for one edge of the test piece. The test taken nearly across the grain of rolling showed a tensile strength of 68,580 lb. per square inch, and a reduction of area of 42 per cent., with a fibrous fracture. I send one end of this piece, which, however, is almost too old and rusty to show its character. Some curious tests made by my father were published in the *Journal* of the Franklin Institute. One series, 1878, shows that steel and iron both, when raised to about 600 deg. heat Fah., lose in ductility and gain in tensile strength; this is also corroborated by bending and tensile tests made in Europe and translated for the *Journal* of the Franklin Institute in 1885. Another set of my father's tests shows the effect of straining iron up to nearly its elastic limit and continuing the strain for twenty-four hours or more, the result being in some cases raising the elastic limit almost to the ultimate strength of the material.



Mr. W. W. Dingee: In reply to query 66, I will say that the J. I. Case Threshing Machine Co. use large amounts of machinery steel in the manufacture of threshing cylinder teeth. This steel cannot be hardened with any certainty by any of the usual methods. The chief trouble with it comes from its uneven texture. It is not very uncommon to find a bar which may be broken like cast steel; when within a short distance of the break it can be bent cold.

Mr. Chas. T. Main: During the year of 1883, when re-arranging the driving system at Lower Pacific Mills, it was thought that steel shafts for head lengths would be stronger and more desirable than iron. Accordingly, quite a large number of these, of 4in. and 5in. diameter, were put in. The calculated sizes were amply sufficient to carry their respective loads, and the shafts were well supported by hangers near the pulleys, and were firmly held. In less than a year, two 5in. shafts had broken in one place, and one in another place, and four 4in. shafts had broken. These were replaced with forged iron shafts, which were subjected to the same conditions of load, speed, &c., the bearings remaining the same as before. The 5in. shafts are still running under the same conditions. The 4in. are still running, although the conditions have more recently been changed. The other steel head lengths which did not break were all changed for iron with one exception, which still remains as it was.

Mr. George R. Stetson: Having taken part in the discussion on steel at the Nashville meeting, and learned through the authority of a member that electro-plating tempered steel is another illustration of the "unexpected which sometimes happens," and having constant reminders in the same line, I should be interested and instructed by the continuance of the discussion of this topic. I forward, for exhibition, the drill spoken of at Nashville. The singular regularity of the fracture is peculiar. The brake was not at a shoulder, but about an inch therefrom. As I stated at the meeting, this piece of steel broke during the night, after having been in the hands of a workman for several hours. This shank was forged from larger stock and cooled by dipping in water. There was heat enough to harden it somewhat, as shown in the groove. The cooling no doubt caused the fracture, but why it should have taken several hours before the break occurred I do not understand. The steel stood rough handling, but broke during the night while lying on a machine, the part shown being found on the floor. I think it is not good practice to hurry the cooling of steel in this way, although the water annealing of steel is usually satisfactory, if carefully done. This breaking after hardening is not unusual, sometimes not developing for several days. One of the members spoke of such an incident happening after months. There may be foundation for the beliefs that clock and watch springs break during a thunder shower more frequently than at other times, and that a razor is improved in cutting qualities after lying unused for some time. I exhibit also part of a large tap broken in hardening—the imperfection of the steel is apparent. Such a fracture is common with large tools; but whether large tools that do not break have this imperfection or not it is impossible to know. The majority of sizes ¼in. and above that do break show irregularity in grain somewhat like the sample. The question naturally arises, Why should so slight a cause produce this result? The most common breakage of taps in hardening is at about one diameter from the entering end of the tap. I think, by screwing an iron washer over the end of the tool to keep the water from it, this breakage could be lessened. This could be done by tapping out the centre for a small machine screw and holding the washer against the tool by this screw. I exhibit also some samples of drills cracked in hardening. Much the larger loss from breakage on drills larger than ¼in. show this peculiar fracture. It is not confined to any part of the twist, though the samples are towards the shank or solid part of the drill. You will notice a peculiar uniformity in the fracture. In all the hundreds I have noticed, the fracture never is reversed or pointing toward the shank. I am convinced that this brake is from solid stock, not being caused by an imperfection in the steel.

Mr. W. E. Crane: The peculiarity of steel shrinking when hardened is valuable in many industries, such as dies for drawing tubes, rivets, &c. When a die becomes worn, it is a simple matter to take it to the blacksmith and have it re-hardened and shrunk. If steel would do this indefinitely, these dies could all be worn out on one size, but there is a limit to the number of times that the same piece of steel will shrink, this number being from five to seven, after which it does not shrink. It is possible that steel might be reheated and cooled seven or eight times—if it would not be injured—and then the tool ground to size and hardened and retain its size.

Mr. Ezra Fawcett: We had occasion some time since to make some large taps and dies for bridge bolts, and, being in a hurry, the forger in annealing left them in a bed of charred—bituminous—coal on the forge over night, to give them a good "soaking," as he called it. On working the steel, we found it to have a very coarse, crystalline structure and brittle. Needing them immediately, we finished them up, tempered, and put them to work. One of them broke after threading some hundreds of nuts, but did not show as large a crystalline structure as before tempering; the others have been in use ever since. The steel was ordered for the special purpose from a well-known manufacturer in Pittsburgh, and had every appearance of being first class.

Mr. Thomas S. Crane: I am surprised that no one has alluded to the peculiar formation of the ingots from which high carbon steel is produced, and I will call attention to the fact that all such ingots are defective at one end, and that such defect is embodied in the bar when the ingot is worked up, and is only eliminated by a tedious process of inspection in the mills. I believe that, with the exception of those breakages which arise in hardening from the peculiar shape of steel articles, most of the flaws and cracks are produced in hardening by the hidden imperfection ordinarily existing in the ingot and afterward preserved in the finished bar. High carbon steel, used for making tools and for other purposes when hardness is required shrinks a great deal in cooling, and the ingots, always have a pipe in the upper end, extending from one-quarter to one-half of its length downward. When the ingot is worked down into a bar of any size whatever, the lack of union between the opposite sides of the pipe forms a flaw or seam, which is quite discernible to the eye when the bar is broken upon its end; and it is common for the inspector to break foot after foot from the end of the bar to remove the injured portion, so that the remainder may be sold with confidence as a sound article. It is very evident that a point in the bar would be reached where the defect would not be perceptible to the eye, but exist in sufficient degree to cause a crack when the metal was exposed to any internal strain in hardening. It is not merely a theoretical conclusion "that a crack would arise when hardening where the defective union between the sides of the pipe remain, as it would weaken the cohesion of the steel at that point;" but it is a matter of common practice in testing samples of steel for such defects to break a piece from the end of the bar and harden it to see if it will crack. No system of inspection is perfect enough to prevent infallibly the existence of such cracks in the steel, and it appears to me that it is the defect or pipe in the ingot to which we must trace many of the extraordinary cracks which arise at peculiar and unexpected points in steel articles when hardened. I hope to present a paper at the next meeting upon the means used to prevent piping in ingots, and have some interesting examples of the defects caused by the pipe in the finished bar.

(To be continued.)

[1] Topical discussion by the members of the American Society of Mechanical Engineers. At the Nashville meeting, in the discussion of Topical Queries No. 309-64, one of the members closed a most interesting debate as follows:—"I think this discussion of the peculiar phenomena exhibited in steel is so very interesting that we ought to have some day a sort of symposium presented by the members of the Society on steel phenomena. Each member can contribute what would amount perhaps to half a page, describing some peculiar phenomena which he has witnessed, bringing facts, not theories, that will add to the amount of our knowledge on steel, and lead to some true or some better theory of these peculiar phenomena. I make that suggestion for the topical discussions for the next meeting." This suggestion was favourably received by the members present, and members were specially requested to send the secretary brief accounts of their experience in manipulation and conduct of all grades of steel, to be presented in this discussion.

LIGHTHOUSE ON CAPE HATTERAS.—Bids will be opened in the office of the Lighthouse Board, July 1st, for the erection of a lighthouse on the Outer Diamond Shoal off Cape Hatteras, N.C. The total cost of the structure is limited, by act of Congress, to 500,000 dols. A lighthouse on the outer shoal would have undoubtedly saved many vessels, as the nearest light on Cape Hatteras is invisible in bad weather. A light has never been erected on this shoal before on account of the extraordinary engineering difficulties in the way, and the work now contemplated will be the greatest undertaking in the line of lighthouse building in the world. There are but two lighthouses in the world that can be compared with it. Those are the Rothersand light situate at the mouth of the Weser River, in the North Sea, and the Fourteen-Foot light at the mouth of the Delaware Bay. The tower is to be 150ft. high from low-water mark to the light in the lantern. The Lighthouse Board does not specify what method shall be adopted, but it is generally understood that an immense caisson, 80ft. to 100ft. in diameter, with a hollow iron cylinder projecting from its centre, will be built at the most convenient port. When it is finally at the site, it will be sunk rapidly until its cutting edges rest on the sands of the shoal. As the sand beneath the caisson is excavated and carried up through the tube the sharp edges will sink lower, until finally bed-rock is reached. When all the edges rest firmly on the rock, the entire caisson and the tube will be filled with concrete to a height of 30ft. above the sea level, converting it into a solid block and column of stone almost as firm as a granite monolith. It will be protected by a rip-rap packing of granite blocks, weighing not less than two tons each. Above this solid structure will rise an iron and steel tower divided into ten stories, including the watch room and the lantern. Work is to be commenced within one month from the date of the approval of the contract, and the contractor is to fix the time within which it is to be completed. No payment is to be made until the lighthouse has been in successful operation a year. Notwithstanding the unusual difficulties in the way of carrying out this work, a number of large engineering firms will probably bid, and it is thought there will be no difficulty in entering into a contract. The primary question to be settled here is the question of securing a foundation. It would be well therefore to separate the proposals for the foundation from those for the lighthouse itself. One is a question of engineering, the other a question of architecture. Contractors who might undertake to establish a foundation in the shifting sand of Hatteras shoals might not be willing to undertake the unfamiliar business of putting a building on it. The foundation should be carried sufficiently above the water to assure the safety of the structure placed upon it.—*Baltimore Sun.*

RAILWAY MATTERS.

GREAT preparations are being made by the Russian Government to begin the construction of the Siberian Railway next spring at both ends.

A PROPOSAL is under consideration by the Indian Council to convert all the narrow-gauge lines of railway in India to broad-gauge lines, at a cost of twenty millions sterling.

THE Ceylon railway line is now laid to within a couple of miles of Bentota, and most of the stations are nearly completed; but the line cannot be opened for traffic until the arrival of the materials for the bridges over the various streams and back-waters. We learn that the surveyors have found an easy trace for the extension beyond Bentota, but the bridges over the large rivers that have to be crossed will, of course, form a costly item.

GREAT activity, says the *Indian Engineer*, is being shown by various railway officials in Southern India, several companies being anxious to secure some new lines proposed. The agent of the Madras Railway, having proposed to undertake the survey of a line on the broad gauge from Nepore to Guntoor, Government has placed Rs. 20,000 at his disposal for this purpose. This line will be an extension of the Madras Railway, and will ultimately be extended to Bezwada.

LAST Tuesday morning, at about three o'clock, the Scotch express ran through Carlisle station, where it should have stopped, and at an estimated speed of about thirty miles an hour dashed into the engine waiting to take the train on. It is supposed that the brakes failed to act; slippery rails are also spoken of in connection with the accident. Four people were killed and several severely injured. Enough is not yet known to permit any definite report to be given of the affair.

THE work of changing the tracks of the West Shore railway at Fort Clinton to make room for the westerly tower of the Hudson Suspension Bridge at the water front is nearly finished, and the bridge company expects that the ground will soon be cleared to permit the beginning of work upon the tower foundation. The *Railroad Gazette* says the company is investigating the use of electricity with a view of hastening the operations at Bull Hill Tunnel, through which is to run the railroad from the western end of the bridge to Turner's Station on the Erie.

GRADUALLY the electric motor is being enlarged, and it is rapidly approaching a size that gives it a capacity not much below our average switching steam locomotive. An American contemporary says:—One of the latest moves in the direction of a higher capacity electric motor is that of the Thomson-Houston Company, who are now building some electric locomotives for the West End Street Railway Company, of Boston, capable of drawing a long train of cars; that is, there will be a powerful motor car drawing a number of cars, as is common with cable systems of street railroads.

IT is reported that the Imperial trains on the Nicolai, Moscow-Koursk, and Warsaw railways, have each been fitted up with the Westinghouse new quick-acting brake; also that the North-Eastern Railway of England, the State Railways in Hungary, Baden, Wurtemberg, and Bavaria, and several lines in Switzerland, have adopted the new brake for all future equipments. As regards the Wurtemberg State, it is officially announced that with the completion of the year 1890, all passenger trains will be fitted with Westinghouse brakes, and the necessary appropriation of 724,786 marks has been made.

THE electrically driven snow sweeper in use on the West End Street Railway, in Boston, consists of a platform car, mounted on a four-wheel truck, two Thomson-Houston motors of 15-horse power each being attached to the axles. Underneath each end of the car is a large cylindrical brush made of rattan, set at an angle of about 45 deg., and reaching across the track. The brushes are revolved very rapidly by power from a 15-horse power electric motor, which is on the platform of the car. The sweepers are propelled precisely the same as the electric cars, the long pole reaching the trolley wire being fixed to a post on the platform.

A SERIOUS accident occurred on Tuesday afternoon to the Flying Dutchman, between Slough and Paddington. It appears that the right-hand front-axle box of the hind bogie of a central carriage heated, and the journal end of the axle was twisted completely off. The wheel that was freed kept rolling, and that at the other end of the axle dropped to the sleeper; but the carriage was prevented from falling by the two wheels behind. A platelayer at Langley saw the box firing, and got the signalman there to telegraph to West Drayton, but Hayes was reached before the train was stopped. At this station the passengers were transferred to the foremost carriages, and the injured coach was left behind. The train ran over a mile with the wheel off.

REFERRING to the tests of locomotive engines with a view to testing the superior economy of the compound system, the *Railroad Gazette* says:—This suggests a fact relative to compound locomotives to which our attention has again been called, this time by Mr. H. H. Westinghouse, who has probably experimented more with compound stationary engines of sizes differing but little from locomotive dimensions than any other manufacturer in this country, and as much as any other in the world, unless it be the Willans Engine Company, of England, which has made a speciality of triple-expansion stationary engines. The Westinghouse engine experiments show conclusively that with a plain, non-condensing, compound engine it matters but little, so far as economy is concerned, whether the cut-off in the high-pressure cylinder be at three-fourths or one-half stroke, and that a decrease of the cut-off below half-stroke rather decreases than increases the economy; and further, that below one-half stroke a throttling governor is quite as economical as an automatic cut-off, so far as the high-pressure cylinder is concerned. Some tests made a few years since at the Massachusetts Institute of Technology showed that at early cut-offs it was quite as economical to throttle the steam as to use the automatic cut-off, and that at very early cut-offs the throttling plan was the more economical.

IN view of the application to Parliament for the absorption by the North British Railway Company of the Glasgow and South-Western Railway, an important agreement, which is scheduled to the Bill, has been entered into with the Midland Railway Company. Under this agreement the Midland Company consent to support in Parliament the proposed amalgamation of the two railways in question, who, on their part, agree to forward annually, by the Midland route, a minimum proportion of English traffic under their control, from Glasgow and places west thereof, equal to the aggregate proportion of the traffic already forwarded by both railways, calculated on a three years' average prior to the 31st January, 1889. The Midland Company further agree to make a fixed monthly payment to the amalgamating companies—based on a three years' average—in lieu of the hitherto fluctuating payment relative to the apportionment of through traffic. On the other hand, the amalgamating companies agree to maintain express passenger and goods train connections with the Midland services at Carlisle, and also to work passenger trains between Balloch and Helensburgh respectively and St. Enoch Station, in connection with the Midland morning and evening up and down express trains between Glasgow and London. It is also agreed to grant the Midland Company running powers between Carlisle, Perth, and Dundee, over such portions of their system as the Midland Company do not at present possess running powers. This agreement, which is to be carried out by a joint committee, to be called "The Midland and North British Through Traffic Committee," is to be construed, in the event of any difference arising, by Lord Grimthorpe or Sir Theodore Martin, whose decision is to be final.

NOTES AND MEMORANDA.

THE deaths registered last week in twenty-eight great towns of England and Wales corresponded to an annual rate of 25·6 per 1000 of their aggregate population, which is estimated at 9,715,559 persons in the middle of this year. The rate varied from 16·5 at Cardiff to 43·7 at Bolton. In two other towns it exceeded 40 and in six 30.

IN London, 2560 births and 1802 deaths were registered last week. The annual death rate per 1000 from all causes, which had been 20·6, 21·3, and 21·8 in the three preceding weeks, declined again last week to 21·3. In Greater London, 3380 births and 2248 deaths, about one every four and a-half minutes, were registered, corresponding to annual rates of 30·6 and 20·4 per 1000 of the estimated population.

AT a recent meeting of the Paris Academy of Sciences, a paper was read on "The state of the Magnetic Field in Conductors of three Dimensions," by M. P. Joubin. The results of these researches, which agree with experience, show that the magnetic field produced by a current exists in the medium traversed by the electric flux as well as in the exterior medium. Another paper was read on "The Mechanical Actions of Variable Currents," by M. J. Borgman. In reproducing, with the limited resources of a laboratory, the interesting experiments exhibited by Prof. Elihu Thomson at last year's Exhibition, the author has obtained some fresh results, which he described.

IN a recent number of the *Comptes Rendus* is a paper "On the Electrical Resistance of Iron and its Alloys at High Temperatures," by M. H. Le Chatelier. The electrical resistances for a considerable range of temperature of a number of iron alloys have been examined. When the results are graphically shown, the curve for ferro-manganese—13 per cent. Mn.—is found to be regular, just as is the case with platinum or platinum-rhodium alloy, while the curves for mild and hard steels show distinctly two singular points at 820 deg. and 710 deg., and a silicon steel—Si = 3 per cent.—shows the former only. Ferro-nickel—25 per cent. Ni—behaves very peculiarly, as below 550 deg. two modifications having quite distinct properties exist, and nickel itself shows a sudden change of curvature at 340 deg.

THE value of metallic products of the United States in 1888 is given as follows by the *Engineering and Mining Journal*:—Pig iron, 6,489,738 long tons, 107,000,000 dols. spot value; silver, 45,783,632 troy ounces, 59,195,000 dols. coining value; gold, 1,604,927 troy ounces, 33,175,000 dols. coining value; copper, 231,270,622 lb., 33,833,954 dols. value at New York; lead, 180,555 tons of 2000 lb., 15,924,951 dols. value at New York; zinc, 55,903 tons of 2000 lb., 5,500,855 dols., at New York; quicksilver, 33,250 flasks, 1,413,125 dols., at San Francisco; nickel, 195,182 lb., 115,518 dols., at Philadelphia; aluminum, 19,000 lb., 65,000 dols., at Philadelphia; antimony, 100 tons of 2000 lb., 20,000 dols., at San Francisco; platinum, crude, 500 troy ounces, 2000 dols., at New York; total, 256,245,403 dols.

DR. SEDGWICK SAUNDERS, the medical officer of health and public analyst for the City of London, has presented his report for 1889. 249 analyses were made during the year, giving a proportion of 202 persons to each sample examined, and of these only eight—namely, six of milk and two of water—failed to reach the prescribed standard. Periodic examinations of the New River Company's water supply to the city, and of the various artesian wells, gave very satisfactory results, and in the only two instances where pollution existed it was directly traceable to contamination by surface drainage, and steps were at once taken to prevent such waters from being used for potable purposes. Adulteration in groceries, drugs, &c., would appear to be practically non-existent in the City, since none of the various samples failed to pass the test as genuine.

THE Royal Society of New South Wales offers its medal and a prize of £25 for, amongst other things, the best communication, if of sufficient merit, containing the results of original research or observation upon each of the following subjects:—The silver ore deposits of New South Wales; on the occurrence of precious stones in New South Wales, with a description of the deposits in which they are found; to be sent in not later than May 1st next. The meteorology of Australia, New Zealand, and Tasmania; anatomy and life history of the Echidna and Platypus; the microscopic structure of Australian rocks; to be sent in not later than May 1st, 1892. On the iron ore deposits of South Wales; on the coals and coal measures of Australasia. The competition is not confined to members of the Society, nor to residents in Australia.

AT the last meeting of the Meteorological Society, a paper was read on "Observations of the Motion of Dust, as Illustrative of the Circulation of the Atmosphere, and of the Development of Certain Cloud Forms," by the Hon. Ralph Abercromby, F.R. Met. Soc. The author has made numerous observations on the motion of dust in various parts of the world, especially on deserts on the west coast of South America. He finds that the wind sometimes blows dust into streaks or lines, which are analogous to fibrous or hairy cirrus clouds; sometimes into transverse ridges and furrows, like solid waves, which are analogous to certain kinds of fleecy cirro-cumulus cloud; sometimes into crescent-shaped heaps with their convex side to the wind, which are perhaps analogous to a rare cloud form called "mackerel scales;" sometimes into whirlwinds, of at least two, if not three varieties, all of which present some analogies to atmospheric cyclones; sometimes into simple rising clouds, without any rotation, which are analogous to simple cumulus topped squalls; and sometimes into forms intermediate between the whirlwind and simple rising cloud, some of which reproduce in a remarkable manner the combination of rounded, flat, and hairy clouds that are built up over certain types of squalls and showers. Excessive heating of the soil alone does not generate whirlwinds, they require a certain amount of wind from other causes to be moving at the time. The general conclusion is that when the air is in more or less rapid motion from cyclonic or other causes, small eddies of various kinds form themselves, and that they develope the different sorts of gusts, showers, squalls, and whirlwinds.

ON the physics and chemistry of the Challenger expedition there is an excellent article in the last number of *Nature*. Special reference is made in it to the work of Van der Waal on the continuity of the liquid and gaseous states; and Professor Tait is very vigorously called to account for his omission to refer to this work in the Challenger report, or for not knowing of the work when he wrote the report. There is also a significant and amusing reference to Professor Tait's book on "Heat." Other indications of a lack of admitted acquaintance with what has been done by others are not wanting. Taking $p(v - a)$ = constant, as the equation to the isothermal of a gas, and assuming that it applies approximately to a liquid, the author concludes "that water [at 0 deg. C.] can be compressed to somewhat less than three-fourths of its original bulk, but not further." He adds that "the whole of this speculation is of the roughest character," but makes no reference to the converging lines of evidence which indicate that liquids could be compressed to from 0·2 to 0·3 of their bulk at ordinary temperatures and pressures. The following values are found by different methods for the volume of the matter in the unit volume of water under standard conditions:—Deduced from observations on the refractive index of liquid water (L. Lorentz), 0·2061; deduced from observations on the refractive index of water-vapour (L. Lorentz), 0·2068; deduced from the molecular volumes of H_2 and O_2 obtained from refractive index or specific inductive capacity, 0·23; deduced from the molecular volumes of H_2 and air given by Van der Waal's theory, 0·33. Professor Tait's value is 0·717.

MISCELLANEA.

THE London Association of Foremen Engineers and Draughtsmen give their annual dinner on Saturday, the 15th, at the Cannon-street Hotel, Mr. W. H. White, Director of Naval Construction, in the chair.

LAST week the Forfarshire Road Trustees had under their consideration the appointment of a road surveyor for the Forfar district. Mr. George Wyllie, surveyor, Coupar-Angus, was, we are informed, awarded the position.

IT is reported that the owners of the leading smelting works of the United States have formed a trust with a capital of 25,000,000 dols., the object being, it is said, to place their interests beyond the control of the Lead Trust.

THE United Asbestos Company, Limited, have removed from Queen Victoria-street to more commodious premises at Dock House, Billiter-street, London, E.C., lately in the occupation of the East and West India Dock Company.

THE Cardiff Coal Trimmers' Benefit Society had a stormy meeting this week; questions of "ton and turn" and relations with "hobblers" have caused some disquietude. The latest strike in Cardiff has been of a novel character—amongst the women unloading potatoes. They demand 2s. 6d. instead of 2s. per day, and upon one occasion during the week kept fifteen vessels from being unloaded.

A LARGE and influential deputation attended from Doncaster on Wednesday to present an invitation to the Royal Agricultural Society to hold the show of 1891 in that borough. The site offered for the show was the famous Town Moor, and a list of subscriptions already promised towards the local funds amounting to £4000 was laid on the table. The council resolved that the invitation be accepted, and that the show of 1891 be held at Doncaster.

THE manufacture of ordnance on the Tyne has hitherto been exclusively in the hands of Messrs. Armstrong, Mitchell and Co., but it is officially reported that Sir C. M. Palmer and Co. are about to open a department for the manufacture of ordnance and gun carriages. The management of the new ordnance works has been confided to Colonel English, R.E., now of Woolwich. Operations are to be commenced as soon as possible, but the scheme is to be brought into existence without making a call upon the present shares. The shareholders will have the first opportunity of subscribing the large amount of capital necessary for the new departure.

THE new vessels launched from the Clyde shipbuilding yards in the past month aggregated 38,192 tons, as compared with 17,740 in the same month of last year, and 5250 tons in February, 1888. The output of the first two months of the year has reached 56,722 tons, which is the largest that has taken place in any corresponding period in the history of the trade, comparing with 31,270 tons in the first two months of last year, and with 18,286 in 1888. But while the tonnage launched is thus exceptionally large, the new orders received have been quite inadequate to supply its place. Only some 3000 to 4000 tons of new shipping has been placed, and the prospects of the trade are at present not very encouraging.

THE ultimate fate of the two great French engineering enterprises—the Panama Canal and the Corinth Canal—is occupying considerable attention in Paris, owing to the steps that are being taken for their resuscitation. The future course to be taken with regard to the Panama Canal will not be known until about the middle of May, when the decision of the Commission upon the report of the engineering delegates to the works is issued. The delegates have been extremely reticent with regard to their recommendation, and this fact is generally regarded as adverse to the completion of the canal upon the lines laid down by M. de Lesseps. In the meantime M. A. Monchicourt has been appointed as liquidator with M. Brunet.

THE Bute Docks Company's tippers, in conjunction with Messrs. Worms, Josse, and Co.'s trimmers, did, by means of the movable tips on the west side of the Roath Basin, last week some remarkable work in coal shipping. The steamship Byron, carrying 3104 tons, commenced loading on Monday afternoon, and finished on Tuesday afternoon. The steamship Syria followed and took 3002 tons, finishing on Wednesday afternoon. The steamship Arbib Brothers then went into berth to load 4246 tons, and finished on Thursday evening. The three steamers were loaded in succession at the same loading berth, and only occupied it seventy-three hours altogether, in which time they received 10,250 tons of coal. This is a shipment rate of over 1,000,000 tons a-year, from a loading berth for one steamer. The time actually occupied in loading the 10,250 tons was only twenty-nine hours. The movable tips referred to were constructed under Taylor's patent.

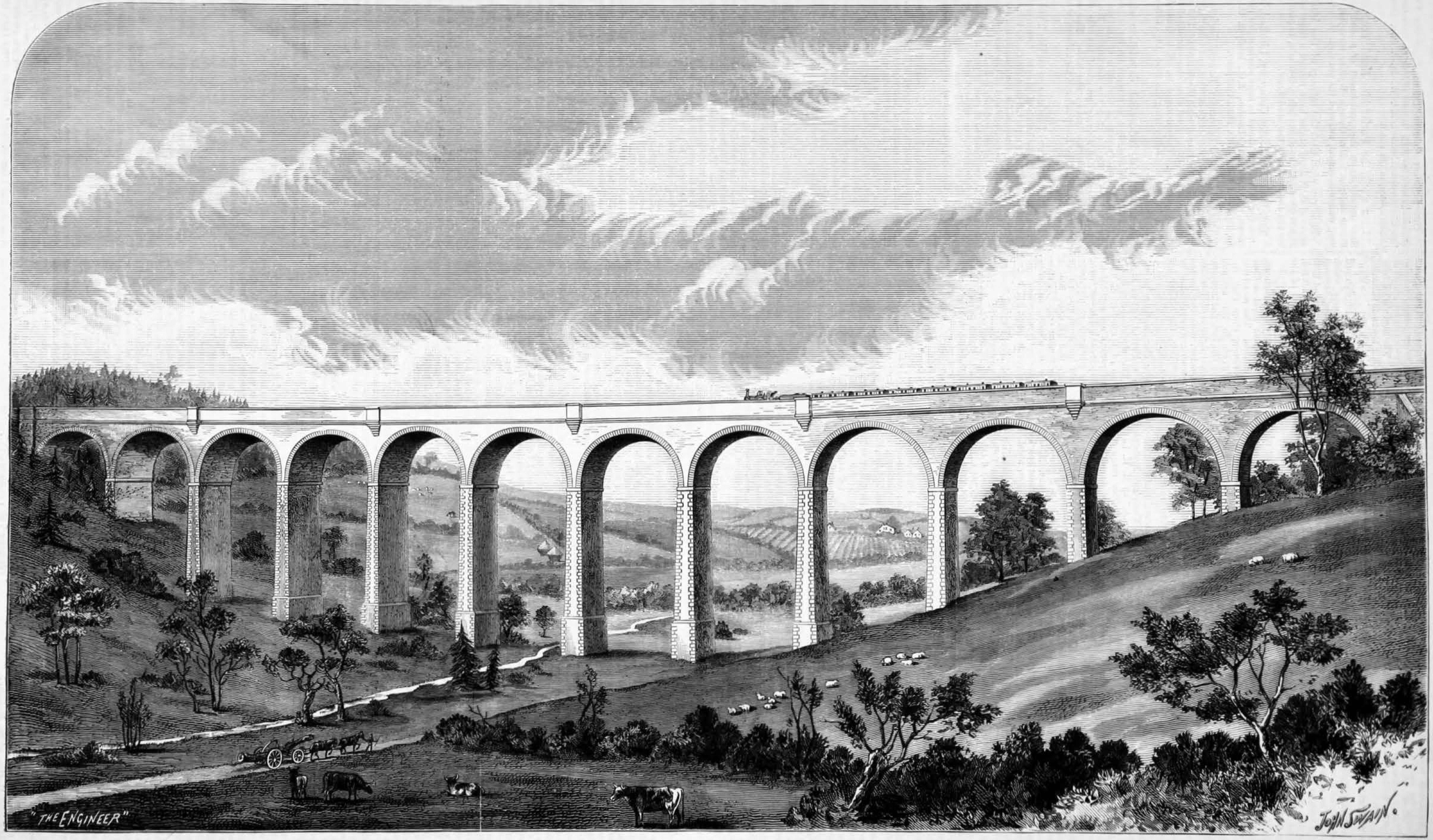
THE land of liberty manages some things rather badly. Street cleaning by private contract on a large scale has been tried both in New York and Philadelphia, and it has always ended in lamentable failure both in economy and general efficiency; but the American *Engineering News* says "the reason therefor is plain enough. Instead of the honest work now performed on Broadway, for private paymasters and under their personal inspection, in the cases mentioned it took but little time for the municipal faction to transform the working force into a political pension bureau and the contractors into second-rate political leaders. It was practically the same condition of affairs which exists in the public departments, where every employé regards his position as a reward or bid for political service. Politics and good work never will mix well together; and it is after all merely a matter of form whether our streets are cleaned by private contract or by the direct employés of the city. Honest constant work, under rigid and intelligent supervision, is the only thing that will keep our streets really clean; and the one remedy that we can suggest is to remove this service out of the realms of politics by reorganising it on a basis as near as possible like that of our present police system. Put a good man at the head of it and keep him there during good behaviour, and let master and man understand that efficient work is the only measure of permanent employ."

ON Wednesday a demonstration was made of the working of the electro-motives and their two carriage trains on the City and Southwark Subway. For some time these have been at work by means of current supplied by a dynamo and engine, temporarily placed at Great Dover-street, near the station in that street on the new line. As it is now proposed to move this plant, the exhibition of the running of the electro locomotives was made, the permanent plant at Stockwell being not yet ready. One of the locomotives used was fitted with two Manchester armatures, each geared by steel pinions to steel idle wheels, which in their turn drive pinions which work the wheels on the driving axles. There is another locomotive in which the armatures are placed direct on the driving axles. The electro-motives weigh about 11 tons, and are proposed for running at a maximum of twenty-five miles per hour, with two long carriages on bogies. The current is conveyed by an iron insulated rail, and taken off by a slipper in front of the locomotive. It is an inverted channel iron on glass insulators. The locomotive is fitted with the Westinghouse air-brake. It attained a speed of about twenty miles an hour, between King William-street and the Elephant and Castle, a distance of a mile and a quarter. The number of visitors carried was about a hundred, and with this load the locomotive dealt easily, the distance from the Elephant to King William-street being covered in about five minutes.

THE PLYMOUTH, DEVONPORT, AND SOUTH-WESTERN JUNCTION RAILWAY.—THE SHILLAMILL VIADUCT.

MESSRS. W. R. GALBRAITH AND R. F. CHURCH, MM.I.C.E., AND MR. J. W. SZLUMPER, M.I.C.E., ENGINEERS.

(*For description see page* 199.)



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PARIS.—Madame BOYVEAU, *Rue de la Banque.*
BERLIN.—ASHER and Co., 5, *Unter den Linden.*
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NEW YORK.—INTERNATIONAL NEWS COMPANY, 83 *and* 85, *Duane-street.*

PUBLISHER'S NOTICE.

FORTH BRIDGE.

*** *Rolled copies (suitable for framing) of the Four-page Engraving of the completed* BRIDGE, *issued with our Special Number of December 13th last, can be had, price* 1s., *post free.*

*** *With this week's number is issued as a Supplement a Four-page Engraving of a Compound Express Locomotive, North-Eastern Railway. Every copy as issued by the Publisher contains this Supplement, and subscribers are requested to notify the fact should they not receive it.*

CONTENTS.

TO CORRESPONDENTS.

Registered Telegraphic Address, "ENGINEER NEWSPAPER, LONDON."

*** *All letters intended for insertion in* THE ENGINEER, *or containing questions, should be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever can be taken of anonymous communications.*

*** *We cannot undertake to return drawings or manuscripts; we must therefore request correspondents to keep copies.*

*** *In order to avoid trouble and confusion, we find it necessary to inform correspondents that letters of inquiry addressed to the public, and intended for insertion in this column, must, in all cases, be accompanied by a large envelope legibly directed by the writer to himself, and bearing a 1d. postage stamp, in order that answers received by us may be forwarded to their destination. No notice can be taken of communications which do not comply with these instructions.*

CHAIN DRIVING BELTS.

(To the Editor of The Engineer.)

SIR,—We shall be obliged to any reader who will give the names and addresses of makers of chain driving belts. H. AND P.

Gloucester, March 3rd.

GAUGE GLASS FOR PARAFFIN TANKS.

(To the Editor of The Engineer.)

SIR,—What would be the best material to use to fit a gauge glass in connection with paraffin or benzoline tanks? JUNIOR.

Neath, March 2nd.

ASBESTOS MACHINERY.

(To the Editor of The Engineer.)

SIR,—I shall be glad if any of your readers would give me the names of makers of machinery for crushing and opening crude asbestos.

Rochdale, February 27th. O. C. A.

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THE ENGINEER *can be had, by order, from any newsagent in town or country at the various railway stations; or it can, if preferred, be supplied direct from the office on the following terms (paid in advance):—*

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Prices for Displayed Advertisements in "ordinary" and "special" positions will be sent on application.

Advertisements cannot be inserted unless delivered before Six o'clock on Thursday evening; and in consequence of the necessity for going to press early with a portion of the edition, ALTERATIONS to standing advertisements should arrive not later than Three o'clock on Wednesday afternoon in each week.

Letters relating to Advertisements and the Publishing Department of the paper are to be addressed to the Publisher, Mr. Sydney White; all other letters to be addressed to the Editor of THE ENGINEER.

MEETINGS NEXT WEEK.

THE INSTITUTION OF CIVIL ENGINEERS.—To-day (Friday), at 7.30 p.m., Students' meeting. Paper to be read:—"Telephonic Switching," by Mr. C. H. Wordingham, A.K.C., Stud. Inst. C.E. Monday, 10th inst., at 12 noon, Students' visit to the s.s. Jumna, of the British India Associated Steamers, Limited. Meet at shed No. 21, Central Station, Royal Albert Dock. Tuesday, 11th inst., ordinary meeting, at 8 p.m. Papers to be discussed:—"The Hawkesbury Bridge, New South Wales," by Mr. C. O. Burge, M. Inst. C.E.; "The Construction of the Dufferin Bridge over the Ganges at Benares," by Mr. F. T. G. Walton, C.I.E., M. Inst. C.E.; "The New Blackfriars Bridge on the London, Chatham, and Dover Railway," by Mr. G. E. W. Cruttwell, M. Inst. C.E.

INSTITUTION OF ELECTRICAL ENGINEERS.—Thursday, March 13th, at the Institution of Civil Engineers, Westminster, S.W., ordinary meeting, at 8 p.m. Adjourned discussion on the following papers:—"The Theory of Armature Re-actions in Dynamos and Motors," by Mr. James Swinburne, Member; and "Some Points in Dynamos and Motor Design," by Mr. W. B. Esson, Member.

LIVERPOOL ENGINEERING SOCIETY.—Wednesday, March 12th, at the Royal Institution, Colquitt-street, at eight o'clock. Adjourned discussion on Mr. Charles H. Yeaman's paper, entitled "Notes on Central Station Electric Lighting," which was read before the Society on the 29th January last. The paper deals with the most recent developments of central station electric lighting as practised in Great Britain.

THE SANITARY INSTITUTE.—A sessional meeting of the Institute for 1889-90 will be held at the Parkes Museum on Wednesday, March 12th, at 8 p.m., when a paper will be read on "The Sanitary Condition of Japan," by Mr. W. Kinninmond Burton, Professor of Sanitary Engineering at the Imperial University, Tokio, Japan. The paper will be followed by a discussion.

ROYAL INSTITUTION.—The evening discourse on Friday, March 14th, will be given at nine o'clock by Professor T. E. Thorpe, Ph.D., F.R.S., M.R.I., on "The Glow of Phosphorus." Afternoon lectures next week, at three o'clock:—Tuesday, Professor G. J. Romanes, F.R.S., M.R.I., on "The Post-Darwinian Period." Thursday, Mr. Frederick Niecks, on the "Early Developments of the Forms of Instrumental Music," with musical illustrations. Saturday, March 15th, the Right Hon. Lord Rayleigh, F.R.S., M.R.I., on "Electricity and Magnetism."

SOCIETY OF ARTS.—Tuesday, March 11th, at 8 p.m.: Applied Art Section. "The Claims of the British School of Painting to a thorough Representation in the National Gallery," by Mr. James Orrock, R.I.—Wednesday, March 12th, at 8 p.m.: Ordinary meeting. "The Chemin de Fer Glissant, or Sliding Railway," by Sir Douglas Galton, K.C.B., D.C.L., F.R.S.—Thursday, March 13th, at 5 p.m.: Indian Section. "Agriculture and the State in India," by Mr. W. R. Robertson.—Saturday, March 15th, at 3 p.m.: Popular lectures. "The Atmosphere," by Professor Vivian Lewes. Lecture II.

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.—The sixth general meeting of the session will be held in the Lecture Hall of the Literary and Philosophical Society, Newcastle-upon-Tyne, on Monday, March 10th, at 7.35 p.m. (1) Minutes of the last general meeting will be submitted for confirmation. (2) The ballot for new members will then be taken. (3) Discussion on paper by Messrs. Kilvington and Taylor on "Boiler Furnaces." (4) Paper on "The Institution's Rule for the Normal Indicated Horse-power of Marine Engines and Boilers," by Mr. R. L. Weighton.

JUNIOR ENGINEERING SOCIETY.—Friday evening, 14th inst., at the Westminster Palace Hotel, Victoria-street, S.W., at 7.45 p.m. Paper to be read:—"Hydraulic Machine Tools," by Mr. A. H. Tyler, Stud. Inst. C.E. Synopsis:—Introduction—The limits of pressure—Cup and V leathers—Rivetters—Design of framing and defects of steel castings—Details of ram and drawback—Distributing valves—Suspending gear of portable rivetters—Portable and fixed rivetters—Description of a large rivetting plant at Rotterdam—Pumps and accumulators—Direct pumping—Hydraulic gantry and cranes—Flanging press—Gland packings—Forging presses—Hydraulic lift and jiggers.—Saturday afternoon next, 8th inst., visit the London Hydraulic Power Company's pumping stations:—No. 1, at Falcon Wharf, Blackfriars, near the bridge; No. 2, at Millbank-street, Westminster, near the Houses of Parliament. The party will meet at three o'clock to view No. 1 pumping station, and will proceed thence to Westminster.

DEATHS.

On the 4th March, at Queenwood, Gipsy Hill, ALFRED PENNY, M.I.C.E., late of Beckenham, Kent, and 20, Abingdon-street, Westminster, in his 79th year.

On the 11th January, at St. Kilda, Melbourne, FRANCIS SHELDON CHITTENDEN, Assoc. M. Inst. C.E., Victoria Railway Department, and late of Kingston-on-Thames, aged 44.

On the 24th ult., CHARLES WILLIAM HARDING, C.E. (many years' Borough Treasurer of King's Lynn), eldest son of W. D. Harding, of Islington Lodge, King's Lynn, in his 45th year.

THE ENGINEER.

MARCH 7, 1890.

FACTORS OF SAFETY IN THE NAVY.

IN our last impression will be found a description of H.M.S. Trafalgar, one of the most recent additions to the British fleet. On the same page we gave an account of the experiments carried out with her armament. The report is in a sense official. The results of the trial are said to be satisfactory in the highest degree, and apparently everyone concerned in the design or construction of the ship congratulates himself and his fellow workers on this. We cannot read the report, indeed, without feeling that everyone is thankful the trial is over, that no one has been killed, no gun damaged or deck blown up. Now this frame of mind is not, it appears to us, that which the modern naval architect, gun maker, or engineer, should enjoy after a trial of a man-of-war. There ought to be no occasion for congratulation. The success of the ship, in all respects, ought to be a matter of course—a certainty in fact, tempered with a very remote chance of accident. When a locomotive superintendent turns out a new locomotive, he does not congratulate himself that it does not break down during the first week. The maker of engines in the mercantile marine does not hug himself with the thought that nothing goes wrong during a trial trip. We do not suppose that Sir John Fowler or Sir B. Baker are specially delighted to find that the Forth Bridge is an enormously strong structure. The locomotive superintendent, the marine engine maker, and the bridge builder, aim at attaining certain results, and if they did not attain them, they would be astonished and disappointed. One or two failures would lead to professional ruin, indeed. But there is nothing at all approaching to this certainty about the Navy. No one seems to know whether anything will do what it is intended to do. If it is a hydraulic buffer, for example, there is jubilation if it takes up recoil without pipes bursting. It is a matter for wonder and delight if a gun when fired does not rip up the decks. As for the engine and boiler rooms, anything may happen in them, either a success or a failure. All this seems wrong, and is certainly perplexing. There is not less talent, or skill, or industry, or money available in the construction of ships and engines and guns, than there is in any one of dozens of other undertakings. Why should the results of their expenditure be so different?

The answer is, we think, that there is a great deal too much attempted, and that consequently the factor of safety is almost unknown in naval matters. There is no margin left for contingencies, and in this the British Navy stands out, we think, in strong contrast to the result of all other work done in Great Britain, always excepting the performances of the jerry builder. Instances and examples crowd upon us. We may select one or two. A certain class of small ships was produced intended to possess high speed; it was perfectly well known that the required speed could not be obtained with less than about 4500 indicated horse-power; it was also well known that such a power could not be exerted without putting a severe strain on the hull. But the hulls of these ships were made of such light scantling, that when the engines got near the required power they threatened to pull the vessels to pieces. The trials had to be stopped, and the hulls will have to undergo a costly process of strengthening. It is clear that no margin of safety was allowed. It is not necessary to say anything about boilers and engines. It has been tardily admitted that the attempt to reduce weight was pushed to a ridiculous extreme with disastrous consequences. Concerning guns, perhaps the less said the better. But let us look at the report of any trial of gun carriages, and what do we find? Either that there has been a failure of some kind in some detail, or that there has been a perfect success, which fills every one with surprise. The Trafalgar is fitted with heavy guns which she is intended to fire, otherwise wooden dummies would be much cheaper and would be easier to carry. Yet it was only on the most urgent representations of Mr. White that the authorities consented to have these guns fired in any way that might possibly injure the ship. If these guns are specially mounted for firing over the decks, it seems evident that the decks should be made specially strong to withstand the effect of the air blast. We learn, however, from the report that the decks only just withstood the shock and no more. A deck beam was forced down 2in. and a stanchion was broken. Just fancy what would be said if a railway bridge intended to carry a certain load deflected 2in. when that load was put on it. Obviously, there is no sufficient factor of safety allowed in the deck beams of the Trafalgar. Immunity from injury can only certainly be secured by taking great care not to fire the big guns.

We know quite well what the excuse or apology or explanation will be. It is that if stronger beams had been used, they would have represented more weight than could be spared to them. It is the same thing all through—more is aimed at than can possibly be secured, and this is, we think, a most mischievous policy. It is perfectly well known, for example, that in a squadron of men-of-war, the breakdown of one may render the others practically useless. It is agreed, however, that out of half-a-dozen ships the chances are that only one will break down, and that it is worth while to give up the margin of safety and take chance, rather than make the whole squadron slower. It is only necessary to state this proposition to render its absurdity manifest. The attempt to do too much is the cause and source of nearly all the troubles that beset our ships of war. It is high time that the imperative necessity of providing a factor of safety in the Navy was recognised. The results might, in the first instance, be regarded as vexatious, but in the long run they would be satisfactory. Our guns burst because they are overloaded; our gun carriages fail because they are not heavy enough, and therefore not strong enough to bear the strain put upon them; our boilers leak because they are expected to make too much steam; our engines break down because they are overdriven. It is not that the guns and carriages and boilers and engines are not as good as it is possible to make them. The failures are all due to the insane desire to make a fine show on paper, and to get results which can only be had by running excessive risk. What would be thought of a railway company which called for tenders for a great bridge over a deep river, and insisted that the weight of the bridge should be so small that the steel should be stressed to fifteen tons on the square inch? A course precisely analogous to this is pursued in the Navy; and the most strenuous exertions of men who are not afraid to face facts will be required to prevent the perpetration of a most mischievous policy.

The principal agent in eliminating the factor of safety is, no doubt, the desire to keep down the weight. But, can it be said that we have really attacked this weight-problem in the proper way or the right spirit? Is it not rather a fact that weight has been piled up because a multitude of interests have had to be considered? The naval architect and the engineer have not been left a free hand, and adventitious structures of all kinds are added here and there as the work proceeds. It is not remarkable that a ship should float a foot, or even two feet, deeper than she was intended. We can quite easily picture the state of mind of the naval architect who finds himself called on to put weight into a ship that he never contemplated; and how, in his desperation, he will cut and carve and reduce here and there and everywhere, until the margin of safety has totally disappeared. It is to be hoped that our new ships will be completed as designed; and, we believe it is not too much to say that on this point, the Chief Constructor's Department is very firm. We may say—not in a spirit of censure—that with much of the criticism to which our ships and guns and engines are submitted we have little patience, because it is at once ignorant and exasperating. But, on the other hand, it is part of our province to direct attention to the failures of the past in order that they may not be repeated in future; and it can do no harm, and may do much good, to tell the official man exactly how official congratulations strike a non-official journal. It does not appear to be a reasonable thing that naval men and architects should be delighted to find that a big ship can fire big guns, with full charges, without hurting herself or her crew. If a proper factor of safety existed, there could be no possible reason for anticipating anything else. About joyful surprises nothing would ever be heard; they would cease to exist.

VALUE OF THE LONDON WATER COMPANIES.

THE Corporation of the City of London are not disposed to let the question of the water supply rest where it is. They have resolved on promoting a public inquiry into the subject, and in order that the result may carry due weight they are anxious that the Government should appoint an expert to conduct the proceedings. For the purpose of defraying the cost the Corporation are prepared to expend £2000. This sounds rather small for so important an undertaking, and rather suggests the idea that the scope of the inquiry is to be somewhat limited. The County Council, who think it is only due to their dignity that they should be in possession of the water supply as well as of sundry other things, are about to ask Parliament for permission to spend £5000 of the ratepayers' money, City and metropolis alike, for a similar purpose. The Council, it is to be observed, seek power to "negotiate" as well as to inquire, and are feeling their way towards getting the power of purchase. The authorities of the City are more particularly impressed with the cost of the supply, and are annoyed with the system whereby the water rate of business premises is levied on the basis of rateable value. Warehouses use little water, but pay big rates to the New River Company, and the consumers are looking about them for some kind of deliverance. The Commissioners of Sewers have been trying for the last three years to sink an artesian well, but have not yet succeeded in getting any water; and when they get it, if ever they do, it is not very clear that they will be able to do anything more with it than supply their own property and give the rest away. The New River Company will not be easily frightened, and it is interesting to observe that the day before the Court of Common Council resolved on setting up a public inquiry on the water question, the fraction of an adventurer's share in the estates and interests of the New River was sold by public auction at a price representing nearly forty years' purchase. A rate of interest equal to no more than $2\frac{1}{2}$ per cent. per annum does not appear very encouraging, but there is a tempting prospect held out to the investor. The revenue of the New River Company is continually increasing, and there is no statutory limit to the dividend. Of all sources of income, there is nothing better than a share in the New River Company. The revenue comes not only from water, but from houses and lands. The Company possesses large and important estates in London, and in the counties of Middlesex and Hertford, the entire area extending over hundreds of acres, capable of yielding splendid revenues in days to come. Already fifty acres are covered with buildings in the heart of London, and the ground rents now received will in twenty years begin to give place to the rack rents, consequent on the falling-in of the leases.

When terms were arranged in 1880 for transferring the London water supply to a public authority, the landed property of the New River Company was not included in the bargain. But the magnitude of the revenue from the water rates is itself remarkable, as also the rapidity of its growth. A statement has been issued showing that the income from "water rents for houses and trade, watering streets, water sold in bulk, and income from other sources," has never decreased during the last twenty years. How these sums are made up we do not know. They exceed in amount anything obtainable from official sources. But taking the net water rental of the New River Company as certified by the Local Government Board, we find a decrease exceeding £2000 in 1883, and again in 1885. But still there is the fact of a rise from £400,816 in 1880 to £453,016 in 1888. The dividend paid is now more than 12 per cent. on the nominal value of the shares. It is also stated that whereas the dividend paid on an entire share in 1868 was £1340, that for 1888 was £2610. Despite the enormous increase thus exhibited, the advance is said to be "without limit as to future progression." But it is this kind of progress which threatens the very existence of the Metropolitan water companies. In the statement promulgated by the eminent firm which effected the recent sale of the New River shares, we meet with certain candid and some very glowing statements, which, although designed for business purposes, are so far correct that they seem rather perilous, as likely to excite a feeling of antagonism, and to bring about some drastic measure for extinguishing so profitable a monopoly. The cause of the increasing income is said to be not only the extension of the metropolis, but the improvements effected in it, and the consequent rise in the annual value of the property on which the water rates are charged. It is added that "continuous extension and improvement in the future, even if, perhaps, not so rapid, must conduce to a corresponding increase." No one need object to an increase in the Company's revenue consequent on an extension of the metropolis; but the feeling is otherwise when a mere rise in the assessment is accompanied by an increased charge for the water supply. The water companies are technically justified in taking the benefit of every rise in rateable value; but while they are thus acting within their rights, this process is doing more than anything else to bring about a crisis in the history of the question. No doubt the water is better in quality than it was some time ago; but there has been no great change in the last eight years, and yet in that period we find water, on the whole, getting dearer. There are exceptions to the rise in price, for four out of the eight metropolitan companies charged less in 1888 than in 1880, but the other four more than counterbalance this reduction, the effect being that water in London has risen, in eight years, from £27 16s. per million gallons to £29 2s. In the same period the charge for the New River water has risen from £38 16s. per million gallons to £41 10s. The advance in price would have been still greater had not the Legislature interposed with the Water Rate Definition Act of 1885, declaring "annual value" to mean "rateable value;" an enactment in harmony with the judgment given in the House of Lords in the famous Dobbs' case in 1883, though we must conclude that the new Act went somewhat further, as otherwise it would not have been required.

If the London water companies are to be bought up and the supply transferred to a public authority, it is evident that delay is making the change more difficult. Although something has been done to check the growing revenue of the companies, still the bare extension of London is enough to furnish a serious annual increment. The growth of the New River interest is a case in point. To enhance the value of the shares in the market, it is remarked that building operations are now proceeding with enormous rapidity in the districts of Highgate, Hampstead, Hornsey, Finsbury-park, Edmonton, Enfield, Cheshunt, and other parts of the northern suburbs, while new buildings are constantly rising throughout the company's districts in the more central parts. Attention is called to the fact that "it is on this large and increasing annual value that the company enjoy the right to charge." The fact that the New River Company has added more than £50,000 to its net water rental since 1880 is indicative of the process that is going on. If we include all the companies, we find the total increment to be very nearly £288,000. This must be paid for, however ingeniously the terms may be arranged. Very good reasons can be given why the water supply should remain where it is. But this splendid income is a golden bait, and as it grows and glitters before the eyes of the London County Council and the Corporation, we may be assured that these authorities will be anxious to deal with it in some shape or way. The so-called "inquiries" are obviously intended not merely to collect information, of which indeed there seems to be enough already, but to promote certain designs, such as may not tend in all respects to benefit the public. We doubt whether the London County Council would manage the affairs of the water supply so well as the companies have done. The New River Company stands at the head, and it is rather entertaining, though still sufficiently true, to find the property of the company spoken of as "a great historic undertaking, beyond the reach of fluctuation, possessing in itself all the elements of security, regularity, realisability, and improvement, combining the simplicity of a Government annuity without the dreaded loss of income, the profits of a trading corporation without its risks, and the prestige of landed proprietorship without its troubles." This combination of an Elysium and an Eldorado can hardly fail to rouse the energies of the London County Council for the acquisition of such a prize. It would help to make up for the loss of the Coal Duty.

A WRECK CAUSED BY A LIGHTHOUSE.

WE have on several occasions in this journal referred to the progress made with the lighting of the many points dangerous to navigation on the coasts of our several possessions in the East. It was but lately that among such references we named the approaching completion of two lighthouses of an important character on the shores of Ceylon, the coasts of which island have been particularly fatal to vessels. According to a list published in the *Ceylon Observer*, no less than thirty-four steamers—including at least five of the fine vessels belonging to the Peninsular and Oriental Company—have been lost since 1857 upon its shores. The importance, therefore, of marking by lighthouses the more dangerous localities along the seaboard of Ceylon will, it is certain, be fully recognised. The two last completed of these have been erected severally on the small island of Barberyn and on the Dondra Head, and a Board of Trade notification, published as far back as October last, intimated as follows:—"Ceylon — Barberyn Island:— Early in November, 1889, a light, showing a quick white flash every minute, elevation 150ft., will be exhibited on this island in 6 deg. $27\frac{3}{4}$ m. N., 79 deg. $57\frac{3}{4}$ m. E. Dondra Head.—Early in December, 1889, a light, showing a quick white flash every twenty seconds, elevation 150ft., will be exhibited on the head—southernmost point of Ceylon—in 5 deg. $55\frac{1}{2}$ m. N., 80 deg. $35\frac{1}{2}$ m. E." It is certain from these notifications that every master of a vessel would rely upon ascertaining his whereabouts by the indications specified on and after the dates named.

It is certainly most astonishing to learn, as we have done, that as late as January 16th of the present year neither of the beacons referred to in the Board of Trade notification had been lighted; nor is it discoverable that any intimation of the delay in doing so had been either conveyed to the maritime authorities of Ceylon or notified in the Board of Trade home publications. Had the first course been followed, proclamation of that delay would in the ordinary course have appeared in the local *Government Gazette;* while in the second case every precaution would have been taken to make known the fact of it throughout all shipping ports. Owing to want of any intimation that to the intentions of the Board of Trade effect could not be given, the s.s. Norsa, while on a voyage from Middlesbrough to Madras with a cargo of coke and railway material, was wholly lost on the coast near to Barberyn. The commander of that ship, Captain Lilienskjöld, pleads that, seeing no light in the position named at Barberyn, he concluded that he was well away from the shores of Ceylon, and, the night being very foggy with squally weather, no evidence of the ship's proximity to danger was apparent before she struck in the position where she now lies a total wreck. The Norsa is a new vessel of about 1800 tons burden, built only in last year, and at the time of her loss was on her maiden voyage. She was owned by Messrs. Herskind and Wood, of West Hartlepool, and we may be sure that those gentlemen, or the underwriters with whom they had insured the ship, will demand that the fullest inquiry shall be made into the allegations we have above given upon the authority of what has appeared in the papers published in Ceylon.

So far for the facts as they have as yet received publicity. It will be admitted, we feel sure, that unless they can be controverted a very grave responsibility will rest upon those officials of the Board of Trade whose duty it is to see that every possible publicity is given to all matters connected with the marks under the protection and guidance of which ocean navigation is carried on. The dates we have quoted show—if the allegations made can be fully established—how negligent of such duty the responsible officials must have been. For the light on Barberyn was advertised to appear early in the November of last year. Until the date—January 16th, 1890—of the Norsa being lost, fully two months must have passed since it must have been known to the Board of Trade that the promise made by it had not been kept. The telegraph would have conveyed notice of the failure throughout the world in a few hours' time; while there was even ample time for fuller details than could be given by that agency—presuming such to have been necessary—to have been dispatched to every port throughout the East by the ordinary mail routes. Unless the default alleged is susceptible of some explanation which we cannot even conjecture, a very serious dereliction from duty has occurred which must demand the strictest inquiry. Unless steps be taken which shall render it—humanly speaking—impossible for such a failure to recur, the course of lighting of which we have hitherto spoken in terms of high commendation, may constitute a dangerous snare, rather than a safeguard, to the whole navigation of the world.

We are curious to learn what may have been the causes which gave rise to the non-illumination of these two important lights. As yet, the only explanation we have seen has been given by a cursory reference in the paper before alluded to, the *Ceylon Observer*. By that journal it has been stated that the non-arrival of the expected supply of colza oil was the reason of the default made. But surely, considering how many other lighthouses have been erected in Ceylon, and even failing these, those upon the neighbouring shores of India, there must have existed ample stores from which a temporary supply could have been drawn. Are we to conclude that the Board of Trade permits such a hand-to-mouth supply only that not even a limited draught on its stores, either throughout Ceylon or India, could be afforded? If we are to do this, the fact must constitute a grave reproach to the administration of that department. But even in such a case, it can hardly be conceived that for temporary use only some alternative illuminant could not have been found. The island of Ceylon is a large oil-producing country, many kinds of its productions, such as cocoanut, sesame, gingelly, and other seeds or trees, yielding oil of degrees of fineness, some of which approach in purity the standard of colza; and it does appear most extraordinary to say the least, that in view of the fact which must, or should have been known to those locally in charge of the Board of Trade's department, of the serious results which the non-appearance of these lights according to notice might entail, some effort was not made to use one or other of the several alternative oils we have named. We by no means desire to prejudice the case which the Board of Trade may have; we can only say that, judging by the facts as these have as yet been made known, its officials will have to make out a very clear one to rebut the statements which at present seem to record so heavily against them.

THE CHEMICAL MANUFACTURE.

THERE are rumours that a "chemical syndicate" is being formed to purchase the chemical works of the country, and to deal with them much as the salt trade is being dealt with. It is certain that there have been negotiations in progress with this end in view, but it is by no means so certain that the end will be attained. The different position of the two branches of the chemical manufacture will be found to be one of the chief obstacles in the way. One of these two—the group of makers who use the Leblanc process—can scarcely be said to be in a flourishing condition, many of them not having, as companies, paid a dividend for some time; and as the tendency of prices over a period of years has been towards decrease, and as the cost of production has of late advanced, the Leblanc chemical manufacture must be looked upon as being one that is not profitable to any general extent. The production of bleaching powder has been so, but since the expiration of the Bleaching Powder Makers' Association, the price of that article has fallen, and shows no sign of recovery. But, on the other hand, the makers of alkali by the ammonia process have made, and are still making, very large profits, and the number of their products is augmenting. In this divergent position of the two branches of the chemical manufacture, there is, it will be at once seen, a practical bar to any union, unless on terms that would allow the further growth of the profitable branch of the trade and would check that of the branch which cannot now be looked on as profitable. Whether there will be any union of either of the two branches—a union of the groups of works—remains to be seen. Such a union of, say, the Leblanc makers might adjust production so that the output of bleaching powder would be under control, and the price might again be raised to the profitable rate of a year or so ago; but it would be by no means so easy to adjust the production of alkali to the demand, because there is the competition to be met of the makers by the other process. It is a position that is surrounded by difficulties, and it is by no means improbable that the solution will be found only in that commercial competition which in the end adjusts supply to demand. For some years the association of the makers has limited the action of that competition; but, despite the limitation, the number of the Leblanc makers has decreased in some of the centres of production. Whether this decrease will continue in the open competition is a question which may be postponed whilst the trade revival enlarges demand, but the postponement will not be of an indefinite length.

A STRIKE AND ITS PERILS.

MANY and grave are the questions which arise out of a national strike of miners. We are all familiar with the frequently pourtrayed picture of a coal famine; the scores of colliery villages struck with a stillness as of death, the men lounging sullenly about, the women and children begging for bread, then the miserable bands of half-starved, yet still defiant, miners perambulating neighbouring towns in a piteous appeal for help, while the workmen of other industries, deprived of employment through their folly, look on half in anger, half in sorrow. No coal means no work for at least one half of England's industries, and it means as well incalculable suffering for every person who has to earn his bread by the sweat of his brow, or whose livelihood depends upon those who do. Closed collieries involve the blowing-out of iron furnaces, the staying of steel-melting, and all the trades of iron and steel paralysed as a man seized with the palsy. Industrial life would leave the whole land. Even our iron highways and our canals would be silent. Without coal the finest engines in the world would be so much useless engineering lumber; the barge and the bargee might retire from business; and the stateliest ship which sails the sea would have to lay up in port, "as idle as a painted ship upon a painted sea." But there is another aspect of the calamity which seems to strike few people. If at such a time we should get involved in war, where would we be? What of our matchless fleet, if there was no coal in the bunkers? Where would our first line of advance be? What of their thunder-speaking guns and impenetrable hide of steel and iron? The coaling of England's Navy is a matter of immense magnitude. If the war-cloud burst even as the strike was ended, or the strike ended because of the war-cloud, the disadvantage to this country would be tremendous. It would require weeks to work up arrears, and these weeks would be of the most priceless importance—possibly meaning all the difference between victory and peace, disaster and humiliation. In such an extremity, the Government is as helpless as a private manufacturer without collieries. Large iron firms, with coal pits of their own, can to some extent provide against the huge calamity by piling up stocks; but when the evil days of dispute between capital and labour devastate the land, the comparatively small wants of the private manufacturer can not be met. Is it not time this peril was fairly faced? Of boards of conciliation we hear much when depressed trade afflicts us, but very little when the boom of business arrives. It would seem, from a national point of view, as if it were more important for the Government to be coalowners than to be steel and gun makers. There is so much liberty in the land that it is in the power of agitators who happen to be "seated in the saddle" to do enormous mischief to the commerce of the country, and to imperil even the national safety. If that power cannot be restricted or controlled within reasonable limits, prudent men at the wheel of state must devise some other means by which danger of such magnitude may be averted.

THE WORLD'S COALFIELDS.

WITH a view to allaying fears as to a rapid exhaustion of the coalfields of the United States, and the consequences resulting therefrom, the Consul-General of that country at Frankfort gives in a recent report upon the commerce and industries of Germany some statistics from a German source, to the effect that coal is spread over a large portion of the globe, and that ten millions of years will elapse before the coal known to exist will be exhausted. The Netherlands, Switzerland, Sweden, Denmark, Germany, Bohemia and Silesia, have 59,000 square miles of coal deposits; Austria, Spain, south-west Poland, Portugal, Italy, Greece, Turkey, and Persia, have 39,000 square miles; Russia, 22,000 square miles; China, 410,000 square miles; at Pekin there are seams 95ft. thick. India has 35,000 square miles, and Japan, 6000. The Falkland Islands, Peru, and Patagonia, have also vast coalfields. The larger part of southern Chili is a coal bed. Brazil has wide extending coal, with seams varying from 17ft. to 25ft. in thickness. Colombia has a cretaceous coal of fair quality, and beds of bituminous coal far down under the surface. Mexico, Vancouver Island, and New South Wales have 25,000 square miles. Queensland, Western Australia, and Victoria, 14,000; New Zealand, 29,000. There are coalfields in Tasmania, New Caledonia, Natal, Alaska, and other parts of the world, aggregating 100,000 square miles more. The coal deposits given do not include any mines already opened, nor any coal lands in North America, except those of Alaska and Mexico. Africa is also excluded, as nothing is known about the coalfields of the Dark Continent. It will be noticed that there is no mention of the Belgian, British, or French coalfields in the preceding statistics.

GAS ENGINEERS AND THE COAL TRADE.

GAS engineers are by no means the least influenced class of the community affected by the present crisis in the coal trade. It is a fact that numerous gasworks in the chief centres throughout the kingdom are at present getting very short of supplies of coal. Indeed, there are not wanting practical authorities who state that a strike at present in the coal trade, affecting, as it would do, gas coals, as well as other sorts, would, if it were prolonged for a few weeks, very soon result in half the towns of England being in darkness. If such a statement is not accepted *in toto*, there yet can be no doubt that the result of the restriction of output, which would follow upon either a general strike, or a general lock-out, would produce the greatest inconvenience at large numbers of gasworks. The fuel market has of late been in such a condition of uncertainty that managers of gasworks, and others responsible for the fuel supplies for those establishments, have hesitated to make their usual renewals of coal contracts, which are given out, as a rule, at the beginning of spring. Instances could be cited in which, at the close of January, many gasworks had only a week or two's supplies; and what has been done since then in the way of getting any more fuel has been, for the reason named, largely of a hand-to-mouth character. It will thus be seen that gas engineers, no less than ironworks and furnace proprietors, are keenly interested in the current phase of the labour question in the coal trade.

LITERATURE.

Transactions of the American Society of Mechanical Engineers. Vol. X. 1889. Published by the Society, New York City.

[FIRST NOTICE.]

FOR several reasons the transactions of the American Society of Mechanical Engineers possess attractions quite unrivalled by any cognate publication in Great Britain, or, indeed, the continent of Europe. The American engineers seem to have solved a difficult problem; and the members of this Society not only provide valuable papers, but discussions which are really worth reading. The volume before us is no exception to the general rule. Its contents are on the whole excellent, and it should be in the possession of every engineer who can manage to obtain a copy. It contains reports of the meetings held at Scranton in 1888, and Erie in May, 1889. It is a big octavo book, admirably printed and carefully illustrated, containing a list of members which fills thirty-four pages, the total number being 985; a copy of the rules; a table of contents of the volume; no fewer than 904 pages of the proceedings proper, and a general index to all the ten published volumes, which index occupies 116 pages. Truly a portentous volume, and one which we may, we think, be excused from noticing in detail. It must suffice if we direct attention to a few of the more prominent subjects dealt with, and speak generally of the way in which they are handled.

One of the papers is on a subject little understood, namely, the "Stresses on a Circular Lid Resisting Pressure," by Mr. L. H. Rutherford, presented by Mr. F. R. Hutton. Mr. Hutton had to design a lid in copper secured to a cast iron ring, for a species of boiling kier; and he asked Mr. Rutherford as a mathematician to calculate the stresses and dimensions. The lid was 73in. in diameter and ⅜in. thick, and had to stand a pressure of 65 lb. per square inch. The subject has been most exhaustively treated. No discussion followed, the paper being too intensely mathematical for that.

The American engineers are, above all things, practical. They look very carefully indeed at the pounds, shillings, and pence side of a question, and with them it signifies nothing that a steam engine should be economical if it is expensive in other respects. We do not mean first cost. Thus, in the discussion which followed a paper on "The Use of the Compound Engine for Manufacturing Purposes," the questions handled most freely and fully were the effect of taking steam from the receiver for steaming the mill instead of from the boiler, and the relative cost of steam and water power; and various facts were adduced to prove that on the whole steam power is in the United States cheaper than water power. Thus, for example, in the city of Binghampton, in the State of New York, the cotton mill of Messrs. J. P. Noyes and Co. has an abundant supply of water all the year round; but from the moment the cold weather sets in, they use steam power. Thus, for about one half the year they run with coal and the other half with water, and the cost of running the mill is just the same in either case. The whole subject seems to have been fairly threshed out. It is one that does not possess much interest in this country, because we have so little water power; but the paper contains much useful information concerning American mill practice quite apart from water power.

Mr. Scheffler commenced a paper on a "Foundry Cupola Experience," which was followed by a useful discussion. Then we have next a paper on "Electric Welding," by Mr. Woodbury. As the subject is now attracting a great deal of attention in this country, we shall reproduce this paper and the discussion at another time, with one of the tables of tests. It will be seen that nothing was said as to the cost—a subject with which he have fully dealt in recent impressions.

Professor Thurston supplies a very long paper on the "Internal Friction of Steam Engines." Nothing at all resembling his experiments in elaboration has been tried in this country. Engines were driven, hot, by another engine through a dynamometer, and a great amount of information obtained. Thus, in a condensing engine with a cylinder 21in. diameter, 20in. stroke, running at about 200 revolutions per minute, the frictional resistance was 7·13-horse power. Of this the main bearing took 3·3-horse power; the piston and rod, crosshead and pins, 1·48-horse power; the valve rods and excentric about as much; and the air-pumps 0·88-horse power. The general conclusions are remarkable and suggestive. We give them here.

These engines were all tested to determine whether the previously reported increase of internal friction with speed were here to be accepted as correct. It was found that the several engines differed somewhat in this respect, but that this variation was in all cases slight, and in some instances insensible or even reversed, the friction decreasing in one case, observably, with increasing speed. It was sufficiently evident, for all the engines here considered, that this variation was so unimportant as to be negligible. The figures given in the several tables which have been presented in the preceding pages are therefore to be accepted as not only correct and reliable, but also as not likely to be affected by construction or method of operation of engine to such an extent as to be inapplicable to steam engines generally. The writer, in the light of existing knowledge, would assume that it is the rule, with all the usual forms of engine, and under all common conditions of operation, that the internal friction of the machine is practically invariable with variation of useful work, and that it is very nearly independent of the speed of rotation and of piston, varying slightly, as a general rule, in the direction of increase with increase of speed. This latter principle leads to the conclusion that the friction coefficient of the rubbing surfaces decreases with the load on the engine and with increase of pressure on them, a result confirmed by numberless experiments of the writer and others, independently. With good lubrication, the coefficient of friction rapidly decreases with intensifying pressures, and to such an extent as to make the actual resistance to movement very nearly constant. It is now possible to study the reported data intelligently, and to deduce useful and reliable conclusions relative to the effect of these new facts upon the theory and upon the principles of designing and constructing as well as operating steam machinery. The most important item of friction waste, in every instance, is that of lost energy at the main bearings. In every case it amounts to one-third or one-half of all the friction resistance of the engine, the higher figures being given by the condensing, the lower by the non-condensing engines, except that the first experiment, with the straight line engine, gives as high a figure as the condensing engines, a fact due, however, rather to the exceptionally low total than to exceptionally high friction on the main shaft. The second highest item is, in all cases apparently, the friction of piston and rod, the rubbing of rings and the friction of the rod packing. This is a very irregular item, as would have been naturally anticipated, and amounts to from a minimum of 20 per cent. to some higher but undetermined quantity. The third item, in order of importance, is the friction of valve, in the case of the engines having unbalanced valves. This is seen to be hardly a less serious amount than the frictions of shaft and of piston. But it is further seen at once that this is an item which may be reduced to a very small amount by good design, as is evidenced by the fact that in the straight line engine, it has been brought down from 26 to 2·5 per cent. by skilful balancing. Ninety per cent., therefore, of the friction of the unbalanced valve is avoidable or remediable. The importance of this fact is readily perceived when it is considered that not only is it a serious direction of lost work and wasted power and fuel, but that the ease of working of the valve is a matter of supreme importance to the effective operation of the governing mechanism in this class of engines. No automatic engine can govern satisfactorily when the valve is unbalanced, and is certain to throw much load on the governor. The frictions of crank-pin, of crosshead, and of excentrics, are the minor items of this account; they are comparatively unimportant.

A cognate paper is one by Mr. Charles E. Emery on the "Cost of Power in Non-condensing Engines." This is a highly elaborate example of the application of mathematics to a practical purpose, the requisite data not being assumed but determined by direct experiment. Mr. Emery's paper elicited an animated discussion, several of the speakers dissenting from his views. One of Mr. Emery's propositions is that the value of a condenser for high-speed engines is practically nothing; but Professor Denton cited certain experiments made with a Buckeye engine, working with 90 lb. steam at 284 revolutions. The arrangements were such that by moving a lever the engine could be worked condensing or non-condensing without other alterations, and it was said that a vacuum of 16in. was productive of economy in the ratio of about 100 to 116. That is to say, the power remaining unchanged, the feed-water rose from 100 lb. in a given time when condensing, to 116 lb. in the same period when the engine was non-condensing.

A very curious paper is one by Professor Denton "On the Identification of Dry Steam." He assumed that if steam was suffered to escape in a jet through a small tube, and the cloud were photographed, that the photographs would indicate a difference according as there was more or less water present. An account of the manner of making these experiments is given, and copiously illustrated by "process" reproductions of the photographs. These photographs support Professor Denton's assumptions, as little as 1½ per cent. of water making a perceptible difference. For the details of the method of check we must refer our readers to the paper itself. The principal conclusion of the author is that, if a jet of steam flow from a boiler into the atmosphere under such conditions that very little loss of heat occurs through radiation, and the jet be transparent close to the orifice, or even of a greyish-white colour, the steam may be assumed so nearly dry that no portable calorimeter can determine the percentage of water present. If the jet be strongly white, then there is at least 2 per cent. of water in it; how much more can only be told by the calorimeter.

One of the most valuable features in the Transactions under notice is the report on topical discussions and interchange of data. We have more than once suggested the adoption of a similar system in this country—unfortunately without effect. The thing is done thus. The secretary or a committee, or any member, suggests a question for discussion, and it is discussed without any reading of papers, and the members who know anything about the subject interchange their information. Thus, for example, the behaviour of steel formed a subject for discussion during the Scranton meeting, and the information supplied was so interesting and valuable on the whole that we commence its reproduction this week in another page. We must postpone the consideration of the second part of this volume, which deals with the Erie meeting and the visits of a number of the members of the Society to Europe last summer.

BOOKS RECEIVED.

The Colonial Year-book for the Year 1890. By A. J. R. Trendell, C.M.G. With introduction by J. R. Seeley, M.A. London: Sampson Low, Marston, and Co. 1890.

Report of the Italian Exhibition, 1888. Translation. London: Waterlow and Sons, Limited. 1889.

Graphical Statics. Two Treatises on the Graphical Calculus and Reciprocal Figures in Graphical Statics. By Luigi Cremona. Translated by Thos. Hudson Beare. Oxford: The Clarendon Press. London: Henry Frowde. 1890.

Electric Light Installations and the Management of Accumulators: a Practical Handbook. By Sir David Salomons, Bart., M.A., Assoc. Inst. C.E. New edition, revised and enlarged, with numerous illustrations. London: Whittaker and Co.; and George Bell and Sons. 1890.

Engineering Estimates, Costs, and Accounts: a Guide to Commercial Engineering. By a General Manager. London: Crosby Lockwood and Son. 1890.

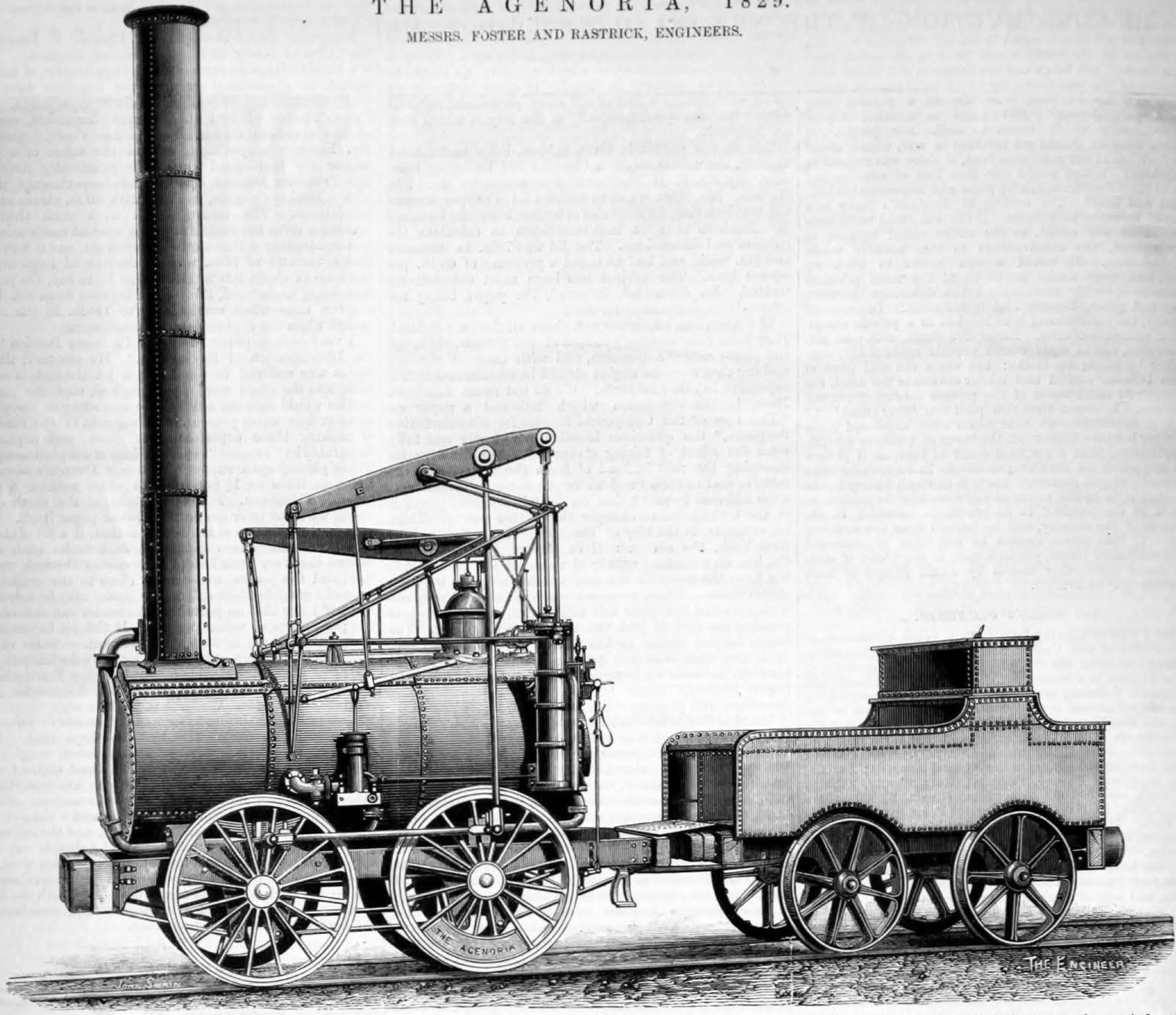
THE NEW DIRECT LINE TO PLYMOUTH.

THE engraving on page 196 is the first of several which we shall publish relating to the Plymouth, Devonport, and South-Western Junction Railway, which commences with a junction with the London and South-Western Railway at Lidford. From Lidford the South-Western Company has hitherto had to reach Plymouth by a single line with steep gradients belonging to the Great Western Railway Company, the length of the line being 22¼ miles. The dual ownership and working of the line has been for many years a great source of traffic inconvenience, and the new line has been constructed to avoid all this. It is a heavy piece of railway work throughout, and an account of it, which we shall give in a future impression with further engravings, will be found of interest.

ROYAL INSTITUTION OF GREAT BRITAIN.—The following arrangements for the lectures after Easter are announced:—The Hon. George C. Brodrick, D.C.L., Warden of Merton College, Oxford, three lectures on "The Place of Oxford University in English History," on Tuesdays, April 15th, 22nd, 29th. Mr. Louis Fagan, Assistant Keeper of Prints and Drawings, British Museum, three lectures on "The Art of Engraving—(1) Line Engraving; (2) Wood Engraving; (2) Mezzotint Engraving," on Tuesdays, May 6th, 13th, 20th. Mr. Andrew Lang, three lectures on "The Natural History of Society," on Tuesdays, May 27th, June 3rd, 10th. Mr. C. V. Boys, A.R.S.M., F.R.S., M.R.I., Assistant Professor of Physics, Normal School of Science, South Kensington, three lectures on "The Heat of the Moon and Stars," the Tyndall Lectures, on Thursdays, April 17th, 24th, May 1st. Professor Dewar, M.A., F.R.S., M.R.I., Fullerian Professor of Chemistry, R.I. Jacksonian Professor of Natural Experimental Philosophy, Cambridge, six lectures on "Flame and Explosives," on Thursdays, May 8th, 15th, 22nd, 29th, June 5th, 12th. Captain W. de W. Abney, R.E., C.B., F.R.S., M.R.I., three lectures on "Colour and its Chemical Action," on Saturdays, April 19th, 26th, May 3rd. Mr. Charles Waldstein, Litt.D., Ph.D., three lectures on "Excavating in Greece," on Saturdays, May 10th, 17th, 24th. The Rev. S. Baring-Gould, M.A., three lectures on "The Ballad Music of the West of England," with musical illustrations, on Saturdays, May 31st, June 7th, 14th.

THE AGENORIA, 1829.

MESSRS. FOSTER AND RASTRICK, ENGINEERS.

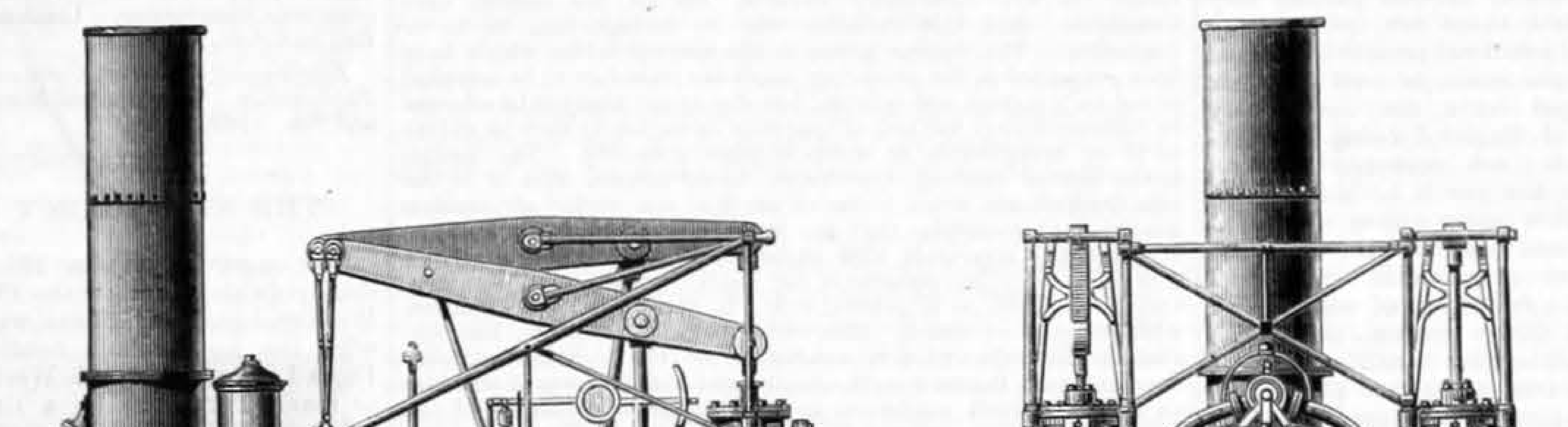


LINKS IN THE HISTORY OF THE LOCOMOTIVE.

No. XX.

We publish this week an engraving and particulars of the splendid compound engines constructed by Mr. Worsdell for the North-Eastern Railway. These engines beyond question represent the very latest development of locomotive engineering. As a matter of interest we also publish illustrations of two of the very earliest locomotives. We have thus before us links at each end of the chain of the history of the locomotive.

The old engines in question are the Agenoria and the Stourbridge Lion. The Agenoria, which has found an honourable asylum at South Kensington, was built by Messrs. Foster and Rastrick, of Stourbridge, in 1829, in which year it commenced working at the Earl of Dudley's colliery at Kingswinford to convey coal along the Shutt End Railway—as it was called—to the Staffordshire and Worcestershire Canal. We are unable to state the precise date at which it ceased working, but it was presented to the Museum in 1885 by Mr. W. O. Foster, of Apley, near Bridgnorth. We believe that it has never been previously noticed in any technical periodical, or by any writer upon the history of the locomotive.



THE STOURBRIDGE LION.

As will be seen by the woodcuts, the two engines are as nearly as possible identical in design, and they also exhibit a close resemblance to the Wylam engine, Puffing Billy—see The Engineer, June 16th, 1876—which was built by William Blackett about 1813. As the Agenoria and Puffing Billy are placed side by side at South Kensington, visitors have every opportunity of making a comparison.

The Agenoria has upright cylinders working half-beams, thus reducing the stroke of the pistons to the cranks. The cylinders are 7½in. diameter, with a stroke of 3ft. There is a parallel motion to the piston-rod, and the feed pump is worked from one of the half-beams. The fire is within a large tubular boiler, branching into two tubes, with the chimney at the end of the boiler, the barrel of which is 10ft. long and 4ft. diameter. The excentrics for driving the slides are loose on the axle, with a clutch to drive either way, and there is hand gear to the valves to cause the axle to turn half round to bring the right clutch into action. The exhaust steam is discharged into the chimney, but it does not necessarily follow that it acted as a steam blast. Indeed, the great height given to the chimney can have had no other object than to create the required draught. The same peculiarity was observable in the Rocket in its original state, when tried on the Liverpool and Manchester Railway in October, 1829. But the question of the invention of the steam blast has been much discussed—see The Engineer, October 23rd, 1857—and need not be re-opened here. To return to the Agenoria, the driving wheels are 4ft. diameter, and there are coupling rods to the front wheels, which are provided with springs. It will be noticed that the driving wheel is furnished with a counter weight, but it is not quite certain that this is original. Locomotive experience in 1829 was very limited, and the necessity for a counterweight could hardly have been suggested by *à priori* considerations, so that we are inclined to think that this is a later addition. At any rate, we find that Thomas Rogers, a well-known American locomotive builder, took out an American patent for balance weights in July, 1837. This is the earliest date which has been assigned to the invention. In our issue for January 30th, 1880, will be found a long article on the subject of counterweighting, in which some interesting letters from the late Mr. George Heaton, of Birmingham, dated 1838, were given.

The line was opened on June 22nd, 1829, and we are able to reproduce a contemporary account of the affair, which appeared in the *Birmingham Gazette* shortly afterwards:—

"The opening of the new railroad from Kingswinford to the Staffordshire and Worcestershire Canal with a locomotive steam engine took place on Tuesday, June 2nd, 1829, amidst an immense concourse of spectators from the surrounding country. We subjoin an account of the experiments made on the occasion; and it gives us pleasure to be enabled to state, that through the spirited and laudable exertions of James Foster, Esq.—whose

RE-CONSTRUCTION OF THE NEWARK DYKE BRIDGE, GREAT NORTHERN RAILWAY.

(*For description see page* 192.)

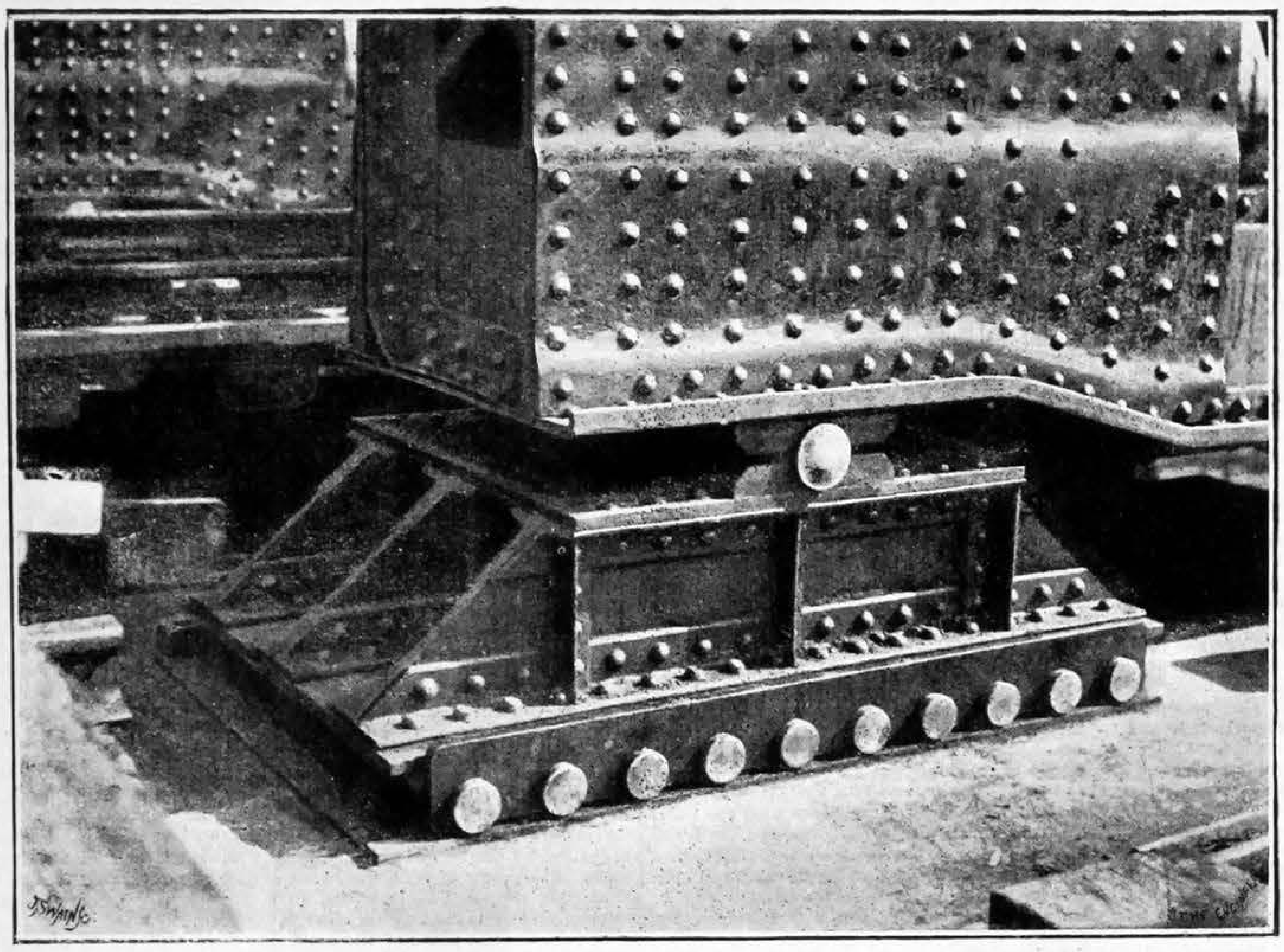


Fig. 9—GENERAL VIEW OF ROLLER BEARINGS.

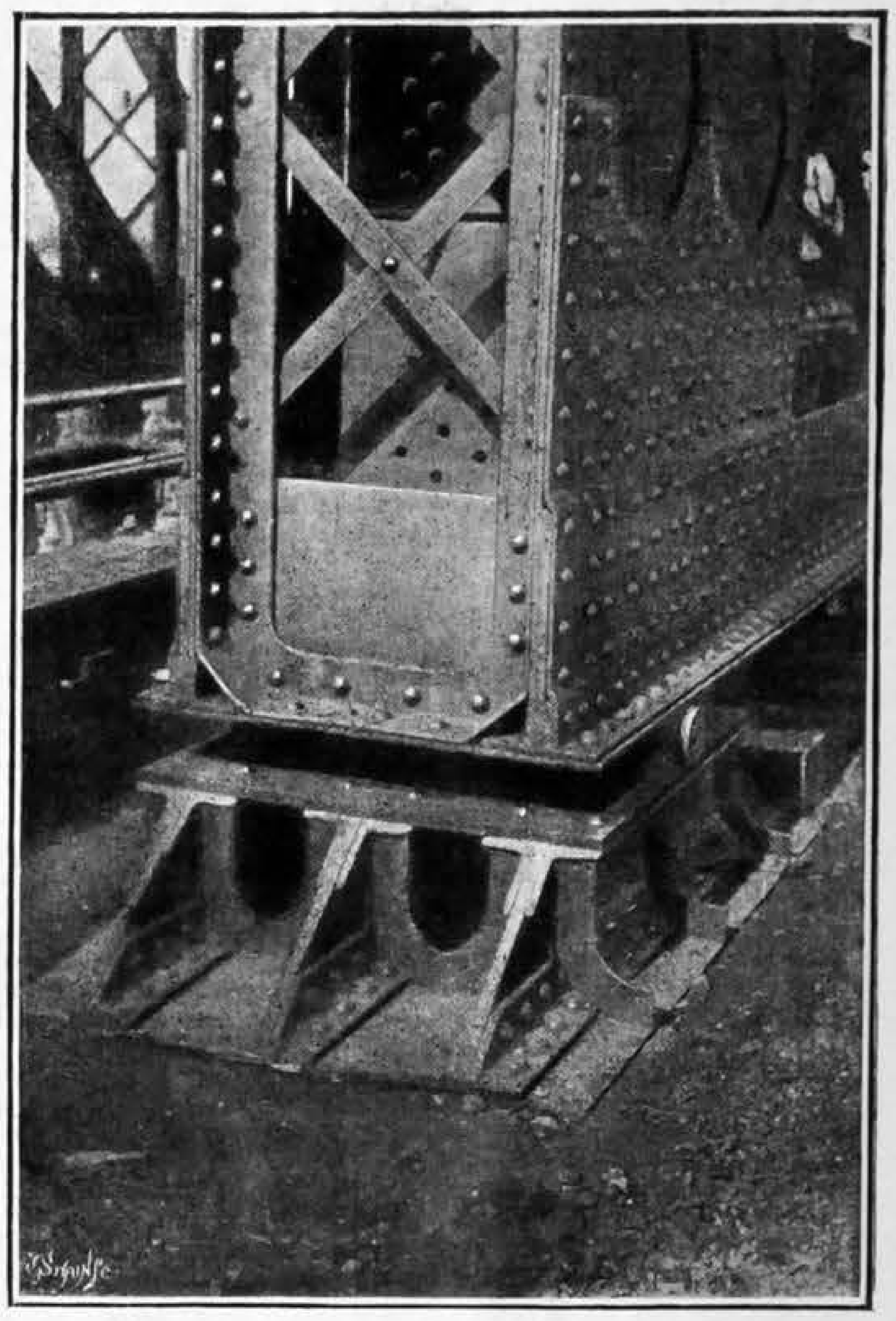


Fig. 8—GENERAL VIEW OF FIXED BEARING.

character for liberality and talents as a manufacturer and mechanist are already so well-known and highly appreciated—the most successful trial yet exhibited of the stupendous power of this machine has taken place in our own neighbourhood.

"The entire length of the railway is three miles and one-eighth; it commences at the colliery of the Earl of Dudley by an inclined plane of 1000 yards in length, having an inclination of $2\frac{3}{10}$ft. in a chain, and the carriages with coal are delivered down the plane in three minutes and a-half, bringing up at the same time an equal number of empty carriages. The railroad then proceeds from the foot of the incline plane for $1\frac{7}{8}$ mile, at an inclination of 16ft. in a mile, and on this part of the railway the locomotive engine travels, and delivers the wagons at the head of another inclined plane of 500 yards in length, having an inclination of $2\frac{35}{100}$ft. in a chain. The wagons are passed down this plane in a similar manner to the first, in one minute and three-quarters. At the foot of this second inclined plane there is a basin 760 yards long, communicating with the Staffordshire and Worcestershire Canal, parallel to which the railroad is continued on both sides, affording the means of loading sixty boats at the same time; and over the middle of this basin is a handsome bridge of eleven arches, on which the road from Wordsley to New Inn passes.

"The experiments on Tuesday commenced by the passing of a train of four carriages, each loaded with $3\frac{1}{2}$ tons of coal, down the first inclined plane, an operation which highly gratified the spectators, from its extreme simplicity. The locomotive engine, named the Agenoria, was then attached to eight carriages, carrying 360 passengers, the weight being—

	Tons.	cwt.	qr.
The eight carriages	8	8	0
Locomotive engine, tender, and water	11	0	0
360 passengers, estimated at	22	10	0
	41	18	0

and the whole proceeded, attended by a band of music, from the foot of the first inclined plane to the head of the second, and returned, being a distance of $3\frac{3}{4}$ miles, in half an hour, or at the rate of $7\frac{1}{2}$ miles per hour. The distance might have been accomplished in much less time, but being the first experiment, all the power of the engine was not applied. On the return of the engine and passengers carriages laden with coal, to the number of twelve, had descended the inclined plane; these were attached to the engine with eight carriages of passengers, the weight being—

	Tons.	cwt.	qr.
Twenty carriages	21	0	0
Engine, tender, and water	11	0	0
Coal in twelve wagons, $3\frac{1}{2}$ tons each ...	42	0	0
360 passengers in the eight carriages, 540 ditto on the coal carriages, and 20 ditto on the engine, tender; 920, estimated at	57	10	0
	131	10	0

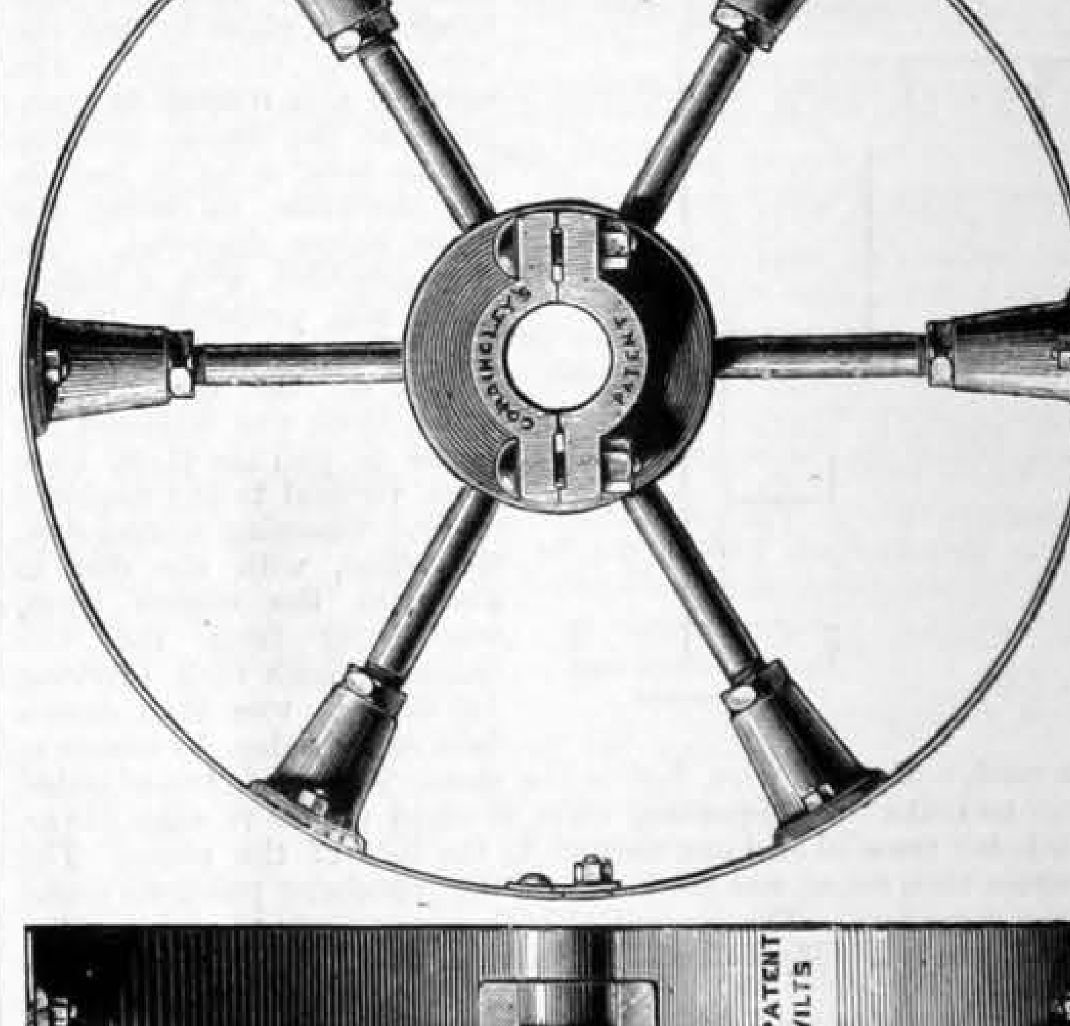
"The engine then started with its load of 131 tons, and proceeded to the head of the second inclined plane; and the distance, $1\frac{7}{8}$ mile, was performed in 33 minutes, being at the rate of nearly three and a-half miles per hour. On arriving at the head of the inclined plane, the carriages loaded with coals descended the plane. The engine next returned with the eight carriages loaded with passengers at the rate of six miles per hour, and on reaching the foot of the first inclined plane, all the carriages were disengaged from the engine, except the engine tender, with twenty persons on it. The engine was again started, and proceeded with the tender and twenty passengers about a mile on the road, performing the trip at the rate of eleven miles per hour, although not more than half of the engine power was laid on. This concluded the experiments; and we are happy to add that not the slightest accident occurred, although an immense crowd was collected about the carriages while proceeding; many of whom, by hanging to them, very much impeded the progress of the engine in the second trip with the twenty carriages. Indeed, it was computed that in addition to the 920 passengers in the carriages, 300 others were dragged along. The engine was made under the superintendence of Mr. J. U. Rastrick, at Stourbridge, who has bestowed no ordinary pains in its construction, so as to obviate the noise and smoke which those of original make, and used in the North of England are subject to. And we must do him the justice to say that he has succeeded beyond what could have been expected; the noise occasioned by the escape of the steam, when discharged from the cylinder, is wholly done away with, and the smoke is scarcely more than that produced by an ordinary chimney. The safety valve is much improved by a spring, so as to prevent the escape of steam from vibrations of the engine; and another safety valve is added, which is entirely inaccessible to the engine-men, thus rendering the engine infallibly secure from explosion. Another very ingenious contrivance is introduced, by which the engine oils its bearings on the carriage at every revolution of the wheels."

Attention should be directed to the spring safety valve and the self-acting lubricators. The tender shown in our illustration is a restoration, and is not at South Kensington.

The Stourbridge Lion "was the first substantial and effective locomotive put upon an American railroad," to quote a paper read before the Albany Institute in April, 1875, by Mr. Joel Munsell, on the "Origin and Progress of the Mohawk and Hudson Railroad." It has a very interesting history, and although a drawing has survived, the machine itself has long since disappeared, with the exception of a few fragments which were shown at the Centennial Exhibition at Philadelphia, in 1876. The description of the Agenoria given above will answer for the Stourbridge Lion, with a few obvious exceptions. It was built in 1828 by Messrs. Foster and Rastrick, to the order of Horatio Allen, who was sent over to this country by the Delaware and Hudson Canal Company — which was contemplating the construction of a railway—in order to obtain information upon the subject of locomotives. The engine arrived in New York in the winter of 1828-9, but it was not placed upon the line until some months afterwards, and not actually tried until August 9th, 1829, when Mr. Allen drove the engine alone from Honesdale along a section of the line about three miles in length. Driving a locomotive was then regarded as an extremely hazardous enterprise, and when the steam was got up Allen took his place on the engine, and said, "If there is any danger in this ride it is not necessary that the life and limbs of more than one should be subjected to danger." So he started alone without even a fireman, though, as he says, he had never run a locomotive before. Mr. Munsell, in his paper quoted above, states that the Lion was never brought into practical use, as it proved too heavy for the road. The engine is said to have received its name from the fancy of the painter, who decorated the end of the boiler with a large head of a lion. The fact that Horatio Allen only died on the 1st of January of this year brings home forcibly to one's mind the thought that our railway system has grown up in a single lifetime. Ericsson, who was one of the competitors in the Rainhill trials on the Liverpool and Manchester line in 1829, only died about a year ago.

CORDINGLEY'S PULLEY.

THE accompanying engraving illustrates a split pulley patented and manufactured by Mr. I. Cordingley, Trowbridge, Wiltshire. The construction of the pulley will be readily understood from the engraving. It will be seen that cast iron



sockets are secured inside the wrought iron rim. The wrought iron spokes are screwed and fitted with nuts, which can be set out against the sockets, so as to make the box truly central. The whole arrangement is very simple, and the wrought iron rim can always be kept the proper shape.

TENDERS.

WIRRAL RURAL SANITARY AUTHORITY.

LIST of tenders for the construction of public sewers at Heswall, Cheshire; Mr. Charles H. Beloe, M. Inst. C.E., Liverpool, engineer; quantities by Mr. Frank E. Priest, Assoc. M. Inst. C.E., Liverpool:—

	£	s.	d.
Thomas and Co., Liverpool (accepted)	4416	16	0
A. Bleakley and Son, Birkenhead	4635	0	0
Holme and King, Liverpool	4760	0	0
Fawkes Brothers, Southport	5100	0	0
Powell and Thackleton, Chester	5366	15	2
J. Fish and Co., Preston	5450	0	0
J. McCabe and Co., Liverpool	5924	16	2
Thornton and Son, Liverpool	5935	0	0
R. Malabar, Liverpool	5959	0	0
W. Hope, Liverpool	5997	12	10
Monk and Newell, Bootle	6179	10	6
J. Dovenor and Co., Liverpool	6233	0	0
Wm. Vaughan, Wrexham	6300	0	0
Sterling and Swann, Manchester	6800	0	0
John Taylor, Garston	9000	0	0

LETTERS TO THE EDITOR.

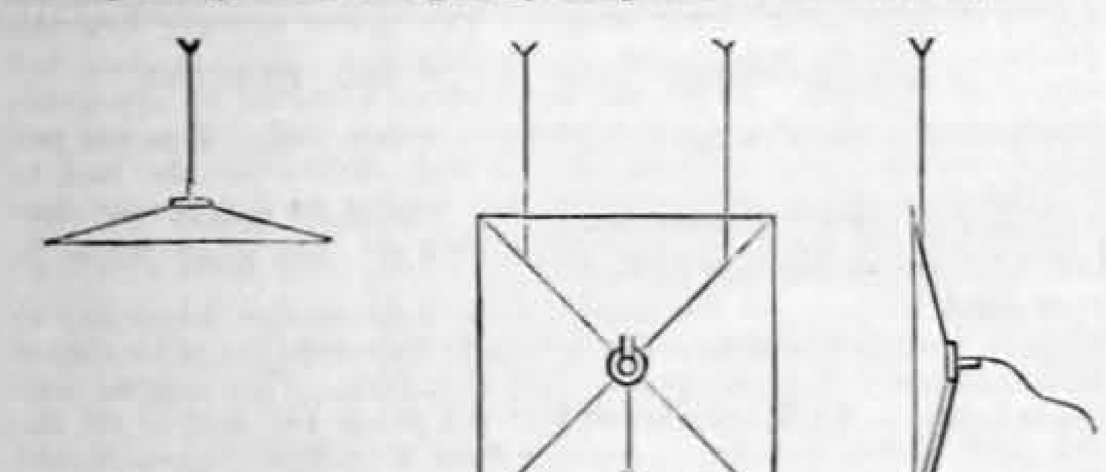
(We do not hold ourselves responsible for the opinions of our correspondents.)

THE REACTION OF AIR ON PLANES.

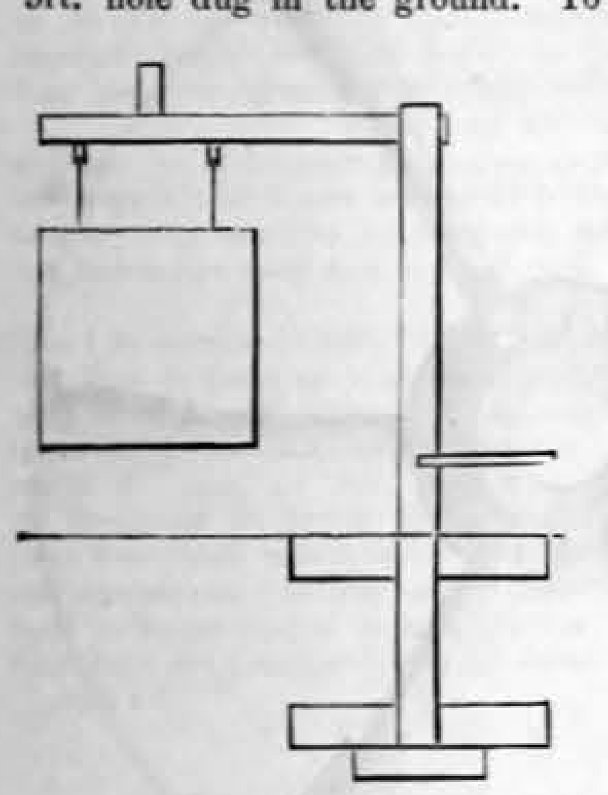
SIR,—The experiment in wind, here submitted, was first made, with some difference in detail, ten years ago, in latitude 27 deg. North, on the Gulf of Mexico, at an elevation of 20ft. above sea level, in an atmosphere of great humidity, with rainfall of 100in. per annum, and sea breezes of great steadiness. It was re-tried, and the experiment made in still air, just concluded, at my present location, 8000ft. above sea level, in an atmosphere of extreme dryness, with no rainfall, and winds of mixed currents and much irregularity. The plane used was 5ft. square, feather-edged all around, one side a true plane and the other a four-sided pyramid 2½in. high in the centre, the plane side measuring 25 square feet. It was made of thoroughly dry and clear pine slats, 1½in. wide and $\frac{3}{16}$in. thick, laid upon a frame of four diagonal pieces, fitted with strips cut between, parallel to the edges. All parts were covered with a coat of shellac varnish before being set to place, and fish glue used; the common article mixed with water, or any adhesive material that shrunk in drying, being inadmissible. Thus made, the ends of the slats formed the four edges of the plane, which, being dressed to feather-edges from the back, made them sufficiently firm to serve the purpose with careful handling. It was then smoothed, varnished, and finished to a polished surface on both sides.

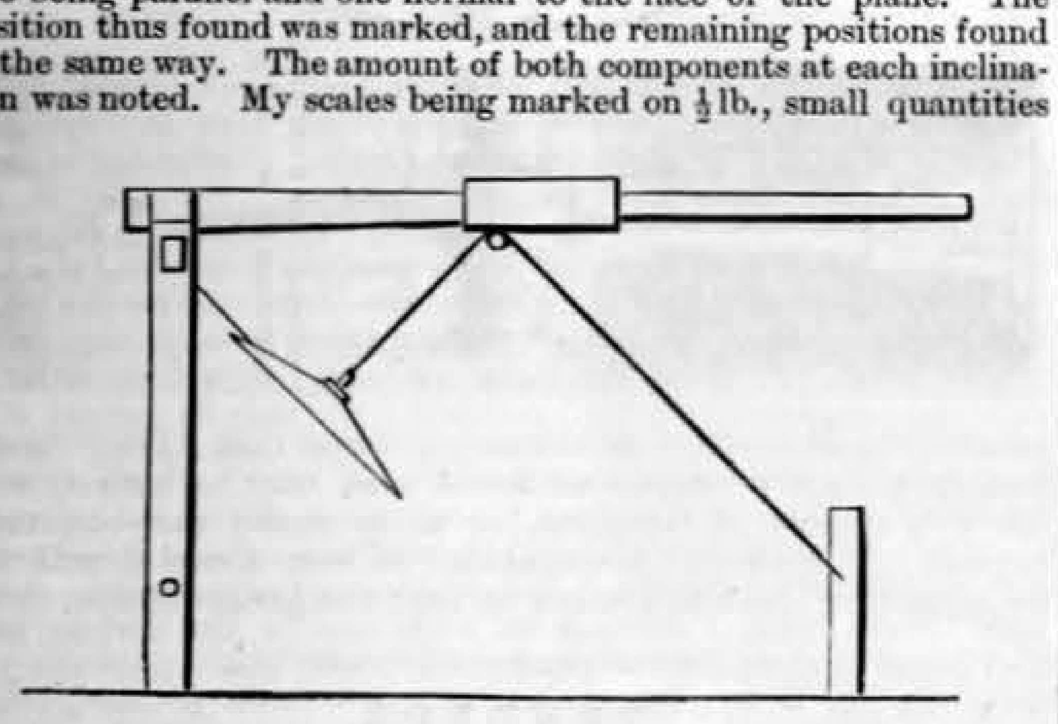
Constructed in this way, it was practically a plane without thickness when used up to an inclination of 5 deg. from level in a horizontal wind, or carried against still air, all parts of the slanting back being below the high edge. It was suspended by the apex of the back and balanced, so that the centre of gravity and centre of measurement of the flat side coincided when it rested level. A rigid stem, 4in. long, was then fixed in this centre, to the top of which the sustaining wire was fastened, thus securing greater stability. A fine wire was fixed to the back, resting upoh it and extending from the stem to within 6in. of one edge. A circular disc of lead, ⅜in. thick, slotted to the centre to slip on the stem, and grooved next the plane to move on the wire, was used to shift the centre of gravity to the rear, to correspond with the shifting centre of air pressure as the inclination of the plane was changed or differences in the air current occurred. The groove clasped the wire sufficiently tight to hold the disc in any position in which it was placed along it. Two fine steel wires were secured near the edge opposite the wire and disc, so that, when suspended by them, with the disc at the stem, the flat side of the plane would hang plumb. The plane, without the disc, weighed 22 lb., and 27 lb. with it.

Three pairs of Chatillon's spring balances were used to determine the quantity of the two gravity components at seventeen positions,



viz.: at 5, 10, 15, 20, 25, 30, 35, 40, 45 deg. from vertical, and the same from horizontal, comprising the arc of 90 deg. in which gravity admits of resolution. In operating, the plane platforms were found to be objectionable, and the least possible framework advisable. A round timber, 15ft. long, was placed vertically in a 5ft. hole dug in the ground. To the top of this was secured a strong cross bar, to which was fastened two balances, sustaining the plane by the two wires near the edge. The upright was framed in gudgeons at the bottom and top of the hole, so as to turn in any direction to bring the plane across the wind. An arm, provided with a sliding block and projecting to the rear, was secured to the centre of the crossbar, to which block was fastened the scales to pull the plane back from vertical to any required angle. Choosing a calm day, the plane, with the disc in place at the centre stem, was hung from the two balances, each scale marking 13½ lb. It was then drawn backwards 5 deg. by means of the cord, scale, and wire, fast to the stem. The block was adjusted so as to make the supporting wires at right angles to each other, two being parallel and one normal to the face of the plane. The position thus found was marked, and the remaining positions found in the same way. The amount of both components at each inclination was noted. My scales being marked on ½ lb., small quantities





were not detected. The components are herewith given from 45 deg. to 5 deg. of horizontal, which will show fractional errors when compared with the exact figures.

At	45 deg.,	parallel,	19 lb.;	normal,	19 lb.		
,,	40 ,,	,,	17 ,,	,,	21 ,,		
,,	35 ,,	,,	16 ,,	,,	22 ,,		
,,	30 ,,	,,	13 ,,	,,	23¼ ,,		
,,	25 ,,	,,	9 ,,	,,	24¾ ,,		
,,	20 ,,	,,	8½ ,,	,,	26 ,,		
,,	15 ,,	,,	6 ,,	,,	26¼ ,,		
,,	10 ,,	,,	4 ,,	,,	26½ ,,		
,,	5 ,,	,,	2 ,,	,,	27 ,,		

There is no wind of my experience equal to a month of May sea-breeze on the Gulf of Mexico for trying this experiment. If the wind is as bad as those of my present locality, some particular inclination must be selected and the plane held back by a fine cord from near each corner, running to pieces across the top of the frame. I have had winds enabling me to operate the entire seventeen positions in a single day, and I have stood an entire day at the post without getting a single one. The centre of pressure beneath the plane varies with the inclination, and some peculiar characteristic of wind, but in all cases it shifts towards the rear. This must be met by adjusting the disc, as it is imperative that the two wires be parallel to the surface at the instant the air pressure balances the normal factor.

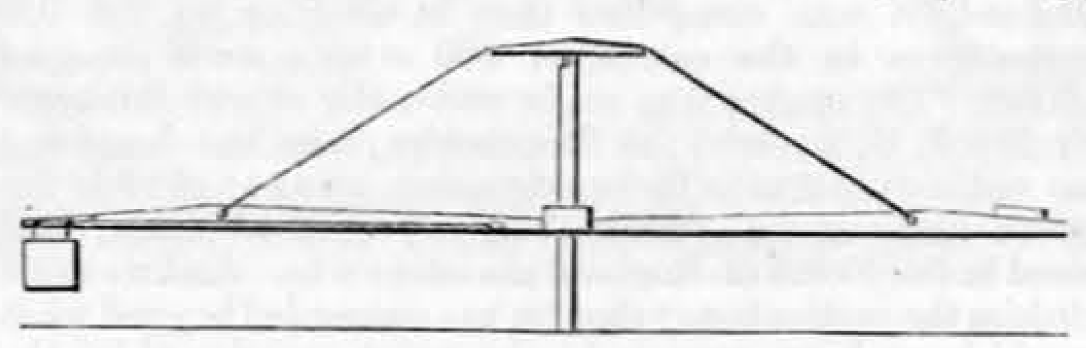
As the wind rises and increases in strength, the plane will swing backward, arriving successively at each of the indicated positions, where it is obvious that the pressure equals the normal component, the wind taking the place of the normal wire. The two scales noting the parallel component remain unchanged at each of these positions, continuing to indicate a pull upon them precisely as they did in calm air. I have tried this experiment in many ways, and at a great number of angles through the 90 deg. arc, and never found a position where the parallel component was acted upon by the wind in the least degree.

To try this experiment in still air, a dead and dry pine tree was selected, 24in. in diameter at the butt, 10in. at the top, and 36ft. long. It was planted 8ft. in the ground, projecting 28ft. vertically above the surface. At the top, a cup with hard brass bottom and Babbitt metal sides was secured, into which stepped an iron pin, with rounded end, carrying a horizontal beam 16ft. long. 18ft. below, an arm was placed 110ft. long, with a ring at the centre encircling and closely fitting the post, which latter was dressed round, concentric with a vertical axis through the centre of the pin above. The arm was fastened rigidly to the beam by a lattice-work cylinder 3in. diameter, encircling the post, the whole being made of wood and superfluous weight avoided. 36ft. from the centre both ways a cross-head 5ft. long was fastened to the arm, from the two ends of which a wire was carried to the beam above. This device formed a trussed chord, capable of rotation in a horizontal plane upon the pin resting in the cup at the top of the post. The top of the cup was flared on the inside, and filled with oil. The outer ends of the arm travelled a circumferential path of 346ft. at each rotation. Friction was small; 1 oz. constant pressure on the outer end of the arm would move from rest, and rotate the truss to a velocity of 5ft. per minute in calm air. The atmospheric resistance was astonishingly great after a velocity of about 15ft. per second at the circumference was reached. The device was not made for this experiment alone, and a weight was placed on the opposite end of the arm to balance the plane operated with.

The same plane, scales, disc, and wires were used as in the wind experiment, and the method of proceeding was the same, with an exception. The motion of the plane as it was carried around prevented reading the scales as they passed. To remedy this the two parallel wires were passed over pulleys to a ring, from which a single wire was carried along the arm to the balance near the post, where the operator could walk around with the arm and read the register. The arm being 10ft. above the ground, the position of the plane could be determined by walking under the arm near the centre. The centrifugal force was not great enough seriously to interfere with the experiment, on account of the slow velocity of rotation.

The outer edge of the plane was hung even with the end of the arm, the positions were noted while at rest and marked by rods fast to the arm. As the arm was rotated, and the plane swung backward to the successive positions, the balance presented the same reading of the parallel component as in the other case. In no instance did it record a greater tension when in motion than when at rest. This method was far superior to the other. Any velocity of meeting of plane and air could be used at will; any angle could be chosen for testing, and the scales noticed from a vertical position of plane to the chosen inclination. The balance would indicate the total weight at starting, and show diminished tension until the selected angle was reached, when the index would stand at the figure representing the parallel component at the given inclination. There was no tremor of plane, as in the other case, but all went on as steadily as clockwork.

Selecting any angle of inclination at the wind device, say 45 deg.,



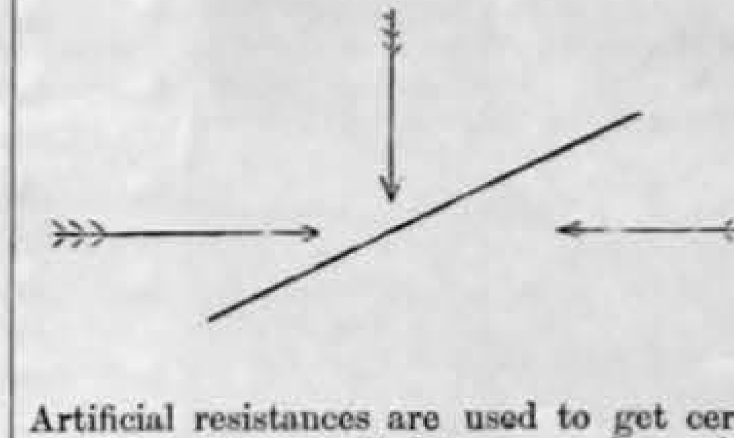
the plane was prevented from going higher by four small steel wires fixed near each corner and extending to pegs in the ground, or to any ready fastening below, so that each wire would be at right angles to the plane. Noting the two balances in wind, it was found that they stood at 19 lb. after the plane was stopped by the wires, no matter how brisk the air current might be. It might get up to a fifty-mile-an-hour gale, and whistle about the post at a great rate, but the index would stand at 19 lb. through it all, though if the wires were cut the plane would go above the 5 deg. inclination in an instant. The same result occurs in the other experiment; two rods must be fastened to the arm and project beneath the plane to hold the four wires, and no matter how fast the rotation may be, the index will stand at the 19 lb., not moving from the position it took before the rotation began.

The golden rule to keep in mind in trying these experiments is, that "rectangular forces do not antagonise each other." The case is very obvious. Two forces are dealt with, the parallel and normal components of gravity. The direction and quantity of each is known, and they are always at right angles to each other. The reaction of the parallel component is the resistance of the arms holding the two wires, and it acts along the wires, being absolutely independent of the air or wind. The reaction of the normal factor is pressure under the plane, and this is normal to the plane in all cases, in direct opposition to the direction of the normal factor. In applying wires, cords, rods, or any contrivance to steady the plane, see that they do not interfere with either of these forces or their reactions. No matter how much bluster there is in the wind, the plane can be secured in a position of steadiness without in the least interfering with the action of the gravity forces.

There is something to be learned from these two experiments. One thing is obvious. It is not the direction in which plane and air meet each other, but the position of the plane, that determines the direction of the reaction; and a curious thing is, that any competent physicist should be able to predict this before the experiment is tried, if he is acquainted with the law of fluid pressures. It is also obvious that the plane is not "held against the air" at all. The air splits gravity in two parts, throws them both out of the vertical, and 90 deg. asunder, antagonises one, and exerts no influence on the other, which still acts on the plane as it would if the latter were in a vacuum. There is plenty of head resistance in text-books and the writings of physicists, but no such thing is found in nature.

As nearly as I am able to determine, the prevalent notion about this matter is, that the air would react upon the plane in these experiments in two ways—one horizontal, or drifting, and the other vertical, or lifting. The first statement of this kind, that I know of, is contained in the "Penny Encyclopædia," under Aëro-dynamics. Then there are Mr. Skye's experiments on inclined planes 1ft. square, wind twenty-three miles per hour. We also have the Aëronautical Society's experiments, made in 1871, and many others, all tending to the same result. I am not informed as to the exact method of getting these factors, but suppose it to be done in this way: An inclined plane is held by two supports—one vertical, the other horizontal. It is then subjected to a horizontal current of air, and the components found by measuring the tension on the two supports. It is then inferred that the air current reacts upon the plane in those two directions to the amount found.

It is a puzzle why these two directions were selected. Why not any other two in the same vertical plane? Why not add another direction, like a three-legged stool, or four, or forty, or any number? The first two resistances act together as the equivalent of one resistance. So do all the three, or four, or any number. The direction of all the resultants is on the normal line, and the quantity equals the amount of pressure beneath the plane. It is very true that any sort of resistance can be offered to the air pressures; but the supposition seems to be that a lifting and drifting force resides in the wind, independently of any resistance offered to the plane. By this method there is no degree of inclination in the 90 deg. arc but what would require a force greater than the weight of plane to support it. It is not surprising that the Aëronautical Society failed to solve the problem of flight on this basis, and it is in this province that such improper methods work bad.



Artificial resistances are used to get certain results, and these results are then applied to cases where there are no such resistances, nor anything resembling them.

But it is when questions of work arise that these two experiments, the subjects of this paper, become significant; and I wish to direct attention particularly to this teaching of the forces in action. Both in wind and calm there is continuous work done. The air is compelled to constant change. It is forced out of place, condensed, and disturbed in various ways. To what agency must this work be referred in each case? Mechanical experts would say, in the case of wind, to whatever set it in motion. In calm, to the force that rotated the arm. We are then beset by difficulties. We have work being done unlike anything known. It is hard to see why wind does not do the work in both cases if it does in one; and if the arm is the active agent, the cross bar holding the two balances should also be. But both arm and bar are preventing the parallel component from acting on the plane, and this is their whole function. Can a force which prevents another force from acting on the plane do the work that the plane is manifestly doing? Besides, the direction in which both arm and bar act is parallel to the plane, and the work is done at right angles to it. Wind is out of the case, for in one experiment the air is calm.

There is going on a play of forces of unique character wherein certain links of the chain of sequence are hidden; we may be in a kind of mechanical quagmire of resultant motions where the factors are not recognised, or there may be forces in action not indicated by the balances. I think the dilemma may be removed without stepping beyond the limits of the two experiments, but if they were supposed to be varied in a certain way we might get analogous results that would clear up the fog.

If we place the plane of the experiments in still air at an angle of 10 deg. from horizontal, and suppose the parallel component to be cancelled and equilibrium to be maintained, it would descend with acceleration in the direction of the normal factor until the air pressure beneath the surface was 26½ lb., when motion would become uniform at the rate of about 25ft. per second. While uniform motion was going on, if we applied against the lower edge at right angles to it in a direction parallel to the surface a constant pressure, the plane would move on the upward slant in obedience to that force, slipping over the condensed air. As it would be at the same time descending, no part of the raised back would be carried against the air, provided motion was great enough to cause a horizontal resultant. The front edge having no thickness, a very small force would generate high velocity against skin friction on the under side of the plane. Say that 1 oz. constant rear pressure produced a uniform parallel motion of 140ft. per second, the plane would then move on a constant resultant path that was horizontal. Suppose it to be at an indefinite distance to the rear of, and approaching at the same level, the location of the experimental plane above given, and wind should gradually arise swinging the latter towards the 10 deg. inclination. As the current became stronger and stronger the motion of the hypothetical plane over the earth's surface would become slower and slower, until at the moment when the 10 deg. inclination was reached by the experimental plane, the other might come to a position by its side and stop, and both planes would rest side by side upon the air. In one case the parallel component of gravity would be hypothetically cancelled; in the other, cancelled as a matter of fact by the cross-bar and wires. The hypothetical 1 oz. of pressure would be acting on one plane, and a matter of fact 1 oz. on the other, but the balances being marked in ½ lbs. it could not be detected by the operator. The normal factor would be doing work on the air alike in both cases.

If the hypothetical plane passed the locality of the arms rotating in still air, it might move tangentially by the side of the experimental plane, as it was carried around on a 10 deg. inclination, in which event the parallel component of one would be hypothetically cancelled, that of the other really so, the 1oz. of postulated and real pressure be acting alike in each case, but the latter not detected because of small motion of the scale index, and the normal factor alike working in each case. It is obvious in the wind experiment with plane at any inclination, if a constant pressure equal to the tension on the parallel wires be applied in the same manner as the 1 oz. against friction, the parallel wires might be cut, and the plane would stand in wind without moving from its locality.

Close attention to the hypothetical case will remove all obscurity from the two experiments, and leave the normal component of gravity in quiet possession of the ground, as the constant working agent, neither wind nor rotating arm assisting or opposing it in the least degree.

I. LANCASTER.

Egeria, Colorado, January 25th.

THE REACTION OF JETS.

SIR,—I am pleased to see that your correspondent, "Old Student," does not find me obscure, and I thank him for the compliment that he pays me. The statical reaction of a jet of fluid, or diametrically opposed action upon a fixed jet nozzle, is equal in amount to the weight of a column of the fluid whose height is such that a body, falling through it under the action of gravity alone, will acquire a velocity equal to that of the jet at the point of issue, and whose uniform area throughout this height is equal to that of the jet at the same point, provided that the fluid is guided without friction to the orifice in such a manner that no subsequent contraction of the cross section of the jet takes place.

In the case where an orifice is made in the thin side of a vessel, the reaction of the jet or force tending to push the vessel in the opposite direction from that in which the jet is moving at the point of efflux, is equal to the weight of a column of the fluid whose height is nearly equal to the distance of the centre of the orifice from the surface of the fluid in the vessel, and whose uniform sectional area is that occupied by the jet at the point where it is moving at its maximum velocity, which area corresponds with that of the throat of the *vena contracta*.

I have said in the preceding paragraph that the height of the column of fluid is nearly equal to, &c. &c., because the velocity at the throat of the *vena contracta* is never quite equal to the theoretical due to the actual head, and if the efficiency of discharge be called K, K being of course less than unity, the real height H that the column must be considered to have will be K^2 H; K in practice is about ·97, and K^2 therefore about ·941. A more convenient practical method is to take the sectional area of the column of fluid as equal to that of the orifice in the side of the vessel, and the height thereof such that a body falling through it under the action of gravity alone would acquire a velocity equal to K times that which it would acquire by falling through a height represented by the difference in level between the surface of the fluid and the centre of the orifice. The quantity K, less than unity, is the coefficient of discharge, and for an orifice in a thin plate is about equal to ·62. The statical reaction of a jet of fluid issuing from an orifice in the thin side of a vessel is therefore :—H being the actual height of the surface of the fluid in the vessel above the centre of the orifice therein, A the area of the orifice in square feet, K the coefficient of discharge, and w the weight of a cubic foot of the fluid in pounds weight.

$$= w \, K^2 \, A \, H.$$

As an example, let the fluid be water, so that $w = 62 \cdot 4$ lb. Let H, or the distance between the centre of the orifice and the surface of the water in the vessel, be 30ft. Also let the orifice be a round one, 4in. in diameter, through the thin vertical side of the vessel, so that

$$A = \left(\frac{1}{3}\right)^2 \frac{\pi}{4} = \cdot 087266 \text{ square feet};$$

and K, according to practice, = ·62 nearly. Then the reaction of the jet issuing from this orifice, the area of the vessel being supposed to be so great that no appreciable lowering of the surface of the water takes place, will be equal to a weight of $62 \cdot 4 \times (\cdot 62)^2 \times \cdot 087266 \times 30 = 62 \cdot 796$ lb., and this is the force that tends to move the vessel away from the jet. If a nozzle could be devised such that the velocity at the throat were exactly equal to the theoretical due to the head, and if it were fixed inside the vessel, so that the cross section of its throat exactly coincided with the orifice in the side, the reaction of the jet would then be = W A H lb. weight, or in our example, 163·362. This your correspondent evidently quite understands and believes.

It is easily proved, because before the orifice and internal nozzle existed, the vessel and its contents were in equilibrio, but now the statical pressure upon a portion of the side of the vessel equal in area to that of the orifice, exists no longer as such, and the equilibrium is disturbed to the extent of a force equal to W A H lb. weight.

When the vessel or jet nozzle itself moves in a contrary direction to that of the jet, the reaction or force tending to push the nozzle backwards is diminished, and is only equal to that which would obtain with a fixed jet working under a head giving a theoretical velocity of efflux equal to the difference between that due to the head in the vessel and that at which the jet nozzle itself moves; and all corrections due to the form of nozzle would have to be applied to this newly found theoretical head as before.

Here we verge upon the theory of reaction wheels, and I must stop, as this is no part of "Old Student's" question.

The term reaction, as distinguished from impulse in the action of a jet upon different forms of vanes in motion, is another branch of the subject altogether. I do not know whether your correspondent has Rankine's treatise on the steam engine, but all this is most clearly explained there, as also is the action of reaction wheels, where centrifugal force greatly modifies that of a fixed jet. If "Old Student" would like to see how far discussion upon the reaction theory may go, he has only to refer to your 1886 volumes, where he will find such a delicious mixture of opinions by professors and readers as can scarcely be met with elsewhere, and that too without any real tangible result having been arrived at, in my opinion at all events. ANTHONY S. BOWER.

St. Neots, Hunts, February 24th.

MONITORS IN THE AMERICAN NAVY.

SIR,—The last paragraph of the able article in your last week's issue is surely the strongest possible argument against Monitors. A modern battleship has to carry a large amount of "tophamper"—by which I understand erections on the upper deck, not part of the general structure of the hull. A Monitor cannot do so; if she does, she ceases to be one. Therefore, a Monitor cannot be a modern battleship. If these erections are not necessary, by all means let us clear them away. The fact that our decks are 20ft. above water, instead of only 4ft., does not make the process more difficult. If they are necessary, and the Monitor has not got them, it is surely all the worse for the Monitor.

It is certain that we are not worse off in this respect than our neighbours. I have before me photographs of the Amiral Duperré and Lepanto, and any advantage they have over the Benbow, for instance, is only due to the greater space on their long and lofty upper decks. The Admiral Nachimoff, the Russian counterpart of the Imperieuse, when I saw her last year, had her upper deck similarly encumbered, and had in addition the brig rig which we have discarded. In comparing the Victoria with the Miantonomoh, we are comparing a ship of to-day with one of twenty-five years ago. In those days, machine guns, torpedo boats, booms and nettings, electric search lights, and forced draught, were not in existence. It is these chiefly which have transformed the Monitor into the Victoria by a gradual process of evolution, every stage of which, except the first, is illustrated in our Navy.

I submit that it is the torpedo boat, not the loss of the Captain, which has killed the Monitor. Torpedo boats will always beat Monitors at the game of invisibility, and could the enterprising commander of a dozen of these craft wish for an easier prey than a 10,000 ton Monitor with four big guns, 4ft. freeboard, and an armour overhang? It is, of course, natural that American naval men, without the experience which we have bought so dearly, should look with favour on their national craft, associated as they are with a glorious past. Moreover, in a coast defending navy they are nearly as valuable as ever. But salt water is invigorating, and, if they go to sea, I venture to prophesy that they will soon grow into Victorias, Trafalgars, and Hoods, and probably end as Sicilias and Sardegnas. G. W. C.

February 24th.

BOILER EFFICIENCY.

SIR,—Professor Unwin is quite right in pointing out that the fraction $\frac{T_o - T}{T_o}$ derived from Mr. Anderson's illustrations has thing to do with the fraction $\frac{T_o - T}{T_o}$ derived from Carnot's cycle, and my introduction of Carnot's name into the paper was about as sensible as Mr. Dick's introduction of King Charles' head into the memorial. All I can say is I have repented of the deed.

But the Professor is quite wrong when he says I blunder in writing T_o as the denominator in my expression for the efficiency of the boiler. Efficiency implies reference to a standard. The standard I referred to in drawing the analogy between the waterfall on the hillside and the temperature fall in the boiler flue, was the whole of the heat received from absolute zero, the sea level of temperature, not the heat of combustion of the coal alone. This standard I expressed by $W \sigma T_o$, and the proportion which $W \sigma (T_o - T)$, the heat available for transfer to the water, bears to $W \sigma T_o$ is $T_o - T : T_o$; therefore having regard to the standard adopted, I did not blunder in writing the denominator T_o. As the Professor says, $\frac{T_o - T}{T_o}$ is not the expression of the efficiency of a boiler in the ordinary sense. I never said it was, but—admitting my assumption regarding specific heat and furnace temperatures—it is the correct expression with reference to the whole heat received, just as the same fraction is the correct expression in the case of the waterfall with reference to the whole fall from the lake to the sea level.

Doubtless, also, as the Professor says, the expression is not a very useful one. Indeed, to him the parable of the waterfall must appear entirely superfluous, since it had nothing whatever to do with the subject of the paper. Sir, the parable was padding, introduced to catch the attention of my audience, and dispose them to listen contentedly to the less imaginative matter that was to follow. The Professor, no doubt, is able to dispense with such small artifices, and, failing to grasp the situation, has attached more importance to the little piece of introductory padding than it deserves. MICH. LONGRIDGE.

12, King-street, Manchester.

TIME TESTS.

SIR,—I asked "Z. Y. X." to determine the acceleration graphically, and instead of doing that, he introduces the well-known equation to the parabola, thence deducing the acceleration by a double differentiation in the form $f = \frac{2d}{t^2}$, where d represents the extension $C^1 D^1$, corresponding to the time $t = O C^1$, and finally adds that any one who knows his Euclid can construct this expression for f by means of a semicircle. Now the diagram which "Z. Y. X." charitably refrains from drawing is really worth the trouble, if only for the sake of showing the inadequacy of the proposed solution. Thus, produce $C^1 D^1$, making $D^1 P$ equal to $C^1 D^1$; so that $C^1 P = 2d$. Join P O and set off O M at right angles to P O, meeting $P C^1$ produced in M; then obviously

$$O C^{1\,2} = C^1 M \times P C^1$$

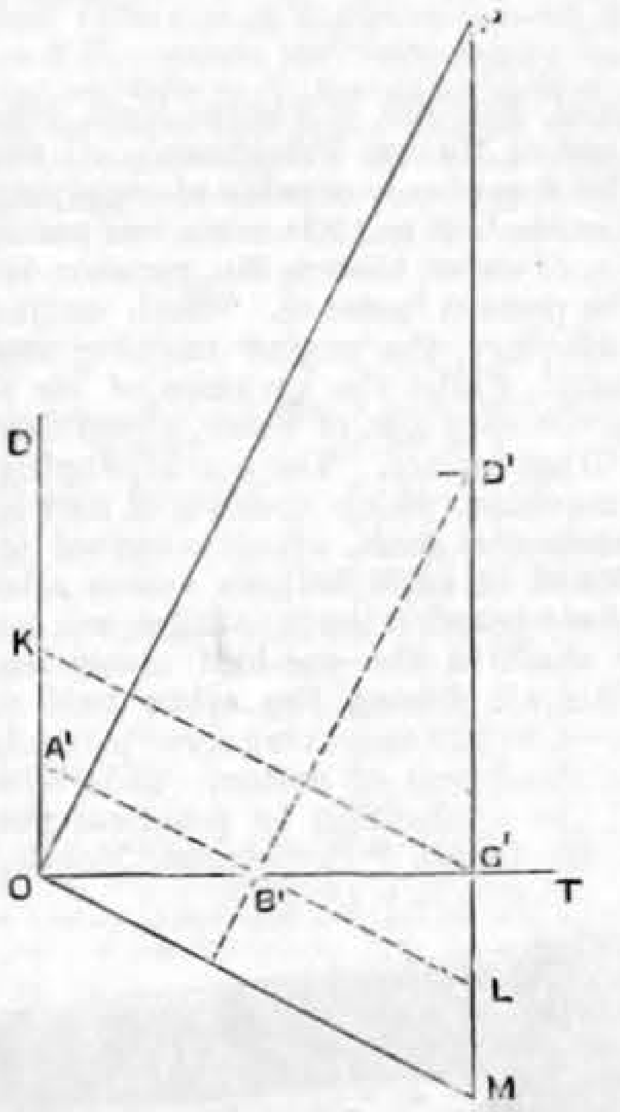
or,

$$t^2 = C^1 M \times 2d,$$

that is,

$$C^1 M = \frac{t^2}{2d} = \frac{1}{f}, \text{ the reciprocal of the acceleration.}$$

It still remains for "Z. Y. X." to find the graphical value of f from its reciprocal in exact measure, which of course may be easily done by means of similar triangles. But, as will be seen, the



process is needlessly circuitous. Thus, "Z. Y. X." has gone all this way round in order to find a length $C^1 M$, which already exists in my diagram; for, since $O B^1 = \frac{1}{2} O C^1$, and the angles $A^1 B^1 D^1$ and P O M are right angles—compare Fig. 2, page 105, *ante*—

$$O A^1 = L M = \tfrac{1}{2} C^1 M.$$

Now, the focal distance $O A^1$ as well as the point B^1 are given. Hence, if we are to base the solution on the second differential coefficient, since $f = \frac{1}{2 \, O A^1}$, all that is needed is to set off, to the given scale, O T equal to the unit length in which acceleration is measured; then join K T, and finally draw T Z at right angles to K T. Let T Z meet D O produced in Z; then, obviously,

$$O K \,.\, O Z = O T^2 = \text{unity}.$$

$$\therefore \; O Z = \frac{1}{O K} = \frac{1}{2a} = f.$$

The method given of finding the true curve from its projection is applicable to all sorts and conditions of time tests, parabolic or other, upon making the changes necessary in each particular case.

March 1st. ROBERT H. GRAHAM.

ENGINEERS IN THE NAVY.

SIR,—Allow me to point out an error in your able article on the above subject. The system of training engineer officers as students in the Government Dockyards was not adopted in consequence of the suggestions of Sir A. C. Key's Committee, which carried out its inquiries in the early part of 1876, but began in 1863. The *raison d'être* of that Committee was the reiterated complaints and seething discontent in the engineering branch of the service—a state of things prevailing at the present time. The Committee, in which the naval element predominated, presented a report so opposed to the evidence as to be inexplicable to any one carefully going through it, and only to be accounted for by the words of the present Parliamentary Secretary to the Navy, "that naval training is not the best for the conduct of civil affairs." Instead of inquiring into the means of securing the highest mechanical skill and scientific knowledge in the management of the various engines in ships-of-war, they occupied themselves with endeavouring to devise means for procuring candidates of a higher social status than formerly. The gist of the Committee's report is contained in paragraph 7:—"The regulations established in 1863 for the practical and theoretical instruction of the engineer officers of the Royal Navy, with the exception of some points of minor importance, are well suited to the object in view." Numerous suggestions were made involving trifling concessions and paltry advances in pay, which have been granted from time to time, but the only suggestion of any value, that contained in paragraph 82, "That engineer officers be classed with the military or executive branch of the service," seems as far off being realised as ever. The Committee conclude by stating that their suggestions, if carried out, will effect the desired purpose. A striking commentary on this conclusion was the fact that within a few years the Admiralty were obliged to engage fifty engineers for temporary service from the mercantile marine, paying these, with three years' service at sea, the same amount as their own highly trained officers who had served for fourteen years.

The system advocated by Admiral Mayne was put in force in the United States Navy many years ago. After three years' trial it had to be abandoned. The executive officers took no interest in engine-room duties, the machinery constantly ran down, and great expense was incurred for repairs. The same plan, or a modification thereof, is being tried in the Japanese Navy at the present time. If the result years ago was a failure, it will be much more so now, when the need of a skilled specialist is indispensable. What would be the effect of the executive undertaking the duties of medical officers?

To the instances of ignorance and indifference to engineering matters in the Navy given by you may be added some additional recent ones. One distinguished naval officer, who poses as an authority on naval matters, stated at a meeting that he was surprised at the number of engineers in the Royal Naval Reserve being so small, and that he did not know why they refused to join. Another, in reply to a statement of the engineers drawing attention to their grievances, and asking for an improvement in their position, threatened them with the fate of the masters who were abolished, doubtless having in his mind's eye some such scheme as that proposed by Admiral Mayne. Even in the last edition of Lord Brassey's "Naval Annual," out of 750 pages, the portion devoted to engineering matters is less than four pages, and the authorities quoted on the subject of engine-room complements are the captains of the ships.

I am afraid the want of appreciation of the engineering requirements of the Navy is not confined to Admirals. In the evidence given before Sir A. C. Key's committee occurs the case of a black petty officer who objected to mess with engine-room artificers, and the present regulations for the entry of engineer students and naval cadets are couched in such different language that they are evidently intended for two entirely different classes of society.

The questions of the supply of engineer officers for the Navy is becoming critical. Last year there were added to the Navy twenty-six vessels of 40,000 tons, and 100,800-horse power and twenty-three torpedo boats. The number of engineers in the Navy list on January 1st, 1890, was fifteen less than on January 1st, 1889, and the supply of candidates for engineer studentships is said to be diminishing. The Admiralty, after saying that the number of ratings as engine-room artificer and stoker, was more than sufficient, have recently sent a recruiting party scouring the country with a view to obtain 500 additional engine-room artificers and 1500 stokers. According to the service papers they have not met with any success, nor are they likely to. The Admiralty have exhausted every means of obtaining a proper supply of engineers, engine-room artificers, and stokers, except the obvious one of offering proper inducements for them to come forward. If this were done the long-standing difficulty would be at an end, and the engineering branch of the Navy no longer be, in the words of a member of the committee on the Naval Estimates, 1888, "in a miserably depressed and starved condition." C. P.

Westminster, S.W., March 4th.

SIR,—I have read with great pleasure an excellent article in the current number of your very valuable paper, on the views of Admiral Mayne, C.B., as to the abolition of the engineers of the Royal Navy, set forth by him in a paper read at the United Service Institute.

In dealing with Admiral Mayne's propositions, you state that the want of appreciation of the duties and requirements of naval engineers appears to be confined to admirals. This, perhaps, is not to be wondered at, for the admiral branch of the Navy is able to turn out mechanical engineers at will, whose achievements are not, I should say, as well known or remembered as they deserve to be. Therefore, with your permission, I will give a few instances where the mechanical knowledge of captains and admirals has been exercised for the nation's benefit.

A well-known captain—now no more—got the Admiralty of the day to make a boiler to his design. This boiler was put into the Fearless, with the remarkable result that her speed at once fell from 7 to 5½ knots. Later, the same officer invented an apparatus for raising a vessel's screw without a screw well. This was put into two ships. One of them got into such difficulties she had to be brought to England long before her tour of foreign service had expired; in the other, through the people on board not using it, the ship managed to put in her time.

Another gallant and lamented captain induced the Admiralty to have an hydraulic engine made to rotate the propeller of his ship at slow speeds, by the pressure of water outside. The engine was made before it was remembered that the power required to rid the ship of the effluent water was rather more than this machine would develope; it was therefore never put in, but it cost a pretty penny to make.

More recently, another captain designed a set of boilers, which were put into the Danæ. Officials from the Admiralty and from Portsmouth dockyard tried all they knew, all one winter, to make them a success, but their efforts were unavailing, and the boilers were condemned and taken out of the ship before she could leave England. Did not Admiral Sir George Elliot design the Waterwitch, and will Admiral Mayne, or some well-informed officer tell us what she has done, beyond perhaps nearly drowning all her crew on her only voyage, and subsequently rotting in Portsmouth harbour.

The civil and mechanical engineering achievements of another admiral in the West Indies and at Gibraltar are, I fear, forgotten. Did they not range from the construction of reservoirs to the manufacture of patent fuel? But he has not been rewarded for this.

Many other instances occur to my mind. For the present I will ask you to be good enough to give these to your readers and the public; for, after all, the suggestions of Admiral Mayne have this amount of method—that, if carried, there will be additional employment for people of his own line, and we may be quite certain that engine-room lieutenants would never be harassed by their brother executive as engineers have been, and even now are; but a great effort would be made to secure any advantage the transfer of duties would bring about, and it is just possible that Admiral Mayne has this in his mind when advocating his wild and half-thought-out proposal. VERAX.

London, March 5th.

THE EDUCATION OF ENGINEERS.

SIR,—As an engineer of the old school, dating back fifty years ago, at the time we served under the old millwrights, I may say at that date large firms received their orders depending on the number of workmen they employed; at this date thing are altered, depending on the number of tools in large factories.

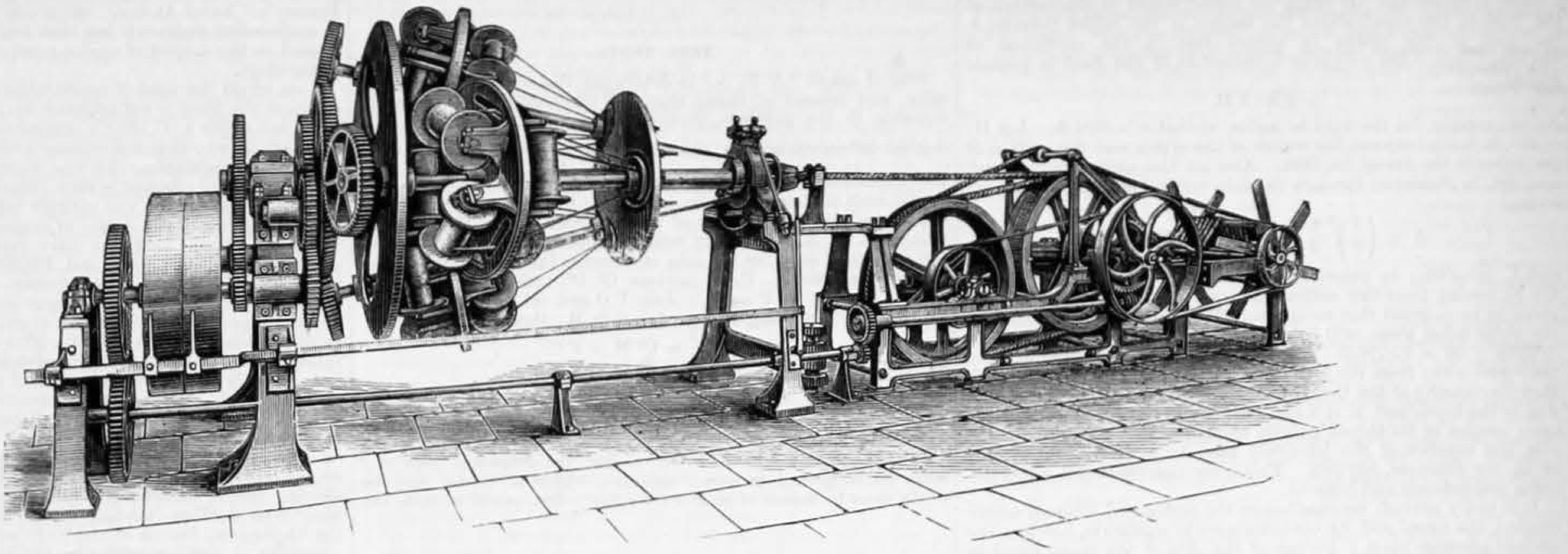
The one thing that crushed many a young man in days gone past was the want of commercial education. Estimates of costs were generally made out, in many instances, by men in the counting-house with but a very superficial knowledge of engineering. In some instances, builders of steam machinery and the uses connected therewith, had to apply to some consumer for the prices they should charge per ton of tonnage, per horse-power, or for general uses. Even at this date, probably, should an order be given for any detail, a correct estimate could only be arrived at by carefully kept books. How many a large undertaking having swallowed up the original estimated cost, may be entirely attributed to a want of commercial education; and more especially amongst civil engineers, undertaking vast iron or steel structures.

I consider all engineering pupils who serve five years or so should insist on receiving a commercial education by the various firms they serve under. Some pupils, who show great proficiency in drawing, and, as it generally follows, good heads for designing—for be it known, no machine can either do the one or the other—spoil themselves; or otherwise their employers, by holding out false hopes, incapacitate many from holding responsible situations. No firm will employ a mere draughtsman as manager, unless he has an efficient knowledge of commercial matters, both as regards running out quantities, and estimating the cost, and time required to execute work. This is more required now-a-days; formerly the men did the work, but now machines do it. We should imagine workmen are not so skilled as in the days of the old millwrights, but with proper commercial training they should become better men to fill responsible situations.

Portobello, February 24th. JOHN G. WINTON.

THE MERSEY BAR.—The Mersey Docks and Harbour Board have instructed Messrs. Simons and Co., of Renfrew, on the Clyde, to design and construct powerful sand pumping appliances to be fitted to one of the steam hopper barges constructed by them some time ago for the Board. When completed, the apparatus will be employed to cut a deep channel through the outer bar of the Mersey.

GLOVER'S ROPE-MAKING MACHINE.



IMPROVED ROPE-MAKING MACHINE.

Messrs. Walter Glover and Co., of Salford, Manchester, have recently completed an improved compound horizontal rope machine, capable of making rope of cotton, hemp, jute, coir, flax, or manilla, with or without cores, up to 3½in. diameter, or about 11in. circumference. The annexed illustration will show the construction of this machine, one of the most important features of which is the manner in which the yarns and strands all converge to one common centre, this arrangement insuring the utmost regularity in lay and tension. The above machine is arranged for making three-strand ropes, each strand being supplied from the yarns contained on six bobbins, thus eighteen bobbins supplying the yarn for the entire rope. Every bobbin runs independently, and a separate break or friction strap is fitted to each bobbin. These bobbin brakes can be adjusted to the greatest nicety, insuring an equal tension on every one of the eighteen yarns, thus insuring a rope of the most perfect uniformity throughout. In order to enable the manufacturer to make hard or soft laid ropes, a full set of change wheels is supplied with each machine, for regulating the hauling-off gear, each regulation or change gear being distinct and separate from the other. The machine is very simple and self-contained, and can be easily managed by one workman, every part of it being under direct control from the stopping and starting lever. The machine runs with remarkable smoothness, and owing to the careful distribution and balancing of the bobbins and discs, &c., it requires very little power to drive machines of the largest size.

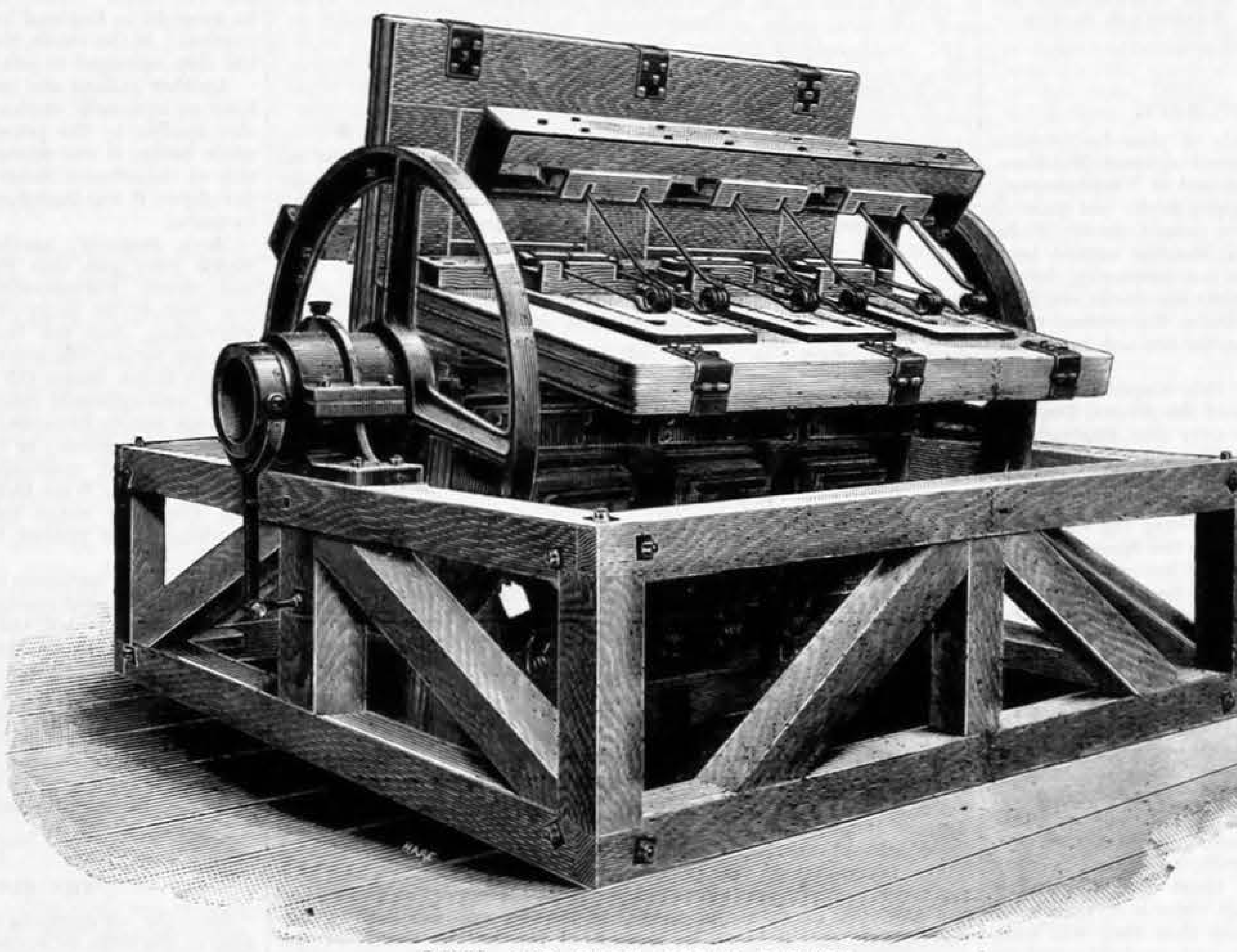
Machines for making ropes of all sizes are made on this principle. The ropes are made in the following manner:—The yarns being wound on the bobbins in suitable numbers, according to the size of the rope to be made, they are from each bobbin threaded through a head-runner of six holes and gathered at a die at which they are closed into the strands, there being a separate die for each of the three strands. The strands being formed, they are then threaded through a main head-runner of three holes, and immediately closed at the main closing die into finished rope. The rope is drawn through the die by means of strong hauling-off drums, and ultimately wound on to a storage creel, the storage creel being made so that the rope can be taken off it without uncoiling.

BLOWING CHURCH ORGANS.

The increasing tendency, at the present time, for larger and more powerful instruments in churches and other places of worship, together with the fact of their usually being fitted with pneumatic action for the purpose of lessening the labour of playing, has caused the requirements of more wind, and that of a higher pressure, necessitating the substitution of engine power for manual labour. In places where a constant and certain pressure of water can be procured, the hydraulic engine meets the case; but Sunday is usually a repairing day with water companies, and thus, during service, frequently no pressure can be insured. This uncertainty leads to the use of gas engines in towns and oil engines in country places.

Hitherto, the principal difficulty with gas and oil engines has arisen from the intermittent requirements of the service, it being practically impossible to stop and start the engine as the organ is required. Generally an apparatus for throwing the belt on and off, or else of allowing the wind to escape through a valve, has been resorted to, but both devices are objectionable. Lately a far better and more ingenious contrivance of revolving bellows, secured by the joint patents of Mr. Herbert Davis and Mr. J. C. R. Okes, of London, has been introduced by the latter.

The machine has the advantage of keeping up a constant pressure of wind—always ready, and yet when the organ is silent and no wind used, none is produced—it moreover has the advantage of never increasing the pressure beyond that to which the feeders are loaded. A machine on this principle has been fitted to blow a large organ of four manuals at All Saints Church, Rudstone, Yorks, the gift of the lord of the manor, Mr. A. Bosville, of Thorpe Hall, Bridlington, and is driven by one of Messrs. Priestman's oil engines of 4-horse power. The machine is capable of supplying any quantity of air from 1 cubic foot to 1300 cubic feet per minute at a pressure of 12in. of water, though 8in. pressure is sufficient for the organ in the present instance. Both engine and blower are highly satisfactory, the engine running steadily and under perfect control, whilst the pressure of air indicated by the gauge does not vary 1in. of water, a qualification which organ builders will appreciate. The accompanying engraving illustrates the machine, which consists of four bellows secured to a hollow horizontal shaft, which is caused to revolve. As the movable board of each bellows comes alternately over and under the fixed board, it tends to fall down, forcing air through the hollow shaft in the one-half revolution, and filling the bellows with air during the other half revolution. The springs shown in our engraving serve to regulate the pressure, and ensure steadiness of action. This blower is a curious example of the application to practical purposes of a very old idea. In Dick's "Perpetuum Mobile," a somewhat similar machine is figured as a device for producing perpetual motion, the whole being submerged, so that the descended bellows shall always be on the rising side.



DAVIS AND OKES' ORGAN BLOWER.

DREDGERS AND DREDGING.[1]

Nearly twenty years ago, I told Messrs. Simons and Co. that their then newly-invented combined hopper dredger could not be economically employed except it had large hopper carrying capacity, and therefore I advised that no hopper dredger should be of less carrying capacity than 1000 tons. It was with this in view that I recommended to several harbour boards for whom I acted as engineer the construction of the large hopper dredgers, viz., the Greenock, of 1000 tons; Willunga, of 950 tons; and Otago, of 1250 tons, all twin-screw vessels, instead of hopper dredgers of 500 tons, or of about half the carrying capacity, at that time proposed.

Since these were built, from ten to thirteen years ago, a number of large hopper dredgers, including stern-well hopper dredgers, have been built by Messrs. Simons and Co.; and it is now a well-established fact that in localities where the materials to be dredged are comparatively hard, and the distances to the places of deposit are short, that the cost of dredging by the hopper system is, as nearly as possible, three-sevenths cheaper than by fixed dredgers, with their attendant hopper barges, when working under similar conditions. This fact led me, when reporting to the Belfast Harbour Commissioners on August 18th, 1882, on the best class of dredging plant to be used for cutting the new channel from the harbour down to Holywood, to recommend the hopper dredger system; and the engineer to the Commissioners reported last year that the actual cost has been under 2d. per ton, inclusive of wages, coal, stores, and repairs, but exclusive of interest and depreciation, for which latter items 1¼d. might be added, or say 3¼d., against 4d. per ton named in my report.

The quantity of materials raised by the two Belfast hopper dredgers of 800 tons each, working nigh and day during the year 1887, was 1,350,400 tons, including depositing at an average distance of nine nautical miles. Similar results as to cost have also been obtained at Grangemouth, where I reported on March 10th 1881, to the Caledonian Railway Company on the advantages of the hopper system for the proposed dredging operations there, and recommended a 1000-ton hopper dredger, which was afterwards reduced to an 800-ton hopper dredger for the work. Other hopper dredgers, such as the Kuphus of 1000 tons at Bombay, have done good work at a very small cost. Those constructed under my invention and patent of September 4th, 1882, viz., the stern-well hopper dredgers at Bristol, of 800 tons; St. Andrew, H.M. Dockyard, Chatham, of 700 tons; the Otter, of 500 tons, for the Natal Harbour Board; and one of 800 tons, now building for the Manchester Ship Canal Works, have been very successful and much reduced the cost of dredging. I understand from Messrs. Simons and Co., that up to the present time they have built, including those now building, no less than forty-two hopper dredgers, or with but three exceptions the whole of the hopper dredgers afloat; also twenty-eight of suction, dipper and fixed dredgers, and fifty hopper barges, making a total fleet of 120. Messrs. Simons and Co. are the inventors of the original hopper dredger, as well as the designers and constructors of the first steam hopper barge.

Glancing over these figures, it would appear that the bias so freely expressed a few years ago against the hopper-dredger system is now gradually lessening, and there is a greater tendency than ever towards the stern-well type of hopper-dredger, with other improvements I have introduced.

As before stated, to insure success it is essential that hopper dredgers should be of great carrying capacity, of not less than 1000, and perhaps it would be better to have them of from 1500 to 2000 tons, having their boilers, engines, ladders, propellers and machinery throughout in duplicate; that is to say, twin dredger vessels having the two ladders working in one well, with their lower tumblers projecting well aft, for stern cutting, and safely housed, or covered, by an overhanging stern — in fact, so arranged that one-half of the machinery forms in every respect a perfect dredger, capable of being independently worked while the other half is at rest or under repair.

In making these remarks on the stern-well hopper system, I by no means wish to convey that under all conditions it is the best to adopt, for in long and wide rivers, and where the materials to be dredged are soft, and the distances to places of deposit are over fifteen or twenty miles, probably the stationary dredger system will continue to be used with economy. It is chiefly with this latter or stationary class of plant that the dredging operations of the Yarra-Yarra river are being carried on by the Melbourne Harbour Trust. Lately two dredgers of this class, named the Francis Henty and G. Ward Cole respectively, have been constructed under my direction for the Melbourne Harbour Board, and these are now on their way to Australia. Everything in connection with these vessels is compact and well arranged. The bridge across the bow of each not only serves as an efficient tie, but provides facilities for suspending and safely housing the lower end of the bucket ladder in such a position that it can be used for bow cutting, and thus dispensing with the expensive top tumbler traversing gear usually fitted up for the purpose.

A trial of the Francis Henty was made on October 16th last, when her buckets were run for a short time at the rate of twenty-four per minute, and while working in 35ft. of water, in very soft ground, each bucket came up more than well filled, and by actual measurement I found that the material lifted was at the rate of about 1500 tons per hour. Such a speed, however, could not be maintained for any length of time without considerable risk, as her ordinary working rate in stiff clay and sand is about 600 tons per hour. When these dredgers arrive in Melbourne, there will then be the Crocodile, Francis Henty, and G. Ward Cole, stationary dredgers; the Willunga, of 950 tons, and Otago, of 1250 tons, hopper dredgers; and also the Batman and Falkner, hopper barges, all built under my direction by Messrs. Simons and Co. At the present time Messrs. Simons and Co. have in hand, under my direction, a 1000-ton hopper dredger for the Aden Port Trust.—*The Shipping World.*

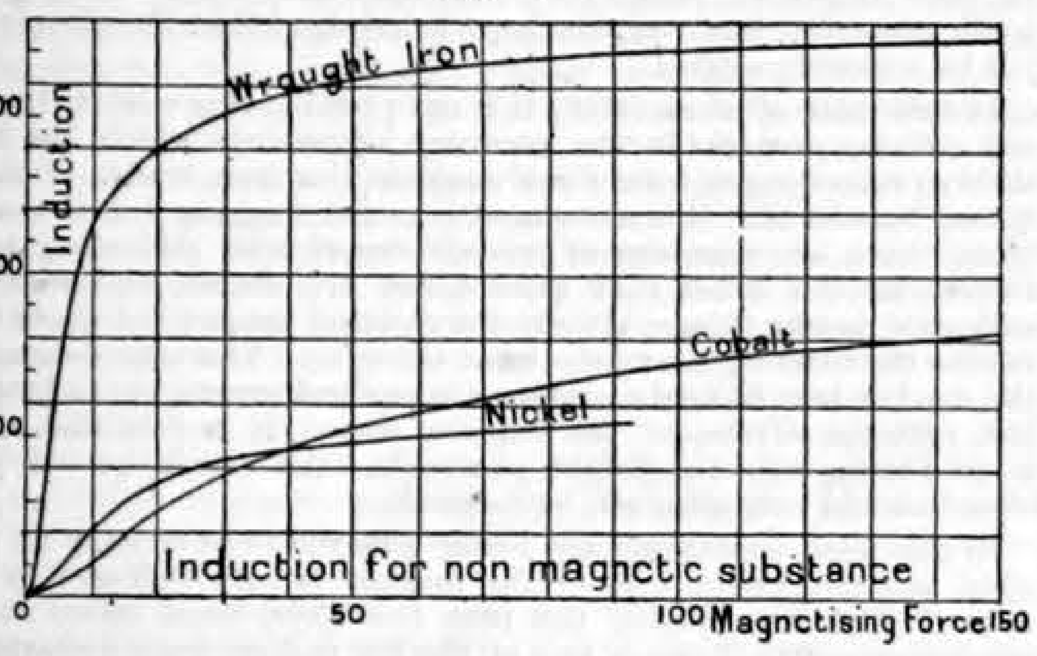
[1] Notes by W. R. Kinipple, M. Inst. C.E.

Massicks and Crooke's Patent Hot-blast Firebrick Stoves.—The Illinois Steel Company has adopted the Massicks and Crooke type of hot-blast firebrick stoves for the four new blast furnaces which it is erecting at its South Chicago works. These furnaces are each 21ft. bosh by 85ft. high, and each will be equipped with four stoves, 22ft. diameter by 70ft. high, giving 30,000 square feet of heating surface to a stove. The blast furnaces at its Union Works, which were re-modelled to Massicks and Crooke's system the past summer, are doing, we are told, better than ever before.

MAGNETISM.[1]

LET us consider a ring of uniform section of any convenient area and diameter. Let us suppose this ring to be wound with copper wire, the convolutions being insulated. Over the copper wire let us suppose that a second wire is wound, also insulated, the coils of each wire being arranged as are the coils of any ordinary modern transformer. Let us suppose that the ends of the inner coil, which we will call the secondary coil, are connected to a ballistic galvanometer; and that the ends of the outer coil, called the primary, are connected, through a key for reversing the current, with a battery. If the current in the primary coil is reversed, the galvanometer needle is observed to receive a sudden or impulsive deflection, indicating that for a short time an electro-motive force has been acting on the secondary coil. If the resistance of the secondary circuit is varied, the sudden deflection of the galvanometer needle varies inversely as the resistance. With constant resistance of the secondary circuit the deflection varies as the number of convolutions in the secondary circuit. If the ring upon which the coils of copper wire are wound is made of wood or glass —or, indeed, of ninety-nine out of every hundred substances which could be proposed—we should find that for a given current in the primary coil the deflection of the galvanometer in the secondary circuit is substantially the same. The ring may be of copper, of gold, of wood, or glass—it may be solid or it may be hollow—it makes no difference in the deflection of the galvanometer. We find, further, that with the vast majority of substances the deflection of the galvanometer in the secondary circuit is proportional to the current in the primary circuit. If, however, the ring be of soft iron, we find that the conditions are enormously different. In the first place, the deflections of the galvanometer are very many times as great as if the ring were made of glass, or copper, or wood. In the second place, the deflections on the galvanometer in the secondary circuit are not proportional to the current in the primary circuit; but as the current in the primary circuit is step by step increased we find that the galvanometer deflections increase somewhat as is illustrated in the accompanying curve—Fig. 1—in which the abscissæ are proportional to the primary current, and the ordinates are proportional to the galvanometer deflections. You observe that as the primary current is increased the galvanometer deflection increases at first at a certain rate; as the primary current attains a certain value the rate at which the deflection increases therewith is rapidly increased, as shown in the upward turn in the curve. This rate of increase is maintained for a time, but only for a time. When the primary current attains a certain value the curve bends downward, indicating that the deflections of the galvanometer are now increasing less rapidly as the primary current is increased; if the primary current be still continually increased, the galvanometer deflections increase less and less rapidly.

Fig. 1

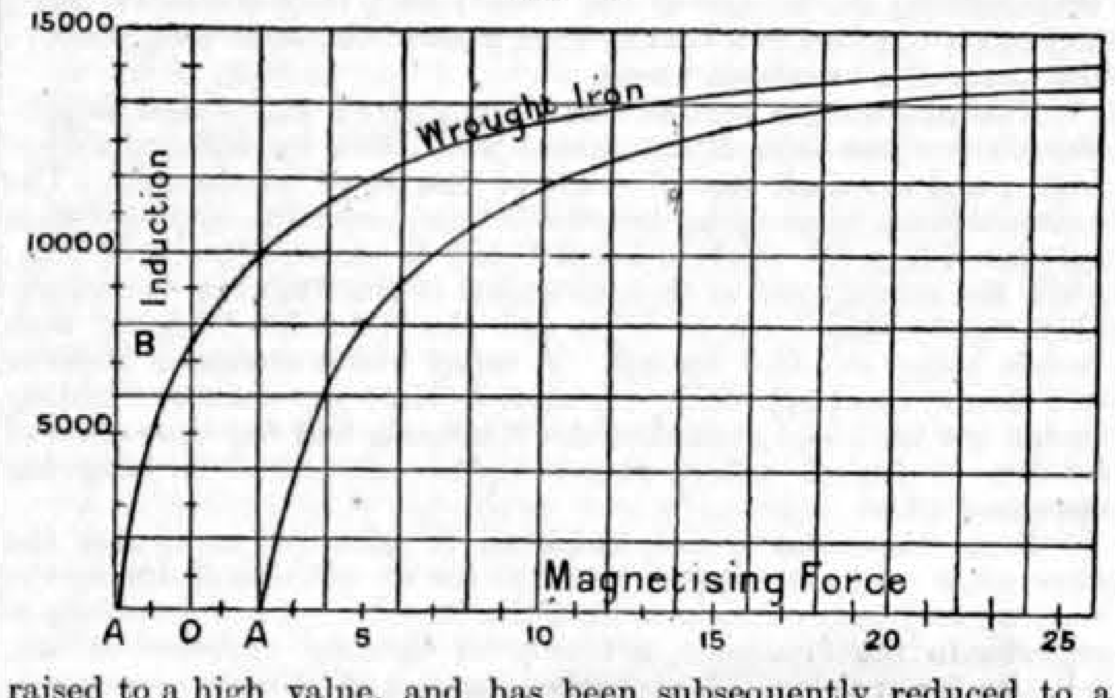


Now what I want to particularly impress upon you is the enormous difference which exists between soft iron, on the one hand, and ordinary substances on the other. On this diagram I have taken the galvanometer deflections to the same scale for iron, and for such substances as glass or wood. You see that the deflections in the case of glass or wood, to the same scale, are so small as to be absolutely inappreciable, whilst the deflection for iron at one point of the curve is something like 2000 times as great as for non-magnetic substances. This extraordinary property is possessed by only two other substances besides iron—cobalt and nickel. On the same figure are curves showing on the same scale what would be the deflections for cobalt and nickel, taken from Professor Rowland's paper. You observe that they show the same general characteristics as iron, but in a rather less degree. Still, it is obvious that these substances may be broadly classed with iron in contradistinction to the great mass of other bodies. On the other hand, diamagnetic bodies belong distinctly to the other class. If the deflection with a non-magnetic ring be unity, that with iron, as already stated, may be as much as 2000; that with bismuth, the most powerful diamagnetic known, is 0·999825—a quantity differing very little from unity. Note, then, the first fact which any theory of magnetism has to explain is: Iron, nickel, and cobalt, all enormously magnetic; other substances practically non-magnetic. A second fact is—with most bodies the action of the primary current on the secondary circuit is strictly proportional to the primary current; with magnetic bodies it is by no means so.

You will observe that the ordinates in these curves, which are proportional to the kicks or elongations of the galvanometer, are called induction, and that the abscissæ are called magnetising force. Let us see a little more precisely what we mean by the terms, and what are the units of measurement taken. The elongation of the galvanometer measures an impulsive electro-motive force—an electro-motive force acting for a very short time. Charge a condenser to a known potential, and discharge it through the galvanometer; the needle of the galvanometer will swing aside through a number of divisions proportional to the quantity of electricity in the condenser—that is, to the capacity and the potential. From this we may calculate the quantity of electricity required to give a unit elongation. Multiply this by the actual resistance of the secondary circuit and we have the impulsive electro-motive force in volts and seconds, which will, in the particular secondary circuit, give a unit elongation. We must multiply this by 10^8 to have it in absolute C.G.S. units. Now the induction is the impulsive electro-motive force in absolute C.G.S. units divided by the number of secondary coils and by the area of section of the ring in square centimetres. The line integral of magnetising force is the current in the primary in absolute C.G.S. units—that is, one-tenth of the current in amperes—multiplied by 4π. The magnetising force is the line integral divided by the length of the line over which that line integral is distributed. This is, in truth, not exactly the same for all points of the section of the ring—an imperfection so far as it goes in the ring method of experiment. The absolute electro-magnetic C.G.S. units have been so chosen that if the ring be perfectly non-magnetic the induction is equal to the magnetising force. We may refer later to the permeability, as Sir W. Thomson calls it; it is the ratio of the induction to the magnetising force causing it, and is usually denoted by μ.

There is a further difference between the limited class of magnetic bodies and the great class which are non-magnetic. To show this, we may suppose our experiment with the ring to be varied in one or other of two or three different ways. To fix our ideas, let us suppose that the secondary coil is collected in one part of the ring, which, provided that the number of turns in the secondary is maintained the same, will make no difference in the result in the galvanometer. Let us suppose, further, that the ring is divided so that its parts may be plucked from together, and the secondary coil entirely withdrawn from the ring. If now the primary current have a certain value, and if the ring be plucked apart and the secondary coil withdrawn, we shall find that, whatever be the substance of which the ring is composed, the galvanometer deflection is one-half of what it would have been if the primary current had been reversed. I should perhaps say approximately one-half, as it is not quite strictly the case in some samples of steel, although, broadly speaking, it is one-half. This is natural enough, for the exciting cause is reduced from, let us call it a positive value, to nothing when the secondary coil is withdrawn; it is changed from a positive value to an equal and opposite negative value when the primary current is reversed. Now comes the third characteristic difference between the magnetic bodies and the non-magnetic. Suppose that, instead of plucking the ring apart when the current had a certain value, the current was raised to this value and then gradually diminished to nothing, and that then the ring was plucked apart and the secondary coil withdrawn. If the ring be non-magnetic, we find that there is no deflection of the galvanometer; but, on the other hand, if the ring be of iron, we find a very large deflection, amounting, it may be, to 80 or 90 per cent. of the deflection caused by the withdrawal of the coil when the current had its full value. Whatever be the property that the passing of the primary current has imparted to the iron, it is clear that the iron retains a large part of this property after the current has ceased. We may push the experiment a stage further. Suppose that the current in the primary is raised to a great value, and is then slowly diminished to a smaller value, and that the ring is opened and the secondary coil withdrawn. With most substances we find that the galvanometer deflection is precisely the same as if the current had been simply raised to its final value. It is not so with iron; the galvanometer deflection depends not alone upon the current at the moment of withdrawal, but on the current to which the ring has been previously subjected. We may then draw another curve—Fig. 2—representing the galvanometer deflections produced when the current has been raised to a high value, and has been subsequently reduced to a value indicated by the abscissæ. This curve may be properly called a descending curve. In the case of ordinary bodies this curve is a straight line coincident with the straight line of the ascending curve, but for iron is a curve such as is represented in the drawing. You observe that this curve descends to nothing like zero when the current is reduced to zero; and that when the current is not only diminished to zero, but is reversed, the galvanometer deflection only becomes zero when the reversed current has a substantial value. This property possessed by magnetic bodies of retaining that which is impressed upon them by the primary current, has been called by Professor Ewing hysteresis, or, as similar properties have been observed in quite other connections, magnetic hysteresis. The name is a good one, and has been adopted. Broadly speaking, the induction as measured by the galvanometer deflection is independent of the time during which the successive currents have acted, and depends only upon their magnitude and order of succession. Some recent experiments of Professor Ewing, however, seem to show a well-marked time effect. There are curious features in these experiments which require more elucidation.

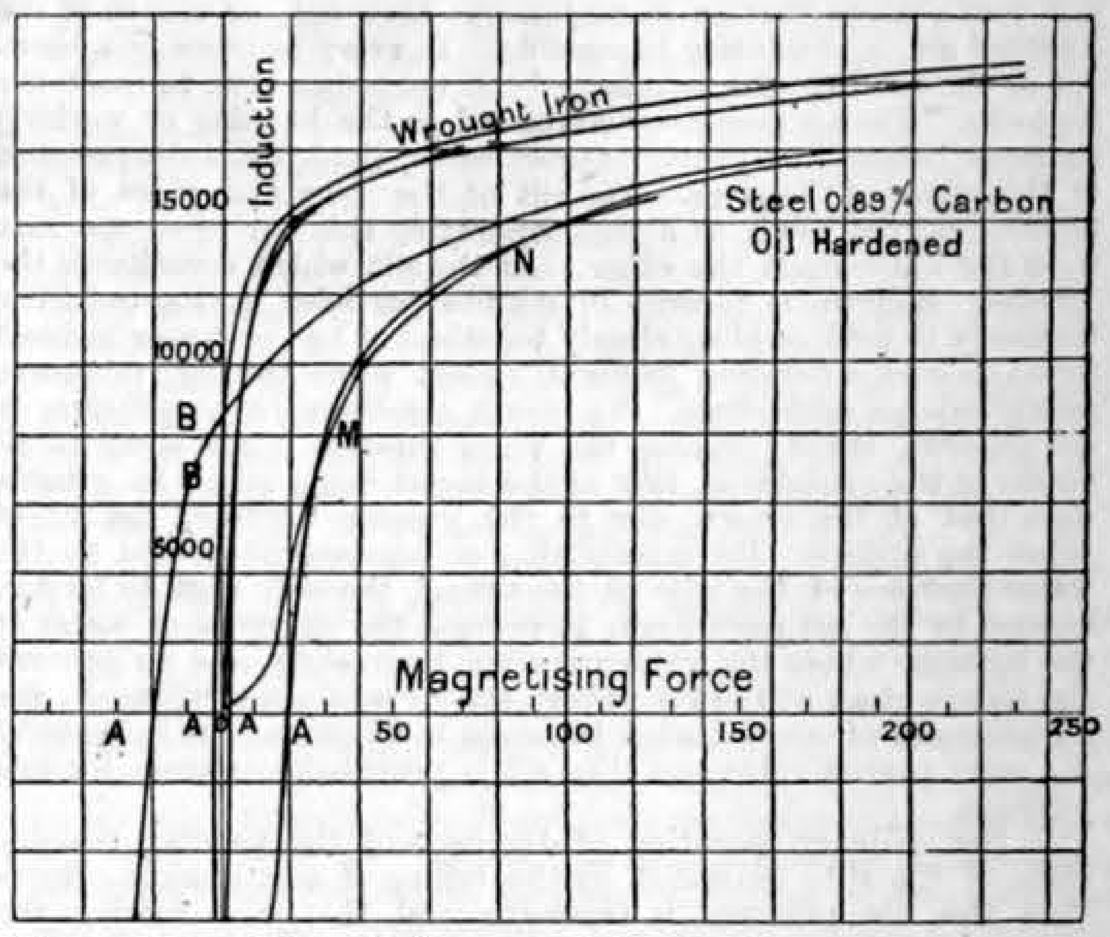
Fig. 2



It has been pointed out by Warburg, and subsequently by Ewing, that the area of Curve 2 is a measure of the quantity of energy expended in changing the magnetism of the mass of iron from that produced by the current in one direction to that produced by the current in the opposite direction and back again. The energy expended with varying amplitude of magnetising forces has been determined for iron, and also for large magnetising forces for a considerable variety of samples of steel. Different sorts of iron and steel differ from each other very greatly in this respect. For example, the energy lost in a complete cycle of reversals in a sample of Whitworth's mild steel was about 10,000 ergs per cubic centimetre; in oil-hardened hard steel it was near 100,000; and in tungsten steel it was near 200,000—a range of variation of 20 to 1. It is, of course, of the greatest possible importance to keep this quantity low in the case of armatures of dynamos, and in that of the cores of transformers. If the armature of a dynamo machine be made of good iron, the loss from hysteresis may easily be less than 1 per cent.; if, however, to take an extreme case, it were made of tungsten steel, it would readily amount to 20 per cent. In the case of transformers and alternate-current dynamo machines, where the number of reversals per second is great, the loss of power by hysteresis of the iron, and the consequent heating, become very important. The loss of power by hysteresis increases more rapidly than does the induction. Hence it is not well in such machines to work the iron to anything like the same intensity of induction as is desirable in ordinary continuous-current machines. The quantity O A, when measured in proper units, as already explained—that is to say, the reversed magnetic force, which just suffices to reduce the induction as measured by the kick on the galvanometer to nothing after the material has been submitted to a very great magnetising force—is called the "coercive force," giving a definite meaning to a term which has long been used in a somewhat indefinite sense. The quantity is really the important one in judging the magnetism of short permanent magnets. The residual magnetism O B is then practically of no interest at all; the magnetic moment depends almost entirely upon the coercive force. The range of magnitude is somewhat greater than in the case of the energy dissipated in a complete reversal. For very soft iron the coercive force is 1·6 C.G.S. units; for tungsten steel, the most suitable material for magnets, it is 51 in the same units. A very good guess may be made of the amount of coercive force in a sample of iron or steel by the form of the ascending curve, determined as I described at first. This is readily seen by inspection of Fig. 3, which shows the curves in the cases of wrought iron, and steel containing 0·9 per cent. of carbon. With the wrought iron a rapid ascent of the ascending curve is made, when the magnetising force is small and the coercive force is small; in the case of the hard steel, the ascent of the curve is made with a larger magnetising current, and the coercive force is large. There is one curious feature shown in the curve for hard steel which may, so far as I know, be observed in all magnetisable substances: the ascending curve twice cuts the descending curve, as at M and N. This peculiarity was, so far as I know, first observed by Professor G. Wiedemann.

I have already called emphatic attention to the fact that magnetic substances are enormously magnetic, and that non-magnetic substances are hardly at all magnetic; there is between the two classes no intermediate class. The magnetic property of iron is exceedingly easily destroyed. If iron be alloyed with 12 per cent. of manganese, the kick on the galvanometer which the material will give, if made into a ring, is only about 25 per cent. greater than is the case with the most completely non-magnetic material, instead of being some hundred times as great, as would be the case with iron. Further, with this manganese steel, the kick on the galvanometer is strictly proportional to the magnetising current in the primary, and the material shows no sign of hysteresis. In short, all its properties would be fully accounted for if we supposed that manganese steel consisted of a perfectly non-magnetic material, with a small percentage of metallic iron mechanically admixed therewith. Thus the property of non-magnetisability of manganese steel is an excellent proof of the fact—which is also shown by the non-magnetic properties of most compounds of iron—that the property appertains to the molecule, and not to the atom; or, to put it in another way, suppose that we were to imagine manganese steel broken up into small particles, as these particles became smaller there would at length arrive a point at which the iron and the manganese would be entirely separated from each other; when this point is reached the particles of iron are non-magnetic. By the magnetic molecule of the substance we mean the smallest part which has all the magnetic properties of the mass. The magnetic molecule must be big enough to contain its proportion of manganese. In iron, then, we must have a collection of particles of such magnitude that it would be possible for the manganese to enter into each of them, to constitute an element of the magnet. Manganese is, so far as I know, a non-magnetic element. Smaller proportions of manganese reduce the magnetic property in a somewhat less degree, the reduction being greater as the quantity of manganese is greater. It appeared very possible that the non-magnetic property of manganese steel was due to the coercive force being very great—that, in fact, in all experiments we were still on that part of the magnetisation curve below the rapid rise, and that if the steel were submitted to greater forces it would presently prove to be magnetic, like other kinds of steel. Professor Ewing, however, has submitted manganese steel to very great forces indeed, and finds that its magnetism is always proportional to the magnetising force.

Fig. 3



When one considers that the magnetic property is peculiar to three substances—that it is easily destroyed by the admixture of some foreign body, as manganese—one would naturally expect that its existence would depend also on the temperature of the body. This is found to be the case. It has long been known that iron remains magnetic to a red heat, and that then it somewhat suddenly ceases to be magnetic, and remains at a higher temperature non-magnetic. It has long been known that the same thing happens with cobalt, the temperature of change, however, being higher; and with nickel, the temperature being lower. The magnetic characteristics of iron at a high temperature are interesting. Let us return to our ring, and let us suppose that the coils are insulated with a refractory material, such as asbestos paper, and that the ring is made of the best soft iron. We are now in a position to heat the ring to a high temperature, and to experiment upon it at high temperatures in exactly the same way as before. The temperature can be approximately determined by the resistance of one of the copper coils. Suppose, first, that the current in the primary circuit which we use for magnetising the ring is small; that from time to time, as the ring is heated and the temperature rises, an experiment is made by reversing the current in the primary circuit and observing the deflection of the galvanometer needle. At the ordinary temperature of the air the deflection is comparatively small; as the temperature increases the deflection also increases, but slowly at first; when the temperature, however, reaches something like 600 deg. C., the galvanometer deflection begins very rapidly to increase, until, with a temperature of 770 deg. C., it attains a value of no less than 11,000 times as great as the deflection would be if the ring had been made of glass or copper, and the same exciting current had been used. Of course a direct comparison of 11,000 to 1 cannot be made. To make it we must introduce resistance into the secondary circuit when the iron is used; and we must, in fact, make use of larger currents when copper is used. However, the ratio of the induction in the case of iron to that in the case of copper at 770 deg. C. for small forces is no less than 11,000 to 1. Now, mark what happens. The temperature rises another 15 deg. C.; the deflection of the needle suddenly drops to a value which we must regard as infinitesimal in comparison to that which it had at a temperature of 770 deg. C.; in fact, at the higher temperature of 785 deg. C. the deflection of the galvanometer with iron is to that with copper in a ratio not exceeding that of 1·14 to 1. Here, then, we have a most remarkable fact:—At a temperature of 770 deg. C. the magnetisation of iron 11,000 times as great as that of a non-magnetic substance; at a temperature of 785 deg. C. iron practically non-magnetic. Suppose now that the current in the primary circuit which serves to magnetise the iron had been great instead of very small. In this case we find a very different order of phenomena. As the temperature rises, the deflection on the galvanometer diminishes very slowly till a high temperature is attained; then the rate of decrease is accelerated until, as the temperature at which the sudden change occurred for small forces is reached, the rate of diminution becomes very rapid indeed, until, finally, the magnetism of the iron disappears at the same time as for small forces. Instead of following the magnetisation with constant forces for varying temperatures, we may trace the curve of magnetisation for varying forces with any temperature we please.

[1] Abstract of Inaugural Address to the Institution of Electrical Engineers. By J. Hopkinson, M.A., F.R.S., President.

BATH AND WEST AND SOUTHERN COUNTIES SOCIETY.—This old-established Society will this year hold its annual Exhibition at Rochester, on June 5, 6, 7, 9, and 10, and money prizes amounting to nearly £3000 are offered for horses, cattle, sheep, pigs, poultry, cheese, butter, cream, hops, wool, preserved fruit, &c., in addition to several gold and silver medals and plate. The display of implements, machinery, and articles of general utility is always a very large one, and among other attractive features will be exhibitions of manufactures, paintings, fruit packing appliances, &c. The butter-making contests, which have been such interesting features of the Society's recent shows, will be again carried out, together with other interesting demonstrations of dairy practice. Regulations, &c., can be obtained of the secretary, Mr. Thos. F. Plowman, Bath.

THE HUDSON TUNNEL BLOW OUT.

THE following article, by S. D. V. Burr, in the *Railroad Gazette* of the 17th January, 1890, will be found of interest, especially considering the numerous accidents in, and the long time this tunnel has been in hand:—

Judging from the accounts in the technical and daily press of the "blow out" at the Hudson River Tunnel, which occurred just before midnight, on the 4th inst., it is apparent that the true character of the work now being done is not well understood. In the accounts given there are several important features: First, the accident took place instantaneously, and it was by mere chance that the men in the heading escaped; next, and this in a technical journal, there was "a failure of the air pressure to properly support the silt in the side of the tunnel, and several tons of the material fell into the tunnel."

To those who have studied closely the method of building the tunnel and the nature of the material through which it is passing, it is very evident that an instantaneous blow-out, or escape of the confined air, is absolutely impossible. In every instance of a blow-out at the heading the men have been warned in time to reach the air locks. The air pressure maintained in the heading or working chamber balances, as nearly as practicable, the hydrostatic pressure of the water of the river. The silt of the face and sides of the heading serves solely as a wall separating this air upon one side from the water upon the other. As the silt which constitutes the dividing medium is formed of minute particles having but little tendency to pack or cling closely together, it has no power in itself to act as such a dividing medium, except when the two pressures nearly balance each other. An exact condition of equilibrium is not possible, simply because the water pressure is not equal at all points of the excavation, that at the invert being over 9 lb. greater than that at the crown, due to the greater depth of the invert below the surface. By maintaining an air pressure equal to the water pressure at the axis of the tunnel, the only work to be performed by the silt partition is to prevent the entrance of water at the bottom, where the water pressure is greatest, and to prevent the escape of air at the top, where the air pressure is in excess, the air pressure, of course, being the same in all parts. It is doubtful if a more perfect substance than silt is provided by nature for this purpose.

In the ordinary operation of digging out the heading the dry state of the silt—indicated by the falling of small lumps—shows that the air pressure is excessive, and that it is forcing the water back into the silt; at the same time the too moist condition of the silt—indicated by little streams of water running down the face—shows that the air pressure is not sufficient to prevent the water entering through the silt. This, since the beginning of work upon the tunnel, has given invariably an accurate indication of the condition of the heading, and whether the pressure of air should be increased or diminished. The recent accident was due solely to the blowing out of the air through the silt at the heading. It was in no sense due, initially, to the incoming of the water. This is evident from the fact that, in a case like this, where the air and water pressures are nearly the same, before any entrance of water in large volume can take place, a portion at least of the air must escape, after which the water can flow in. It is further evident that this action of both the air and water must be intermittent, since both pass through the same channel. If an opening was formed at the bottom for the entrance of water at the same time the air was rushing out at the top, the action would be continuous; but this would require such a refinement of detail as almost to place it beyond the range of possibility. At the accident of two weeks ago the first indication of non-equilibrium between the air and water was given by the falling of small pieces of silt. This attracted the attention of the men, all of whom were working at the bottom. Upon examination it was found that the lower part of the face of the heading was coming in slowly but inevitably, while the air was forming a passage through the top. The men then started for the air lock, and had all reached the completed portion of the tunnel when the "whirlwind," as some reporters styled it, occurred. This was caused by a comparatively large volume of air escaping through the disintegrated silt at the top, allowing the expansion of the air remaining. The pressure was reduced to such an extent as to open the door of the air lock into which the men entered. It is essential to mention that in the tunnel are two air locks built in masonry bulkheads, placed about 400ft. apart. The air pressure in the tunnel between the locks is from 10 lb. to 15 lb., that in the heading averaging about 33 lb. To permit the free opening of the door of the inner lock the pressure in the heading must have been reduced to or below that between the locks, or 10 lb. to 15 lb.

It is now that we come to the most interesting feature of the accident. After the air pressure had been reduced to a point certainly below that existing between the locks—and this required some time, as the men all reached the lock—the silt was forced into the heading by the pressure of the water upon its outer side. It entered as a plunger, and forced its way up the tunnel until arrested by the cushion of air still confined, and the pressure of which was increased to correspond with what it was before any escaped. The air and water pressures were again in equilibrium, although perhaps not to such a nice degree as formerly. Only one man of the twenty odd at work was injured. One leg and one hand were caught and crushed by the air lock door when it was violently closed by the almost instant increase of pressure created by the passage up the tunnel of the silt plunger. Had the door been either closed or wide open no harm could have resulted. But, as the door was ajar, it sustained the full force of the blow of the air. This accident proves, as have all others of a similar character that have happened in the tunnel, that, provided there is a watch kept on the exposed face of the silt, ample time can be given in case of a blow-out for all the men to escape. Before work can be resumed the disturbed silt will be allowed three or four weeks during which to settle and so compact itself as to again be capable of preventing the passage of air through it. The heading will then be reopened. The hole formed in the bed of the river by the silt filling the heading has been filled by material dumped from the surface of the river.

A MONITOR AS IT IS.

MANY of our Navy officers will recall the sensation created abroad, and especially in England, by the visit of the double-turretted monitor Miantonomoh to Europe just after the war. She carried with her the Assistant-secretary of the Navy, Gustavus V. Fox, who made a report to the Navy Department of the performance of the vessel and his conclusions concerning her. Mr. Fox said:— "We can scarcely hope to see the day when the flagship of the Mediterranean fleet will only rise 36in. out of the water. We wait for war to convert old sailors to such a novelty as this. But how many ships and how many noble crews, that no money can replace, may be sent to the bottom before admirals can be brought to reason? It is the public, not the service, that will lead the way.

"The English pilot who accompanied the Monitor from the Thames was somewhat suspicious of the strange craft and had his doubts of her ability to stand a heavy sea. He afterwards said that the first gale he encountered, when he saw a green sea 18ft. deep of solid water roll over her bow, he gave himself up for lost, believing that the Monitor was going down head foremost. But, the tops of the turrets keeping clear of the terrific waves, he gathered courage to look around, and, seeing an American sailor quietly sewing a patch upon his trousers apparently unconscious of the coming on board of the water, which all his experience had taught him was fatal to a ship, he regained his equanimity. In subsequent gales he became charmed with the steadiness of the vessel and he left her with regret."

Considering more in detail the future of Monitors this man, whose theories had been determined by his experience as a naval officer and a naval secretary, as well as by his close study of principles, said:—"There remains but one fact to discuss concerning the Monitor type of ironclads invented by Captain Ericsson. Can they be constructed so as to make them efficient fighting sea-going cruisers? If not, then we must adopt the European models, abstain from any further attempts at progress, and content ourself with a naval force for defensive purposes only, or invite new schemes. The facts with regard to the behaviour of this vessel in a moderate gale of wind and heavy sea are as follows: Head to the sea, she takes over about 4ft. of solid water, which is broken as it sweeps the sea along the deck, and after reaching the turret it is too much spent to prevent firing the 15in. gun directly ahead. Broadside to the sea, either moving along or stopped, her lee guns can always be worked without difficulty, the water which passes across the deck from windward being divided by the turrets, and her extreme roll so moderate as not to press her lee guns near the water. Lying in the same position, the 15in. guns can be fired directly astern without interference from water, and when stem to sea, the water which comes on board is broken up in the same manner as when going ahead to it. In the trough of the sea her ports will be liable to be flooded, if required to use her guns to windward. This, therefore, would be the position selected by an antagonist who designed to fight a Monitor in a sea-way.

"An ordinary vessel, high out of the water, and lying in the trough of the sea, broadside to, is attacked by a wave which climbs up the side, heels her to leeward, and, passing underneath, assists in throwing her back to windward, when another wave is met and the heavy lee lurch is repeated. A wave advancing upon a Monitor in a similar position finds no side above the water to act against; it therefore climbs aboard without difficulty, heels the vessel a few degrees to windward, and passes quickly to leeward underneath. The water which has got on board, having no support to part it on, and an inclined deck to ascend, becomes broken water, a small portion going across the deck and off to leeward, but the largest part tumbling back to windward, overboard, without sending against the turret anything like the quantity which first got on deck. The turret guns thus occupy a central position, where, notwithstanding the lowness of the vessel's hull, they are more easily and safely handled in a seaway than guns of the same weight above the water in a broadside vessel.

"The axis of the bore of the 15in. gun of this vessel is 6½ft. above the water—the Miantonomoh was 259ft. by 53ft., she drew 14¾ft., and her deck was 31in. above the water at the side. The extreme lurch when lying broadside to a heavy sea and moderate gale was 7 deg. to windward and 4 deg. to leeward, mean 5½ deg.; while the average roll at the same time of the Augusta—a remarkably steady ship—was 18 deg.; and the Ashuelot 25 deg.; both vessels being steadied by sail. A vessel which attacks a Monitor in a seaway must approach very close to have any chance of hitting such a low hull, and even then the Monitor is half the time covered by 3ft. or 4ft. of water, protecting herself and disturbing her opponent's fire.

"From these facts, not unknown to Monitor men, and the experience we have derived from the use of sail vessels during the war, we may safely conclude that the Monitor type of ironclads is superior to the broadside, not only for fighting purposes at sea, but also for cruising. A properly constructed Monitor, possessing all the requirements of a cruiser, ought to have but one turret, armed with not less than 20in. guns, two independent propellers, the usual proportion of sail, and should be constructed of iron. The comforts of this Monitor to the officers and men are superior to those of any other class of vessels in the Navy, arising chiefly from her steadiness, ample accommodations, artificial ventilation, and the great quantity of light afforded by having the bull's-eyes overhead instead of at the side.

"We present this statement, in connection with those published last week, as sufficient answer to the misrepresentations of the Monitor type of vessels contained in a communication from the Washington correspondent of the *New York Herald*, appearing in the issue of that paper of Febuary 14th."—*U.S. Army and Navy Journal.*

DEATH OF MR. STANDFIELD.—We are sorry to have to announce the death of Mr. Standfield, the well-known floating dock engineer. The facts are as follows:—It will be remembered that a petroleum steamer, the Ville de Calais, blew up some time since. Mr. Standfield bought the hull and machinery for Clarke and Standfield, and had the stern portion fitted with a bulkhead and patched up and brought to this country. She left Calais in tow of the tug Challenger on Saturday night. The Ville de Calais had on board Mr. Standfield, his son, Mr. Frank Standfield, his nephew, Mr. Lewis Standfield, the master, Mr. William Denton, and the crew of twelve hands. All went well until the ship reached the Margate Roads, when the hawser parted. The tug made several attempts to get a fresh hawser on board, but without avail, and she then kept as close as possible to the vessel. It was then deemed advisable to launch a boat and put the crew on board the tug; and at the same time signals were made for assistance from the shore. While the boat was being lowered from the davits one of the ropes either broke or was let go, and the whole of the occupants were precipitated into the water. Two of them, J. C. Roberts and Stephen England, succeeded, with great difficulty, in getting back to the vessel, six were picked up by the tug, and the remaining four, including Mr. Standfield, sen., were drowned. In the meantime, the Margate surf boat, Friend to All Nations, had put off, but before she could reach her the steamer foundered, off the Nayland Rock. Mr. Frank Standfield seized a life-buoy, jumped into the water, and, together with another of the men, who was found clinging to the ladder, was picked up by the lifeboat. The remaining four men took to the rigging, from which they were, with much difficulty, rescued by the surf boat.

KING'S COLLEGE ENGINEERING SOCIETY.—At a general meeting of this Society, held on February 18th, Professor Robinson in the chair, Mr. Stanford read a very interesting paper on the Rathmines Waterworks. The construction of these works was greatly complicated by an Act of Parliament, which secured to the millowners of the Upper Dodder the use of 1500 cubic feet per minute of the Dodder, and as compensation for the springs impounded, a second reservoir was to be constructed capable of supplying 392,000 cubic feet per diem. The catchment area consists of two parts. The upper part, from which the Dodder rises, is covered with peat, which discolours the water. This discoloured water is carried along an artificial watercourse to a weir and slot gauge, so arranged as to allow 1500 cubic feet per minute to flow through the slot gauge, whence it is conveyed by a pipe under the lower reservoir to the original bed of the Dodder, while the excess flows over the weir into the lower reservoir. The lower part of the catchment area produces a large supply of spring water, which is carried into an upper reservoir, which has a capacity of 357 million gallons for the supply of the township. At both banks on the eastern side of the valley there occurred deposits of sand and gravel, into which headings had to be driven and filled with concrete to prevent leakage from the reservoir. The embankments of both reservoirs are of earth, with a puddle wall in the centre, and it has been found necessary to build a storm wall on both embankments to prevent the waves washing over and damaging the banks. At the toe of each embankment outlet towers are placed to control the delivery of the water. In the upper tower there is a water-tight chamber with three openings, so that the water may be drawn off at different levels. The water is then carried to a service reservoir two miles from the township. There are also pipes for emptying the reservoir. From the lower tower emptying pipes are laid, and also a pipe for supplying the compensation water for the millers. This water is gauged over a waste weir below the bank. A covered screening chamber is erected near the service reservoir, and the water for the town passes through strainers of fine copper wire to remove suspended impurities.

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

(*From our own Correspondent.*)

THE position of the coal crisis is the matter that is receiving most attention in the iron and coal trades of the Midlands this week. Alike on 'Change in Wolverhampton on Wednesday, and in Birmingham on Thursday, this was a leading topic of conversation, and the probabilities of the situation were earnestly discussed. The opinion was freely expressed that the masters had acted throughout the proceedings in as fair a manner as possible by offering to throw open their books for examination. Any cause of complaint which the miners may imagine themselves to have, by reason of previous average selling prices having been ascertained from firms selected by the employers, must surely, it is thought, be removed by the suggestion that eight of the proposed sixteen firms whose books are to be examined shall be chosen by the men themselves.

Although the South Staffordshire coalfield is not at present affected by the coal trade wages dispute, some disappointment is yet experienced that the Conference did not lead to any definite result, but at the same time it is a hopeful feature that there was not a definite rupture, and, although no official intimation to such effect has been made, there yet seems reason to suppose that the masters' proposals will meet with the further consideration of the men. In this last connection it is noteworthy on behalf of the operatives that a suggestion was made that if another Conference were to be held in a week's time a settlement might perhaps be arrived at. The effect of a strike would just now be prejudicial, not alone to the coal trade, but likewise to the iron and steel trades. The immediate effect of the new stage which has been arrived at has been to create some apprehension at certain of the ironworks and furnaces, and thus consumers of manufacturing fuel who think it likely that there will yet be a struggle, were to-day—Thursday—in Birmingham, disposed to offer enhanced prices for immediate deliveries. Taking the trade generally, however, the hope is indulged that the matter will yet be amicably settled.

In this state of uncertainty it is not possible this week to report any striking progress in the recovery movement, which has been slowly proceeding now for some weeks in the iron trade. Indeed, it may be said that this movement is rather flagging; at the same time, there are numbers of manufacturers who still cling tenaciously to the belief that good times are ahead, and who are expecting better things, if only the demand keeps good enough to relieve the existing heavy stocks at Glasgow. The convalescence of the market may be tardy, and may in fact last several weeks longer; but, with the advance of the shipping season, it is felt that there is no reason why the bright prospects with which the old year closed should not, after all, be realised.

In this hope quotations are being adhered to as strictly as possible, and the general tone of the market is very well seen in the outcry which has, during the past few days, been raised at the announcement that one or two of the bar makers were declaring a 10s. drop. This movement has elicited an official disclaimer from the list houses, and they continue to uphold the standard of £9 10s. for marked qualities.

There are those who believe that there is plenty of business to be given out, and that the current quietude is due to a natural reticence to place contracts in the present unsettled state of the market, as when things assume a more steady tone, it is thought that new work will come to hand much more freely than at present. How to tide over the interval is, however, a matter which, it must be confessed, is taxing the resources of some departments of trade, notably the makers of black sheets and galvanised sheets. Since our last report, the South Staffordshire Sheet Ironmakers' Association, comprising Staffordshire, Shropshire, and Worcestershire, have decided to appoint a committee to consider the systematic reduction of the output. It is proposed that the mills shall be stopped one week in four.

Black sheet makers naturally hesitate to go on making for stock, and no doubt under the circumstances restriction of output is the best course to pursue, until the new business becomes more plentiful. If the foreign demand for galvanised sheets were to improve, black sheet ma'ers would feel a corresponding benefit, but at present this demand is extremely slack, and in fact some of the works are standing.

The quotation for marked bars, as intimated above, is upheld by the list houses at £9 10s., with £9 as the figure for second-class sorts, whilst common bars can be obtained at from £8 5s. to £8 10s. Galvanised sheets are quoted as low as £14 10s. for common sorts, 24 gauge in bundles f.o.b. Liverpool; but the best Australian brands are maintained at about £17.

The Association prices for sheets continue £11 15s. for lattens, £10 15s. for doubles, and £10 5s. for singles. Boiler-plates range from £10 10s. to £11, and hoops are in fair demand for shipment at about £9 5s., whilst £9 is asked for gas tube strip.

The pig market remains somewhat unsteady from the causes enumerated at the opening of this report. Quotations are, however, maintained at—Best all mine forge iron, £4 10s.; medium, £3 17s. 6d. to £3 15s.; and common, £3 2s. 6d. to £3.

The coal trade is somewhat upset by reason of the prevailing uncertainty in the matter of wages, but the notices which have been given by the colliers in the Netherton and Old Hill districts for higher wages have been withdrawn, and the men have just resolved to abide loyally by the Wages Board, and to wait for its meeting in April, when the next average will most probably give them an advance under the sliding scale.

Extensive additions to pumping plant have, during the week, been decided upon in connection with the Birmingham waterworks. The County Council has given authority for the purchase of a freehold site at Longbridge for the purpose of an additional deep well, and for the provision of pumping plant, mains, &c., at an estimated cost of £25,185. It is estimated that in another two years the necessary supply to be pumped will amount to an average of as much as sixteen million gallons a day.

The firm of Messrs. Hatton Sons and Co., tin-plate and best sheet iron makers, has been formed into a limited liability company, with a capital of £80,000, a large proportion of which is divided among the existing partners.

The question of the best way to unwater the waterlogged mines of Wednesbury is still receiving consideration at the hands of the South Staffordshire Mines Drainage Commissioners. At a meeting of that body on Wednesday, in Wolverhampton, a resolution was carried requesting the engineer to prepare a report stating the conclusions that have been arrived at by the joint committees of Commissioners and mine-owners who have recently had the matter under their notice. There were about 11½ million tons of coal to be obtained. The estimated cost of driving a level from the Wednesbury mines to the existing Bradley engine would be about £12,000, which meant 1d. per ton on three million tons—which was the estimated output for ten years. But rates from that quantity would mean £11,250. Supposing they took the £11,250 as a sinking fund to pay for the level in ten years, that would leave a clear income to the Commissioners of £10,000 a year, so that the one outlay of £12,000 would speedily pay itself back.

Mr. Enoch Edwards, of Burslem, has been selected by the Midland Counties Miners' Federation, which represents some 28,000 men, to be a candidate at the next General Election for some Staffordshire constituency at present unspecified. Mr. Edwards, who is agent to the North Staffordshire Miners' Federation, also occupies the positions of president of the Midland Counties Federation and treasurer of the National Federation of Miners. He is a member of the Burslem Town Council.

NOTES FROM LANCASHIRE.

(*From our own Correspondent.*)

Manchester.—The continued depression in the iron trade of this district, and the further complications which are threatened by the colliers' strike, which now seems imminent, are causing an increasing feeling of anxiety with regard to the future. The present outlook is certainly not at all encouraging; in many of the principal iron-using branches of industry inquiries with regard to new work show a decided falling off, and, although there are plenty of orders in hand to prevent any actual slackness being experienced for some time to come, it is evident—unless the present lull is only temporary, a belief to which many still adhere—that both iron and engineering works before long will be compelled to seek for business under conditions which may necessitate a decided retrocession in prices. The agitation now going on, not only amongst the miners, but in many branches of the iron and engineering trades for further advances in wages, is therefore very ill-timed, and if persisted in may lead to disastrous results both to the workmen and the employers.

The Manchester Iron Exchange on Tuesday brought together about the usual attendance; but there was again an extremely dull market, with a downward tendency in prices. So far as makers' iron is concerned, so little new business is coming into their hands, either for pig or finished iron, that their prices are scarcely tested. Generally they are still acting on the policy of working on with their contracts as long as possible before coming upon the market to seek new business, which could at present only be obtained at excessively low prices. On the other hand, consumers are with equal persistency holding back from buying, and are covering their requirements as long as possible with the iron they have yet to come in, on account of contracts already placed. Where they are compelled to place out orders, they are generally able to cover their wants with cheap parcels, obtainable through second hands, at prices very far below those that makers are quoting. For Lancashire pig iron makers are asking about 67s. 6d., less 2½, for delivery equal to Manchester as the basis price; but so far as the Manchester market is concerned, any such figure is altogether out of the question, and what business they are doing is confined to small sales where they have exceptionally favourable rates of delivery. District brands show a further easing down since last week, Lincolnshire being readily obtainable at about 65s. for forge and foundry, with Derbyshire quoted at about 72s. 6d. to 75s. for good foundry qualities, less 2½, delivered equal to Manchester. These prices, however, do not bring forward business, and so far as Derbyshire is concerned are practically simply nominal. In outside brands makers are holding with considerable firmness to late rates, good foundry brands of Middlesbrough being still quoted by makers at 68s. 4d. net cash, delivered equal to Manchester, but this is a figure altogether unobtainable in the face of ordinary g.m.b.'s offering at quite 6s. to 7s. per ton less. Eglinton delivered at the ports remains at about 60s., and Glengarnock at about 68s. 6d. per ton.

In hematites there is still only a very limited business doing, and it is difficult to quote anything like fixed prices, but 85s., less 2½, remains about the average current figure for good foundry qualities delivered here.

Finished iron makers are booking very few new orders, but as they have mostly still sufficient work on their books to keep them fully employed for the present, they are holding pretty firmly to the prices quoted last week, Lancashire bars remaining at £8 10s. and North Staffordshire qualities at about £8 15s., delivered in the Manchester district. There are, however, sellers who would take 2s. 6d. to 5s. per ton under these figures.

In steel plates, both for boilermaking and shipbuilding purposes, there is only a restricted business doing, a general absence of inquiries of any weight being reported, and prices are decidedly weak. For steel boiler plates it is scarcely possible to quote any really definite prices, but certainly £11 per ton for delivery in the Manchester district would seem to be the top figure that buyers at present are disposed to pay, whilst for steel ship-plates, delivered ex steamer, Liverpool, £10 5s. to £10 7s. 6d., less 2½, are about the average prices.

In the metal market there is a continued absence of new business coming forward for any description of manufactured goods, and although the leading makers have still orders in hand to keep them going for some time; there is an easier tendency in prices, concessions of ⅛d. per lb. upon list rates being made here and there to secure orders.

In the engineering branches of industry the outlook for the future is scarcely so satisfactory, reports being now very general that so far as new work is concerned there is a falling off in the weight of inquiries coming forward. For the present, however, all departments are being kept well employed, and the leading engineering firms throughout this district have generally sufficient work in hand to keep them fully going for some months to come.

The Allen patent portable pneumatic rivetting machines introduced by De Bergue and Co., of Manchester, are meeting with a steadily increasing demand which has necessitated the building of a large additional erecting shop by the above firm for their special class of work which has recently been crowding out their other other departments to an uncomfortable extent. The new shop is being filled with the special tools required for the works, and Messrs. Vaughan and Co. are supplying one of their new patent 10-ton travelling cranes. Amongst recent orders for these new rivetting machines secured by Messrs. De Bergue are rivetting plants for the Butterley Iron Company, Messrs. Swan and Hunter, Thomas Beeley, Thomas Woodall, and Messrs. Ives and Barker, the erectors of the Liverpool overhead tramway. For this last-named work special rivetting machines have been designed by Messrs. De Bergue for rivetting the Hobson patent flooring. Instead of being slung in the usual way, these machines travel upon trolleys. One machine is furnished with a swivel motion in every direction, and balanced on weighted levers. In the other machine, the trolley has a longitudinal motion, and the rivetter is placed in a pivotted frame suspended on a balanced lever, so as to permit of rivetting in a circular direction, following the curves of the floor-plates. Another special tool which the firm have in hand is a patented multiple punching machine for bridge and boiler plates, which they are making for America. This machine is constructed to take in plates 25ft. long by 4ft. wide, and it will punch eight or more holes across the girder plate at each stroke either in line or zig-zag, and by self-acting motions will traverse and punch the plate from end to end, with holes any desired pitch without stopping, whilst during this operation, and without stopping the machine, any of the punches, if required, can be thrown in or out of gear. Any irregular punching, however broken, can be punched in any part of the plate with the greatest accuracy, the traversing motions throughout being controlled by a standard guide screw. The special feature in connection with this machine is that the plates require no setting out or marking, and no templates are necessary. All that is required is to centre-line the plates longitudinally and indent them with a centre punch at each end to receive the gripping points of two light carriages running along planed levels. The punches having been previously placed the proper distance apart, the plate is traversed by a screw driven by change wheels, so that plates can be punched any pitch from end to end at a speed of about fifteen strokes per minute. For punching broken pitches the automatic motion is stopped, without, however, stopping the machine, and the traverse regulated by a hand connection with a dial plate; this being done, the automatic traverse is again thrown into gear and the regular pitch resumed. The machine is worked by one man and two assistants, and it is claimed that for large plates or for ordinary straight work the machine is equal to at least ten ordinary machines employing thirty to forty men, independent of the saving in templates or marking. Messrs. De Bergue have just completed for India a specially designed multiple drilling machine for boiler work. This machine is arranged for drilling horizontally a series of drills, the number of which can be regulated according to requirements, and is carried upon a horizontal table, which rises and falls in pedestals to accommodate the machine to different sizes of boilers. The boiler whilst being operated upon is supported on rollers, so that it can be turned round as holes have to be punched in different seams. The pedestals and rollers stand upon one bed plate, along which the pedestals slide forward towards the work, so as to bring the drills into position according to the size of the boiler. This machine is constructed for drilling a boiler up to 11ft. long in one operation along any particular seam.

The coal trade during the past week has necessarily been in an unsettled condition, owing to the threatened strike of colliers for a further advance in wages, and the unsatisfactory result of the conference between the Coalowners' Federation and the Miners' National Federation held in London on Tuesday leaves the relations between the employers and their men in so critical a position that a more or less general stoppage of work would seem to be imminent. Buyers are showing considerable anxiety to get in extra supplies in anticipation of a strike, and colliery proprietors, who are largely filling up out of stock, are finding it difficult to meet the requirements of their customers. This demand, of course, is no indication of increased requirements, but only a temporary pressure owing to causes above mentioned; but for the time being it is bringing about a very disturbing condition of trade. So far, except upon engine classes of fuel, prices remain without quotable change, but full list rates have been held to more firmly both for house fire and steam and forge coals, whilst upon burgy and slack advances of fully 1s. per ton have been demanded from outside customers seeking special supplies. At the pit's mouth best coals are firm at 12s. 6d. to 13s.; seconds, 11s. to 11s. 6d.; common coals, 9s. 6d. to 10s.; good qualities of burgy, 8s. 6d. to 9s.; and best qualities of slack, 7s. 6d. to 8s. per ton.

For shipment there is a decidedly more active demand, with better prices obtainable; good qualities of steam coal delivered at the High Level, Liverpool, or the Garston Docks, fetching 11s. 6d. per ton.

Barrow.—The hematite pig iron trade shows no new life this week. The demand is not of large dimensions, and the chief sales reported are of hematite warrants, which are gradually being reduced in bulk. It was naturally thought when stocks began to decrease there would be some hope of better prices but although they have gone down over 5000 tons prices are still depressed, and they are, in fact, so far as hematite warrants are concerned, fully 20s. less per ton than they were in the beginning of the year. There does not seem much hope of any cheaper supply of raw material at present, indeed it is thought probable that coal will soon be dearer, and in all probability coke will follow the same example. Some makers are quoting as low as 72s. per ton and up to 80s., but with raw material and labour at current prices iron cannot be produced at under 75s. per ton.

It is probable some results will follow the proposal to restrict the make of pig iron in the West Coast district. The makers are conferring together and endeavouring to devise a scheme for putting out of blast a number of furnaces now engaged in iron manufacture, and as the necessity of this step is the chief force at work in urging a policy of restriction, there seems every reason to believe that makers, in their own interests, if from no other cause, will formulate and carry out some scheme which will reduce stocks of iron, and enable the masters to have a controlling influence in the trade.

Steel makers are very busily employed, but the new orders to hand are comparatively few. There is no spirit in the demand, but makers are looking forward to a better state of things before they have cleared out the heavy contracts which are still on their books. Rails are very quiet, but some large orders are pending. Steel shipbuilding material is not in very large request for new work, but makers are already well sold forward. There is next to nothing doing in tin-plate bars, as many of the mills are stopped, but local makers are fairly sold forward for some time to come.

There is nothing new to note in the shipbuilding trade. No new orders have been booked, but there is great and increasing activity in both the building and the engineering departments.

A strike of joiners, affecting about 200 men, has taken place at the works of the Naval Construction and Armament Company, Barrow. The men asked for an advance from 34s. to 36s. per week, and want time and a-half for overtime.

Stocks of hematite warrants have again been reduced this week to the extent of 893 tons. They now stand at 380,437 tons, or 1210 tons less than at the beginning of the year.

Shipping still shows increased activity. The tonnage of iron and steel exported from West Coast ports during the week represented 22,152 tons, compared with 18,667 tons in the corresponding week of last year, or an increase of 3485 tons. The total for two months, however, is in favour of 1889. During this year so far there has been shipped 165,414 tons, as against 177,369 in the corresponding period of last year, or a decrease in 1890 of 11,955 tons. It is probable this adverse tonnage will soon be reduced.

Iron ore is very steady in tone, and makers can readily dispose of all they raise. Prices for ordinary qualities realise from 14s. to 17s. per ton, net at mines.

The mines of the Hodbarrow Mining Company at Millom, South Cumberland, have just been re-assessed. They now stand at a rateable value of £67,254, or £10,000 more than last year.

The following are the ruling quotations this week:—Mixed Nos. of Bessemer iron, 75s. per ton, net f.o.b.; steel rails, heavy sections, £6 12s. 6d.; light and colliery rails, £8 5s.; steel ship-plates, £8 10s.; angles, £7 15s.; tees, £9 10s.; hoops, £10; billets, blooms, and slabs, £7; tin-plate bars, £6 17s. 6d.; speigeleisen, 130s.

THE SHEFFIELD DISTRICT.

(*From our own Correspondent.*)

THE conference between the coalowners' and colliers' representatives at the Westminster Palace Hotel, London, on Tuesday, was most protracted. Though both parties adhered stiffly to their positions—the one to demand, and the other to refuse a 10 per cent. advance—the deadlock which ensued is not without hope. I am quite convinced there will be no strike. If the employers had seen their way to offer 5 per cent., the miners' agents would no doubt have accepted it. As it is the position of the coalowners is a strong one, and the probability is that there will be no general turn-out of the miners. Business is undoubtedly falling off, except in railway material and several other heavy specialities. The value of fuel is falling, and summer is approaching. To persist in a fight for more wages in the face of diminishing trade and a falling market, would be against all precedent, and simply court defeat later on. The coalowners are determined to make a firm stand against the present movement, though it is no secret that those who make the collieries subsidiary to their iron and steel works would prefer to pay even the 10 per cent. than have to set down their establishments. But even in these instances the employers are acting loyally with the colliery proprietors pure and simple.

The saloon carriage in which the Prince of Wales and party travelled from London to open the Forth Bridge, on Tuesday, was built by Messrs. Craven Brothers and Co., at the Darnall Carriage and Wagon Works, Sheffield, for the Great Northern Railway Company, and delivered about a month ago. This carriage is believed to be the finest running in this country. It is fitted with special suites of compartments—one for the Prince, one for the Princess, as well as another for attendants. The coach is 60ft. long, and runs on two six-wheeled bogies, similar to the dining cars Messrs. Craven built for the same company. Sir John Fowler, the eminent engineer, who has received a baronetcy in recognition of his ability in this great work, is a native of Wadsley, an outlying suburb of Sheffield, and was at one time elected as a Conservative candidate for the Hallamshire division, which includes his native district and a portion of Sheffield.

In the Sheffield rolling mills business is now "easing off" a little, and the managers express themselves as rather pleased than otherwise. They have been troubled to overtake the work poured in upon them, and the quieter time which has now come will enable them to get out some of the arrears. With regard to the complaints made of the increased charges imposed in the rolling mills, the managers admit that when the prices of fuel went up they increased their statement not only to cover the higher quotations for coal, but to compensate in some measure for the lean years during which the shareholders had no dividends, or very small return for their money. They express themselves as anxious to give their shareholders some interest for the capital they have invested in these undertakings.

An extra demand is reported in the file trade, the workmen being fully employed, with every prospect of this gratifying condition of affairs being maintained. The colonial markets are not yielding the orders which were anticipated at the beginning of the year; but the home and foreign call is good, and some exceptionally heavy lines have been booked within the last three weeks. No difficulty whatever has been experienced by the workpeople in obtaining the full statement price recently agreed upon between the Manufacturers' Association and the representatives of the men. The file cutters are thoroughly organised at present, there being over 2000 members in the File Cutters' Union.

The London horn sales have an important bearing on the Sheffield cutlery trade, that article entering largely into hafting of many descriptions of goods. Best buffalo horns, owing to extreme competition, advanced £5 to £15 on previous sales. This upward movement has rather taken the trade by surprise. It is said to be owing to buffalo horn tips coming into use as handles of bicycles. Woods used in the Sheffield trades have materially advanced in value, some kinds as much as 100 per cent., the average being about 25 per cent. There is less being received from Jamaica, Cuba, and other similar districts. In ivory, 27½ tons have been imported into London since the January sales, the new arrivals consisting of 2½ tons East Indian and East African, 15 tons of Ambriz (West Coast of Africa), and a good parcel of Malta and Alexandrian weighing some 10 tons. In the same period, 42 tons have passed out of the dock; the present stock is 88½ tons.

The shareholders in Brown Bayley's Steel Works, Sheffield, had a pleasant meeting at London. Mr. Robert Armitage, son of the chairman, has been appointed as the sixth director. The dividend at the rate of 17½ per cent., making, with the interim amount of 7½ per cent. already paid, 25 per cent. for the year, was confirmed. Mr. Davy, one of the directors, stated that in all his experience he never remembered seeing a stronger balance sheet than that placed before the shareholders. The debts owing to the company amounted to nearly £80,000, and there was in cash and bills in hand nearly £19,000, making altogether about £100,000, whereas the accounts owing by the company to sundry creditors were under £27,000.

Chesterfield has by a town's meeting expressed its approval of the proposed new Manchester, Sheffield, and Lincolnshire Railway extension from that town to Heath. This line will bring Chesterfield into connection with the trunk system of the Manchester, Sheffield, and Lincolnshire, give the town direct access to the London and North-Western and Great Northern Railways, and, by the extension now in progress, from Beighton to Chesterfield and Annesley to Nottingham, make "the City of the Crooked Spire" the centre of a coalfield calculated at 800,000,000 tons. It was stated at the meeting that the contract for constructing the line from Staveley Junction to Annesley was already let. About ten miles to the north of Nottingham was let to the firm of Messrs. Baldry and Yerburgh, and six and three-quarter miles on the Chesterfield side, extending to Staveley Junction, was let to Messrs. Logan and Hemmingway, the contractors now engaged in executing the works from Beighton to Chesterfield.

THE NORTH OF ENGLAND.

(*From our own Correspondent.*)

THE Cleveland iron trade is still in a somewhat inanimate condition, and new orders are few and far between, and new inquiries are equally small. After last week's market, prices remained steady for a day or two, but fell somewhat towards the end of the week. At the market held at Middlesbrough on Tuesday the position did not perceptibly improve. Consumers showed no desire to purchase, though prices were again reduced. For prompt delivery merchants were prepared to accept 52s. per ton for No. 3 g.m.b., and some of them would have taken 3d. less. Quotations for delivery over next quarter were made at 53s. 6d., but no one seemed eager to close. Makers still adhere to their stereotyped quotations in the hope that the opening of the shipping season will enable them to sustain them. They have orders on their books which will last for some weeks longer. Forge iron being solely in the hands of makers is still dearer than No. 3, and the price varies from 54s. to 56s. per ton.

Warrants which were 42s. 4½d. per ton at the beginning of last week, have now fallen to 51s. 7½d. per ton.

The decrease in Connal and Co.'s Middlesbrough stock was last week 2920 tons, the quantity held on Tuesday being 176,866 tons Their stock at Glasgow declined 9451 tons in the same time.

Shipments from Middlesbrough still show no signs of improvement. The quantity exported last month was only 41,967 tons, or the smallest total ever recorded for February. The decrease is mainly in the consignments to Scotland. The principal export items are as follows:—To Scotland, 13,581 tons; France, 6400 tons; Holland, 5745 tons; Belgium, 4629 tons; and Germany, 3290 tons. Finished iron and steel exports were better in proportion, the total being 52,677 tons, of which India took 15,046 tons.

Finished iron and steel makers complain that their prospects are not encouraging, and they are booking but few fresh orders.

Iron ship plates are now offered at £7 5s. per ton on trucks at makers' works, steel ship plates at £8 5s., and steel rails at £8 5s.

In the course of a speech which, two or three years ago, Sir Charles Palmer made before a Jarrow audience, he stated that the company over which he presides was contemplating the establishment of a new industry with a view of making itself and its workmen less dependent on the more or less prosperous condition of the shipbuilding trades. Since then the Jarrow Company has considerably extended its plant by putting down one of the largest mills in the country for rolling steel angles, bulbs, girders, and similar sections; and is expected to be in operation before very long. But important as this addition to the works must be, it does not appear to be the promised new industry, as was supposed by many persons. It is now stated that the directors have decided to establish a new department for the manufacture of ordnance of all kinds, so that war ships may be armed as well as built and engined at the Jarrow establishment. It is intended to create additional capital for this purpose, the shares being offered to existing shareholders in the first instance, and afterwards to the general public. Colonel English, R.E., of the royal gun carriage factory, Woolwich Arsenal, has been named as being about to undertake the organisation and management of the new department.

There is perhaps nothing connected with the iron and engineering trades which for some years has been more in demand, and which has been more lucrative to those engaged in it, than the manufacture of heavy ordnance and the steel forgings from which it is made. This new venture is therefore likely to be highly successful under the exceptionally favourable conditions which are certain to surround it at Jarrow.

The threatened strike of miners engaged in the Durham collieries, which has been for some time detrimentally influencing the coal and iron trades of the North, has fortunately been averted. The result of the voting was made known on Monday last, and was as follows, viz.:—For accepting the 5 per cent. advance offered by the coalowners, 17,251; for a general strike, 14,378; for open arbitration, 1307. These figures seem to admit of some such interpretation as the following. Very few of the miners believed that a full and fair investigation of their employers' books would have resulted in an award of more than 5 per cent. advance. A large number—nearly one-half of those who voted—believe that more could have been obtained by a strike, or threat of a strike, than the 5 per cent. offered, or what mere arbitration might possibly have brought them. But, happily, somewhat more than one-half believe that a bird in the hand is worth two in the bush, and that a certain 5 per cent. without stoppage was the best of their three choices. Many disinterested persons are of opinion that, but for the sharp downward reaction which has taken place in the iron and allied trades since the New Year commenced, those in favour of striking if the full 15 per cent. demanded were not conceded, would have been in a large majority.

It is reported that a Tyneside shipbuilding firm has just booked an order for three steamers, and that another one has made a contract for one of unusually heavy tonnage. On account of the slackness which has overtaken the trade, such events are now watched with the keenest interest. Six months ago they would probably have passed unnoticed.

Lloyd's Committee have just given notice that they have constituted Middlesbrough, Stockton, and Whitby into a separate district, with offices in the Exchange, Middlesbrough. The principal surveyor for the new district is Mr. C. Davidson, who has for long resided at Stockton. Hitherto the head-quarters have been at West Hartlepool.

The ironmasters' statistics for the month of February were issued on the 4th inst. As compared with January, three more furnaces appear to be now in blast, and these are at present on hematite pig iron. As regards stocks there was an increase of 7137 tons. This increase represents the difference between an extra accumulation of 15,314 tons in makers' stocks and a decrease of 8177 tons in makers' and Connal's stores. It is quite clear that the Cleveland trade is still suffering from the high price of pig iron as compared with that produced in Scotland. This leads to loss of trade. Not only can it not be expected that Cleveland pig iron should go in quantity to Scotland, unless there is a difference in price equivalent to the carriage, but also under present circumstances Scotch iron is successfully competing in a great many neutral markets, to the disadvantage of Cleveland.

NOTES FROM SCOTLAND.

(*From our own Correspondent.*)

THERE has been great lack of strength in the Glasgow warrant market this week. When sales of pigs had to be made, prices at once gave way, as the outside public are not now giving any support to the market. Large withdrawals of iron are taking place from the public stores, the reduction for the last two weeks having exceeded 9000 tons a week, and the shipments are also improving; but the speculative market is nevertheless very dull.

The past week's shipments were 9154 tons, against 6361 in the corresponding week of last year, and of the total Canada took 20 tons; South America, 225; India, 150; France, 210; Italy, 1410; Germany, 140; Holland, 515; Belgium, 250; and China and Japan, 200, the coastwise shipments being 5826 tons.

The prices of makers' iron, which have again been reduced this week in amounts varying from 6d. to 2s. 6d. per ton, are as follows:—Gartsherrie, f.o.b. at Glasgow, per ton, No. 1, 72s., No. 3, 64s. 6d.; Langloan, 74s. 6d. and 67s. 6d.; Summerlee, 72s. and 65s.; Coltness, 74s. 6d. and 67s. 6d.; Calder, 72s. and 62s. 6d.; Clyde, 67s. 6d. and 57s. 6d.; Carnbroe, 53s. 6d. and 53s.; Monkland, 52s. 6d. and 52s.; Govan, 52s. 6d. and 52s.; Glengarnock, at Ardrossan, 73s. and 66s.; Dalmellington, 61s. and 60s. 6d.; Eglinton, 54s. and 53s. 6d.; Shotts, at Leith, 74s. 6d. and 67s. 6d.; Carron, at Grangemouth, 77s. and 68s.

During the past week there was shipped from Glasgow locomotives to the value of £1050 for Calcutta; machinery, £9600; sewing machines, £6020; steel goods, £9700; and general iron manufactures, £30,000.

The malleable iron trade is very quiet at present. Makers have still a good amount of work on hand, although in some cases it is understood to be getting disposed of more quickly than of late. In fact it is much easier to get early delivery of materials, because there is now no pressure of new orders. The trade is in a transition state, and it is difficult both for merchants and manufacturers to know what course to pursue. The unsettled state of the pig iron market is the cause of the uncertainty that prevails. For a number of weeks there was a strong opinion that the market would have a substantial advance, and the result of this would have been support of former prices of manufactured iron. But the position of the pig iron market has continued so long unsatisfactory that a feeling at length appears to be growing that concessions will require to be made to customers if work is to be obtained to take the place of the contracts that are now being rapidly worked off.

The position of the steel trade shows scarcely any change. There are still large quantities of steel to be supplied to the shipbuilders and others, but the additions that are being made to existing contracts are, for the most part, of small importance.

There has been a good business in the coal trade in the past week. The requirements of manufacturers are on an extensive scale, and the demand for household coals has been very brisk within the last few days, in consequence of the recurrence of very cold weather. The shipments are also improving in quantity, and the total clearances at Scotch ports in the course of the week were 108,493 tons against 91,823 in the correspoonding week of last year. Of the total 36,858 tons were cleared at Glasgow, 13,818 at Grangemouth, 11,114 at Burntisland, and 10,643 at Methil. The prices free on board ship at Glasgow are:—Splint coals, 10s. 9d. to 11s. 3d. per ton; main, 9s. 9d. to 10s.; ell, 10s. 6d. to 10s. 9d.; and steam, 11s. to 11s. 6d.

The colliers have been working fairly well, generally five days per week. In the West of Scotland the men profess to be waiting till they see what course is adopted by the English miners, as regards the wages question. Mr. Weir, the agent of the Fife and Clackmannan miners, has been advising the men in his district that the circumstances of the trade do not admit of a further advance of wages at present, and it is hoped that the men will be guided by his advice.

WALES AND ADJOINING COUNTIES.

(*From our own Correspondent.*)

CLOSE upon 180,000 tons of coal were sent foreign from the Bute Docks last week, and taking the collective business, export and import, the record has again been broken. This is gratifying in the teeth of Barry opposition, especially when it is noted that the rival dock keeps steadily to its average of 50,000 tons weekly.

Taking the collieries from Swansea Valley to the Rhondda, and including the Monmouthshire, the drain is simply enormous, and at present there are no signs of abatement in either quantity or price. It is now unquestionably the good times in coal. Coalowners get a profit, and colliers are doing well. Some colliers are earning £20 a month, and many are saving against the inevitable relapse.

Now would be an excellent time for societies to be started in colliery districts, for enabling colliers to acquire their own freehold. This would lead to saving habits and discourage strikes.

With the exception of Monday, the 3rd of the month, collieries have been worked well of late, and the various railways have presented a busy appearance. At the docks, too, the utmost vigour has prevailed, and some exceedingly satisfactory work has been done—especially at the Bute Docks. I note a case or two. Last week the Byron steamer, 3104 tons, began working Monday afternoon, and was finished about the same time on Tuesday. The Syria, 3002 tons, followed, and was finished on Wednesday afternoon. At one time, when three tips were working on the same steamer, the rate was nearly 600 tons per hour!

Notice of the stoppage of a Rhondda colliery and of one of the Dowlais collieries has been given. At the present express speed of operation this state of things must be expected.

Imports are increasing at Cardiff, and Edwards and Robertson have just started a line of steamers for New York trade.

Great as is the coal yield, it is not equal to the demand, and prices are going up. Sales were freely effected this week of best steam at 16s. to 16s. 6d.; and seconds, 15s. to 15s. 6d. As for small steam, it has touched 11s., a most unusual figure. House coal is quite as buoyant, best selling at 16s., and even No. 2 small fetches 10s. 6d. There is no class of coal but what is firm. Patent fuel, too, is stiff in price, and a good trade is being done. Large cargoes are going this week to Vigo.

The only industry showing a slight falling-off is that of coke. Prices have drooped from 1s. to 2s. This is probably due to lessened demands outside the district. Within, the demand is well kept up.

The iron and steel trades show no change on any account, though it is but natural that some falling-off will take place in bookings, as regards tin bar. In railway iron and steel it has been a good week all round, and some large cargoes have been dispatched, notably 3400 tons to Calcutta, and 1130 to Colombo, besides cargoes to Paysander and Buenos Ayres. Newport has also been active in shipments of rails and tin-plates to Liverpool.

The demand on local works for local needs has been large, and has been freely supplemented with pig from Glasgow and Whitehaven, and tin bars from Barrow, and an unusual one of tin bar from Antwerp.

It is rumoured here that increased make of steel is likely at Bilbao, but it is not certain to interfere with our trade, and at present the requirements are more than can well be met.

The Exchange, Swansea, has been well attended this week, and though a reduction in the warrant market caused some uneasiness, business was not affected to any large extent. Pig was quoted at 50s. 9d., Middlesbrough 51s. 7½d., hematites 63s. 6d. Welsh bars are at £7 10s. to £7 15s. Steel nails are slightly easier, quotations, heavy £7 to £7 5s., light £7 15s. to £8. Tin bars £7 15s. Siemens £8 2s. 6d. Swansea port had a good week.

Partial stoppages here and there of tin-plate works are reported, but there is not the unanimity that is required by those who suggest the limitation of make. One large employer openly ridicules the plan, and regards it as suicidal, and an encouragement to America, now the largest customer, to make another supreme effort to do without us. Seventeen mills are likely to be stopped in the Swansea district next week, and there is a hitch at Melingriffith, near Cardiff, which may lead to a stoppage, though it is hoped that as it is a wages question it will be only of a temporary character. Tin-plates are firm at last quotations. The fact is that makers cannot reduce without a loss, and the generality are firm in resisting any change. The exports are now beginning to show over-make, and stocks to decline in proportion. This is a more hopeful sign. Last week Swansea exported nearly 62,000 boxes, and received from works 51,422 boxes. Stocks are now 259,000.

A steamer in Barry Roads had a narrow escape from fire last week; her bunker coal, 200 tons, was damaged and had to be discharged.

A change in the colliery management at Plymouth Works, the coalfield of which is being energetically worked, is announced consequent on the retirement of Mr. E. Bailey.

The Willows Wire Works, Merthyr, is, I hear, again in the market.

The attention of buyers of scrap iron, old plant, &c., having been called to my notice of the forthcoming sale of the accumulations at Abernant, Aberdare, I am informed that the sale will be duly announced by advertisement, and that it will be by public auction. These works were most important in the time of the Fothergill family, and a good class of iron was turned out.

NOTES FROM GERMANY.

(*From our own Correspondent.*)

DURING the week the firm condition of the iron markets has been maintained. Some reserve is perceptible on the part of the brokers; their stocks being well filled, they seem inclined to wait to see how business will further develope.

On the Silesian market, pig iron is in fair request, and finds ready sale at firm quotations. As has been reported in a former letter, the Wrought Iron Convention has been prolonged for three years, and is now negotiating with the blast furnaces in order to secure the pig iron required for that period. As minimum quotation for pig iron, M. 90 is to be fixed, while the basis price for malleable iron will be M. 210. Sheets have retained their high price of M. 265. For castings the basis price has been raised on M. 150 p.t. Old rails have of late met with an extremely brisk demand; they have been much advanced, and are scarcely to be had at M. 115 p.t. The Austro-Hungarian iron trade remains lively at firm quotations. Buyers appear in sufficient number to maintain the favourable situation of the market. For pig as well as for finished iron demand is very good. The iron and steel trades are extremely busy. In the building line especially large inquiries are coming forward.

Great quietness reigns on the Belgian iron market, buyers, as well as sellers, being rather reluctant. This is the cause why the wrought iron syndicate has ordered no change in prices. An advance was quite out of the question, orders coming in scantily; on the other hand, a reduction in prices seemed not likely to take place in the near future. Numerous orders for sheets are coming in from Holland, but bars and girders meet with little or no request. The Liège Company "Conduite d'eau," is reported to have bought—of Hamburg speculators—5000t. French pig iron, from Longwy, at 75f. p.t. The Maatschappy tot Exploitatie van Staatsspoorwegen, at Utrecht have given 400 sets of wheels and axles to the Belgian company, Dyle et Bacalan, at Louvain. Hitherto, the Rhenish-Westphalian works took a leading part in the supply of the Dutch State Railways. On the Belgian coal market everything seems to indicate that prices are beginning to return to a quiet level.

The French iron trade is keeping its firm position in every respect. Orders have increased of late, and in almost all branches a full activity is being maintained. This may chiefly be said of the wire mills, their articles finding most brilliant sale. The rolling mills of the Nord have raised wrought iron, on an average, 5f. p.t., basis price for common sorts being 200f., for better qualities 210 to 215f. p.t. at works. The French coal market continues lively. English coal has gained ground of late, owing to the miners' strikes in Belgium and Pas de Calais. The output of coal in the Departement du Nord and Pas de Calais was in 1889, 13,433,847 tons, against 12,376,434 tons in 1888.

Regarding the Rhenish-Westphalian iron market there is but little of a novel character to communicate, a quiet but firm tone prevailing. Prices for Luxemburg minette are firm and paying, there being a strong inland demand. Prices are about the same as last quoted. Pig iron was, on the whole, firm; although for some sorts a slight reduction in price has set in. The returns now published show a considerable decrease in the production of pig iron. The total production in Germany—including Luxemburg—was, for the month of January, 1890, 374,066 tons, of which 178,913 tons were forge and spiegeleisen, 36,476 tons Bessemer, 114,279 tons basic, and 44,398 tons foundry pig. In December, 1889, production was 391,523 tons; and in January, 1889, 367,111 tons.

On the whole, business moves on in a steady way, and no concession whatever are made on the prices given. They are, for spiegeleisen—10 to 12 p. c. grade—M. 103; good forge quality, M. 91 to 92; No. 2, M. 88; No. 3, M. 82 to 83; foundry, No. 1, M. 89 to 100; No. 2, M. 95 to 97; No. 3, M. 91 to 92; Basic, M. 79 to 82; Bessemer, M. 93 to 96; Luxemburg forge pig is still noted 85f. The rolling mills are in good operation, and will continue to be so for some time to come. In bars a tolerably good business has been doing. The plate and sheet trade is in a satisfactory condition; no change in price has taken place. For wire and wire nails the slightly raised quotations are, in most cases, paid without questioning. Foundries, as well as machine and wagon factories, are well employed. At a late tendering for rails M. 165 was the lowest offer, others ranging between M. 168 to 172 p. t. Latest list quotations are as follows:—Good merchant bars, M. 200 to 205; angles, M. 210 to 215; girders, M. 140 to 150; hoops, M. 210 to 215; bars in basic and Bessemer, M. 200 to 205; billets ditto, M. 145 to 150; boiler plates, M. 260 to 265; tank ditto, M. 235; sheets, M. 250 to 255, in some cases M. 260; plates in basic and Bessemer, M. 225 to 230; tank ditto, M. 210 to 230. Iron wire rolls, common quality, M. 195; drawn wire in iron and steel, M. 190 to 200; wire nails, M. 200 to 220; rivets, M. 290; steel rails, M. 165 to 175; steel sleepers, M. 160 to 165; complete sets of wheels and axles, M. 380 to 385; axles, M. 255 to 260; steel tires, M. 270 to 285; light section rails, M. 165 to 170, all per ton at works.

The working of electricity for lighting purposes appears to have proved highly satisfactory in Barmen, Rhenish-Prussia, and further utilisation of this powerful factor in modern life is being contemplated by the Town Council. Also the question is raised if electric lighting may not be produced at lower cost—as low, at least, as gas.

The programme on the Labour Question submitted by the German Government to those Governments which are invited to the Berlin Conference is, in its principal features, similar to that of the Swiss Labour Conference. It contains the following heads:—

1. Regulation of labour in mines, with sub-questions: If working under ground is to be prohibited for children under a certain age and for women. If restriction of working hours is to be provided for such mines, where working is particularly dangerous to health. If it is possible to place under international regulations the safe labour in coal pits, in the regular output of coal?

2. Regulation of Sunday labour, with sub-question: If Sunday labour, excepting cases of need, is to be prohibited. What exceptions are to be permitted. If exceptions are to be stipulated by international convention, by law, or by administrative measures?

3. Regulation of children's labour, with sub-questions: If children up to a certain age are to be excluded from industrial labour. What age is to be considered as excluding. If for all branches of industry, or for some of them only, and for which of them are restrictions in duration and kind of working to be provided?

4. Regulation of young men's labour, with sub-questions: If labour of young men, who have passed childhood, is to be restricted, and up to what age. What kind of restrictions are to be prescribed. Are differences to be provided for particular branches of industry?

5. Regulation of women's labour, with sub-questions: If the labour of married women by day or in the night is to be restricted. If the labour of all women is to be restricted. What kind of restrictions are to be recommended. If differences are to be provided for certain branches of industry, and for which of them?

6. Execution of the regulations concerning the carrying out of rules to be adopted, and their superintendence, are to be fixed. If repeated conferences of the representatives of the Governments interested are to be held, and what mission would have to be assigned to them?

AMERICAN NOTES.

(*From our own Correspondent.*)

New York, February 21st, 1890.

THE only visible sign of weakness in the American crude iron market arises out of the fact that during December nearly all buyers of iron made contracts for supplies to last them up to April 1st. Since the opening of the year but little business in iron has been done; in fact, there was no room for it, because the capacity of furnaces had been about sold up for three months. The only parties who have iron to sell are the makers of inferior brands, and these makers have been taking advantage of the absence of competitors to sell their inferior product at the best prices obtainable, knowing that when better iron should be offered on the market their poorer makes would have no show. The report has therefore gone out that crude iron has weakened; but when quality is considered, there has been no weakness whatever. Makers of standard brands of forge, who understand the situation thoroughly, are to-day declining to take anything less than 18 dols. Bessemer pig is still quiet at 21·50 dols. Billets are offered at 37 dols. A drop of 30c. on Southern freights has made a little difference in Western markets.

Steel rails have been quoted in large blocks at 35 dols., but no large orders have been placed as yet. There have been unprecedented snow storms in the West. There is some little apprehension in manufacturing circles over the continued agitation of the eight hour question. Kansas and Nebraska railroad managers expect to reduce corn freights in a few days. The exports from this port for the past seven months foot up 21,500,000 dols. more than the corresponding period of the previous year.

There is a general depression in the anthracite coal trade, and the production this year has fallen off about 400,000 tons, as compared to last year. The bituminous trade is on the increase, amounting to about 230,000 tons over same time last year, among the mines which ship the great bulk of their product to tidewater markets. No doubt a very active demand for all kinds of crude and finished material will set in very early this year. Municipal requirements will be very heavy for pipes, engines, and machinery, electrical appliances, cable and electric roads, and for all manner of material used by cities and towns for construction work. A great deal of interest is felt in the prosecution of work intended to improve the interior water ways.

LAUNCHES AND TRIAL TRIPS.

On Wednesday afternoon Messrs. Raylton, Dixon and Co., launched the Monrovia, a steel screw steamer built for Messrs. Elder, Dempster and Co., of Liverpool. This vessel is built on the raised quarter-deck principle, having a continuous bridge deck, forming a partial awning deck. Dimensions: Length, 307ft.; breadth, 40ft.; depth moulded, 21ft. 4in.; with a dead-weight capacity of about 3600 tons. Her engines, which will be fitted by Messrs. Thos. Richardson and Son, of Hartlepool, are of 190 nominal horse-power, with cylinders 22in., 35in. and 59in. by 39in. stroke.

On Saturday, the screw steamer Coomassie, which has been built to the order of Elder, Dempster and Co., of Liverpool, was launched from the yard of the Naval Construction and Armaments Company, at Barrow. The Coomassie is built of steel, and is classed 100 A at Lloyd's, she is 312ft. long, 39ft. beam, and 27ft. 6in. deep, with triple expansion engines, having cylinders 23in., 38in., and 62in. in diameter and 42in. in stroke. The boilers are two single-ended ones, 14ft. 6in. diameter, and 10ft. 6in. long, at a working pressure of 160 lb. to the square inch. This is the fourth steamer exactly of this description that has been launched from this yard, two for Elder, Dempster and Co., and two for the British and African Steam Navigation Company.

THE SANITARY INSTITUTE.—The council have accepted an invitation from the Town Council of Brighton to hold the Autumn Congress and Health Exhibition in that town in September next.

NEW COMPANIES.

THE following companies have just been registered:—

Cortex Calorifuge Company, Limited.

This company was registered on the 25th ult., with a capital of £10,000, in £1 shares, to acquire, upon terms of an unregistered agreement, certain inventions, particulars of which are not given, and to buy, sell, manufacture, and deal in engine and other packing and stores and ships' stores. The subscribers are:—

	Shares.
*Walter Glynn, 20, Water-street, Liverpool, shipowner	1
*J. R. Montgomery, 24, James-street, Liverpool, shipowner	1
*Emil Buntzen, 14, Atherton-street, Liverpool, shipowner	1
*R. Dalyell Welch, Tower-chambers, Liverpool, merchant	1
*F. Richmond, 11, Seel-street, Liverpool, distiller	1
J. Jardine, 30, Brunswick-street, Liverpool, merchant	1
W. H. Walker, 40, Castle-street, Liverpool, chartered accountant	1

The number of directors is not to be less than three, nor more than five; the first are the subscribers denoted by an asterisk; qualification, £250 in shares or stock. The company in general meeting will determine remuneration.

Henry Lister and Son, Limited.

This company was registered on the 25th ult., with a capital of £80,000, in £10 shares, to take over the business of Henry Lister and Son, silk, woollen, and worsted spinners and manufacturers, carried on at Ash Brow Mills, Huddersfield; Ford Mills, Horbury; and at 49, Bow-lane, London, E.C. The subscribers are:—

	Shares.
*Henry Lister, Huddersfield	1
*H. R. Lister, Huddersfield	1
*A. E. Lister, Huddersfield	1
*J. Law, Cleckheaton, card maker	1
*W. Blackburn, Cleckheaton, worsted spinner	1
G. Harrison, Huddersfield, cashier	1
S. Britton, Huddersfield, salesman	1
H. S. Peace, Huddersfield, finisher	1

The number of directors is not to be less than three, nor more than five, the first being the subscribers denoted by an asterisk, the first two being managing directors; qualification, 200 shares. Messrs. Henry Lister and H. R. Lister will be respectively entitled to £1000 and £600 per annum, and each other director to £100 per annum. Solicitors, Messrs. Ramsden and Co., Huddersfield.

Kings Norton Metal Company, Limited.

This company was registered on the 21st ult., with a capital of £140,000, in £10 shares, to acquire certain freehold land at Lifford, Kings Norton, Worcester, under an agreement to be entered into with Thomas Richard Bayliss and George Hagger, and to carry on the business of manufacturing, casting, and rolling metal of all kinds, also to manufacture metal sheets, tubes, wire nails, screws, arms, ammunition, and projectiles. The subscribers are:—

	Shares.
*Arthur Greenwood, Albion Works, Leeds, engineer	1
*John Palmer, jun., 50, Finsbury-square, merchant	1
*Major-General E. Micklem, 36, Hans-place	1
G. Greenwood, 16, Great George-street, S.W., engineer	1
G. Hagger, 16, Great George-street, S.W., engineer	1
Herbert Melville Smith, 27, Duke-street, W., engineer	1
C. E. Bonsor, 8, Vincent-square, S.E., clerk	1

The number of directors is not to be less than three, nor more than seven; qualification, £500 in shares; remuneration, £1050 per annum, divisible. The first three subscribers are the first directors. Solicitors, Messrs. Rollit and Sons, 12, Mark-lane.

Thomas and J. S. Turner, Limited.

This company was registered on the 26th ult., with a capital of £20,000, in £100 shares, to take over the businesses of gun makers, nail, rivet, wire, and wire article makers, carried on at 6, Fisher-street, Birmingham, and 19, Brook-street, Middlesex, by Thomas Turner and James Sandon Turner, trading as Thomas Turner and Turner and Co. The subscribers are:—

	Shares.
*Thomas Turner, sen., Sutton Coldfield, Warwick	1
Thomas Turner, jun., 6, Fisher-street, Birmingham, gun maker	1
*J. S. Turner, 6, Fisher-street, Birmingham, nail and rivet maker	1
Mrs. J. S. Turner, Sutton Coldfield	1
*A. W. Lorton, Aston, gun maker	1
G. H. Blackwell, Aston, nail and rivet maker	1
J. Foulkes, 7, Strachan-place, Fulham, gun maker	1

The number of directors is not to be less than two, nor more than five; the first are the subscribers denoted by an asterisk. Mr. Thomas Turner is appointed chairman and secretary, and Mr. J. S. Turner managing director, each at a salary of £2 per week. Mr. Lorton will not be entitled to remuneration as a director. Solicitors, Messrs. J. B. Clarke and Co., Birmingham.

Richmond Ironworks, Limited.

This company was registered on the 21st ult., with a capital of £25,000, in £10 shares, to carry on the business of iron and steel manufacturers and founders in all branches. The company will enter into an agreement with Wm. Cowper, particulars of which are not specified in the registered documents. The subscribers are:—

	Shares.
J. Shiel, M.E., Durham	1
T. G. Reah, Newcastle	1
J. E. Stead, Middlesbrough, analyst	1
J. A. Birkbeck, Middlesbrough, engineer	1
H. Smith, Stockton	1
E. Kirby, Middlesbrough, bank manager	1
J. M. Lennard, Middlesbrough, shipowner	1

The number of directors is not to be less than three, nor more than seven; qualification, £500 in shares; the subscribers are to appoint the first. The company in general meeting will determine remuneration. Solicitor, Mr. C. T. Whinney, 10, Old Jewry-chambers.

Reliance Portland Cement Works, Limited.

This company was registered on the 20th ult., with a capital of £60,000, divided into 3000 10 per cent. cumulative preference shares, and 3000 deferred shares of £1 each, to enter into an agreement with the London Agency, Limited, particulars of which are not given in the registered documents, to acquire lands for mining, quarrying, winning, and getting chalk, brick, earth, clay, gravel, &c. The subscribers are:—

	Shares.
*R. E. Workman, 23, Lime-street, ship broker	1
T. W. Wellsted, 396, Kennington-road, accountant	1
J. Riches, 25, Abchurch-lane, solicitor	1
C. W. Kirk, 138, Brecknock-road, N., accountant	1
J. W. Fricker, 14, Addiscombe-grove, Croydon, secretary to a company	1
J. S. Jarvis, 13, Wickham-terrace, Towcester, clerk	1
C. Bathe, 6, St. Andrew's-villas, Gravesend, cement expert	1

The number of directors is not to be less than two, nor more than five; the first are Mr. A. E. Carey, G. Fraser, and B. E. Wirkman; qualification, ten shares; remuneration, £100 per annum each.

Williams, Fry, and Company, Limited.

This company was registered on the 21st ult., with a capital of £20,000, in £5 shares, to take over as a going concern the business of Portland cement manufacturers carried on by Arthur John Williams and Stephen Henry Fry, at Greenhithe, Kent, under style of Williams, Fry, and Co. The subscribers are:—

	Shares.
*A. J. Williams, Stone, Greenhithe, cement manufacturer	1
*S. H. Fry, Stone, Greenhithe, cement manufacturer	1
Lieutenant-Colonel F. C. Goad, 15, Harlington-road, Ealing	1
J. O. Collier, 59 and 60, Chancery-lane, clerk	1
J. W. Davies, 34, Guildford-street, W.C., accountant	1
R. W. Vaughan, C.E., 64, Broad-street-avenue	1
W. M. Bemister, Broad-street-avenue, clerk	1

The first two subscribers are appointed directors, and will be entitled to retain office so long as they may respectively hold 1000 of the shares to be allotted in pursuance of an unregistered agreement. The company in general meeting will determine remuneration. Solicitor, Mr. R. T. Bowerman, 3, Gray's-inn-square.

THE PATENT JOURNAL.

Condensed from the Journal of the Commissioners of Patents.

Application for Letters Patent.

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

24th February, 1890.

2906. Glass Decoration with Metallic Linings, E. V. Caspar, London.
2907. Clips for Endless Ropes, &c., N. Williams, Manchester.
2908. Garter, J. Martyn, Southwold.
2909. Shoes for Horses and other Animals, W. Rose, Birmingham.
2910. Washing Machines, S. Gregson, London.
2911. Letting-off Motion for Looms, I. Kirkbride, London.
2912. Gas Brackets and Chandeliers, H. H. Badams, Birmingham.
2913. Fountains, J. F. Bennett and E. P. Hides, Sheffield.
2914. Meal Sponge Rusks or Casks, T. Sturtewagen, Bath.
2915. Gas Lamps, S. Gratrix, Manchester.
2916. Detective Photograph Cameras, E. and T. A. Underwood, Birmingham.
2917. Sole and Fishplate Iron Trough, W. Lewis, Dublin.
2918. Stockings, J. A. Barfoot, Leicester.
2919. Petroleum Engines, J. N. Grob, O. Schultze, and A. Niemczik, London.
2920. Flash Lamps, H. Campbell, London.
2921. Show Tickets for Goods, A. G. Pinfold, London.
2922. Corsets, M. L. Barlow, London.
2923. Tea Caddies, &c., S. Bridge, Lye.
2924. Steam Stamps, E. S. Brett and J. Hazlewood, Birmingham.
2925. Abatement of Smoke from Furnaces, J. Ryson, Bury.
2926. Tins, &c., for Convenience in Transit, H. H. Badams, Birmingham.
2927. Supplying Air to Flues of Boilers, J. Petrie, Rochdale.
2928. Advertising, J. F. Bennett and E. P. Hides, Sheffield.
2929. Cropping Machines for Hearthrugs, J. Beever, Halifax.
2930. Easing the Shuttles in Looms, R. Eccles, Halifax.
2931. Checking Receipt of Money in Vehicles, J. M. Black, London.
2932. Paper-making Machinery, M. Duxbury and J. Hargreaves, London.
2933. Glove Fasteners, E. Randnitz, London.
2934. Producing Stay Busks, W. G. Causer and H. C. Hopkins, London.
2935. Propelling and Measuring Fluids, L. Vojacek, London.
2936. Looms for Weaving, J. Seed, London.
2937. Necklaces, &c., V. Milward, London.
2938. Stop-motion for Twisting Frames, F. L. Lumb, London.
2939. Facile Chimney Cleaner, G. W. Crane, London.
2940. Composition for Roadways, &c., H. Benjamin, London.
2941. Continuous Acting Kiln, G. Appiani, London.
2942. Record and Tallying Sheets, H. E. Dane, London.
2943. Portable Domestic Fire-extinguisher, T. R. Douse, London.
2944. Panels in Imitation of Chinese Cloisonne Enamel, C. Bamberger, London.
2945. Electric Secondary Cells, A. M. F. Laurent-Cely and L. A. Timmis, London.
2946. Shooting Stockings, L. Parsey, Leybourn.
2947. Torpedoes, D. K. Presgrave, London.
2948. Chimneys of Gas, &c., Burners, F. P. Leca, London.
2949. Seating of Chair Bottoms, G. C. Thompson, London.
2950. Combined Fuel Economiser, Smoke Consumer, and Manufacturer of Oil, R. Laird, Boston, U.S.
2951. Fire Pails, A. D. Warren, Worcester, U.S.
2952. Hinges for Box Ottoman Couches, W. Parker, London.
2953. Canisters, H. Coventry.—(*H. C. Ferron, Holland.*)
2954. Gas Engines, J. Roots, London.
2955. Continuous Distillation of Tars, H. Propfe, London.
2956. Velocipedes, A. White and F. Stephenson, London.
2957. Electric Meters, J. J. A. Aubert, London.
2958. Alcoholic Beverages, J. Stevenson.—(*E. Riglet, France.*)
2959. Delivering Fortune Goods, &c., B. Knapp, London.

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2960. Nitro-Compound Powders, W. D. Borland, the "E.C." Powder Co., London.
2961. Producing a Liquid Spray, F. E. Beeton, London.
2962. Securing Bottles, S. T. Oldridge and F. J. Russell, London.
2963. Working Electric Railways, R. C. Sayer, Bristol.
2964. Hoists, W. Clifford, Sheffield.
2965. Flushing Water Closets and Drains, H. Brookfield, Sheffield.
2966. Fastenings for Window Sashes, G. R. Bayley, Manchester.
2967. Range Finders, H. C. Fleming and C. F. Hilder, London.
2968. Fluid-actuated Brakes, J. E. Loughridge, London.
2969. Duplex Target, W. Wright and T. H. Lidstone, Plymouth.
2970. Magazine Cartridge Bags, T. W. Deane, Old Trafford.
2971. Lamp Feeders, J. Bridge, Staffordshire.
2972. Oil and Spirit Lamps, A. Whicker and W. H. Parker, Birmingham.
2973. High-pressure Valve Tap, A. W. King, Eastbourne.
2974. Ashpans for Fireplaces, J. E. Aykroyd, Bradford.
2975. Necktie Holder, W. F. Lumley, jun., Chelmsford.
2976. Rotary Motors, A. E. and E. O. Tompkins, Manchester.
2977. Rivets, T. P. Lomas, London.
2978. Artificial or Block Fuel, C. H. Mowll, London.
2979. Back Straps for Vests, D. Holgate, Leeds.
2980. Drum Whistles, H. A. Ward and P. McDonald, Birmingham.
2981. Steel, M. F. Coomes and A. W. Hyde, London.
2982. Socks for Boots and Shoes, R. G. E. Lempriere, Bristol.
2983. Combined Sash Fasteners and Lifts, J. Collins, Birmingham.
2984. Brass Taps, H. S. Lazams, London.
2985. Fire-extinguishers, M. Frankal and W. M. Majorkiewicz, London.
2986. Electric Lamp Sockets, W. F. Wollin and E. H. Werline, Birmingham.
2987. Metallic Mattresses, E. R. Billington and J. Holding, Liverpool.
2988. Striking Balls in Lawn Billiards, Henning Bros., London.
2989. Zinc Plates for Colour Printing, W. L. Hare, London.
2990. Supplying Carbonic Acid Gas, H. S. G. Stephenson, London.
2991. Consuming Strips for Lightning Devices, J. H. Farrel, London.
2992. Automatic Button-sewing Machines, A. J. Boult.—(*The American Button Fastener Company, United States.*)
2993. Blasting, J. Beswick, Liverpool.
2994. Preventing Disagreeable Sounds from Valves, W. P. Thompson.—(*E. S. Hildebrandt, United States.*)
2995. Numbering and Perforating Machines, J. Brady, Liverpool.
2996. Electric Motors, R. J. F. Mostyn, London.
2997. Tilting Ladies' Dresses, H. G. Atkins, London.
2998. Fairy Crystal Maze, B. Elkan, London.
2999. Protecting Throw Straps of Looms, F. Waněček, London.
3000. Machine for Drying Grain, &c., C. R. Bonne, London.
3001. Hydro-carbon Gaslight Apparatus, L. Göhmann, London.
3002. Stirrups, G. Weber and A. Zachau, London.
3003. Regulator for Weaving Loom Tackle, E. Höfel, London.
3004. Manufacture of Waterproof Boards, &c., C. Weygang, Child's Hill.
3005. Advertising, A. I. Lightenhein and E. H. Burton, London.
3006. Pessaries, J. S. McCants, London.
3007. Compound Steam Engines, R. M. Beck, London.
3008. Secondary Batteries, W. B. Hollingshead, London.
3009. Bleaching, &c., Fibrous Materials, S. D. Keene, London.
3010. Chair for Suspending Rails, &c., F. A. Barth, London.
3011. See-saws, P. W. Atkinson, London.
3012. Combined Pianette and Harp, W. G. Jarvis, London.
3013. Storage or Secondary Batteries, C. J. Hartmann, London.
3014. Wheel Tires, E. F. Eldredge, London.
3015. Automatic Laundry Water Dyer, E. V. Goad, London.
3016. Wrappers for Holding Tobacco, J. Wadsworth, London.
3017. Compressors, H. C. Sergeant, London.
3018. Machines for Cutting Wood, J. Howard and J. H. Geddes, London.
3019. Cigar Bunching Machines, H. H. Lake.—(*J. K. Williams, United States.*)
3020. Steam Boilers, B. V. Steenbergh, London.
3021. Manufacture of Chisels, J. O'Brien and J. Carew, London.
3022. Railway Vehicles, H. H. Lake.—(*W. H. H. Sisum, United States.*)
3023. Combined Box, &c., Croggon and Co. and H. J. Gardner, London.
3024. Electric Motors, H. H. Lake.—(*E. B. Parkhurst, United States.*)
3025. Plastering Material, G. West, London.
3026. Advertising, J. Cooper, London.
3027. Stoves for Cooking Purposes, &c., D. C. Defries, London.
3028. Dynamo-electric Machines, A. C. Reignier, London.
3029. Steam Boiler Furnaces, M. E. Herbert, London.
3030. Starch, A. Weisz, London.

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3031. Starting and Stopping Gear of Compound Engines, A. H. Wallis, Basingstoke.
3032. Paper Envelopes, J. V. Elsden, Storrington.
3033. Urinals, E. D. Bush, Manchester.
3034. Closet or Commode, E. D. Bush, Manchester.
3035. Magazine Rifles, G. Perrna and M. Theoharescu, London.
3036. Bread, J. Adair, Waterford.
3037. Fastening Skates to Boots, G. Hoyes, Barnsley.
3038. Coloured Lace Curtains, J. B. Wharton, London.
3039. Tea and Coffee Pots, W. H. Bulpitt, Birmingham.
3040. Opening Tin Cans, T. F. and P. Bennison, Stockton-on-Tees.
3041. Valve Gear for Steam Engines, M. Wilson, Glasgow.
3042. Globes for Illumination, R. Scott, Newcastle-on-Tyne.
3043. Steam Boiler Furnaces, A. and A. J. Bell, Manchester.
3044. Finishing the Sides of Wooden Boxes, &c., W. Cummings, Glasgow.
3045. Security of Watches, C. Brawn, London.
3046. Wrap for Encasing Umbrellas, P. A. Martin, Birmingham.
3047. Reservoir Writing Tube and Pen, W. Brown, Sheffield.
3048. Smoke-consuming Fire Bridge for Steam Boilers, T. Dale, Kirkcaldy.
3049. Sprinkling Liquids upon Turnips, T. Holmes, Manchester.
3050. Rack Pulleys for Window Blinds, H. Smith, Birmingham.
3051. Adjustable Bearings for Rotary Spindles, &c., J. C. Dalman and E. J. Blincoe, Birmingham.
3052. Cigar-making Machines, H. Brogden, Manchester.
3053. Producing Matrixes for Stereotyping, M. Smith, Manchester.
3054. Advertising, A. H. Heggs, Manchester.
3055. Sample Cans, S. F. Cousins, London.
3056. Steam Boiler Feeding, &c., Apparatus, J. Murrie, Glasgow.
3057. Stoppering Bottles and Jars, C. Melin, London.
3058. Electric and Tubular Pneumatic Action in Organs, J. J. Binns, London.
3059. Spade Handles, J. Lee, Birmingham.
3060. Driving Chains, C. H. Brampton, Birmingham.
3061. Tagging Machines, H. Collet and M. Merichenski, London.
3062. Treatment of Sewage, &c., F. L. H. Danchell, London.
3063. Traps for Steam, W. A. Clark, London.
3064. Portable Drawing Board, G. C. Inkpen, Southsea.
3065. Sale of Sweets, J. Hont, London.
3066. Manufacture of Gloves and Cuffs, T. Hill, London.
3067. Checking and Recording, T. W. Duffy and D. Embleton, Leeds.
3068. Advertising, M. Grieten, Glasgow.
3069. Combined Sketching Box and Easel, H. Hickley, London.
3070. India-rubber-wood Pavements, W. Weaver, London.
3071. Electric Meter, W. J. S. Barber-Starkey, London.
3072. Self Collecting Rent Chairs, M. Korn, London.
3073. Spring Fastenings or Safety Pins, F. Redman, London.
3074. Pumping Engines, J. G. Elliot, Liverpool.
3075. Intercepting Traps for Drains, G. H. Light, London.
3076. Devices for Suspending Clothes, H. Gerbo, London.
3077. Protectors for Boots and Shoes, J. M. Henry Liverpool.
3078. Microphone, D. J. Wadén, London.
3079. Safety Lamp, J. Etherington, London.
3080. Trousers, C. E. Winter, London.
3081. Inserting Charges in Gas Retorts, C. Kingsford, London.
3082. Filaments for Electric Lamps, R. Langhans, London.
3083. Diving Dresses, W. Carey, London.
3084. Regulating the Supply of Steam to Steam Engines, B. J. B. Mills.—(*T. W. Q. Honeywill and C. J. E. Linnemann, New Zealand.*)
3085. Regulating the Supply of Steam to Screw Engines, B. J. B. Mills.—(*T. W. R. Honeywill and C. J. E. Linnemann, New Zealand.*)
3086. Cutting Boards from a Log of Wood, G. A. Oncken, London.
3087. Evaporating Salt Liquors, E. G. Lawrance.—(*S. Pick, Galicia.*)
3088. Boiler Attachment for Notifying the Rise or Fall of the Water Level, H. J. Haddan.—(*F. J. Haut, Belgium.*)
3089. Drying Granular Materials, S. Seckendorf.—(*M. Reuland, Germany.*)
3090. Reducing the Vibration in Cycles, G. Jepson, London.
3091. Moulds, B. Bloomer, London.
3092. Moulds, B. Bloomer, London.
3093. Pressing Cloth, H. H. Lake.—(*D. Gessner, United States.*)
3094. Portable Electric Lamps, The Mining and General Electric Lamp Company, D. G. Fitzgerald, and A. H. Hough, London.
3095. Colouring Matters, H. H. Leigh.—(*R. G. Williams, United States.*)
3096. Electric Meters, S. Z. de Ferranti, London.
3097. Electric Meters, S. Z. de Ferranti, London.
3098. Colouring Matters, H. H. Lake.—(*Wirth and Co., Germany.*)
3099. Directing Guns and Torpedoes, M. H. Hurrell, London.
3100. Burners for Hydrocarbon Lamps, J. W. B. Wright, London.
3101. Breech-loading Ordnance, C. E. S. Parker, London.

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3102. Numerical Counters, T. W. Harding, Leeds.
3103. Sampling Butter, W. McDonnell, Limerick.
3104. Fire Lighters, G. Myers, Sheffield.
3105. Heating Railway Cars, T. S. Glover, London.
3106. Washing Machines, T. Bradford, Manchester.
3107. Shuttles for Weaving, W. Knight and R. Ashworth, Manchester.
3108. Billiard Cues, C. E. Harrison, Manchester.
3109. Plates, A. S. Tanner and B. Jackson, London.
3110. Springs for Magazine Small-arms, B. F. Cocker, Sheffield.
3111. Distributing Dry Lime, &c., F. J. Blinkhorn, London.
3112. Adjustable Pneumatic Sole, J. J. Mason, Lincoln.
3113. Couplings for Propeller, &c., Shafts, R. Berggrin, Erith.
3114. Grinding and Polishing Stones, W. Crosland, Miles Platting.
3115. Sewing Machine Treadles, J. Alcock, Stafford-shire.
3116. Boiler Tubes, W. Keyworth, Hull.
3117. Aerated Water, J. P. Jackson, Liverpool.
3118. Ships' Berths or Beds, E. R. Billington, Liverpool.
3119. Opening Railway Carriage Windows, F. W. Wright, London.
3120. Heating and Ventilating Houses, R. H. Radcliffe, Waterloo.
3121. Manufacture of Glass Bottles, D. Rylands, Barnsley.
3122. Frying Fish, A. H. Tucker, London.
3123. Cricket Bats, C. Rose, jun., Southampton.
3124. Stopping and Starting Tramcars, J. W. Peirce, London.
3125. Manufacture of Spring Hooks, M. Turnor, Birmingham.
3126. Bolt Staples, Sockets, or Plates, A. W. J. Littley, Cheltenham.
3127. Metallic Packing for Piston-rods, J. T. Hedley, Newcastle-on-Tyne.
3128. Speed-varying Gear, W. J. Munden, London.
3129. Shuttles, G. W. Lyons, Hulme.
3130. Gas Lamps, T. C. J. Thomas, London.
3131. Indicating and Controlling Fares, H. Müller.—(*E. Knoop, Russia.*)
3132. Down Quilts, E. W. Frankenberg, London.
3133. Electric Lamps, F. R. Boardman, London.
3134. Washing or Dipping Sheep, &c., I. S. and J. T. McDougall, London.
3135. Tin Openers, J. T. Stewart, Hartlepool.
3136. Self-opening Lid for Casks, S. Beckett and T. Wood, Hull.
3137. Glass Bottles, W. Ambler, London.
3138. Glass Bottles, W. Ambler, London.
3139. Brakes for Vehicles, A. J. Boult.—(*A. Kretzschmar, Saxony.*)
3140. Ladies' Riding Habits, W. P. Thompson.—(*W. H. Phelps, India.*)
3141. Preventing Horses from Bolting, G. M. and T. Parkinson, London.
3142. Lifting Invalids on Beds, &c., T. Duncanson, Liverpool.
3143. Taking Dimensions of the Foot, J. R. y Cid de la Paz.—(*M. R. y Cid de la Paz, Spain.*)
3144. Collapsible Landing Net, D. Reid, Glasgow.

3145. Portable Oil Gas Furnace, The Lucigen Light Company and T. M. Jarmain, London.
3146. Guides for Fingers of Registering Dials, A. Wood and T. Davies, London.
3147. Safety Stirrups, R. Fiek, London.
3148. Construction of Spin Top, T. S. James, London.
3149. Checking Shuttles of Looms, G. Thomson and J. Hampshire, Huddersfield.
3150. Chairs, R. H. Gudgeon, London.
3151. Preventing Incrustation in Boilers, W. Grove and L. Lewis, London.
3152. Manufacture of Electrical Conductors, W. A. Thoms, London.
3153. Manufacturing Electrical Conductors, W. A. Thoms, London.
3154. Manufacture of Alloys, W. A. Thoms, London.
3155. Photographic Camera Slides, F. A. Gregory and H. F. Ainley, London.
3156. Lubricators, &c., G. Butler and T. Kendrick, London.
3157. Pipes for Footpaths, R. P. Fisher, Fargate.
3158. Preparing Sticks for Umbrellas, &c., J. Metz, London.
3159. Feeding Paper to Printing Machines, R. Cresswell and M. Heslop, London.
3160. Apparatus for Making Water-gas, B. von Steenbergh, London.
3161. Clocks, E. Edwards.—(*J. Pallweber, Germany.*)
3162. Paving Material, J. C. Merryweather, London.
3163. Electric Switches, P. P. Alexander, London.
3164. Shirts, C. Mays and W. P. Pepys, London.
3165. Apparatus for Playing a Game, J. N. Tripp, London.
3166. Food for Horses and Cattle, T. G. Whitehouse, London.
3167. Manufacture of Carpets, G. T. Todd and W. Tannahill, Glasgow.
3168. Lasting Boots, C. Wassell, J. Hunter, and P. Grant, Glasgow.
3169. Electro-heating Apparatus, C. E. Carpenter, London.
3170. Multiple Drilling Machine, R. Griffith, London.

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3171. Appliance for Holding Sleeves, T. S. Lavis, Newton Abbot.
3172. Velocipedes, J. J. Wardle, Newcastle-on-Tyne.
3173. Torpedoes, G. R. Murphy, London.
3174. Ring Frame Spindles, &c., T. Wrigley, Manchester.
3175. Fastener for Window Sashes, E. Pearson, South Woodford.
3176. Matches, C. F. Martin, Cheltenham.
3177. Knobs, Handles, &c., for Doors, W. J. Rogers, Birmingham.
3178. Grinding Cards of Carding Engines, G. Casey, London.
3179. Regulating Temperature, G. W. Crowe and W. K. Massam, Barnsley.
3180. Nautical Appliances, T. Y. Rowe and M. D. Hammill, Liverpool.
3181. Fringed Shawls, &c., G. Reiss and J. Bauer, Manchester.
3182. Cotton Goods, R. Middleton and H. T. Jones, Manchester.
3183. Bracelets, Scarf Slides, &c., H. Allsopp, Birmingham.
3184. Paving Block, A. Rovedino, London.
3185. Travelling Trunks, G. Martin, Bradford.
3186. Mechanical Stokers, J. Proctor, Manchester.
3187. India-rubber Tires for Bicycles, H. H. Waddington, Manchester.
3188. Knitting Hosiery, G. Hadden, Manchester.
3189. Hearth Rugs and Mats, W. and T. W. Millward, Manchester.
3190. Lace, E. Doughty, Nottingham.
3191. Tool-holding Machines, &c., A. Muir, Manchester.
3192. Centrifugal Machines, R. S. Baxter and G. D. Macdougald, Dundee.
3193. Transformers, J. Swinburne, Wimbledon.
3194. Driving, &c., Looms, R. L. Hattersley and J. Hill, Keighley.
3195. Combination of Spoons, &c., with the Covers of Tables, &c., J. W. Tolhurst, London.
3196. Electrical Application for Alarms in Valves, S. Walker and G. Mills, Radcliffe.
3197. Circular Saws, J. E. Bott, London.
3198. Pneumatic Drawback for Rams, W. Norris, Knebworth.
3199. Screw Propellers, J. Harper, Liverpool.
3200. Registering Orders in Hotels, &c., G. B. Bulmer, Leeds.
3201. Cloth-stretching Machines, C. L. Jackson, London.
3202. Detachable Clip for Neckties, W. G. C. Hughes, London.
3203. Tinting Opal Glass, C. Leigh, London.
3204. Blocks for Gulleys and other Traps, P. Mooney, Manchester.
3205. Lightning Conductors, F. Cook, London.
3206. Canopy-winged Stove Front, E. V. Goad and A. Tuck, London.
3207. Insurance against Accidents, J. Tourtel, London.
3208. Milk Delivery Cans, F. J. Ingram and J. R. Hill, London.
3209. Separating Sand from Water, G. F. W. Hope, London.
3210. Cotton Gins, W. Fenwick, Manchester.
3211. Screw Bolts, R. B. U. H. J. Duncan, London.
3212. Stoppers for Oil Cans, W. Redman, London.
3213. Rotary Engine, C. E. Challis, London.
3214. Manufacture of Buttons, &c., K. Wagner, London.
3215. Fastening Door Knobs to Spindles, R. A. Meredith, London.
3216. Toasting Apparatus, G. F. Griffin, London.
3217. Apparatus for Cutting Veneers, C. W. Spurr, London.
3218. Tightener for Butter Casks, &c., J. White, Glasgow.
3219. Motive Power, R. Gold, Glasgow.
3220. Production of Metallic Sodium, J. Greenwood, London.
3221. Flushing Apparatus for Water-closets, W. H. Hawkins, London.
3222. Joint for Fishing Rods, &c., J. R. Bolton, London.
3223. Receptacle for Railway Tickets, F. Cowley, London.
3224. Heating Resisting Lining, L. d'Emile Muller, London.
3225. Hat Brim Protector, M. Slater, London.
3226. Jewellery, W. Barr, jun., and D. McKay, Glasgow.
3227. Filling Flexible Bladders, H. Duerden, London.
3228. Churns, T. Bradford, London.
3229. Supporting Glost Ware, E. Leak and H. Aynsley, London.
3230. Padding for Garments, J. Tillett, London.
3231. Keeping Electromotive Force Constant, J. Shipp, London.
3232. Making Links for Metallic Chains, W. Fiddian, London.
3233. Rolls for Iron Tubes, C. Faulkner and W. H. Lloyd, London.
3234. Direct Acting Steam Pumps, M. Kohn, London.
3235. Clip Bracket Holder, H. Schooling, jun., London.
3236. Hot-air Gas Lamps, F. Siemens, London.
3237. Ships' Gangways and Companion Ladders, C. Thomson, London.
3238. Sleeve Links, J. A. Fincher, London.
3239. Elevating Bands for Ordnance, T. English, London.
3240. Artificial Tartaric Acids, A. A. Brehier and B. G. Talbot, London.
3241. Field Gun Carriages, T. English, London.
3242. Utilising Liquid Hydrocarbons for Lighting and Heating, H. H. Doty, London.
3243. Collapsible, &c., Metal Tubes, H. C. Sanders, London.
3244. Bottle-washing Apparatus, W. Beetham, London.
3245. Separating Gold from Ores, W. D. Bohm, London.
3246. Separating Gold from Ores, W. D. Bohm, London.
3247. Spoon for Administering Food, A. K. Cordes, London.
3248. Game, J. le Messurier, London.
3249. Sockets for Game Courts, J. le Messurier, London.
3250. Toy Cycles, D. Blaikley, Glasgow.

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3251. Removing Water from Pipes, A. Masson and R. Scott, London.
3252. Self-supplying Pen, A. Hill and G. Appleton, Birkenhead.
3253. Portable Stands, &c., A. W. Kemp and J. G. Rollason, Birmingham.
3254. Penholders, C. W. Robinson, London.
3255. Oil Cans, &c., A. Donald, Dundee.
3256. Cleaning Lamp Glasses and Bottles, A. Franks and S. W. Williams, Wolverhampton.
3257. Gear for Detaching Boats, W. Cooper and J. Holdsworth, Hull.
3258. Combination Tool Cabinets, E. H. Marples and F. Lamburn, Sheffield.
3259. Crushing Machines, G. Norman, Sheffield.
3260. New Constructive Toy, T. Sturgeon, London.
3261. Filtering Water, H. H. Lake.—(*O. H. Jewell, United States.*)
3262. Bolts or Catches for Lowering Boats, W. Cooper and J. Holdsworth, Hull.
3263. Extensible Standards for Lamps, H. D. Hinks, Birmingham.
3264. Waterproof Paper and Textile Fabrics, A. A. Haigh, Manchester.
3265. Ventilating the Temperature in Factories, B. Ormerod, J. F. Davies, and W. Haythornthwaite, Manchester.
3266. Horizontal Sawing Machines, B. Townson and J. Dixon, Barrow-in-Furness.
3267. Cutting Machines, H. M. Marsden, Sheffield.
3268. Securing Windows, J. Coppard, London.
3269. Three Way Valves, G. W. Crowe and W. K. Massam, Barnsley.
3270. Waterproof Garments, L. Mistovski, Manchester.
3271. Dynamo-electric Machines, C. N. Russell and R. A. Scott, London.
3272. Controlling Electric Currents, G. E. Fletcher, Edgeley.
3273. Lighting of Railway Trains, G. E. Fletcher, Edgeley.
3274. Metal Tanks, &c., W. Orr and P. S. Brown, Glasgow.
3275. Reduction of Metallic Ores, G. Simonin, Manchester.
3276. Telephonic Apparatus, A. Whalley, Helsby.
3277. Gas Governors, E. Patterson, Glasgow.
3278. Door Mats, &c., R. Grunwell and G. R. Scarr, Halifax.
3279. Heating Water, W. H. Skinner, Exeter.
3280. Lozenge, P. Kent, London.
3281. Stands for Displaying Photographs, E. J. Wakeling, London.
3282. Pencil Pocket for Coat, &c., J. R. Alexander, Edinburgh.
3283. Perambulators, &c., E. J. A. Babbage, Plymouth.
3284. Dental Implement called Cutter and Die, H. A. Laurence, Ealing.
3285. Machinery for Making Bricks, &c., W. Sayer, London.
3286. Glass, J. G. Sowerby, London.
3287. Marine, &c., Steam Boilers, A. Anderson, Monkwearmouth.
3288. Detaching Hooks, W. H. Wise, Brockweir.
3289. Roller Mills, A. M. Robinson, Liverpool.
3290. Fire Revivers for Domestic Use, E. P. Scruby, London.
3291. Grates for Gulley Traps, H. Bagshaw, Sheffield.
3292. Tubular Apparatuses for Heating Feed-water, A. Schneider, London.
3293. Toy, G. Carette, London.
3294. Floral Ornaments for Wearing Apparel, B. Kempner, London.
3295. Producing Tannage, P. Houston and C. Beakbane, London.
3296. Studs to Prevent Slipping for Horseshoes, J. Whatmough, London.
3297. Tap, F. B. Hanbury, London.
3298. Curtain Pole Ring and Eye in One Piece, G. H. Dreghorn, Inverness.
3299. Advertising, &c., Cards, G. Delgado, London.
3300. Frames for Optical Glasses, R. Wells, London.
3301. Machinery for Printing Fabrics, E. and A. Samuel, London.
3302. Steam Generators, I. S. and J. T. McDougall and T. Sugden, London.
3303. Fast Dye Stuffs, B. Willcox.—(*The Farbenfabriken vormals F. Bayer and Co., Germany.*)
3304. Apparatus for Supply of Gas, &c., M. C. Greenhill, London.
3305. Starting and Stopping Tramcars, &c., J. Stark, London.
3306. Furnace for Continuous Carbonising, H. Ekelund, London.
3307. Saucers, C. J. C. W. Hyne, London.
3308. Fountain Pens, F. O. Chorley, London.
3309. Tobacco Pipes, F. O. Chorley, London.
3310. New Puzzle, R. Smith, London.
3311. Adjustable File, J. Pugsley, Bristol.
3312. Purification of Sewage, W. E. Adeney and W. K. Parry, London.
3313. Boat Detaching Apparatus, E. J. Hill, London.
3314. Combination Kettle and Spirit Stove, E. Werninck, Birmingham.
3315. Pellerines, M. Wedlake, London.
3316. Lifts, H. C. Walker, London.
3317. Fastening Device for Gloves, &c., A. Thiemt, London.
3318. Boiler Pumps, A. Müller, London.

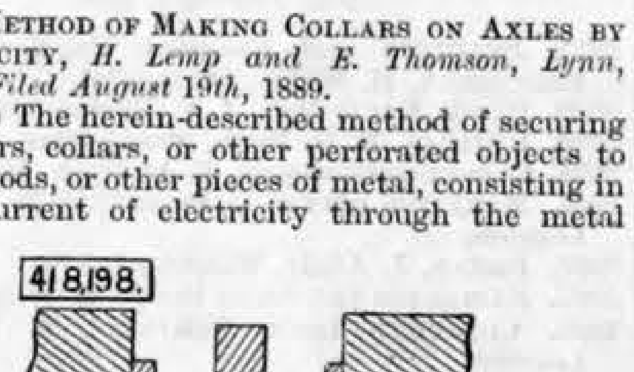
SELECTED AMERICAN PATENTS.

From the United States' Patent Office Official Gazette.

418,198. Method of Making Collars on Axles by Electricity, *H. Lemp and E. Thomson, Lynn, Mass.—Filed August 19th, 1889.*

Claim.—(1) The herein-described method of securing rings, washers, collars, or other perforated objects to metal bars, rods, or other pieces of metal, consisting in passing a current of electricity through the metal

418,198.

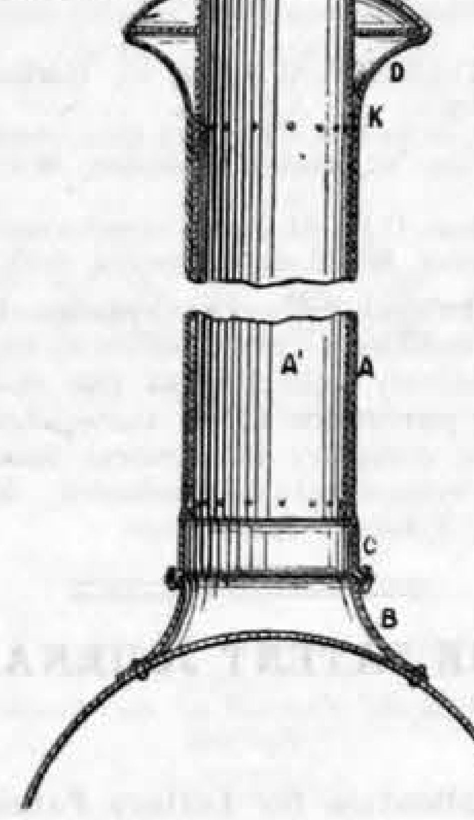


piece in volume sufficient to soften the same, and then subjecting the piece to endwise pressure, so as to swell or expand it at both sides of the perforation. (2) The herein-described method of fastening a perforated piece of metal to another metallic piece passing through the perforation, consisting in including said metallic piece in an electric circuit, passing an electric current through the same in amount sufficient to soften it, and then subjecting such piece to compression, so as to cause it to expand laterally at either side of the perforated piece. (3) The herein-described method of securing a perforated piece of metal to another piece threaded through the perforation, consisting in causing a heating current of electricity to pass through the threaded piece until the same is heated to a welding temperature, and causing it to swell or expand laterally at either side of the perforated piece, as and for the purpose described. (4) The herein-described method of keying a perforated object to a piece of metal threaded through the perforation, consisting in providing the perforated object with recesses, openings, or depressions to one side of the perforation, subjecting the threaded piece to a heating and softening current of electricity, and then applying force in a direction to cause it to swell or expand laterally at the sides of the perforated piece, and to enter the said recesses or depressions. (5) The herein-described method of keying a perforated piece of metal to a bar or rod, consisting in softening the bar or rod by an electric current passed through it and then subjecting the bar to pressure, so as to cause the softened metal to expand and enter key openings or recesses in the perforated piece. (6) The herein-described method of limiting the longitudinal extent of the expansion to either side of the perforated piece, consisting in applying collars to the piece subjected to electric heating and pressure at points thereon removed a determined distance from the perforated piece. (7) The herein-described method of fastening a perforated piece of metal to another piece threaded through it, consisting in providing one or more notches at the edge of the perforation, passing a softening current of electricity through the threaded piece, and then subjecting said piece to a force which will cause the same to expand laterally into the notch and to either side of the perforated piece.

418,182. Locomotive Smoke Stack, *E. W. M. Hughes, Chicago, Ill.—Filed May 23rd, 1889.*

Claim.—(1) In a smoke stack, the combination, with the two cylinders A and A', of a pressed steel base secured thereto, the upper portion of which is provided with a cylindrical flange, which is secured between said two cylinders, substantially as described. (2) In a smoke stack, the combination, with the cylindrical portion, of a base secured thereto, composed of two

418,182

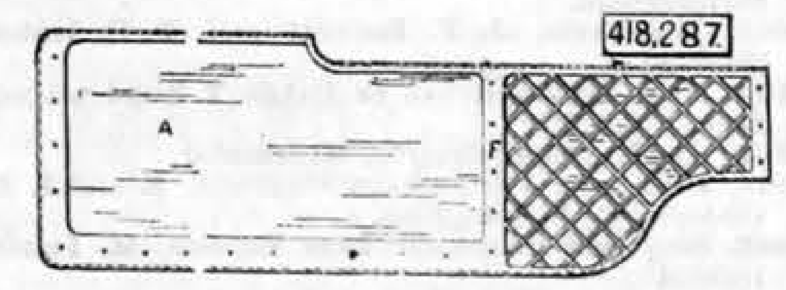


flanged pressed steel pieces B and C, one of which is bell-shaped and cut away at the front and rear, substantially as described. (3) In a smoke stack, the combination, with the two cylinders A and A', of a top composed of two pressed steel pieces D and E, one of which is provided with a flange K, which is secured between said two cylinders, substantially as described.

418,287. Running Board for Locomotives, *E. W. M. Hughes, Chicago, Ill.—Filed July 3rd, 1889.*

Claim.—(1) The pressed steel running board for locomotives, consisting of one or more pieces, one end of which A has a plain flat surface, and the other end B is provided with corrugations G, pressed therein in the process of manufacture, substantially as described.

418,287



(2) The pressed steel running board for locomotives, one portion of which is provided with corrugations G upon its surface, and the combined ridges F, all pressed therein in the process of manufacture, substantially as described.

418,365. Thrashing Machine, *L. Bronson, Buffalo, N.Y.—Filed June 13th, 1887.*

Claim.—In a thrashing machine, the combination, with the cylinder or concave having openings or perforations, of a series of knives provided with screw-threaded shanks arranged in said openings, screw nuts

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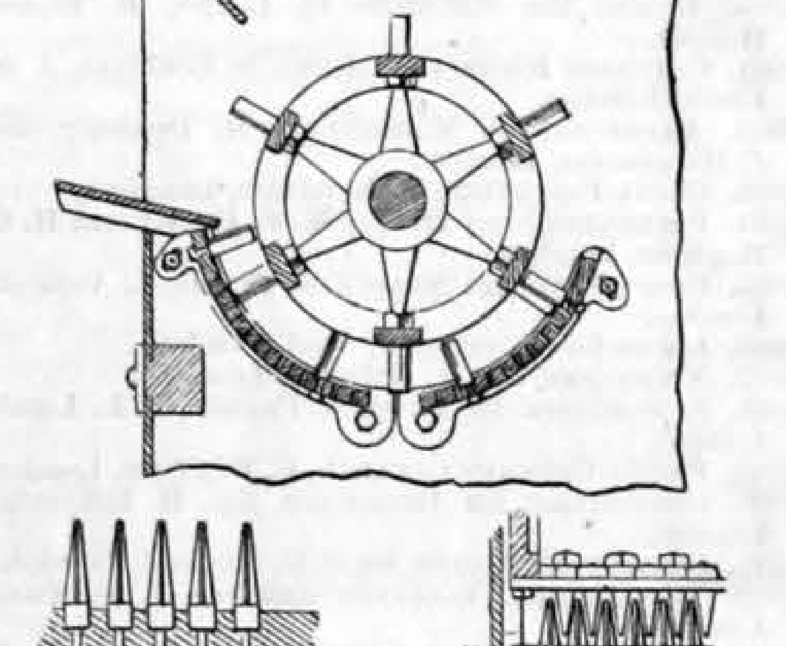
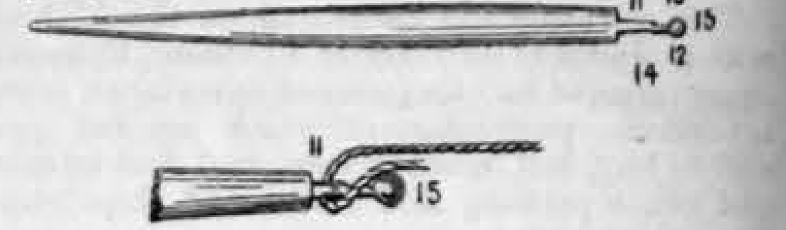


applied to the shanks of alternate knives, washers applied to the shanks of the intermediate or intervening knives between the nuts of the adjacent knives, and screw nuts whereby said washers are secured in place, substantially as set forth.

418,393. Belt Lacing Needle, *H. Bosworth, Plattsburgh, N.Y.—Filed June 26th, 1889.*

Claim.—(1) A lacing needle having an eye in its butt end and a reduced shank extending beyond the eye in the direction of the length of the needle and provided with an enlargement at its extremity, the said shank and enlargement being of less width at their points of greatest width than the diameter of the butt of the needle, substantially as set forth. (2) A lacing needle having its butt reduced and provided with an eye, and a shank or extension projecting from the said reduced portion in the direction of the length of the needle of less diameter than said reduced portion, and having an enlargement at its extremity, substantially as set forth. (3) A lacing needle having its butt end reduced, as at 11, and formed with a shank 12 of less diameter than the said reduced portion, extending in the direction of the length of the needle and terminating in a circular

418,393.

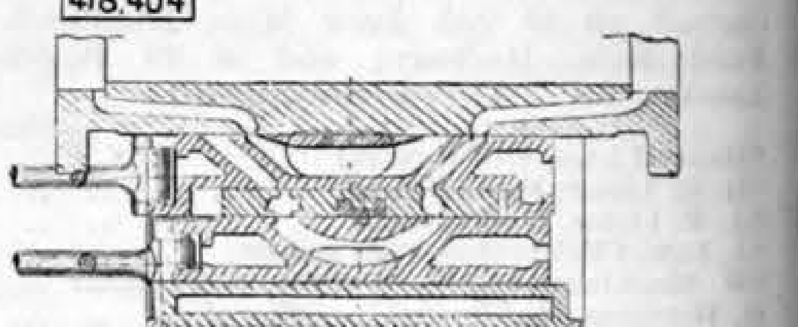


head 15, diagonally opposite shoulders 13, 14, being formed at the junction of the said parts 11, 12, and an eye in the reduced portion 11, substantially as set forth.

418,404. Valve Gear, *G. A. Franke, Mülhausen, Prussia, Germany.—Filed March 5th, 1889.*

Claim.—(1) In a valve gear, the combination, with a main valve provided with inlet ports adapted to regulate with the cylinder ports, of cut-off plates having ports operating on the inlet ports of the said main valve, a governor for controlling the said cut-off plates to cut the steam off sooner or later to the main valve, and an expansion valve provided with a steam inlet passage adapted to register with the ports in the said cut-off plates, substantially as shown and described. (2) In a valve gear, the combination, with main valve provided with inlet ports and an exhaust port operating over the cylinder ports, of cut-off plates provided with ports adapted to register with the inlet ports of the said main valve, the said cut-off plates being controlled by the governor, and an expansion valve provided with a steam inlet passage adapted to register with the ports in the said cut-off plates, substantially as shown and described. (3) In a valve gear, the combination, with main valve provided with inlet ports and an exhaust port operating over the cylinder ports, of cut-off plates provided with ports adapted to register

418,404

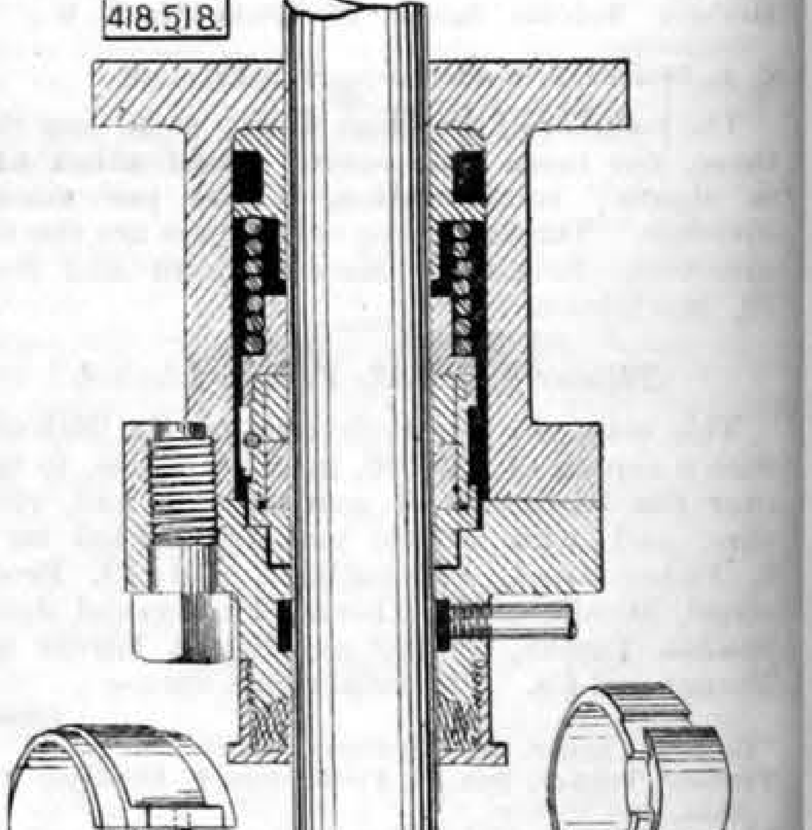


with the inlet ports of the said main valve, the said cut-off plates being controlled by the governor, an expansion valve provided with a steam inlet passage adapted to register with the ports in the said cut-off plates, and two excentrics driven from the crank-shaft and controlling the said main valve and the expansion valve, substantially as shown and described. (4) In a valve gear, the combination, with a main valve provided with inlet ports adapted to regulate with the cylinder ports, of cut-off plates having ports operating on the inlet ports of the said main valve, a governor for controlling the said cut-off plates to cut the steam off sooner or later to the main valve, and two excentrics controlling the said main valve and the said expansion valve, and elliptical wheels driven from the crank shaft and operating the said excentrics, substantially as shown and described.

418,518. Piston-rod Packing, *C. C. Jerome, Chicago, Ill.—Filed August 27th, 1889.*

Claim.—(1) The combination, with a stuffing-box and a piston-rod, of a series of sectional soft-metal packing-rings arranged to break joints, an expansible steam-setting band embracing the series of packing-rings, a screw attached to one end of said band and loosely passing through the other end for limiting the expansion of said band, and cups forming tight joints with the packing-rings, substantially as set forth. (2) The combination, with a stuffing-box and a piston-rod, of a pair of soft-metal sectional packing-rings arranged side by side to break joints, an expansible steam-setting band slightly narrower than the combined thickness of the packing-rings, and the cups forming

418,518.

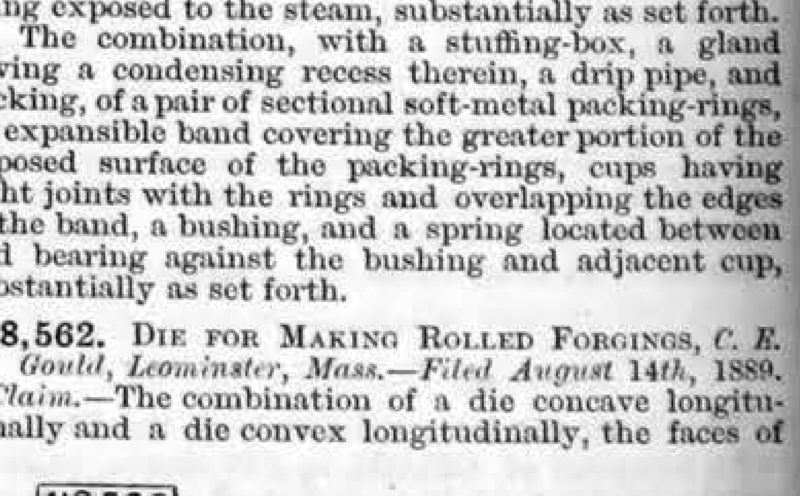


tight joints with the rings and overlapping the side edges of the band, the central portion of said band being exposed to the steam, substantially as set forth. (3) The combination, with a stuffing-box, a gland having a condensing recess therein, a drip pipe, and packing, of a pair of sectional soft-metal packing-rings, an expansible band covering the greater portion of the exposed surface of the packing-rings, cups having tight joints with the rings and overlapping the edges of the band, a bushing, and a spring located between and bearing against the bushing and adjacent cup, substantially as set forth.

418,562. Die for Making Rolled Forgings, *C. E. Gould, Leominster, Mass.—Filed August 14th, 1889.*

Claim.—The combination of a die concave longitudinally and a die convex longitudinally, the faces of

418,562.



said dies having grooves and outwardly-bevelled cutting-bosses at the sides of the grooves, the bevelled sides of said bosses being provided with indentations, the bases of said indentations being flush with the surface of the bosses, substantially as described.

COMPOUND EXPRESS LOCOMOTIVE NORTH-EASTERN RAILWAY.

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