AN INVESTIGATION INTO THE INTERNAL STRESSES OCCURRING IN CAST IRON AND STEEL.

By GENERAL NICHOLAS KALAKOUTSKY.

No. III.

Reduction of observations and mode of determining the limit of resistance in a hollow cylinder.—From the foregoing description of the method of conducting my experiments, it will be seen that by cutting up the discs into concentric rings, and by that means gradually reducing the thickness of the metal, the inherent stresses were removed step by step, and this effect was made manifest by the alterations in the length of the radii. The amount of displacement δ in the direction of the radius of any point, situated at a distance r_x from the axis of the disc, is expressed by the following equation:—

$$\delta = \frac{r_x}{3\Sigma} \cdot \frac{P_o r_o^2 - P^1 R^2}{R^2 - r_o^2} + \frac{4}{3r} \cdot \frac{r_o^2 R^2 (P_o - P^1)}{\Sigma (R^2 - r_o^2)} \quad \text{(I.)}$$

Here P_o and P^1 represent the internal and external pressures, R and r_o the outer and inner radii of the disc, and Σ the coefficient of elasticity of the metal, which was taken as 2,000,000 kilogrammes on the square centimetre for steel and 1,000,000 for cast iron.

For $P^1 = o$, *i.e.*, when the cylinder is only subjected to internal pressure—

$$\delta = \frac{P_o}{3\Sigma} \cdot \frac{r_o^2 (r_x^2 + 4R^2)}{r_x (R^2 - r_o^2)} \quad . \; . \; . \; . \; . \quad \text{(II.)}$$

For $P_o = o$, *i.e.*, when the cylinder is subjected to only external pressure—

$$\delta = -\frac{P^1}{3\Sigma} \cdot \frac{R^2 (r_x^2 + 4r_o^2)}{r_x (R^2 - r_o^2)} \quad . \; . \; . \; . \quad \text{(III.)}$$

The above fundamental formulæ were used for computing the pressures from the experimental data. In order to follow out the process of calculation, let us take, for example, Experiment No. 65, in Table 15.

When the outside layer or ring No. 6 was parted off, then, the external pressure P^1 being equal to o, the alteration in the length of the radius r_6'' must have been caused by the removal of the internal pressure acting on the circumference of radius r_6; and therefore

$$p_6 = \frac{3\,\Sigma\,\delta_6\, r_6''\,(R_6^2 - r_6^2)}{r_6^2\,(r_6''^2 + 4 R_6^2)} \quad . \; . \; . \; . \; . \; . \; . \quad \text{(A).}$$

Substituting the corresponding values from Table 15, we find $p_6 = -\,0{\cdot}0000477\ \Sigma$, or 95·5 atmospheres.

The ring thus detached was then turned down in the lathe, and its outer radius, instead of being $R_6 = 273{\cdot}75$ millimetres, became $\overline{R_6}^1 = 251{\cdot}75$ millimetres. From the renewed change in the length $\overline{\delta_6}$ of the radius r_6'' we can compute a second pressure in the same layer on the radius $\overline{R_6}^1$. The values p_6 and $\overline{\delta_6}$ are known, and therefore

$$\overline{p_6}^1 = p_6 \frac{r_6\,(r_6''^2 + 4\,R_5'^2)}{\overline{R}_6^{2\prime}\,(r_6''^2 + 4\,r_6^2)}$$
$$-\,3\,\Sigma \frac{\overline{\overline{\delta_6}}\,(\overline{R}_6'^2 - r_6^2)\,r_6''}{\overline{R}_6'^2\,(r_6''^2 + 4\,r_6^2)} \quad . \; . \; . \quad \text{(B).}$$

Substituting the corresponding values and calculating out, we find $\overline{p_6}' = -\,0{\cdot}0000309\ \Sigma$, or 61·8 atmospheres.

When ring No. 6 was cut off, an alteration took place in the lengths of the radii r_5'', r_4'', r_3'', r_2'', r_1'', of the remaining portion of the disc. The values of these alterations were determined by experiments. And since $P_0 = 0$, consequently, on the removal of the pressure on the radius r_6, a certain additional pressure appeared on the radius R_5, which may be represented thus:—

$$p_5' = -\,3\,\Sigma\,\frac{\delta_5\, r_x''\,(R_5^2 - r_0^2)}{R_5^2\,(r_x''^2 + 4\,r_0^2)} \quad . \; . \; . \quad \text{(C).}$$

Had all the measurements been equally accurate, or if, in the remaining portion of the disc there had not existed complex stresses, which are as yet unknown to us, we could take δ_5 on any radius r_x''; but since the variations which occur are very small, and also depend upon certain influences in the interior of the disc, we must adopt, for computation, either some mean value (bearing in mind that its probable accuracy is dependent on the ratio of the value of the radii r_x'') or else take the variation of that radius, for which the calculated pressure most nearly approaches the one preceding—p_6. In the case given above, if we compute p_5' from r_1'', we obtain the value $p_5' = -\,0{\cdot}0000502\ \Sigma$, or 100·4 atmospheres. The pressure, however, even according to the mean value of the variations, approximates closely to $\overline{p}_6$, for it amounts to about 98 atmospheres.

After this, from the remaining portion of the disc (whose outer and inner radii were R_5 and r_5), the second ring No. 5 was cut. The pressure p_5' being already determined, and the alteration of the radius r_5'' known, therefore,

$$\ddot{p}_5 = p_5' \frac{R_5^2\,(r_5''^2 + 4\,r_5^2)}{r_5^2\,(r_5''^2 + 4\,R_5^2)}$$
$$+\,3\,\Sigma\,\frac{\delta_5\, r_5''\,(R_5^2 - r_5^2)}{r_5^2\,(r_5''^2 + 4\,R_5^2)} \quad . \; . \; . \quad \text{(D).}$$

Calculating out we obtain $p_5 = -\,0{\cdot}0000867\ \Sigma$, or 173·4 atmospheres.

The ring No. 5 was then turned up in the lathe; its outer radius became $\overline{R_5}' = 217{\cdot}1$ milim., and the consequent pressure is determined by formula B. Continuing the process of calculation to the end of the experiment, and using the formulæ given above, we determine, by the aid of the experimental data, the pressures on 16 radii of the disc. The results obtained are shown in the table in next column.

An examination of this table shows that the results obtained by experiment are sufficiently satisfactory, and although we find a certain irregularity in the case of the radii r_2 and R_2', it is not great, and can be easily corrected by plotting the curve, which represents the pressures calculated.

In the construction of the diagrams for discs cut from gun tubes and hoops, the scale adopted for the ordinates which represent the calculated pressures and the alterations in the radii was 1 mm. = 0·00001 Σ or 20 atmospheres, and for the abscissæ the length of the radii to a scale of 1 mm. = 2 mm., that is to say, half the natural size. In the diagrams for the discs cut from steel shot or shell the thickness of metal was represented full size, and the ordinates were drawn to the scale of 1 mm. = 0·00002 Σ or 40 atmospheres.

	Radii of disc in millim.	Pressures in atmosph.		Radii of disc in millim.	Pressures in atmosph.
r_1	65·4	0	r_4	171·25	229·4
R_1'	76·5	149·4	R_4'	182·75	193·0
R_1	96·1	152·6	R_4	201·75	176·6
r_2	100·75	125·2	r_5	206·0	173·4
R_2'	111·3	146·0	R_5'	217·1	170·0
R_2	132·5	186·0	R_5	236·0	100·4
r_3	135·75	256·0	r_6	240·0	95·5
R_3'	146·25	266·0	R_6'	251·75	61·8
R_3	166·5	240·0	R_6	273·75	0·

We have now described a method of calculating the stresses in a disc by cutting out successive rings and measuring the alteration in the length of the radii in the remaining portions. But in the greater number of our first experiments the discs were merely cut up at once into rings, and the changes in the length of the radii of the rings made alone measured. In order to calculate the stresses under such circumstances we can write as many equations as there are rings; but the number of ascertained values entering into these equations is insufficient for the determination of all the stresses. If, however, the experiments be conducted in a certain order, and comparisons be instituted with others having the full quantity of data, it is possible to obtain approximately the values sought for. For such cases the following method of calculation was adopted:—Let us suppose that any disc was at once cut up into six rings; by formula A we determine the exact pressure p_6 on the radius r_6. From this we deduce approximately the pressure on the radius R_5 in the following manner:—On the axis of the abscissæ from r_6 erect an ordinate at a distance equal to twice the width of the incision made by the cutting tool between the rings No. 6 and No. 5, and determine its length graphically; assume that the value so found is that of the pressure acting on the radius R_5; then, from this pressure and from δ_5 determine p_5 by formula I. Proceeding in this manner, we calculate the pressures on the radii of the three outermost layers. For the three innermost rings the calculation must be commenced from ring No. 1, for which the exact pressure on the radius R_1 can be determined by formula C, and the calculations may be continued in like manner for the others.

The method of investigation by cutting out rings in succession furnishes more data for computation, and is entitled to preference on this account as well as from the greater accuracy of the results obtained; the process, however, is extremely laborious, and requires much time. When the number of discs to be examined is considerable, and especially when they are cut up into a large number of rings, the second method, that of cutting up the discs into the full amount of rings at once, will, no doubt, be more frequently adopted, because the investigation can be conducted very rapidly and with sufficient precision for ordinary practical purposes.

We are now in a condition to determine the strength of hollow cylinders. For this purpose we must ascertain the tangential stress acting circumferentially. There are several methods of arriving at this from the ascertained radial pressures. If we assume that the portion of the curve which represents the distribution of pressures between the radii r_o and $\overline{R}^1$ is a straight line, then from the pressure $\overline{p_1}^1$ we can determine the stress T_o on r_o. In that case we shall have:—

$$t_o = \frac{d\,(p\,r)}{d\,r};\; p = a\,(r - r_o);\; p\,r = a\,r\,(r - r_o);$$

$$\frac{d\,(p\,r)}{d\,r} = a\,(2\,r - r_o);\; t_o = p + a\,r;$$

$$p = a\,(r - r_o),\text{ and } t_o = p\,\frac{2\,r_o - r_o}{r - r_o},\text{ or}$$

$$p\,\frac{r_o}{r - r_o} \quad . \; . \; . \; . \; . \; . \; . \; . \; . \; . \; . \; . \quad \text{(E)}$$

Applying this expression to experiment No. 65, and taking $r = \overline{R_1}^1$ and $p = 149{\cdot}4$ atmospheres, we find $t_o = 801{\cdot}5$ atmospheres, and as the elastic limit of the steel of the disc was 2400 atmospheres, it follows that the loss in power of resistance due to the presence of detrimental internal stresses is about 33 per cent. If we make a similar calculation for the radius R_1, we shall obtain for the tension in the direction of the tangent a considerably less value.

There is also a method of computing the tangential stresses by means of two points on the curve, the position of which depends upon the two corresponding pressures along the radii nearest to the bore.

$$p = a\,(r - r_o) + b\,(r - r_o)^2$$
$$p_1 = a\,(r_1 - r_o) + b\,(r_1 - r_o)^2$$
$$p_2 = a\,(r_2 - r_o) + b\,(r_2 - r_o)^2$$

a and b being determined, we can find t_o;

$$t_o = a\,(2\,r - r_o) + b\,[(r - r_o)^2 + 2\,r\,(r - r_o)],$$

and when $r = r_o$; $t_o = a\,r_o$,

$$t_o = \frac{p_1\, r_o\,(r_2 - r_o)}{(r_1 - r_o)\,(r_2 - r_1)} - \frac{p_2\, r_o\,(r_1 - r_o)}{(r_2 - r_o)\,(r_2 - r_1)}. \quad \text{(F)}$$

Making $r_1 = \overline{R_1^1}$, $r_2 = R_1^1$, $\overline{p_1} = \overline{p_1^1}$, and $p_2 = p_1^1$, *i.e.*, substituting the values taken from experiment No. 65, we obtain $t_o = 568$ atmospheres.

For the purpose of computing the resistance of cylinders, in which the initial internal stresses have been determined by calculation, we use by preference the formulæ of Colonel Pashkévitch—*Artillery Journal* for 1855, St. Petersburg—on account of their being extremely simple and convenient. He holds that when during the discharge internal stresses and external pressures exist simultaneously in the bore, the total relative elongation z of the layer under consideration is equal to the algebraic sum of x and y, where x represents the relative elongation due to internal stresses of any layer when at rest, and y the extension under fire of the same layer in the same direction, supposing internal stresses to be absent. Taking z equal to the elastic limit, determining x from experimental data, and knowing that P_o and y are connected by the following relation:

$$y = P_o \left[\frac{u}{3\,U} \cdot \frac{r_o^2}{R^2 - r_o^2} + \frac{u}{3\,U} \cdot \frac{4\,R^2}{R^2 - r_o^2} \left(\frac{r_o}{r_x}\right)^2 \right], \quad \text{(G)}$$

we can determine P_o. In the above formula R and r_o represent the external and internal radii of the cylinder, and u the relative elongation corresponding to the elastic limit U.

In conclusion, we may cite yet another method for computing the strength of a hollow cylinder from experimental data, which has been proposed by Lieutenant-General Gadolin. According to him, in order to determine the limit of the resistance, we must determine that radius for which the value

$$P_o = \frac{P_1\, R^2\,(r^2 + r_o^2) + (R^2 - r_o^2)\, r^2 \left[U + \dfrac{d\,(r\,p)}{d\,r} \right]}{r_o^2\,(r^2 + R^2)} \quad \text{(H)}$$

is a minimum; and this minimum will be the limit of the resistance of the cylinder to internal pressure.

To be able to determine the least possible value of P_o from Equation (H), we must know $\frac{d\,(r\,p)}{d\,r}$ in terms of r. We have already given a method for determining stresses on a series of radii differing slightly one from the other; consequently, the values for $r\,p$ are also known. Let us put $r\,p = \alpha$, and indicate to what radius this α belongs. Of such values for α three consecutive ones may be connected by the equation,

$$\alpha = A + B\,r + C\,r^2 \quad . \; . \; . \; . \; . \; . \; . \quad \text{(K).}$$

Substituting the corresponding radii and stresses, an determining A, B and C, we find

$$\frac{d\,(r\,p)}{dr} = \frac{d\,(\alpha)}{dr} = B + 2\,C\,r \quad . \; . \; . \; . \; . \quad \text{(L).}$$

Applying this calculation to experiment No. 65, and substituting for r, the radii r_o, $\overline{R}^1$ and R^1, together with the pressures p_1, $\overline{p^1}$ and p^1, we find that $\frac{d\,(r\,p)}{dr} = -\,1520$ atmospheres.

According to this computation, the strength of a cylinder in which injurious stresses exist, is about 34 per cent. of the strength calculated on the supposition that internal stresses are absent.

But, bearing in mind the fact that in certain other experiments we have been unable to obtain such complete data as in the case of experiment No. 65, and consequently the calculated increase or decrease in the strength of selected discs will not be so considerable, we assume the loss of strength in disc No. 65 as only 47 per cent. *i.e.*, the mean of the values obtained by the various methods of calculation named.

Having thus acquainted the reader with the general principles adopted as a basis for calculation, I pass on to the consideration of the results to be deduced from my experiments.

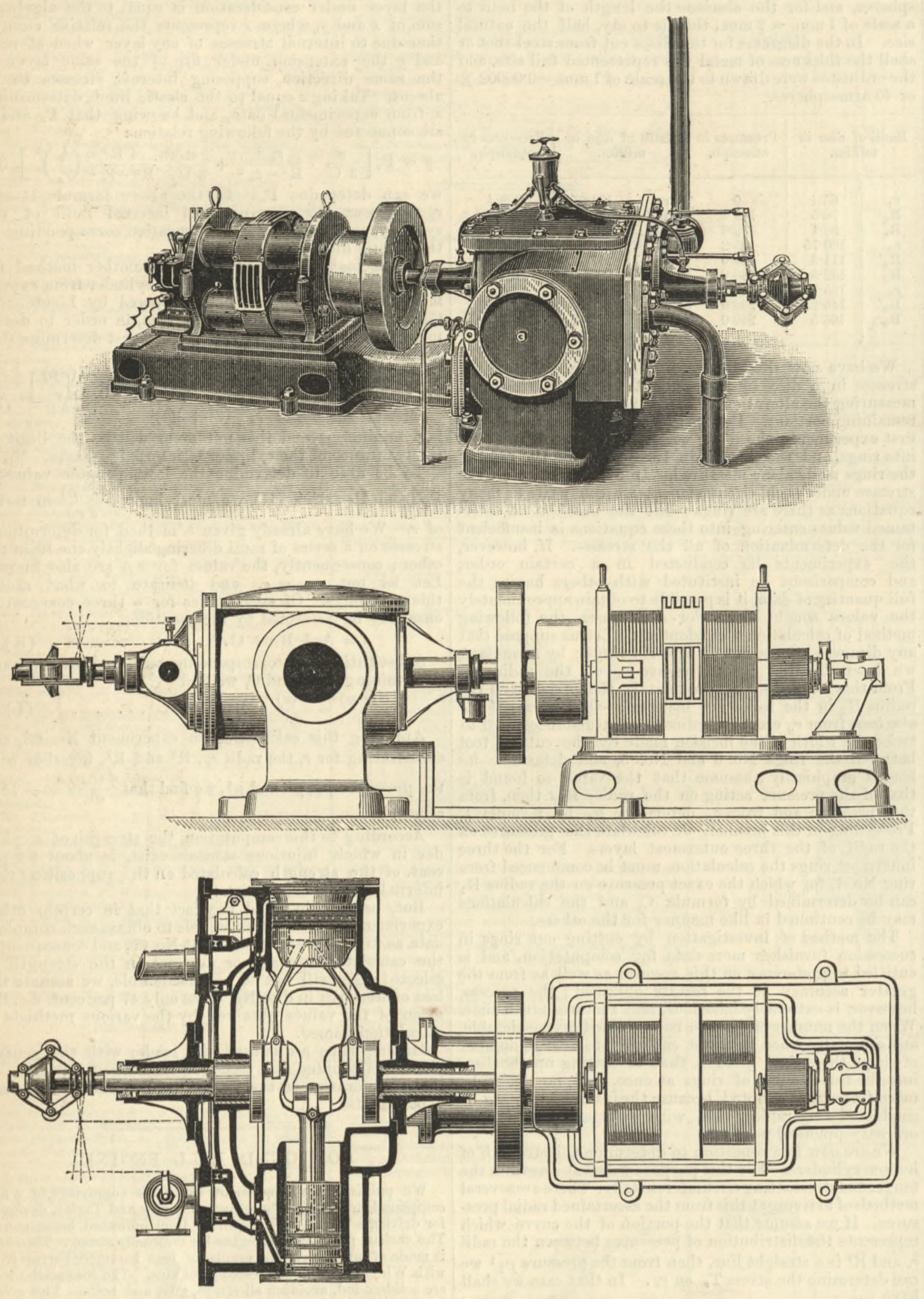
COMPOUND MILL ENGINE.

WE publish as a supplement this week engravings of a fine compound mill engine by Messrs. Buckley and Taylor, designed for driving a cotton mill, requiring 1000 indicated horse-power. The various parts of this engine are unusually strong. The shaft is made of mild steel; the cranks of best hammered scrap iron, with Whitworth's fluid pressed steel pins. The connecting-rods are solid-ended, avoiding all straps, gibs, and bolts. The crossheads, piston-rods and air-pump levers are made of mild steel. The cylinders are 29in. and 52in. in diameter, and 6ft. stroke. The high-pressure is fitted with steam valves of the Corliss type, and an equilibrium safety valve which comes into operation only in case of derangement in governing. The exhaust valves are slides, with a long traverse, worked by separate excentrics; their arrangement reduces the port space to a minimum, and in practice slide valves are found to keep more steam-tight than Corliss valves. The low-pressure cylinder is fitted with two slide valves of the ordinary box type, with a long traverse, and are found in practice to meet all requirements for low-pressure cylinders. The air-pump is of the bucket type, with india-rubber foot and delivery valves, worked as shown on the plan direct from the main crosshead. The fly-wheel is 30ft. in diameter, and prepared for thirty-four ropes 1¾in. in diameter, with two centre bosses with twelve arms each; the outer rim is made in two rings of twelve segments, each crossing the other's joints, and secured together with bolts. The beds are made in the box form, and of unusual strength, planed on the bottom, and secured to an ashlar bed in the usual way, and are strengthened longitudinally with two 4in. bolts extending from the front end of the cylinder to the outside of the pedestal bed, which relieves the cast metal of a portion of the tensile strain.

We give diagrams from this class of engines working with the cranks at right angles, and also with them having the low-pressure crank leading 30 deg. Those marked No. 2 are from the engines illustrated with cranks at right angles. This is a very fine class of engine, which maintains the reputation of English engineers all over the world.

TRADE MARKS IN ROUMANIA.—It will be interesting to trade mark owners whose goods are exported to Roumania to learn that proceedings instituted by the Trade Mark Protection Society of London, on behalf of Messrs. A. and A. Crompton and Co., the well known cotton spinners, of Shaw, near Oldham, against certain traders at Craiova in Roumania to restrain the infringement of the company's trade mark, have recently resulted in the defendants being condemned in fines and costs. The defendants stubbornly resisted the proceedings, and appealed from Court to Court, but the defence they put forward failed on every point, Messrs. Crompton having taken the precaution to have their trade marks fully registered. The proceedings being the first of this nature instituted in Roumania, the result is regarded as being of great importance among manufacturers and trade mark owners generally.

BEVER AND DORLING'S HIGH-SPEED COMPOUND ENGINE.



COMPOUND HIGH-SPEED BOX ENGINE.

In the Saltaire Exhibition, Messrs. Bever and Dorling, Dewsbury, exhibited one of Bever's high-speed engines, having a 6in. and a 9in. cylinder and 6in. stroke. The engine was coupled to a No. 1 Gulcher dynamo, which lighted a 3000-candle power arc lamp. The two cylinders are placed at opposite ends of a box-frame, and work on opposite cranks, so that the weights and pressures are balanced at all parts of the stroke. One valve works both the cylinders, and as it has a gyratory motion, it has no tendency to cut or groove the valve face. This valve is clearly seen in the sectional plan, which shows that the steam from the high-pressure cylinder passes through it on its way to the low-pressure cylinder, the valve being worked by an eccentric on the crankshaft. The internal working parts are constantly and automatically lubricated by dipping into a bath of oil.

THE AUTOMATIC GAS MACHINE.

We need scarcely remind our readers that many attempts have been made with varying sucess to use the volatile benzole compounds of mineral oils in the production of gas. Generally the process consists in carburetting a certain volume of air with the vapour of the benzole and using the air so treated precisely like ordinary coal gas. The extremely volatile nature of the petroleum spirits, as they are sometimes called, renders their use very dangerous unless special precautions are taken, and this fact has, no doubt, limited their employment.

There is now to be seen at work, in Westminster, a new system, which appears to overcome this difficulty. The benzole is contained in a cistern or tank, which may be buried in the ground at a distance from any house. The gas-making machine is shown at work on almost every conceivable form of burner, and on Sugg's cooking stoves. A machine occupying a space of less than 2 cubic feet suffices to supply a 6-horse Atkinson gas engine, also shown at work.

We illustrate the machine on page 509. As we have said the spirit, known in the trade as gasoline, is contained in a tank, which is buried in the ground at any desired distance from the building to be lighted. This, unlike the carburetter of the air-blowing gas machines, is simply a reservoir for holding the oil, having no compartments or absorbent material whatever. From the top of this reservoir two pipes extend to the surface of the ground, into the larger of these the gasoline is poured directly from the barrel. The smaller pipe gives vent to the enclosed air, and also admits air as the oil is pumped out. From the bottom of the reservoir a pipe extends to and is connected with the gas machine, an oil pump being placed in this pipe just below the machine.

The gas machine may be placed in the house, hall, or cellar, or other convenient location. It consists essentially of an air-pump, A; a generator, C; and a gasoline pump, GH. The piston of the air-pump is connected with the piston of the generator by means of the beam O, so that as one piston rises the other descends. The beam is enclosed in a gas-tight iron box P, fastened to the bottom of the machine. This is called the mixing box, because the gasoline vapour and the air from the air-pump both pass into it, and there become partly mixed on their way to the mixing tank. The piston-rod of the air-pump extends entirely through the piston and top of the air-pump. The gasoline reservoir is connected with the top of the generator C by a pipe. Through this pipe a very small but definite quantity of gasoline is pumped into the generator at each stroke of the pump. Beneath the generator is a small gas jet M, which is kept constantly burning, and is so regulated as to keep the temperature of the generator, as indicated by the thermometer S, at from 180 deg. to 200 deg., that is sufficiently hot to vapourise the gasoline as it is pumped into the generator.

The reservoir having been filled with gasoline, we will suppose that the machine is in operation and sufficient gas has been made to fill the mixing tank and distributing pipes throughout the building. The gas jet beneath the generator is burning and the temperature of the generator is between 180 deg. and 200 deg. Upon the approach of darkness the gas is lighted in different parts of the building, any desired number of burners being brought into use—from one up to hundreds—according to the size and capacity of the machine. As these lights withdraw the gas from the mixing tank, tending to produce a vacuum, the piston B of the air-pump A descends, forcing at the same time a cylinder full of the atmosphere into the mixing box P. As the piston descends by means of the beam O, it forces up the piston of the generator; it at the same time operates the pump G H in such manner that a very small but definite quantity of the gasoline is pumped into the generator at the moment its piston D reaches its highest point. The heat of the generator converts the gasoline liquid into a vapour, the sudden expansion of which forces the piston D down, and through the walking-beam the piston of the air cylinder is forced upward. As this piston ascends it forces another cylinder full of air into the mixing-box, the air-pump being double-acting. This movement also permits the gasoline vapour to escape from the generator into the mixing-box through openings provided for the purpose. The constant repetition of these movements produces a continuous supply of gas of a uniform quality.

The automatic device by which the temperature of the generator is regulated, no matter how much or how little gas is being made, depends for its action upon the well-known law of the expansion of metals by heat and their contraction by cold. The gas jet M is usually kept burning all day as well as at night, so that the machine is always in operation, making only enough gas to supply this little jet when no gas is used in other parts of the building, or making enough to supply any number of lights as they are brought into use, up to the full working capacity of the machine, and this is regulated automatically simply by lighting the gas in any part of the building. We will suppose that the machine has been working all day, making only enough gas to supply this little jet, and at night fifty burners are lighted in different parts of the building; the withdrawal of gas from the mixing tank causes the piston B of the air pump to descend more quickly. This action repeated pumps the gasoline liquid into the generator with more frequent strokes. As this is converted into vapour the absorption of the latent heat tends to cool the generator, the contraction of which by this very slight reduction of temperature turns on more gas by means of the lever N, giving a large flame under the generator. In a very few seconds this flame becomes adapted in size to the number of burners in use, and the generator is thus kept at the proper temperature. Late at night we will suppose the gas-lights to be turned off. The piston of the air-pump then descends very slowly, and the gasoline is supplied to the generator much less frequently. As the larger flame is still under the generator this becomes somewhat hotter. The expansion of the metal generator by this increased heat instantly and automatically, by means of the lever N, shuts off a portion of the gas beneath it, and in a very few seconds the size of the flame again becomes adapted to the amount of gas needed for its supply, and the proper temperature of the generator is maintained. This same action occurs without regard to how many or how few burners are in use. Of course the expansions and contractions of the metal are slight, amounting only to a very minute fraction of an inch.

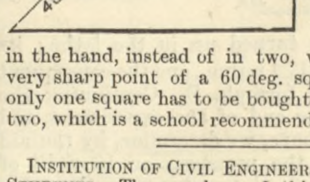
As the gas is formed by the mixture of gasoline vapour and air, it is evident that the quality of the gas must depend upon the relative proportions of these two substances. Hence, by increasing or decreasing the quantity of gasoline vapour, the quantity of air remaining the same, a richer or poorer gas is formed, as may be desired. In the automatic gas machine this mixture consists of two cylinders full of air to one generator full of vapour, the quantity of air never being varied. It is therefore evident that the quality of the gas never varies when once set at any desired candle power. But in the automatic gas machine the quantity of gasoline pumped into the generator may be made greater or less simply by turning the regulating screw R, thus making a very rich or less rich gas as may be desired. This is usually set at about sixteen-candle power, and it need not be changed unless varying qualities of gasoline be used. The gasoline should be of one standard quality of 880, and in order to secure this it should be ordered from reliable dealers. We have made arrangements to supply those who favour us with their orders with gasoline of a standard quality, in any quantity desired, at the regular market price.

By the above simple device the quality of the gas is so regulated that there will be no smoke produced, as there is in coal gas, thus avoiding unsightly smoked ceilings and walls, and preventing the vitiating of the atmosphere which is taken into the lungs. It also avoids the necessity of using burners, which have to be adjusted frequently to prevent smoke, as is the case with all carburetting machines.

The accompanying letters of reference explain the construction of the machine, which is being introduced into this country by the Automatic Gas Machine Company, Victoria-street:—A, air-pump of cylinder; B, piston or air-pump; C, generator; D, piston of generator; E E, valves of air-pump; F, opening for the admission of air to the air-pump; G, device for working gasoline pump; H I I, connection of the device G with the pump H; J J, pipe from gasoline reservoir to the generator; K, pipe leading to the mixing tank; L, supply pipe to gas jet M beneath the generator; M, gas jet; N, lever arm regulating the supply of gas beneath the generator automatically; O, walking beam connecting piston of air-pump with that of the generator; P, iron gas-tight box enclosing the walking beam, and into which the gasoline vapour and atmosphere are both forced on their way to the mixing tank; R, screw for regulating quality of gas; S, thermometer; T, top of generator, to be removed occasionally to clean generator; U, lever connecting the piston-rod of the air-pump with the pumping device of the gasoline pump.

CAPLE'S COMBINATION SET SQUARE.

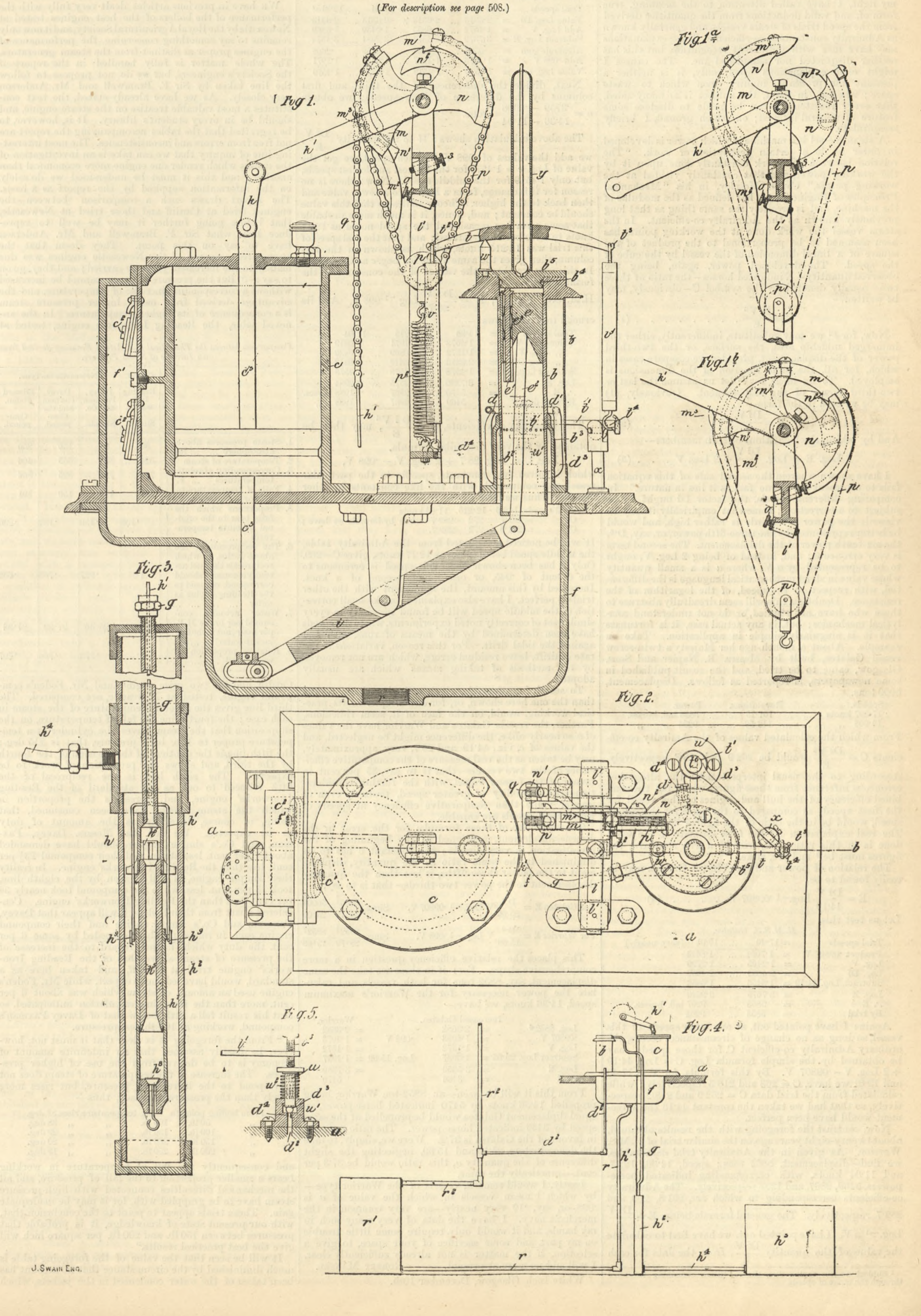
There are few combination tools in which each part is not more or less in the way or mars the handiness of every other part. This is not the case with the combination set square, which is illustrated herewith, as invented and registered by Mr. W. H. Dashwood-Capel, architect, Cardiff. Every experienced draughtsman prefers for all general work a set square of some size, and this lends itself to the construction of the combination square and secures the advantages of two set squares in one, and the further advantage of convenience and time saved by having the five angles in the one tool in the hand, instead of in two, which must be changed. The very sharp point of a 60 deg. square is moreover avoided, and only one square has to be bought and lost or broken, instead of two, which is a school recommendation of some force.



Institution of Civil Engineers—Association of Birmingham Students.—The members of this Association held their second annual dinner at the Colonnade Hotel, Birmingham, on Thursday, December 15th; Mr. E. Pritchard, M. Inst. C.E., in the chair. The President, in proposing the success to the Association, congratulated the members upon their progress. He hoped that in a very short time the Association would be able to compare favourably with the other branch associations of the—parent—Institution. Amongst the visitors present were Messrs. W. S. Till, M. Inst. C.E.; A. Comber, M. Inst. C.E.; J. E. Willcox, Assoc. Memb. Inst. C.E.; R. Godfrey, E. M. Scott, T. W. Debne, J. Tangye, T. Smartt, and F. H. Hewitt.

THE AUTOMATIC GAS MACHINE.

(For description see page 508.)



J. SWAIN ENG.

ON ADMIRALTY CO-EFFICIENTS.

By ROBERT MANSEL.

FOR many years, as opportunity offered, according to my light, I have called attention to the meaning, true form of, and valid deductions from the quantities derived from the speed trials of steam vessels, and generally known as Admiralty constants or co-efficients. These explanations may have met with indifferent recognition, but this has neither disquieted nor astonished me. The causes I might offer explanations upon; only, it is neither a pleasant nor profitable inquiry upon which to waste space; whereas, in itself, the subject is so many-sided, that every restatement can be made to disclose some feature of general interest; on which ground, I briefly recapitulate.

A steam vessel is a machine in which power is developed in order to do a certain description of work. "The relation between the work constantly done upon it by the working power, and that constantly yielded at the working points," Canon Moseley, in his "Mechanical Principles of Engineering," has defined as the modulus of the machine, and is precisely the same thing as that long previously known as the Admiralty co-efficient. In the steam vessel the work done at the working points has been assumed to be proportional to the product of the square of a lineal dimension of the vessel by the cube of the speed. The developed power, again, being the observed quantity—E indicated horses—the ratio of these two—usually denoted by the symbol C—obviously, may be written—

$$C = \frac{l^2\,V^3}{E} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

Now, for l^2 we may substitute, indifferently, either the immerged midship area, the surface, or the two-third power of the displacement, provided we compare cases in which, for all, the same function of the dimensions is employed. To fix ideas, for l^2 let us assume the last or two-third power of the displacement. Obviously, (1) may be written in the form—

$$E = \frac{D^{\frac{2}{3}}\,V}{C}\,V^2 \quad . \quad . \quad . \quad . \quad . \quad (2)$$

And by taking the logarithms of both members—

$$\text{Log. } E = \text{Log. } \frac{D^{\frac{2}{3}}\,V}{C} + 2 \text{ Log. } V \quad . \quad . \quad . \quad (3)$$

I have shown wherein the second side of this equation fails to represent the "true fact as it lies in nature." In comparing different vessels, the factor $D^{\frac{2}{3}}$ ought to be subject to a correction; somewhat empirically it may be viewed: the power two-thirds is rather high, and would be better represented by the three-fifth power, or, say, $D^{\cdot 6}$, the six-tenth power of the displacement. The second term is very erroneous; and, instead of being 2 Log. V, ought to be represented by a V, where a is a small quantity whose value in strict mathematical language is the differential, with respect to the speed, of the logarithm of the resistance. Doubtless this will seem dreadfully abstruse to those who have not studied, or do not understand analytical mechanics; but, in any actual case, it is fortunate that it is singularly simple in application. Take an example. About a month ago her Majesty's twin-screw vessel Galatea, built by Messrs. R. Napier and Sons, Glasgow, came to be tried, and the result published in some newspapers, is reported as follows. Displacement, 5000 tons.

Speeds.	Revolutions.	Power.
17·397 knots	101·15	5858 ind. horses.
19·008 ,, ...	113·50	9204 ,, ,,

From which the calculated values of the Amiralty co-efficients $C = \frac{D^{\frac{2}{3}}\,V^3}{E}$ would be 262·9 and 218·2 respectively. According to the usual interpretation: the altogether erroneous inference from these figures would be; the combined efficiency of the hull and engines of this vessel for the first speed, as compared to the same for the second speed, would be in the ratio of the figures 262·9 to 218·2. The real explanation is: the false estimate of the work done is in this ratio, but, tried by a true standard, the figures must be,[1] and are, alike.

The relation of power and speed in the Galatea may be easily found to be,

$$E = \frac{D^{\frac{2}{3}}\,V}{44{\cdot}19}\,\text{Log.}^{-1}\,{\cdot}09807\,V \quad . \quad . \quad . \quad . \quad . \quad (4)$$

Let us test this.

H.M.S.S. Galatea.

Trial speeds	= 17·40	... 19·01	(very nearly)
Product ·09807 V	= 1·7064	... 1·8643	
Log. V	= 1·2405	... 1·2790	
Log. $D^{\frac{2}{3}}$	= 2·4660	... 2·4660	
Subtract, Log. 44·19	= 1·6453	... 1·6453	
Log. E	= 3·7675	... 3·9640	
∴ E	= 5858	... 9207	ind. horses.
By trial	= 5858	... 9204	,, ,,

Again: I have pointed out, at any other speeds of this vessel, so long as no change of circumstances occurs, the ordinary Admiralty co-efficient C, for those speeds, may be obtained by the simple formula Log. C = Log. 44·19 + 2 Log. V − ·09807 V. By this formula, for V = 17·40 and 19·01 we have, C = 263 and 218·3 respectively; while calculated from the trial data C = 262·9 and 218·2 respectively, so that had we taken the constant 44·18 the agreement would have been perfect.

Now, contrast the foregoing with the results obtained, about twenty-eight years ago, on the similar trial of H.M.S. Warrior. As given in the Admiralty trial data tables, we find—displacement, 8852 tons; speed, 14·36, 12·17, and 11·04 knots, with corresponding indicated horse-powers, 5469, 2867, and 1988 respectively. The Admiralty co-efficients corresponding to which are, 231·8, 269, and 289·7 respectively. The general formula being, $E = \frac{D^{\frac{2}{3}}\,V}{c}$ Log.$^{-1}$ a V. I have pointed out, we have first to calculate the value of the quantity $\frac{D^{\frac{2}{3}}\,V}{E}$, from the data for each speed; and, knowing that each value thus obtained ought to satisfy the condition Log. $c - a$ V, where a and c are constants, the reason of the following calculations ought to be obvious:—

Trial speeds ...	=	14·36 ...	12·17 ...	11·04 ...	12·215?
Value Log. $D^{\frac{2}{3}}$	=	2·6313 ...	2·6313 ...	2·6313 ...	2·6313
Add Log. V	=	1·1572 ...	1·0853 ...	1·0430 ...	1·0869
Subtract Log. E	=	3·7379 ...	3·4574 ...	3·2984 ...	3·4574
Algebraic sum	=	·0506 ...	·2592 ...	·3759 ...	·2608
Add ·098 V	=	1·4073 ...	1·1927 ...	1·0819 ...	1·1971
Value Log. c	=	1·4579 ...	1·4519 ...	1·4578 ...	1·4579

Next, divide the differences of the third and first columns by the difference of their speeds; we obtain

$$a = \frac{{\cdot}3759 - {\cdot}0506}{14{\cdot}36 - 11{\cdot}04} = {\cdot}098.$$

The above calculation shows: If to the quantity $\frac{D^{\frac{2}{3}}\,V}{E}$, we add the values of ·098 V, for each speed, we get the value of Log. c = 1·4579 for the highest and lowest speeds, but only 1·4519 for the middle speed. Now: there is no reason for this change, from a higher to a lower value and then back to the higher. Theory indicates that this value should be constant; and, hence, it is much more probable that some error has occasioned the speed noted as 12·17 knots to have been understated; and that the real speed of this trial was 12·215 knots, which, as shown in the last column, then gives the same value for Log. c as the others. In this way we obtain the values of the constants in the formula for,

H.M. S.S. Warrior, $E = \frac{D^{\frac{2}{3}}\,V}{28{\cdot}7}$ Log $^{-1}$ ·098 V. And its crucial test, as follows:—

Trial speeds	=	14·36 ...	12·215 ...	11·04	
Values ·098 V	=	1·4073 ...	1·1971 ...	1·0819	
,, Log V	=	1·1572 ...	1·0869 ...	1·0430	
,, Log $D^{\frac{2}{3}}$	=	2·6313 ...	2·6313 ...	2·6313	
Subtract Log. 28·7	=	1·4578 ...	1·4578 ...	1·4578	
Log. E	=	3·7380 ...	3·4575 ...	3·2984	
∴ E	=	5470 ...	2867 ...	1988	horses.
By trial data	=	5469 ...	2867 ...	1988	,,

The Admiralty co-efficients, $C = \frac{D^{\frac{2}{3}}\,V^3}{E}$, may then be obtained by the very dissimilar formula,

$$\text{Log. } C = \text{Log. } 28{\cdot}7 + 2 \text{ Log. } V - {\cdot}098\,V,$$

which involves two constants, specific to the particular vessel, and comparable with the like constants in other vessels. Thus we have:

Trial speeds,	14·36	12·215	11·04 knots	
C	= 231·7	272	289·7	while by formula we have;
C	= 231·8	272	289·7.	

It will be noticed, as quoted from the Admiralty table, the middle speed being taken as 12·17 knots, gives C = 269. Only it has been shown that this speed is erroneous to the extent of ·045, or one twenty-second of a knot. Increased by this amount, the agreement with the other trials is perfect. I have also explained: a like small correction of the middle speed will be found necessary in every similar set of correctly noted experiments, where the speeds have been determined by the means of runs, with and against the tidal drift. For this reason, variations in the rate of drift, leave residual errors, which are not removed by the methods of taking means which are usually adopted.

To search for a formula which will give closer results than the one here shown, or, for one simpler in its practical working, would, on the face of it, seem ridiculous. Further, the vessels Galatea and Warrior have the values of a so nearly alike, the difference might be neglected, and the values of c, viz., 44·19 and 28·7, very approximately, may be taken as the real measure of the comparative efficiencies of the two vessels—that is to say, 35 per cent. in favour of the former vessel, with the further consideration—the capability of greater speed, probably even of greater value than comparative efficiency at speeds of which both vessels are capable.

The correction of these formulæ for the error in the dimensions element, mentioned at the beginning of the investigation, is very simple; the constant c has to be diminished in the same ratio as the quantity, displacement to the power three-fifths, is less than the quantity displacement to the power two-thirds—that is to say,

For Galatea $E = \frac{D^{\cdot 6}}{25{\cdot}05}$ V Log. $^{-1}$ ·09807 V. Since, $\frac{5000^{\frac{2}{3}}}{44{\cdot}19} = \frac{5000^{\frac{3}{5}}}{25{\cdot}05}$

For Warrior $E = \frac{D^{\cdot 6}}{15{\cdot}69}$ V Log. $^{-1}$ ·098 V. Since, $\frac{8852^{\frac{2}{3}}}{28{\cdot}70} = \frac{8852^{\frac{3}{5}}}{15{\cdot}69}$

This places the relative efficiency question in a more comprehensive shape. For: if in these we take the same displacement, say, 8852 tons for both vessels, and calculate the power necessary for the Warrior's maximum speed, 14·36 knots, we have—

	Increased Galatea.		Warrior.
Log. $8852^{\cdot 6}$	= 2·3682		= 2·3682
·09807 V	= 1·4083	·098 V	= 1·4073
Log. V	= 1·1572		= 1·1572
Subtract Log. 25·05	= 1·3987	Log. 15·69	= 1·1947
Log. E	= 3·5350		= 3·7380
∴ E	= 3436		5470

From this it will be seen—an 8852-ton Warrior, being propelled 14·36 knots by 5470 indicated horse-power, an equal diplacement Galatea would be propelled at the same speed by 3436 indicated horse-power. The ratio per cent. in favour of the Galatea is 37·2. Were we, simply, to take the denominators, 25·15 and 15·69, neglecting the slight difference of the quantity a, this ratio would be 37·3 per cent.—practically the same.

Lastly, I would remark, vessels of the Warrior type—by which I mean vessels in which the value of a is ·098, or, say, ·10 very nearly—are very common in the merchant navy. I have the data of very many such in my hands, and it would only require some little trouble on my part, and some sacrifice of your space, to give a selection, if the matter is not already sufficiently clear. I will add no more at present. ROBERT MANSEL.

White Inch, Glasgow, December 10th.

[1] Subject to the explanation, the conditions remaining unaltered through the range of speeds.

STEAM ENGINES AT THE ROYAL AGRICULTURAL SOCIETY'S NEWCASTLE SHOW.

No. IV.

WE have in previous articles dealt very fully with the performance of the boilers of the best engines tested at Newcastle by the Royal Agricultural Society, and it now only remains to say something concerning the performance of the engines proper as distinct from the steam generators. The whole matter is fully handled in the report of the Society's engineers, but we do not propose to follow the line taken by Sir F. Bramwell and Mr. Anderson very closely. As we have already stated, the text constitutes a most valuable treatise on the steam engine, and should be in every student's library. It is, however, to be regretted that the tables accompanying the report are not free from errors and inconsistencies. The most interesting line of inquiry that we can take is an investigation of the causes which render one engine more economical than another; and this it must be understood we do solely on the information supplied by the report as a basis. The report draws such a comparison between the engines tried at Cardiff and those tried at Newcastle, that before going further it may be well to reproduce here what Sir F. Bramwell and Mr. Anderson have to say on this point. They deem that the augmented economy of the Newcastle engines was due mainly to the increased pressure carried; and they go on to say:—"But the pressure of steam cannot be increased without a corresponding increase of temperature, and the advantage derived from using higher pressure steam is a consequence of its higher temperature. In the annexed table, the Reading Ironworks engine, tested at

Comparison between the Theoretical and Actual Economy derived from an Increase of Steam Pressure.

	Cardiff.	Newcastle-on-Tyne.		
	Reading Iron-works. Simple.	Davey, Paxman, and Co. Simple.	Davey, Paxman, and Co. Com-pound.	Edward Foden. Com-pound.
1. Steam pressures above atmosphere ... ... lbs.	80	95	150	250
2. Temperature of steam F.°	324	334	365	406
3. Corresponding absolute temperatures ... F.°	784	794	825	866
4. Falls of temperature to 215° or 675° absolute F.°	109	119	150	191
5. Proportions which the falls bear to the original absolute temperatures	·139	·150	·182	·220
6. The reciprocals of the above ratios, to which reciprocals the fuel actually consumed should correspond, reduced to the Reading engine as unity	1·	·927	·763	·632
7. Water actually consumed per brake H.P. per hour (not including jacket-water) ... lbs.	30·22	26·40	21·33	21·38
8. Relative proportion of water used	1·	·873	·706	·707

Cardiff, and the two prize engines and Mr. Foden's compound engine, tested at Newcastle, are compared. The third line gives the absolute temperature of the steam in each case; the fourth line the fall of temperature, on the supposition that the steam leaves the cylinder at a temperature proper to 1 lb. back pressure, that is 215 deg.; the fifth line is the quotient of the division of the fourth by the third, and shows the proportion of work to be expected. The sixth line is the reciprocal of the fifth reduced to one as the standard of the Reading Ironworks' engine, and represents the proportion in which the steam should have been consumed, that being, of course, inversely as the amount of duty to be expected. We see that Messrs. Davey, Paxman, and Co.'s simple engine should have demanded about 7 per cent. less steam, and their compound 23½ per cent. less than the Reading Ironworks' engine. In reality their simple engine, as will be seen by the eighth line, took 13 per cent. less, while the compound took nearly 30 per cent. less than the Reading Ironworks' engine. Considered apart from their boilers, it will appear that Davey, Paxman, and Co.'s simple engine and their compound engine each in round numbers exceeded by some 6 per cent. the duty which, having regard to the increase of the pressure of steam above that of the Reading Ironworks' engine tried at Cardiff, and taken here as a standard, would have led one to expect, while Mr. Foden's engine used an amount of steam which was about 6 per cent. more than the foregoing calculation anticipated, so that his result fell a little below that of Davey Paxman's compound, working at 100 lb. less pressure.

"From the foregoing it is clear that it must not, however, be hastily assumed that an indefinite amount of economy is to be derived from the use of higher pressures. The increase in the temperature of steam does not correspond to the increase in pressure, but rises more slowly than the pressure increases; thus—

From boiling point to		50 lb.	temperature rises	88 deg.
,,	50 lb.	100 lb.	,, ,,	38 deg.
,,	100 lb.	150 lb.	,, ,,	29 deg.
,,	150 lb.	200 lb.	,, ,,	20 deg.
,,	200 lb.	250 lb.	,, ,,	18 deg.

and consequently the fall of temperature in working bears a smaller proportion to the fall of pressure, and all the mechanical difficulties connected with high-pressure steam have to be grappled with, for it may be inadequate gain. These trials appear to point to the conclusion that, with our present state of knowledge, it is probable that pressures between 150 lb. and 200 lb. per square inch will give the best practical results."

It will be seen that the value of the foregoing table is much diminished by the circumstance that no account has been taken of the water condensed in the jackets, which may be sufficient to alter the whole comparison, because the jacket condensation is never identically the same in any two engines, being variable by a host of conditions and influences. Furthermore, with all due deference to the eminent authors of this statement, we venture to say that their own figures show that the superior economy of the Newcastle engines was due to something more than higher pressures. In the case of Mr. Foden, it will be seen that the actual result was 6 per cent. under the calculation, while in the case of Messrs. Davey, Paxman, and Co. it was considerably over it. We have only to look at Mr. Foden's low-pressure diagram to see why he did so badly. For some unexplained reason, the action of the steam at the front end of the low-pressure cylinder was extremely bad. The initial pressure was only 24 lb., while the back pressure was no less than 6 lb. We find, too, that the range of expansion in the high-pressure cylinder was very considerable, whereas it was very moderate in the low-pressure cylinder. Furthermore, the exhaust line in the high-pressure cards falls continuously, showing that the intermediate receiver space was too large or the cut-off too early. If we turn now to the diagrams of Messrs. Paxman's engine, and those of Messrs. McLaren, we shall find much that is very instructive. In the former the cut off takes place in the high-pressure cylinder very sharply at not much less than one-third of the stroke, and in the low-pressure cylinder the expansion is well marked. The exhaust lines of the high-pressure cards are curved showing a small intermediate receiver. In Mr. McLaren's cards we find that the cut-off took place at a little more than one-sixth of the stroke. The terminal pressure in the Paxman high-pressure cylinder was about 28 lb. above the atmosphere, while in the McLaren engine it is 20 lb. The whole range of expansion in the Paxman high-pressure cylinder is a little over five times, while in the McLaren high-pressure cylinder it is about seven times. Now, we have repeatedly pointed out in these pages that the reason why the compound engine is so economical must be sought in the fact that the steam resulting from re-evaporation during the exhaust stroke of the high-pressure piston is used *expansively* in the low-pressure cylinder. In practice this means that the expansion should be divided between the two cylinders. We see that in the Foden engine the expansion takes place almost wholly in the first cylinder. In the McLaren engine it takes place to a much larger extent in the small than in the large cylinder; and in the Paxman engine the expansion is much more fairly divided. Here then is, in our opinion, one of the reasons why Mr. Paxman beat his competitors. We have either tested ourselves, or received from others particulars of tests, and we have never yet met with a case where maximum economy was realised unless the steam was worked with a comparatively early cut-off, say, half-stroke, in the large cylinder. It is, of course, mainly a question of cylinder capacity, clearance, and intermediate receiver space. The capacity of the Foden high-pressure cylinder was $17{\cdot}72 \times 10 = 177{\cdot}2$ cubic inches. That of the low-pressure cylinder was $70{\cdot}88 \times 10 = 708{\cdot}8$ cubic inches, neglecting clearance. The capacities were therefore as four to one. In the Paxman engine the capacity of the high-pressure cylinder was $26 \times 14 = 364$. That of the low-pressure cylinder was $67{\cdot}2 \times 14 = 940{\cdot}8$ cubic inches. The ratio here is 2·6 to one nearly. In the McLaren engine the capacity of the high-pressure cylinder is $26 \times 15 = 390$; and of the low-pressure, $63{\cdot}6 \times 15 = 954$ cubic inches, and the ratio is 2·44 to one nearly. There does not seem to be any good reason why, with such proportions, Messrs. McLaren should not have divided their expansions better than they did. Much, however, depends on the question of clearance and intermediate receiver space, concerning which we have no information concerning Mr. Foden's engine. The figures given in the report for the other two engines are as follows:—

	Paxman. cubic inches.	McLaren. cubic inches.
Mean clearances and ports of high-pressure cylinder...	54	62·2
Ditto low-pressure cylinder	128·5	103
Intermediate space...	517	427·4

A comparison of the indicated and brake horse-power of the different engines is not without value. During the Newcastle trials a careful allowance was made, for the first time, for the friction of the brakes. Taking the corrected figures, we have—

	Foden.	Paxman.	McLaren.
Indicated horse-power ...	18·63	22·77	24·02
Brake horse-power	17·57	20·33	21·07
Difference	1·06	2·44	2·95
Ratio of brake horse-power to indicated ,, ,, ...	·943	·893	·877

In a former article we gave the water used per indicated horse-power per hour, and unintentionally did Messrs. McLaren's engine an injustice, caused by the mal-arrangement of the tables in an early copy of the report. We gave the indicated power of his engine as 22-horse instead of 24. We now give the corrected figures. It will be understood that these figures include the water condensed in the jackets and re-evaporated, as estimated, and they therefore differ in the case of the McLaren engine from those published in our pages, as obtained by Professor Barr and Mr. Halpin, who took no account of jacket-water.

Water per indicated horse-power per hour.

Foden.	Paxman.	McLaren.
23·75 lb.	21·45 lb.	24 lb.

From these figures we gather that there was considerably more condensation going on in the cylinders of Messrs. McLaren's engine than there was in those of the other two; but although this is probably true to a certain extent, it will not account for the whole loss. There were a couple of leaking rivets in the fire-box, through which a certain amount of water escaped. A slide-valve rod was metallic packed. This passed steam, and then there was, we believe, besides, what we may term an internal leak from the jacket into a cylinder, which represented a further loss.[1] All these things were due to the excessive haste with which the construction of the engine was hurried in order to get it into the show-yard in time. There is, however, a suggestive passage in the report of Mr. Halpin and Professor Barr which appeared in our impression for December 2nd. Describing the engine, they say:—"The cylinders, 5⅝in. and 9in. diameter by a 15in. stroke, were bolted directly to the top of the fire-box casing, *both being surrounded by the steam passing from the boiler to the high-pressure valve chest.*" If these words are to have their legitimate meaning, then the steam entering the high-pressure cylinder passes first through the low-pressure jackets, which is an extremely defective arrangement—so defective that we fancy that Mr. Halpin and Professor Barr are mistaken. However, it is proper to add that if they are not, Messrs. McLaren are by no means the only engineers who have adopted the system. Indeed, not many years have elapsed since it was held to be excellent practice to have all the steam supplying non-compound engines passed through the jackets, on the plea that the efficiency of the jacket was thus secured, and would more than compensate for any loss incurred by the slight cooling of the steam.

It will not have escaped our readers that a vigorous controversy is going on in our pages concerning the accuracy of the R.A.S.E. brakes. It would extend this article beyond reasonable limits to consider here the points raised; nor is this the proper place to discuss them. We have taken the report as it stands, assuming, as is right, that the eminent engineers who have issued it are satisfied that the trials on which it was based were accurately conducted. The possible errors of brakes constitute quite a different subject for consideration, which we shall probably deal with on another occasion. There can be no doubt that an error *may* be introduced by the action of the compensating levers of the Appold brake as pointed out by Messrs. McLaren and Mr. Halpin. Professor Kennedy says, page 632, in "The Mechanics of Machinery," after describing the action of the Appold brake, "This may in cases cause a very sensible error in the estimation of work done, an error always in excess." Whether any sensible difference in error may exist between any two brakes of the same construction as used by the Royal Agricultural Society is, however, quite another thing.

Meanwhile, it is enough to say that we do not suppose that the brakes used by the Royal Agricultural Society have ever been put forward as giving results absolutely correct. That would be far too much to expect. Messrs. McLaren have done good service by carrying out experiments, and they have undoubtedly obtained some very curious and even startling information concerning the use of water as a lubricant, and its effect on brakes, which, in due time, we hope to place before our readers.

[1] Mr. Pidgeon says in his report:—"Before the trial run had begun a leak declared itself, which made it necessary to remove the cover of the high-pressure cylinder, and to plug with wood a ½in. hole, through which the jacket of the cover itself was supplied with steam. During the run another difficulty occurred. The Crosby sight-feed lubricator partially failed of its office, with the result that the slide valve of the small cylinder 'seized' and caused its excentric strap to heat badly. Mr. McLaren plied his oil can vigorously, but without avail; the excentric strap was hot, and growing hotter. Some fire-box stays, too, were dripping during the trial; so that when the run terminated it is not to be wondered at that the Paxman compound performance remained unbeaten. This engine ran 4 h. 24 min. actual, and 4 h. 51½ min. mechanical time, taking a supply of 202½ lb. of coal, equal to a consumption of 2·18 lb. of coal per horse-power per hour."

OFFICIAL TRIAL OF THE NORDENFELT SUBMARINE VESSEL.

THE first approach to any official trial of the Nordenfelt submarine vessel took place on Monday last, December 19th. It was not by any means a formal official trial, but the boat has been matured to a sufficient extent to exhibit its powers and capabilities, allowance being made for want of practice. The opportunity of witnessing such a trial was seized by representatives from the Admiralty, Ordnance Committee, Royal Engineers, and the Naval Attachés of foreign Powers. As our readers generally are aware, the object of this boat is to approach a ship under water, so as to escape observation, and thus discharge a torpedo in such a way as to strike an enemy with certainty, and in a vital place. In her ordinary mode of progression the vessel lies very low in the water, and is much less visible than a service torpedo boat. She would approach an enemy thus till she reached a distance at which she might run in danger of being perceived, perhaps from 700 to 500 yards; then she would close all escape for smoke and all passage for air, and sink so low that nothing remains above water but two small glass domes fixed at the top of two cupolas. These domes are sufficiently large to contain a man's head, one in the fore part of the ship and one aft. In this position the vessel would depend on her store of steam provided for as hereafter described, and her crew on her imprisoned air. The captain takes his stand with his head in the forward dome, a position which, it is said, gives him a singularly clear view along the surface of the water at night for such distances as are not affected by limit of horizon. Close to his hand are the handles or levers for regulating the speed and the direction of the boat, also the working of the horizontal propellers employed for descending below the surface. For rising again no propeller is necessary, the system being to adjust the boat to float with the surface of a wooden deck—which has recently been added as a superstructure—nearly level with the surface of the water. As the boat eventually nears her enemy, she descends entirely under the water, so that nothing is visible except the eddies on the surface formed by the revolution of the horizontal propellers, and these would probably be seen only in smooth water. This boat, the Nordenfelt, is intended to carry four, possibly five, torpedoes. Obviously the discharge of these will need skill and practice in a system so nicely adjusted. Nothing has been as yet carried out in this direction. The trial with which we now deal related exclusively to the working of the boat and to the handling of it in submerging it or in bringing it to the surface. The form of the boat, which is 135ft. long and 12ft. in beam, is not here discussed, because it can be best seen by drawings, which we propose to give in a future number. Captain T. Garrett, who has had considerable experience with a submarine boat of a cigar form, has found this one much more manageable.

Two trials took place in the afternoon in Southampton water near the lightship; the first consisted in running the vessel at a fair speed when in the highest position, that is, with the flat deck or superstructure a few inches above the surface of the water, in which condition the displacement is 160 tons; when submerged it is 230 tons. The object was to enable those who witnessed the trial to judge how far the boat was visible and how far vulnerable in comparison with a service torpedo boat. The superstructure is, of course, not of any vital importance. Beneath it the boat is protected by a turtle back of steel 1in. thick, and the conning towers or cupolas by 1in. of steel. It is intended in future vessels to increase this to 3in. The boat thus running at high speed obviously offered a very small mark to artillery.

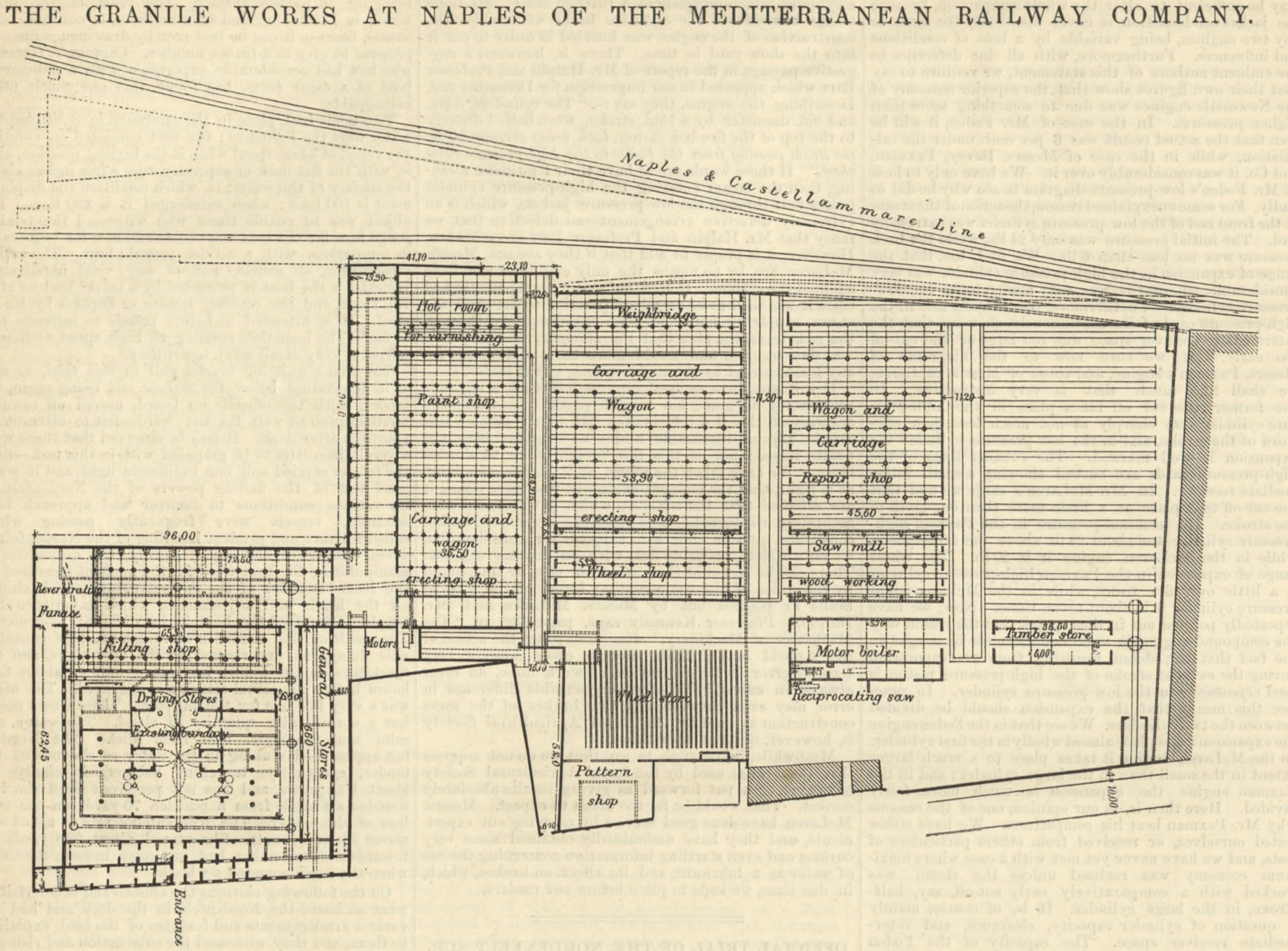
The boat acquitting herself well in this trial, as well as in descending below the surface and rising again, the tender, with the officials on board, moved off towards Southampton to wait for the Nordenfelt to attempt an approach after dark. It may be observed that there were several difficulties to be grappled with in this task—first, the tender carried only one indifferent light, and it was a good test of the finding powers of the Nordenfelt in its various conditions to discover and approach her; secondly, vessels were frequently passing which called for care and prudent handling of the Nordenfelt to avoid danger of collision. Thirdly, the difficulties of manipulating the boat were for the moment increased by the recent addition of the superstructure which altered all the levels and adjustments, which experience had taught best suited the boat in its different movements. The result of this condition of things was that considerable delay was experienced in the operations, and the spectators on the tender had a long wait of about four hours before the actual attack was achieved. The night was a very fair one for the purpose. There was a moon, but a considerable quantity of cloud. The water was calm and the night free from mist. The Nordenfelt approached, sinking in the water as she neared the tender, eventually travelling submerged wholly for about 100 yards, and was not perceived until she had sounded a whistle from a position 70 yards on the port bow of the tender. The Nordenfelt's rate of speed was about 3½ or 4 knots. She moved about 600 yards off towards a steamer that had just come in from the Cape, when she again sounded a whistle.

On the following morning the officials and other visitors went on board the Nordenfelt in the dock and had the various arrangements and features of the boat explained to them, and they witnessed the submersion and rising of the boat, which was repeated so as to show that it was completely under control. Altogether the trial was most successful, but there remains much to be done before the Nordenfelt can be brought into condition for actual service. The introduction and successful discharge of the torpedoes have to be mastered. Then great experience is needed for handling the boat below water. Not only has the speed been hitherto kept very low, but also every change in position has been slowly and carefully effected. With a cigar-shaped boat experience has shown that there is a great liability to plunge head down, which is very dangerous in water of limited depth; but the fact is that destruction, as Captain Garrett well expressed it, is always within a very limited number of feet. But the crew of a craft engaged in naval warfare has always to run risks, and the crew of the Nordenfelt would be very much safer than the men in an ordinary torpedo boat. The safety of this boat is mainly secured, first, by Mr. Nordenfelt's plan of working her in a condition when the revolution of the horizontal propellers is necessary to keep her under water, so that in any stoppage or breakdown she rises at once; and secondly, by a reserve of hot water under pressure, which, if ejected by steam, gives very great power to rise, though in a condition of partly expended motive power and temporary helplessness. Altogether the physical questions involved are very interesting To a ship attacking harbours in the future the various forms in which attack may come to her must be peculiarly interesting. From a dynamite gun, a torpedo in the shape of a huge dynamite or gelatine shell may come hurtling through the air and fall close to her. Near the surface of the water she may strike the circuit closer of a submarine mine lying near the bottom, and at any desired depth the Nordenfelt boat may approach and discharge a torpedo at her. Near a harbour, in fact, the air, the surface and the depths of the water to the bottom itself may bring surprises upon an enemy, and this from torpedo warfare alone.

NAVAL ENGINEER APPOINTMENT.—The following appointment has been made at the Admiralty: Alfred T. H. Stone, assistant engineer, to the Brisk.

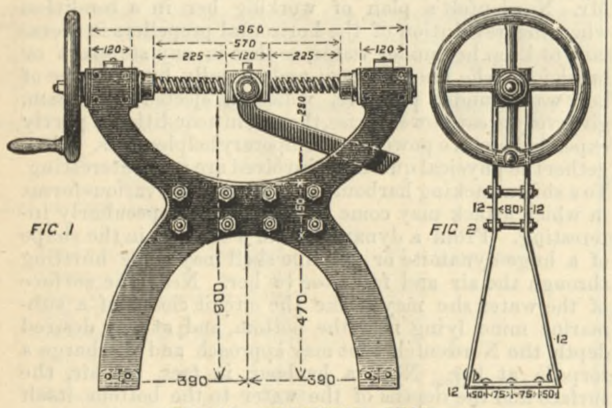
THE CONCEALMENT OF TORPEDO BOATS.—One well-known drawback in torpedo-boats is the visibility of the flame and smoke when within a distance of 2500 to 3000 yards of the object to be attacked. Experiments at the Rochefort Arsenal and on the Seine with an apparatus invented by an engineer of the name of Oriollo, of Nantes, as is reported, have demonstrated that his arrangement is capable at night of quite obscuring the torpedo-boat. The flame and sparks disappear, the smoke, which is reduced in temperature from 100 deg. to 30 or 40 deg., spreads itself out in a horizontal layer over the surface of the water, becomes inhalable and envelopes the boat in an impenetrable vapour, which defies the electric search-light to discover the boat. A notable point in the application of the arrangement is that, it in no way whatever interferes with the proper working of the engines or the boat. The steam pressure and the speed remain undiminished; the improvement is confined exclusively to the funnel, and the extra weight which it adds to the boat is insignificant. France is engaged in applying this improvement, and Spain and Italy will, probably, shortly introduce it to their navies.

THE GRANILE WORKS AT NAPLES OF THE MEDITERRANEAN RAILWAY COMPANY.



THE MEDITERRANEAN RAILWAY CO.'S PIETRARSA AND GRANILE WORKS, NAPLES.

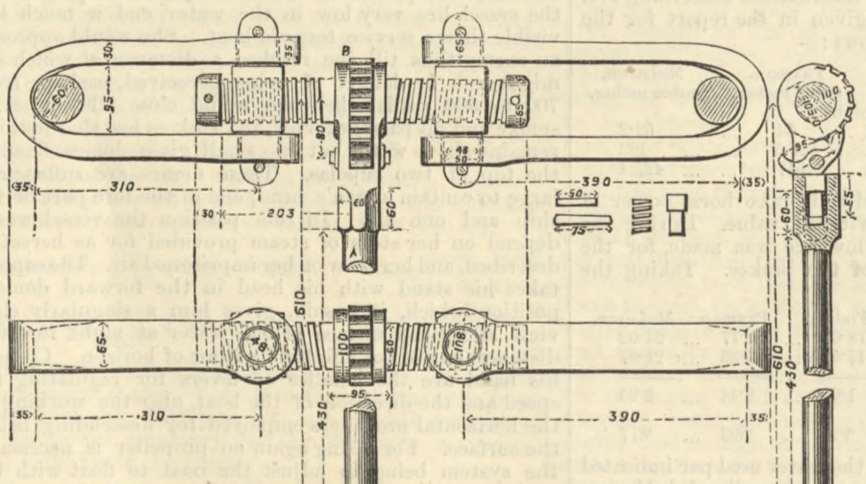
THE Pietrarsa Works, situated between the line from Naples to Portici and the shore of the Bay of Naples, are among the oldest, if indeed not the oldest of any importance in Italy, having been founded in 1842 by Ferdinand II. Until lately a gigantic statue of this monarch, cast at the works, overlooked the dock, now disused, communicating directly with the Mediterranean; but this prominent object, having been found to serve as a butt for irreverent marksmen from the sea shore, is now ignominiously relegated to the oblivion of a storehouse. The primary object of this establishment was to roll rails for the railway between Naples and Caserta, so as to be independent of England, although English coal and pig iron could not then be dispensed with. In 1860 Pietrarsa became an arsenal of the Government, and the battlements overlooking the Mediterranean still exist. In 1862 the works passed into the hands of a company, which, however, failed in 1868, when the management was resumed by



ITALIAN REVERSING GEAR.

the Italian Government. In 1885, when the railway convention gave the working of all the lines on the west coast of Italy to the Mediterranean Co., Pietrarsa, situated directly on the main line of the southern section, came in very handily for repair shops. The first Italian locomotive was made here in 1867-8, and since that time 265 have been turned out complete, except the boilers, which are made at the Granile Works. The present erecting shop is the original foundry, with its massive pillars, where cannon were formerly cast. Some relics of the past may be seen in an old beam engine and a pillar engine with inverted cylinder, made at the works and still doing duty; but there is a modern horizontal engine in the forge, where draw-hooks are stamped out under the hammer. Most of the machine tools are by English makers, including a double key-way cutting machine by Sharp, of Manchester. Turntables, points and crossings are made here; but disc and other wheels are obtained from Krupp's and Bochum. A sketch is appended of the engine and tender coupling, in which there is a ratchet-brace arrangement with double pawl for coupling and uncoupling. An illustration is also given of the screw reversing gear that is now fitted to many of the engines, the bracket being in the form of a Roman seat. A great deal of work—pistons, for instance—usually made of iron is cast from brass turnings and borings, as this practice is found cheaper under existing circumstances. Carriages, guards' vans and wagons are also made at these works, the bodies of the two former being entirely covered with sheet iron. Ingegnere Doux is Works' Manager at Pietrarsa, which now employs about 650 men, and is shortly to be reconstructed and brought up to the level of modern practice.

The Granile Works are so called because of their proximity to the historic granaries near Naples, which give their name to the district. They also adjoin the works of Messrs. C. and T. T. Pattison, which employ about a thousand hands, and of which we have something to say in a separate article. The Granile Works, which, owing to the clear atmosphere, appear almost at the foot of Vesuvius, have had a considerable share in the industrial history of Italy, because they turned out the bridges for the Messina and Catania Railway, and the engines for such vessels as the Principe Amedeo, and the Scilla e Caribde, and

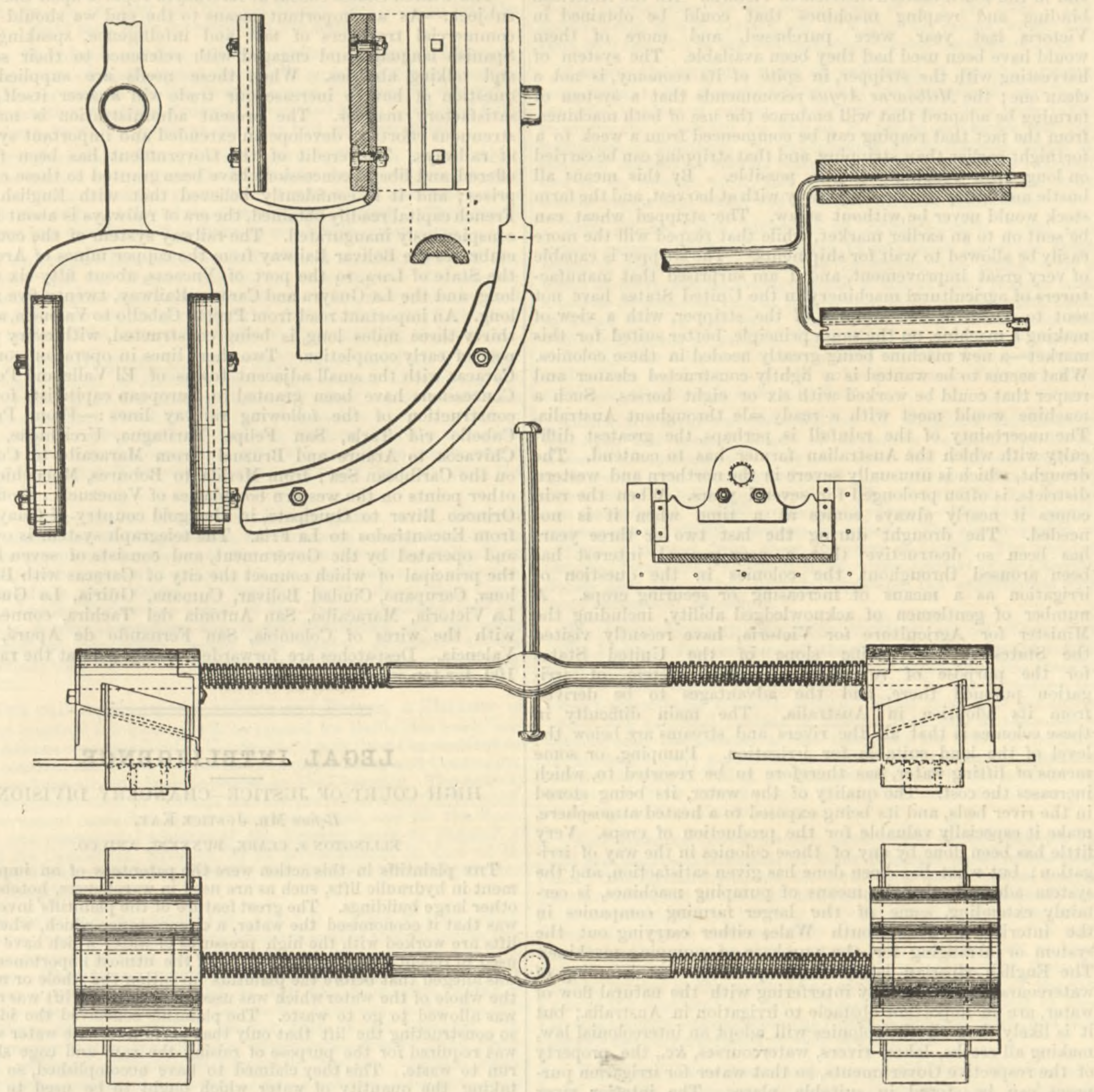


ENGINE AND TENDER COUPLING.

have always obtained high awards at exhibitions. To the Turin Exhibition of 1884 they sent the 60-H.P. engine, with Bouvret valve gear—a modification of the Corliss system—which drove the machinery in motion. The works were started by a M. Henri with only thirty-five or thirty-seven hands, but rapidly increased in importance under the Società Nazionale di Industria Meccanica, from 1863 to 1868, when the company got into difficulties, and the Government took the works in hand to prevent their being closed. In 1885 they were bought by the Mediterranean Railway Co. for about 5,000,000 lire = £200,000; and now it is decided to spend another million lire, or £40,000, in reconstructing them according to the annexed plan. All the iron and brass castings required for the Mediterranean system—iron 60 tons and brass 10 to 12 tons a month—are produced at the Granile Foundry. A very good foundry sand is obtained from Monte Sarchio, near Gaeta, in the province of Terra di Lavoro; but, as might be expected, the methods at present employed are not the most recent. There are, however, two new Voisin cupolas for melting the metal. Here are cast the abnormally large brake blocks with which the engines and tenders are provided. These works produce every part of a locomotive except axles, wheels, and tires, which latter are imported from Sheffield, but not the complete locomotive, only tenders. In the boiler shop, soon to be disestablished and transferred to Pietrarsa, the boiler shells are placed on rollers at the ends of cross beams, so that they can be easily turned in the absence of overhead travelling cranes. The wagon department, which is lighted by electric arc lamps, is provided with some good yet simple and inexpensive wood-working machinery, made on the spot, including a horizontal drilling and mortising machine, in which the drill is brought up to the work by a lever, and the cross travel given by the same means, the workman holding a lever in each hand and thus making a mortise very quickly. There are about 650 men employed at this establishment, which has turned out work of considerable importance with very slender means. The works' manager is Ing, Ferraro, Capo Sezione, who is under the Capo Opificio, Sig. Gramegna; but both the Granile and Pietrarsa works are in charge of the Capo Divizione, Cav. Fadda, who in turn looks for instructions to Commendatore Frescot at Turin.

While the reconstruction of the Granile Works is decided upon in accordance with the above plan, the remodelling of the Pietrarsa Works—a very necessary proceeding—is decided upon in principle, but not to take effect until that of the Granile is accomplished. An impression prevails at Pietrarsa that that establishment will share with the new works now being put up at Turin the task of providing new locomotives for the Mediterranean system; but we have it from headquarters that this will not be the case. As stated in our article on "The Mediterranean Railway"—see THE ENGINEER of 2nd December—all new locomotives, except the first of a type, will be let by open contract. At present Messrs. G. Ansaldo and Co., of Sampierdarena, near Genoa, supply a large number of locomotives to the Mediterranean Company, in continuance of the arrangement made with the Italian Goverment when the lines were worked by the State. These works are also being extended and modernised, and at the same time provided with some excellent machine tools, so as to be put under favourable conditions for retaining a large portion of the work in future, notwithstanding its being thrown open to public competition. When one compares some of the antiquated locomotive works in various parts of Europe, with complete modern shops like those of the L.N.W.R. at Crewe, the L. and Y. at Horwich, and those now being put up by the Mediterranean Company at Turin—to be described in a future number—the reason is abundantly manifest why some go to the wall, others are entirely reconstructed, and others again are transferred to more favourable situations.

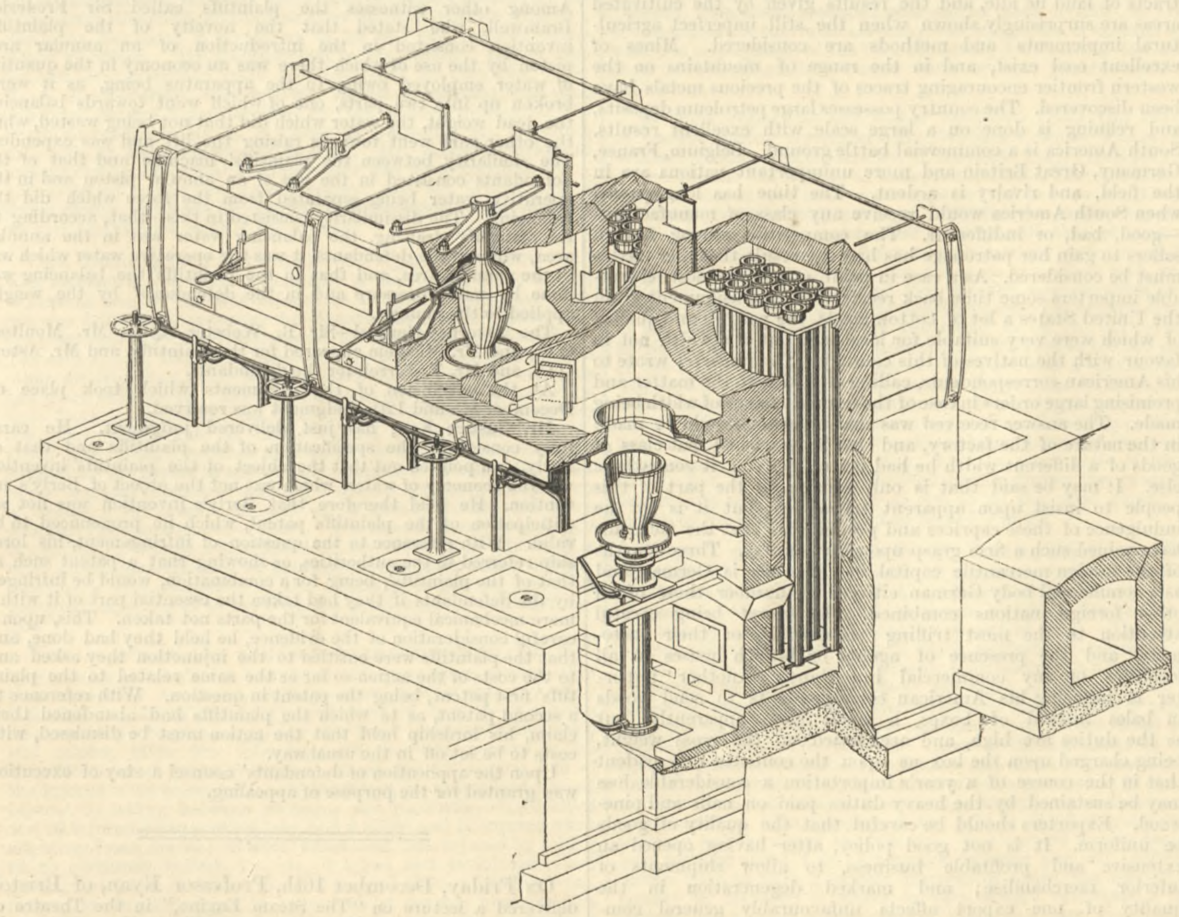
COBBETT'S BELT STRETCHER AND BELT GUIDES.



BELT GUIDES AND BELT STRETCHERS.

FOR the purpose of providing a better surface and decreasing the friction of belts against the surface of belt guides and forks for shifting belts, Mr. W. W. Cobbett has brought out the glazed porcelain guide attachments illustrated by the annexed engravings. Leather and cotton belts rub past these porcelain surfaces with an exceedingly small amount of friction, and last much longer without frayed edges than when the ordinary guides are used. The porcelain pieces are made for round or flat stems as shown. The belt clamps illustrated are also made by Mr. Cobbett. From the engravings it will be seen that the clamps automatically grip the belt. The loss of time usually occupied in fastening the ordinary screw clamps is thus avoided, for the action of turning the stretching screw brings the nuts down upon the automatic clamping piece, to which it is loosely attached by the guide projections on the lower part, as seen in the section at the upper part of the engraving.

THE CASTNER SODIUM FURNACE.

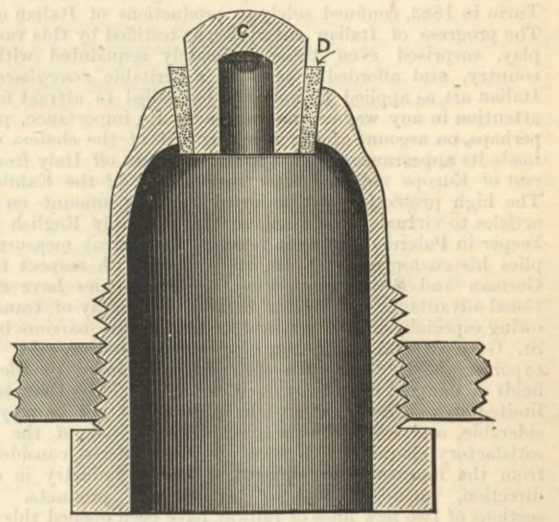


THE CASTNER SODIUM FURNACE.

IN our last volume a description of the method of producing sodium from caustic soda, invented by Mr. H. Y. Castner, of New York, was given at page 509, and we have now to supplement it by an illustration of the reducing apparatus employed. This consists essentially of a gas-fired air furnace open at the bottom, but which can be closed by a circular disc on the top of a hydraulic plunge. This disc also carries the cast-steel crucible in which the reduction is effected, the latter being connected to it by a pin passing through a socket at the bottom. The furnace is heated by gas from a Wilson producer, which is burnt by air previously brought to a high temperature in a pipe-stove placed in the path of the spent flame. Three of these reducing chambers are built together in one block and secured by iron back-staves, and the rods as shown in the accompanying figure, which represents the furnace in isometric projection with different parts in section. In the right-hand chamber the crucible is lowered to the position for filling, and the parts of the walls removed show the gas burner formed by the gas and air passages, and a deflecting plate to cause the flame to pass round the crucible. The air-heating pipes occupy the whole height of the furnace at the back. In the centre chamber the crucible is represented in the working position, the top cage being pressed home by the ram against the dome area forming the bolt-head, which conducts the sodium vapours by the side tube into the condenser in front. This cover is kept in position by a plug at the top, fixed into the centre of the three-armed casting at the roof of the chamber. The condenser is a cast iron box, whose width is very small when compared with its length and depth, placed in front of the chamber, in which the reduced metal condenses by cooling in an atmosphere of hydrogen. A strong rod with a spiral blade, passing through a packed gland on the condensers, keeps the delivery tube free from stoppage by solid matters. For a description of the working of the process we must refer to our former article. We believe that works for carrying it out on a large scale have been erected in South Staffordshire, near Birmingham. The gas admission and the hydraulic lifts are regulated by hand wheels and levers in front of each furnace.

WILLIAMS' FUSIBLE PLUGS.

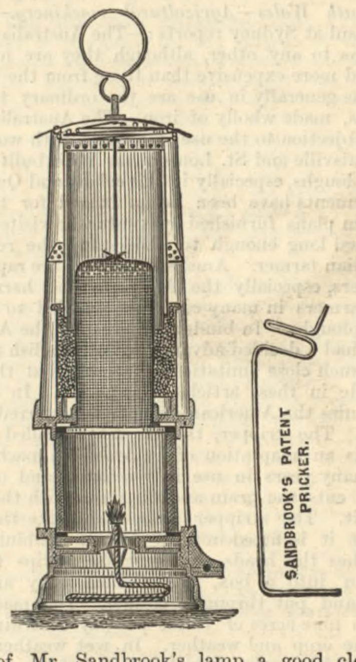
THE accompanying engraving represents a new fusible plug which has many excellent features. Its construction will be understood in a moment from the illustration. The fusible metal is supplied in the form of a ring, into which is driven a plug of gun-metal. The fusible metal is thus between two good



conductors, and is, therefore, admirably placed for prompt action; at the same time it is so far removed from the furnace, and protected by the cup in which it is set, that it can only be fused by the boiler plates getting hot—a consideration of importance. This fusible plug has already come into extended use. It is being introduced in Lancashire by Mr. Simon, of St. Anne-street. In the engraving, C is the gun-metal plug, D the fusible ring.

SANDBROOK'S SAFETY LAMP.

MR. SANDBROOK, of Ebbw Vale, is now introducing the safety lamp which we illustrate by the accompanying engraving. It will be seen that it is a lamp of the combination glass and gauze type, while it shuts off the admission of air and gas as soon as there is an explosive mixture. Coal dust has little or no effect on the lamp. The miners can with this lamp make a clean sweep, knocking off the cap at once from the top of the wick.



By the use of Mr. Sandbrook's lamp a good clear light is obtained at once. The locking arrangement is simply the old-fashion screw-lock, with a lead plug inserted behind the screw and stamped. It is, in fact, a double-locking arrangement—the screw and the lead plug. By this arrangement it is also possible to get the case off without taking the lamp out, which is a considerable advantage; or, the lamp can be taken out without taking the case off. Thus the fireman can use it to test gas, &c., just as well as with the old Clanny lamp. The shut-off appliances rest on a fusible plug, which will not fuse with the heat of the lamp, but when a blue flame of gas enters the lamp the plug melts, and all danger is prevented, it is claimed, at once. The lamp has been pronounced excellent by eminent mining engineers and colliery managers.

THE CIVIL AND MECHANICAL ENGINEERS' SOCIETY.—At the meeting of this Society on the 7th inst., an interesting address was delivered by the president, Mr. Regd. E. Middleton, M.I.C.E.

ABSTRACTS OF CONSULAR AND DIPLOMATIC REPORTS.

Italy.—Trade and foreign competition in Sicily.—With a yearly ascending total of imports, those of British origin have decreased in past years. Among the principal imports from England are coals, copper, iron, water pipes from Glasgow, lead, machines, tin plates, and zinc. All these are principally brought in English bottoms. The boats of the Flurio-Rubattino Company convey a considerable portion of the coal. About thirty steamers of this company go to America with fruit in the course of the year, returning either direct with petroleum or calling at England and importing coal or other English goods into Sicily. There has been a diminution in the importation of coals to the amount of 16,312 tons, valued at £23,208. The hardware trade is completely in the hands of the Germans, who keep a sprinkling of English goods to satisfy old-fashioned notions. The imports of iron, iron goods, machinery and metals was greater in 1886 than in 1885; that of iron and iron goods increased by 41,068 tons, valued at £28,777. The greater part of the iron importations came from Liverpool, of the imported water pipes from Glasgow. The British portion of these imports, which in 1885 formed 81 per cent., is on the decrease owing to Belgian competition, while formerly British iron was supreme in this market. The import of machinery, chiefly sewing-machines, has slightly increased. The decrease of British imports is due in some measure to the energetic action of the Germans and Swiss, who contrive every year to get a greater portion of the retail and wholesale trade of Sicily into their hands; but in a still greater degree to the progress made by the Italians in the north of Italy in the art of manufactures themselves, as was evidenced by the magnificent Exhibition at Turin in 1883, confined solely to productions of Italian origin. The progress of Italian enterprise, as testified by this vast display, surprised even those intimately acquainted with the country, and afforded a proof of a veritable *resorgimento* of Italian art as applied to industry, but failed to attract foreign attention in any way commensurate to its importance, partly, perhaps, on account of the breaking out of the cholera which made its appearance at that time, and shut off Italy from the rest of Europe not long after the opening of the Exhibition. The high protective duties levied in Italy amount on some articles to virtual prohibition, so that the only English shopkeeper in Palermo dealing in textures in a great measure supplies his customers with Italian goods. With respect to the German and Swiss competition, those countries have exceptional advantages over Great Britain in the way of transport, owing especially to the removal of the Alpine barriers by the St. Gothard and other tunnels; and, moreover, the great exporters of England turn their attention more to the vast fields of demand offered by our Colonies and India than to the limited area of Sicily, where the gains could not be very considerable, and where business relations are not of the most satisfactory character. France has also suffered considerably from the increased development of Italian industry in every direction, including that of agricultural products. Two sections of two new lines of railway have been opened this year, one of the direct line from Palermo to Messina, and one of the Central Sicilian from Palermo to Carleone. The line from Palermo to Cefalu is still running, but that from Palermo to Carleone has been stopped through the faulty construction of the line, which caused landslips during the winter rains. The coast line from Palermo to Messina will be much shorter than the line now open through Roccapalumba and Catania, which shoots off southwards, traverses the centre of the island, and then makes a sharp turn to the north. The whole length of the line is 210 miles. The more direct coast line will be about 173 miles long, and would be much shorter but that the line follows the undulations of the coast. Both lines are much called for in Sicily, as are others, many of the chief towns of the island, Cartagirone, Castelbuono, Mistretta, Rivona, Vizzini, &c., still being outside the system of railway communication; but railways in Sicily have been of slow growth, the present line from Messina to Palermo having been eighteen years in construction. The harbour works at Palermo are proceeding slowly. The depth of water is gradually being increased by dredging and flushing operations under the conduct of an English firm.

New South Wales—Agricultural machinery.—The United States Consul at Sydney reports:—The Australians prefer their own ploughs to any other, although they are much clumsier, heavier, and more expensive than those from the United States. The ploughs generally in use are the ordinary two and three furrow ones, made wholly of iron. The Australian farmer has a decided objection to the use of ploughs with wooden handles. Several Louisville and St. Louis firms have built up a trade in American ploughs, especially in this colony and Queensland; but these implements have been manufactured for the Australian market from plans furnished by agents who visited the colonies, and remained long enough to understand the requirements of the Australian farmer. American harrows are rapidly supplanting all others, especially the American disc harrows, for with them the farmers in many cases are enabled to dispense with the use of ploughs. In binders and reapers the Americans have heretofore had a decided advantage, but English manufacturers now make such close imitations of them that the competition for the trade in these articles is very keen. In some portions of the colonies the American stripper is preferred to the binder and reaper. The stripper, though usually called an Australian invention, is an adaptation of an American machine which has been for many years in use in California and other Western States. It cuts the grain and dispenses with the necessity for thrashing it. The stripper is operated like the binder and reaper, but it is fitted in front with a combining apparatus, which catches the heads of the grain, strips them off, and passes them into a box, from which they are discharged in a heap and put through a cleaner. The machine can cut from five to nine acres of wheat per day according to the condition of the crop and weather. In wet weather, or in early morning, it does not act well. Some of the machines have placed in them ordinary thrashing drums, which thrash any heads not stripped. The machines with drums attached are called damp-weather strippers. The stripper was first made in Adelaide, South Australia, where it is more popular than in any of the other colonies, but recently factories for its manufacture have been established in Melbourne and Sydney. The introduction of the American binder and reaper did not at first interfere with the supremacy of the stripper, especially in South Australia, but in time the American became a very formidable rival. In some localities where straw is regarded as being of little value the stripper is almost sure to be preferred; besides, harvesting with the stripper is generally admitted to be a very economical process, from there being only one loss instead of several, as in the different processes of binding, carting, stooking, and thrashing. In some districts of Australia the crops are so short and thin that they cannot very well be harvested with the reaper, and it is said that the practice of burning the straw on the field renders the land very fertile, an advantage which cannot be had when the reaper is used; but the reaper is becoming more popular, especially near the large cities and towns where straw is required, and is invariably used along the Goulburn and in the south-eastern districts of Victoria. All the American binding and reaping machines that could be obtained in Victoria last year were purchased, and more of them would have been used had they been available. The system of harvesting with the stripper, in spite of its economy, is not a clean one; the *Melbourne Argus* recommends that a system of farming be adopted that will embrace the use of both machines, from the fact that reaping can be commenced from a week to a fortnight earlier than stripping, and that stripping can be carried on long after reaping will be possible. By this means all bustle and hurry can be done away with at harvest, and the farm stock would never be without straw. The stripped wheat can be sent on to an earlier market, while that reaped will the more easily be allowed to wait for shipments. The stripper is capable of very great improvement, and I am surprised that manufacturers of agricultural machinery in the United States have not sent to Australia for samples of the stripper, with a view of making a machine, on the same principle, better suited for this market—a new machine being greatly needed in these colonies. What seems to be wanted is a lightly-constructed cleaner and reaper that could be worked with six or eight horses. Such a machine would meet with a ready sale throughout Australia. The uncertainty of the rainfall is, perhaps, the greatest difficulty with which the Australian farmer has to contend. The drought, which is unusually severe in the northern and western districts, is often prolonged for several years. When the rain comes it nearly always comes at a time when it is not needed. The drought during the last two or three years has been so destructive that a very general interest has been aroused throughout the colonies in the question of irrigation as a means of increasing or securing crops. A number of gentlemen of acknowledged ability, including the Minister for Agriculture for Victoria, have recently visited the States in the Pacific slope of the United States for the purpose of reporting upon the system of irrigation pursued there, and the advantages to be derived from its adoption in Australia. The main difficulty in these colonies is that all the rivers and streams are below the level of the land suitable for irrigation. Pumping, or some means of lifting water, has therefore to be resorted to, which increases the cost. The quality of the water, its being stored in the river beds, and its being exposed to a heated atmosphere, make it especially valuable for the production of crops. Very little has been done by any of these colonies in the way of irrigation; but what has been done has given satisfaction, and the system adopted, that by means of pumping machines, is certainly extending, some of the larger farming companies in the interior of New South Wales either carrying out the system or arranging for the purchase of pumping machines. The English riparian laws, which prohibit the damming of watercourses or in any way interfering with the natural flow of water, are an important obstacle to irrigation in Australia; but it is likely that all the colonies will adopt an intercolonial law, making all creeks, lakes, rivers, watercourses, &c., the property of the respective Governments, so that water for irrigation purposes can be stored in suitable places. The interior river system of New South Wales offers enormous facilities for water storage in the river beds, from which it is estimated that 5,000,000 acres can be supplied with irrigation water. The cost would be enormous, but the result would more than justify it, as an immense area of land is of excellent quality for the purpose.

Venezuela.—How to increase trade.—The United States Consul at Maracaibo reports:—As in all other parts of this Republic, much depression during the past twelve months, though Zulia has supplied less than any other section. As a home for immigrants, should the Government recognise the necessity of attracting foreigners, and comply with its duties towards the immigrants in assisting and protecting them, this section will be one of the most promising fields for successful colonisation. Immense tracts of land lie idle, and the results given by the cultivated areas are surprisingly shown when the still imperfect agricultural implements and methods are considered. Mines of excellent coal exist, and in the range of mountains on the western frontier encouraging traces of the precious metals have been discovered. The country possesses large petroleum deposits, and refining is done on a large scale with excellent results. South America is a commercial battle ground. Belgium, France, Germany, Great Britain and more unimportant nations are in the field, and rivalry is ardent. The time has long passed when South America would receive any class of manufactures—good, bad, or indifferent. The competition among foreign sellers to gain her patronage has had the result that her tastes must be considered. As a case in point, one of our most respectable importers some time back received in a consignment from the United States a lot of cotton goods, the pattern and quality of which were very suitable for local sale, but of a width not in favour with the natives of this country. The importer wrote to his American correspondents, calling attention to the matter and promising large orders in case of the desired change of width being made. The answer received was that no change could be made in the nature of the factory, and that if he wished that class of goods of a different width he had better look for it somewhere else. It may be said that is only caprice on the part of this people to insist upon apparent trivialities; but it is by the indulgence of these caprices and peculiarities that the Germans have gained such a firm grasp upon the country. Three-fourths of the foreign mercantile capital in Venezuela is German, and as a commercial body German citizens outnumber those of all other foreign nations combined, the secret being careful attention to the most trifling peculiarities of their customers, and the presence of agents or branch houses in all localities of any commercial importance. Another importer is inducing his American correspondents to send goods in bales instead of boxes, a small item apparently, but as the duties are high, and are levied on the gross weight, being charged upon the box as upon the contents, it is evident that in the course of a year's importation a considerable loss may be sustained by the heavy duties paid on nails and pine-wood. Exporters should be careful that the quality of goods be uniform. It is not good policy, after having opened an extensive and profitable business, to allow shipments of inferior merchandise; and marked degeneration in the quality of one export affects unfavourably general commercial reputation. I must also call attention to the importance of personal representation of our manufacturers and merchants. One bright agent will do more in a week than can be accomplished by months of correspondence. Every mail brings numbers of letters requesting the assistance of the consulate in establishing business relations. Occasionally satisfactory results have been obtained, but most of the houses here are conservative in their ideas, and it is not often that they will be persuaded to step out of their beaten track by means of correspondence. It is different when they are approached personally, and even in the times of greatest business stagnation no capable commercial traveller has ever left Maracaibo without having reaped some benefit from his visit.

The United States consul at La Guayra reports upon the same subject:—As an important means to the end we should have commercial travellers of tact and intelligence, speaking the Spanish language, and engaged with reference to their seeing and talking abilities. When these needs are supplied the question of how to increase our trade will answer itself in a satisfactory manner. The present administration is making strenuous efforts to develope an extended and important system of railways. The credit of the Government has been freely offered, and liberal concessions have been granted to these enterprises; and it is confidently believed that with English and French capital readily obtained, the era of railways is about to be conspicuously inaugurated. The railway system of the country embraces the Bolivar Railway from the copper mines of Area, in the State of Lara, to the port of Yncacas, about fifty-six miles long, and the La Guayra and Caracas Railway, twenty-five miles long. An important road from Puerto Cabello to Valencia, about thirty-three miles long, is being constructed, with every prospect of early completion. Two short lines in operation connect Caracas with the small adjacent towns of El Valle and Petare. Concessions have been granted to European capitalists for the construction of the following railway lines:—From Puerto Cabello *viâ* Tarla, San Felipe, Yaritagua, Urcichiche, and Chivacoa to Araure and Bruzual; from Maracaibo to Cojaro, on the Caribbean Sea; from Merida to Bobures, Mucuchies, or other points on the western boundaries of Venezuela; from the Orinoco River to Guicipata, in the gold country of Guayana; from Encontrados to La Fria. The telegraph system is owned and operated by the Government, and consists of seven lines, the principal of which connect the city of Caracas with Barcelona, Carupano, Ciudad Bolivar, Cumana, Güiria, La Guayra, La Victoria, Maracaibo, San Antonia del Tachira, connecting with the wires of Colombia, San Fernando de Apuré, and Valencia. Despatches are forwarded to any part at the rate of 10d. for ten words.

LEGAL INTELLIGENCE.

HIGH COURT OF JUSTICE—CHANCERY DIVISION.

Before Mr. Justice Kay.

ELLINGTON *v.* CLARK, BUNNETT, AND CO.

The plaintiffs in this action were the patentees of an improvement in hydraulic lifts, such as are used in warehouses, hotels, and other large buildings. The great feature of the plaintiffs' invention was that it economised the water, a circumstance which, when the lifts are worked with the high pressures of water which have been used in recent times, is, it was said, of the utmost importance. It was alleged that before the plaintiffs' invention the whole or nearly the whole of the water which was used each time the lift was raised was allowed to go to waste. The plaintiffs conceived the idea of so constructing the lift that only that portion of the water which was required for the purpose of raising the ram and cage should run to waste. This they claimed to have accomplished, so that, taking the quantity of water which ought to be used to raise 700 lb. or 800 lb. 60ft. as 32 gallons, while under the former process the whole of those 32 gallons ran to waste, under the plaintiffs' invention only 4½ gallons were wasted. The means whereby this was accomplished was, roughly speaking, by applying pressure separately at different points of the ram, and, by keeping the pressure constant at one point and varying it at the other, the lift could be lowered with the loss only of the water used at the point of varying pressure. In the plaintiffs' invention the constant as well as the varying pressure was a water pressure. The defendants had constructed hydraulic lifts which according to the plaintiffs' allegation, were identical with those of the plaintiffs, except that the constant pressure was a weight which was applied at a different part of the machine. The defendants denied the infringement and the validity of the patent, alleging that the plaintiffs' invention had been anticipated by an invention of a Mr. Berly, the specification of which was filed a few days before that of the plaintiffs. Among other witnesses the plaintiffs called Sir Frederick Bramwell, who stated that the novelty of the plaintiffs' invention consisted in the introduction of an annular area piston by the use of which there was an economy in the quantity of water employed owing to the apparatus being, as it were, broken up into two parts, one of which went towards balancing the dead weight, the water which did that not being wasted, while the other part went towards raising the lift and was expended. The similarity between the plaintiffs' machine and that of the defendants consisted in the use of an annular piston and in the operative water being separated from the force which did the balancing. The dissimilarity consisted in this—that, according to the plaintiffs' drawing, the balancing water was in the annular area, while in the defendants' it was the operative water which was in the annular area, and that in the plaintiffs' the balancing was done by water pressure and in the defendants' by the weight applied to the plunger.

The Attorney-General—Sir R. Webster, Q.C.—Mr. Moulton, Q.C., and Mr. Micklem appeared for the plaintiffs, and Mr. Aston, Q.C., and Mr. T. Terrell for the defendants.

At the conclusion of the arguments which took place on December 8th and 12th, judgment was reserved.

Mr. Justice Kay, has just delivered judgment. He carefully considered the specification of the plaintiffs and that of Berly, and pointed out that the object of the plaintiffs' invention was the economy of water, which was not the object of Berly's invention. He held therefore that Berly's invention was not an anticipation of the plaintiffs' patent, which he pronounced to be valid. With reference to the question of infringement, his lordship referred to the authorities, as showing that a patent such as that of the plaintiffs', being for a combination, would be infringed by the defendants if they had taken the essential part of it with a mere mechanical equivalent for the parts not taken. This, upon a careful consideration of the evidence, he held they had done, and that the plaintiffs were entitled to the injunction they asked and to the costs of the action so far as the same related to the plaintiffs' first patent, being the patent in question. With reference to a second patent, as to which the plaintiffs had abandoned their claim, his lordship held that the action must be dismissed, with costs to be set off in the usual way.

Upon the application of defendants' counsel a stay of execution was granted for the purpose of appealing.

On Friday, December 16th, Professor Ryan, of Bristol, delivered a lecture on "The Steam Engine," in the Theatre of the University College, Nottingham. In illustration of the subject of rotary engines, models of the Tower spherical engine—Messrs. Heenan and Froude—and of the Fielding engine—Fielding and Platt—were exhibited, eliciting considerable interest. Some remarkably good recent results obtained with the former were quoted. The pulsometer and several models and experiments were exhibited. Modern valve gears were dealt with, and Cawley's gear illustrated. Interesting reminiscences of the surface condensers invented by Samuel Hall, of Basford, were supplied by Mr. G. R. Cowen, of the Beck Ironworks, where it was originally constructed. Nearly 800 persons were present.

RAILWAY MATTERS.

WHILE clearing snow-drifts on the Caraquet and New Brunswick Railway an engine and tender, with snow plough, got off the line on crossing the Caraquet Bridge, and plunged into the river. Eight men were drowned and five hurt.

IN Monday's sitting of the Swiss National Council, Berne, it was officially stated, in reply to an interpellation concerning the repurchase of the North-Eastern Railway by the Swiss Confederation, that the Federal Council had made an offer of 450f. per share, to which, however, no reply had yet been given.

THE *American Manufacturer* says:—"It is stated that the car famine in the Connellsville district is growing worse, and that on this account the production of coke is not more than two-thirds the full capacity of the ovens in the district." This seems curious in a country that is doing so much with natural gas.

A CONTRACT has been made between the Ministry of the Interior and the United Steamship Company of Copenhagen regarding regular communication twice a week, every Tuesday and Saturday, between Esbjerg, Jutland, and London, *viâ* Parkeston. This route will be opened for traffic at the beginning of January.

THE Birmingham Town Council sanctioned on Tuesday the contribution of £1000 towards the expenses of carrying out improvements at the Saltley Railway Viaduct, which would cost in the aggregate about £6000. It is proposed to widen the viaduct at Saltley, carrying the road over the Midland Railway and river Rea, with a view to complying with the conditions under which alone the Central Tramway Company can carry their line over the viaduct.

A DEPUTATION from the Birmingham and District Association for the Suppression of Nuisances arising from Steam Trams presented the Mayor of Birmingham (Councillor Pollock) on Friday with a memorial praying for an amelioration of nuisances arising from steam trams. In replying to the deputation, Councillor Lawley Parker—on behalf of the Mayor—promised that the Public Works Committee, the Watch Committee, and the other committees concerned, would give careful attention to the memorial that was to be presented, and to the views of the deputation.

THE railway between Athens and Patras, a distance of three hundred kilometres, will be opened for traffic this week, and the Athens correspondent of the *Standard* says "the Conventions for the construction of other lines in the Peloponnesus and Continental Greece have already been approved by the Chamber. The activity in the construction of railways that has prevailed since the Tricoupis Government came into power is unprecedented, and all the financial and commercial schemes of the Premier seem to succeed, so that the Opposition, irritated by its powerlessness in face of the compact majority of the Ministry, has decided to withdraw from the Chamber."

MESSRS. SHARP, STEWART, AND CO., Atlas Works, Manchester, announce the approaching removal of their business from their present address, in anticipation of the expiration of their leases. They have arranged to transfer their business to Glasgow, where it will be continued at the new locomotive works recently erected by the Clyde Locomotive Company, under the style of Sharp, Stewart, and Co., Limited, Atlas Works, Glasgow. The company will have the following directorate—Messrs. John Robinson, chairman; Walter Montgomerie Neilson, William Steele Tomkins, Archibald Gilchrist, John Frederick Robinson, Alexander Wilson. Mr. J. F. Robinson will take the post of managing director, and will have the assistance of Mr. Alexander Wilson. Mr. Tomkins will for the present remain in Manchester, where the existing works will continue open until certain contracts now in hand are completed, and his services will be at the disposal of the company for transacting business in London and elsewhere.

THE Manchester, Sheffield, and Lincolnshire Railway Company is about to lose the services, through ill-health, of one of its ablest and most respected officers, Mr. William Bradley, the chief superintendent of the line. Mr. Bradley has been with the company for a quarter of a century, having previously been a district superintendent on the Great Northern Railway. For a considerable time he has been in indifferent health, to recruit which he obtained six months' leave two years ago, when he visited the south of France and cruised in the Mediterranean. Few men will be more missed from the wide extent of country covered by the Manchester, Sheffield, and Lincolnshire Railway than Mr. Bradley, who is as courteous a gentleman as he was efficient and painstaking an officer. His successor will be Mr. Richard Brown, who has had some seventeen years' experience with the company. Mr. H. A. P. Hamilton, who was Mr. Bradley's assistant, has been appointed district superintendent for the eastern division of the line in succession to Mr. H. B. Coens, of Retford. Mr. Hamilton will take up his residence at Retford. Mr. Richard Barker, at present chief goods agent at Manchester, has been appointed outdoor assistant to the new superintendent, and Mr. Williamson, of Guide Bridge, succeeds Mr. Barker at Manchester. Other changes are made in various parts of the system.

OUR Birmingham correspondent says:—"A trial trip with an electric car was, on Thursday of last week, made on the Willenhall line of the Wolverhampton Tramways Company. The car was built at Shrewsbury for Messrs. Elwell and Parker, who are preparing it for the Australasian Electric Tramway Company. The car has been built and fitted on the plan of continental and other electric lines, with which Messrs. Elwell and Parker have had much experience. The accumulators are slipped in under the seats from the outside, and carry about 100-horse power for one hour which can be taken by the motor placed underneath, and through switches arranged at each end of the car manipulated by the driver in any quantity required to meet the work of the car, and capable of running the latter for about seven hours of ordinary full work. In this car a great advance has been obtained upon any previous effort. The electric motor is arranged to give high power at a slow speed of revolution, and admits of a very simple arrangement of gearing to the main axles. It promises to be very successful, as the difficulty of gearing has been the great impediment to the adoption of this mode of driving tramcars."

THE report on the accidents to passengers on our railways during the first nine months of this year from causes other than accidents to trains, rolling stock, permanent way, &c., including accidents from their own want of caution or misconduct, accidents to persons passing over level crossings, trespassers, and others, gives the following:—Of the 344 persons killed and 706 injured in this division, 75 of the killed and 542 of the injured were passengers. Of the latter, 17 were killed and 47 injured by falling between carriages and platforms, viz., 8 killed and 29 injured when getting into, and 9 killed and 18 injured when alighting from, trains; 13 were killed and 366 injured by falling on to platforms, ballast, &c., viz., 2 killed and 44 injured when getting into, and 11 killed and 322 injured when alighting from, trains; 24 were killed and 14 injured whilst passing over the line at stations; 52 were injured by the closing of carriage doors; 2 were killed and 17 injured by falling out of carriages during the travelling of trains; and 19 were killed and 46 injured from other causes. 51 persons were killed and 26 injured whilst passing over railways at level crossings, viz., 23 killed and 23 injured at public level crossings, 17 killed and 3 injured at occupation crossings, and 11 killed at foot crossings. 141 persons were killed and 87 injured when trespassing on the railways; 49 persons committed suicide on railways; and of other persons not specifically classed, but mostly private people having business on the companies' premises, 28 were killed and 51 injured.

NOTES AND MEMORANDA.

THE deaths registered during the week ending December 10th, in twenty-eight great towns of England and Wales, corresponded to an annual rate of 21·1 per 1000. The annual death rate in London per 1000 from all causes, which had been 23·0 and 21·1 in the two preceding weeks, declined to 19·5.

AMONG the various uses of celluloid, it would appear—according to the *Annales Industrielles*—to be a suitable sheathing for ships, in place of copper. A French company now undertakes to supply the substance for this at 9f. per square-metre and per millimetre of thickness. In experiments by M. Butaine, plates of celluloid applied to various vessels in January last were removed five or six months after, and found quite intact and free from marine vegetation, which was abundant on parts uncovered.

THE Rhine Falls, situated at Schaffhausen, form the largest cataract in Europe. Some twenty miles below the point where it issues from the Lake of Constance, the Rhine, with a width of 350ft. and an average depth of about 21ft., plunges over a barrier of rocks varying in height from 45ft. on the right bank to about 60ft. on the left. Including the rapids the total fall within a distance of a little over a third of a mile is estimated at 150ft. The volume of water passing over the falls per second varies from a minimum of 118 cubic metres in February to a maximum of 502 cubic metres in July.

SOME work on the combustion of weighed amounts of hydrogen and atomic weight of oxygen is described by E. H. Keiser. Palladium was weighed with and without occluded hydrogen, it was then heated, and the hydrogen thus expelled passed over heated copper oxide. The water which was formed was also weighed. 1·5935 grammes of hydrogen—from three experiments—gave 14·23972 grammes of water. The atomic weight of oxygen calculated from these numbers is 15·872. The number obtained from Stas's figures is 15·84. The *Journal of the Chemical Society* says the author intends repeating the experiments with large amounts of palladium.

M. JULES GIRARD has been writing in *La Nature* on "The Probable Temperature of the Pole," based upon the results of the circumpolar expeditions of 1882-83, and upon the observations of some earlier expeditions, in which he has tabulated the mean temperatures for each month. From these data the author traces two principal centres of intense cold, one in the north of Siberia, near the mouths of the Lena, and the other to the north of Hudson's Bay, near Boothia. The lowest mean temperature quoted for July is 30 deg. at Jeannette Island, to the north of the islands of New Siberia, and the lowest mean for January is − 49 deg. at Fort Yukon, Alaska.

THE Russian Government have made arrangements for day and night storm signals at their principal ports in the Black Sea. The signals are shown for forty-eight hours, unless instructions are received to lower them before that time has elapsed; also, the cause assigned for hoisting each signal will be posted up at the respective signal stations. The day signals consist of a cone, hoisted either alone or with a drum, both painted black, and each about 3ft. in diameter. The night signals consist of three red lights, hoisted at the angles of an equilateral triangle, of the same size as the cone used by day. These signals correspond to those in this country—except that the drum is not now used, and night signals are only exhibited at very few stations.

NOW that there is so much being said about the discovery and probable working of gold-bearing strata in Wales, the following extract from "Jenkinson's Practical Guide to North Wales" may be instructive:—Merionethshire is the only county in Britain where gold has been mined to any extent and at a profit. It was when examining the Cwm Eisen lead mine in 1844 that Mr. Arthur Dean found fragments of quartz in the *debris* of the mine that gave as much as seven ounces of gold to the ton. Local adventurers now set to work, the principal of whom, at the old Vigra and Clogau mine were, after many disappointments and failures, under which they were reduced financially to *extremis*, rewarded with a cluster of bunches of gold to the value of nearly £40,000. Their good luck created a gold fever in the district. Companies were formed, machinery bought, and, without much preliminary survey, lavish expenditure was incurred. The result was ruin, and the hill sides are to this day strewn with the wreck of the machinery. One mine only, the Clogau, produced gold in 1876. Its yield was 288 oz. 18 dwt. 6 gr., of the value of £1119. Another mine near Dolgelly, Cefn Coch, produced gold to the value of £100 in 1875. It is yet possible that with economy and judgment in mining, and with the employment of the best machinery for dressing the ores, some of the mineralised quartz veins will yet pay to work for gold."

IN their report on the water supplied from the rivers to London during November, Mr. William Crookes, F.R.S., Dr. William Odling, F.R.S., and Dr. C. Meymott Tidy, F.R.S., say:—"Save on the occurrence of exceptional floods, the variations in the character of the river water supplied to London are, for the most part, very limited in range. Within the range, however, some variation usually makes itself manifest with the coming on of the month of November, and accordingly a slight variation in the composition and character of the water, as prevailing with great uniformity during the previous four months, was recognisable in last month's supply. Thus the mean proportion of organic carbon in the Thames-derived supply was found to be ·145 part, with a maximum in any one sample examined of ·166 part in 100,000 parts of the water, as against a mean of ·137 part, and a maximum of ·169 part in the preceding four months' supply, the variation, it is observable, being very insignificant. Similarly as regards the colour-tint of the water—almost always too small to be appreciable by ordinary observation, but capable of being measured by suitable instruments—it is noticeable that while the mean ratio of brown to blue tint in the Thames-derived supply during the preceding four months was found to be as 4·6 to 20, the ratio during the month of November was found to be as 6·5 to 20."

FROM a report by Mr. W. H. Preece, F.R.S., on Mr. Schanschieff's primary batteries, it appears that the peculiar novelty of the cell, which distinguishes it from others, is the character of the solution, and the means by which the residue of the battery can be recuperated by means of heat. The cell is a zinc carbon, and the solution basic sulphate of mercury. A very accurate series of measurements were made with a lamp which produced one candle power light for eight hours, at a cost for materials consumed of 1d. The residue of this battery is principally mercury, but zinc is also consumed, and is converted into sulphate of zinc. The mercury which is thrown down by the decomposition of the mercuric sulphate can either be reconstructed into mercuric sulphate by Mr. Schanschieff's process, or it can be sold in the market or taken in exchange in part payment for additional solution. The duration of the light is simply a question of the lamp and the size of the battery. One ampère flowing for one hour requires about 1 oz. of mercuric solution per cell. Given a certain lamp to burn a certain number of hours, the size of the battery to maintain it alight is very simply calculated. The battery has a high electro-motive force and very low internal resistance. It is highly efficient, is a constant cell, showing almost entire freedom from polarisation; it is eminently adapted for portable lighting, miners' lamps, and many other purposes; no gas, or smell, is given off from the battery either when at work or at rest; it is as easily charged by an ordinary workman without risk of failure, as an existing lamp is filled. The four-cell miner's lamp weighs only 5 lb., and can be kept for any length of time ready for use, without any consumption of materials or loss of energy. It will cost for lighting, taking everything into consideration, about one penny per shift.

MISCELLANEA.

IT is announced that the old-established business of engineers, coppersmiths, white lead, and chemical manufacturers, carried on by Messrs. Pontifex and Wood for upwards of a century, has been converted into a limited company. No shares, however, will be issued to the public.

ON Wednesday last Messrs. Fuller, Horsey, Sons, and Cassell sold at the Mart, Tokenhouse-yard, 180 tons old Government boiler tubes lying at Portsmouth, Devonport, Chatham, and Sheerness Dockyards, in the presence of a large company, and the price realised was from 4¾d. to 5d. per lb.

THE operatives in the Birmingham brass trades are negotiating a conference with the operatives with a view to considering "the restoration of the 5 per cent. bonus which was conceded by the men to the employers during the severe commercial depression of 1879, and also for other reforms, including the establishment of a Conciliation Board."

IT is stated that in various military districts of North and South Germany, as well as in Holland, trials have been made of wire soles covered with a substance resembling india-rubber. These soles are said to be more durable than those made of leather, and to cost only about half the price of leather. These soles have hitherto been made at Nuremberg, where they were invented by a retired glove manufacturer named Lindner.

MR. A. S. TUCKER, of Euston-road, sends a four-fold pocket foot-rule, with the scales of ⅛in., ¾in., 1in., and 1½in. to the foot, and a calendar for the year 1888 printed on card in gold, black, and red, and as accurately divided as possible by printing. A linen lining runs through the card. Mr. Tucker says those "who wish one sent by post must send twopence in stamps, and should the result be a profit, I will hand the same over to a charitable fund."

THE Remington type-writer, now manufactured by Messrs. Wykoff, Seamans, and Benedict, has been greatly improved both in design and workmanship. The chief improvements consist in enlarging the bearings of the type levers, hanging them on two circles of centres, so that the types lie in an oval plane and do not foul one another, and locking the paper roll carriage when in the position for writing. Perfect rigidity is given to the carriage by lengthening the rocking bar to the whole width of the machine, which permits of two locking arms being introduced, thus causing the line of printing to be perfectly straight.

AT a recent meeting of the University College Engineering Society, Professor Alex. B. W. Kennedy in the chair, Mr. J. Thoraton read a paper on "Dynamos." After touching briefly on the history of the dynamo, Mr. Thoraton described the essential working parts giving at the same time the theoretical explanation of each. The different work which the series shunt and compound machines are used for was next treated, the method of compounding being explained. The author next described some of the dynamos in the market with direct current and alternating, concluding with an account of the ordinary method of testing dynamos, and also of a static test for the determination of the magnet coil windings.

AN inquest was held this week at Pelsall upon the deaths of the three men who were killed by the explosion of a boiler at No. 19 pit of the Pelsall Coal and Iron Company. The colliery engineer said that since the explosion he had found that the plates of the boiler were corroded and thinned in a line along the side under the brickwork, and that, he thought, was where it had first given way, the plates being ripped right along that line. This corrosion, which he imagined had arisen from earth-damp, could not have been discovered without taking the boiler off its seat. The plates were also thinned in other parts. As Mr. E. B. Marten, C.E., engineer to the Midland Boiler Company, has been instructed to make an examination of the boiler, the inquiry was adjourned.

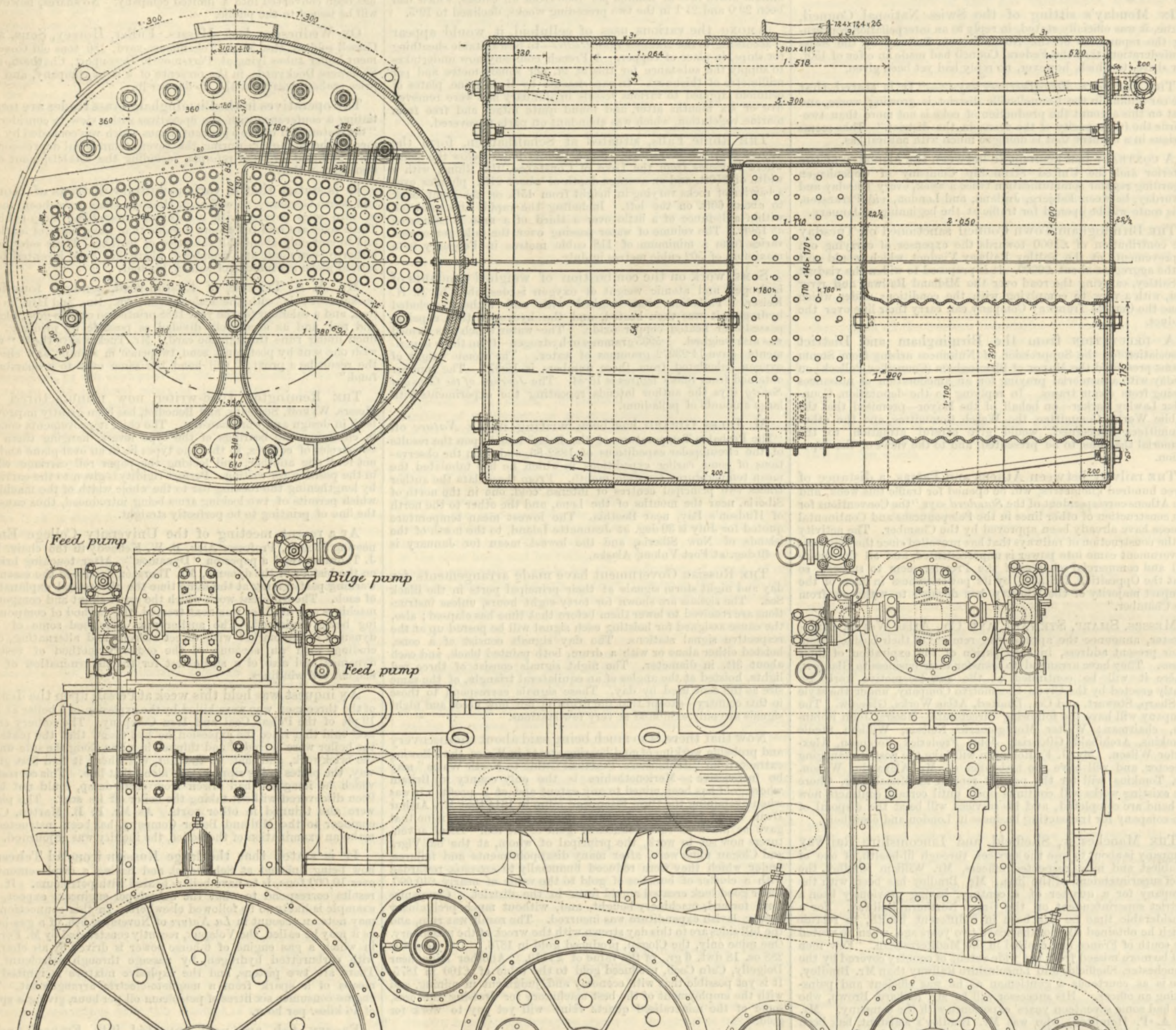
IT is stated that the large Russian ironclad Tchesme, now being finished at Sebastopol, and having a displacement of over 10,000 tons, is to have boilers heated with petroleum. If the results correspond to what the Sebastopol engineers expect, the example is likely to be followed elsewhere. In this connection we may note an account in *La Nature* of November 5th, of a gas-boat, as it may be called, the Volapuk, recently constructed by M. Forest, in which a gas engine of 6-horse power is driven by air charged with carburetted hydrogen, by passage through petroleum oil. There are two pistons, and the explosive mixture is ignited by means of a spark from a magneto-electric arrangement. The engine consumes six litres of petroleum oil per hour, giving a speed of 16 kilos. per hour.

FROZEN fish are now imported into France, and a society formed in Marseilles for the purpose of developing the trade—the Société du Trident—has a steamer and a sailing vessel engaged in it. The steamer Rokelle lately came into Marseilles with some 30,000 kilogrammes of frozen fish in its hold, the temperature of which is kept at 17 deg. C. below zero by means of a Pictet machine—evaporating sulphurous acid. The fish are caught with the net in various parts of the Mediterranean and Atlantic. After arrival they are despatched by night in a cold chamber. Experiment has shown that fish can be kept seven or eight months at low temperature without the least alteration. These fish are wrapped in straw or marine Algæ, and have been sent on to Paris, and even to Switzerland.

AT the Mason College, Birmingham, Mr. A. Wilson, engineer, of Stafford, lectured last week, on "Water Gas for Heating and Illuminating." The water gas, which had proved so successful in steel melting, and was extensively used as an illuminant, was produced as follows:—A cupola-shaped furnace is employed, in which coke is raised to an incandescent heat by means of a blast of air. When it reaches that temperature steam is passed through it, with the result that an inflammable mixture of hydrogen and carbonic oxide is obtained. This mixture is then passed through a water scrubber in the ordinary way, and thence goes to the gasholder. It is burnt as an illuminant with the aid of a new incandescent burner known as the Fahnejelm magnesia comb, and is so brilliant that a No. 3 Bray burner gives a light equal to that of twenty sperm candles of standard make. Water gas is a very old invention. We may add that very large sums have been expended in the United States in the endeavour to get it into use, without any success. As a heating gas it is in its way quite satisfactory; as an illuminating gas it cannot compete with carburetted hydrogen.

THE large raft of logs which was being towed from Canada to New York, as mentioned in our last impression, was lost on Sunday last in latitude 40 deg. 16 min., longitude 70 deg. 6 min., in a gale, and it is believed to be now drifting in a southerly direction. It was composed of 27,000 logs, bound together with heavy iron chains, and it is believed that the structure will hold together for a long time, in which case there is reason to fear that it will become a danger to navigation, as it is only 15ft. out of water. The raft is 560ft. long, 65ft. wide, and 38ft. deep. The 27,000 logs forming it measure 500,000 lineal feet of timber, valued at £30,000. The steamer Miranda, which was towing the raft, had lengthened her hawsers and tried to make the strain easy with the raft 940ft. behind, but off the Nantucket Shoals a terrific gale sprang up and the large hawser broke with a tremendous snap, and the small hawser tore the bitts to which it was fastened clear out of the deck. It was found impossible to pick up the raft, which was last seen sixty miles off Block Island, drifting southwards. It is considered that one touch of it would cause as much damage to a vessel as striking a rock. An American Government vessel has been sent to look for it.

BOILERS AND ENGINES, GERMAN MAIL STEAMERS.



BOILERS AND ENGINES OF THE ORIENTAL ASIA MAIL STEAMERS.

In our impression for December 2nd we illustrated the triple-expansion engines of the German steamers built by the Vulcan Works Company, Bredow, near Stettin, and we now give a general plan of the engines and sections of the boilers. Each ship is fitted with four main and two auxiliary boilers. They are made of Siemens-Martin steel, except the tubes, which are of iron. The four main boilers are double-ended. They are grouped in pairs and fired fore and aft. They are 12ft. 6in. diameter and 17ft. 5in. long. The furnaces are 3ft. 8in. diameter, and the grates are 6ft. 3in. long. Each square metre = 10·76 square feet—produces 341 indicated horse-power, the total indicated power being 3500. Of the two auxiliary boilers one is employed for working the steam winches, while the other and smaller boiler is chiefly used for heating the saloon and state rooms.

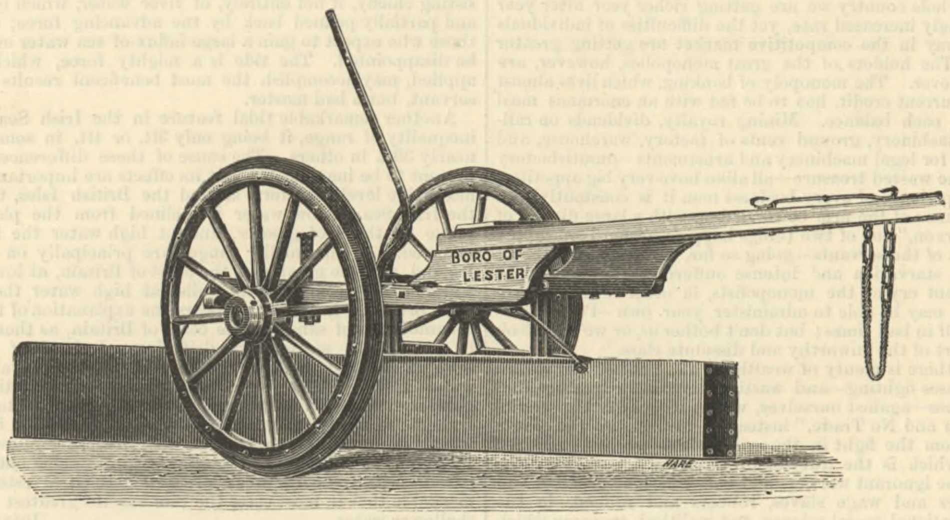
The cooling water for the condenser is supplied by two centrifugal pumps with fans 2ft. 6in. diameter. The boilers can be supplied with water when the main engines are standing by a Körtings injector, as well as by donkeys supplied with steam by the auxiliary boilers; a pulsometer is then used for draining the bilges and supplying the baths.

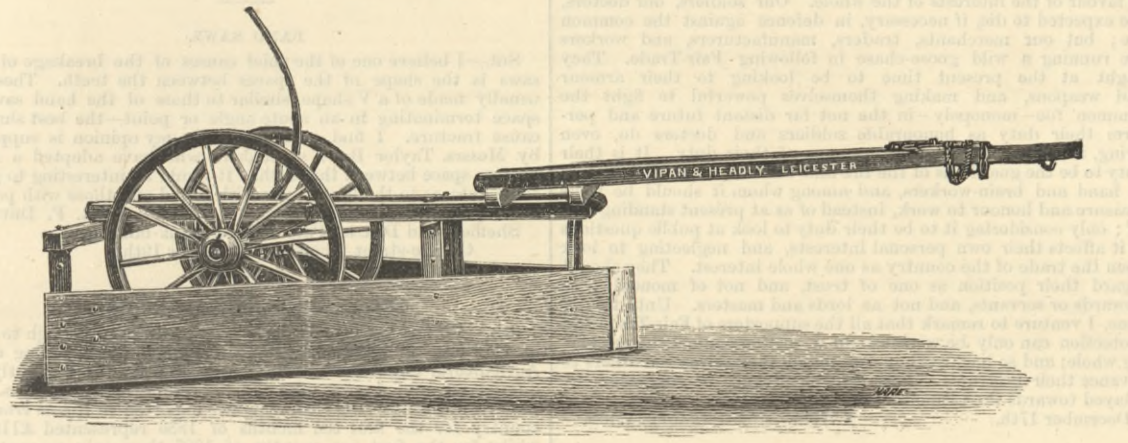
The official trial of the ship gave the following results:—Mean draught of the ship, 19ft. 11in.; displacement, 6000 tons; pressure, 143 lb. per square inch; horse-power indicated, 4000; revolutions, 68 per minute; speed of ship, 14·72 knots; slip of propeller, 10·9 per cent.; coal per horse-power per hour, 1·6 lb.

THE GREAT EASTERN.—The famous Great Eastern steamship, which is now lying in the Clyde, has been purchased from the first mortagee by a well-known firm of metal brokers having establishments in London, Liverpool, and Swansea. Their Glasgow representatives have been instructed to take possession of the vessel. It is understood that the huge hulk is to be broken up, the cost of which operation is estimated to be from £10,000 to £15,000. The cost of purchase was £16,500.

THE LATE PROFESSOR BALFOUR STEWART.—We regret to announce the death of Professor Balfour Stewart, M.A., LL.D., F.R.S. Mr. Balfour Stewart, who had only just completed his fifty-ninth year, was educated at the Universities of St. Andrews and Edinburgh. In 1859 he was appointed to the directorship of the Kew Observatory, and in 1867 to the secretaryship of the Meteorological Committee, which last appointment he resigned on his promotion to the Professor's chair of Natural Philosophy in Owens College, Manchester, in the year 1870, a post which he held until his death. Two years before this distinction was conferred upon him he had been awarded the Rumford medal by the Royal Society for his discovery of the law of equality between the absorptive and radiative powers of bodies. Together with Messrs. De la Rue and Loewy he wrote "Researches on Solar Physics," and he and Professor Tait published their researches on "Heating produced by rotation in Vacuo." Besides these he wrote a number of treatises especially on the subjects of meteorology and magnetism. The article in the "Encyclopædia Britannica" on "Terrestrial Magnetism" is from Professor Balfour Stewart's pen. Among the many works of which he was sole or joint author may be mentioned the "Elementary Treatise on Heat," "Lessons in Elementary Physics" (1871), "Physics" (1872), "The Conservation of Energy" (1874), and "Practical Physics" (1885). Most of these are text-books on the subjects of which they treat. He and Professor Tait also produced the "Unseen Universe," a work of which twelve editions have been published. At the time of his death he was President of the Physical Society of London, and was a member of the committee appointed to advise the Government on solar physics. Professor Balfour Stewart died on Monday last at Ballymagarvey, Balrath, in the county of Meath.

LEICESTER SNOW PLOUGHS.





SNOW PLOUGHS.

THE coming weather—or the weather that may be expected to be coming—will make implements of the kind here illustrated necessary. These snow ploughs are made to clear a centre track and two side tracks, so that three following each other clear a total width of 21ft. Fig. 1 clears the centre track of 7ft., and two as shown at Fig. 2, one right-hand and one left-hand, each clear 7ft., so that the whole 21ft. of snow can be cleared into the roadsides at one passage of the implements. The wheels of the side-clearing plough are fitted with annular plates of iron bolted to the sides of the felloes, to prevent the side skidding by the side thrust of the plough breast. These ploughs, made by Messrs. Vipan and Headly, are very highly spoken of by Mr. J. Gordon, the borough surveyor of Leicester, and they ought to be available to clear the London streets after a fall of snow, instead of its being left to convert the streets into mud canals as is usual now.

BROWN'S STREET SURFACE BOX.

WE illustrate herewith a new form of street surface box now being introduced by the Glenfield Co., of Kilmarnock. The lid of the box is provided with a novel form of lock or catch, which is quite as effective as the more complicated forms in use, while its extreme simplicity enables the boxes to be produced at a very low rate. It will be seen from our illustrations that the lid is provided on its under side with two cam-shaped loops A, through which passes the hinge pin B. When the lid is closed, the points C of the cams fall behind two projections or brackets D, which are cast on the sides of the box. If an attempt is made to open the box by lifting the lid by means of a key in the ordinary way, the points of the cams engage with the brackets and prevent the lid being raised. To open the box it is necessary to use the key to lever up the back or hinge end of the lid, as shown by dotted lines in Fig. 2, until the points of the cams are clear of the brackets, when the lid can be thrown open, and this lifting action at the same time throws out any dirt which may have accumulated at the hinge. The mere shutting of the lid suffices to relock it. The two loops are cast at the sides of the lid, so that when the lid is open they are not in the way, but plenty of room is left for the passage of the hand or key.

Now that it is becoming the universal practice to fix stop-cocks on house service pipes for gas and water, which stopcocks are generally situated beneath the footway, the use of surface boxes of this kind will prevent the recurrence of accidents to passengers through the lids of the boxes being thrown open by accident or neglect. They are also suitable for hydrants and sluice valves, being made in many sizes.

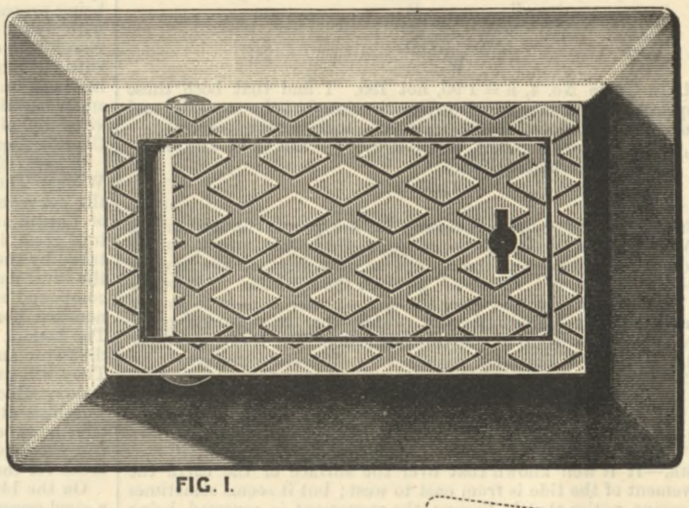
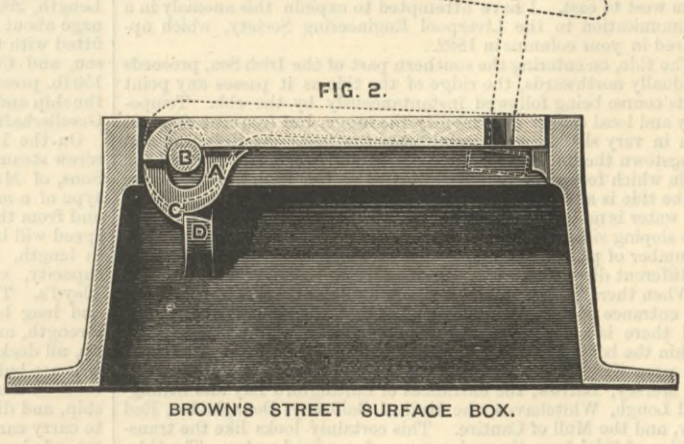


FIG. I.

FIG. 2.



BROWN'S STREET SURFACE BOX.

EXPRESS ENGINE—MIDLAND RAILWAY.

IN February, 1885, we published, as a supplement, an engraving of one of the new express engines with Joy's valve gear, then commencing work on the Midland Railway. The fine proportions of the engine, and the interest which it excited, rendered our supplement so attractive that the impression on which it was contained very speedily went out of print. We have since continually received applications for it, which we have been, of course, unable to satisfy, and we have therefore deemed it desirable to republish the engraving, believing that in so doing we shall gratify the wishes of large numbers of our readers. Originally the engraving appeared on white paper, now it has been printed by a new process on toned paper.

The engines of this class were to some extent experimental, having cylinders 19in. in diameter and 1050ft. of boiler surface. Mr. Samuel Johnson, the locomotive superintendent, believed that by using this great cylinder capacity steam could be worked more expansively and more economically. The result was, however, not wholly satisfactory, as the engines tended to "get out of breath" on heavy sections of the line, and they were therefore to a certain extent remodelled, while retaining all their external characteristics. The tube surface was augmented, and they now have 1250 square feet of surface, while the pressure has been raised from 140 lb. to 160 lb.; this change has proved of the utmost value, and the engines will now take, without a pilot, seventeen fully loaded coaches from London to Leicester—$99\frac{3}{4}$ miles—without a stop and up to time, and with a similar load from Leicester to London, the train starting five minutes late has arrived up to time. This is a splendid performance.

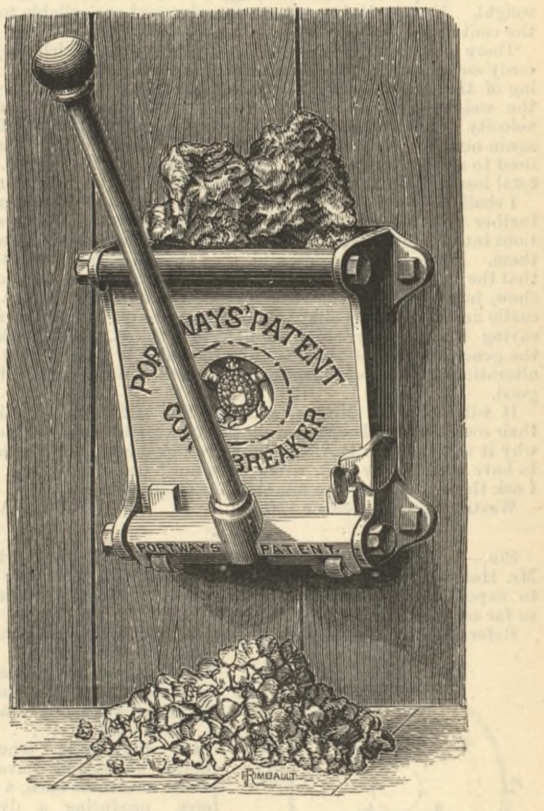
The tendency on the Midland Railway is not in favour of compound locomotive engines, but in the direction of large-sized engines and higher boiler pressure. Twenty express passenger engines have been built during the years 1886 and 1887 in the locomotive workshops at Derby, to Mr. Johnson's usual standard type and size, viz., 18in. cylinders by 26in. stroke, with 7ft. driving wheels, four coupled, and a four-wheeled bogie in front, with boilers carrying 160 lb. pressure per square inch, in place of 140 lb. per square inch as heretofore.

These engines have given very satisfactory results, the average reduction in fuel on the various services of trains worked by them being 3 lb. to 4 lb. per mile, as compared with the same class of engines working the same services with 140 lb. pressure per square inch only. The goods engines recently built are of the standard type and size for heavy mineral trains or main line work, viz., 18in. cylinders by 26in. stroke, with six wheels coupled, 4ft. 9in. in diameter, and boiler pressure 140 lb. per square inch. For express goods and heavy excursion traffic a similar engine is built, but with wheels 5ft. 2in. in diameter; and these engines are completely fitted with the automatic vacuum and steam brakes.

For working fast passenger and express trains, four wheels coupled or single-wheeled engines, with a four-wheeled bogie in front, possess considerable advantages over the ordinary type of six-wheeled engines, as they run much smoother and steadier at high speeds, and are less trying to the permanent way. A valuable addition to the working of single express engines has been made by the use of a small ejecter arrangement for supplying, by means of a jet of steam, a fine film of sand under the driving wheels; and, so far, this seems to answer its purpose in practice as well as it has done experimentally, and will most probably make the use of single-wheeled engines more general than has been the custom of late years. Mr. Johnson has had running for some time two single-wheeled engines with a bogie in front, which are, we understand, giving most satisfactory results.

ROYLE'S COKE BREAKER.

THE annexed engraving illustrates Portway's hand coke-breaker. Its dimensions are:—Length, 14in.; width, 11in.; handle, 24in. in length. The capacity is given as 1 cwt. of coke



broken small in twenty minutes by a lad fourteen or fifteen years old. It is a very useful tool in large houses and where coke is burned in "tortoise" and other stoves and ranges, but is also utilised by both traders and private individuals for the crushing of ice, soda, alum, bones, and almost any other substance which can be placed in the hopper. It consists of a cast-iron hopper adapted for hanging on a wall, having an outside plate mounted on pivots, the lower part of which plate is made to approach the opposite side of the hopper, and to break the contents of the same between the two surfaces by means of a lever handle, the shorter arms of which are in the form of cams or friction rollers. The downward motion of the handle causes the necessary pressure, and the upward motion withdraws the pressure and permits the broken portions to pass through the open slit at the bottom into the receptacle placed to receive it.

BRITISH TRADE IN FOREIGN MARKETS.—It is often said that figures may be made to prove anything, but is is more often that their incompleteness misleads the unknowing. Mr. J. W. Wells, M.I.C.E., F.R.G.S., delivered before a meeting of the London Chamber of Commerces on Monday an address on "Competition with British Trade in Foreign Markets, with special reference to South America." Mr. Wells had carefully studied all reliable statistics which bore on his subject, and his previous opinion had been completely confirmed—that the competition of foreign manufacturers had caused a want of increment in the supplies of British products to foreign markets, owing to which our manufacturers did not keep pace with the natural increase of population and the consequent increased producing power of the country. Quoting from the "Statistical Abstract for the United Kingdom, and for the Principal and other Foreign Countries," he stated that in examining the sum totals of the values of the imports and exports of the United Kingdom for each year, from 1873 to 1886, as given in that abstract, the average of each of the intervening years was $2\frac{2}{3}$ per cent. less than the trade of 1873, or, in other words, if during the past thirteen years the trade of the country had remained absolutely stationary, irrespective of increase of population, the country would have done more business than it had done to the amount of £241,139,314. The population had increased during the past thirteen years by about 14 per cent., while the value of the consumption and production of each inhabitant had decreased $9\frac{1}{2}$ per cent. This is so obviously erroneous that it would appear advisable to see what of the numerous modern manufactures have failed to get into the statistical abstracts, especially as Mr. Wells says:—An examination of the statistics of the values of exports, apart from those of the imports, showed still more discouraging results. Since 1873 the annual average of the total exports showed a decrease of $14\frac{1}{2}$ per cent., which, compared with those of 1873, meant a falling off of over £473,000,000. These statements require examination or rejection.

LETTERS TO THE EDITOR.

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

THE R.A.S.E. STEAM ENGINE TRIALS.

Sir,—Your readers will scarcely fail to see that Messrs. M'Laren have really not attempted to controvert any statement I have made by using arguments. They simply repeat statements which they have already made, but they do not try to prove them. I am obliged, however, for the very reasonable and satisfactory explanation they give concerning the variation in grate area. I think, however, that few persons who have tried the Hartnell governor will be disposed to agree with Messrs. M'Laren's assertions concerning its failure to govern. The Hartnell governor has been before the world for years, and it has remained for Messrs. M'Laren to be the first to find fault with it in print. I venture to say that it did not act well because it was not fitted on to the engine as it ought to be, or was not properly made by Messrs. McLaren.[1] However, this is beside the mark.

I find it extremely difficult to find out what Messrs. M'Laren mean. In one place they say that, unless certain arrangements were made and precautions taken, the error in the R.A.S.E. brake may amount to 56 per cent. Now these precautions were not taken in the showyard at Newcastle. Are we to assume that the brakes there were 56 per cent. wrong? Nothing of the kind, according to Messrs. M'Laren. Why, I ask, was this? How is it that in Messrs. McLaren's shed an R.A.S.E. brake had to be calibrated to the extent of 56 per cent. to get an accurate reading from it, while identically the same brake in proportions at Newcastle was not calibrated or compensated in any way, and yet gave, as far as I can judge from Messrs. McLaren's figures, results not 5 per cent. from the truth.

To make the point clear, let me ask Messrs. McLaren what result they got when they worked their R.A.S.E. brake without the springs fixed to the top end of the compensating lever?

My contention is that the pull at the top of the compensating lever is caused by the tension in the brake strap, and by nothing else. It may be made to amount to anything by tightening or slackening the hand screw, and it has nothing whatever to do with the load on the engine. The tension of the strap determines whether the friction between the wheel and the strap shall be sufficient to keep the weight floating, but it does not diminish the weight. Messrs. McLaren have not advanced one syllable to prove the contrary.

There is a source of error in Appold brakes to which they curiously enough do not allude, and that error is caused by the jumping of the weight, and is always against the engine. Every time the weight is lifted work is done in imparting to the mass a velocity which it had not previously, and when the weight falls again none of the loss is returned to the engine. The dash pot used to steady the brake augments the work due to jumping. The total loss is, however, very small if the brake be properly managed.

I shall be very glad to discuss this most important question further with Messrs. McLaren, but unless they put their propositions into some different form it will be impossible to deal with them. As I have already said, they started with the statement that the R.A.S.E. brakes were all wrong. Their own engine tests show, however, that the results obtained at Leeds and at Newcastle are very nearly alike. This they attempt to account for by saying that they corrected the defects in the R.A.S.E. brake, yet the general effect of the result is to make it appear that these alterations and improvements had no effect of any kind, bad or good.

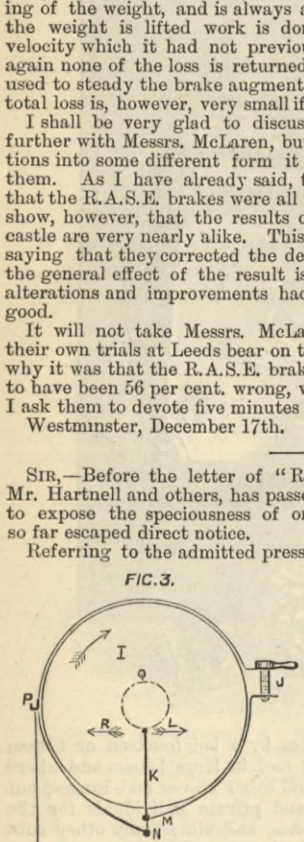
It will not take Messrs. McLaren five minutes to explain how their own trials at Leeds bear on the Newcastle trials, and to show why it was that the R.A.S.E. brake, which ought on their showing to have been 56 per cent. wrong, was not 5 per cent. wrong. May I ask them to devote five minutes to this question?

Westminster, December 17th. R. A. S.

Sir,—Before the letter of "R. A. S.," so well dealt with by Mr. Hartnell and others, has passed into oblivion, it may be useful to expose the speciousness of one of its arguments, which has so far escaped direct notice.

Referring to the admitted pressure of the lever K against the stop L, "R. A. S." says, "The stress is static, not dynamic. . . . . If the mere resting of the point L against a fixed stop . . . . could cause the brake wheel to rotate, we should have perpetual motion at once, a static force producing a dynamic result."

FIG. 3.



No doubt, but the resting of K against L has a cause, which will "cause the brake-wheel to rotate," for if the weight O be removed while the wheel is at rest, the mere tightening of the screw J, while it causes K to "rest against" L, will also rotate the wheel in the direction of the arrow, for the simple reason that rotation eases the stress upon the brake band. By moving to the left, the band is free to—comparatively—straighten out; so it moves, and the wheel with it. By tightening the screw sufficiently, the weight O could be lifted off the ground and left suspended, being balanced—of course, statically—by a force of which the pressure at L is rightly treated as one of the factors, because it is a resultant of the tension upon the strap. No one has alleged the action to be dynamic. It is simply a statical balancing during the trial of a part of the weight erroneously supposed to be maintained by the engine. The smaller the co-efficient of friction, the greater the proportion of the weight so balanced, because the greater the tension put upon the band by the altered position of the compensating lever.

"Static" and "dynamic" are fine words, but should be used with judgment. Some highly statical-looking objects have a good deal of dynamics in them, and even a mare's nest may turn and rend you, if you screw it up tight enough. There be mares' nests both static and dynamic.

Is it not time that a better accredited champion than "R. A. S." took up the defence of the Society's trials, if they can be defended? Names reputed great are concerned in the matter. Have their owners anything to say, or is judgment on the scandal to go by default? R.

December 17th.

FREE TRADE AND NO TRADE.

Sir,—It appears to me that one of the chief reasons why the system of free imports should be upheld is, that in consequence of better opportunities for cultivation, or natural advantages, countries from whom we import are able to supply us better than we can supply ourselves. It is extremely absurd to suggest that a country should be taxed because it has better climatic conditions, say, for the growing of cereals. As a matter of fact our imports have for many years exceeded our exports. Now if this fact were presented by an accountant to the head of a firm, the latter would say that he was so much the richer, and instead of bewailing the fact, and trying to stop this large excess of imports over exports, which I prefer to call profit, he would, as the head of a firm, rejoice at the large increased profit coming in from all the quarters of the globe. As another matter of fact, population has here increased much slower than the increase of wealth. Wealth having increased, as compared with increase of population, as 3 to 1.

Now I fancy the reason why so many firms are disturbed is that although as a whole country we are getting richer year after year at an astoundingly increased rate, yet the difficulties of individuals to make headway in the competitive market are getting greater and greater. The holders of the great monopolies, however, are better off than ever. The monopoly of banking, which lives almost entirely upon current credit, has to be fed with an enormous meal of dividend at each balance. Mining royalty, dividends on railways, canals, machinery, ground rents of factory, warehouse, and home, taxation for legal machinery and armaments—unsatisfactory even with all the wasted treasure—all alike have very big appetites. Now, in the experience of every business man it is constantly seen that if the business of the firm be carried on with a large display of useless "hangers on," one of two things happens, either bankruptcy or ill-treatment of the servants—going so far, as is now seen in our large towns, as starvation and intense suffering. Be thrifty! be sober! is the cant cry of the monopolists, in other words, "Save up, so that you may be able to administer your own—Poor Law—relief to yourself in bad times; but don't bother us, or we shall look upon you as part of the unworthy and dissolute class."

In fine, Sir, there is plenty of wealth for all, but because we are a nation of houses fighting—and wasting invaluable treasure and life in the process—against ourselves, we are discussing the merits of "Free Trade and No Trade," instead of utilising all the efforts we can spare from the fight in the competitive world to advance the one cause which is the duty of every civilised man, viz., the education of the ignorant workers and non-workers, thriftless and thrifty, masters and wage slaves, robbers and robbed, in the elements of a national social science and political economy which discards the petty jealousy of a trade or section of the community in favour of the interests of the whole. Our soldiers, our doctors, are expected to die, if necessary, in defence against the common foe; but our merchants, traders, manufacturers, and workers are running a wild goose-chase in following Fair-Trade. They ought at the present time to be looking to their armour and weapons, and making themselves powerful to fight the common foe—monopoly—in the not far distant future and perform their duty as honourable soldiers and doctors do, even dying, if needs be, in the performance of their duty. It is their duty to be the guardians of the life and honour of the whole nation of hand and brain-workers, and among whom it should be their pleasure and honour to work, instead of as at present standing afar off; only considering it to be their duty to look at public questions as it affects their own personal interests, and neglecting to look upon the trade of the country as one whole interest. They should regard their position as one of trust, and not of monoply; as stewards or servants, and not as lords and masters. Until this is done, I venture to remark that all the supporters of Fair-Trade and Protection can only be working for a section against the remaining whole; and so long as they can delude themselves and others to advance their nostrums so long will the advance of civilisation be delayed towards the ultimate and certain goal of

December 17th. International Co-operation.

THE FLOW OF WATER.

Sir,—In your last issue in the report of my paper on "A New Formula for the Flow of Water in Pipes and Open Channels" there are two slight errors, which I should be glad to have notified in your next issue. 1st. The formula should read,

$$v = \frac{R^{x+y}\sqrt{\frac{z-R}{R}}}{c\sqrt[n]{S}}$$

not

$$v = \frac{R^{x+y}\frac{\sqrt{z-R}}{R}}{c\sqrt[n]{S}}$$

2nd. In Table No. 4, $n = 1{\cdot}95$, not 195. I find that both these misprints were in the printed tables circulated at the meeting, and I am sorry I did not notice them in time to have them corrected.

7, Westminster-chambers, London, S.W. Edgar C. Thrupp.
December 19th.

Sir,—It would be quite necessary for the proper understanding of Mr. Thrupp's formula given on page 499 of last number to let readers know what are the values or meanings of the several letters "R, S, x, y, z, c, and n" given in the formula. I presume "v" means velocity, but poor x, y, z, c, and n have to play so many parts in the mathematical drama, that it is hard to guess what *rôles* they sustain in this representation. Mr. Irving as Faust, and Mr. Irving as Benedict, express very different meanings.

Cork, December 20th, 1887. D. L.

TIDAL ESTUARIES AND THE BAR OF THE MERSEY.

Sir,—It is well known that over the surface of the earth the movement of the tide is from east to west; but it seems sometimes to escape notice that in Europe the movement is reversed, being from west to east. I have attempted to explain this anomaly in a communication to the Liverpool Engineering Society, which appeared in your columns in 1882.

The tide, on entering the southern part of the Irish Sea, proceeds gradually northwards, the ridge of the tide as it passes any point in its course being followed instantaneously by the ebb. Temporary and local causes may modify the usage, but frequent observation in very shallow water establishes the fact. At Holyhead and Kingstown the uniform advance ceases, and over a large part of the basin which forms the northern portion of the Irish Sea the action of the tide is almost simultaneous; that is to say, the elevation of the water is no longer like that of a weir, with a ridge or crown and two sloping sides, but as though the force acted upwards through a number of planes, the inclination of which is continually varying in different directions.

When there is high water at the Scilly Isles there is low water at the entrance of the northern basin, so that the ridge is at the isles, and there is a slope over 200 miles long with a fall of 16ft. But within the basin the water is raised by the flood tide at practically the same time at Holyhead, Dalkey, Balbriggan, the entrance of the Mersey, Barrow, the entrances of Carlingford Bay and Strangford Lough, Whitehaven, the Mull of Galloway, Donaghadee, Red Bay, and the Mull of Cantire. This certainly looks like the transmission of tidal force through a mass of confined water. The tide, which enters the basin from the north, is detained at the Mull of Cantire for four hours after it was high tide in Ballycastle Bay, by a mass of water nearly eighty fathoms high at its greatest depth, the width of the entrance not exceeding twelve miles. The resistance thus encountered is so great, the tidal range is only 4ft., though the tide has travelled a distance much less than that travelled by the tide from the south. I infer then that the basin becomes an hydraulic chamber, from which the tide travels into the several loughs, rivers, and other branches through which it proceeds as usual, that is, by horizontal progression, the tide, as it advances through the channel south of Holyhead, acting as the principal ram in compressing the water, the northern tide being comparatively insignificant, except as closing the gap or aperture which otherwise would prevent the hydraulic action. This then becomes further evidence that the tide in itself is pure and simple force, and not the movement of large masses of water. Such movements are caused by inequalities of level, resulting by the passage of the force under the water to be raised, as air sometimes passing under a table-cloth or carpet produces waves in miniature. No doubt there is a transposition of water in small masses, consisting chiefly, if not entirely, of river water, which is temporarily and partially penned back by the advancing force; consequently those who expect to gain a large influx of sea water every tide will be disappointed. The tide is a mighty force, which judiciously applied, may accomplish the most beneficent results—it is a good servant, but a bad master.

Another remarkable tidal feature in the Irish Sea is the great inequality of range, it being only 3ft. or 4ft. in some places, and nearly 30ft. in others. The cause of these differences appears at present to be inexplicable, but its effects are important; for as the mean tide level is uniform around the British Isles, the surface of the Irish Sea at low water is inclined from the places of small range to those of greater, and at high water the inclination is reversed. As the smaller ranges are principally on the coast of Ireland, and the greater on the coast of Britain, at low water there will be a fall from Ireland, whilst at high water the fall will be from Britain. In this fact appears one explanation of the enormous accumulation of sand on the coast of Britain, as there is likely to be a constant subaqueous drift from Ireland of the matters brought down by the rivers of that island, the prevalent westerly winds aiding. This conjecture receives confirmation from the greater distance of the twenty-fathom line from Britain than from Ireland; and it suggests an important consideration for those who would improve such rivers as the Dee, the Mersey, and the Ribble. It would appear essential to supply some outwork or rampart by which the invader's progress may be arrested. It is remarkable that in most cases the tide has its greatest range in the shallower water. Joseph Boult.

Liverpool, December 17th.

BAND SAWS.

Sir,—I believe one of the chief causes of the breakage of band saws is the shape of the spaces between the teeth. These are usually made of a V shape, similar to those of the hand saw, the space terminating in an acute angle or point—the best shape to cause fracture. I find on inquiry that my opinion is supported by Messrs. Taylor Bros., sawmakers, who have adopted a round bottom space between the teeth. It would be interesting to get at some data as to the life of saws with round and those with pointed or V spaces. R. F. Drury.

Sheffield and District Patent-office, Bank-buildings,
George-street, Sheffield, December 19th.

THE EXPORT OF STEAM ENGINES.

Sir,—Referring to the remarks you were good enough to make in your last week's issue, having reference to the meeting of the Agricultural Engineers' Association, I find you have slightly misquoted me, and I now take the liberty of rectifying this. My remark was that "the steam engines exported to Russia from this country for the first ten months of 1886 represented £115,000, whilst for the first ten months of 1887 they only amounted to £83,000, and that I feared it would much decrease during the next year in consequence of the increased tariff," whilst you say my firm had sent out engines, machines, &c. R. Marshall, President.

Britannia Ironworks, Gainsborough, December 21st.

LAUNCHES AND TRIAL TRIPS.

On the 14th inst. Messrs. William Doxford and Sons launched a new screw steamer, the Junio, for the Compania Bilbaina de Navegacion, Bilbao; direcctors, Messrs. Agnar and Astigaraga. The Junio is built of steel, 275ft. by 39½ft. by 24ft. 9in., on the spar deck rules, with two decks laid, and beams for third deck being prepared for wine trade. Her engines are triple expansion, with cylinders 21in., 35in. and 57in., with a 39in. stroke. The vessel will carry 3300 tons cargo on 20ft. draught, and is fitted with the most modern arrangement for economical loading. She has been built under the superintendence of Mr. Antonio Uribe, superintendent of the company, and the engines have been supervised by Mr. Wm. Baird. She will sail under the command of Captain Aspiazu.

Messrs. Edward Finch and Co. have received orders from Sir William Thomas Lewis for a superior saloon paddle steamer for the conveyance of passengers and merchandise between the ports of Cardiff and Bristol. The vessel, which will measure some 260 tons gross, is to be wholly built of Siemens steel, to be manufactured by the Dowlais Iron Company. Her boilers will also be of the same material. The machinery will consist of a pair of vertical compound surface-condensing oscillating paddle engines of 125 nominal horse-power, with paddle-wheels about 16ft. diameter. The boilers, two in number, are to be of Navy type, about 8ft. 9in. diameter and 17ft. long, and will be placed wholly under deck. They will supply ample steam for upwards of 750 indicated horse-power, which will enable the vessel to make her passage in all weathers at a speed of not less than 14 knots per hour. She will thus be superior to anything of her class that has yet appeared in the Channel. We also understand that this firm have secured the order for the large caissons for the new Barry Graving Dock.

On the 14th inst. the Tyne Iron Shipbuilding Company launched a steel screw steamer, the Karnak, of the following dimensions:—Length, 290ft.; breadth, 40ft.; depth moulded, 27ft.; gross tonnage about 2520. She is built to class 100A at Lloyd's, and will be fitted with triple expansion engines by Messrs. Wigham, Richardson, and Co., cylinders 24in., 37in., and 62in. by 42in. stroke, 150 lb. pressure, and has all the latest improvements for working the ship and cargo. The vessel is for the Deutsche Dampfschifffahrts Gesellschaft Kosmos, of Hamburg.

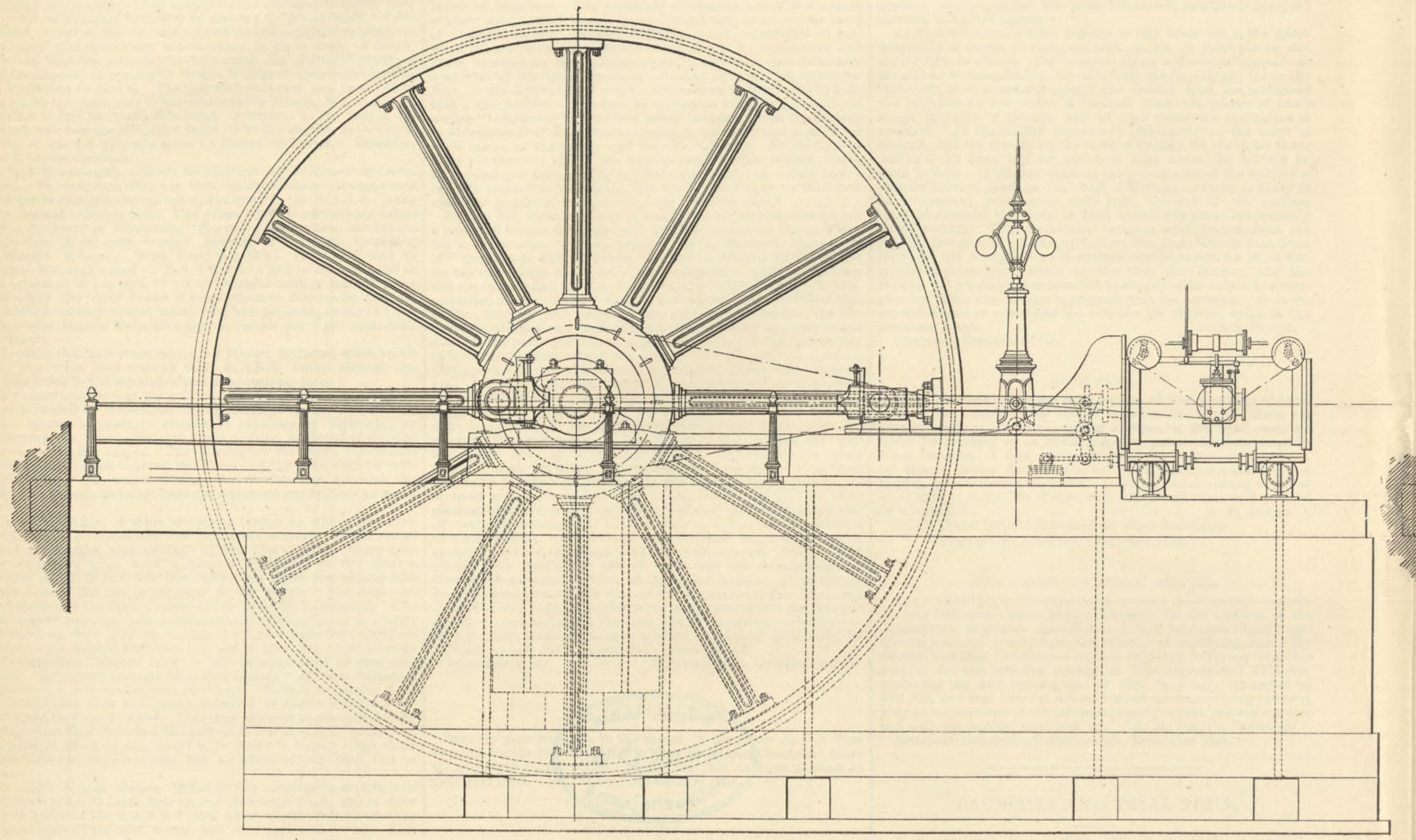
On the 15th inst. Messrs. Edward Withy and Co. launched a screw steamer, the Melbourne, for Messrs. W. Howard Smith and Sons, of Melbourne, Sydney, and Brisbane. The vessel is a fine type of a modern cargo boat, and is built of Siemens-Martin steel, and from the fine design of her lines it is anticipated that a good speed will be attained by the vessel. She is a steamer over 300ft. in length, with a large measurement and dead-weight carrying capacity, and built to the 100A1 class under special survey at Lloyd's. The vessel has a long, raised quarter-deck, short poop, and long bridge-house, with a top-gallant forecastle. For extra strength, and in order that the vessel may be economically kept up, all decks, deck erections, skylights, bulwarks, rails, bulkheads, &c., are built of iron or steel. In the main and after holds she is built on the web frame system, which gives a very strong type of ship, and dispenses with all hold beams, thus enabling the vessel to carry cargoes of the most bulky description, such as machinery, torpedo boats, large guns, &c. She has a cellular bottom, all fore and aft—Withy and Sivewright's patent—and the after peak will also be available for water ballast. Nearly all the shell plates are in 24ft. lengths, making the structure of the ship very strong. Four steam winches will be fitted, one to each hatch, with a patent windlass on forecastle. Instead of the anchors having to be landed on the forecastle deck with davits, &c., she is fitted with stockless anchors hauling up into hawse pipes. Two donkey boilers are fitted in the fore end of the boiler room, hand and steam steering gear amidships, and Hastie's patent screw stand-by gear aft. The accommodation for officers, passengers, &c., is under the poop aft, and is fitted up in hard wood with beautifully hand-painted panels by the lady decorative staff of the firm. The vessel is rigged as a two-masted fore-and-aft schooner, having iron masts with square sail on forecastle. She will be fitted with triple expansion engines by Messrs. T. Richardson and Sons, Hartlepool.

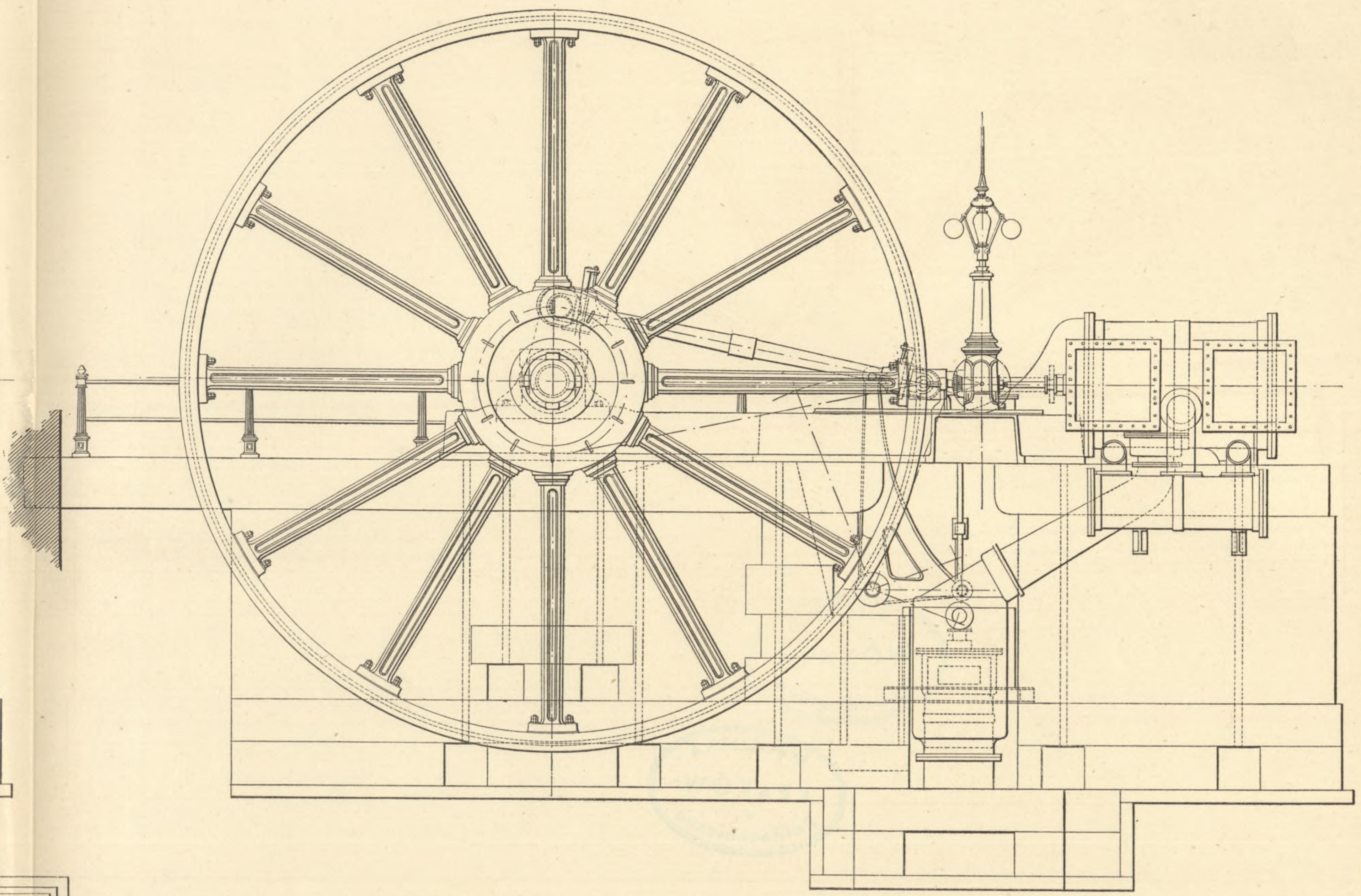
[1] Our correspondent is here in error. We understood from Messrs. McLaren that they obtained their governors from Messrs. Turner, of Ipswich, who manufacture under Mr. Hartnell's patents.—Ed. E.]

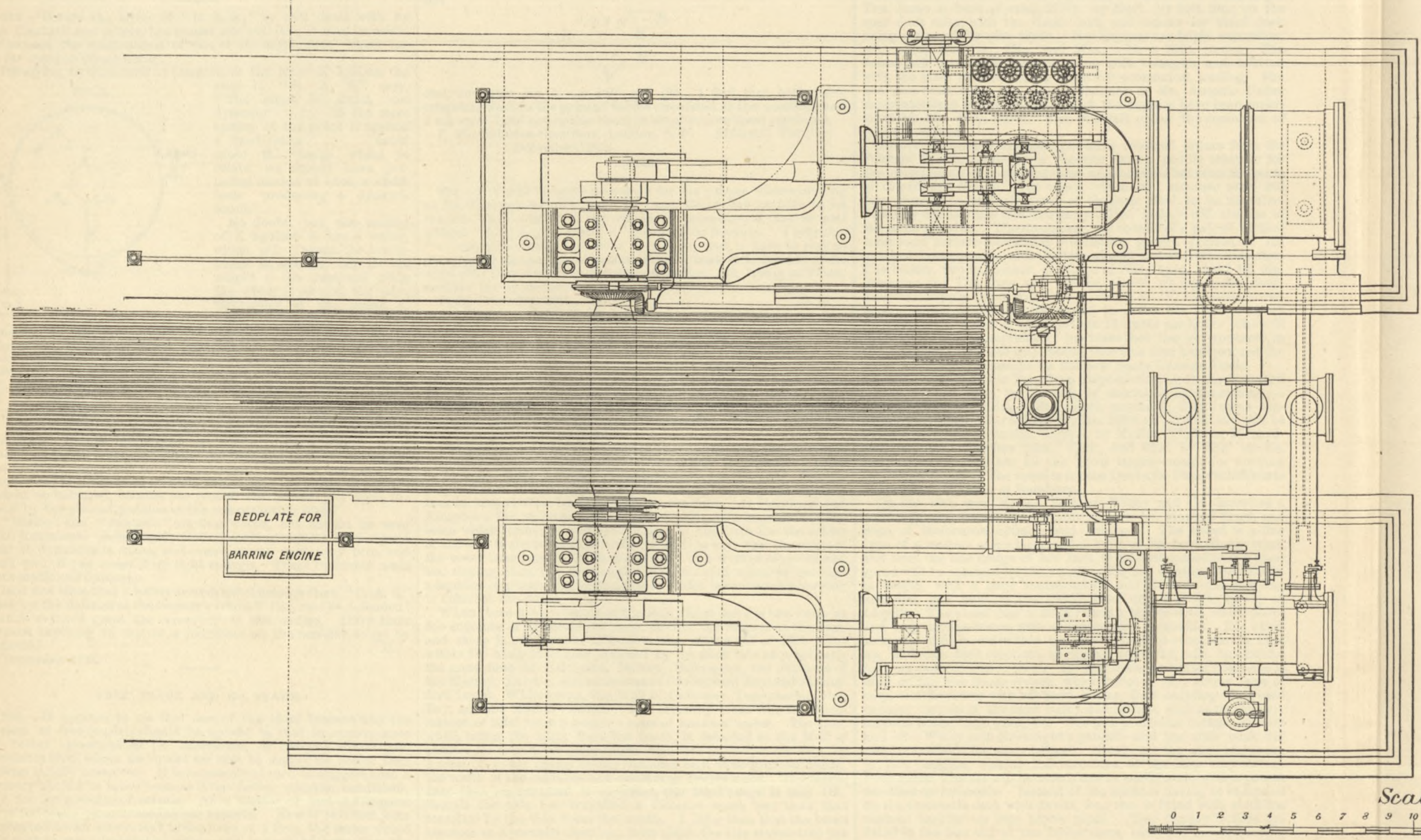
ONE THOUSAND HORSE-POWER COMPOUND MILL ENGINE.

MESSRS. BUCKLEY AND TAYLOR, OLDHAM, ENGINEERS.

(*For description see page 507.*)



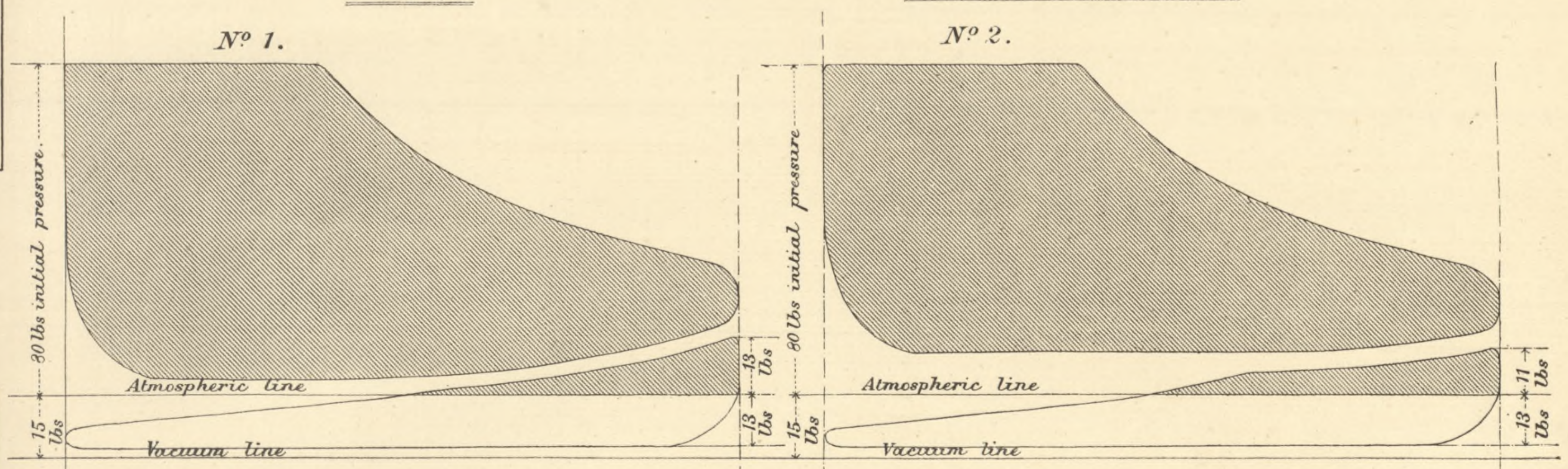




Scale of Feet.

Scale 1/40th

Cut off at 3/8ths of the stroke



Cylr.	Stroke	Speed in ft per min	Av Pr.	I H P
27	6'-0"	660	52	592
52	6'-0"	660	13·3	565
		Total	I H P.	1157

Cylr.	Stroke	Speed in ft per min	Av. Pr.	I H P.
27	6'-0"	660	48	547
52	6'-0"	660	13·5	574
		Total	I H P	1121

J. SWAIN ENG.

[SUPPLEMENT TO THE ENGINEER, DECEMBER 23, 1887.

FOUR-COUPLED EXPRESS LOCOMOTIVE, MIDLAND RAILWAY.

PUBLISHER'S NOTICE.

*** *With this week's number are issued two Supplements, one a Two-page Engraving of a Four-coupled Express Locomotive on the Midland Railway; the other a Two-page Engraving of a 1000-Horse Power Mill Engine by Messrs. Buckley and Taylor, of Oldham. Every copy as issued by the Publisher contains this Supplement, and subscribers are requested to notify the fact should they not receive it.*

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THE ENGINEER, December 23rd, 1887. PAGE

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.*

E. C.—*We have for some time been endeavouring to get information of the kind you want, not only for Crewe and Manchester, but for Great Britain, up to the present with indifferent success.*

A FIFTEEN YEARS' SUBSCRIBER.—*We fancy such tools would have a comparatively limited appreciation. Messrs. Howard, of Bedford, have, however, given attention to the subject, and you might bring your suggestions before them.*

T. C.—*We cannot give you any formula which would satisfactorily answer your purpose without a long explanation, which would be out of place in this column. You will find everything you want in Neville's Hydraulic Tables.*

DELTA.—*Only a small proportion of the American inventions we illustrate is patented in this country. All published English specifications can be had from the Great Seal Patent-office, Southampton-buildings, Chancery-lane, London.*

J. B. (Warrington).—*You are wrong in your analogies from first to last. There is nothing in common between a high centre of gravity in a locomotive and in a ship. You have evidently either not read carefully, or else fail to understand what Professor Greenhill has written.*

QUERY.—*An apprenticeship served in any engineering works will do. You must get, after you are out of your apprenticeship, a berth as third engineer in a cargo steamer, or fifth or sixth in a large vessel. You must then serve 365 days at sea, not necessarily consecutively, and then you are eligible to pass your examination and get a certificate as second engineer from the Board of Trade.*

VERAX.—*Professor Unwin's rule for breaking load in tons of wrought iron columns of angle, tee, channel, or cruciform section, with fixed ends, is*

$$W = \frac{19\,a}{1 + \frac{l^2}{r^2\,900}}$$

The sectional area "a" of your column appears to be 3 + 3 + 2·25 × ·375 = 3·09 *square inches. The ratio "r" of length to diameter = 48, and hence you would have as breaking load* W = 58 ÷ 1·053 = 55 *tons, and with a factor of safety of 5 you would have 11 tons as safe load; but as your section is more nearly the section you sketch than either of these, the safe load you arrive at is probably quite high enough.*

BUTTON-MAKING MACHINERY.

(*To the Editor of The Engineer.*)

SIR,—I shall be greatly obliged if any of your correspondents can inform me where machinery for making buttons in ivory, bone, or brass can be obtained.

C. S. M.

Manchester, December 21st.

COMPRESSED LIME CARTRIDGES.

(*To the Editor of The Engineer.*)

SIR,—We shall esteem it a favour if any correspondent can send us any information as to who are the makers of compressed lime cartridges, same as used in coal mines; and whether they are likely to be of assistance in the removal of slate rock, when the use of explosives is prohibited.

A. H. P.

December 16th.

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Remittance by Bill on London.—Austria, Buenos Ayres and Algeria, Greece, Ionian Islands, Norway, Panama, Peru, Russia, Spain, Sweden, Chili, £1 16s. Borneo, Ceylon, Java, and Singapore, £2 0s. 6d. Manilla, Sandwich Isles, £2 5s.

ADVERTISEMENTS.

MEETINGS NEXT WEEK.

ROYAL INSTITUTION.—Tuesday, December 27th, at 3 p.m.: The first of a course of six lectures on "The Sun, Moon, Planets, Comets, and Stars," by Sir Robert Stawell Ball, F.R.S.

DEATH.

On the 19th December, at Ballymagarvey, Balrath, County Meath, Ireland, BALFOUR STEWART, M.A., LL.D., F.R.S., Professor of Natural Philosophy, Owens College, Manchester, aged 59.

THE ENGINEER.

DECEMBER 23, 1887.

THE NORDENFELT.

WHEN describing the Jubilee Naval Review, in our impression for the 29th of July we laid stress on the presence with the fleet, of the Nordenfelt submarine torpedo boat, as indicating the possibility of a mode of warfare which would set steel-clad ships at defiance. It will be seen from the account which we publish on another page of experiments at Southampton, that our anticipations of the future of submarine naval operations are in a fair way to be fulfilled. The trial of the boat resulted in success in every shape. Not only did her machinery perform as it should have done, but Mr. Garrett succeeded in stealing on his imaginary foe unawares, under very great difficulties, the greatest being that of necessity neither he nor anyone else can have much experience to guide him in his operations. Nothing more than practice seems to be wanted to enable him to do just what he wishes with the strange craft which owes something of its success to his talents as an inventor as well as his skill as a steersman. In the Nordenfelt we have all the elements of a system of attack and defence which will certainly put blockades at an end, and introduces an awful element of danger into any attack made by ships on forts. A celebrated naval officer once said, "For God's sake keep out the shells, whatever you do." Armour supplied the answer to his request; but how are we to contend with such a foe as the Nordenfelt? The question must for the present remain unsolved.

The general principles involved are extremely simple; but, as is very often the case in other matters, the application of the principle in practice has demanded a vast amount of time and talent, skill, genius, and money. There was no scientific teaching to fall back upon; even a professor could not help Mr. Nordenfelt in his self-imposed task. All the libraries in Great Britain did not contain printed information which would indicate the precise construction of a detail. It is not remarkable therefore that the production of a successful submarine boat has been a slow process. It is as though the egg which Columbus cracked had had an extremely hard shell, difficult to smash by ordinary means. But the feat has been performed, and there is no longer any reason to doubt that it will be early repeated, but it can only be repeated, we think, by Mr. Nordenfelt. Only those who are intimately acquainted with the boat can form an adequate idea of how much she depends for success on details which we need scarcely say the inventor does not care to make public. He has arrived at a knowledge of them, and their influence by an inquiry extending over years, which few would now care to repeat, with the certainty that Mr. Nordenfelt has got a start in the race which will enable him to keep ahead of all possible competitors. We may —we hope we shall—have quite a little fleet of Nordenfelts when Christmas comes round again. When once Columbus had shown the way to America the route was freely traversed.

The Nordenfelt was built by the Barrow Shipbuilding Company. The main engines are double compound, with two high and two low-pressure cylinders, and four cranks equally spaced 90 deg. from each other. Steam is supplied by two boilers, and very special precautions had to be taken to prevent not only the entrance of water down the funnel when the vessel is submerged, but the leakage of smoke out of the furnaces, which would quickly stifle her crew. All this has been effected in a most ingenious way. The boat if left to herself would always float with a considerable portion out of the water. Direct force is required to sink her, and that is provided by two screws with vertical shafts, one in a recess at the bows, the other at the stern, by which she is forcibly screwed down into the depths of the sea. The moment these screws stop revolving she comes to the surface. Steam is supplied when she is under water on the system suggested many years ago by Dr. Lamm, and used in America for propelling street cars. If the pressure in a boiler is lowered the temperature falls, and part of the sensible heat of the water becomes converted into latent heat by evaporation. The two boilers contain about 27 tons of water. The pressure of the steam is, let us say, 160 lb. above the atmosphere, or 175 lb. absolute. The corresponding temperature is 371 deg. Fah. Now, the engines will work well with steam having a pressure of 50 lb. above the atmosphere, or 65 lb. absolute, the temperature of which is 298 deg. In falling from one of these temperatures to the other, each pound of water gives out 371 deg. − 298 deg. = 73 units. There are 60,480 lb. of water, and 60,480 × 73 = 4,415,040 units. Each pound of steam at 65 lb. pressure will represent 904 units, and $\frac{4,415,040}{904}$ = 4883, nearly, pounds of steam of 50 lb. pressure, which can be supplied after the ship has been submerged. Assuming that her engines use 20 lb. of steam per horse per hour—a very high estimate—we have $\frac{4883}{20}$ = 244-horse power for one hour. But when submerged the speed is very slow and she requires little power to work her, so that she readily stores energy enough to remain for as much as three hours under water. The air contained in the hull is ample for breathing purposes for that time. There is of course no reason why the pressure should not be as much as 200 lb., or even more. We have said enough to show that with a pressure not greater than that carried in most modern steamships, power enough can be stored up for all practical purposes. The Nordenfelt arrived in Southampton last July. The time which has elapsed since has not been wasted. She has had a deck fitted to her by Messrs. Oswald, Mordaunt, and Co., and various modifications and additions have been made to her machinery and fittings as deduced from accumulating experience. She is a curious-looking craft, as will be understood from the engraving of her which appared in our last volume, page 409. She is 125ft. long by 12ft. beam, and displaces when entirely submerged 230 tons, her displacement when light being 160 tons. Her engines indicate 1000-horse power, and drive the boat at a speed of 15 knots when light, and of course on the surface. She has an under-water speed of about 5 knots. The midship section is a circle; any other section will show two arcs of a circle, and the vertical line passing through the centre of such section will be the chord of the arcs. In order to maintain the strength of the hull in unison with the midship section, which is round, a deck has been placed on a spreader where the arcs become small at each end. The spaces under these decks are divided by bulkheads into tanks, which, being filled with water or emptied, affect the balancing and displacement of the vessel. The coal bunkers are in the centre of the boat, and therefore interfere little with the fore and aft position of the centre of gravity. The centre of gravity of the boat in its most unstable condition is 6in. below the centre of the boat, and the metacentre in its most unfavourable position is 2in. below the centre of the boat. This means that the vessel will not capsise unless forcibly deflected more than 180 deg. from its upright position. Properly handled as regards coal and water ballast, the boat is more than sufficiently stable. She carries about 35 tons of cold water in her tanks, and, as we have said, 27 tons of hot water in her boilers. This 27 tons of water is expected to give off, as we have just explained, sufficient steam to drive the boat a distance of 20 knots. The 35 tons of cold water, when pumped out, make her sufficiently buoyant to be seaworthy on the surface. The fact that the 27 tons of hot water can be blown out in five minutes does much to promote the safety of the crew. The cold water is pumped out by three pumps, each of which has a 3in. diameter discharge pipe, and, for security, these pumps have separate engines. The coal bunkers hold 8 tons of coal, and 1 ton will drive the boat 100 miles at a speed of ten miles per hour. At a speed of 8 to 9 knots per hour, the 8 tons of coal will drive the boat 1000 miles. Should a great distance be intended to be travelled, twenty additional tons of coal can be carried in the cold-water tank. The boat could steam from England to Constantinople by coaling at Gibraltar. In fact she could steam to India or any other distance. The sinking propellers are operated by separate engines, which are entirely under the control of the captain, and he can by them force the boat under water or allow her to rise to the surface; or by giving different speeds to the bow or stern propeller, depress the bow or stern as required, and thus cause the boat to maintain the horizontal position. An automatic arrangement exists whereby, should the captain not stop these engines at the right time, they will cease to act at a depth to be arranged.

The boat is steered by steam, the engine for which is also controlled from the forward conning tower, which is in communication with the stokehole and engine-room by speaking tubes. In the conning tower are instruments to show the depth, the level, and the course. The boat is lighted by candles. The crew consists of captain, mate, two seamen, engineer, assistant, and two firemen, also a cook. Each man has a separate bed. In addition to the fittings of a submarine boat, the Nordenfelt carries masts, side lights, compasses, anchors, &c., as an ordinary surface vessel. She is registered under the Board of Trade and passed and classed at Lloyd's. There are two torpedo tubes placed in the bow, and there is a place provided for two spare torpedoes. It is proposed to arm the boat with two 2 lb. Nordenfelt quick-firing guns. The conning towers are round, 2ft. 6in. diameter, and of 1in. steel.

SUCCESSFUL RAILWAY LEGISLATION.

IN THE ENGINEER of February 25th last, we described and explained the main provisions of the Inter-State Commerce Act, then about to come into action. We pointed out that the measure was one of stringent character, and so likely to create a great deal of opposition among railway companies; that some of its most important clauses were of doubtful meaning, and thus liable to lead to litigation; and that a very wide discretion was left to the Commissioners appointed to administer the

Act, rendering them in great measure responsible for its success or failure. At the same time we characterised the measure as a bold and well-intended attempt to correct the abuses of the railway system in the United States; and expressed the opinion that if the Commissioners proved wise and prudent, they would be able to clear away many of the difficulties caused by bad drafting, so that the Act might work more smoothly than its adverse critics predicted. These remarks and anticipations have been entirely justified by the experience of the Commissioners, as shown in a report which they have just issued. Difficulties have occurred through bad drafting or loose definition, some of which are not yet cleared up; but, on the whole, the Act has been carried out with remarkable success, and with much less friction than even its most enthusiastic supporters could have expected. The railway companies, as a rule, appear to have accepted the inevitable with a good grace, and to have made the best of the new regulations, though some of them kicked a good deal at the outset, or at least threatened to make things awkward for the Commissioners and the public. After all, moreover, if we may take the verdict of the Commissioners, they have not been injured. On the contrary, according to the report, the general results of the Act have proved in many ways beneficial to the companies as well as to their customers. So far as we have at present been able to ascertain, this conclusion is endorsed by capable critics in the United States, who do not fail to attribute it in a great measure to the careful and sagacious administration of the Commissioners, who have really effected much more by a conservative and persuasive policy than could have been done by a harsh exercise of their great powers, or a strained interpretation of the stringent provisions of the Act. Thus they are able to state that some of the most serious evils which called for the enactment of the law have ceased to exist, and that even with respect to those which have not been got rid of altogether there is manifest improvement.

As the American Act embodies, in principle at least, every demand made by the most thorough-going railway reformers in this country, the account which the Commissioners give of the operation of its leading provisions possess much interest for us in this country, in view of possible legislation upon the subject at an early date. In the article already alluded to we showed how stringent were the restrictions against undue preference. Companies were forbidden to favour any person, corporation, or locality, or any particular description of traffic, at the expense of another. Unequal charges under like conditions were declared unlawful. In particular, under what is known as the "long and short haul clause," they were prohibited from charging more "in the aggregate" for conveyance "of passengers or of like kinds of property, under substantially similar circumstances and conditions for a shorter than for a longer distance over the same road in the same direction, the shorter being included within the longer distance;" and it is somewhat awkwardly added that this is not to be understood to mean that they are authorised "to receive as great compensation for a shorter as for a longer distance." There is nothing in the section to prevent a company from raising a through rate instead of lowering the rate for an intermediate distance previously as high as or higher than the through rate, and this is precisely what some companies threatened to do, and actually did in the first instance. Apparently, however, they found it impolitic to continue the arrangement. At any rate the Commissioners state that a majority of the companies have reduced local rates where these were higher than through rates, though in some instances a compromise has been arrived at. In special cases, after investigation, the Commissioners were authorised to permit the rule as to the long and short travel to be departed from, and to allow less to be charged for the long than for the short distance. No doubt the use of this discretion, dangerous as it seems, has enabled the Commissioners to smooth away difficulties which otherwise would have caused a great upset to traffic and important interests, such as that connected with the conveyance of grain from remote wheat districts to the ports of shipment. On the other hand, where the cutting of freights had been excessive—through the competition of rival companies—they have in some cases been raised, to the great advantage of the shareholders. Quite recently we noticed that the through rates from Chicago to Liverpool were raised by agreement between the companies concerned, because complaints had been made to the Inter-State Commissioners on the ground that the charges were actually lower than those on the same classes of goods sent from Chicago to Atlantic ports. Another important point to which we called attention in our previous article was the prohibition of the practice of pooling earnings, provided by certain companies in order to save themselves from the effects of competition. It was expected that the companies would make a strong stand against this prohibition, or render it nugatory by some subterfuge; but they appear to have given way entirely upon the point, and to have done their best to make regulations for uninterrupted and harmonious communication and exchange of traffic within the territory embraced by their several lines.

In addition to the duty of seeing that acts declared unlawful were not persisted in by the railway companies, the Commissioners had imposed upon them the perplexing and difficult task of deciding as to the justness and unreasonableness of any rate or charge brought under their notice, and of reducing any which they deemed unfair or excessive. Wider powers were probably never given to any set of judges, and yet the Commissioners have managed to exercise them with such discretion as to give general satisfaction. No doubt the elastic character of their powers in this respect, which gave rise to fears of great mistakes, if not of abuses, have enabled them to use their judgment discriminatingly in regard to different circumstances and conditions with a view to doing justice to the companies and their customers alike. To facilitate the work of the Commissioners every railway company or other public carrier was ordered not only to print and keep for public inspection schedules of their charges for passengers and goods, but also to send such schedules to the office of the Commission; and this they have done to the extent of 110,000 documents, which had been filed at the date of the writing of the report by five hundred different corporations. Considering that it is less than a year since the Act came into force, great progress has clearly been made in settling disputes and bringing railway arrangements into satisfactory working order.

Two lessons may be learnt from the success of the Inter-State Commerce Act. The first is that a bold and thoroughgoing measure of the kind, administered by capable men, may be made to work smoothly where a timid and illogical compromise would give rise to endless disputes and dissatisfaction; and the other is that such a measure is not in reality hostile to the interests of the railway companies, which are generally and in the long run identical with those of the public at large. It may be objected that it is to the interest of railway companies to get as much, and to that of the public to pay as little as, possible; but that would be a very superficial view to adopt. In the long run and for the public as a whole, it would not be advantageous to force companies to work at a loss, for the obvious reason that there would soon be an end to the work under such conditions. On the other hand, it is not to the interest of a railway company in the long run to behave extortionately or in any way unfairly to the persons who use the railroad, for such conduct prevents traffic which it is desirable to develope.. The rule of putting on each class of traffic as heavy rates as it will bear may appear very smart to railway directors; but probably it has done their shareholders more harm than any other policy that has been adopted. Directors are not omniscient, and it is impossible that they can tell what dimensions traffic in a given district may attain under fairly favourable circumstances. A good measure of the spirit of the shopkeeper, who knows that it is to his advantage to please his customers, might with great benefit be enforced into the directorate of every railway company.

Perhaps we might add that there is a third lesson to be derived from the experience of railway reformers in America, though on this point we cannot feel perfect confidence in a like cause producing like effects. We refer to the elasticity of the powers vested in those who administered the American Act. There is nothing which railway companies are so naturally averse from as being bound by rigid legal rules and arrangements, suitable perhaps to one case but not to another Provided that certain important principles are clearly and imperatively laid down, there would be no serious danger, and a great deal of possible advantage, in leaving details to the judgment of the Commissioners. We should hesitate to recommend as wide a discretion as was allowed to the administrators of the American Act, though it does not appear to have been abused; but our legislators, in passing the next Railway Bill, might with advantage follow a successful precedent to a moderate extent. At all events they have now before them a mass of experience which cannot fail to be useful, and it is much to be hoped that they will be helped by it to produce a measure which will ultimately—for it cannot be hoped for at the outset—smooth away the unhappy and michievous hostility which has so long existed between our railway companies and their customers.

THE RAILWAY HALF-YEAR.

WE are now sufficiently near the end of the half-year to allow the results of the working of the chief railways to be estimated in some degree. The last six months of 1887 prove to have been months in which, on most of the chief lines of the country, there has been a slight increase of the traffic, or perhaps it would be better to put it that there has been an increase in traffic and a slight increase in the traffic receipts, for there are indications that the traffic has been, on many of the lines, of a cheaper class, and that more work has been done for the revenue. Coming to the chief companies, we find that there have been increases of traffic receipts on the Lancashire and Yorkshire, the North-Eastern, the London and North-Western, the Midland, Manchester and Sheffield, Great Northern, Great Eastern, and London and Brighton, some of the amounts of the increases being however, very small. The North-Eastern has the largest increase so far, and for the half-year, when completed, it should have nearly £80,000. The Lancashire and Yorkshire has recorded a steady increase during nearly all the half-year, and with a continuance at the same rate, the gain would be about £72,000. Putting the increase of the London and North-Western at about £55,000, the Midland Railway at £25,000, the Manchester and Sheffield at £20,000, we shall probably have included most of the companies which have large increases, though as far as the passenger railways to the south are concerned, there is to be borne in mind the fact that Christmas Day falls on a Sunday, and that thus they will have only one day of the small Sunday traffic in that holiday time, instead of a second. One or two of the large railways had decreased receipts for the first few months of the half-year, and they are now making these up; but they are not likely to show much increase. In the case of the South-Eastern, the Metropolitan and Metropolitan District, there are decreases of some moment—especially in the case of the latter—and they will be probably the three companies which have any important decrease. On the whole there is tolerable certainty that the railway receipts will show an enlargement for the half-year; and, in a few instances above estimated, the increase is important. As far as can be ascertained, the working of the traffic has not been more costly than a year ago; in some important points it has been cheaper. All the lines have had the advantage of cheap fuel, the price of coal having been rather less than a year ago; and as the contracts of the companies for iron were made when it was at about its lowest price, they may be said to have had the advantage of very low prices for many of the most important of the materials they use. Wages have not advanced, but on one or two lines economies in this large item have resulted in decreased cost, and with the exception of one great accident on the Manchester and Sheffield the cost of compensation is lower. There is, however, on two or three lines, such as the Midland, the element of increased capital to a considerable extent, and that item will take up all the increased earnings of companies such as that named, to pay a dividend such as that paid for the previous corresponding half-year. In the case of three or four companies at the head of the list in the increases we have above given, a higher dividend may be paid than in the corresponding period, if the saving in working be at all important. But as the increase has to allow its working expense to be deducted, and as an addition of a quarter per cent. to the dividend takes from £15,000 to £30,000 in the case of the great companies, it will be seen that whilst it may be expected that the dividends of a year ago should be in all cases nearly maintained, yet in few cases will there be any large increase of the dividend of the great railway companies.

IRONFOUNDERS AND STEEL CASTINGS.

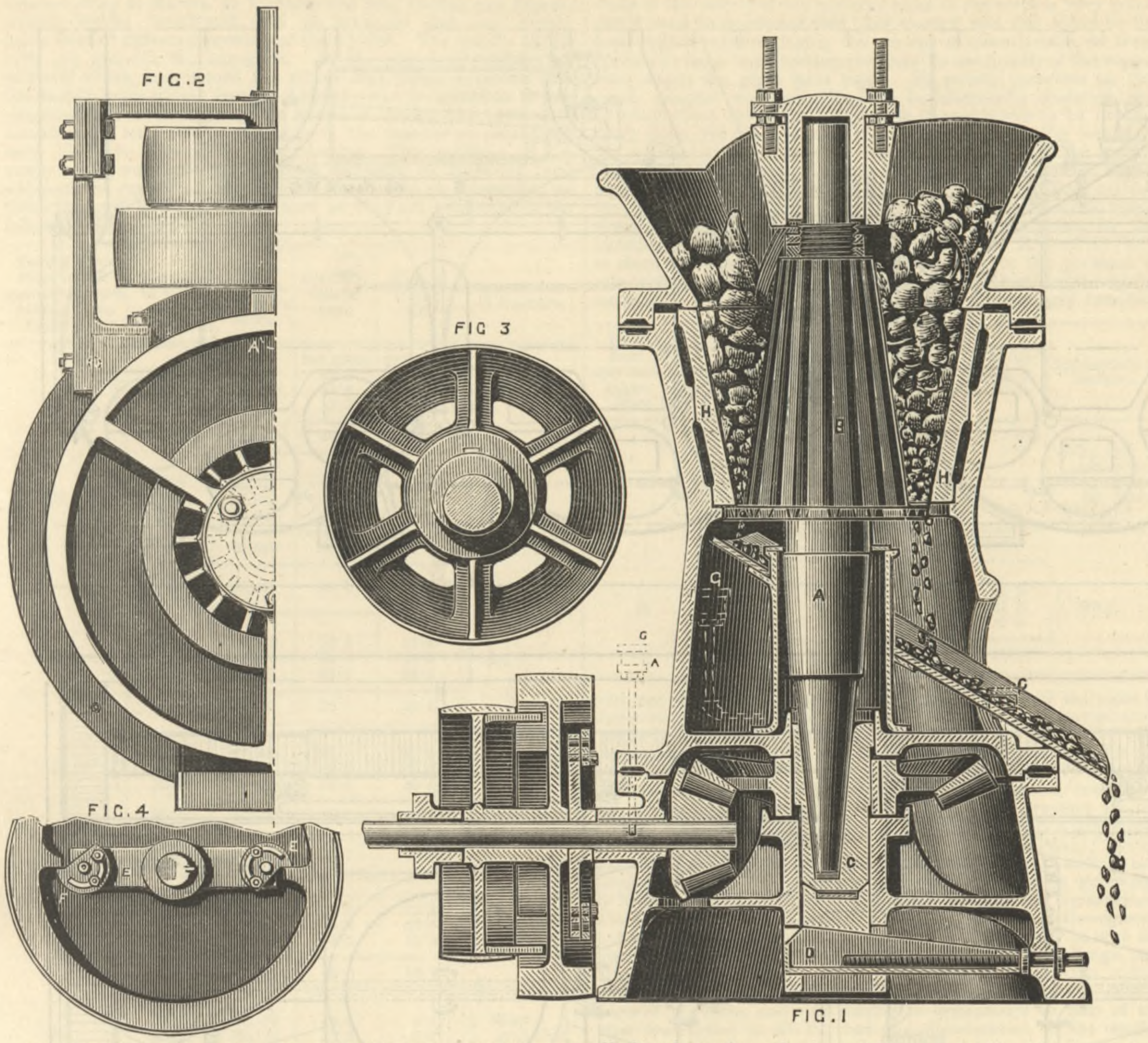
THE rapidly increasing use of steel castings cannot fail to produce uneasiness in the minds of the majority of ironfounders. In some departments of engineering, iron castings have already been all but discarded, while in many other branches the field for their employment is daily growing more restricted. Marine engineering, which at one time absorbed large quantities of first-class iron castings, is fast becoming independent of iron in any form; and in numerous engines of recent construction little beside the cylinders has been of cast iron. This is a natural result of the demand for combined strength and lightness, but none the less it is a very unsatisfactory development for the proprietors of ironfoundries, who thus see the best paying branches of their business passing altogether out of their hands. At first sight the remedy for this state of matters appears simple. The ironfounder must adapt himself to the times, and make steel castings. But a little consideration shows, and experience has proved, that in most cases this course is neither simple nor profitable. Steel for castings of any size is now almost universally melted in open hearth furnaces, and the founder who has decided to commence this manufacture builds a furnace and attendant plant large enough to turn out the heaviest articles he is likely to be asked for; he engages experienced assistants, and commences operations. If sufficient work can be secured to keep the furnace going with something like regularity, he will in all probability, after experiencing some ups and downs during the first few years of his venture, find himself fairly established in a profitable business. But this keeping the furnace regularly employed is the special difficulty with the newly-established steel founder. Even a small furnace is capable of making fifty to eighty tons of clean castings per week; and when only enough orders are booked to make up two or three casts per week, instead of twelve or fifteen casts, it is plain that the work must be done at a loss. The open hearth furnace cannot, like the cupola, be put in working order at a few hours' notice. It requires several days to bring it up to a working temperature, and, once started, must be kept going, burning gas, wasting brickwork, and requiring attendance, whether actually in use or not, as long as there is any probability of its being wanted. In addition to the direct losses thus occasioned, the irregular working leads to the production of inferior and "waster" castings; while the expedient of making ingots to fill up time generally proves to be an unsatisfactory and unremunerative proceeding. These considerations naturally deter ironfounders from embarking in the steel trade, but it is at the same time certain that they do not view the diversion of their business into the hands of the large steel corporations with equanimity, and that many of them would gladly adopt any process for making steel castings which could be conducted intermittently without pecuniary loss. We are not prepared to discuss the nature of such a process, but may say that indications point to the use of "blow-pipe" furnaces burning gas of high calorific power, and to the use of aluminium as an agent for reducing the temperature of fluidity of the steel. The whole subject is one of great interest and importance, and well worth the careful attention of metallurgic chemists and engineers.

THE PRACTICE OF PIG IRON MANUFACTURE.

HOW far the ordinary pig iron producers of the kingdom can assist manufactured ironmasters and steelmasters to produce a satisfactory material with less labour than is at present bestowed by them upon the elimination from the pig of injurious elements, is a matter worthy of the thoughtful attention of modern pig makers working upon scientific principles. The subject has just received some notice at the hands of the Staffordshire Institute of Iron and Steel Works Managers. Than such a body no class of men could be more concerned in a solution of the problem. Located in a part of the kingdom where the puddling furnace is maintaining its hold better than in any other of the ironmaking centres, it would be to Staffordshire a boon of the greatest magnitude if blast-furnace proprietors could take out in their part of the manufacture more of the injurious elements which now have to be dealt with by the laborious work of the puddler and the shingler, and by the process of the re-heating furnace. Certain of the younger members of the Institute, themselves being blast-furnace managers, working by the aid of constant chemical analysis, lately boasted that they could supply finished ironmakers and the steelmakers with any class of pig they required if they would only tell them exactly what were the chemical ingredients they required in low proportion, and what were the chemical ingredients they required in high proportion. The finished ironmakers expressed a good deal of incredulity, and it so happens that when, on Saturday last, a pigmaker read a paper before the Institute on "The Production of Pig Iron of a Definite Composition," pigmakers, when closely questioned, had to cry off considerably from their former boasting. One of the main difficulties which lies in the way of meeting the finished iron and steel masters' desires in this particular is that the ingredients which will suit one firm are not the best that will suit the production of another finished ironmaker or steel-producer. Nevertheless much reform might be brought about by an increased spirit of inquiry among the pig makers.

AT the Victoria Corn Mills, Sheffield, experiments have been made with the Grinnel automatic sprinkler and fire-alarm. Several of the large corn millowners in various parts of the kingdom were represented. It is claimed for this sprinkler that it has already extinguished 240 fires at an average cost of not more than £23. The fire extinguisher consists of a system of piping laid throughout the building, and so arranged that on the outbreak of a fire the heat itself not only turns on a copious supply of water, but also rings alarm bells in as many centres as there is a connection. The sprinkler has been supplied throughout the whole of the Victoria Mills, valued, with machinery, at £50,000. A fire was ignited and within fifty-five seconds the water poured on to the flames, which in a minute or two were extinguished. At the same time the alarms were set going all over the place. The experiments were regarded as highly satisfactory. The automatic sprinklers were supplied by Messrs. Mather and Platt, and the electric alarms were arranged by Messrs. Tasker, Sons, and Co.

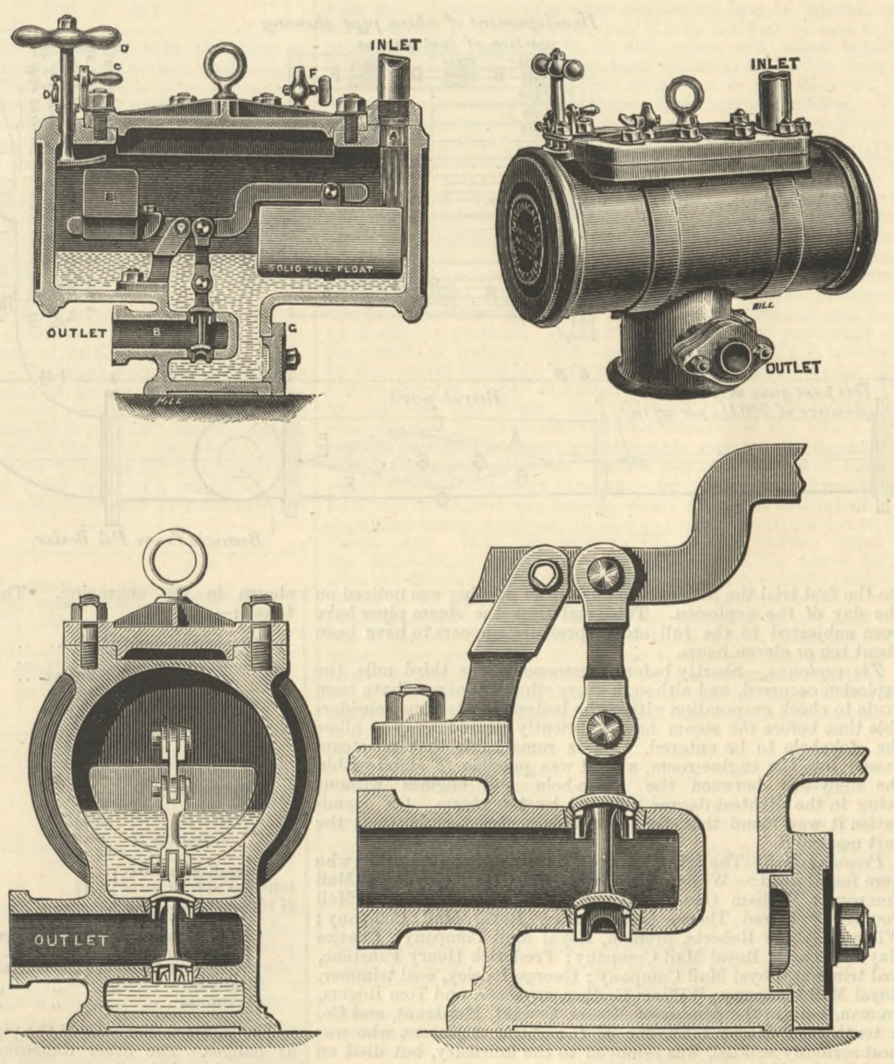
LOWRY'S CONTINUOUS ACTION GYRATORY STONE BREAKER.



CONTINUOUS ACTION GYRATING STONE BREAKER.

THE gyrating stone breaker illustrated by the accompanying engraving is a continuous action machine made by Messrs. James Farrar and Co., under Lowry's patent, for breaking ores, limestone, and all kinds of rock. The shaft A, which carries at its upper part a long crushing cone B, receives a gyratory motion imparted to it by the gearing shown at the lower part of the machine, which gives rotary motion to the long gun-metal step bearing C, which supports the shaft. This step is adjustable as to height by means of the wedge D. A section of the excentrically bored step brass is given at Fig. 3. At Fig. 4 is shown the method of driving as shown in Fig. 1 and Fig. 4. An arm E carries two adjustable pieces F F, which are set to bear equally against projections cast within the rim of the fly-wheel. The machine has a very large crushing surface within the ring H encircling the crushing cone, and the output of the machine is consequently large. The continuous action offers several advantages, amongst which is economy of power. The machine is being largely used, amongst other things for crushing anthracite coal; a No. 2 machine, for instance, weighing about 4 tons, breaking 12 to 13 tons per hour, and a No. 3 machine, weighing about 8 tons, breaking 18 to 20 tons per hour.

McDOUGALL'S STEAM TRAP.



THE steam trap illustrated by the accompanying engravings is made under McDougall's patent by the Chadderton Ironworks Company for ejecting the water of condensation from jacketted pans, steam worms, steam pipes, drying cylinders, and engine cylinders, automatically and without loss of steam. The apparatus consists of an iron vessel of a cylindrical form adapted to withstand high-pressure, with suitable inlet at A and outlet at R, having a movable cover for access to the internal parts. Within this cylinder moves a lever on a suitable fulcrum. A weight E of great specific gravity—a hollow cylinder of cast iron filled with lead—is adjustable above one end of the lever in the steam space, and on the other end an earthenware weight of less specific gravity is adjusted below the lever, so as to cause a considerable displacement as the water rises in the vessel. Near the fulcrum, which has a knife edge joint, a short link connects the lever with the equilibrium valve. As the tile float is lifted by the accumulating water in the vessel, the valves are opened and the water discharged. Both the weight and float are solid, and free from contact. The moving parts are as free from friction as possible, and complication is carefully avoided. A loose test lever D, with a rest and movable pin C, passing through a stuffing-box with a handle outside, is provided for testing or to blow through the valves, when steam is first turned on, any grit that may have settled on the valve seatings. By altering the pin the valves are again released and the lever set free. To expel the air a pet cock F is provided, which can be substituted by an automatic air valve when required. The trap is now largely used, and some of the advantages claimed for McDougall's steam trap are that it provides a balanced stop valve, which works freely, and opens and shuts independent of pressure; that it has a solid balanced tile float, working on a knife edge, to actuate the valve in place of the ordinary hollow floats, which are liable to collapse and burst; that it can be tested whilst at work; that it will work either at high or low pressures.

THE EXPLOSION ON BOARD THE ELBE.

WE publish this week three important papers, all bearing on the bursting of the steam pipe of the s.s. Elbe. It is to be regretted, perhaps, that the Board of Trade report was not issued sooner, because there is a tendency even in such lamentable catastrophes as this in question to become a nine days' wonder. The matter is forgotten after a little time, and the useful lessons drawn from it do not make sufficient impression. However, in this case the questions raised are of such vital importance that they are not likely to be overlooked; and the delay which has occurred is, in the end, not likely to prove injurious.

The reports in question are three in number. We give first that of the Board of Trade. As Mr. Kirkaldy's report has already appeared in our pages we do not reproduce it.

The second report is that prepared long ago by Mr. W. Parker, chief engineer-surveyor to Lloyd's. It is, we think, a masterly piece of reasoning; and we have no hesitation in adopting its conclusions as true. Mr. Parker gives engravings which are practically the same as those accompanying the Board of Trade report, which will be found on page 522. To save space we have omitted Mr. Parker's description of the accident, because that given in the Board of Trade report is sufficiently precise.

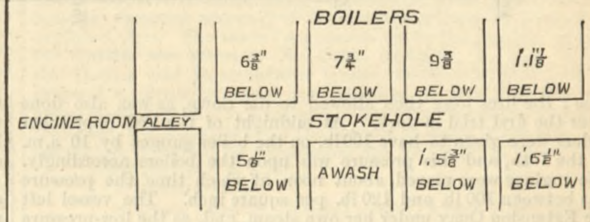
The third report is in the form of a paper read by Mr. Sinclair before the Institution of Engineers and Shipbuilders in Scotland. It explains itself.

Consultative Branch, Marine Department, Board of Trade,
Bedford-street, Covent-garden, London, W.C.
21st October, 1887.

Sir,—In accordance with instructions, we have the honour to submit the following report respecting the above-mentioned explosion, which occurred about 5.30 p.m., on the 19th ultimo, while the vessel was undergoing her steam trial at Stokes Bay.

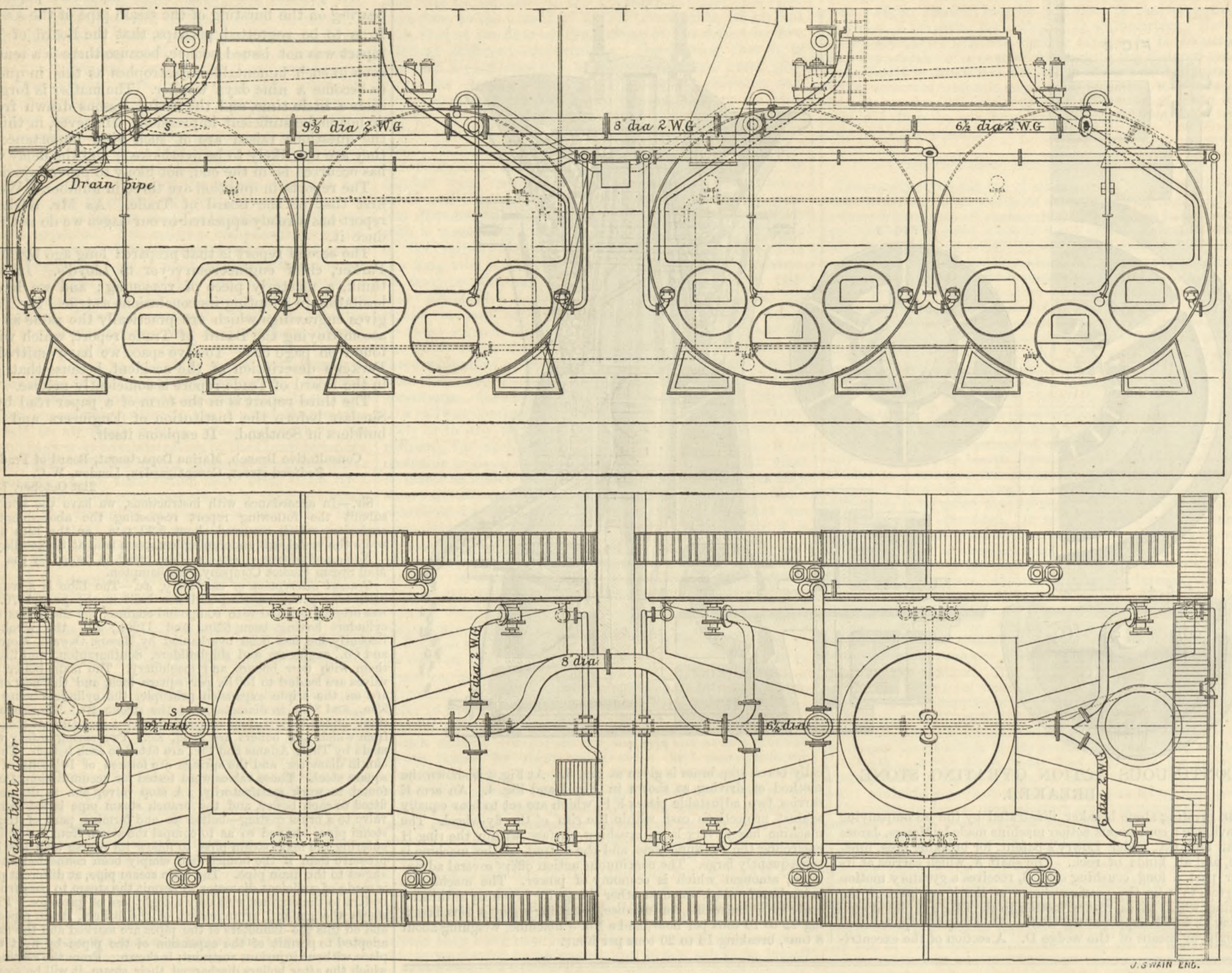
Name and address of owners.—The vessel is owned by the Royal Mail Steam Packet Company, Southampton.

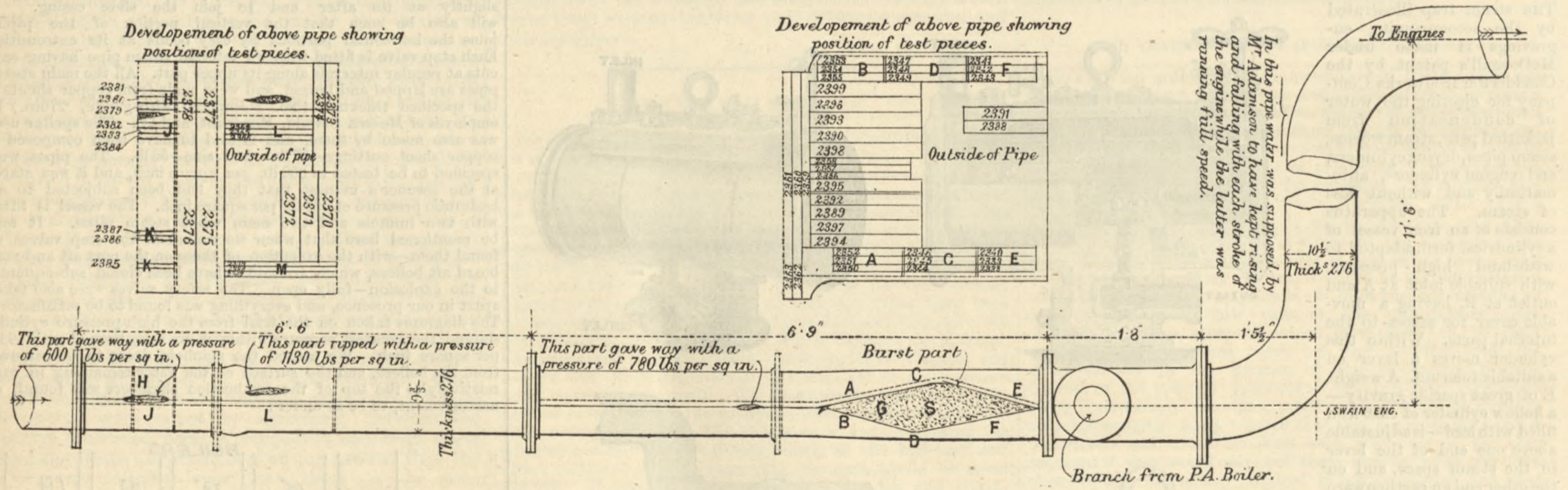
General description of machinery, &c.—The Elbe is a vessel of 3108 tons gross register, and was built in the year 1870. She was originally fitted with compound engines, the diameters of the cylinders having been 62in. and 112in., and the stroke 4ft. Recently she has been overhauled by Messrs. Oswald, Mordaunt, and Co., engineers and shipbuilders, Southampton, and fitted by them with new boilers and machinery. The main boiler safety valves are loaded to 150 lb. per square inch, and the new engines are on the triple expansion principle, the cylinders being 33in., 53in., and 88in. in diameter, and the stroke 4ft. There are eight single-ended boilers, four on each side of a fore-and-aft stokehole, from which the boilers are fired, &c. Two spring safety valves, made by Thos. Adams and Co., are fitted to each boiler. They are 3in. in diameter, and the springs are formed of $10\frac{1}{2}$ coils of $\frac{11}{16}$in. square steel. These valves were tested for accumulation, &c., and found to work satisfactorily. A stop valve, 5in. in diameter, is fitted to each boiler, and the branch steam pipe is led from this valve to a brass casting—bolted to and forming part of the main steam pipe—shaped so as to compel the steam from the boiler, on entering the main steam pipe, to follow its course with less loss of pressure than if the branch had simply been connected at right angles to the main pipe. The main steam pipe, at different points, is made of sufficient diameter to permit the steam to pass from the boilers to the engines with only a slight loss of pressure. Plate I. shows the general arrangement of the boilers, steam pipes, &c., and on this the diameters of the pipes are marked and the method adopted to permit of the expansion of the pipes by heat taking place without injurious restraint, is shown. From the casting into which the after boilers discharged their steam, it will be seen that the main pipe rises vertically for a height of 11ft. 6in., and is thence continued horizontally into the engine room, dipping slightly at its after end to join the slide casing. It will also be seen that the vertical portion of the piping joins the horizontal portions by easy bends at its extremities. Each stop valve is fitted with an internal steam pipe having saw-cuts at regular intervals along its upper part. All the main steam-pipes are lapped and brazed, and were made from copper sheets of the specified thickness (No. 2 Imperial wire gauge, ·276in.) by employés of Messrs. Oswald, Mordaunt, and Co. The spelter used was also made by them, and is said to have been composed of copper sheet cuttings—57 lb.—and zinc—56 lb. The pipes were specified to be tested to 300 lb. per square inch, and it was stated at the coroner's inquest that they had been subjected to an hydraulic pressure of 350 lb. per square inch. The vessel is fitted with two funnels and two main waste steam pipes. It may be mentioned here that when we examined the stop valves we found them—with the exception of those on the port aft and starboard aft boilers, which are said to have been closed subsequently to the explosion—fully open. The safety valves were also taken apart in our presence, and everything was found to be satisfactory. The diagrams taken on the trial from the high-pressure cylinder showed the greatest pressure within it to have been about 146 lb. per square inch. We caused the manhole doors to be removed from the boilers, and the surface of the water remaining in each relatively to the top of the combustion chambers was found, on measurement, to be as under:—



Boilers—Trials, &c., under steam.—After the boilers and machinery were placed in the ship it appears that the fires were lighted for the first time at 10.45 p.m. on the 18th August, 1887. At 6 a.m. on the following day the boilers were heated to enable them to be coated with a non-conducting composition, the pressure kept on them for that purpose being about 20 lb. per square inch. Fires remained in the boilers, and on the 22nd August the pressure of steam was raised on six of them to 150 lb. The boilers were under the charge of William Godber, who was a certificated sea-going engineer in the employ of the builders, and the object of raising steam to the full pressure was to ascertain that all the joints, &c., were in good order before covering up the pipes and other parts. Steam was again raised to 150 lb. on the 27th August in order to have a trial of the machinery in the dock; the full pressure was on the steam pipes for about three or four hours on this occasion. On Tuesday, 30th August, the safety-valves of the six boilers were adjusted, the valves on the remaining boilers being tested on the following Friday. The stop valves were not opened on either of these occasions. On Monday, 5th September, the vessel proceeded down Southampton Water for a steam trial, on which occasion the low-pressure piston-rod became heated and bent, owing to a tight gland; full pressure was on the steam pipes for about six hours. The vessel was brought back on the next day, the pressure being from 100 lb. to 120 lb. per square

GENERAL ARRANGEMENT OF BOILERS, S.S. ELBE,





inch; the fires were then allowed to die down, as was also done after the first trial in dock. At midnight of the 18th September orders were given to have 100 lb. on the boiler gauges by 10 a.m. on the 19th, and this pressure was upon the boilers accordingly. The engines were moved about noon, at which time the pressure was between 100 lb. and 120 lb. per square inch. The vessel left the Extension Quay under her own steam, and, as the low-pressure piston-rod again showed signs of heating at the bottom end, the lower gland was slackened back, but as the tail end of the rod also began to give trouble it was concluded that the stuffing-box was too tightly packed, and the engines were stopped for about an hour, during which time the gland was removed, and replaced after taking out one turn of the packing. The engines were again started and ran at about 47 to 50 revolutions per minute, the rods giving no further trouble. On the arrival of the vessel at Stokes Bay it was ascertained that all the stop valves on the boilers, and the throttle and regulating valves on the engines, were fully open. The steam pressure was then rising, and word was passed to the stokehole that full steam was required. There were two gauges in the engine-room showing the pressure in the steam pipes; the pipe from one was led to the after four-way casing in the stokehole, and the other to the steam pipe, close to the slide casing. It is said that both gauges indicated 148 lb. shortly before going on the first mile run, and that at the same time the gauge on the medium cylinder casing showed 45 lb. to 50 lb., that on the low-pressure slide casing from 10 lb. to 12 lb. and the vacuum gauge fully 29in. The first mile appears to have been run in three minutes forty-five seconds—it was slack water at the time. After running some time the vessel was got in position for commencing the second mile, which took over four minutes to complete against wind and tide. The revolutions of the engines varied from 62 to $63\frac{1}{2}$ per minute. On the first trial the boilers primed, but no priming was noticed on the day of the explosion. The total time the steam pipes have been subjected to the full steam pressure appears to have been about ten or eleven hours.

The explosion.—Shortly before commencing the third mile, the explosion occurred, and although every effort appears to have been made to check evaporation within the boilers, it was some considerable time before the steam had sufficiently cleared away to allow the stokehole to be entered. It is remarkable that no steam passed into the engine-room, and it was possible to stand within the alley-way between the stoke-hole and engines without being in the slightest degree affected by the steam. On examination it was found that the main steam pipe had burst at the part marked S.

Persons killed.—The following are the names of the nine men who were found dead:—William Thompson, chief engineer, Royal Mail Company; William George Ewing, second engineer, Royal Mail Company; Alfred Thorn, boiler-maker, Royal Mail Company; William George Roberts, fireman, Royal Mail Company; Charles Hayes, fireman, Royal Mail Company; Frederick Henry Fanstone, coal trimmer, Royal Mail Company; George Paisley, coal trimmer, Royal Mail Company; William Godber, engineer, and Tom Rogers, fireman, both in the employ of Messrs. Oswald, Mordaunt, and Co. A tenth man, Henry Flux, one of the ship's engineers, who was most seriously scalded, was removed to the infirmary, but died on the following Tuesday morning.

Part which gave way, &c.—We first visited the vessel on the 21st of September, and made such an examination of the pipe as was possible at that time, the pipe being then in position. We caused it to be taken down and removed to the upper deck in order to make a closer inspection of the fracture, the form of which is clearly shown in the engraving. The following are the dimensions taken:—

Greatest opening at B .. .. $8\frac{3}{8}$in. at outside of pipe.
,, ,, ,, ... $8\frac{1}{8}$in. at inside of pipe.
,, internal diameter .. .. .. $10\frac{5}{8}$in.

	In.		In.
Length A B =	18	Length A E =	$22\frac{1}{4}$
,, B C =	$17\frac{1}{2}$	,, E C =	$13\frac{1}{4}$
,, C D =	$1\frac{3}{4}$	,, C D =	$1\frac{3}{4}$
	$37\frac{1}{4}$		$37\frac{1}{4}$
Depression at D	$\frac{7}{16}$		$\frac{7}{16}$
	$36\frac{13}{16}$		$36\frac{13}{16}$
Length A D	36		36
Longitudinal extensions at torn parts of pipe..	$\frac{13}{16}$		$\frac{13}{16}$

Circumferential extension at torn parts of pipe .. *Nil.*
Thickness of pipe .. .. ·276in.
Average thickness of pipe at fracture .. .. .. $\frac{3}{16}$in.
Minimum ,, ,, ,, ... $\frac{1}{8}$in. full.
Maximum ,, ,, ,, ... $\frac{1}{4}$in. bare.

The internal diameter of the pipe was $9\frac{3}{8}$in. at middle and $9\frac{1}{2}$in. at flanges. The other dimensions are shown on Plate II. The appearance of the fracture was coarsely granular and of a very dark colour. This will be specially referred to further on.

Experimental tests, &c.—Arrangements were made to have the material of the burst pipe tested for tensile strength, elongation, &c., but the testing was unavoidably delayed until the coroner's jury consented to the removal of the pipe for that purpose, and their approval was not obtained until the adjournment of the inquest, on the 29th ult. The portion of the pipe shown on Plate II. and portions of the pipe forward of it were then forwarded without delay to Messrs. D. Kirkaldy and Son, Testing and Experimental Works Southwark, and we arranged that they should make tests of different portions of these pipes. The results of the tests are given in the Appendix. As the object of testing the material which had formed the pipes—that which exploded and the length immediately forward thereof—was to ascertain if any alteration had been made in its condition during the process of manufacture, we arranged the tests in the manner we considered most likely to accomplish that purpose. The positions of the pieces which were selected by us are indicated on Plate III., and although the results of the tests are recorded in an Appendix, we think they will be better understood as they are presented in the following summary:—

Part of pipe from which specimens were taken. (See Plate III.)	Number of test piece.	Tensile strength per square inch.	Contraction of area.	Elongation in 5in.	Appearance of fracture.
		lbs.	per cent.	per cent.	
A	2350	30,289	49·6	23·6	Silky.
	2351	31,430	51·8	23·8	
	2352	32,126	57·0	30·4	
	Mean	31,281	52·8	25·9	
B	2353	31,341	46·6	21·0	do.
	2354	31,866	51·8	26·4	
	2355	31,562	51·1	24·6	
	Mean	31.589	49·8	24·0	
	Mean of means.	31,435	51·3	24·9	
C	2344	30,822	53·3	17·4	do.
	2345	31,415	58·5	28·2	
	2346	32,214	63·7	33·6	
	Mean	31,483	58·5	26·4	
D	2347	31,903	37·7	21·6	do.
	2348	32,029	49·6	29·8	
	2349	32,096	50·4	30·4	
	Mean	32,009	45·9	27·2	
	Mean of means	31,746	52·2	26·8	
E	2338	27,323	25·4	12·2	Silky and granular.
	2339	26,761	23·8	10·4	
	2340	28,386	34·8	18·2	
	Mean	27,490	28·0	13·6	
F	2341	23,728	13·6	4·6	Silky, granular, flaw.
	2342	25,128	13·6	5·2	
	2343	24,400	12·0	4·0	
	Mean	24,418	13·0	4·6	
	Mean of means	25,954	20·5	9·1	

Specimens from back of Pipe.

Part of pipe from which specimens were taken. (See Plate III.)	Number of test piece.	Tensile strength per square inch.	Contraction of area.	Elongation in 5in.	Appearance of fracture.
		lbs.	per cent.	per cent.	
G	2356	33,081	60·0	33·8	Silky.
	2357	32,563	58·5	32·4	
	2358	33,644	58·5	33·2	
	Mean	33,096	59·0	33·1	

The test pieces (G) cut from the pipe as far from the seam as possible, may fairly be taken to represent the normal condition of the sheet copper at that part. The mean results of the three tests selected, and which were numbered 2356, 2357, 2358, give a tensile strength of 33,096 lb. per square inch, contraction of area 59 per cent., and elongation 33·1 per cent. in a length of 5in., thus showing that the material of which the pipe was made was of good quality. It will be seen that the parts near the brazing (A, B, C, D, E, and F), which had necessarily been heated have thereby suffered a reduction of tensile strength, contraction of area, and elongation, and the loss is, in some cases, very marked. Proceeding to the portion near the flange (E), we find the mean results of tests, numbered 2338, 2339, 2340, give a tensile strength of 27,490 lb. per square inch, contraction of area 28 per cent., and elongation 13·6 per cent. in a length of 5in., while the test pieces (F), cut from the opposite side of the seam, and numbered 2341, 2342, 2343, show a tensile strength of 24,418 lb. per square inch, contraction of area 13 per cent., and a mean elongation of 4·6 per cent. in a length of 5in. The mean of the six tests cut from the two sides of the seam gives a tensile strength of only 25,954 lb. per square inch, contraction of area 20·5 per cent., and elongation 9·1 per cent. in a length of 5in., whilst the worst result included in these shows the contraction of area to be as low as 12 per cent. and the elongation not more than 4 per cent. in a length of 5in. The results of the tests of the parts marked H J in Plate III. are as follows:—

Part of pipe from which specimens were taken. (See Plate III.)	Number of test piece.	Tensile strength per square inch.	Contraction of area.	Elongation in 3in.	Appearance of fracture.
		lbs.	per cent.	per cent.	
H	2379	31,704	38·9	25·3	Silky.
	2380	31,352	34·3	22·3	
	2381	31,880	43·5	27·3	
	Mean	31,645	38·9	24·9	
J	2382	20,925	21·3	8·0	Silky flaw.
	2383	28,203	28·7	12·7	Silky.
	2384	31,694	38·9	31·2	
	Mean	28,940	29·6	17·3	

The above results are much superior to those obtained from the parts near the flange of the burst pipe, yet the part between these two sets of test pieces was found cracked, for three-fourths of its thickness, from the outside when tested by hydraulic pressure. The average results of the tests 2385, 2386, 2387, which were cut from the good part of this pipe K, gave a tensile strength of 33,466 lb. per square inch, contraction of area 51·3 per cent., and elongation 37·6 per cent. in a length of 3in., thus showing that the material in this pipe had also been such as would be considered satisfactory. In the case of the portions of the pipe marked L, M on Plate III. the Table on next col. shows the results of the tests:—Here it will be seen that the test pieces cut close to the seam gave a mean tensile strength of 23,114 lb. per square inch, contraction of area 11·7 per cent., and elongation 3·5 per cent. in a length 5in., while those cut through the part of the pipe distant from the seam gave a tensile strength of 33,032 lb. per square inch, contraction of area of 50·1 per cent., and elongation 31·2 per cent. in a length of 5in. In all the above results the deterioration which has been made in the nature of the material close to the seam is very great, and it must be concluded that this change was due solely to the treatment it received during the course of manufacture, as there appears to have been nothing abnormal in the quality of the copper from which the pipes were made. To satisfy ourselves on this point, samples were submitted to be chemically analysed, and although there was not sufficient time to enable this to be exhaustively done, yet the following report, coupled with the results of the mechanical tests, show no reason to doubt that the quality of the copper was good : "I have tested the two samples of copper pipe marked *x* and *z* from the s.s. Elbe, but have found nothing that would lead me to suppose that an exhaustive analysis would reveal such impurities in the copper as would account for the bursting of the pipe. Of course the time at my disposal has been so short that I have been unable to examine it for the presence of sub-oxide of copper. There is certainly no sulphur in either of the samples." Messrs. Oswald, Mordaunt, and Co. willingly complied

Part of pipe from which specimens were taken. (See Plate III.)	Number of test piece.	Tensile strength per square inch.	Contraction of area.	Elongation in 5in.	Appearance of fracture.
		lbs.	per cent.	per cent.	
L	2364	25,472	17·6	5·6	Silky and granular.
	2365	20,284	5·6	2·2	Silky, granular. flaw.
	2366	23,048	12·0	2·8	Silky and granular.
	Mean	23,114	11·7	3·5	
M	2367	33,736	51·2	35·2	Silky.
	2368	33,352	46·4	27·0	
	2369	33,008	52·8	31·6	
	Mean	33,032	50·1	31·2	

with our request that they should test one or more of the pipes to destruction, and with that view the length of pipe immediately forward of that which failed was removed to the works and subjected to hydraulic test, the Board's gauges being used for the purpose of indicating the pressure. The pipe gave way when the pressure had reached 600 lb. per square inch, at an old crack near the outside edge of the seam. The colour of the fracture for the greater part of its depth was a deep purple, and only a thin streak at the inside, average about 1/16in. thick, had metallic lustre. The damaged part of the pipe was then cut off, and a new flange brazed on the good portion, which was again submitted to hydraulic pressure until it burst, at 1130 lb. per square inch. The fracture in this case was of a bright copper colour throughout, but of a somewhat granular appearance. The sound part of the pipe which burst on board the vessel was fitted with a flange, and afterwards destroyed by internal pressure of 780 lb. per square inch. The resulting fracture was in this case close to the outside edge of the seam, and was similar in appearance to that of the pipe that failed at 600 lb., but the discoloration of the outside portions would be more properly described as a deep brown, and in this case the discoloration only extended through about one-half the thickness of the pipe.

As the fracture of the Elbe's pipe which burst under steam pressure and the fractures obtained at two of the hydraulic tests to destruction, referred to above, were of a similar character, we thought it desirable to make a series of bending tests of pieces of copper in various conditions in order readily to illustrate the effects of different treatment. Sketches of these bends are attached, and the necessary references are given in an Appendix D. The pieces marked A 1, A 2, S, and T exactly reproduced the dark appearance of the fractured pipes, with the thin streak of bright metallic copper, to which reference has already been made, but the grain of the metal in S and T was fine, whereas that of A 1 and A 2 was coarse, as in the pipe that burnt under steam pressures, and as in the discoloured portion of the pipe that burst with a pressure of 600 lb. per square inch. These bending tests are exceedingly interesting and useful, inasmuch as they show that, although copper when overheated may be injured, and even cracked, by a slight blow, yet, if it be allowed to cool in air before work is put upon it, it will, when cold, stand bending through an angle of 180 deg. without fracture, and, when broken, there is little or no perceptible difference in the colour of the resulting fracture and that of copper in its normal condition. The copper is, however, altered in character, as will be seen by reference to the results of the tests in the Appendix, and will not bear such rough treatment as copper in its normal condition. These tests also show that overheated copper is rendered less ductile by cooling in cold water, whereas the ductility of copper, heated in its normal state to brazing temperature only, is increased by such treatment. The particulars of these tests and positions of fractures are given. In order to properly estimate the results obtained from the tests referred to, it was considered desirable to construct a copper pipe for experimental purposes of nearly the same description and dimensions as those of the pipes which we had seen burst by hydraulic pressure. Accordingly, a pipe, the particulars and the results of tests of which are given in Appendix B, was made by Mr. George Brockley, coppersmith, Chipka-street, Poplar, from a stock sheet of copper of ordinary quality, not specially selected. Its thickness was ·264in., and its bursting pressure 1380 lb. per square inch. It will be seen that the strength of the Elbe's pipes which were tested compare unfavourably with the results obtained with the experimental pipe. Tensile and other tests were made of pieces cut from the sheet of copper from which this experimental pipe was made, and the results, which are given in Appendix C, show that it was practically similar to the uninjured portion of the Elbe's pipes. With reference to the elastic stresses given in the Appendix, it is necessary to point out that the pieces tested were cut from a portion of the pipe which had previously been subjected to an internal pressure of 1130 lb. per square inch; while those recorded on Appendix are the results obtained from testing specimens of the sheet copper in its normal condition. The latter show the ratio of the elastic to the ultimate stress to be nearly 23 per cent. The following table contains the results of all the hydraulic tests, and shows that as the intensity of the discoloration at the fracture increases the bursting pressure decreases:—

Pipe under test.	Bursting pressure per sq. in.	Appearance of fracture.	Remarks.
	lbs.		
New pipe	1380	Granular, and of the ordinary colour of copper	Relative bursting pressure of this pipe, had it been of exactly the same dimensions as the burst pipe 1456 lb
Pipe forward of the one that burst, 2nd test	1130	Coarsely granular, and of the ordinary colour of copper	—
Uninjured part of the pipe that burst	780	Granular; about one-half of section dark brown; remaining portion of the ordinary colour of copper	—
Pipe forward of the one that burst, 1st test	600	Coarsely granular, about three-fourths of section deep purple; remainder ordinary colour of copper	This pipe, where fracture occurred, was thinned considerably

Conclusions as to cause of explosion.—We consider that the opinions we had previously formed as to the cause of this disaster have been amply confirmed by these tests, by the tests made at Messrs. Kirkaldy's works, and by the results obtained from the hydraulic tests, which showed portions of the pipes to have failed respectively at 600, 780, and 1130 lb. per square inch internal pressure, while 1566 lb. was the corresponding pressure at which the experimental pipe would have given way had it been of the same thickness and diameter. Apart, however, from the results of the test, the appearance of the fractures in the pipes, &c. support our views as to the cause of the disaster, viz., that—(1) Either the copper was cracked while the pipe was over-heated, or (2) the process of rounding and planishing produced incipient flaws which, on the pipe being again put on the fire for the purpose of brazing the flanges, extended and received the distinctive coloration referred to. The first view is strongly supported by the discovery of the crack in the pipe that failed with a water pressure of 600 lb. per square inch, and by the coarse appearance and discoloration of the fracture. It is, however, possible for the pipe to have been cracked in accordance with the second view, if the material had been hard and brittle, but looking to the satisfactory results of testing the back portions of ths pipes, it is improbable that this was the case in the present instance, unless portions of the pipes had been previously overheated in the process of brazing. The burst pipe was manifestly weaker than the one forward of it, for although the latter was in a dangerous condition it did not burst, and, moreover, it had no appearance of being strained when examined by ourselves and others, prior to its being tested to destruction. The rip probably began at the part marked F., and extended along the pipe in both directions until stopped by the flange on the one hand, and on the other by an iron band —hanger—which supported the pipes. The dark appearance of the metal throughout the fracture was doubtless partly due to the cause or causes which produced the discoloration of the other fractures referred to herein. We have proved experimentally that steam does not materially alter the appearance of fresh broken copper, whereas hot salt water darkens it, and it is to this agent that we attribute the discoloration of those portions of the fracture which were produced by the explosion. It may seem paradoxical that a pipe which had been tested by water pressure to 350 lb. per square inch should have burst with a steam pressure of 150 lb. per square inch, but if due allowance be made for the reduction in the strength of copper when heated to the temperature of steam of 150 lb. pressure, and to the stress produced by the longitudinal expansion which, while raising steam may have been unequal throughout the pipe, and to the variation of pressure within the pipe while the engines were at work, we think its failure was only what might have been expected, seeing we have good reason to believe that the pipe had been dangerously cracked in the course of manufacture. It should be mentioned here that the brazing of the burst pipe at the ruptured part was defective, and there was also evidence of the seam having "drawn," and of the spelter having partly "drained," but these defects of themselves would not account for the pipe failing with a pressure so very low as that to which it was subjected when the explosion occurred.

General remarks.—Three different suggestions as to the cause of the failure of the pipe were made at the coroner's inquest. The first was that of Mr. Adamson, manager of Messrs. Oswald, Mordaunt, and Co.'s works. He had formed the opinion that the presence of water, either through priming or condensation in the pipe, caused it to burst. He thought a body of water had lodged in the vertical portion of the steam-pipe, and falling back after the slide had cut off, met at the same instant another body of water coming from the boilers, and thus caused a shock which rent the pipe. The first body of water had, he believed, been rising and falling for some considerable time, and, not being able to clear itself through the cylinders owing to the height of the vertical portion of the pipe, fell back by gravitation, and met the other body of water flowing with the steam from the boilers. This might, he thought, occur at any time, although the set of circumstances which would cause it to do so might happen very rarely. In our opinion this is a most remarkable theory; it is inconsistent with every-day experience, and one not likely to be seriously entertained by practical engineers. It is necessary, in order that it may be possible, that water should possess properties which are at variance with all preconceived ideas, and that the action of the laws which govern fluid motion should have been suspended for a short time on this particular occasion. There was not the slightest evidence of priming on the trial either in the glass water-gauges, cylinders, or steam pipes, and there is not the slightest probability that any bodies of water, such as is imagined were in the pipes, could be there without giving some indication of their presence. As to condensation, the pipes were thickly coated with a non-conducting composition, and since the engines had been running at full speed for some considerable time, it is absolutely unreasonable to imagine that a body of water could by this means be formed within the pipe. But supposing two such bodies of water to exist from any cause, known or unknown, is it probable that they came forcibly into collision within a steam pipe, and, if they did, that such collision would result in the destruction of this particular pipe, had it been sound? The conception of the whole theory demands such a fertile imagination, that, in the face of facts, we do not think the subject worth pursuing further. Two of the tested pipes gave out at such a low pressure that it was thought necessary to offer some reason for their deficiency of strength. It was contended that they must have suffered on the occasion of the occurrence of priming at the previous trial. Unfortunately for this contention, the fractures showed that it was from the outer surfaces of the pipes that the flaws commenced, and the inner surfaces of the pipes were not damaged as they would have been in a thick cylindrical pipe if the cracks had resulted from internal pressure. If the priming had been very great, we think the lower bend of the vertical pipe and the portion of piping abaft this would have suffered most, especially as these pipes are 1⅛in. larger in diameter and only of the same thickness as that of the exploded pipe. The second suggestion as to the possible cause of the disaster was given by Mr. David Kirkaldy, M. Inst. C.E, of the Testing and Experimental Works, Southwark; this took the shape of a calculation which was designed to show that the pipe, owing to its defective brazing and consequent reduction of effective thickness, was insufficient for the purpose to which it was put. The calculation is certainly a remarkable one, and is given below:—

"Mean diameter = 9·75in.
× 3·1416 = 30·61.
× steam pressure (150 lb.) = 4591, which I call pressure per superficial area.
To resist we have—
1·00 × ·16 = ·16 square inches sectional area.
Strength of copper = 30,400.
30,400 × ·16 = 4864."

It is scarcely credible that such figures could be placed before a Court by a gentleman of Mr. Kirkaldy's position. Why mean diameter is taken, or for what reason the "pressure per superficial area" is to be compared with the estimated resistance of 1in. length of one thickness of the copper, Mr. Kirkaldy refused to explain, but he pointed out that 4591 and 4864 were so very near each other that the cause of the explosion was not wrapped in any mystery whatever. The thickness of the pipe used in this calculation is neither the minimum, mean, nor maximum, at the line of fracture, while the tensile strength of copper taken is, in round numbers, that obtained from the three pieces numbered 2391, 2392, and 2393, that were experimentally heated to brazing temperature, and consequently uninjured. On the other hand, the results of the pulling tests as presented herein show that portions of the piping near the brazing were materially injured, and those parts should not be ignored when making a calculation of this kind. Mr. Kirkaldy would, however, have found them inconsistent in this instance for, by his method of calculation, the pipe should then have burst with a cold water pressure of about 130 lb. per square inch, or about 20 lb. less than the steam pressure to which it had been subjected for several hours. It would be idle to minutely criticise Mr. Kirkaldy's calculation, but we may state, however, that he very far under-estimated the strength of the pipe, relatively to that of the forces tending to tear it asunder.

Mr. Kirkaldy's method reduced to formula is—

$$D \times 3{\cdot}1416 \times P = T \times f$$

$$\text{or } P = \frac{T \times f}{D \times 3{\cdot}1416}$$

where D = mean diameter of the pipe in inches.
P = internal pressure per square inch tending to burst the pipe.
T = thickness of the pipe in inches.
f = assumed tensile strength of 1 square inch of copper in lbs.

and, by applying this to the new pipe made by Mr. Brockley—if the actual dimensions of the pipe and strength of copper be taken the same as was assumed by Mr. Kirkaldy—it will be seen that the bursting pressure of the new pipe should have been about 265 lb., whereas the actual bursting pressure was no less than 1380 lb. Further comment on this calculation is, we feel, quite unnecessary. Mr. Steele, one of the Board's surveyors at Southampton, gave as his opinion that the pipe had been overheated. This was the third suggestion, and from our report we think it will be seen that there were grave reasons for coming to this conclusion. It is consistent with the facts of the case that the pipes were injured in this manner in the course of their manufacture, whereas the conclusions of Messrs. Adamson and Kirkaldy are at variance therewith. With regard to copper steam pipes in general, we consider the tensile strength usually assumed in calculation to be too high. While the tensile strength of good sheet-copper probably varies from about 30,000 lb. to 33,000 lb. per square inch, it must be remembered that the copper has been toughened by the process of rolling, but when it is afterwards worked in the fire it loses a considerable portion of its strength. This, of course, the subsequent planishing received by the pipe somewhat restores, but when the flanges are brazed on, the copper, for several inches from the flange, is again softened, and in this state the pipes are usually fitted, for, if further planishing is attempted, the brazing at the flanges is likely to be started. From this point of view it would appear desirable to leave the whole pipe unplanished, and so avoid possible injury by the hammer. Here we must express our opinion that, for high-pressures especially, it is desirable that copper steam pipes should be solid drawn or have their longitudinal seams rivetted, as, by so making them, we could more certainly estimate their value, and the risk of overheating, &c., would be minimised. We have examined various rules which are said to be used by different firms in designing copper steam pipes, but none of these appear to us to be wholly satisfactory. A high factor of safety is commonly thought to be necessary for such pipes; but while some have an apparent factor of safety of from 10 to 15, the real factor is often far less. There are many considerations which it is necessary to have in view when framing a rule for thickness of steam pipes, and to formulate one which would give full effect to them would be very difficult; at any rate the formula obtained would be most unwieldy, and in order to be of practical value, the expression for the thickness required must be to some extent empirical. When calculating the strength of a copper pipe the effects of temperature, amongst other things, should not be overlooked, there being a rapid diminution in the tensile strength of copper with only a moderate increase of temperature—see Appendix E. The usual hydraulic test for brazed steam pipes should, we think, be materially increased, and after the pipes are fitted into the ship the whole range of piping, as well as the stop-valves, &c., should be tested to at least double the working pressure. It is very difficult to provide for all cases, but in this instance, if the stop valves had been so arranged that they could have been closed from the deck, &c., earlier access could have been obtained to the stokehole, and, in addition, the risk of injury to the boilers from shortness of water would have been obviated. It would also seem desirable to fit each boiler with a reliable valve which would close automatically in the event of the steam pipes bursting, but which would not act in ordinary cases of priming; so far as we know, however, such a valve has yet to be devised.

In conclusion, we have pleasure in stating that Messrs. Oswald, Mordaunt and Co. afforded us every facility for making our inspection, and willingly carried out the hydraulic bursting tests of the Elbe's pipes, to which reference has herein been made.

We are, &c.,
PETER SAMSON,
WILLIAM H. WOODTHORPE.

Observations of the Engineer Surveyor-in-Chief.—After carefully reading this important and interesting report, and weighing all the facts and circumstances of the case, I cannot come to any other conclusion than that the pipe was cracked in the process of manufacture. It is quite clear that the pipes tested by hydraulic pressure were both cracked from the outside, and not from the inside, and it is also clear that such a defect might exist and not show out at the hydraulic test. I have no reason to think the explosion was caused by water in the pipes, and the working pressure would not have ruptured them had they been sound, notwithstanding that the thickness of the one that burst was somewhat reduced at the seam.

THOMAS W. TRAILL.
The Assistant Secretary, Marine Department, Board of Trade.

Mr. Parker's report runs thus:—

Lloyd's Register of British and Foreign Shipping.

Sir,—

In accordance with the committee's request that I should inquire into the cause of the accident on board the Royal Mail Steam Packet Company's steamer Elbe, and draw up a report for their information as to the evidence taken at the coroner's inquiry, the result of the investigation that was to be held, and the particulars of the experiments, tests, &c., that were to be made with a view to arriving at a conclusion as to the cause of this lamentable accident, I beg to remark as follows:—

The copper of which the pipe was made was obtained from a first-class manufacturer in Birmingham, and was, when analysed, found to be of the best quality. Taking this copper to have had an ordinary strength of 30,000 lb. per square inch when cold, and assuming that its tenacity was reduced 18 per cent. when heated up to 360 deg.—the temperature of steam at a pressure of 150 lb. per square inch—the bursting pressure of the pipe would be about 1460 lb. per square inch. This assumption is based on the results of the following experiments made since the explosion with a view of ascertaining the effect of such a temperature on copper, and which are corroborated by a series of experiments made on this subject by the Franklin Institute, America.

No.	Degrees Fah.	Tenacity at these temperatures in lbs.	Tenacity cold in lbs.	Remarks.
1	370	21,400	28,100	Percentage of loss by raising copper from 60 deg. to 360 deg. = 18 per cent.
2	370	24,300	27,500	
3	332	21,900		
4	300	21,400		
5	150	25,000		

It appeared from the evidence given that the pipe had been carefully made by a skilled workman, was thoroughly examined after being made, and tested by hydraulic pressure on two occasions; on the first occasion to 300 lb., for the satisfaction of Messrs. Oswald, Mordaunt, and Co., and on the second occasion to 350 lb., for the satisfaction of the late Mr. Thompson, the owners' inspecting engineer.

These tests were pronounced to be perfectly satisfactory, and so far as could be seen, every care had been exercised by the makers to obtain as good a piece of workmanship as possible; and, so far as the pipe itself was concerned, no blame whatever could be attached to Messrs. Oswald, Mordaunt, and Co.

The coroner's inquest upon the bodies of the ten men who lost their lives was opened at Southampton, on the 19th September, and evidence was taken as to when and where the accident happened. It was then adjourned until the 21st ult., in order to admit of the Board of Trade sending engineering experts to assist the coroner in conducting the inquiry, and accordingly Messrs. Samson and Woodthorpe were appointed to act as engineering assessors.

At the resumption of the inquiry on the 21st ult. a number of witnesses were examined, and Mr. T. A. Adamson, the engineering manager to Messrs. Oswald, Mordaunt, and Co., in the course of his examination, gave an explanation as to how, in his opinion, the accident happened, and its cause. The theory he set up was that the pipe burst from a sudden shock of water; and he stated that, in his opinion, at the time of the explosion, water had accumulated in the bent part of the pipe which leads to the cylinders, as shown on the plate, and the boiler priming, a volume of water had been carried along the main steam pipe, and coming into contact with the water that had accumulated in the bent pipe near the engine, a sufficient force was exerted to burst the after length of it. Mr. Bowers, the superintendent engineer to the owners, and other engineers were examined, but they could not give any reason, or assign any cause which would account for the accident, and the inquiry was again adjourned until the 13th inst., to admit of the copper in the exploded pipe being tested, and other experiments being made.

During this time, Messrs. Oswald, Mordaunt and Co. tested to destruction three pieces of the main steam pipe of the Elbe. The first piece tested was the length next to the one that burst, marked B on the plate. This pipe burst as shown, through the solid copper near to the seam at a pressure of 600 lb. per square inch. The fracture was of a granular nature, and showed signs of the material having been injured before the hydraulic test was applied. The next pipe tested was a short length cut from the exploded pipe marked C, it burst in a like manner to the previous one, at a pressure of 780 lb., and this fracture had a granular and discoloured appearance.

The third experiment made is marked D. This piece of pipe was cut from the pipe that formed the first experiment, marked B; it burst, as shown through the solid copper, at a pressure of 1140 lb., and the material at the fracture had also a granular appearance, but was not discoloured. The exploded pipe was sent to Mr. David Kirkaldy's Testing and Experimental Works at Southwark, to have strips cut from it, both in the vicinity of the fracture and elsewhere, and the short length of pipe marked B was also sent to these works for a like purpose.

Test strips were cut as shown on the enlarged sketch of the exploded pipe marked A, at seven distinct places, which are marked A, B, C, D, E, F, G, and were tested by Mr. Kirkaldy in his machine. The strips marked G were taken from the solid copper directly opposite to the centre of the fracture, and were found to have a mean tenacity of 33,096 lb., with an extension of 33·1 per cent. in a length of 5in., the appearance of the copper at the fracture being silky. The other test pieces, eighteen in number, were taken from as near to the edge of the seam as possible, so as to ascertain the strength of the material at these points, the first test pieces being distant from the edge of the fracture to the centre of the specimen ½in., the second pieces 1⅛in., and the third pieces 1¾in. The results of those tests are as follows:—

Mark.	Mean tenacity in lbs.	Elongation in a length of 5″.	Contraction of area.	Appearance of fracture.
		Per cent.	Per cent.	
A	24,418	4·6	13·0	Silky. Granular.
B	32,009	27·2	45·9	,,
C	31,589	24·0	49·8	,,
D	27,490	13·6	28·0	,, Granular.
E	31,483	26·4	58·5	,,
F	31,281	25·9	52·8	,,
G	33,096	33·1	59·0	,,

Similar test-pieces were taken from the pipe marked B, in a like manner, with the following results:—

Mark.	Mean tenacity in lbs.	Elongation in a length of 3″.	Contraction of area.	Appearance of fracture.
		Per cent.	Per cent.	
A	31,645	24·9	38·9	Silky.
B	28,940	17·3	29·6	,, one piece flawed'
C	33,466	37·6	51·8	,,

It will be observed from these experiments that the tenacity of the copper which formed the exploded pipe at the parts marked A, D, had been reduced from 33,096 lb. per square inch in its natural state to 24,418 lb. per square inch at A, and 27,490 lb. at D; the elongation was reduced from 33·1 to 4·6 per cent. at A, and 13·6 per cent. at D; and the mean contraction of area from 59 per cent. to 13 per cent. at A, and 13·6 per cent. at D; and the appearance of the fractured part of the pipe was such as to leave little doubt that the condition of the material had undergone a marked alteration during the process of brazing. Again, in the tested pipe marked B, which burst at 600 lb., the tenacity of the copper near the fracture at B was very much less than that of pieces taken from the back of the pipe at C, and the elongation and contraction of area were very much reduced. In addition to this the copper at the fracture of the pipe exhibited the same appearance as that of the exploded pipe.

The thickness of the copper at the fracture of the exploded pipe was not more than $\frac{5}{16}$ of an inch, and it appeared as if the lap joint had slipped slightly during the process of brazing. However, with this reduced thickness, the estimated strength of the pipe by the usual formulæ would be over 1000 lb. per square inch, with an ample margin of strength for a working pressure of 150 lb. per square inch; but from the appearance of the fracture it showed that a portion of the pipe had been cracked, the depth of the crack being indicated by the discoloured metal, which commenced from the external part of the pipe and ran inwards; this showed that very little of the copper had been holding, the discoloured part clearly indicating how far the flaw or crack in the copper had extended.

Another point that seemed curious was that all the pipes that were tested burst at exactly the same part, slightly to one side of the seam, and always near the flange. This, perhaps, can be accounted for when it is considered that after the pipe is brazed it is heated both internally and externally at the ends during the operation of brazing the flange, which would of course render the copper more liable to be injured in this locality by burning.

Further, the hammering or planishing of the plain part of the pipe before the flange is brazed would harden the copper and increase its tenacity. But when locally heated at the ends for the purpose of brazing the flanges on, the copper would be again softened, and this, perhaps, would account for all the pipes bursting at exactly the same part.

It has long been known that at certain temperatures which copper is very often subjected to during the process of working it becomes very brittle; and it is also known that the range of temperature from the point of brittleness to the point at which copper is brazed is not very great, and that it is not an uncommon thing to burn a pipe during the operation of brazing.

In order to obtain some information on this point, and to ascertain something more definite on the behaviour of copper at various temperatures, I had some experiments made on flat strips of copper. (1) I had a piece of good copper taken from a sheet, bent and broken cold. (2) A similar piece was heated until it became red-short, and broke with its own weight. (3) A piece was heated to about the above temperature, allowed to cool, and then broken cold. A piece was heated to a temperature a little below that of the last specimen, and partially broken while hot, allowing the remaining part that was still holding to cool and then be broken.

The fracture of these pieces of copper are very interesting. The first piece broke with a silky fibrous fracture; the second of course was black from the effect of the fire; but in the case of the third piece that had been raised to about the same temperature as the second one and allowed to cool before being broken, its tenacity and ductility were almost entirely restored. This experiment was repeated by testing some pieces in a testing machine, when the strength of the copper in its normal state was found to be 35,212 lb. per square inch with an elongation of 40 per cent. in a length of 5in. and having a contraction of sectional area of 39·9 per cent. After being burnt, then cooled and tested, the tenacity was only reduced to 31,337 lb., and the elongation and reduction of sectional area were practically the same as that of the copper that had not been burnt. This experiment was repeated with copper strips that had been heated to a brazing heat, and other temperatures, with similar results.

The behaviour of the fourth piece and the appearance of the fractures were still more interesting. It was partially broken through while hot, and the appearance of that part of the fracture was discoloured by the action of the fire; but the part that was allowed to cool had its ductility restored, and afterwards broke with a bright appearance. This experiment was repeated a number of times with similar results, and the appearance of the fractures corresponded exactly with the appearance of the fractures of not only the exploded pipe, but also the fractures of the other pipes that were experimented upon and burst at pressures of 600 lb. and 780 lb. respectively; the only difference in these fractures was the depth to which the crack, as shown by the discoloration, had extended, so that the appearance of the fractures of the exploded pipes and the pipes experimented upon was reproduced artificially by burning the copper and treating it as described.

From this it will be seen that a copper pipe may be overheated or even burnt in the process of brazing, and still the properties of the material be restored after it has cooled.

It might also be partially cracked through the copper when at this dangerous heat, and that crack would exist in a latent state and not be discovered until the pipe gave way. The small part of the material remaining intact being sufficient to hold the pipe together, and stand the hydraulic test of twice the working pressure without showing any signs of weakness.

The evidence given at this inquiry, and the experiments made during the course of the investigation, clearly point to the fact that an element of danger exists in the present practice of brazing large heavy copper pipes intended to be subjected to such high pressures as are now so common; it is generally admitted that welds or brazed joints in any material must possess certain elements of uncertainty, and in the case of copper worked over a fire, these elements of uncertainty, as the above tests show, are greatly increased, and should be eliminated.

The conclusion that I have arrived at from the evidence given at this inquiry, the experiments I have made, and the thought I have given to the whole case, is that the pipe that gave way had been permanently injured during the process of brazing; the flaw or defect that existed in the copper was of a latent nature, it could not be discovered by any amount of careful inspection, and even the hydraulic test of 350 lb. was not sufficient to develope it; but when the pipe was subjected to the strains that would be brought upon it, by expansion due to the temperature of the steam, this latent flaw developed itself at a local point, and then the escaping steam, at a pressure of 150 lb., expanding into the atmosphere, tore the pipe open as shown.

It is not considered that any excessive abnormal pressure was set up in the pipe by a sudden rush of water, as stated by Mr. Adamson—in fact this could hardly be seeing that the engines were running at full speed, and had been working at full speed, very satisfactorily for hours before, so that any water that it contained must have been carried into the cylinders; and evidence was produced at the inquiry to show that there was no priming or signs of excessive water in the cylinders a few minutes before the explosion took place. After hearing this evidence, the jury retired, and after a few minutes' deliberation returned into court with a verdict of "Accidental death," adding that they found no evidence of culpable negligence against any person brought before them, and I cannot see that they could have come to any other just conclusion. This is one of those unfortunate accidents which will always be more or less associated with the use of steam where no one is really to blame, but from the results of which further engineering knowledge is obtained, and it has caused all who are engaged in the manufacture and working of marine engines at high pressures to consider what steps should be taken to eliminate this element of danger, and it becomes a question in my mind whether large steam pipes such as these, intended for high pressures, should not be worked cold, and instead of being brazed over a fire, rivetted with butt straps or lap joints, or if copper cannot be rivetted steam-tight to withstand these high pressures, whether it would not be wise to use solid drawn pipes, or, perhaps, steel pipes, or, perhaps, even brazed pipes served with steel, copper, or brass wire; but this is a question for the consideration of the engineering world at large, and until they know the full particulars of this case, and have had time to consider all the surroundings, I do not feel justified in recommending the Committee to take any active steps. At the same time, in view of the diversity of opinion that is sure to arise on this subject amongst the various engineering firms in the country, I would recommend that this report, which will give to them the particulars of the case, be printed and circulated amongst them. In the meantime, I shall continue to co-operate with the members of the principal engineering firms who have been kind enough to favour me with their views on the subject, and who have undertaken to make some interesting experiments bearing on the same, with a view to arriving at a common understanding in the measures to be adopted in reference to this most important subject.

I am, Sir,
Your obedient Servant,
WILLIAM PARKER,
Chief Engineer-Surveyor.
B. Waymouth, Esq., Secretary,
Lloyd's Register, London, E.C.

THE STRENGTH OF COPPER STEAM PIPES.

MR. NISBET SINCLAIR read a paper on the 22nd of November, before the Institution of Engineers and Shipbuilders in Scotland, "On Experiments on the Strength of Copper Steam Pipes, made at Lancefield," which further elucidates this question. It runs as follows:—

"I was instructed by Mr. Kirk, our president, to have a series of tests made to ascertain the strength of copper steam pipes, and, as much attention is being bestowed on this subject, owing to the unfortunate accident on board the Elbe, the results may be of interest to this Institution.

"The tests were made from plates and pipes obtained from a leading coppersmith in town, and the strips cut from them were tested at different temperatures up to the highest temperature of steam at present in use.

"The testing machine was a simple lever machine, the pieces being tested in a vertical position, and those pieces which were not tested cold had the required temperature produced and maintained during the process of testing, by suspending them in a bath of hot oil. Of course, in testing the pieces in this way it was necessary to have those strips that were cut from pipes straightened, and this was done carefully by the coppersmith. Three sets of tests were made.—

"*A Series.*—On pieces cut from two flat plates, brazed together for the purpose of these experiments in the same way as copper pipes are usually done.

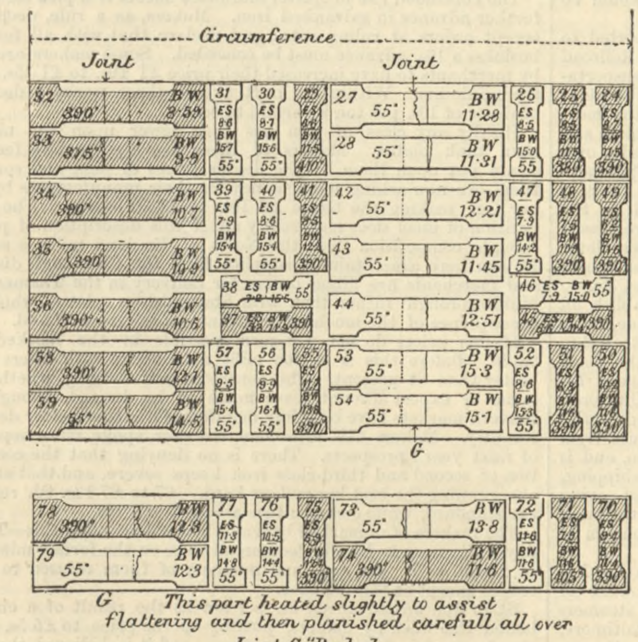
"*B Series.*—On pieces cut from a high-pressure steam pipe, 14in.

MR. SINCLAIR'S EXPERIMENTS ON COPPER PIPES.

Results of Experiments made at Lancefield Engine Works, to ascertain some of the Mechanical Properties of the Copper and Brazing found in ordinary High-pressure Steam Pipes of large size.

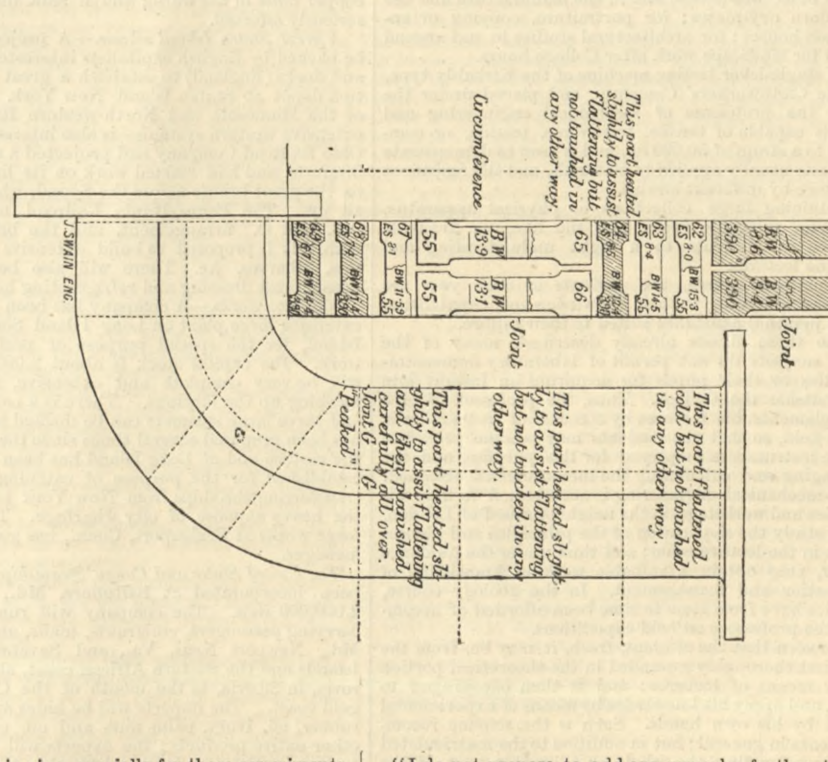
Series	Number.	Description.	Temperature when broken.	Original dimensions. Size at point of fracture.	Original dimensions. Area at least section.	Original dimensions. Area at point of fracture.	Ultimate stress. Total.	Ultimate stress. Per square inch of least original section.	Ultimate stress. Per square inch of original section at point of fracture.	Ultimate stress. Per square inch.	Area at fracture.	Contraction of area.	Extension.	Elastic stress per square inch of least original section.	Elastic stress. / Ultimate stress.	Load on least original section, at which extension was first visible.	Where broken.	Appearance of fracture.	Remarks
			deg. Fah.	in.	sq. in.	sq. in.	lbs.	lbs.	lbs.	tons.		Per cent.	Per cent.	lbs.		lbs. p. sq. in.			
A. SERIES. Tests of a joint of flat copper plates of the quality used in ordinary high-pressure steam pipes, scarfed and brazed similarly, except that during brazing the plates were flat instead of cylindrical.	1	Cut across joint	55 atm.	1·7 × ·25	·425		9800	23058		10·293			4·75 in 3in.				Joint slipped and broken	Granular	
	2	,, ,,	330	1·75 × ·25	·4375	·4375	9408		21504	9·6	·3729	14·76	4·0 ,,				Inside edge of joint	Part silky, part granular	
	3	,, ,,	150	1·725 × ·25	·43125		10976	25451		11·36			6·66 ,,				Joint slipped and broken	,, ,,	
	4	,, ,,	55 atm.	1·71 × ·25	·4275		10976	25674		11·46			7·0 ,,				,, ,,	Granular—flaw	
	5	,, ,,	370	1·72 × ·25	·43		7840	18232		8·14			None in material				Joint at brazing	Brazing torn away and	
	6	,, ,,	330	1·75 × ·25	·4375		6272	14336		6·4			2·75 in 4in.				Joint slipped and broken	Flaw [curled up sepa-	
	7	,, ,,	150	1·78 × ·23	·4095	·4095	10192		24895	11·113	·2324	43·24	5·0 in 3in.				Outside edge of joint	Granular [rately	
	8	,, ,,	370	1·74 × ·25	·435	·435	9408		21627	9·65	·2673	38·55	5·66 ,,				,, ,,	,,	
	9	Cut clear of joint	55	1 × ·25	·25	·25	8120		32480	14·5	·165	34·0	24·03 in 5·375in.					Silky	
	10	,, ,,	55	1 × ·25	·25	·25	8260		33040	14·75	·160	36·0	24·3 ,,					,,	
	11	,, ,,	370	1 × ·25	·25	·25	6270		25080	11·19	·176	29·6	16·98 ,,					,,	
	12	,, ,,	370	1 × ·25	·25	·25	6776		27104	12·1	·162	35·2	21·53 ,,					,,	
B. SERIES. Tests of the copper and brazed joint of a new and unused steam pipe, not specially prepared for testing.	13	Cut across joint	330	1·72 × ·42	·6536	·7224	15484		21434	9·57	·5338	26·107	11·6 in 3in.				Inside edge of joint	Silky	Not broken at least section.
	14	,, ,,	55 atm.	1·784 × ·376	·6530	·6707	18816		28054	12·52	·496125	26·028	14·0 ,,				Clear of joint, near inside edge	,,	
	15	,, ,,	330	1·765 × ·385	·6688	·679525	14896		21921	9·78	·6118	9·966	10·75 ,,				Outside edge of joint	,,	
	16	,, ,,	370	1·725 × ·42	·645	·7245	15484		21371	9·54	·47525	36·88	13·2 ,,				Just clear of inside edge	Part silky, part granular	
	17	,, ,,	55 atm.	1·71 × ·47	·666	·8037	18788		23376	10·435	·6765	15·825	10·5 ,,				Through joint near inside edge	Granular	
	18	,, ,,	150	1·775 × ·39	·6745	·69225	17360		25077	11·19	·6084	12·112	10·7 ,,				,, ,,	Part silky, part granular	
	19	,, ,,	370	1·79 × ·375	·67125	·67125	16268		24235	10·819	·477	28·938	15·0 ,,				Outside edge of joint	,, ,,	
	20	Cut clear of joint	55 atm.	1 × ·375	·375	·375	11976		31883	14·23	·280	25·33	20·63 in 2·5in.					Silky	
	21	,, ,,	370	1 × ·375	·375	·375	9408		25808	11·52	·276	26·4	19·35 ,,					Granular	
	22	,, ,,	55 atm.	1 × ·375	·375	·375	11760		31360	14·0	·249	33·33	20·63 ,,					Silky	
	23	,, ,,	370	1 × ·375	·375	·375	9408		25808	11·52	·2324	38·0	19·35 ,,					Part silky, part granular	
C. SERIES. Tests of the copper and brazed joint of a new and unused steam pipe, not specially prepared for testing, to show the effect of re-heating at flanges, and of planishing.	24	Cut clear of joint	390	1·015 × ·239	·24157	·2425	6272		25864	11·54	·16044	51·18	29 in 2in.	19478	·75	7304		Silky	
	25	,, ,,	380	1·015 × ·245	·245388	·2486	6384		25680	11·46	·170	31·61	32 ,,	19169	·74	15974		Part silky, part granular	
	26	,, ,,	55	1·015 × ·243	·2436	·2466	8228		33608	15·0	·18156	26·39	32·5 ,,	19075	·57	6812		Silky	
	27	Cut across joint	55	1·516 × ·225	·3411		8624	25282		11·28	·3212	5·80	7·27 in 3·16in.				Joint slipped and broken	Part silky, part granular	
	28	,, ,,	55	1·516 × ·245	·34671	·3714	9408		25531	11·308	·290	21·01	9·54 in 3·25in.				Outside edge of joint	Granular	Not broken at
	29	Cut clear of joint	410	1·0145 × ·2358	·2380	·2393	6188		25859	11·54	·1302	45·59	30 in 2in.	14823	·57	9882		Silky	least section.
	30	,, ,,	55	1·015 × ·2364	·2385	·2399	8400		35004	15·62	·1152	51·97	55·5 ,,	19608	·56	9337		,,	
	31	,, ,,	55	1·015 × ·241	·2405	·2446	8624		35257	15·74	·120	50·94	49·0 ,,	19231	·58	9158		,, [curled up separately	
	32	Cut across joint	390		·3638		7000	19241		8·59			5·77 in 2·25in.				Joint slipped	Brazing torn away and	
	33	,, ,,	375	1·516 × ·345	·3638	·3790	8428		22237	9·9	·3175	16·22	10·2 ,,				Outside edge of joint	Granular	Not broken at
	34	,, ,,	390	1·525 × ·24	·3660	·3660	8848		24175	10·7	·2750	24·86	17·0 ,,				Beyond joint	,,	least section.
	35	,, ,,	390	1·525 × ·25	·3736	·38125	9324		24456	10·9	·2840	34·92	17·3 ,,				,, ,,	,,	
	36	,, ,,	390	1·525 × ·252	·38125	·3843	9128		23752	10·6	·2488	35·25	13·8 ,,				Inside edge of joint	,,	
	37	Cut clear of joint	390	1·02 × ·238	·2415	·2427	6496		26765	11·9	·12750	52·53	19·0 in 2in.	12985	·49	8576		Silky	
	38	,, ,,	55	1·02 × ·238	·2427	·2427	8400		34610	15·45	·1312	45·94	42·5 ,,	16151	·46	7269		,,	
	39	,, ,,	55	1·025 × ·238	·24395	·24395	8428		34548	15·42	·11856	51·39	45·0 ,,	17675	·57	7690		,,	
	40	,, ,,	55	1·025 × ·2382	·2436	·2441	8400		34412	15·363	·1185	51·49	44·0 ,,	19270	·56	8029		,,	
	41	,, ,,	390	1·025 × ·24	·2427	·246	6720		27317	12·2	·1215	50·8	42·5 ,,	19035	·69	10152		,,	
	42	Cut across joint	55	1·516 × ·245	·3395	·3714	10164		27366	12·212	·322425	13·19	15·38 in 3·25in.				Outside edge of joint	Part silky, part granular	Not broken at least section.
	43	,, ,,	55	1·525 × ·2406	·3523	·3669	9408		25641	11·446	·35816	2·4	9·23 ,,				,, ,,	,, ,,	
	44	,, ,,	55	1·525 × ·245	·3492	·3736	10472		28030	12·513	·2688	28·05	15·26 in 3·375in.				,, ,,	,, ,,	
	45	Cut clear of joint	390	1·02 × ·24	·2448	·2448	6272		25620	11·40	·1406	42·56	40·0 in 2in.	14869	·58	8464		Silky	
	46	,, ,,	55	1·02 × ·24	·2448	·2448	8232		33627	15·01	·13957	43·01	40·0 ,,	17614	·52	8807		,,	
	47	,, ,,	55	1·025 × ·25	·25625	·25625	8120		31687	14·146	·1755	31·42	25·5 ,,	17592	·55	7539		,,	
	48	,, ,,	390	1·025 × ·25	·25625	·25625	6272		24481	10·9	·1875	26·80	28·0 ,,	16830	·69	6557		,,	
	49	,, ,,	390	1·022 × ·25	·2550	·2556	6328		24757	11·0	·1706	33·25	23·0 ,,	13835	·56	8894		,,	
	50	,, ,,	390	1·02 × ·24	·2448	·2448	6384		26078	11·6	·1491	39·0	29·5 ,,	22875	·88	15212		,,	
	51	,, ,,	390	1·02 × ·24	·2397	·2448	6440		26307	11·7	·1278	47·7	30·5 ,,	15189	·58	7208		,,	
	52	,, ,,	55	1·02 × ·24	·2427	·2448	8120		33170	15·254	·16320	33·33	33·5 ,,	19215	·58	7205		,,	
	53	Cut across joint	55	1·513 × ·223	·3374	·3374	11564		34273	15·3	·2363	29·96	16·0 in 3·375in.				Inside edge of joint	Part silky, part granular	Slight gutter
	54	,, ,,	55	1·516 × ·1836	·2783	·2783	9408		33805	15·09	·2002	28·06	4·74 ,,				,, ,,	Granular	at outside
	55	Cut clear of joint	390	1·02 × ·22	·2244	·2244	6580		29322	13·0	·1072	52·22	25·0 in 2in.	26203	·89	26203		Silky	edge.
	56	,, ,,	55	1·02 × ·232	·2366	·2366	8512		35976	16·06	·11455	51·60	45·0 ,,	22336	·62	7929		,,	
	57	,, ,,	55	1·02 × ·235	·2389	·2389	8288		34576	15·435	·1050	56·19	40·0 ,,	21258	·61	8994		,,	
	58	Cut across joint	390	1·516 × ·224	·3395	·3395	9240		27216	12·1	·2127	37·34	5·92 in 3·375in.				Inside edge of joint	Granular	
	59	,, ,,	55	1·525 × ·19	·2897	·2897	9408		32475	14·49	·18176	37·27	9·48 ,,				,, ,,	,,	[side edge
	60	,, ,,	390	1·51 × ·163	·2461	·2461	5208	21162		9·4	·1152	flaw	4·74 ,,				Joint slipped and broken	Brazing bad	Gutter at in-
	61	,, ,,	390	1·51 × ·225	·33975	·33975	6552	19284		8·61							,, ,,	,,	Portion of
	62	Cut clear of joint	55	1·025 × ·234	·23985	·23985	8232		34321	15·321	·11935	50·25	43·0 in 2in.	17977	·53	10623		Silky	cramp.
	63	,, ,,	55	1·025 × ·235	·250	·250	8120		32480	14·5	·12956	48·2	42·5 ,,	18816	·58	13326		,,	
	64	,, ,,	390	1·025 × ·23	·2357	·2357	6580		27916	12·4	·1064	54·85	17·0 ,,	19126	·68	11879		,,	
	65	Cut across joint	55	1·514 × ·197	·29825	·29825	8736		29298	13·08	·21390	28·28	17·84 in 3·25in.				Outside edge of joint	,,	
	66	,, ,,	55	1·51 × ·16	·2416	·2416	7560		31291	13·96	·1441	40·35	15·7 in 3·375in.				Inside edge of joint	,,	
	67	Cut clear of joint	55	1·025 × ·2425	·2439	·2485	8036		32337	14·436	·1596	35·77	39·5 in 2in.	18140	·56	16563		,,	
	68	,, ,,	390	1·025 × ·2387	·24395	·24466	6356		25974	11·59	·1495	38·87	37·0 ,,	16528	·63	8493		,,	
	69	,, ,,	390	1·025 × ·238	·24395	·24395	6216		25480	11·37	·16450	32·5	22·5 ,,	14921	·58	9297		Part silky, part granular	
	70	,, ,,	390	1·01 × ·227	·22523	·22927	6384		27844	12·43	·10472	54·3	38·0 ,,	22252	·79	8329		Silky	
	71	,, ,,	405	1·01 × ·235	·22725	·23735	6272		26425	11·8	·11250	52·6	41·5 ,,	17742	·67	7392		,,	
	72	,, ,,	55 atm.	1·01 × ·225	·2222	·22725	7448		32774	14·63	·12090	46·8	37·0 ,,	24698	·75	8820		,,	
	73	Cut across joint	55 atm.	1·515 × ·1466	·2221	·2221	6888		31013	13·84	·13940	37·23	21·08 in 1·85in.				Inside edge of joint	,,	
	74	,, ,,	390	1·51 × ·14	·2114	·2114	5488		25961	11·59	·14100	33·3	11·29 in 2·125in.				,, ,,	Granular	
	75	Cut clear of joint	390	1·01 × ·22	·2222	·2222	6188		27848	12·43	·14110	36·49	32·5 in 2in.	15499	·55	8442		Silky	
	76	,, ,,	55 atm.	1·01 × ·23	·2323	·2323	7476		32182	14·36	.151255	34·88	33·5 ,,	23624	·73	14343		,,	
	77	,, ,,	55 atm.	1·01 × ·231	·2333	·2333	7756		33242	14·84	·139689	40·12	31·0 ,,	25203	·76	16442		,,	
	78	Cut across joint	390	1·515 × ·15	·22725	·22725	6272		27599	12·32	·17280	23·9	·17in. all local				Just clear of inside edge of joint	Granular	
	79	,, ,,	55 atm.	1·51 × ·170	·2567	·2567	7056		27489	12·27	·197425	23·09	·125 ,,				Inside edge of joint	Silky	

GENERAL NOTE.—The pieces which broke at the joint generally showed a fracture of a deeper red colour, and much more decidedly granular than the fractures in the less heated regions, the latter tending to a slightly fibrous texture, indicated by the expression "silky."



G This part heated slightly to assist flattening and then planished carefull all over Joint G "Peaked."

NOTE:-Tests above temperature of Atmosphere shaded
BW=Ultimate Stress in Tons per Square Inch
ES=Elastic Stress " " "



bore, not prepared for this purpose, and which had been thrown aside without any flanges having been put on.

"*C Series.*—On pieces cut from a high-pressure steam bend pipe, 9in. bore, not prepared for this purpose, and which had been thrown aside without any flanges having been put on. A flange was brazed on each end of this pipe, specially for these experiments.

"The positions in the plates and pipes of the various test pieces, and the treatment to which they were subjected previous to testing, are indicated by the engraving. The table gives in detail the results of the tests.

"I do not propose to add any remarks further than to express the hope that in view of the importance of the subject, others may be induced to bring forward additional results of tests, or other experience bearing on this matter, and that a discussion of real interest and value may be the issue."

THE ENGINEERING AND APPLIED SCIENCE DEPARTMENT OF KING'S COLLEGE, LONDON.

THIS Department is now entering upon the fiftieth year of its existence; a life short enough, it is true, when compared with those of some of our ancient foundations, whose chief object was to furnish a so-called liberal education, but comparatively old amid the numerous technical colleges which have sprung up of recent years to meet a want which King's College was one of the first to recognise and to satisfy.

In 1838 the technical "Department of Engineering and Applied Science" became a distinct branch of King's College. From the first the Council have sought, in arranging a *curriculum*, to combine a thorough knowledge of the theoretical portions of the subjects taught with a practical acquaintance with the methods by which the theories are applied in the various experiences of engineers, whether civil or mechanical, electrical or hydraulic, military or sanitary, metallurgical or chemical. The lectures, themselves illustrated largely by diagrams, models, or experiments, have always been supplemented as far as possible by individual instruction and frequent practice in the laboratory, workshop, or drawing office, as well as on the field; or by visits to manufactories.

The subjects recommended for study are mathematics, mechanics and physics, chemistry and metallurgy, mineralogy and geology, photography, drawing, and workshop practice, with surveying and civil engineering, manufacturing, art, and mechanical engineering, and building construction and architecture. An intelligent student may thus fit himself for any professional position by a sound knowledge covering a wide range of subjects. Or he may specialise in any branch of engineering, or of "pure science," in which he may develope an interest.

The tendency of modern education on these subjects being increasingly practical, it may be of interest to sketch the manner in which this class of teaching is carried out at King's College.

The period of time proposed for the course of studies is three years; and during the whole of that time the student is expected to attend the drawing classes, where he receives personal instruction in the different branches of geometrical, engineering, mechanical, and architectural drawing.

Workshop practice is progressive, and also extends over the entire three years of study. By making for himself various articles or models of wood, the student first learns the use of the lathe and the tools of the carpenter's, turner's, joiner's, and pattern-maker's shops. Passing thence into the foundry he receives instruction in moulding and casting in iron or brass; in the fitting shop he acquires the use of metal-working tools; in the smithy he gains experience at the forge; and after some practice in metal turning, and with the machine tools in the shop, he is taught the art of working in sheet metals. Finally, under adequate supervision, he is encouraged to design and construct suitable machines or models. The workshop is placed in the charge of an experienced mechanical engineer, with trained assistants in each branch of the work. All the lathes, drilling, planing, slotting, and other heavy machinery are driven by steam power, but the lathes are convertible, so that they may also be worked with the treadle.

The chemical laboratories are two in number: in the junior laboratory the second year's students, having already in their first year attended a course of lectures on experimental and applied chemistry, are trained in the use of the blowpipe, and in conducting such analyses as may be ordinarily required in the practice of their profession. In the senior laboratory those students who wish to make a special study of chemistry may undergo a complete course of instruction in analytical or research work; and for the encouragement of such original research a scholarship has been founded in memory of Professor Daniell, the first holder of the chair of chemistry.

The metallurgical laboratory, together with the lectures on metallurgy, are attended in the third year of the course; and in this year, or in his fourth if he should elect to prolong his studies, a student may gain the Siemens Gold Medal and prize, founded by the late Sir William Siemens, "with the object of stimulating the students of King's College, London, to a higher standard of proficiency in metallurgical science." This department is one of the most recent additions to the College, and is fully equipped with assay, muffle, and large brass-melting—crucible—furnaces, lathe, and testing machinery; it is intended for instruction in assaying and mineral analysis, in the treatment of ores and metallurgical products, and in the practical examination of the properties of the metals and their alloys.

The physical laboratory, in which Sir Charles Wheatstone conducted his historical experiments with the electric telegraph, and to which he bequeathed a large collection of apparatus, is also attended during the course. Here the student gains experience in the use of the apparatus, in the methods of physical measurement, and in the investigation of physical and mechanical laws. An installation of dynamo-electric machinery, with the necessary instruments and apparatus for measuring and dealing with large currents, has lately been added in order to meet the increasing demand for a thorough practical knowledge of electrical science and methods.

The photographic laboratory is used during the last year of study. It has recently been much enlarged by the addition of a new glass-house and developing room, and now affords facilities for practice with the older wet-plates, and in the manufacture and use of the more modern dry-plates; for portraiture, copying or enlarging in the glass-houses; for architectural studies in and around the College; and for landscape work after College hours.

There is also a single-lever testing machine of the Kirkaldy type, presented by the Clothworkers' Company, and placed under the joint control of the professors of mechanical engineering and metallurgy. It is capable of tensile, transverse, torsion, or compression tests up to a strain of 50,000 lb., and is used to demonstrate the mechanical tests usually applied to materials, and the resistance of bodies to rupture by different strains.

Museums containing large collections of physical apparatus, chemical specimens, minerals, rocks, and the like, are available for the assistance of students to a right understanding and appreciation of the lectures.

In the mathematical course, the students of each year are arranged in classes according to their knowledge and capabilities, and thus receive personal assistance suited to their calibre.

In addition to these classes already described, many of the lecturers, whose subjects do not permit of laboratory demonstration, give facilities to their pupils for acquiring an insight into practical work outside the College. Thus, the professor of civil engineering supplements his lectures by a course of instruction in surveying in the field, so that the students may become proficient in the use of the instruments employed for this purpose, and the method of arranging and calculating the measurements obtained. The professor of mechanical engineering is accustomed to take his classes to factories and workshops in the neighbourhood of London, where they may study the application of the principles and devices they have learnt in the lecture-room; and thus, under the guidance of the professor, they obtain a valuable working knowledge of machine construction and management. In the geology course, also, opportunities have from time to time been afforded of accompanying one of the professors on field expeditions.

Thus it will be seen that the student, fresh, it may be, from the school-room, is first thoroughly grounded in the theoretical portion of a subject by means of lectures; and is then encouraged to confirm, enlarge, and apply his knowledge by means of experimental work performed by his own hands. Such is the scheme recommended for students in general; but in addition to the matriculated students who are attending the whole or a greater part of the course, there are many "occasional" students, who, requiring a special knowledge of one or more subjects, devote their whole time to these in the laboratory or the class room for periods varying from a month to three or even four years, according to the circumstances and requirements of the student.

AMERICAN ENGINEERING NEWS.

(*From a Correspondent.*)

Railroad tracks through cities.—In former years and up to within a very short time, it was considered a matter of course that railroads should lay their tracks through the streets of a city, but with the increase of railroad and street traffic the accidents at the grade crossings have been so numerous that there is a general movement now to eliminate them. The Pennsylvania Railroad and the Board of Public Works of Jersey City, N.J., have at last come to an understanding as to the proposed elevation of the railroad through the city. The road will be partly an iron viaduct and partly embankment, with retaining walls. One street will have to be closed, but as it is now crossed by thirty-four tracks, covering 395ft. of the street, it will not be much loss. The work will cost about 1,000,000 dols., and the railway company will bear the entire cost. The Pennsylvania Railroad Company is also contemplating the elevation of its tracks through Pittsburg and Allegheny, Pa. In Connecticut the Legislature has been petitioned to abolish grade crossings, and the New York, New Haven, and Hartford Railroad Company is already making several alterations along its line for this purpose. At Hartford, Conn., this company is at work on the elevated structure and a new depôt. The grades will be a little heavier, and the four tracks will run for some distance on a solid earth bank with vertical retaining walls as high as the sub-grade, then there will be iron trestlework to the new depôt. Throughout the East there is considerable agitation on this question, as the danger and delay to traffic aggregate enormously in a large city with railroad grade crossings.

New Croton Aqueduct.—The following is the estimate of the expenditures of the Aqueduct Commission for 1888.

	dols.
Section No. 1	600,000
Sections Nos. 2 to 9, A and B, and Section No. 12 ..	2,600,000
Sections No 13 and No. 14	450,000
Section No. 15 (Gate house)	200,000
Head houses to shafts, gate houses at South Yonkers, Pocantico and Ardsley, highway bridge, cut No. 8, Gould's swamp adit, adit shaft No. 34, pipe line section No. 16, east branch reservoirs, dam, &c., and work on the Quaker Bridge dam	2,200,000
	6,050,000
Commissioners' expenses	430,000
Ten per cent. amount reserved for work done	1,520,000
Total	8,000,000

A contest is now going on between the contractors and the city as to the allowances to be made to the contractors for extra excavation at the tunnels. The contracts provide that the diameter of the tunnels excavated should be 16ft., but the chief engineer gave orders to the division engineers to allow for 8in. more. The contractors also claim for the spaces caused by blasting, where rock has been loosened to a greater extent than called for by the specifications. The chief engineer and one of the commissioners side with the controller in opposing the claims. The claims will aggregate 2,000,000 dols. by the time the aqueduct is completed. The settlement will be looked for with interest on so important a question. The commissioners are now advertising for proposals for the construction of the masonry dam, and work connected therewith, on the east branch of the Croton river. Proposals will be opened December 7th.

Atchison, Topeka, and Santa Fé Railroad.—The company has filed its annual report with the Railroad Commissioners of Kansas. Authorised capital stock, 68,000,000 dols.; total issued, 64,903,250 dols.; amount issued during the past year for the purchase of the Gulf, Colorado, and Santa Fé Railroad, 3,458,000 dols. The total cost of construction and equipment to June 30th, 1887, is 135,126,034 dols., of which 44,030,247 dols. is in Kansas. Total length of main and leased lines, 1895 miles. The equipment consists of 366 locomotives, 83 first-class cars, 4 chair cars, 8 official cars, 2 pay cars, 38 Pullman cars, 50 emigrant sleepers, 15 express cars, 23 baggage cars, 4443 box cars, 257 fruit cars, 947 stock cars, 2576 coal cars, 850 flat cars, and 733 combination cabooses. The average passenger rate per mile is 1·74 cents for through and 2·81 cents. for local. The road has 8356 employés, and the average wages for labourers is 1·40 dols. per day. During the year the road carried 1,449,701 passengers and 3,241,887 tons of freight. The total earnings for the year were 15,949,136; total expenses, 15,094,102, including 7608, operating expenses. A dividend at the rate of 6 per cent. was paid.

Lighting the Hoosac tunnel.—The great Hoosac tunnel on the Fitchburg Railroad, in Massachusetts, is to be lighted by electricity, for the purpose mainly of facilitating the work of track inspection and maintenance. The incandescent system will be used; wires will be laid in wooden troughs alongside the tracks, and on each side of the tunnel will be lamps at intervals of 40ft.; the lights will be placed alternately, so that there will be a light every 20ft. from one side or the other.

The Montana copper regions.—The spread of the fires in the Calumet and Hecla copper mines in Michigan, and the probable necessity of flooding the mines, which will render them inoperative for a year or more, will probably result in more attention being paid to the development of the copper mines in Montana, which are reported to be very rich. The Calumet and Hecla is the largest copper mine in the world, and if shut down the market would be seriously affected.

A great Staten Island scheme.—A project is on foot, reported to be backed by English capitalists interested in the Furness Railroad and docks (England) to establish a great shipping and transportation depôt at Staten Island, New York. Mr. Stickney, President of the Minnesota and North-western Railroad—one of the most extensive western systems—is also interested. The Baltimore and Ohio Railroad Company had projected a similar scheme in its own interests, and had started work on its line from Philadelphia and on the great bridge across the Sound, when the late deal broke it all up. The Pennsylvania Railroad now has a hand in the "B. and O." arrangement, and the bridge is being progressed with. It is proposed to build extensive docks, warehouses, elevators, wharves, &c. There will also be cattle yards, slaughter house, meat dressing and refrigerating houses, grain stores, &c.

New iron works.—A company has been organised to establish an extensive forge plant on Long Island Sound, at Whitestone, Long Island, for the special purpose of performing heavy steamship work. The capital stock is about 2,000,000 dols., and the plant will be very complete and extensive, including machinery for finishing up the forgings. There is a natural harbour 300ft. long, and three large steamers can be docked together. This enterprise has been proposed several times since the transatlantic route from the eastern end of Long Island has been in contemplation, and is established for the purpose of catching the European shipping, transferring the ships from New York to Whitestone, and saving the heavy expense of city wharfage. The manager of the large forge works at Bridgeport, Conn., has gone to the new concern as manager.

The United States and Congo Steamship and Emigration Co. has been incorporated at Baltimore, Md., with a capital stock of 2,000,000 dols. The company will run a line of iron steamers carrying passengers, emigrants, mails, and freight from Baltimore, Md., Newport Neus, Va., and Savannah, Ga., to the Canary Islands and the western African coast, along the coast from Monrovia, in Siberia, to the mouth of the Congo, and also along the gold coast. The imports will be hides and pelts, gold dust, cane, rubber, oil, ivory, palm nuts and oil, coffee, chocolate, rice, and other native products; the exports will be cotton fabrics, manufactured articles, and general freight. Henry Cox, of Washington, D.C., is president, and Geo. W. Nelson secretary of the company.

The New York Arcade Railroad.—The Arcade Railroad, one of the numerous projects for constructing an underground railroad in New York, is again reported to be bobbing serenely up again. The route authorised by the charter starts from The Battery, at the extreme south end of the island, under Broadway to 59th-street and 8th-avenue, with a branch from Madison-square, under Madison-avenue to 42nd-street; and an extension to the Harlem River and King's Bridge is also authorised. The estimated expense, including stations and equipment, is 3,000,000 dols. per mile, and these figures are reported to be accepted by several engineers. The project is for a four-track tunnel, or rather arcade, the outer tracks being for way trains, with stations at short intervals, and the inner track for express trains, with stations further apart. So far so good, but the road passing under Broadway, the busiest thoroughfare of the city, is assured of powerful opposition, which, if work were actually commenced, would probably, by a series of injunctions and other legal weapons, tire out or impoverish the company.

Another underground railroad.—Another project for an underground railroad in New York, and one which appears practicable from every point of view, is what is known as the Elm-street route. In order to relieve the press of traffic on Broadway the city will open a new street, almost paralleling that thoroughfare, from the entrance to the Brooklyn Bridge up town; and it is proposed to take advantage of this work for the construction of the underground road, which is apparently backed by the New York Central Railroad capitalists. The route is from the Post-office to the Grand Central Depôt at 42nd-street, a distance of about three miles. There will be a four-track tunnel, for express and way trains, and underneath will be a subway for sewers, steam, gas, and water pipes, electric wires, &c. This latter part of the scheme is approved by the Department of Public Works. Mr. Church, chief engineer of the new Croton Aqueduct, says:—"The underground railroad ought not to be considered separate from an improved system of subways. Interests that by themselves are expensive could be combined so as to economise in and improve all." The cost of brick tunnel—which will be lighted with the electric light—subway, and equipment, is estimated at 2,000,000 dols. per mile, and it is thought that the road, built in conjunction with the new street, can be completed in two years. The projectors have the consent of seven-eighths of the property owners along the route. Electric or fireless steam locomotives are proposed. A proposed extension of the road is to run from the Post-office to and under the Hudson River, connecting with the railroad termini in Jersey City. Branches are also proposed along 23rd-street to the Hudson, and along 34th-street to the East River. Developments will be awaited with interest.

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

(*From our own Correspondent.*)

CHRISTMAS finds the iron and steel trades of the West Midlands in a condition of increasing prosperity. Even as at Christmas last year so now, the ironmasters enter upon the holidays with bright anticipations. The works are well supplied with orders, and the prospects of business after the holidays close are wholly satisfactory. The fluctuations of the Scotch and Cleveland markets are being watched here with a good deal of interest; but the effect of the lower prices for pigs is fully counterbalanced by the exceeding improvement which marks the manufactured iron and steel trades of the Northern centres.

The finished iron trade seems to be developing those elements of improvement which became conspicuous some weeks ago. Something like excitement was noticeable in some branches on 'Change in Birmingham this afternoon. There is a larger demand for all descriptions of iron, and prices are improving in proportion. More money is asked for sheets, tank plates, tube strips, and steel, and the opinion was generally expressed on 'Change that the January quarterly meetings will be made the occasion for declared advances. Forward business at previous minimum rates is rejected, makers urging that the upward movement in pigs renders the declaration of higher rates for finished iron imperative.

The branch of trade in which this week the newest features are presented is best thin sheets, used for stamping and working-up purposes. Meetings of the trade have lately been held, at which it was resolved to take unanimous action in advancing prices. This resolution, it was thought, was rendered necessary by the higher prices asked for hematite. What the exact advance will be there is no means at present of definitely ascertaining, but the intimations received by merchants indicate a probable rise of fully 10s., and in some cases 20s., per ton.

Makers of Staffordshire and Worcestershire tin-plates have also likewise decided upon declaring an advance, their action being justified by the higher value of tin and spelter. The latter metal has risen £8 upon the minimum, the £14 of some months back being now £22. The unsettled state of the block-tin market renders quotations of tin-plates liable to much fluctuation, and sales are made at figures fully 2s. 6d. to 3s. 6d. per box above the former minimum. Large tinned sheets are also dearer by from £3 to £4 per ton.

Black sheets consumed by galvanisers keep in such excellent demand that makers fairly command higher prices for future deliveries. £6 10s. to £6 15s. was this afternoon freely quoted for forward sales of sheets of 24 gauge, and even on these terms makers were very unconcerned about booking further business. They are certain that more money will be obtainable next year.

The continued rise in spelter and black sheets is a plea for a still further advance in galvanised iron. Makers, as a rule, decline to accept orders at ruling rates, and declare that with all forward business a 10s. advance must be conceded. Some makers are said by merchants to have increased their price £1 10s. to £1 15s. upon the minimum. Within the next two or three weeks a declared advance of 10s. per ton is certain to occur.

Hardly any class of iron has been lower upon the market than tank plates. Makers of these are the first to feel the strain put upon them by the dearer prices of pigs, and some of them are now asking more money for their manufactures by 10s. per ton, making the figure £6 10s. to £7 at works. The competition of steel does not greatly affect this description of plates, though competition from the North of England mills is severe. Buyers here are obtaining supplies from the Cleveland district, and merchants are filling orders for delivery in the Thames with Middlesbrough rather than with Staffordshire plates, wholly in consequence of the much more advantageous terms offered.

Higher prices do not yet seem possible in the marked bar trade. Before this is so the mills must fill up with orders much better than at present. The contracts now arriving, whether on home or export account, leave much to be desired, though the Eastern markets have certainly manifested a rather better demand recently. Makers this afternoon, however, spoke more hopefully of next year's prospects. There is no denying that the competition of second and third-class iron keeps severe, and that steel is also running the best bar makers hard. £7 to £7 12s. 6d. remains the standard, while common bars are £5 to £5 10s.

The makers of unmarked bars and hoops demanded this—Thursday—afternoon in Birmingham an advance on the former minimum of 2s. 6d. to 5s. per ton, and numbers of them refused to book orders except at this advance.

Strip iron was advanced 5s. per ton as the result of a circular issued this week by makers, putting up the price to £5 5s. The circular is signed by seventeen firms, and it is believed that the united action thus secured will produce a great moral effect upon the tube trade, and do something to check unwise and unnecessary underselling. The matter, it is stated, has been submitted to the strip makers of Scotland, in the hope that it may be possible to issue a circular simultaneously here and across the border, fixing the price of strip.

The Snedshill Iron Company, Shifnal, Shropshire, reports improved business in all branches of its works. Notwithstanding the growth of the steel industry, the demand for best marked bars and iron boiler plates to meet stringent tests is, in the experience of this company, increasing, and the company reports heavy lines in such directions. It has recently put down extensive plant for making rivets from its well-known rivet iron. Mr. Thomas McBean, of Birmingham, will now represent this company in Birmingham and the Midland district for the sale of iron and steel.

The mild character of Snedshill iron is exemplified by some tests of treble best rivet iron, which carried 24 tons per square inch with an elongation of 30 per cent. and a reduction of area of no less than 60 per cent. A rivet of this iron will flatten out to a disc over 4in. diameter without cracking on the edges. This company is also introducing a special quality of plates branded "Special Snedshill Firebox," for heavy flanging. These plates give a tensile strain of from 22 to 23 tons per square inch, with 10 to 20 per cent. reduction of area. An extensive rivet-making plant has just been laid down by the Snedshill Company.

The pig makers are becoming increasingly independent, and contract works are being closed right and left, makers only consenting to accept small lots just to keep in with old customers. Native pig makers are in a much more enviable position than for a long time past, and previous losses are now being turned into a fair profit. The advance of 5s. per ton quoted last week for cinder pigs by a few makers was repeated this afternoon, making the quotation 33s. 9d. per ton. Most makers were, however, willing to sell at 32s. 6d., and some firms at 31s. 3d.

Derbyshire and Northampton makers are reluctant to quote, not desiring business. Prices of the former are named as 41s. at stations, and Northamptons 40s. per ton. Lincoln pigs have not risen in equal proportion to Derbyshire, since the demand is largely for export.

It is one of the best indications of the good volume of business now doing at the ironworks that the railway carriers in this district are particularly busy. The London and North-Western, Midland, and Great Western lines have not been so active in minerals and goods traffic in this part of the kingdom for a long time as they are just now alike in the matter of arrivals and departures. The agents of the companies gave excellent accounts of their business.

The coal trade is improving somewhat, the demand for manufacturing sorts being larger than for a long time past. Certain of the collieries in the Cannock Chase, Walsall, and Bloxwich districts are at the present time largely increasing their output. Prices of Black country forge coal are 5s. 6d. to 5s. 9d. per ton for common forge, 6s. to 6s. 6d. for superior, 7s. for mill, and 7s. 6d. to 8s. for furnace. Cannock Chase house coals are ruling: Best deep, 9s. per ton into boats; deep one-way, 8s.; and kibbles, 7s. Prices of coal from the shallow seams are 1s. per ton less as to all the qualities.

Mr. B. Hingley, M.P., chairman of the South Staffordshire iron trade, has just combatted a renewed contention of some of the ironworkers' leaders, who are opposed to the present method of regulating wages, that the selling price of bars should no longer mainly regulate the men's remuneration, but that sheets should supersede bars. He points out that it is a mistake to suppose that sheets and not bars are now the largest make of iron in the districts over which the Board has control. Statistics collected by the Wages Board in 1885 showed the following results:—Made in South Staffordshire in the year, 211,800 tons of bars, 23,500 tons of hoops, 89,400 tons of sheets, 5500 tons of plates, 6800 tons wire and nail rods, and 2670 tons steel sheets; Shropshire, 3900 tons bars, 1570 tons sheets, and 1200 tons nail rods; Lancashire, 78,000 tons bars, 35,800 tons hoops, 22,260 tons sheets, 5800 tons plates, 30,600 tons nail rods, and 1450 tons steel sheets. It has to be observed that there is no return from North Staffordshire, where the bar iron production exceeds 100,000 tons a-year, and sheet iron is almost nil. The general result is that the Midland districts, including North Staffordshire, produced in 1885 about 450,000 tons of bars and other descriptions of iron against 120,000 tons of sheets. The make of both is doubtless larger at the present time, but the increase is proportionate, or nearly so.

Some little while ago I mentioned in this correspondence some splendid rolls which had been turned out at West Bromwich to form part of a complete plant for linoleum rolling in the United States. To what I then said I may now add that the order for the complete plant was placed with Messrs. T. and W. Summers, High Orchard Ironworks, Gloucester, who sub-let a portion of the roll plant to a West Bromwich house. Messrs. Summers make a specialty of linoleum machinery, and this order was from the Nairn Linoleum Company, Newark, United States, the president being Mr. Michael B. Nairn, who is also head of the well-known firm of Messrs. M. Nairn and Company, Scottish Floorcloth and Linoleum Works, Kirkcaldy. The calender rolling machine is the largest of its kind ever made, the rolls being of chilled iron 36in. diameter by 12ft. 6in. long on the face. They are four in number, and lie in a horizontal position, the whole machine being worked by a compound condensing steam engine.

The mixing machines are on Messrs. Summers' improved system, and will go to form one of the most important linoleum factories in the world. The plant will manufacture linoleum four yards wide. It speaks volumes for the excellence of the work of Messrs. Summers that the Nairn Linoleum Company consider it to their advantage to buy the machinery from them notwithstanding the 45 per cent. import duty, which means a very considerable item in this extensive order. A repeat order will probably by-and-bye be placed.

The ironworkers of Brierley Hill are considering the question of giving more support to the ironworkers' union. Mr. W. Ancott, president of the Associated Iron and Steel Workers of Great Britain, at a meeting which has just been held, said that there was more necessity now for organising than there was in 1864, owing to the rapid transition of iron manufacture to that of steel, and in order to meet this and other difficulties they must have an organisation upon a broad basis with a more perfect machinery than that which at present existed. A resolution, pledging the meeting to join the Association of Iron and Steel Workers, was passed.

The manufacturers of brass hardwares are in a position of some difficulty, not all of them are yet able to get prices which repay the higher prices which they have to pay for brass and copper. Castings have risen 2d. to 3d. per lb., and rolled brass 2½d. to 3d. per lb. The price of brass and copper wire has further advanced ½d. per lb., making the list price 8¼d. for brass and 10¼d. for copper wire. Discounts on brass-cased tubes have been officially reduced 5 per cent., and on brass stair-rods 2½ per cent.

NOTES FROM LANCASHIRE.

(*From our own Correspondent.*)

Manchester.—The heavy buying which has been going on recently is now being followed by somewhat of a lull in the market. Merchants and consumers are for the most part so well bought that except for longer forward delivery than sellers care to entertain, there are very few buyers of any weight left in the market, whilst makers generally are so fully sold that for the present they are indifferent about booking further orders, and it is not likely there will now be very much more done until after the turn of the year. As regards prices, a generally firm tone is maintained so far as makers are concerned, and although the fluctuations which have taken place in Glasgow and Middlesbrough warrants have to some extent had a tendency to unsettle the market, they have been so much the result of speculative transactions that they have had no very appreciable effect upon what has been really legitimate business. The general result is that the year closes with an unquestionably strong tone in the market, and a more hopeful outlook for the future. So far, the upward movement, although it has been rather sudden, has not been more than a legitimate advance, and there is still a considerable margin for a further advance before prices would be brought up to a point which would afford a sufficient inducement for any largely increased production. The orders which the makers of common pig iron have been able to put upon their books have placed them in a fairly strong position, which will carry them well into the new year; and, as regards hematites, the increasing activity in the steel trade, as the result of the large demand for structural and shipbuilding materials, affords an encouraging prospect which is giving a decided upward tendency to prices. In the finished iron trade the outlook for manufactures is also much more satisfactory than it has been, Atogether, the general tendency of the market seems to confirm the prevalent feeling, to whcih I have previously referred, that trade is better, and that a real improvement has commenced.

There was about a full average attendance on the Manchester iron market on Tuesday, but only a slow business doing. For common pig iron there was but a limited inquiry, apart from offers here and there from buyers for long forward delivery, that makers were not at all disposed to entertain. Quoted prices were generally the same as last week. Lancashire makers were firm at 38s. 6d. for forge and 39s. 6d. for foundry, less 2½, delivered equal to Manchester, and at these figures they have recently secured a fair weight of business, which has pretty well filled up their books for the present. In district brands Lincolnshire is practically the only iron that is now being really offered in this market, Derbyshire makers having ceased to quote at all. For Lincolnshire iron the average quotations remain at about 37s. 6d. for forge to 39s. for foundry, less 2½, delivered equal to Manchester, and makers are not at all anxious sellers at these figures. In fact, in one instance prices which are really prohibitive are being asked. Outside brands, so far as makers' prices are concerned, also remain firm at late rates, and good-named foundry brands of Middlesbrough are held at 43s. to 43s. 6d. net cash, delivered equal to Manchester.

In hematites the tendency of prices continues upwards, and for good No. 3 foundry qualities delivered in the Manchester district 54s. 6d. to 55s., less 2½, is now being quoted. These prices, however, seem rather to check buying, and I do not hear of business of any moment being done at them, but makers are very firm.

The rapid and considerable advance which has taken place in steel plates seems also to have had the effect of checking business. Since my last report there has been a further advance of 7s. 6d. per ton, both Lancashire and Scotch steel boiler plates delivered in the Manchester district being now quoted at £8 5s. per ton; but buyers do not seem disposed to pay this figure, and so far as local makers are concerned, it has only been got on a few small sales. Whether it will be fully maintained seems rather doubtful, but makers have sufficient orders on their books to be under no immediate necessity to press sales.

Finished iron makers report a very fair amount of business coming forward, but buyers want to place out orders for longer forward delivery than sellers care to entertain. The advance announced last week of 2s. 6d. per ton upon late minimum rates is being fully maintained, and delivered in the Manchester district prices are steady at £5 per ton for bars, £5 5s. to £5 7s. 6d. for hoops, and £6 12s. 6d. to £6 15s. per ton for local made sheets.

Although there is no perceptible actual improvement in the engineering branches of industry in this district, but, if anything, rather the usual temporary slackening off at this season of the year, a generally more hopeful tone is apparent. The increasing activity in the shipbuilding centres is, of course, looked upon as a very encouraging feature, and if it continues it must of necessity lead to an increased amount of work being given out in other branches. Then there is undoubtedly some improvement throughout the country generally in other branches of engineering, such as stationary engine building, tool making, and locomotive building, of which there is evidence in a decreased number of men on the books of the trades unions in receipt of out-of-work support, which all tends to encourage anticipation of a better trade for next year.

I understand that the Board of Conciliation appointed to settle the wages dispute in connection with the Bolton engineering trade has been unable to agree, and the matter has now been referred to an arbitrator.

Messrs. Maybury, Marston, and Sharpe, finished iron makers, of Huyton Quarry, near Liverpool, and Pendleton, near Manchester, are putting down additional sheet rolling mills at both their works, which will enable them to increase their output by about 200 tons per week.

I had an opportunity the other day of going over the works of Sir Joseph Whitworth and Co., at Openshaw, near Manchester, where considerable extensions have been made during the past twelve months. About 40 acres of land have now been acquired for these works to meet the constantly growing requirements. Already about 25 acres have been covered in with buildings, and in the various shops there are between 900 and 1000 machine tools of different types, from the smallest lathes for the most delicate work, up to the most massive and powerful tools of this class that have so far been made, and capable of dealing with pieces of metal over 100 tons in weight. Large new shops have been erected and specially laid out for the manufacture of guns and steel forgings and castings of the heaviest class. Ingots are now being cast up to 60 and 70 tons and steel castings up to 40 tons in weight. The chief additions have been in the large new shops for finishing guns of the heaviest calibre, and special lathes have been set down for boring and rifling guns up to 50ft. in length and 150 tons in weight, whilst a shrinking pit has been erected with suitable cranes and machinery in which tubes can be shrunk on to guns up to 50ft. in length. At present guns are being dealt with up to 68 tons in weight, and the orders in hand include guns for the English Government, for France, and other foreign countries. Messrs. Whitworth are also particularly busy in Nordenfelt guns, which are being largely used all over the world. The firm are also just completing for the English Government a large order for steel gun carriages, which have been made from special designs. Another large addition is a new steel foundry in which castings can be turned out up to practically any weight, and which is equipped with all the requisite appliances for making anything that may be wanted in steel. In their ordinary steel forgings Messrs. Whitworth have large orders in hand for marine shafts, a number of which are for American cruisers and for the Russian Government. In machine tools the firm are also very busy with foreign orders, chiefly for Russia and Spain. One order for Spain is a large slide lathe, which is specially designed for naval work, and which will weigh close upon 200 tons, and will be perhaps the most powerfully-geared tool of its class that has ever been made in this country. They have also just delivered for the same place a large boring machine for boring cylinders up to 12ft. diameter.

In the coal trade, with the exception that house-fire classes of fuel have been moving away rather more freely as the result of the colder weather and the usual getting in of supplies just prior to the holidays, there is no real improvement to report. All descriptions of fuel continue plentiful in the market, and prices quite as low as ever, the average quotations at the pit mouth remaining at 9s. for best coals, 7s. to 7s. 6d. seconds, 5s. 6d. to 6s. common house coals, 5s. to 5s. 6d. steam and forge coals, 4s. 6d. to 5s. good qualities of burgy, 3s. 6d. up to 4s. best slack, and 2s. 6d. to 3s. per ton for the common sorts.

For shipment there has been rather more doing, but no better prices are obtainable, 6s. 9d. to 7s. per ton being the full average price for good qualities of steam coal delivered at the high level, Liverpool, or the Garston Docks.

The colliers have again commenced their periodical agitation with regard to wages, and the coalowners have been asked to hold a meeting to consider the question of a ten per cent. advance, but it is scarcely likely they will waste time in discussing a matter with regard to which they must already have a most decisive opinion.

Barrow.—There is a very good business doing in the hematite pig iron trade, and the sales made during the past week have been on a large scale at the improved rates which were quoted last week. Makers are firm at 47s. per ton net, f.o.b., in the quotations for Bessemer qualities of pig iron in mixed numbers, and 46s. 3d. for No. 3 forge iron. Even holders of large stocks of iron are firm, and are waiting in anticipation of higher prices for all the qualities of pig iron which are produced in the district. There is a very steady tone all round, and though there is no doubt that the restriction in the output of pig iron was the first cause of the revival in the demand, there is now a movement to restore the output to meet the improved demand accompanied by better prices. The business in the hands of makers is very considerable, and most of the stocks which are held are not in the hands of makers, but of merchants or speculators on the one hand, and legitimate users on the other, who have bought largely forward, but are not quite ready to accept deliveries. The North Lonsdale Iron and Steel Company, which held its meeting last week, reported through the directors that a profit had been made on the year's working of £4660. It is about to re-light one of its idle furnaces. In the steel trade there is a very active business doing. Rails are in brisk request, and light sections are quoted at £4 7s. 6d., and heavy sections at £4 2s. 6d per ton net, f.o.b. There is a good demand for both bars and billets at about £4 1s. 3d. to £4 2s. 6d. per ton; but the principal event of the week is the impetus which has been given to the steel plate trade, owing to the large tonnage of shipping which has been recently placed, as well as that which is now offering. Some large orders for plates have been booked, and prices have advanced to £7 5s. per ton net, f.o.b., at which figure they are firmly held. There is every indication of a good trade in shipbuilding and engineering, and the new year is likely to show a considerable improvement on 1887. There is a sign of increased activity in marine shipbuilding, and boilermakers are also likely to be busier. Finished iron is in better demand, on account of the business doing in shipbuilding. Iron ore is in better demand, and prices are steady at from 9s. 6d. to 13s. 6d. per ton net at mines. Coal and coke firm and steady, with a prospect of an advance in prices. Shipping is well employed, considering the time of the year.

THE SHEFFIELD DISTRICT.

(*From our own Correspondent.*)

The coalowners of South and West Yorkshire have held a meeting at Sheffield this week, mainly to frame a new code of rules required under the Mines Regulation Act recently passed. They had before them the question of miners' wages, an advance of ten per cent. having been asked for, and letters exchanged with the miners' officials on the subject. No decision was arrived at or sought for; but it may be taken for granted that no advance in wages will be conceded at this time, many of the pits being worked at a positive loss, while others are making no profit.

At the Sheffield Town Hall, on Monday, the first case under the new Merchandise Marks Act occupied the attention of the stipendiary magistrate for four hours. A firm of cutlery manufacturers, whose trade mark was X X, brought an action against another firm who struck K K, the contention being that K K so nearly resembled X X as to be calculated to deceive. Evidence of experts was called. A "small master" deposed to making tens of thousands of dozens of knives for the firm against whom the proceedings were taken, and others; and that he struck K K, and had done it since the 23rd of August, the date on which the Act came into operation. The principal of the firm went into the witness-box, and declared he did not know the other people's trade-mark, and that he had given instructions K K was not to be struck after the 23rd August. The stipendiary, in delivering judgment, said that K K was undoubtedly so near to X X as to be calculated to deceive; but as the defendant had ordered the mark not to be struck after passing the Act, he thought that excused him of intent to deceive, and acquitted him. The case has excited very great interest in the local trades.

I mentioned to you some time ago that the Sheffield Coal Company had sunk a new shaft to its Birley pits near Woodhouse. This work has now been completed, and at the annual dinner of managers, agents, clerks, and deputies, on Saturday, "Success to the Sheffield Coal Company and to the new shaft," was the chief toast. The dinner, indeed, was specially in celebration of the new winning, which is now well at work.

At all our principal establishments this week efforts are being made to complete orders before the Christmas holidays begin. The American fall orders have this year come forward very early, and this has considerably relieved the manufacturers. Trade is undoubtedly brisker all round. I have been in most of the large works during the last fortnight, and on every hand it is admitted that work is more plentiful. Profits, it is generally urged, are not sufficient for the outlay and labour; and with the exception of the rise in iron and some sorts of railway specialities, values seem to be very much what they were in the end of 1886. The most gratifying feature in the cutlery and edge tool trades appears to be the call for articles of higher quality. This particularly applies to the American market, where in all directions the reign of cheapness appears to be coming to an end. It is similarly evident in Canada and other markets. At home, owing to the prolonged depression in the agricultural districts, very little business is being done. What are called "the country markets" have rarely been less animated. A notable exception is Ireland. Confidence appears to be spreading in the island; and our leading cutlery house reports an accession of better orders even from Cork, Dublin, and the Wexford and other troubled districts.

I have been going over the statistics of Sheffield exports to the United States during the eleven completed months of the year. The total value has been £995,125, as compared with £642,055 for the corresponding period of 1886. Steel ranked for £356,451, and cutlery for £233,595, against £306,533 and £209,566 for the eleven months of 1886. When the return for December is obtained the volume of Sheffield business with the States will be seen to have swelled to a large extent.

A series of tables published by the *Sheffield Telegraph* show that forty-six limited companies mainly connected with coal, iron, and steel, have a called-up capital of £12,449,326. On December 1st, the capital of thirty-seven of the companies, according to the exchange value, had depreciated to the amount of £4,577,758; and the remainder had increased by £619,409.

THE NORTH OF ENGLAND.

(*From our own Correspondent.*)

Having regard to the excitement which has prevailed during the last three weeks, and in view of the near approach of the Christmas holidays, it is scarcely surprising that the Cleveland pig iron trade has become quieter, and that prices are again somewhat heavier. The reaction which has taken place at Glasgow has had its due influence on prices in England, but they do not fluctuate to the same extent here as further north. At the market held at Middlesbrough on Tuesday last, neither buyers nor sellers seemed anxious to do business, and it is scarcely likely that they will resume operations to any considerable extent before the end of the year.

For prompt delivery only small lots were sold, the price accepted by merchants being 33s. per ton, or 9d. less than last week. Makers are not quoting less than 35s. Most of them have enough on their books to last over the next two months, and they hope to obtain better prices by that time. Forge iron has been but slightly affected by the speculation which has recently been so rife, and the price is more easily maintained. Some makers, whose books are well filled, ask 33s. per ton, but others are willing to accept 32s. 3d. to 32s. 6d.

Stevenson, Jaques, and Co.'s current quotations: "Acklam Hematite," Mixed Nos., 45s. per ton; "Acklam Yorkshire," Cleveland, No. 3, 35s.; "Acklam Basic," 35s.; refined iron—hematite, 65s. and Cleveland, 55s.; chilling iron, 55s. to 60s., net cash at furnaces.

The value of warrants has lately varied considerably. On the 13th inst. 34s. 3d. was the price quoted. On Tuesday last 33s. was asked by sellers, and 32s. 6d. to 32s. 9d. was offered by buyers.

The stock in Messrs. Connal and Co.'s Middlesbrough store increased 2799 tons during the week ending Monday last, the quantity then held being 332,667 tons.

Shipments continue to be exceedingly good for the time of year. The pig iron exports from the 1st to the 19th inst. amounted to 46,693 tons against 39,471 tons during the corresponding portion of November.

Orders for finished iron are numerous, and makers seem to be all of one mind in asking the higher prices. Ship plates have been advanced to £5 per ton on trucks at works, and it is difficult to place orders at anything less. Common bars are quoted at £4 17s. 6d., and best bars at £5 7s. 6d., all less 2½ per cent. discount.

A further advance in the price of steel plates has taken place, £7 5s. at works being now the minimum rate. Several of the makers are unable to book orders for delivery over the next three months.

Meanwhile some consternation has been produced by the circulation of a rumour that a contract for no less than 3000 tons of steel ship plates for delivery on the Tyne has been placed with a German maker.

A somewhat unusual way of demolishing a chimney stack was last week adopted at the West Hartlepool Rolling Mills. At the works in question preparations are in progress for the addition of a new steel melting and cogging plant. An old chimney of considerable size and height being rather in the way of the operations, it was decided to take it down; the foundations were undermined, and wooden chocks were substituted for the brickwork at certain parts. When these had fairly got the weight they were set on fire—presently the chimney fell in the desired direction with a tremendous crash.

On Saturday last the busy seaport towns which constitute the Hartlepools were all *en fête* on the occasion of the launching and testing of a new lifeboat called the Cyclist. The cost of the boat amounting to £700, was defrayed by subscriptions from no less than 6000 cyclists distributed throughout the United Kingdom. The idea originated in a general desire to commemorate the Jubilee year of her Majesty's reign in a way in which all members of the craft might unite, and of the utility of which they would all be certain cordially to approve. The preliminary expenses, amounting to £80, were paid by the firm of Iliffe and Sturmey, cycle manufacturers, of Coventry; and the funds derived from the general subscriptions of cyclists have proved sufficient not only to pay the cost of the boat, but also to maintain it for four years to come. The presentation was made by Mr. Henry Sturmey, member of the above firm, and the originator of the movement; and was acknowledged on behalf of the Royal National Lifeboat Institution by Lieut. Willoughby Beddoes, R.N., who said that no less than 32,000 lives have already been saved by the boats and crews of the National Institution. In the course of the tests which were made the new boat was intentionally upset, and immediately afterwards righted itself.

NOTES FROM SCOTLAND.

(*From our own Correspondent.*)

Since last weekly report the Glasgow pig iron warrant market has been in an unsettled state. The upward movement in prices was checked last week when warrants had reached 44s. 10d.; they have fallen about 2s. 6d. a ton, and the fluctuations have been frequent. The fall in price is ascribed to holders realising, and there is an impression that, owing to the general improvement in trade, the prices will again advance, particularly as they reached a considerably higher figure a year ago, when there was apparently much less reason for an upward movement. The past week's shipment of pigs were 8868 tons, as compared with 4539 in the same week last year. Of the exports, 1550 tons went to Italy, and 1355 to the United States. There are now 85 furnaces in blast, against 72 at the corresponding date. Two furnaces have been finally put out at the Monkland Ironworks, where the production of pigs is to be entirely discontinued. The stock in Messrs. Connal and Co.'s Glasgow stores is still increasing at the rate of about 1500 tons a week.

The prices of makers' iron are unsteady and rather easier:—Gartsherrie, f.o.b. at Glasgow, per ton, No. 1, is quoted at 48s. 6d.; No. 3, 45s. 6d.; Coltness, 53s. and 45s. 6d.; Langloan, 51s. 6d. and 45s. 6d.; Summerlee, 51s. 6d. and 45s.; Calder, 49s. 6d. and 43s.; Carnbroe, 46s. and 43s.; Clyde, 46s. 6d. and 43s.; Monkland, 45s. 6d. and 43s.; Govan, at Broomielaw, 44s. 6d. and 41s. 6d.; Shotts, at Leith, 49s. 6d. and 46s. 6d.; Carron, at Grangemouth, 53s. 6d. and 42s. 6d.; Glengarnock, at Ardrossan, 49s. and 43s.; Eglinton, 44s. and 42s.; Dalmellington, 45s. and 43s.

The Spanish ore trade is active, and large purchases have been made by Scotch smelters. The current rate is 14s. 9d. to 15s. per ton delivered in Clyde over next year.

A number of additional orders for steam and sailing vessels, chiefly the former, have been placed with Clyde builders in the course of the week. The tonnage on hand is estimated at about 180,000 tons, which is about 30,000 more than has been available at the beginning of a year for several years back. Marine engineers, plate and tube makers, ship furnishers, and others, are benefitting by the activity that prevails in the shipyards, and if the wages question can be kept from causing difficulty an active time is assured for the Clyde during the next six months at least.

In the malleable iron trade there is continued animation. This branch had been so long in a backward way that old firms had in not a few cases given it up altogether, deeming it better and more profitable to restrict themselves to the manufacture of pig. The consequence is that the effective malleable works are few in number, and at present they are nearly all as busy as possible. Since last week prices have been advanced about 5s. a ton, and although the backward turn in pigs and the continued addition to stock both here and in Cleveland may have a quieting effect, the present idea is that, owing to the amount of work on hand, the present rates may possibly be maintained for some time. Merchants quote best bars at £5 7s. 6d.; common bars, £5; angle rivet iron, £5; nut iron, £4 15s.; and plates, £5 12s. 6d.; all less five per cent. discount. Shipping orders are somewhat scarce, but the inquiries are of such a character as to lead merchants to expect that a better foreign business may be experienced.

Several Glasgow firms have combined to secure freights at Cardiff for about 100,000 tons of Bilbao ore for delivery next year, the rate paid being rather more than Glasgow brokers quote at present.

Private advices from New York to merchants here state that the business in steel blooms, billets, and sheets cannot be placed there at the quotations wired from this side, as rates in America are weaker rather than stronger.

There is more animation in the coal trade, and about 3d. a ton of an advance is being obtained by coal-masters for household coals. As yet shipping qualities are without material change.

WALES AND ADJOINING COUNTIES.

(*From our own Correspondent.*)

There is a healthier character about the coal trade, and though totals did not quite touch 150,000 tons foreign exports at Cardiff last week, yet wind and weather were charged with the cause, and coalowners on the whole are satisfied that the improvement of late is fairly sustained. This may be expected to continue. An improvement in iron such as is taking place is generally accompanied by a change for the better in general industries, and coal always follows. I note, too, an anxiety to keep the foreign coaling stations well stocked. Foreign affairs are regarded as critical, and coalowners do not forget that every war, from that of the Crimea to the Franco-German, brought a tide of prosperity to the coal trade in Wales. Large tonnages are being sent to Gibraltar. On one day this week from Cardiff and Newport, between 6000 and 7000 tons of coal were despatched; to Aden and Bombay also there is a steady shipment. Messrs. Cory and Co. continue to figure largely amongst the coal shippers to foreign destinations.

It is stated, on good authority, that the Dowlais Iron Company contemplates an extensive coal sinking, as the latest one at Bedling has not been satisfactory. The first selection made was at the Deri, on the Rhymney and Bargoed Railway, but this is now stated to be abandoned, consequent on the projected removal to Cardiff of the iron and steel works, and of the anticipated amalgamation of the Bute and Taff Vale Companies. The statement made is that a very likely selection of ground will be near the Aberdare Junction in the Taff Valley. I have once or twice referred to this place as almost the largest, and the last of the virgin spots left. It occupies the centre of the coal basin. Old-fashioned mining engineers have shaken their heads about it, fearing that the water would be a troublesome and expensive item, but the experience at Penrhiwceiber was useful at the Albion, and will be so at the new Dowlais colliery, which might well be called the Wimborne. Deep sinkings, and probable heavy cost, and possible disaster, are the things which help to retard the opening of the deep measures of Monmouthshire. Interest is being centred on the experiment going on in the Caerphilly Valley, in which large coal owners are concerned.

I am glad to report a stoppage of local agitation amongst the colliers on sliding scale matters. In the face of the coming Christmas, good work is being done.

One of the leading ironmasters of the North, commenting on the transfer of Dowlais to the seaboard, "regarded it as highly probable," adding, "We shall all drift down to the sea sooner or later." Movements are on foot now daily at the Moors, Cardiff, for the erection of the works. It has been finally arranged, I hear, and the lease signed by Sir W. T. Lewis for the Marquis of Bute, Mr. Clark and Mr. E. P. Martin for Lord Wimborne, and Mr. Pilman for the Bute Dock Company. This removes all doubts. The arrangements are to be that the whole transfer shall be completed in ten years. Three furnaces with all accessories are to be ready in two years; in the next three years Siemens furnaces, and all appliances for sleepers, ship plates, boiler plates, &c.; and within ten years complete removal of all operations now carried on at Dowlais. Doubtless a good deal of the new plant will be made at Dowlais Works, and as trade is improving, a tolerable burst of prosperity may yet be enjoyed there.

Pig iron has advanced, in some cases as much as 5s. per ton extra has been quoted. It will be seen by the following list from the Swansea Exchange this week that prices are hardening all round. Pig iron Glasgow warrants, 42s. 6d.; hematite Bessemer, closing price 44s. 7½d., one month; Welsh merchant bars, £4 10s. to £4 12s. 6d.; iron sheets, £6 17s. 6d.; steel rails, heavy, £4 to £4 5s.; light, £4 17s. 6d. to £5 2s. 6d.; steel sheets, £7 10s. to £8 10s.; Bessemer tin-plate blooms, £4 5s.; bars, £4 15s.; Siemens bars, £5 2s. 6d.

The steelworks continue busy, and at Dowlais improvement of existing plant and additions continue to be made.

Cyfarthfa works are very brisk and the repairs to the coke ovens are almost completed. The heat generated at the ovens was so intense as to fuse everything. I was over the ovens after the completion and could not but admire the thoroughly workmanlike manner shown by the contractor.

The steel bars for tin-plate are being sent away freely from Cyfartha to all parts. I am not surprised at this, for in the matter of figures and quality the Brothers Crawshay are able to compete with anybody.

Tin-plate continues to absorb attention. The Aberdare tin-plate works are to be floated again, and I hope successfully. The works lie well for water power.

Prospects of trade were regarded by the merchants at the Exchange as good, and a probable corner was hinted at. This is certain, that stocks are getting low, home and foreign, and demand is setting in well. The "tin-corner" men have reached a certain figure—highest £166—and it is thought that somewhere about this will be a permanency. Bookings forward are governed somewhat by this. Latest quotations on 'Change at Swansea were as follows:—Cokes, 15s. to 15s. 3d.; Bessemer, 15s. 3d. to 15s. 6d.: Siemens, 15s. 6d. to 16s.; best, 16s. 6d. to 17s. 6d.; ternes, 26s. to 28s.; charcoals, 18s. to 22s.; wasters, 6d. to 9d. per box less than the quotations for primes.

Shipments at Swansea and Newport continue good. Last week at Swansea they were much in excess of production.

The Powells Duffryn Company has put a stop to a very injurious custom. In the district, whenever even a slight accident happens, the men leave the pit. In one case, at Aberdare lately, this entailed a loss to the company of £31 10s., and four men were accordingly prosecuted for leaving work without notice. The decision of the magistrate was 5s. and costs.

Latest coal quotations are, steam, 8s. to 9s. 6d.; bunkers, 6s. 9d. to 8s., according to quality. House coal quotations firm, and advancing.

Rhondda No. 3 in good demand. Coke firm, and in request. Pitwood improving.

NOTES FROM GERMANY.

(*From our own Correspondent.*)

The iron markets show again this week the same firm tendency, and there is every reason that they should remain so for a considerable time to come, or even develope themselves more favourably, always excepting political disturbances. The demand continues ample and prices are stable, on account of the effect produced by the various conventions, and at present unsteadiness either to the one side or the other is not anticipated, the better notations on American and other foreign markets having also a share in this. This firmness has found clear expression too on 'Change, and on the share markets.

The Silesian market still manifests animation; the pig iron production finds ready sale; four works have disposed of the whole of their output till the termination of the pig iron convention at the end of 1890, at M. 53, whilst last week's current price was M. 50 p.t.; dealers in wrought iron are purchasing freely, so that all the mills are well engaged, including also the foundries and constructive works generally. As the steel works have come in for their share of the large State railway orders lately awarded, they, like their competitors in Westphalia, are satisfactorily employed.

Neither in Belgium nor in France has any special change or improvement taken place since last report; both markets, however, are firm. The Cockerill Company is about to make a second attempt to procure work from China and Japan, as the first mission failed, and is sending out this time M. Nieuwenhuyse, engineer, for the purpose.

As specially regards the Western districts, the trade in ores has developed and is more animated; and, as was before remarked as likely to happen, the former trade in foreign mineral has now mostly been transferred to the native sources, and Siegerland, Nassau, and Luxemburg ores now find ready sale in Westphalia. The cessation of the competition of Spain, and the increased demand for native ores through the consolidation of the pig iron convention, have tended to stiffen prices, and they have advanced a little, Luxemburg minettes, now largely consumed in Westphalia, being noted at M. 2·10 for grey; roasted, 2·50; and red calcareous, 3·20 p.t. at mines. Again an attempt to form another pig iron convention, or rather a common sales office, which is nearly sure to be accomplished, is to be noted, namely, in the Siegerland, where twenty-six blast furnaces are in full work. This was scarcely required in order to improve the pig iron trade, which was excellent as it was, but still it has had the effect of strengthening the situation. Spiegel iron, which is, so to say, on the Continent still only made in the Siegerland, the place of its origin, has been raised M. 1 p.t., and now stands at M. 51 to M. 52 for the lowest grades, which are firm and find good sale at home, but the higher grades, which mostly go to America, are dull, as little is being exported and is down in price in that market. Forge pig is as brisk as can be, and below M. 47 is not easily procurable; 46·50 is offered at once freely. Large lots for the second quarter of next year are already disposed of. Foundry finds pretty good sale at M. 49 to 56 for No. 3; basic is in moderate demand at M. 44, and Bessemer goes off steadily at M. 49 to 51, whilst Luxemburg forge is lively and in good demand at M. 34 to 36, and occasionally higher, free on trucks at works. The rolling-mill masters keep up a buoyant appearance; native demand is pretty good, prices are steady and remunerative, and the works are pretty regularly employed, though no doubt part of the output is going into stock, as specifications do not come in fast enough to counterbalance the production. Export is not at all what is desired. Some think it is caused by the advanced prices, while others maintain that the German iron can hold its own in quality against all competitors; that its goodness has now been discovered by foreign buyers and users; and that the price is a secondary consideration. The latter view is perhaps a little too optimistic. Hoop iron continues in brisk request, and the tendency of prices is upwards. Boiler plates, at the old price of M. 150, are in slightly better demand. Sheets are in the same position as last week, the trade very active, and below the old price of M. 142 are not procurable; no rise has yet been announced by the convention, but one is shortly to be declared. Tin-plates have now been raised M. 2 per box since the first advance of tin began. In the first ten months of this year the export of them has only amounted to 228 t. against 187 t. last year for the corresponding months; so competition from the quarter is not very formidable. The import has been thirty times as much. With regard to wrought iron tubes, till not long ago an English speciality, the figures are more significant, for in the same ten months 18,096 t. were exported against 15,709 t. the year previously. Wire rods have decidedly been more animated the last week or so, and America has again placed some large orders here. The foreign trade in general is more active and prices have hardened, and it is almost certain that the new sales office will raise the present base prices very soon. Buyers of wire and wire nails are seeking to place orders, and prices have risen. Iron wire rods are noted M. 116 and higher; drawn iron and steel wire, 135; and steel rods, 115 on trucks at works stations; wire nails, 145 p.t. The wire nail convention, the most recent in the list, is on the point of completion. The light chain-makers of Westphalia are endeavouring to form a union with those of Rheinland, Silesia, and South Germany, and a preparatory step will be to raise the prices in harmony with those of wire rods. Large lots of steel rails and sleepers have been, and are still about to be given out all over the country. The prices of those already tendered for have varied from M. 118 to 122 p.t. at works. It appears England exerts such a pressure abroad that Germany has little to hope for in the competition, as lately seen in Italy, unless bad times should return, and the works have little to do at home. The two new steel works, branches of the Bochum Steel Company, Westphalia, in Italy and Spain, appear to be doing well from the reports received. The Savona works have just received orders for 12,000 t. of rails at 175f. and 179f. p. t. at works, which amounts to 2,000,000f.; and the works at Seville have received from the Spanish Admiralty orders for material for the marine for upwards of 300,000f., with more in expectation. It is to be hoped English works are on the *qui vive* in these quarters. The wagon works are experiencing an influx of orders, and the machine and constructive iron works in general are so far well employed that complaints on this score are not so rife as formerly; but the less said about profits on working, as a rule, the better.

The Rhenish and Silesian zinc rollers have raised the base price of sheets M. 15 p. t., and it is reported that the output of all the spelter zinc works is contracted for to the second quarter of next year.

After months of one of the lowest Rhines known, a moderate flood has set in, so the coal trade has become very active. However, no change of price in coal is observable, though coke has gone up a little. It is satisfactory to note that England has sent more coal to Holland from January to October this year, namely, 225,475 tons, against 210,530 for the corresponding period of last year, in face of the fierce competition of Belgium and this country.

It would appear as if the stringency of the new English trade-mark law had not till now been sufficiently observed or appreciated by exporters on this side, so the syndicate of merchants of Berlin is about to have the principal regulations published and circulated. This, it is to be hoped, will have a deterrent effect, but those who practice habitually such crooked ways are very ingenious, and a sharp watch in every quarter will still have to be kept up.

AMERICAN NOTES.

(*From our own Correspondent.*)

New York, December 9th.

The situation in the industries throughout the United States is even more favourable than a week ago, owing to the booking of a great many orders from railroad companies, manufacturers, founders, and manufacturing interests generally. More or less business has been held back all along in view of the possibility of weaker prices, but the demand for the past week or so shows that consumers have about made up their minds to run no further risk. Throughout the Mississippi Valley a great deal of new business is coming forward. The wheat supply is not very heavy. There is a serious falling off in corn, and the cotton crop will not show that increase which manufacturers would like to see in the interest of lower prices. The agricultural area has been considerably expanded throughout the States during the past four or five years, but on the other hand, the production of wheat, corn and cotton per acre has fallen off, and the earnings of the agriculturists have actually fallen off. Tin has advanced 50 per cent. within six months. Copper is steadily moving up. Lead and spelter are 20 per cent. higher than three months ago. Petroleum certificates have reached the highest figure of the year—76c. Grain staples have advanced, wheat, 3c.; corn, 5c.; oats 2c. These straws show which way the wind is blowiug. The iron trade all along the Atlantic coast is in a very vigorous condition. Mills and furnaces are all on full time, and orders are coming in for the winter's output. Prices are strong on account of the increasing cost. Margins are a little closer. Southern iron furnaces are selling all they can make in the Mississippi Valley instead of along the Atlantic coast—that is, the production goes to the interior of the country instead of to the sea-coast. Rails are quoted at 32 dols. 50c. to 33 dols. 50c. at mill. American Bessemer, 18 dols. to 19 dols.; foreign, 20 dols. to 21 dols.; steel blooms, nominally 29 dols. Very few orders are going abroad. Business of all kinds is in good shape. The winter will be an open one, according to weather prophets, and this will be favourable to activity in all sections. A great deal of house and mill building is projected, and building material of all kinds is very firm in price. The anthracite coal trade is extremely active, and all anxiety as to an absolute scarcity is over. Rail makers expect to sell very large quantities of rails during the coming three months. As to the extent of railroad construction next year high authorities are not in accord. Public sentiment is being aroused throughout the States as to the importance of Government action in the building up of American shipping. It is quite probable that a law will pass Congress facilitating American ownership of vessels, but there is such a difference of opinion among politicians that no great expenditure by the Government can be relied upon. The tariff question is also said to occupy the attention of politicians. The rank and file of the democratic party would prefer to leave tariff duties where they are, but the leaders are determined, if possible, to force the reduction of tariff duties to an issue. They say the policy will probably jeopardise democratic success in the presidential canvass. Republican politicians are quietly encouraging them in their course, knowing that out of the distrust and discontent which will result, they will have better opportunities of regaining political power.

NEW COMPANIES.

THE following companies have just been registered:—

Bath and District High Level Waterworks Company, Limited.

This company proposes to acquire, carry on and extend the waterworks situate at Midford and Combe Down, near Bath. It was registered on the 8th inst., with a capital of £20,000, in £10 shares. The subscribers are:—

	Shares.
J. F. Stilwell, Dover, engraver	1
W. Stephens, Bath	1
J. D. Young, Bath	1
W. F. Gould, Bath, outfitter	1
J. Day, Bath, engraver	1
E. F. Day, 25, Collingham-gardens, S.W.	1
C. R. Stephen, 110, Jermyn-street	1

The first directors are Messrs. Player Isaac, Josiah Thomas, and W. S. Loder. Mr. Joseph Day is appointed managing director.

Great She Gold Mining Company, Limited.

This company was registered on the 12th inst., with a capital of £450,000, in £1 shares, to purchase 143 gold mining claims in the De Kaap Goldfield, South African Republic, with water, timber, and other rights. The purchase is subject to an agreement with William Wynn Kenrick—as attorney for the Great She Gold Mining Syndicate—William Robert Taylor, Maynard Roberts, and Edward Slater. The subscribers are:—

	Shares.
T. Shepherd, 5, Acacia-road, St. John's Wood, clerk	1
A. K. R. Ramsay, 2, Metal Exchange-buildings, chartered accountant	1
W. Martin, 12, Poplar-grove, West Kensington Park, clerk	1
G. J. Offer, 5, Bismarck-road, Highgate, clerk	1
A. G. Beveridge, Hornsey Park-road, N., clerk	1
A. T. Havers, 40, Palace-street, S.W., clerk	1
C. K. M. Smith, 11, Brixton-road, clerk	1

The articles of association refer to the prospectus for the names of the first directors. The number of directors is not to be less than three, nor more than nine; qualification, 250 shares each; remuneration, £1500 per annum. The vendor is empowered to nominate two directors.

Great Steamship and Hotel Company, Limited.

Registered on the 10th inst., with a capital of £40,000, in £1 shares, to trade as shipowners, merchants, hotel and tavern keepers, wine and spirit merchants, and showmen. The subscribers are:—

	Shares.
S. W. Coe, Baltic-buildings, Liverpool, steamship agent	1
A. J. Thomas, Gilwern, brewer	1
J. R. Thomas, Baltic-buildings, Liverpool, shipowner	1
W. J. Austin, 31, Great George-street, Liverpool	1
A. W. Moulding, 5, South Albert-road, Liverpool	1
F. Harley, City-buildings, Liverpool	1
D. F. Houston, 15, Sweeting-street, Liverpool, secretary	1

Registered without special articles.

Kohler Sewing Machine Company, Limited.

Registered on the 10th inst., with a capital of £50,000, in £1 shares, to trade as sewing machine manufacturers and mechanical engineers. The subscribers are:—

	Shares.
J. A. Oliver, 10, King's Cross-road, clerk	1
J. Gray Durant, 5, Guildhall-chambers	1
T. Durant, jun., 5, Guildhall-chambers, solicitor	1
J. Fraser, 5, Guildhall-chambers, clerk	1
H. Ellington, 107, Fleet-street, journalist	1
E. Kohler, 64, Fore-street, machinist	1
F. W. Thornton, Royal Hill, Greenwich	1

The number of directors is not to be less than two, nor more than seven; the subscribers are to appoint the first; qualification, £500 in shares and stock.

Phonophore Syndicate, Limited.

This company was registered on the 10th inst., with a capital of £90,000, in £1 shares, to purchase from Mr. Arthur Rust, of Leicester, certain inventions relating to telephony and telegraphs. The subscribers are:—

	Shares.
E. Churchill, 9, Gilbert-street, W.C., electro-metallurgist	1
J. Cromar, 348, Munton-road, S.E., clerk	1
P. Parminter, St. John's, S.E., clerk	1
E. M. Drive, Blomfield House, London-wall, secretary	1
A. Cumnew, 70, New North-road, clerk	1
S. R. Habben, 71, Coburg-road, S.E., clerk	1
C. D. Kimber, West Hill, Putney, articled clerk	1

The subscribers appoint the first committee of management; qualification, 100 ordinary shares. The remuneration of the committee will be at the rate of £100 per annum each, with £50 additional for the chairman, provided that the maximum be £1500 per annum.

Pontifex and Wood, Limited.

This is the conversion to a company of the engineering business carried on by Messrs. Pontifex and Wood, at Shoe-lane, Millwall, and elsewhere. It was registered on the 14th inst., with a capital of £100,000, in £1 shares, whereof 400 are founders' shares. The subscribers are:—

	Shares.
*E. A. Pontifex, Shoe-lane, engineer	1
*E. L. Pontifex, Shoe-lane, engineer	1
*M. Pontifex, St. Andrew-street, E.C., solicitor	1
H. W. Neild, Shoe-lane, engineer	1
C. Major Dain, Shoe-lane, market clerk	1
W. Scott Metzner, Shoe-lane, office manager	1
Sydney Pitt, St. Andrew-street, E.C., solicitor	1

The number of directors is not to be less than three, nor more than twelve; the first are the subscribers denoted by an asterisk and Messrs. Wm. Pontifex and Austin Joseph King. The remuneration of the ordinary directors will be £200 per annum.

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.

13th December, 1887.

17,115. TUBBING, W. L. Purves, London.
17,116. BRUSH or BROOM HANDLES, W. P. and T. Fox, Sheffield.
17,117. SADDLES, J. B. Brooks, Birmingham.
17,118. WINDOWS, A. Lever, J. T. Pearson, and T. Richmond, London.
17,119. FORMING and SHAPING METALS, A. Paterson, London.
17,120. BUTTON-HOLES, H. J. Allison.—(*The Harris Button Hole Attachment Company, United States.*)
17,121. SASH LOCKS, J. T. Lister, London.
17,122. PRESSING TOBACCO DOWN in PIPES, W. H. Welshman, Birmingham.
17,123. STRETCHING TROUSERS, &c., H. J. Morris, London.
17,124. MOWERS, J. MacGregor, Glasgow.
17,125. GLASS PLATES, A. D. Brogan and A. M. Malloch, Glasgow.
17,126. SCREW GILL-BOXES, J. Stake, Halifax.
17,127. TEMPERING STEEL WIRE, J. and H. Law, Halifax.
17,128. BRAKES, R. Simpson, Birmingham.
17,129. KEYLESS WATCHES, H. East and F. L. Turner, Birmingham.
17,130. GLAZING ROOFS of STATIONS, &c., T. R. Shelly, Smethwick.
17,131. ACTUATING VACUUM BRAKES, W. H. Blakeney, Dundee.
17,132. TEA-POTS, S. Gibson, Longport.
17,133. SHOWING OPTICAL ILLUSIONS, A. P. Wire, Essex.
17,134. BOILER, D. B. Morison, Hartlepool.
17,135. IMPERVIABLE CANE for BASS BROOMS, J. Griffin, London.
17,136. CISTERNS, A. Carter, Liverpool.
17,137. BOWS for STRINGED INSTRUMENTS, C. R. Betjemann, London.
17,138. VOLTAIC INDUCTION APPARATUS, R. H. Courtenay, London.
17,139. COVERING WIRE for HAT-SHAPES, A. Horowitz, London.
17,140. DAMP-PROOF SOLES for SLIPPERS, R. J. Bagguley, London.
17,141. VENTILATING FANS, J. S., T. A., and E. R. Walker, Liverpool.
17,142. NAIL-SETS, P. Jensen.—(*D. P. Cowl, United States.*)
17,143. PILE FABRICS, J. Worrall and J. Kershaw, London.
17,144. REGULATING SUPPLY of WATER, H. W. Heale, London.
17,145. VANS for CARRYING HAY, &c., H. Rundle, London.
17,146. NEEDLE, O. Heynold, London.
17,147. COMBINED SHIRT, WAISCOAT, and BRACES, G. O. Crowther, London.
17,148. CATTLE CRIBS, E. Pratt, London.
17,149. COMPRESSING POWDERED SUBSTANCES, J. A. McFarran, London.
17,150. AFFIXING CASTORS to FURNITURE, J. U. Hanks, jun., London.
17,151. GRAVITATION RAILWAYS, A. W. McMurdo, Glasgow.
17,152. MACHINE and HEAVY GUNS, A. M. Maude, Glasgow.
17,153. FILTERS, &c., F. H. Urry and O. Trimming, London.
17,154. TUBING, G. F. Sheath, London.
17,155. INCANDESCENT ELECTRIC LAMPS, T. A. Edison, London.
17,156. PURIFYING ALLOYS of MANGANESE, J. Bedford, London.
17,157. BATTERIES, H. H. Lake.—(*J. O. Whitten, United States.*)
17,158. STEAM BOILERS, H. H. Lake.—(*N. H. Daniels, United States.*)
17,159. PLANING METAL, J. Y. Johnson.—(*W. Sellers and J. S. Bancroft, United States.*)
17,160. LAMPS, H. Salsbury, London.
17,161. VENTILATING CARRIAGES, W. Sherman and G. Cordwell, London.
17,162. METALLIC PLATES, C. Salcher and H. Schwertschlag, London.
17,163. SHAFTS of CARRIAGES, &c., C. A. Sundgren, London.
17,164. SHOES, A. and J. Lion, London.
17,165. LAND ROLLERS or CLOD CRUSHERS, W. Jones, London.
17,166. ORNAMENTING ARTICLES with PLUSH VELVET, S. H. Levi, London.
17,167. EXPLOSIVES, J. Y. Johnson.—(*F. C. Glaser, Germany.*)
17,168. VALVE GEAR for MOTIVE POWER ENGINES, D. Joy, London.
17,169. COATING METAL PLATES with TIN, &c., D. Edwards, R. Lewis, and P. Jones, London.
17,170. MOUNTING GUNS, T. Nordenfelt, London.
17,171. CHAINS for WORKING on CHAIN WHEELS, F. Ley, London.
17,172. SAIL HANKS, T. O'R. Jameson, London.
17,173. SALE and DELIVERY of ARTICLES on the INSERTION of COINS, W. H. Davis, London.

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17,174. PROTECTING BOXES without LOCK or KEY, R. Slagg, London.
17,175. PHONOGRAPHS and PHONOGRAMS, G. E. Gourand.—(*T. A. Edison, United States.*)
17,176. PROTECTING HOUSES from BURGLARY, &c., T. Harrison, Alcester.
17,177. WHEELS for GRINDING, &c., E. D. Barker, London.
17,178. STEAMING HAY, &c., H. Jephson, Derby.
17,179. FLUSHING CISTERNS, &c., H. G. Frost, Deal.
17,180. INDICATING the DIRECTION in which SHAFTS are REVOLVING, W. D. Thompson, Liverpool.
17,181. HYDRATED PHOSPHATES, L. G. G. Daudenart, Liverpool.
17,182. CAP BARS of TOP ROLLERS of MACHINES for DOUBLING, &c., YARN, C. W. Lancaster, Halifax.
17,183. CLIPS, &c., G. Wilkinson and D. A. Bremner, London.
17,184. BLADES of SKATES, M. W. Maylard, Croydon.
17,185. STOP MOTION for LOOMS, C. Bedford, Halifax.
17,186. ORNAMENTING METALLIC SURFACES, R. E. Hides, Sheffield.
17,187. THIN METAL WEDGE, W. Atherton, Todmorden.
17,188. MATTRESSES, E. J. Bates, Liverpool.
17,189. PREVENTING AIR and DUST PASSING under DOORS, F. Cook, Halifax.
17,190. CUPS or FLIERS of SPINNING MACHINES, G. Glydon, Birmingham.
17,191. DECORATING FURNITURE, A. L. Bayley, Sutton Coldfield.
17,192. AUTOMATIC COUPLING of RAILWAY CARRIAGES, T. Reeves.—(*G. D. Pearson, Canada.*)
17,193. BOILER MUFFLES, J. Pursall and W. Lister, Birmingham.
17,194. SLEEVE HOLDER and CUFF PROTECTOR, S. S. Watts, Birmingham.
17,195. LAMPS, R. Grindle, Birmingham.
17,196. PUMPS, J. Anderson, Dundee.
17,197. FIXING ORNAMENTAL SUBSTANCES, A. L. Bayley, Sutton Coldfield.
17,198. FASTENERS, B. C. Sykes and G. Blamires, Halifax.
17,199. DRYING STOVES, J. H. Shorrock, London.
17,200. SACK HOLDER, J. Caldwell, London.
17,201. ECONOMISING FUEL in FURNACES, W. Gaskell, London.
17,202. WHEELS, &c., T. Caveney and C. Wrench, London.
17,203. WATER METERS, E. Schlindler, London.
17,204. SIEVE, J. Doughty.—(*F. W. Blows, India.*)
17,205. FASTENERS for WINDOWS, T. Bailey, jun., London.
17,206. WATER-CLOSET APPARATUS, A. J. Hopkins, London.
17,207. SCREW CAPS of LUBRICATORS, T. F. Braime, London.
17,208. CONNECTING the RING of a LANDING NET to the HANDLE, T. H. Gould, London.
17,209. SWITCH and ELECTRIC LAMP SUPPORT, J. Willing, jun., and A. D. Douglass, London.
17,210. AUTOMATIC LOCK, H. Moore, London.
17,211. DISTRIBUTING FERTILISERS, W. Schmidt and P. B. Spiegel, London.
17,212. ESCAPEMENT and RELEASING MECHANISM, F. Foster, London.
17,213. HOT-WATER and STEAM RADIATORS, J. Russell, London.
17,214. ENGRAVING MACHINES, J. Bryce, Glasgow.
17,215. FRICTION CLUTCH, T. Bailey and J. Cook and Son, London.
17,216. WARP LACE MACHINES, W. Start, jun., London.
17,217. SHIRTS, &c., G. Templeman, London.
17,218. OIL, &c., BURNERS, R. Wallwork and A. C. Wells, Manchester.
17,219. MAKING WATER CANS, &c., W. J. Howcroft, London.
17,220. FILTERS, P. A. Maignen, London.
17,221. COUNTERBALANCING HAULAGE ROPES, R. H. Arthur, London.
17,222. DRIVING GEAR of TRICYCLES, &c., J. S. Kerr, Glasgow.
17,223. REFLECTING GAS and other LIGHTS, J. Cobbe, London.
17,224. VIVARIUM, W. Henley, London.
17,225. SWITCHBACK RAILWAYS, A. Barnes, London.
17,226. SAFETY HOOKS, H. J. Haddan.—(*H. Guarracino, Ottoman Empire.*)
17,227. RULERS, H. J. Haddan.—(*H. Guarracino, Ottoman Empire.*)
17,228. CHAIN WHEELS, &c., C. Thompson, London.
17,229. BOTTLE STOPPERS, J. J. Vanderford, London.
17,230. VENTILATORS, BLOWERS, &c., H. Kraemer, London.
17,231. DISTRIBUTION of ELECTRICITY, H. Edmunds, London.
17,232. PROTECTING ELECTRIC CIRCUITS, W. T. Glover and H. Edmunds, London.
17,233. SPRING ROLLERS for WINDOW BLINDS, G. D. Peters, London.
17,234. FRILLING, C. G. Hill, London.
17,235. ARMATURES for DYNAMO-ELECTRIC MACHINES, E. J. Paterson and C. F. Cooper, London.
17,236. BAKING OVENS, J. Mason.—(*J. E. J. L. Mounié, France.*)
17,237. SIGNAL ALARUMS for LOCOMOTIVES, D. Drummond, London.
17,238. COOKING STOVES or RANGES, M. E. Owen, London.

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17,239. LOCKING DEVICE for COVERS of ROTATING SHAFTS, W. Taylor.—(*F. Lejeune, Austria.*)
17,240. PURIFYING and CIRCULATING WATER in STEAM BOILERS, J. C. Jopling, Sunderland.
17,241. COMBINED SPANNER and PINCERS, J. Foster, Birmingham.
17,242. COAL VASES, &c., W. Patrick, York.
17,243. ROLLING and UNROLLING MAPS, &c., T. P. Johnston, Glasgow.
17,244. COMBINED REVERSIBLE KNEELING and FOOT-STOOL, W. G. Barrett, Dublin.
17,245. REVOLVING MOTION connecting PICKERS with PICKING STICKS and STRAPS in LOOMS, G. P. Jaques and W. Holliday, Leeds.
17,246. HERNIA TRUSSES, J. S. Burgess, Manchester.
17,247. MALT KILN FLOOR, C. E. Mumford, Bury St. Edmunds.
17,248. HYDRAULIC RIVETTING MACHINE, R. B. Smith, Glasgow.
17,249. SHADE HOLDERS for CANDLES, P. E. Ayton, Birmingham.
17,250. TRAVELLING TRUCKS, &c., J. Tonry, Wolverhampton.
17,251. COFFINS, A. E. Lloyd, Bristol.
17,252. DYNAMITE GUNS, H. S. Maxim, London.
17,253. TREATING RIFLE BARRELS to PREVENT them BECOMING CROOKED while FIRING, H. S. Maxim, London.
17,254. DYEING, &c., YARN, G. W. Liddiard, Manchester.
17,255. CONDENSERS, D. Herman, Liverpool.
17,256. TONIC LOZENGE, &c., T. Needham, Halifax.
17,257. CUTLERY BOLSTERS, &c., J. G. Crowther, Sheffield.
17,258. MOUNTING STEREOTYPE PLATES, C. T. Jacobi, London.
17,259. BILLIARD and DINING TABLE COMBINED, S. Twist, Birmingham.
17,260. BRONZING INDIA-RUBBER, &c., J. F. Kelly, London.
17,261. BLIND RACKS, W. H. Hazlewood, Birmingham.
17,262. FIXING SHARPENED PIECES to HORSESHOES, I. Ratcliffe, Glasgow.
17,263. VELOCIPEDES, C. Lurie, London.
17,264. OPENING DOORS, T. J. Hancock, Twickenham.
17,265. APPARATUS for STREET CARS, J. Rhodes, Birmingham.
17,266. CIGAR CASES, J. S. Rhodes, Birmingham.
17,267. ELECTRIC SWITCH, A. W. Southey and H. Mellor, London.
17,268. PRESERVED FOOD, M. Frischer, London.
17,269. CONSTRUCTING STEAM WINCHES, F. W. Cannon, London.
17,270. WALKING STICKS, &c., F. J. Biggs, London.
17,271. WATER-CLOSET, &c., CISTERNS, J. Honeyman, Glasgow.
17,272. HOLDING or PUTTING OFF SHIPS' BOATS, J. D. Morton, Liverpool.
17,273. MANUFACTURE of CHLORINE, L. Mond and G. Eschellmann, Liverpool.
17,274. BAGS, W. P. Thompson.—(*W. H. Kerr, United States.*)
17,275. WHEELS, &c., W. P. Thompson.—(*L. Moreau, Belgium.*)
17,276. COCKS for use with LIQUIDS, E. Beauvalet, London.
17,277. REDUCING VALVES, W. L. Wise.—(*F. Heuser and Co., Germany.*)
17,278. SEAT STANDARDS for SCHOOLS, J. Heywood, Ridgefield.
17,279. BOOTS, E. Quick, London.
17,280. BUTTRESS THREAD SCREW TOOL, E. Breffit and Co., London.
17,281. ORNAMENTING METAL WORK, S. Tuddenham, London.
17,282. UMBRELLAS, F. S. Liley, London.
17,283. ARTIFICIAL COLD, &c., F. W. Chapin, London.
17,284. CURVED METAL PIPES, H. Russell.—(*A. Boll, Germany.*)
17,285. CURING SMOKING CHIMNEYS, H. A. Hancock, London.
17,286. ENABLING HEIGHTS to be MEASURED, J. Gozney, London.
17,287. APPLYING SAND to PREVENT SLIPPING, J. Jeffrey, London.
17,288. COMPOUND CASTINGS for ARMOUR-PLATES, S. Siemang, London.
17,289. TRASHING, &c., SUGAR CANE, T. Tomlinson, London.
17,290. EVAPORATING BRINE, A. Knoop, London.
17,291. GLOVES, W. Vaughan, London.
17,292. INKSTANDS, W. T. Shaw, London.
17,293. DIES, T. Nordenfelt, London.
17,294. TELESCOPE SCREW FASTENER, C. C. Wright, London.

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17,295. ROLLERS for DRAWING or ROVING MACHINES, J. Wilcock and F. Pearson, London.
17,296. REGISTERING PHOTOGRAPHIC PRINTING FRAME, W. H. Prestwich, London.
17,297. STAMPING MEASURES, W. L. Evans, Cardiff.
17,298. ELECTRO-PNEUMATIC ACTION, E. H. Suggate, London.
17,299. GARDENER'S TABLET, C. Longbottom, Bradford.
17,300. ALARM VALVES for STEAM BOILERS, J. E. Slack, Manchester.
17,301. AUTOMATIC SALE of SCENTS, &c., E. Thomas, London.
17,302. SPADES, H. McC. Alexander, Cheltenham.
17,303. INK PAD, C. H. Green, London.
17,304. CARRIERS for PNEUMATIC TUBES, F. B. Welch Manchester.
17,305. APPLIANCE for READING, J. Jameson, Newcastle-upon-Tyne.
17,306. NON-CONDUCTORS, E. T. Atkin, Sheffield.
17,307. GRISTLE TANNED RAW HIDE, J. Taylor, Rochdale.
17,308. WATER BOTTLES, J. P. West, Horsham.
17,309. KNIFE CLEANERS, D. Shaw, Brighton.
17,310. FOG SIGNALLING, E. Walsh, Isle of Man.
17,311. DISINFECTING APPARATUS, J. Robertshaw, Manchester.
17,312. BAKER'S FIRE-BOX, W. Begg, Sale.
17,313. PRESERVING MILK, J. M. Dowden, London.
17,314. PADDLE-WHEELS, W. Alexander, Glasgow.
17,315. BRICKS or BLOCKS from COAL DROSS, L. A. Brode, Glasgow.
17,316. TREATING ORES, H. Aitken, Glasgow.
17,317. BOX NAILING MACHINES, A. Bridgman and R. J. Hodges, London.
17,318. WRAPPING and PACKING BUTTER, &c., C. G. Sörenson, London.
17,319. ANCHORS, W. L. Byers and J. B. Storey, London.
17,320. LIGHTING ELECTRIC LAMPS, C. Auty, London.
17,321. COMBINATION STAND, P. R. Allen, London.
17,322. CLEANING COTTON or other FIBRES, J., R., and J. Greenhalgh, London.
17,323. HYDRANTS, J. Hanford, London.
17,324. CONSUMPTION of SMOKE, &c., J. Southwick, London.
17,325. SMOOTHING IRONS, J. A. Bourry, London.
17,326. OPENING and CLOSING FANLIGHTS, J. Hill, London.
17,327. BEER MACHINES, P. Gaskell and J. Young, Birmingham.
17,328. LOCKS, J. Schubert, London.
17,329. CASES for PENCILS, &c., J. Y. Johnson.—(*H. Berobzheimer, United States.*)
17,330. TROUSER CLIP, T. H. H. Cauty and T. Grob, London.
17,331. CIGAR-MAKING MACHINES, F. Hachnel, London.
17,332. CHEST PROTECTORS, M. B. Scott, Glasgow.
17,333. CASH TILLS, G. R. Stokes, W. Loney, and T. M. Favell, London.
17,334. FIRE-ARMS, T. S. Heffer, London.
17,335. SEWING MACHINES, I. Hendrickx, London.
17,336. FEED-WATER INJECTORS for BOILERS, W. Wentz, London.
17,337. DYE COLOUR for LACE GAUZES, &c., C. J. Cox, London.
17,338. MINERS' SAFETY LAMPS, &c., E. Bainbridge, Sheffield.
17,339. PETROLEUM ENGINES, W. W. W. Moore London.
17,340. OINTMENT, J. Thomson, London.
17,341. APPARATUS for EXHIBITING VIEWS, G. Hughes.—(*V. Bonnet, H. Lissagaray, and A. and A. Richard, France.*)
17,342. FUMIGATOR, W. Finch, London.
17,343. FINISHING and FILLING CARTRIDGE CASES, G. Hone, London.
16,344. CHAIRS, H. H. Lake.—(*L. Dommartin and Diouw, fils, France.*)
17,345. FIRE-ARMS, Sir H. St. J. Halford, W. E. Metford, and A. Greenwood, London.
17,346. VEGETABLE SUBSTANCES, A. J. Boult.—(*I. B. Lehmann, Switzerland.*)
17,347. AMMONIA, E. Meyer, London.
17,348. PRIMARY LIGHTS, E. Robbins, London.
17,349. DENTAL ENGINES, S. Pitt.—(*A. Weber, United States.*)
17,350. SIGHTS for ORDNANCE, T. Nordenfelt, London.
17,351. BREECH MECHANISM for GUNS, T. Nordenfelt, London.

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17,352. BICYCLES, &c., G. Patrick, London.
17,353. GOVERNING SPEED of GAS ENGINES, R. Wallwork and T. Sturgeon, London.
17,354. LATHES, A. B. Milne, Birmingham.
17,355. AXLE PULLEYS, A. B. Milne, Birmingham.
17,356. PROVIDING METALLIC OBJECTS with a COATING of MOLTEN TIN, A. E. Barthel and J. C. J. Möller, London.
17,357. MACHINES for FORMING SCREWS round the ENDS of TUBES, W. H. Allen, London.
17,358. HOSIERY, F. Jackson, Leicester.
17,359. LOOSE-REED LOOMS for WEAVING, R. Riley, Manchester.
17,360. CARRIAGE WHIP HOLDER, J. G. Stidder, London.
17,361. SHAFT BEARINGS, J. Hopwood, Southport.
17,362. GETTING COAL, &c., L. C. Cox Ravenstone.
17,363. SHAPING DUCTILE METALS to FORM CONCAVE, &c., ARTICLES, &c., J. and J. Kirkwood and D. W. Kemp, Glasgow.
17,364. SPEAKING TUBE FITTINGS, H. Coppin, London.
17,365. CARTRIDGES, J. Nicholas and H. H. Fanshawe, London.
17,366. CONSTRUCTION of BILLIARD TABLES, S. Abrahams, Glasgow.
17,367. PREVENTING WASTE and BREAKAGE of YARN on BOBBINS, J. Wright, Bradford.
17,368. STRETCHING WIRES of PIANOFORTES, &c., J. F. Vaughan, Birmingham.
17,369. MATERIALS for SURGICAL DRESSINGS, H. P. Appleby, Manchester.
17,370. SEPARATING LIQUIDS from SOLID MATTERS, J. S. Sawrey and H. Coleet, London.
17,371. PREVENTING MOTION of PERAMBULATORS, &c., J. Boylan and J. E. Carter, Halifax.
17,372. STIFFENER for the BOTTOMS of TROUSERS, L. Wacks, London.
17,373. SELF-SUPPORTING LAWN TENNIS POLES with FEET, A. Cammick, London.
17,374. METAL HANDLES for FURNITURE, E. S. Cope and W. Allman, Birmingham.
17,375. DETACHABLE BUTTONS, E. Korte, Barmen.
17,376. PIPES for CONVEYING WATER, &c., F. E. Plumb, Leeds.
17,377. STOPPERS for BOTTLES, W. and E. Hazlehurst, Rochdale.
17,378. RECOVERY of BYE-PRODUCTS, J. Jameson, Newcastle-on-Tyne.
17,379. CALICO PRINTING ROLLERS and CYLINDERS, &c., W. and J. Thompson and A. F. Macfarlan, Glasgow.
17,380. AUTOMATIC POOL INDICATOR, W. Fairservice, London.
17,381. BYE-PRODUCE, C. H. and R. L. Roeckner, Tynemouth.
17,382. ORGANS, W. G. Clark and M. Hetherington, Wallsend-on-Tyne.
17,383. GAS TAP, M. W. Utting, Liverpool.
17,384. MAGAZINE GUNS, A. J. Boult.—(*M. Hartley, United States.*)
17,385. BROBS for FLAT-BOTTOMED RAILS, T. Thomson, Liverpool.
17,386. SOLES of BOOTS, W. F. Hart.—(*C. S. Larrabee, Germany.*)
17,387. WHEELS of RAILWAY VEHICLES, R. Bradshaw, Manchester.
17,388. APPARATUS for PLAYING GAMES, W. F. Barrett, Liverpool.
17,389. HEATING by RADIATION, A. J. Boult.—(*J. Wauters and A. Mignot, Belgium.*)
17,390. VALVES for STEAM GENERATORS, M. Wilson, Glasgow.
17,391. GUNPOWDER, T. G. Hart, London.
17,392. GAS-BURNERS, H. J. Davis and H. C. Turner London.
17,393. GUIDE FRAMING of GAS-HOLDERS, S. Cutler London.

17,394. MECHANICAL TELEPHONE LINES, W. H. Munns.—(*D. M. Monjo, United States.*)
17,395. STOP MOTION for WARPING MILLS, B. Cooper, London.
17,396. COMBUSTION STOVE GRATES, R. W. Dickenson, Sheffield.
17,397. DAMPING STOVES, J. H. Shorrock, London.
17,398. UTILISING WASTE HEAT, E. Tapsell, London.
17,399. LOCKING NUTS, W. P. Wilson, London.
17,400. THILL COUPLING, C. E. Struck and J. A. Baldwin, London.
17,401. SECURING RADIATION of GAS, W. Phelps and W. Sirrell, London.
17,402. PRINTING on BALLS, W. L. White, London.
17,403. LUBRICANT for MILL ROLLS, W. Cooke, jun., and M. K. Cooke, London.
17,404. CARRYING PARCELS, I. W. Parmenter.—(*C. Elliott, United States.*)
17,405. SAFETY GUARDS, W. J. Lloyd and W. Priest, London.
17,406. STRAIGHTENING WIRE, S. Sanders, London.
17,407. AUTOMATICALLY DELIVERING GOODS, G. F. Lütticke, London.
17,408. REGENERATIVE APPARATUS, B. F. Elderton, London.
17,409. ELECTRICAL PRIMERS, C. A. McEvoy, London.
17,410. MANUFACTURE of PAPER BOXES, E. S. Higgins, London.
17,411. STOPPERING BOTTLES, T. Sharples, T. Schofield, S., and J. E. Hall, London.
17,412. MANUFACTURE of SODIUM, &c., H. H. Lake.—(*C. Netto, Germany.*)
17,413. WARMING CONSERVATORIES, &c., C. Toope, London.
17,414. ATTACHING BUTTONS to LEATHER, H. H. Lake.—(*I. J. Saunders, United States.*)
17,415. MEASURING, &c., APPARATUS, J. G. Lorrain, London.

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17,416. AQUATIC ROUNDABOUTS, A. Pengelly, Ringmore.
17,417. CARRIAGE SPRINGS, R. Grindle, Birmingham.
17,418. STEAM BOILERS, J. M. Stratton, Glasgow.
17,419. PRESSURE VACUUM GAUGES, T. S. McInnes, Glasgow.
17,420. PORTABLE HUT, J. C. H. Peacocke, East Indies.
17,421. VENTILATORS for SHIPS, J. Broadfoot, Glasgow.
17,422. UMBRELLAS, &c., W. Ross, Glasgow.
17,423. MANUFACTURING BRUSHES, H. Besson, London.
17,424. OPTOMETER, F. Robson, Newcastle-on-Tyne.
17,425. EXTINGUISHING FIRES, J. Rayner, Halifax.
17,426. JACQUARD MACHINES, W. and H. A. Fielding, Manchester.
17,427. JACQUARD MACHINES, J. Leeming and R. Wilkinson, Halifax.
17,428. OIL LAMPS, J. Linley and J. T. B. Bennett, Lozells.
17,429. HARDENING the POINTS of NEEDLE-POINTED CARD TEETH, G. F. Priestley, Halifax.
17,430. PUMPS for GASES, &c., M. C. Bannister, Liverpool.
17,431. BACK-HAND BUCKLE, L. F. Wish and C. Ellis, London.
17,432. CORSETS, A. Lane, London.
17,433. ENGINES, L. Sanderson, Essex.
17,434. SKATES, A. J. Boult.—(*A. Diamant, Austria.*)
17,435. AUTOMATIC WEIGHING MACHINES, A. Harris, Liverpool
17,436. MEASURING DISTANT OBJECTS, &c., T. Myers, Liverpool.
17,437. PIVOTTING SWING LOOKING-GLASSES, W. J. Payne, London.
17,438. FOG SIGNAL APPARATUS, R. H. Hughes, London.
17,439. BOILING WATER, O. de Zastro, London.
17,440. WEARING APPAREL, F. Kingston, London.
17,441. HOBBY HORSES for ROUNDABOUTS, J. and W. Wass, London.
17,442. FORMING SURFACES for ADVERTISING, A. Ford, London.
17 443. CIGAR HOLDER, H. Machtanz, London.
7,444. LOCKING SCREW NUTS of BOLTS, E. P. Prince, London.
17,445. PENCIL DRAWING COMPASSES, W. Bridge, jun., London.
17,446. FISHING APPARATUS, O. de Zastro. London.
17,447. PAPER WALKING STICKS, J. H. Clymer, London.
17 448. PRODUCING MOTIVE POWER, A. Fehlen, London.
17,449. CARTRIDGES, E. W. Creecy and S. G. Browne, London.
17,450. NEEDLES, R. Sunyé and V. L. A. Blumberg, London.
17,451. CRANES, W. H. Ridgway, London.
17,452. PROJECTILE, De L. Kennedy, London.
17,453. APPARATUS for CASTING INGOTS, &c., M. Scott, London.
17,454. SEWING MACHINES, F. S. Sharpe and The Moldacot Pocket Sewing Machine Company, London.
17,455. LOCK-STITCH SEWING MACHINES, F. S. Sharpe and The Maldacot Pocket Sewing Machine Company, London.
17,456. LOCK-STITCH SEWING MACHINES, F. S. Sharpe and The Maldacot Pocket Sewing Machine Company, London.
17,457. ELECTRIC SAFETY LAMPS, H. E. M. D. C. Upton, London.
17 458. CHIMNEY TOP, S. Hollyman and J. Horne, London.
17,459. CABINET FOLDING BEDSTEADS, F. E. McMahon, London.
17,460. VEHICLES, J. Stevenson.—(*A. and V. Lacanan, and F. Garino, France.*)
17,461. PHOTOGRAPHING, J. Hines, E. and A. Howail, Glasgow.
17,462. DELIVERY of PREPAID GOODS C. Walling, London.

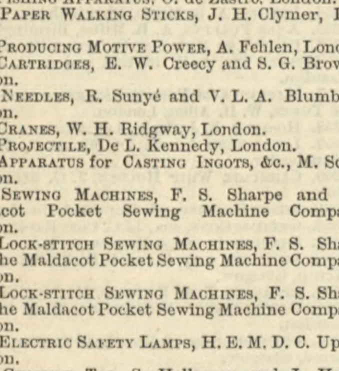
SELECTED AMERICAN PATENTS.

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

370,389. BLAST OR EXHAUST FAN, *M. Gregg, Rochester, N.Y.—Filed April 1st, 1887.*

Claim.—In combination with a revolving disc, K, a

370,389

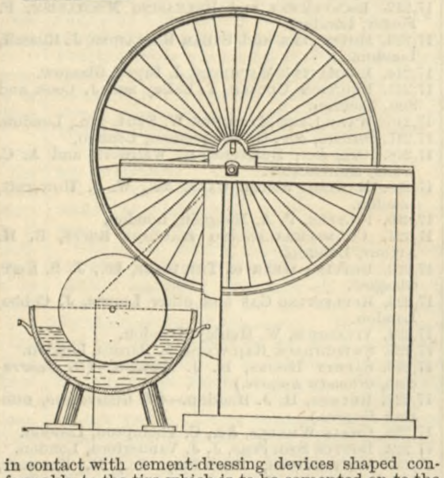


blast fan, similar right and left-hand open frames *c*, secured to said disc and extending beyond the periphery thereof, and a blade, *b*, placed to cover said frames and tie them together, substantially as shown and described.

370,396. PROCESS OF SECURING RUBBER TIRES IN WHEEL RIMS, *T. B. Jeffery, Chicago, Ill.—Filed October 4th, 1886.*

Claim.—The hereinabove-described process of fastening rubber tires upon wheels, which consists in, first, rotating the wheel with its rim in contact with the rim of a secondary wheel which runs in the cement; next, rotating the wheel with its cement-covered rim

370,396



in contact with cement-dressing devices shaped conformably to the tire which is to be cemented on to the rim; thirdly, stretching the tire over the rim; fourthly, heating the rim sufficiently to make the cement yield to the tire; and, lastly, revolving the wheel, with its tire exposed to radial pressure, while the cement is cooling, substantially as set forth.

370,405. INJECTOR, *W. R. Park, Taunton, Mass.—Filed September 13th, 1886.*

Claim.—In combination, the steam supply C, the chambers A and B, the double valve *a b*, the passage a^3, leading from chamber A, the water supply D,

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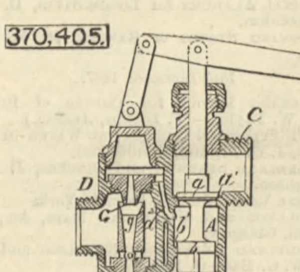
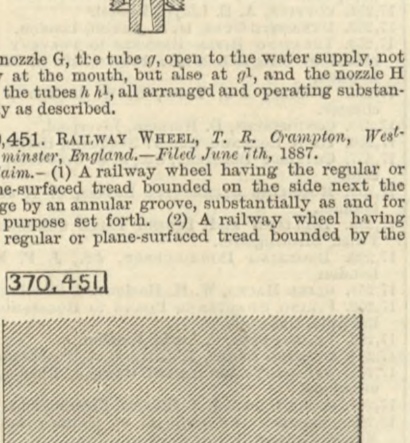


the nozzle G, the tube *g*, open to the water supply, not only at the mouth, but also at g^1, and the nozzle H and the tubes *h* h^1, all arranged and operating substantially as described.

370,451. RAILWAY WHEEL, *T. R. Crampton, Westminster, England.—Filed June 7th, 1887.*

Claim.—(1) A railway wheel having the regular or plane-surfaced tread bounded on the side next the flange by an annular groove, substantially as and for the purpose set forth. (2) A railway wheel having the regular or plane-surfaced tread bounded by the

370,451

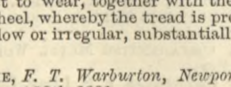


two annular grooves, substantially as and for the purpose set forth. (3) A railway wheel having the regular or plane-surfaced tread bounded on one or both sides by a groove or grooves, and so constructed that its bounding edges traverse laterally upon the face of the rail and are subject to wear, together with the rest of the tread of the wheel, whereby the tread is prevented from wearing hollow or irregular, substantially as set forth.

370,508. BALE TIE, *F. T. Warburton, Newport News, Va.—Filed August 12th, 1886.*

Claim.—The combination, with the buckle B, having a transverse slot with parallel upper and lower sides, of the band sections A, having enlarged ends *a*, said slot and band ends being proportioned to each other,

370,508

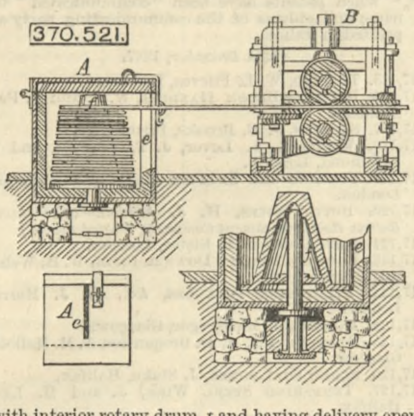


as hereinbefore specified, that is to say, the slot being wider than the combined thickness of the body of the band and one of its thickened ends *a*, but narrower than the combined thickness of both said ends *a*, as and for the purpose specified.

370,521. ROLLING MILL PLANT, *C. B. Beach, Cleveland, Ohio.—Filed April 6th, 1887.*

Claim.—(1) In a metal rolling plant, the combination, with a train of rolls, of the coiled billet heat-retaining box A, said box inclosing a reheated coiled billet as the latter, taken from a reheating furnace, is being uncoiled and fed into the roll train, substantially as set forth. (2) In a metal rolling plant, the combination, with the first stand of rolls B in a roll train, of the coiled billet heat-retaining box A, located in front of and close to said stand of rolls, said box provided

370,521

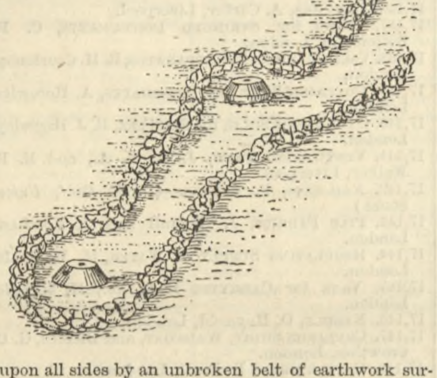


with interior rotary drum *f* and having delivery opening *e*, substantially as set forth.

370,501. FORTIFICATION FOR COAST AND HARBOUR DEFENCE, *T. L. Sturtevant, Framingham, Mass.—Filed November 30th, 1885.*

Claim.—A system of fortification consisting of batteries floating in a body of water enclosed practically

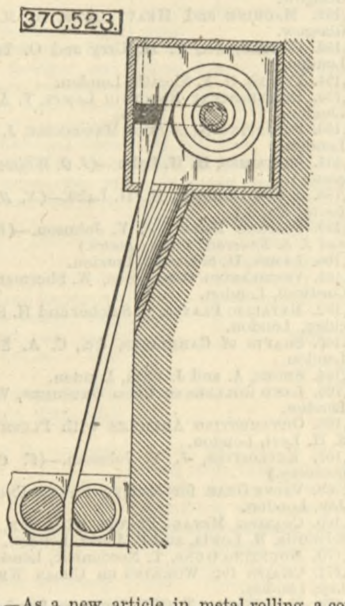
370,501



upon all sides by an unbroken belt of earthwork surrounding and protecting it, substantially as and for the purposes hereinbefore set forth.

370,523. ROLLING MILL PLANT, *C. B. Beach, Cleveland, Ohio.—Filed February 18th, 1885.*

370,523

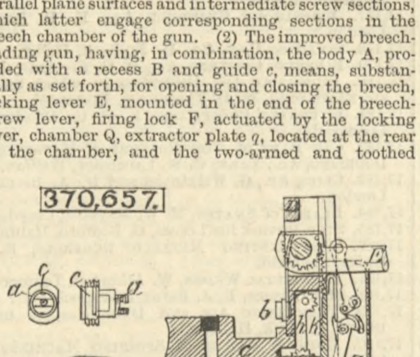


Claim.—As a new article in metal rolling, a coiled billet, substantially as set forth.

370,657. BREECH-LOADING ORDNANCE, *G. Quick, Chipping Campden, Gloucester, England.—Filed January 15th, 1887.*

Claim.—(1) In combination with a breech-loading gun having a transverse opening to permit the breech-block to be slid transversely to axial position in the breech of the gun, a breech-block having opposite parallel plane surfaces and intermediate screw sections, which latter engage corresponding sections in the breech chamber of the gun. (2) The improved breech-loading gun, having, in combination, the body A, provided with a recess B and guide *c*, means, substantially as set forth, for opening and closing the breech, locking lever E, mounted in the end of the breech-screw lever, firing lock F, actuated by the locking lever, chamber Q, extractor plate *q*, located at the rear of the chamber, and the two-armed and toothed

370,657

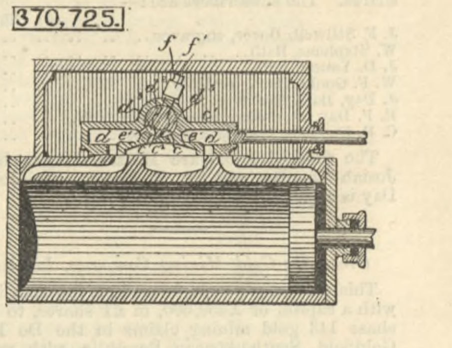


extractor lever *h*, arranged to engage with the rack bar *k* and with the toothed guide-pin *r* of the extractor, all as set forth. (3) In combination, with the body A, having the recess B, with a portion of its screw thread removed, the breech screw C, obturator *o*, mechanism, substantially as described, for opening and closing the breech, locking lever E, firing lock F, actuated by such lever, chamber Q, extractor plate *q*, located at the rear of the chamber, and extractor lever *h*, all as set forth. (4) The combination consisting of the locking lever located at the breech of the gun, the vent shutter, firing lock actuated by the locking lever, primer extractor, extractor lever, arranged and operating as hereinbefore described and shown.

370,725. SLIDE-VALVE, *T. T. Brown, Chicago, Ill.—Filed November 24th, 1886.*

Claim.—(1) The combination, with a slide-valve formed with suitable main and auxiliary exhaust passages and a rock-valve seated in said auxiliary passages, of an operating arm on this rock-valve, and a guide for said arm swivelled upon the steam chest at

370,725

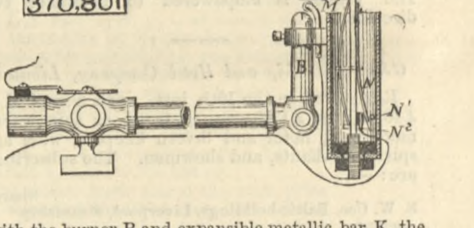


a point past which the auxiliary valve is carried by the stroke of the main one, substantially as and for the purpose set forth. (2) The combination, with the main valve c^1 formed with the cored passage c^2, the chambers *d*, and the passages d^1 *e* c^1 of the rock-valve d^2, seated transversely in the main valve and formed with the passages d^3, the arm *f*, sleeve or guide f^1, and the stud f^2, on which it is swivelled, all constructed and arranged to operate substantially as and for the purpose set forth.

370,801. ELECTRIC GAS-LIGHTER, *J. J. McGowen, Ithaca, N.Y.—Filed February 7th, 1887.*

Claim.—(1) An electric gas-lighting apparatus organised with a cock and burner, a primary circuit breaker connected to said cock and arranged to close the circuit when the gas is turned on, an incandescent resistance coil arranged to light the gas, and a secondary circuit breaker arranged to break the circuit by the heating and consequent expansion by the gas flame of some of the parts of said secondary circuit breaker. (2) In an electric gas-lighter, in combination

370,801

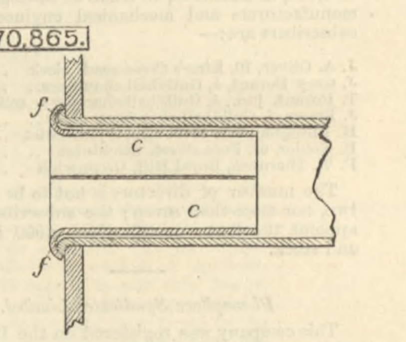


with the burner B and expansible metallic bar K, the spring M, attached to said bar, said spring being made of metal less expansible by heat than said bar, and arranged to be deflected from a straight line by the cooling and consequent contraction of said bar, substantially as and for the purposes described. (3) In an electric gas-lighter, in combination with the burner B, expansible bar K, and less expansible spring M, attached to said bar, the key N N^1, and insulated plate N^2, said key being rigidly connected to and influenced by said spring and arranged to break the circuit by the straightening and to close the circuit by the bending of said spring, substantially as set forth.

370,865. DEVICE FOR PROTECTING BOILER TUBES, *W. Hague and W. B. Cookson, Pittsburg.—Filed June 22nd, 1887.*

Claim.—In combination with a boiler fire tube, the corrugated section *c*, provided with an outwardly-

370,865

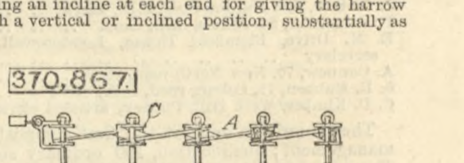


projecting flange *f*, and cut or divided along one side in the direction of its length, as and for the purpose described.

370,867. HARROW, *J. T. Hamilton and G. W. Hamilton, Friend, Nebr.—Filed April 26th, 1887.*

Claim.—(1) A connecting bar for harrow sections having an incline at each end for giving the harrow teeth a vertical or inclined position, substantially as

370,867



and for the purpose specified. (2) The connecting bars A, having an incline at each end, in combination with the bars or frames C of a harrow, for connecting the bars or frames, substantially as and for the purpose specified.