THE BUCHAREST TURRET TRIAL.

It appears that the Commission appointed to decide on the respective merits of the French and German turrets, tried at Bucharest, are delaying their final recommendations until they receive the reports of the foreign officers attending the experiments. Nothing could be more reasonable, seeing that these officers have been sent by Governments who have long had to deal with armour experiments, and are presumably selected with a view to special knowledge and experience in these matters. In our case the artillery officer, Major O'Callaghan, has superintended all the experiments at Shoeburyness for several years, and naturally has had experience which can hardly be obtained in any other position. Our engineer officer, Captain Clarke, of the Inspector-General of Fortifications department, is also a specially qualified man. If the Roumanian Commission wait and can support their recommendations by actual reference to written opinions received, they will go far to raise their experiment to the rank of a European one. In the meantime rumour is busy as to the views of the Commission. From France, for example, we hear that six of the members are in favour of the Mougin turret as it stands, and the remaining three with certain modifications. Our immediate business, however, is not to speculate on the conclusions of the Commission or of the representatives of the foreign Powers, but simply to express the best opinion we can offer on the facts as they stand, and the time has now come to do this.

Looking at the trial in its general features, we may describe it as the competition of two designs in which the questions of armour and also of general structure are involved. These naturally are shaped to each other, but they form distinct branches of the inquiry, and some specially connect with plate-upon-plate armour, might have recommended very much the same wall as that of the Mougin turret supposing that an upright turret should be adopted. We may regard this armour then as English in its character, but as we have already hinted above, this is equally true of the Grüson-Schumann turret.

The first turret tried in England, that of the Trusty, was conical. The fact that we have so universally used upright walls since that time, is due to the circumstance that unless the armour is sufficiently inclined to make the shot glance there is nothing gained by the inclination, for the decrease in thickness of wall is exactly made up by the increased area of plate required to cover any given height by a sloping wall, even in a straight face, and in a turret there would be considerable increase in weight owing to the great increase in circumference. The glancing angle in wrought iron is very oblique, and with muzzle-loading guns, where good head room is needed right up to the port, the employment of inclined wrought iron was out of the question. The introduction of breech-loading guns on the one hand, and on the other of steel-faced armour against which shot glance at more direct angles than against iron, changed these conditions, and the Eastbourne conical steel-faced turret now under trial exemplifies the recognition of this by our engineers. In fact, the Grüson turret trial is very valuable to those who have such a design in hand as the Eastbourne turret, for it shows what is the effect of an increase in the angle, and how steel-faced armour can be applied to the curved dome so long identified with Grüson's name. Observing, however, that Grüson's plates differ from ours in having two kinds of steel superimposed, we venture to think that his experience in steel-faced armour must be inferior to our own, and that the application of what we may call an aggravated form of German armour showed a decided advantage over that of the French turret.

We must not omit, however, to observe that Grüson's bolts behaved abominably, flying out in a wholesale manner. The bolts were very bad, and we think that better bolts might be made to stand well, though no doubt the soft massive armour of the Mougin turret puts them under more favourable conditions. Altogether, we are inclined to think that Grüson's experience in steel-faced armour is as yet very limited, for we may remind our readers that this is not the Grüson shield at all, but a special experimental article made by him. We should consequently expect the steel-faced armour to improve, while we can hardly look for better wrought iron than that exhibited in the French turret. As to the armoured wall alone, then we do not hesitate to say that, so far as we can judge, the victory lies with the German turret.

We ought, no doubt, to say a word or two about the glacis attack. In this attack the German turret suffered greatly, shot actually entering and destroying all semblance of defence. Looking at the sections, we cannot observe the least difference in the nature of glacis plate—*avant cuirasse, vorpanzer*—employed in each turret, and consequently we cannot see that the failure of the German turret can be attributed to anything but misfortune, or to the fact that the shot struck it at a greater angle of descent. If this angle was due to the difference of system in any way, of course it would be a great advantage to score in favour of the French turret; but this does not seem to be the case. We can therefore say nothing as to relative power of either turret against glacis attack. If there is anything to be urged, we shall be glad to hear it.

As to vertical or high angle fire attack, in the absence of any hits, nothing can be said beyond the obvious facts

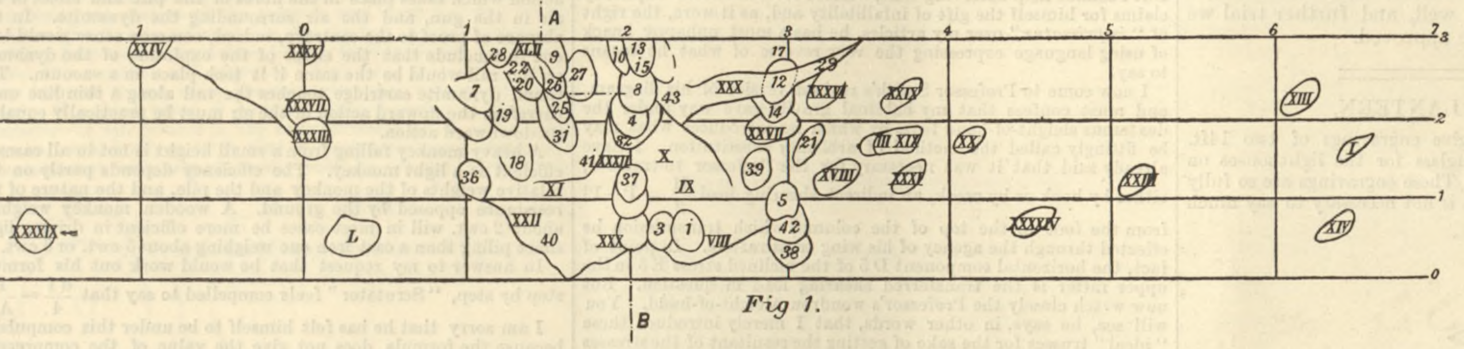


Fig 1.

Fig 2.
Section through A.B.

features admit of separation from the designs of which they form part. For example, the German turret has the features of inclined armour and also a non-recoil gun, whose muzzle is fixed in its port. Suppose the inclined armour should be preferred but the non-recoil gun rejected, it is perfectly possible to make a turret in accordance with this conclusion, though in so doing a salient feature in the design is rejected, and an entirely new structure as to carriage demanded. The English turret, now under trial at Eastbourne, has inclined compound armour and a gun that does not recoil. This certainly calls into play the principle involved in the armour of the German turret, while it wholly differs from it in structural fittings. This will serve to explain why we separate the questions of armoured wall and turret structure. To commence with the armoured wall.

The French Mougin turret armour depends on the well-established power of soft wrought iron to resist the long continued fire of guns which are unable to perforate it. This is a principle that has been recognised and acted on from early times in this country. Our coast forts are examples of it. In them we meet the full blow like the Mougin turret, by an upright shield which we hope will oppose a sufficient thickness of iron to keep out any single shot, and if so, we do not dread the effect of any

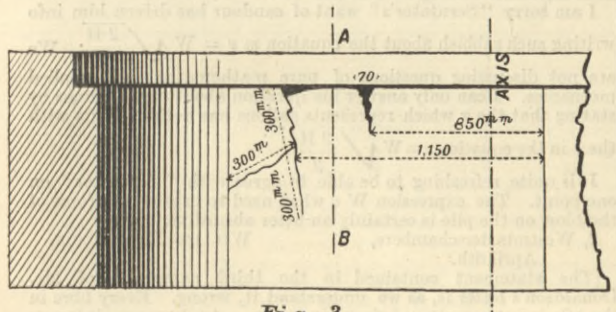


Fig 3.
Section of Wall and Interior Elevation

prolonged fire that is likely to be brought to bear on it. As the power of guns increase we hope to add plates to the front of our shields, and have made actual provision for doing so on the plate-upon-plate system. The Mougin turret so far resembles our armour as to consist of three layers of iron, and if it differs from it in the fact that there are no intermediate layers of wood, it seems as if circumstances rather than difference in views led to this. The object of a wood cushion is to prevent the plates cracking from jarring on each other under the blow of impact. Such an effect can surely only be caused by a heavy blow. Now, the Mougin turret armour is, as we described it in our issue of March 5th last, 17·7in. thick. Any blow delivered by a siege gun may well be assumed not to be a heavy blow in comparison to such a structure, consequently cracking plates could hardly be looked for, nor, judging from the numerous photographs sent home, did it occur. On the other hand, layers of wood would have greatly increased the weight of the structure, not of course merely by the amount of wood added but by the increased diameter, and consequent enlargement of the rings of iron. Speaking merely on conjecture, we could conceive that our own engineers, even General Inglis himself, whom we

steel-faced armour to a curve was a daring experiment to attempt in the face of officers representing all Europe. On the whole, then, we ought in this country to be able to judge of the behaviour of these two kinds of turret armour without prejudice, regarding them both as representative of our own turrets in different forms. Figs. 1, 2, 3, 4, and 5 show the effect of the breaching fire commenced against the turrets on December 26th, and also on January 14th and 15th last. Judging from the photographs, of which we gave engravings on March 5th, and also from these drawings, the French turret armour was excellent. Sixty-two hits delivered close about the same spot formed a very severe test, and the wall which eventually yielded, as in the nature of things it was bound to yield under blows thus poured in, did so with as little cracking as could be expected. Those who look at Fig. 2 can hardly fail to conclude that to a shot striking in the weak spot near the

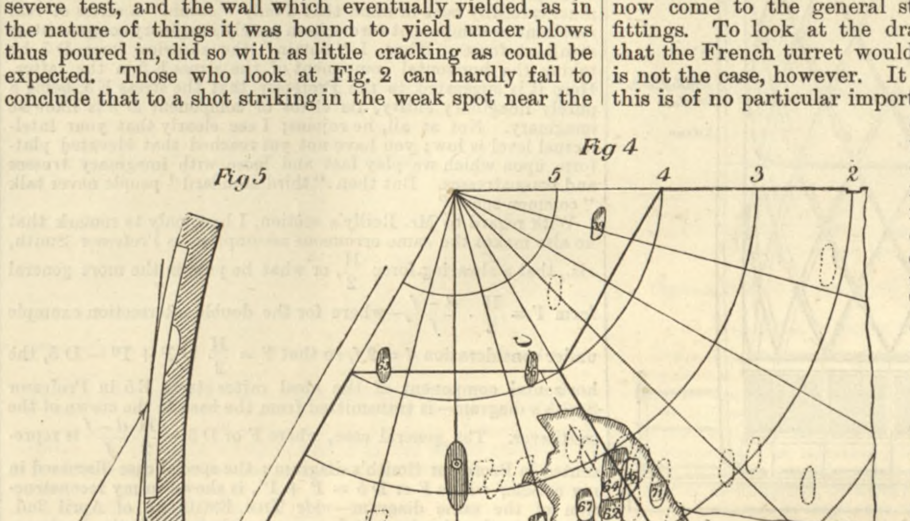


Fig 5 *Fig 4*

top perforation was secured, and although it might not be easy to strike this exact spot at once from 1094 yards range, shots delivered about it must soon effect an entrance.

The German armour, shown in Figs. 4 and 5, was not, so far as we can judge, at all so nearly perforated, and might have borne some continuance of fire. About one-third of its thickness had been carried away over a spot of considerable area, and it had lost its hard resisting surface, but still two-thirds of it remained, and this would have been hardly perforated for some time by fire in so oblique a direction.

Besides the question of actual perforation, we have to consider the chances of hitting. On December 26th thirty hits were obtained on the French turret in fifty-one rounds, and on the German thirty rounds and five ricochets were obtained in eighty-five rounds. On service the shooting would probably be rather less accurate; consequently, the that the German turret with a larger diameter is more likely to be struck, the areas being nearly in the proportion of 3 to 2. We do not anticipate that any sensible effect would be produced by this class of fire from siege pieces. If it were so, if 21cm. (8·26in.) projectiles might injure the roof of the French turret, which is 7in. thick, what a terrible effect might be produced by the fire of larger howitzers such as might be found in coast forts, on the decks of ironclads, which are at most 3in. thick. Of course the German turret curved roof 20 cm. (7·87in.) thick is stronger than that of the French turret flat roof 7in. (18 cm.) thick. Either is strong enough, we think. We now come to the general structure, including the port-fittings. To look at the drawings it would be expected that the French turret would be much more costly. This is not the case, however. It is a great deal heavier, but this is of no particular importance when once erected, and any disadvantage arising from this cause is involved in the cost of working, so that we may disregard it as a separate matter. The German turret offers much more room to a detachment. The French turret is rather crowded. This objection applies to our own English turrets, but that does not prevent its being an objection.

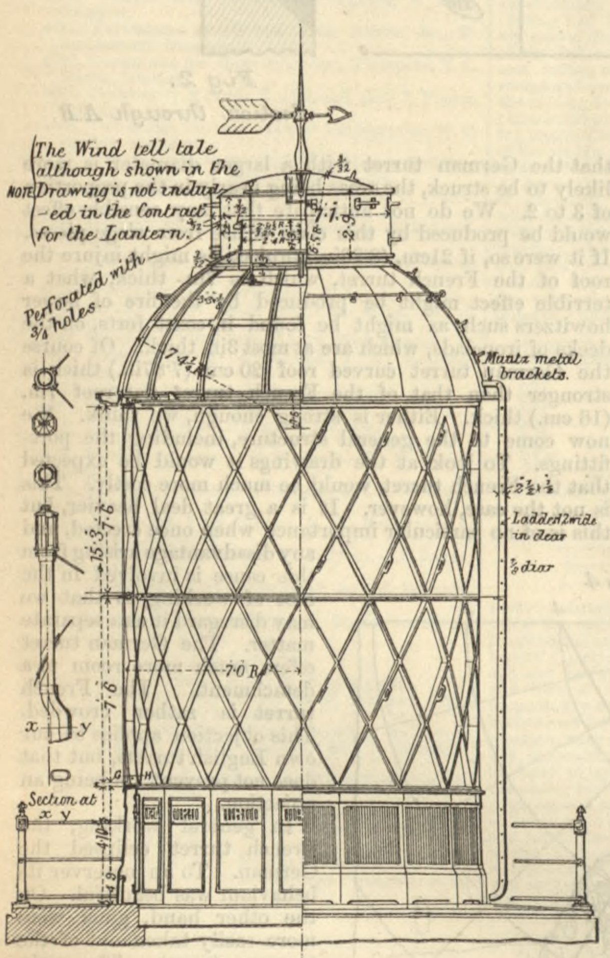
In general working, the French turret eclipsed the German. To an observer its behaviour was beautiful. On the other hand, guns were more easily taken out of the German turret. The main differences in construction, however, group themselves round and depend upon the non-recoil principle in the German turret. This involves a great deal. It offers undoubtedly the advantages of a closed port, of open interior space, and absence of troublesome non-recoil carriage apparatus, but it necessitates the evil of springs on all the trucks of the turret. The two German guns hardly fired a perfect salvo, so we understand. It appears to us that for quick and accurate fire a perfect salvo in a two-gun turret is a necessity. There is not the least reason why it could not be given by the German turret, but when this takes place the turret receives the full shock of discharge instead of being saved by the rotation set up in the turret when one gun only is fired. This shock, we understand, can be very fairly met by the German turret with its springs, but it must be borne in mind that the 15-cm. (5·9in. guns) in these turrets do not represent the most powerful 15 cm. (5·9in.) guns extant. They fired 85·3 lb. projectiles (38·7 kg.) and 19·8 lb. charges (9 kg.). We find, in consulting the "Austrian Naval Almanack," which is as good an authority as we know on these matters, that there exists already in the German navy a long 15 cm. gun firing projectiles of 112·4 lb. (51 kg) and charges of 33·1 lb. (15 kg.). We have a 6in. gun firing a projectile weighing

100 lb. with 42 lb. of powder. Surely before long it will be desired that so important a structure as a turret should mount the most powerful guns of their class. How will these turrets meet such a demand? The length of the gun no doubt deserves some consideration. Both guns may easily be made to project, for the muzzle-pivotting principle might equally be applied to any point some distance from the muzzle. We may hope to learn before long what are the chances of injuring a gun thus projecting. Should they be considerable, it may prove that the German muzzle-pivotting non-recoil system may be the best, and that the length of the gun must be curtailed to suit the turret accordingly. Can a gun bear the risk of exposure under these conditions—a risk which in a siege is out of all proportion to that incurred in coast forts or ships? Much hangs on this question. If it can, then we think that these turrets will have to be adapted before long to more powerful guns than those tried at Bucharest, and it looks to us as if the French turret would admit of this better than the German. In the former a stronger arrangement to check the recoil would be necessary. In the latter the turret must be made by means of more springs, or some other device, to meet the difficulty.

On the whole, while we have no hesitation in preferring the form and armour of the German turret, we cannot speak with confidence of the internal arrangements. To say that the French structure has shown itself better at Bucharest would be to go too far; for in this trial, while it acted in a way that showed that its details had been worked out more perfectly, we should not know what fact we could allege in support of its having shown any superiority in principle *under the conditions of trial*. The truth is that further test with more powerful guns is called for. The transfer of the shock of discharge into a comparatively small and rather complicated structure like a turret is a difficult operation to perform well, and further trial we think is needed before it can be approved.

LIGHTHOUSE LANTERN.

HEREWITH and on page 302 we give engravings of two 14ft. lanterns designed by Sir J. Douglass for the lighthouses on Bishop's Rock and Round Island. These engravings are so fully dimensioned and described that it is not necessary to say much



about them here. The engraving annexed is an external general view of the lantern, which is made largely of phosphor bronze. The various details will be readily made out by comparing the engraving on page 302 with that given above. The contract for these lanterns has, we believe, been signed.

TENDERS.

TOXTETH PARK.

FOR the construction of sewers in Smithdown-road, between Claremont and Greenbank roads, for the Toxteth Park Local Board. Quantities by the engineer, Mr. John Price, Assoc. M. inst. C.E.

	£	s.	d.
Anwell, Wainwright, and Dyson, Park-road, Liverpool	792	17	2
Maccabe and Co , Lambeth-road, Liverpool	772	12	5
Sayce and Randle, Widnes	751	8	8
J. Randall, Weaste, Salford..	749	3	8
Worthington & Pownall, Rusholme-road, Manchester	722	17	5
Wm. Vaughan, Longsight, Manchester	698	10	0
Jas. White, Aigbarth Vale, Toxteth Park	676	16	7
Walkden and Co., Brasenose-road, Bootle	675	3	9
R. Lomax, Eccles, near Manchester—accepted	567	12	6
W. F. Inglis, Castle-street, Liverpool	524	16	6
Engineer's estimate	630	0	0

NEW RANKS IN THE NAVY.—By an Order in Council of February 26th, 1886, four new ranks have been established in the Royal Navy, viz.:—Fleet Engineers, Staff Engineers, Fleet Paymasters, and Staff Paymasters; and the same has come into effect by the appointment of fifty-four Chief Engineers to the first-named rank; seventy-three Chief Engineers to the second rank, eighty-eight Paymasters to the third rank, and forty-four Paymasters to the last rank.

LETTERS TO THE EDITOR.

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

AMERICAN BRIDGE DESIGN.

SIR,—I feel compelled to return once more, and decidedly for the last time, to the subject under discussion chiefly between Professor Smith and myself. You will remember that in my first letter I stated that Professor Smith's peculiar solution depended on three unacceptable assumptions. (1) That an indirect shearing load $P + P^1$ was transmitted from the base to the crown of the cantilever; (2) that for very obvious reasons the line D C must bisect the line O 4; and (3) to effect these objects it was necessary to introduce wing trusses or other bracing which had no real existence, and which completely altered and simplified the nature of the problem. Then, I said, deny the first assumption and the other two collapse. Following this letter came Professor Smith's reply, in which I was surprised to find that he did not attempt to justify the first and fundamental assumption, but confined himself to qualifying my notion that D C must bisect O 4 as "incomprehensible." In my next letter I gave a very simple proof of this evident fact, and now again Professor Smith thinks it wiser to draw off the attention of your readers to other matters largely of a personal nature. I will presently show that the first assumption includes the fundamental error underlying both Professor Smith's diagram and Mr. Reilly's sectional operations. I would, however, at once remove a misconception which apparently exists in the minds of both your correspondents. In my article of the 5th ult., I did not accept Professor Waddell's assumptions. My line of argument was this. Granting the premises, the method is none the less incorrect, or in the words of the article, "falls by the sheer force of its weight." I shall here continue to argue the matter on the same ground.

Taking first Professor Smith's letter, I have to inform him that he makes a great mistake when he assumes that I have abandoned any position I have taken up in this controversy. With regard to Professor Smith's denial that he ever charged me with "attacking" Professor Waddell in his absence, and the lame explanation he gives of his own words in your present issue, I think I may safely leave that to the good sense and discrimination of your readers. But I cannot help observing that, whilst Professor Smith implicitly claims for himself the gift of infallibility and, as it were, the right of "*imprimatur*" over my articles, he has a most unhappy knack of using language expressing the very reverse of what he means to say.

I now come to Professor Smith's revised version of his diagram, and must confess that my habitual gravity gave way under the dexterous sleight-of-hand feats by which he introduces what may be fittingly called the method of arbitrary substitution. I have already said that it was necessary for the Professor to transfer, either by hook or by crook, an indirect shearing load $\frac{H}{2} = P + P^1$ from the foot to the top of the column, which transmission he effected through the agency of his wing truss rafters. In point of fact, the horizontal component D 5 of the inclined stress E 5 in the upper rafter is the transferred shearing load in question. But now watch closely the Professor's wondrous sleight-of-hand. You will see, he says, in other words, that I merely introduce these "ideal" trusses for the sake of getting the resultant of the stresses acting in their members. After using the rafters of my wing truss to convey forces from the base to the crown of the cantilever, I finally discard them altogether. To all this verbiage, which is a true account of Professor Smith's argument, I ventured to suggest—But you will admit that your resultants or components, as the case may be, must be of the same kind as the stresses from which they are derived. *Qualis causa, talis effectus.* If, therefore, your trusses and truss stresses are purely "ideal," the resultants or components derived from them are ideal too. Then the Professor rises with his magic wand and would in vain dispel my illusions. You see, he implicitly says, the key to the whole solution lies in the wondrous force conveyed by the convenient dissyllable "obtain." It is not true, he would observe, that I resolve the force at the foot F of the post in two directions—namely, a pull O F along the column and a thrust along the rafter. I merely "obtain" these stresses in that way. Again, he would add, you must carefully bear in mind that I only "obtain" a series of real resultant or component forces from purely imaginary component or resultant forces. Thus, I "obtain" the shearing force D 5 by taking the horizontal component of the stress E 5 in the rafter. Here it is suggested to the Professor that the stress E 5, being a purely imaginary entity, its effect or component D 5 is likewise imaginary. Not at all, he rejoins; I see clearly that your intellectual level is low; you have not yet reached that elevated platform upon which we play fast and loose with imaginary trusses and truss-stresses. But then "third standard" people never talk "common sense."

With regard to Mr. Reilly's section, I have only to remark that he also makes the same erroneous assumption as Professor Smith, viz., that a shearing force $\frac{H}{2}$, or what he puts in the more general form $F = \frac{H}{2} \cdot \frac{d - f}{f}$,—where for the double intersection example under consideration $d = 2f$, so that $F = \frac{H}{2} = P + P^1 = D\,5$, the horizontal component of the ideal rafter stress E 5 in Professor Smith's diagram—is transmitted from the base to the crown of the cantilever. The general case, where F or $D\,5 = \frac{H}{2} \cdot \frac{d - f}{f}$ is represented in Professor Smith's diagram; the special case discussed in my article, where F or $D\,5 = P + P^1$, is shown in my reconstruction of the same diagram—*vide* THE ENGINEER of April 2nd. Therefore the fundamental error, underlying both Professor Smith's diagram and Mr. Reilly's analytical accompaniment, is the groundless assumption that an indirect shearing load D 5, or $P + P^1$ in the double intersection case, is transmitted from the base to the crown of the cantilever. It presupposes that the forces at the feet of the column compound and resolve themselves as if the lower panel were braced. The only difference between the two is that, whilst Professor Smith transmits the indirect load through the rafters of his ideal truss, Mr. Reilly leaves the method of transmission open. But it is manifest that the transmission of a shearing force can only occur in one of two ways, namely, either by bracing or bending moment. The first means is impossible, because the lower panel is unbraced; the second is also impossible, for in cantilevers shearing forces are transmitted by means of bending moments only in the direction of from free to fixed end. It is therefore against the nature of things to suppose a shearing force transmitted from the fixed to the free end of a cantilever by means of bending moment. I would, in fact, as soon believe that water could run up the side of the Matterhorn, or the ludicrous statement of Mr. Coventry in your present issue, that the bending moment in a cantilever decreases in the direction of the fixed end or base, where it vanishes upon "the same mechanical principle" as it vanishes at the two abutments of a freely supported beam. Seeing that Mr. Coventry subscribes to this principle, I could scarcely anticipate that he would agree with my statement that the column tension, simultaneously with the bending moment, attains a maximum at the foot or fixed base of a cantilever. I would also add that owing to the close outside packing of the chord eye bars, the insertion of fillers and diagonal eye bars between the two channels of an American bridge post, its foot would be in very fair condition to establish a fixed riding upon the pin, so as to take up whatever bending moment was brought down by the frame acting as a cantilever.

It must have amused some of your readers to find that whilst in their former letters Professor Smith and Mr. Reilly incidentally agreed to deny—not, of course, by any collusion—that there was any local bending moment at the foot F or E, this week they both make identically the same cautious reservations on that point; and both, as it were, agree to concentrate all their efforts to show that a shearing force F or D_5 is transferred from the foot to the crown of each column. In fact, Mr. Reilly's sectional operations amount simply to taking account of the horizontal components of the stresses in the rafters in Professor Smith's wing trusses. I must, however, bring him back to sober reality, reminding him that as these rafters do not really exist, his sectional plane cannot possibly cut them. When, in fact, Professor Smith touches these rafters with his magic wand they disappear, together with all the stresses or stress components to which, if they really existed, they would undoubtedly give rise. I must here withdraw absolutely from this discussion, merely reminding your readers that, although I have argued against Waddell's method on the assumption that his hypothesis of the frame acting as cantilever was correct, I do not hold that hypothesis to be justifiable.

R. H. GRAHAM.

April 10th.

PILE DRIVING.

SIR,—I was very pleased to see that you had devoted a leading article to the discussion of this question. I feel sure that it will lead to a settlement of the dispute in one of two ways: either a correct solution of the problem, or an acknowledgment that mathematical science has not yet been able to achieve it. I am afraid the solution will not come from "Scrutator."

The suggestion you make for the solution of the problem, viz., that the product of the mean resistance of the substance into which the pile has been driven at each blow is equal to the potential work stored in the monkey at the instant of impact has already been fully discussed in the course of this correspondence. Retaining the notation already explained, it is expressed by the equation

$$R\,S = W\,(H + S) \quad \ldots \ldots \quad (1)$$

If we assume that the penetration ceases at the instant the monkey is brought to rest, the whole of the work stored up in compressing the pile is given out again in simply sending back the monkey, and therefore not expended in causing penetration. R S is therefore not equal to the whole work done by the monkey.

The element of time has nothing to do with the question. The total compression of the material of the pile does not take place in the way you describe. Every fibre in the pile is being compressed simultaneously. There is not the slightest analogy between the action which takes place in the fibres of the pile and effect of the air in the gun, and the air surrounding the dynamite. In the absence of proof to the contrary, indeed, common sense would lead one to conclude that the effect of the explosion of the dynamite on the rail would be the same if it took place in a vacuum. The round dynamite cartridge touches the rail along a thin line only, therefore the upward action of the air must be practically equal to its downward action.

A heavy monkey falling from a small height is not in all cases so efficient as a light monkey. The efficiency depends partly on the relative weights of the monkey and the pile, and the nature of the resistance opposed by the ground. A wooden monkey weighing about 2 cwt. will in most cases be more efficient in driving light sheet piling than a cast iron one weighing about 5 cwt. or 6 cwt.

In answer to my request that he would work out his formula step by step, "Scrutator" feels compelled to say that $\frac{d\,l}{4} = \frac{P}{A\,E}$.

I am sorry that he has felt himself to be under this compulsion because the formula does not give the value of the compression produced by a sudden blow, and therefore does not give the value of the pressure between the monkey and the pile.

From what source has "Scrutator" obtained 72,000 lb. per square foot as the value of the so-called modulus of elasticity in compression? According to Rankine, this is the value of the ultimate shearing stress per square foot, whilst the modulus of extension is stated to be equal to 200,000,000 lb. I cannot come across the results of any experiments to settle the value of the modulus of compression, but it certainly cannot have a less value than that of the modulus of extension. Adopting this value, the range of pressures calculated from "Scrutator's" formula must be altered from a range of about 100 tons to 500 tons to a range of about 5000 tons to 30,000 tons!

I avail myself of this opportunity of again stating that the so-called moduli of elasticity in extension and compression have nothing in reality to do with the elasticity of the material. They are simply the forces calculated from the forces producing observed small increments and decrements which would extend a bar of the material to twice its length or produce a compression equal to its length. They are simply, of course, convenient artifices used for purposes of calculation. The moduli of elasticity of any material subjected to either extension or compression are simply the ratios of the efforts of the material to regain its original shape to the forces producing the deformation, and can never exceed unity. In fact, in the most elastic materials known this ratio is less than unity. Bodies may have a very large modulus of elasticity both in compression and extension, and very small moduli of extension and compresssion, such, for instance, as india-rubber and kindred substances.

The discussion with "Scrutator" has led me to a train of reason which will, I think, enable me to solve the problem. I shall have more to say on this point.

I am sorry "Scrutator's" want of candour has driven him into writing such rubbish about the equation $m\,v = W\sqrt{\frac{2\,H}{g}}$. We are not discussing questions of pure mathematics, but applied mechanics. I can only answer his question about the x gallons by stating that the x which represents gallons has nothing to do with the x in the equation $x = W\sqrt{\frac{2\,H}{g}}$.

It is quite refreshing to be able to agree with "Scrutator" on one point. The expression $W\,v$ when used to express the force of the blow on the pile is certainly an utter absurdity.

2, Westminster-chambers, April 8th. WILLIAM DONALDSON.

[The statement contained in the third paragraph of Mr. Donaldson's letter is, as we understand it, wrong. Every fibre in the pile is not compressed simultaneously. As, however, it is possible that we have failed to catch our correspondent's meaning, we shall say nothing further on this point until he explains himself.—ED. E.]

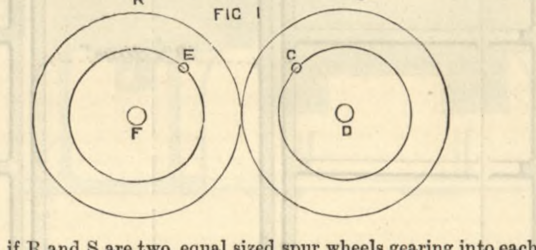
SIR,—Your correspondents on the subject of the dynamics of pile driving are in my opinion going too deeply into the subtleties of elasticity and vibration before gaining a clear idea of the elementary dynamics of what is observed in driving a pile, which, after all, differs only in scale from the familiar operation of driving a nail into a piece of wood with a hammer.

The following question, extracted from a recent Cambridge mathematical examination paper, will serve as elementary drill for your correspondents, and when they have worked it out they will have a common starting point of agreement from which they can proceed to the attack and defence of the advanced parts of the questions at issue:—"An inelastic pile of w pounds is driven vertically a feet into the ground by n blows of a hammer of W pounds, falling h feet. Prove that $\frac{n\,W^2}{W + w}\,\frac{h}{a}$ pounds superposed on the pile in addition to W would drive it down slowly, supposing the resistance uniform. If the pile is crushed x feet by each blow, x being a small fraction, the mean pressure exerted by the hammer during blow is $\frac{W\,w}{W + w}\,\frac{h}{x}$ pounds, and each blow lasts $\frac{x}{h}$ of the time of falling of the hammer. If, however, the resistance of the ground is proportional to the penetration of the pile, then $\frac{2\,n\,W^2}{W + w}\,\frac{h}{a}$ pounds must be gradually superposed to drive the pile down slowly." The solution of these questions is only an exercise on the principles of elementary dynamics, but will, I hope, be found to elucidate the disputed points of the advanced theory.

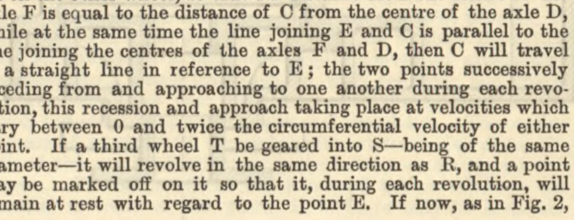
Department of Artillery Studies, A. G. GREENHILL.
Woolwich, April 9th.

ROTARY ENGINES.

SIR,—Although a little late, I hope you will permit me to say a few words in order to explain more fully the device put forward in my letter of February 3rd, which appeared in your issue of February 19th last, because judging from the remarks made by "Long Stroke" and "Rotary," it appears that I have not made myself very clearly understood. "Long Stroke" cannot see how a point can possibly travel in a straight line and in a circle at one and the same time. Well, what I meant was, that as motion is always relative, that is to say, as you cannot speak of a point being either absolutely at rest or absolutely in motion, nor of it moving in a certain path, but you must speak of it as resting, or moving, or describing that path in reference to some other point, so you may speak of a point C moving in a straight line in reference to another point E, and in a circle in reference to a third point D.



Thus, if R and S are two equal sized spur wheels gearing into each other, then each wheel will make one revolution in the same time; and any point C on one of the wheels will describe a circle in reference to the centre of the axle D. Also if a point E be marked off on the other wheel, so that its distance from the centre of the axle F is equal to the distance of C from the centre of the axle D, while at the same time the line joining E and C is parallel to the line joining the centres of the axles F and D, then C will travel in a straight line in reference to E; the two points successively receding from and approaching to one another during each revolution, this recession and approach taking place at velocities which vary between 0 and twice the circumferential velocity of either point. If a third wheel T be geared into S—being of the same diameter—it will revolve in the same direction as R, and a point may be marked off on it so that it, during each revolution, will remain at rest with regard to the point E. If now, as in Fig. 2,



the two points E and E_1 are so marked off that they remain at rest in reference to each other while the wheels make a revolution, then a crank-pin may be placed at each point and the two wheels coupled together by a coupling rod A A_1. If this coupling rod has a slot along its middle, then the point C will move back and forward opposite this slot during each revolution; or if a crank-pin be fixed at C and a slide-block B fitted on it, then B will slide back and forward in the slot during each revolution; the distance travelled through by B in reference to A A_1 during one revolution being equal to eight times the radius C D, while the distance travelled through by the centre of the crank-pin C in reference to the centre of the axle D is 6·28 times the radius C D. I suppose it is not necessary to show how by substituting a hollow cylinder for the slotted rod A A_1 and a piston for the slide block B, and dispensing with the spur wheels, the above mechanism is transformed into the device illustrated in my former letter; such practical modifications suggest themselves.

I think also it may now be evident why I called the device a truly rotary engine, viz., because every point in the cylinders and pistons, or in the coupling-rod and slide-block during each revolution describes a circle in reference to a point in the fixed framework, while at the same time every point in the pistons or in the slide-block describes a straight line in reference to a corresponding point in the cylinders or the coupling rod. Although, therefore, the motions might with equal truth be called either rotary or reciprocating, yet as one usually, when speaking of the motion of mundane matter, speaks of it in reference to *terra firma* or to some fixed point thereon, I think that the motions in this case are preferably called rotary. At the same time, I admit that it is only the motion of each point, and not of the cylinders, &c., that can be, strictly speaking, called rotary—when considering that the word, according to its derivation, signifies to turn as a wheel. But firstly, I could find no better word; and secondly, the device possesses one of the important practical advantages aimed at by rotary engine inventors, viz., the doing away with the alternate starting and stopping of the piston and gear during each revolution. I also wish to say that the sentence, "all the parts move in circles," is scarcely correct, because no part nor even particle of the cylinders and pistons moves in a circle, but every point, that is, every mathematical point in the cylinders and pistons describes a circle. Finally, I must most emphatically disclaim any similarity between my device and the one illustrated by "Rotary" in your issue of March 19th; he says my machine is similar to the one he illustrates. Well, I should say his machine is similar to mine in the same manner that a parody is similar to the original.

Glasgow, April 6th. H.

THE INSTITUTION OF CIVIL ENGINEERS.

SIR,—The necessity for some prompt measures being taken for providing suitable house accommodation for the rapidly increasing ranks of the Institution of Civil Engineers, to which you have called attention in your last issue, is one of great interest and importance to its members, and now that, thanks to you, special attention has been drawn to it, I trust everyone interested in the welfare of the important society to which we have the honour to belong will use his influence in bringing the question to an early and satisfactory issue. You have so clearly stated the case as to leave little or nothing to be added to prove the necessity for prompt and united action. I cannot, however, refrain from endorsing all you say as to the totally inadequate accommodation for members in the meeting hall, as well as to the difficulty which one experiences in putting one's hand on some required volume or other in consequence of the over-crowded state of the library, while the need for constantly transferring the reading-room and the council chamber, as well as other rooms, into cloak and tea rooms, is productive of an immense amount of inconvenience to every one.

Perhaps I may here be allowed the opportunity of saying that I for one look forward with hope and expectation to the time, at, I trust, no distant date, when we shall have house accommodation adequate to enable the President's annual *conversazione* to be brought back, like a wandering pilgrim, to the home from which it has, by the necessity of the situation, been excluded for some years past; an exclusion which I, along, I am sure, with many members, have regretted, owing to its having resulted in so marked and disadvantageous a change in many ways in the character of these meetings from what they were when, some sixteen years ago, I first had the honour as a member of being invited to them, and which has robbed them, if I may say so without seeming to be wanting in due appreciation of the kind and munificent hospitality accorded to us by each respected President in turn, of much of their original meaning and enjoyment. ROBT. H. BURNETT.

Victoria-street, Westminster,
April 10th.

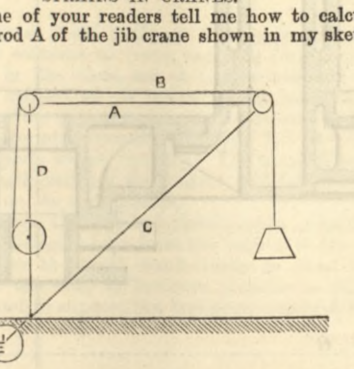
SIR,—The thanks of all classes of members are due to you for your able article on this building in your paper of the 9th inst., setting forth its inefficiency, or rather showing how utterly inadequate it is for its purpose. In addition to your remarks I would say that whenever we have a paper or lecture on an interesting subject, the lecture-room is so crowded that it is often impossible to get a seat, or even standing room; and more than this, there is so little provision for ventilation that the air soon becomes asphyxiated, and a splitting headache the next morning is the result. We want a room capable of holding 700 or 800 people for these meetings.

Again we want a room for seeing people in; at present we have only two—the reading-room and the library—in neither of which talking ought to take place; and we want more writing accommodation. But I could enlarge on these and many of the topics you have so well brought forward, as to the absolute necessity of a much larger building in every respect, and I can only hope that an abler pen than mine will take up the matter in all seriousness, and that you, Sir, will continue to keep the subject alive till it is noticed by the President and Council. I believe that if a meeting of all classes of the community were summoned to discuss the matter we should soon have a building worthy of our profession.

London, April 10th. MEM. INST. C.E.

STRAINS IN CRANES.

SIR,—Will some of your readers tell me how to calculate the strain on the tie rod A of the jib crane shown in my sketch? By



the ordinary rules for the composition and resolution of forces, there is no strain of any kind in A when a load is being hoisted, the strain being taken entirely by the crane chain B parallel to A, and by the strut C and crane post D. If, however, an attempt be made to apply this in practice, it will be found that the strut C will tumble down, and this even if its own weight be balanced by a counterweight at the opposite side of the crane post, as at E. Why is this, and what is the relative amount of stress on A and B?

London, April 10th. STORK.

FREE TRADE AND NO TRADE.

SIR,—Mr. Robinson admits my contentions so frankly that it would be unkind of me to criticise his letter of the 31st March too keenly, but he must pardon me for pointing out that all the U.S.A. bonds that we exported are not paid off, and supposing that none had been paid off, we would have required to export them just the same. This fact is important, because though the U.S.A. are the only nation that is paying off its debt, it does not therefore follow that they are the only nation to whom we are sending securities. Besides bonds, I think we have exported considerable amounts of shares in the old-established U.S. railways, and the new railways that we have gone into only pay about 1½ per cent. all round, if that.

Interest-bearing securities are included in "Trader's" phrase, "money in its larger sense." Mr. Robinson now admits that an unknown proportion of our excess imports is paid for by the export of such money, and that the Board of Trade returns do not include it. This was "Trader's" contention. He therefore has the best of the argument, and Mr. Robinson should not gird at him so unkindly. "Trader" is no fallacy-monger, and he does not pretend to be a political economist.

The "remarks on trade" in my table were extracted from the newspapers of the day. They give the feeling of the time. Mr. Robinson correctly points out that much of the foreign trading of 1871-72 was unsound, and that its fruits did not justify the feeling of prosperity that accompanied it. May it not be that, as then, we were unduly elated, so now we are unduly dispirited? I have facts and figures bearing on this point that I will trouble you with if you print this, but I will close now by urging the practical point that was in my mind when I wrote to you first, viz., we ought to have a record published annually of the creation and extinction of interest-bearing securities in this country, and of our imports and exports of such things. Parliament should charge the committees of our various Stock Exchanges with the duty of keeping such a record. It would be nearly as useful as the labour statistics that Mr. Bradlaugh is obtaining. Is this good work to be left to him also? WM. MUIR.

Edmonton, April 12th.

SIR,—It would be affectation on my part to say that I am sorry Mr. Robinson has withdrawn from this discussion. On the contrary, I am glad, and this because he has done as much as any one could do to lead the discussion away from the point I wished to see discussed, and has repeated the old, well-worn theories and propositions of the political economist *ad nauseam*. Never for one moment has he touched the subject practically. In fact, I feel certain that he has no practical acquaintance with it. He has been mystical and oracular, but he has to all intents and purposes left the matter just where it was. Concerning the question of imports and exports he can supply no information of any kind. In order to narrow the discussion, I took the trade of this country with France, Germany, and Belgium in 1884, and showed that we imported 78,000,000 of pounds worth of goods, and exported 33,000,000 of pounds worth wherewith to pay for them. I honestly asked for information how the difference was met, and Mr. Robinson admits that he does not know. He gives in your last impression four different explanations concerning the mode of payment, but he cannot attach any precise value to any one of them. It is all vague generality. However, he makes one admission of importance, to which I will come in a moment.

Not content with my own limited experience as an importer, I have applied to others. One of these gentlemen is a very large importer of silk in all its forms, from China, France, and Italy. To my query how he paid for this he replies, "With money, of course. The exporters draw bills on my house, which we accept and pay cash for when they come to maturity." He never exports anything. His trade lies altogether in England. His customers pay him with cheques, and he remits to those from whom he buys, letters of credit, and drafts, or bills falling due in France or Italy or China, and bought by him for transmission abroad. He is one of many. I am fully convinced, as the result of my inquiries, that very large sums indeed are sent abroad to pay for goods imported over and above the payments made "in kind," to which Mr. Robinson attaches so much importance. These sums ultimately resolve themselves, in the case of the United States at all events, into bonds and other securities. I need no longer insist on this point against Mr. Robinson, because in his last letter he has made the important admission to which I have referred above. Among other means of payment, he names, "(3) Goods sent to us as interest upon the loan of English goods sent abroad at previous periods without payment. In other words, interest on loans and investments abroad." This is all I want.

Taking leave of Mr. Robinson, I come back once more to the propositions with which I began. The first of these is that that country will be on the whole best off in which there is most employment. No one has seriously attempted to dispute this. The second proposition is that a moderate import duty put on certain goods would be directly followed by more employment at home. No one has disputed this proposition. Your correspondents all argue round and round these propositions, but forbear to tackle them. They even admit that I am right, but hold that the results would not be satisfactory.

Now, no good purpose can be attained by indefinitely extending this discussion, and I once more, and for the last time, ask your readers to honestly consider this matter from my point of view, and then from their own, and explain clearly where I am wrong.

To keep the discussion within reasonable limits, I must narrow my illustrations. Your other correspondents are never so happy as when ranging over illimitable fields. So I shall speak of the individual instead of the nation. *Ex uno disce omnes.* Mr. John Smith has invested abroad £50,000, partly in France, partly in Germany. He is paid the interest on this, not in money—money is not used between nations, according to Mr. Robinson, save in a very temporary way—but in goods. These goods are made by French and German workmen. They come into this country duty free, and Mr. John Smith gets them cheaper in consequence. Now, if a moderate duty was put on them, Mr. Smith would not take goods from abroad in payment of interest. He would insist on being paid in money, and the result would be that instead of keeping, say, five Frenchmen and five Germans working for him, he would keep, say, seven Englishmen working. This, I maintain, would be a good thing for the working men of England, and also for the employers of working men. But let it be supposed that the foreign debtors insisted on paying in goods. Then, as Mr. Smith would not pay the duty, the foreign debtor would have to do it, and Mr. Smith would still employ foreigners to supply his needs; but England would still be better off, because the duty paid by the foreigner would help to pay our taxes.

This is my case in a nutshell. I will not amplify it in any way. I leave it as simple as possible, and I ask your readers to explain where I am wrong. If I am labouring under a delusion, the sooner this is removed the better for me. What has Mr. Muir to say on this point? TRADER.

London, April 13th.

GOOD AND BAD CHAINS.

SIR,—We have been asked to supplement our letter of the 26th ult. by publicly expressing our experience in manufacturing chains of mild steel to compete with high class chains made of iron. In complying with this request, we may say that some years ago we were of those who thought that very mild steel might sooner or later supersede iron. But, after twenty-five years' careful observation, during which period we have experimented upon nearly every kind of steel bar made expressly for the purpose, we have no hesitation in saying that a steel chain with welded links can never hope to be classed with anything above a third-rate quality of iron, in consequence of the difficulty of insuring a sound weld on account of the treacherous nature of the material.

We may quote an instance which has recently come under our notice. Since the correspondence upon good and bad chains commenced we have been favoured with an order from the Clifton and Kersley Colliery Company, near Manchester, for a quantity of wagon couplings, consisting of two links, each 10¾in. long, and made of 1⅝in. exact iron—A1 special best best J. W. and Co. registered brand. The couplings were made in our usual way and duly advised for delivery. Mr. Nicholas Fogg, the company's special inspector, called at our works to examine them, after which he promiscuously selected two samples from the bulk for testing purposes, and, in order to compare them with other brands, he brought with him two other couplings—one in steel and one in iron—of the same size and dimensions, but made specially for high testing by another house. The four samples were taken to Lloyd's public testing machine at Tipton, on the 3rd inst., and tested to destruction in the presence of Mr. Fogg and Messrs. Lloyd's superintendent, with the following results:—No. 1 sample, Siemens steel, made purposely for testing, broke in weld at 45 tons; No. 2, Bowling iron, made purposely for testing, broke in iron at 59½ tons; No. 3, A1 special best best J. W. and Co.'s registered brand, taken promiscuously from bulk, broke in weld at 65¾ tons; No. 4, A1 special best best J. W. and Co.'s registered brand, taken promiscuously from bulk, broke in iron at 67½ tons. We submit these recent tests, which confirm our previous experience of steel chains, and hope the information may be of use to some of your readers.

JOSEPH WRIGHT AND CO.

Tipton, Staffordshire, April 14th.

SIMPLE FORMULÆ FOR STEAM ENGINES.

SIR,—I have read Professor Unwin's paper in your last impression with much disappointment. It certainly does not fulfil the promise contained in its title.

No engineer can regard formulæ with fractional indices as simple. When Fairbairn used them, writing for engineers, he gave a table of the powers for reference; but, leaving this on one side, I would ask—Of what possible value can the formulæ be to steam engine makers, or designers, or users? Admirable steam tables exist which are in daily use by engineers, and no one would think of calculating pressures and volumes for himself, when he can find what he wants in a moment by looking at a table.

May I venture the hope that this paper is only the first of a number much more practically valuable that Professor Unwin will favour us with? ERG.

Great George-street, April 12th.

A CONDENSER PUZZLE.

SIR,—With your permission I beg to offer a few remarks in the hope that they will be of service to your corespondent, "Puzzled." When describing the air-pump, "Puzzled" does not say what kind of valve is used for the delivery, and judging by the diagram it is not improbable that the knock is caused by a sluggish working of that valve, and also of the bucket valve. The delivery of a pump of the size mentioned should take place through a number of small valves, and not through a single large one, also the depth of water in the hot well over the valves should not exceed 1in.—the valves will then open freely.

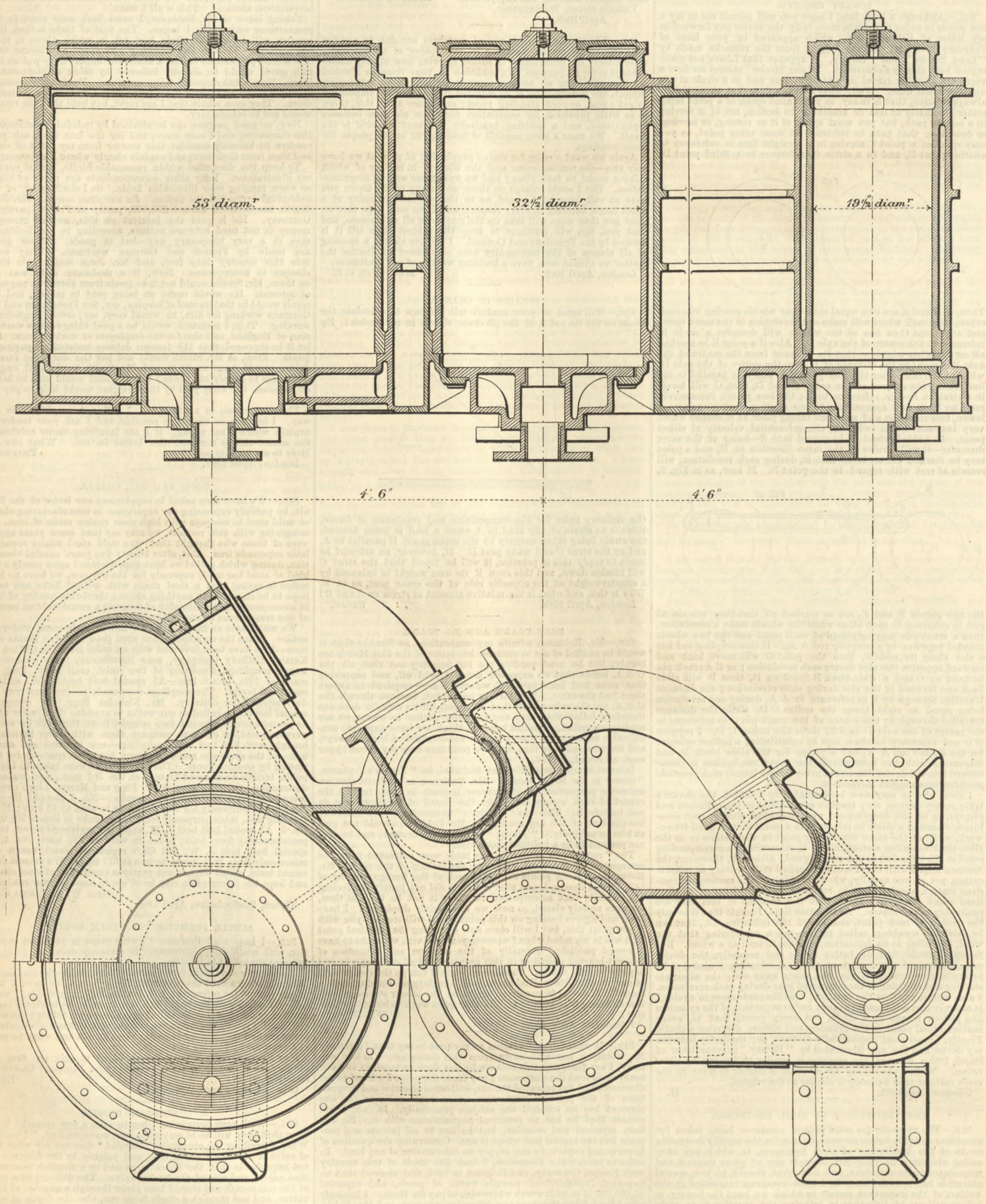
A small non-return valve with regulating screw to admit air underneath the discharge valve is also an advantage, as the air forms an elastic cushion between the discharge valve and the top of the bucket, which materially reduces the shock when the water strikes the top previous to opening the discharge. The bucket should also have a number of small india-rubber grid valves, each about 6in. diameter, instead of a single large one, and the pump will generally give satisfaction if set to work under these conditions, and it will be found that a foot valve can usually be dispensed with, as it is a frequent cause of breakdowns when the pump gets choked with water. ERECTOR.

April 12th.

A FEW days ago a fatal explosion of stive took place at Messrs. A. and R. Tod's flour mills, Leith, causing the death of a man and two boys and injury to several other persons. The explosion occurred in the exhaust house, which was situated over the boiler compartment. The building, two storeys in height, was destroyed,

DETAILS OF CYLINDERS OF THE S.S. COOT.

THE CENTRAL MARINE ENGINEERING COMPANY, WEST HARTLEPOOL, ENGINEERS.



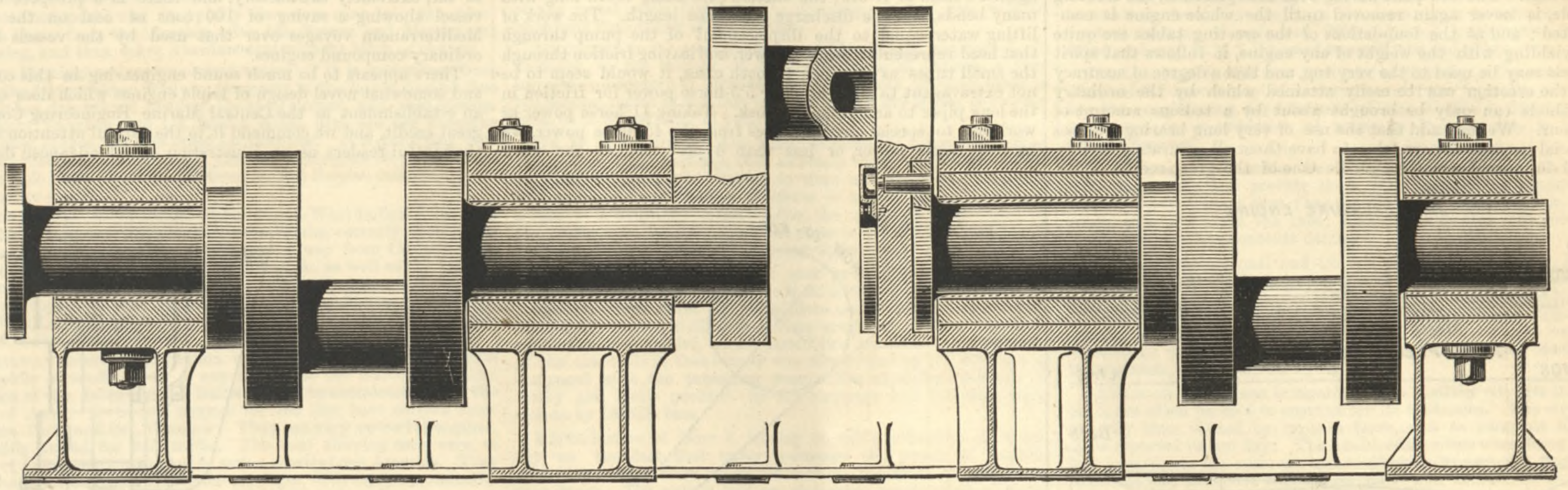
TRIPLE EXPANSION ENGINES OF THE S.S. COOT.

Now that marine engines on the triple expansion, or tri-compound, system have come so much into use, it affords us much pleasure to be able this week to give our readers a two-page engraving, together with description and other views, of a fine set of engines designed on this principle. The engines of the s.s. Coot are the third set of triple expansion engines built by the Central Marine Engineering Company, of West Hartlepool, under the patents of Mr. Thomas Mudd, their managing engineer. The cylinders are 19½in., 32½in., and 53in. diameter respectively, and 36in. stroke. They are intended to indicate 750-horse power, with a boiler pressure of 150 lb. per square inch above the atmosphere. The cylinders are placed in line over the centre of the ship, and work on three separate cranks set at angles of 120 deg. The centre line of the middle engine is equidistant from the centre line of the other two. All the cylinders are fitted with hard cast iron liners, and are all steam jacketed; the jackets being fitted with separate inlet valves, so that the pressure can be regulated in each jacket independently. They are also fitted with separate draining arrangements and water gauge glasses.

Slide valves have been entirely dispensed with in these engines, and their place supplied by valves of the piston type, which are driven by a gear which is a modification of the well-known dynamic motion first patented about a quarter of a century ago by Mr. John Hackworth. The piston valves are of a simple design, and are arranged in such a way that the pressure of steam in the steam chest supports the weight of the valve and spindle, so that the work done by the valve gear is extremely light, the valves being altogether in equilibrium. All the valve chambers are lined with separate hard liners like the cylinders themselves.

The engraving shows a detailed view of the valve gear, certain features of which have been patented by Mr. Mudd. This gear requires only one excentric to drive it either ahead or astern, and therefore takes up small room on the shaft; it has extremely few working parts and joints, and gets a very direct lead to the valve spindle. It is arranged so as to be easily got at and readily disconnected for examination; all its parts are adjustable both for wear and for length, so that the motion of the valve may easily be kept constant; it is designed so that the excentric strap is obliged to work constantly in the same vertical plane, being quite independent of all fore and aft movement of the crank shaft. This gear also lends itself admirably to a simple arrangement of reversing gear, and the ease with which engines fitted with this gear can be reversed is not the least of its advantages. Apart from these practical qualities it should not be overlooked that valve gear on this principle is superior to link motion, in that it provides a constant lead opening at all grades of expansion, and a tolerably quick cut-off. The diagramatic sketch we publish will clearly illustrate the motions of the gear. The pin between the crank shaft and the eye at the outer end of the excentric rod is a slide pin. This pin is forged solid with a

BUILT UP CRANK SHAFT, S.S. COOT.



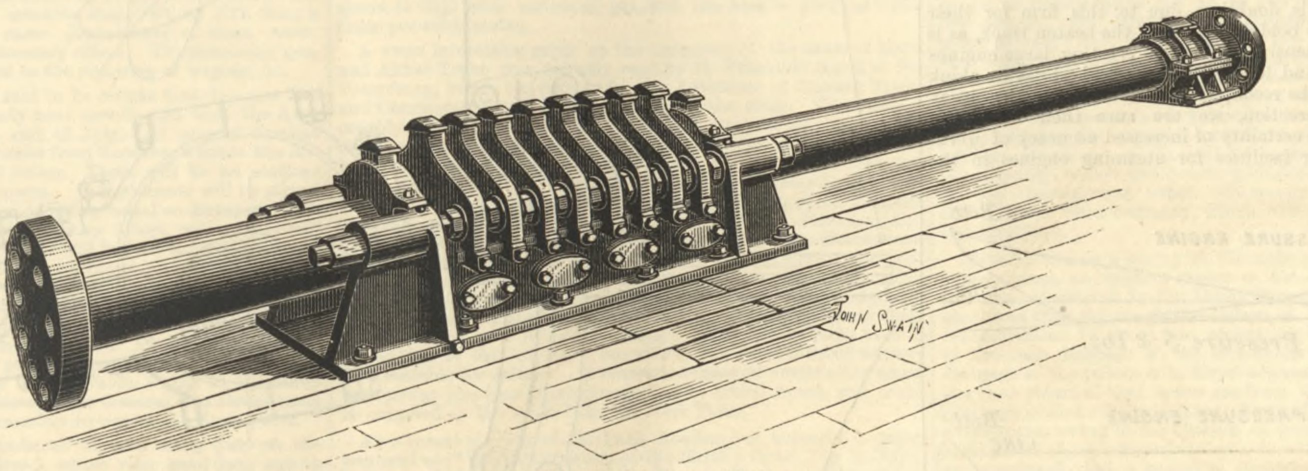
sliding piece, which works in a slide whose angle is alterable by the reversing gear from the ahead position to the astern position, the middle position between these two being such that the valves only open the amount due to lead, and therefore the engine will not move either way when the gear is so placed. It is impossible in a combined view of the plan to show the actual slide, and we found a plan view would convey no satisfactory impression to a person unacquainted with the gear, and therefore give the views that we think most clearly elucidate its action and show its great strength and simplicity. The outline diagram of motion will certainly make matters clearer, as the path of the eye that attaches to the valve connecting-rod can be seen. The tail guide at the left-hand has no effect on the essential motions of the gear. It is there only to keep the excentric strap always working in the same vertical planes, independently of any fore and aft movement of the crank shaft. As our readers know, marine crank shafts need a considerable amount of end freedom, usually ¼in.; and this tail and the slide pin about equidistant on each side of the excentric retain the excentric strap constantly in the same vertical plane, and allow the crank shaft and excentric sheave to move through the strap in a fore and aft direction freely without affecting the valve gear.

The crank shaft, of which we give a detailed view, is designed so as to secure a number of very important good qualities; it is of the built-up description, the body parts and cheeks being of forged scrap iron, and the pins of hollow hammered steel. The one excentric that is necessary for driving the valve gear of each engine is forged solid with the after crank cheek of each crank. The forward cheek is recessed to receive the flange of the adjoining body piece of the shaft, and in this way it becomes possible to make the shaft in three sections, each containing a crank and a piece of shaft precisely like the others, so that the crank belonging to one engine will fit either of the other two, and it is only necessary to carry one crank as spare gear. Besides this, the arrangement renders it possible to carry the crank shaft on only four main bearings, and these bearings may—as, indeed, they do in the engines of the Coot—extend the full distance between one crank and the next. The advantage to a marine crank shaft of having such an abundance of length of bearing cannot be over-estimated, and there can be no doubt that the frequent breakage of crank shafts is partly traceable to the want of a sufficiency of main bearing, which results in the bearings wearing out of line and permitting the crank webs to open and close at each revolution. The main bearings of these engines are made, not of brass in the usual way, but of very stout and rigid blocks of cast iron, lined with a white bronze of very high quality over their whole surface. The design of crank shaft and valve gear being such as to afford a surplus of length of main bearing, a good share of the length was naturally given to the crank pins, so that they too are well supplied with length of bearing; and the crank pin brasses are made in a similar manner to the main bearings, and lined with the same white bronze. It will be observed from our front view that the system of having four main bearings in the triple engine accommodates itself easily to the application of strong cast iron forked columns as front supports for the cylinders. These columns in the Coot are of a very massive and rigid design, and are utilised as oil tanks. They leave the engine particularly accessible at every part; the large keeps of the two centre bearings forming excellent footing for the attendant between the engines whilst running. The connecting-rods are five cranks in length between the centres, and therefore work at very easy angles on the main guides.

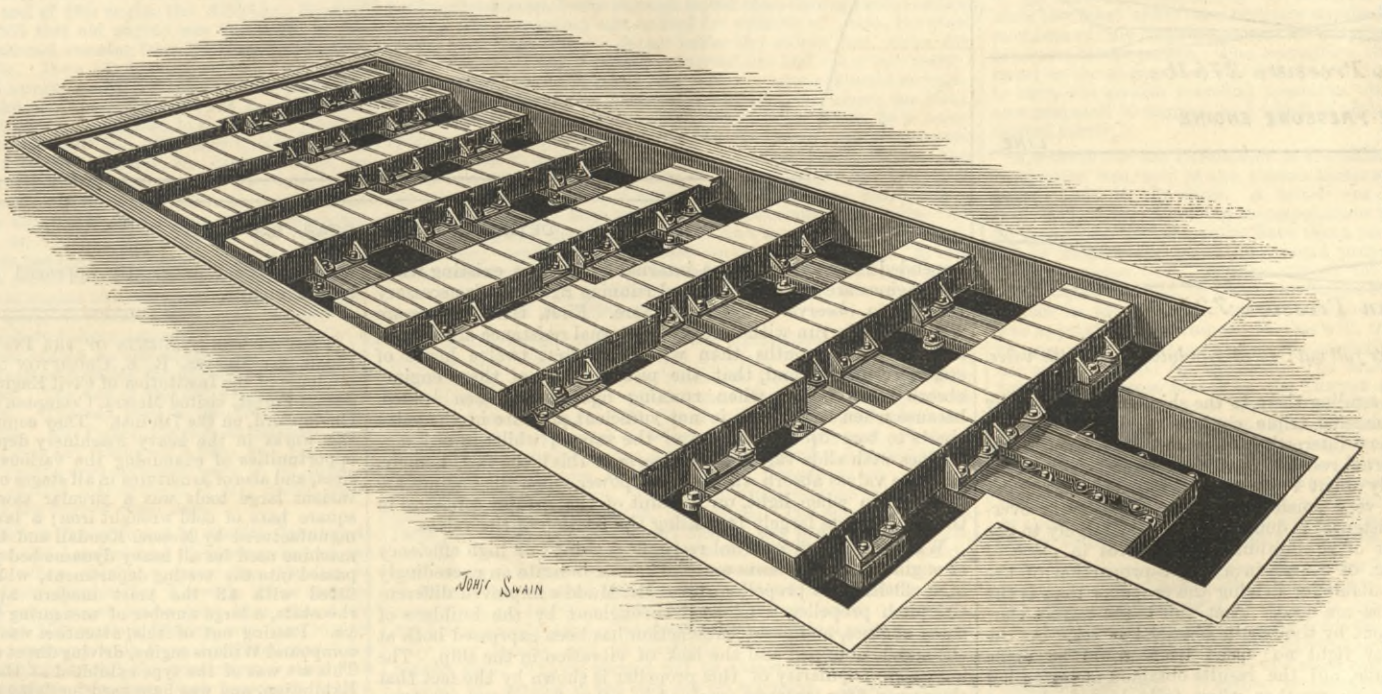
It will be observed that the bed-plate is made quite flat on the bottom, and is sufficiently high from the bottom to the centre of the shaft to allow the built crank-cheeks to clear the ship's engine-seat. In this way it becomes possible to have a flat engine seating, and to support the bed-plate and bolt it thereto right across beneath the crank-shaft, in line with the main stresses. The bed-plate of the Coot is cast in one piece throughout the whole foundation of the engine, and up to about the middle of the condenser; the upper half of the condenser, together with the back columns, is bolted to it by means of a horizontal joint, there being no vertical joint whatever throughout the whole framework of the engines.

In dealing with such high steam pressures the designer of these engines has wisely avoided the use of large steam joints. The main joints between the cylinder castings are mere bracket connections for securing strength to the structure, and are not steam joints, the steam passing from one cylinder to another by means of pipes at the back.

It will be seen by our plan of the cylinders, page 298, that the three piston valves are placed at the back of the engines, so that the cylinders are as close together as possible, and the valves are also very close to their respective cylinders, a plan which gives the minimum of clearance in the ports. The valves are in a line oblique to the centre line of the cylinders, and by placing a lifting bar over their centres the valve covers and valves may be easily drawn for examination.



THRUST BLOCK, S.S COOT

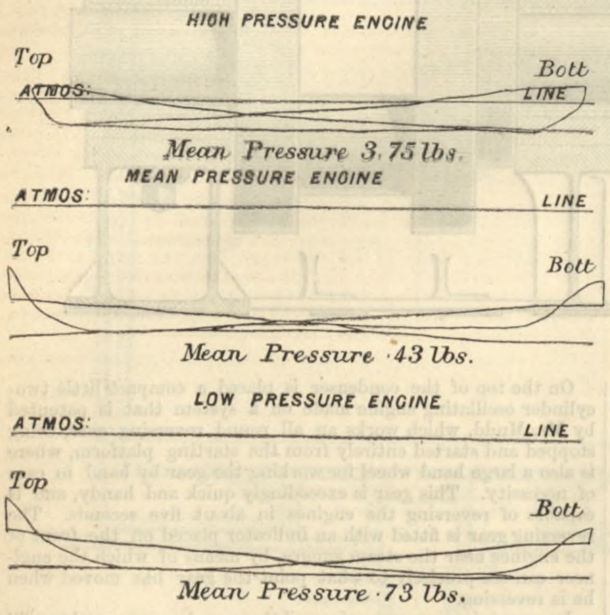


ERECTING TABLES, CENTRAL MARINE ENGINEERING WORKS.

On the top of the condenser is placed a compact little two-cylinder oscillating engine made on a system that is patented by Mr. Mudd, which works an all round reversing gear, being stopped and started entirely from the starting platform, where is also a large hand wheel for working the gear by hand in case of necessity. This gear is exceedingly quick and handy, and is capable of reversing the engines in about five seconds. The reversing gear is fitted with an indicator placed on the front of the engines near the steam gauges, by means of which the engineer can see precisely to what point the gear has moved when he is reversing.

In examining our engravings of these engines our readers will observe the general compactness and neatness of design combined with great structural rigidity, abundance of strength of working parts, and unusual extent of wearing surfaces. These qualities appear to be the result of the engines having been designed in the absence of all restraint in the way of existing patterns or other impedimenta. The Central Marine Engineering Company commenced business on a large scale just at the period when triple expansion engines were coming into vogue, and as its first four sets of engines were on this principle, it had an opportunity denied to most other marine engineers, of designing its engines entirely on their own merits. To engineers who were already supplied with full patterns of ordinary compound engines of every size, and the necessary templates and tools which their manufacture involves, doubtless the simplest way to construct a triple expansion engine was to add a third engine at the end of the existing compound patterns; but this plan of course renders the engines very long, increasing the space necessary in the ship to accommodate the machinery. The engines of the Coot occupy no more space fore and aft than the ordinary compound engine of the same power, and this alone is a feature of considerable importance to shipowners. The arrangement of the machinery and boilers on board the ship is such that though very compactly arranged there is a free passage for the engineers, both at the forward and after ends of the engine.

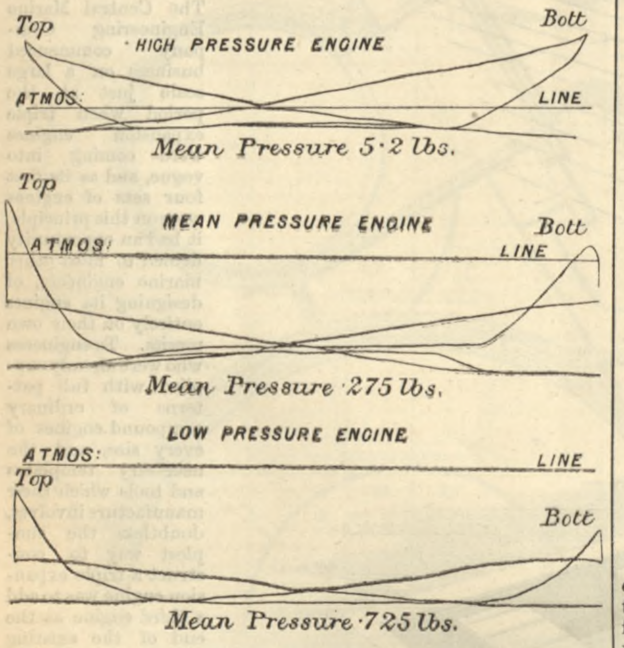
The system of erecting the engines in the shops at the central engine works is novel, and deserves special notice. In the floor of the erecting shop a number of piles were driven down to a solid foundation, and on these a large bed of concrete was placed, upon which were secured a number of longitudinal cast iron girders planed on the upper surface; above these were placed a series of transverse girders planed on the upper and lower surfaces, and fitted with T grooves on the top. These girders are capable of sliding in a longitudinal direction upon the lower girders, the whole system forming what are called erecting tables. Our engraving on this page gives a perspective view of the tables in the shop floor. The bed-plates of the engines are planed on their under side and placed on this planed level erecting table, and whilst there all the main bearings are bored out at one time by means of a very powerful boring machine and a long solid steel bar. It will be seen that this ensures absolute truth in the alignment of the main bearings, and the complete freedom from the least tendency to show signs of heating in any main bearing of any engine that has yet been turned out by this firm is an excellent comment on the superiority of this system, and the advantage of long bearings. The bed-plate having been thus placed on the erecting table, is never again removed until the whole engine is completed; and as the foundations of the erecting tables are quite unyielding with the weight of any engine, it follows that spirit levels may be used to the very top, and that a degree of accuracy in the erection can be easily attained which by the ordinary methods can only be brought about by a tedious amount of labour. We may add that the use of very long bearings, unless special precautions are taken to have them all accurately in line, will do more harm than good. One of the great merits of Mr.



Set 1.—Expansion gear full in; speed regulated by throttle valve.

Mudd's system of erection is that it renders the use of very long bearings admissible.

Considerable credit is, doubtless, due to this firm for their enterprise in making so bold a step out of the beaten track, as is represented by this extensive system of erecting large engines on carefully prepared and levelled tables; and whilst we think it likely that they will be recouped in the future for the outlay by reduced cost of erection, we are sure their customers will benefit by it in the certainty of increased accuracy of work. The tables also offer facilities for steaming engines in the



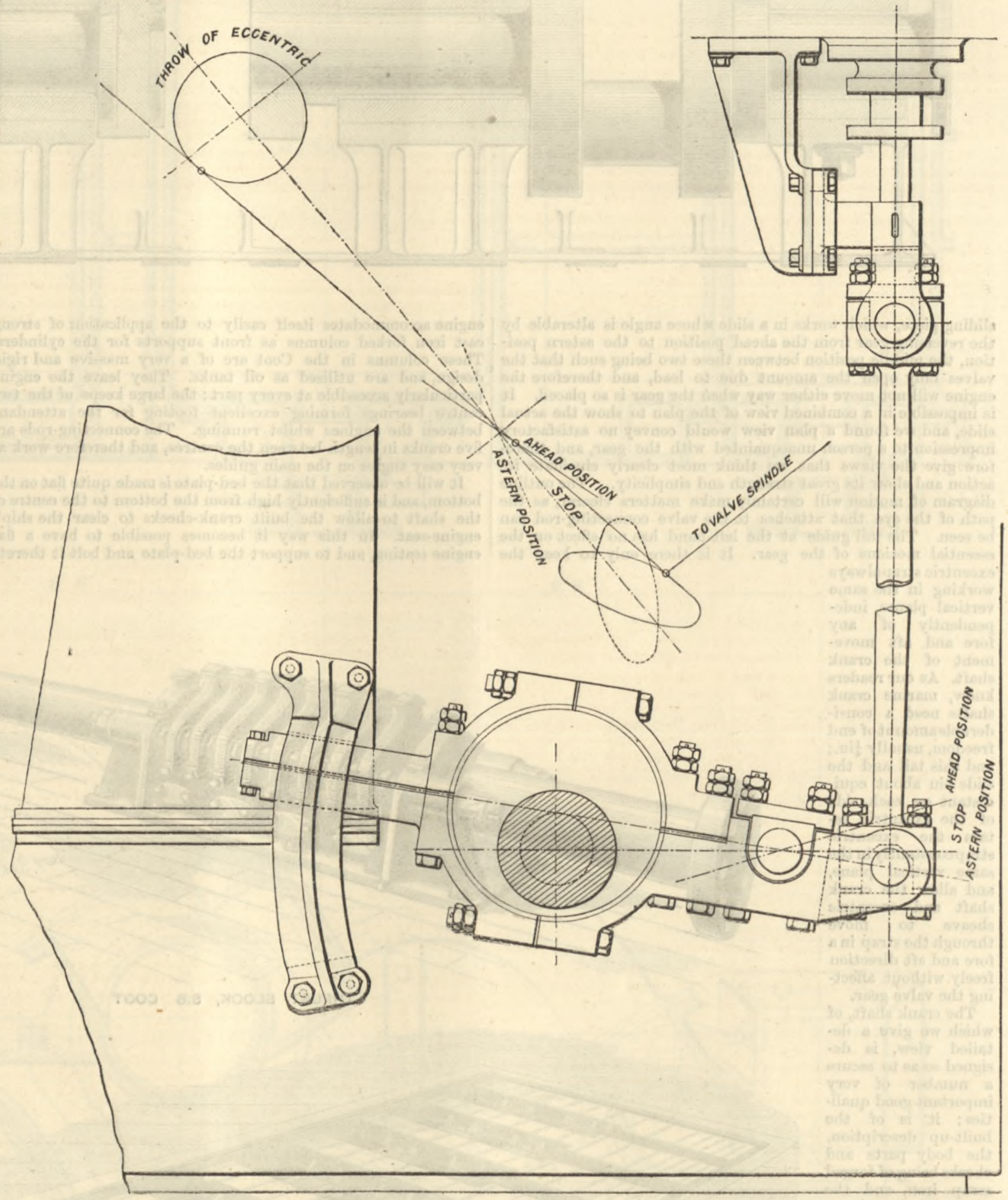
Set 2.—Expansion gear full out; speed regulated by throttle valve.

erecting shop before sending them to the ship, and it is worthy of note that in so steaming triple engines of the type which we illustrate some very interesting diagrams have been taken which show the internal resistances of these engines when running light to be only about 4 per cent. of the ordinary maximum power. This very small absorption of power in overcoming internal resistances is doubtless due very largely to the adoption throughout of equilibrium piston valves in place of slide valves, resulting, of course, in a larger proportion of the total power being available for driving the propeller than is the case when slide valves are used. That this is the correct view appears to be borne out by the results obtained at sea. As the Coot was taken away light no speed trials could be made over the measured mile, but the results obtained at sea on her first voyage in ordinary weather when fully loaded show a speed coefficient by the displacement of 353, and by the midship section of 918, when running with the engines linked in considerably below full power. This corresponds fairly well with the trial trip results of a former vessel fitted with engines of the same type but larger, when the coefficients were 366 and 942 respectively. We give above carefully reduced copies of diagrams taken from the somewhat larger engines of the Cleveland. The engines of the Cleveland have cylinders 21in., 35in., and 57in. diameters, 39in. stroke. These engines are intended to work with a boiler pressure of 150 lb. per square inch when on board ship; but on the trial in erecting shop were supplied by the factory boilers situated 250ft. away from the engines, the pressure at the boilers being 80 lb., and the steam, of course, much wiredrawn at the engines through the throttle valve. With a vacuum of 25in. and 63 revolutions per minute, the horse-power exerted was, with gears full out, H.P. engine, 21·4; M.P. engine, 3·29; L.P. engine, 22·9; 47·59 H.P. total. With gears full in, H.P. engine, 16·1; M.P. engine, 5·13; L.P. engine, 23·1; 44·33 H.P. total. The indicated horse-power at 63 revolutions with loaded ship may be taken at 900; and calling the power developed in the shop at 63 revolutions, 45 indicated horse-power, the latter bears the proportion of 5 per cent. to the former. This, however, does not accurately represent the measure of the internal resistances under ordinary conditions, because the circulating pump was pumping out of the dock against a head of 19·5ft., the suction pipe being 450ft. long with many bends, and the discharge pipe same length. The work of lifting water equal to the displacement of the pump through that head represents 5·5-horse power, and leaving friction through the small tubes as common to both cases, it would seem to be not extravagant to allow another 5·5-horse power for friction in the long pipes to and from the dock. Taking 11-horse power as work due to special circumstances from the 45-horse power, we have 34-horse power, or less than 4 per cent., as the work expended in overcoming the internal resistances existing when the engines are on board ship and running light. It is necessary further to observe two points more. First, that engines are well known to run with much less internal resistance after being at work a few months than within the first twelve hours of starting; and second, that the piston valves of these engines absorb more power when running light than when loaded, because when light there is not sufficient pressure in the valve chests to bear up the weight of the valves; whilst in ordinary engines with slide valves the converse of this is the fact, namely, that the valves absorb vastly more power when the engines are loaded than when light, on account of the greater pressure in the valve chests largely increasing the friction of the valves.

Whilst the small internal resistances point to a high efficiency of engine, the coefficients we have named indicate an exceedingly high efficiency of propeller also. Mr. Mudd's improved differential pitch propeller is adopted throughout by the builders of these engines, and great satisfaction has been expressed both at the speeds obtained and the lack of vibration in the ship. The increasing popularity of this propeller is shown by the fact that close upon fifty steamers engined by other firms have now been fitted with it, and the pressure of business in this department has necessitated the laying down of sufficient plant to enable a propeller to be turned out every three days.

The s.s. Coot is a vessel 270ft. by 37ft. by 18ft. 6in. mean draught, and carries 2650 tons. She is built of steel, and classed 100 A1 at Lloyd's. The vessel is of the well-decked type, with poop aft containing a handsome saloon and cabins for officers and a few passengers; long raised quarter deck connected to a long bridge, which is carried forward of the foremast, and accommodates the crew. She was built by Messrs. Wm. Gray and Co., to the order of the Cork Steamship Company, Cork. The vessel has not completed her first round voyage yet, but, after hearing from the chief engineer at Malta, the superintendent engineer of the company, Mr. F. C. Kelson, of Liverpool, wrote to the builders, saying:—"There was no stoppage of the engines throughout the voyage from London to Malta, and there was not the slightest hitch the whole way. The average speed throughout was 9 to 9½ knots. Speaking of the performance of the machinery the chief engineer says 'there was never a better working job put into a vessel.' The captain and officers say they were never in a ship's cabin placed aft where there was so little noise or vibration. Entering harbour the engines handled well, stopping and starting again without the slightest difficulty, and maintaining the vacuum over 17 minutes. Altogether I think the results, so far, extremely satisfactory, and there is a prospect of this vessel showing a saving of 100 tons of coal on the round Mediterranean voyages over that used by the vessels having ordinary compound engines."

There appears to be much sound engineering in this compact and somewhat novel design of triple engines which does so new an establishment as the Central Marine Engineering Company great credit, and we commend it to the careful attention of our thoughtful readers as an illustration of an advanced development of the now greatly approved triple expansion type of marine engine.



DETAIL OF VALVE GEAR, S.S. COOT.

VISIT OF THE STUDENTS OF THE INSTITUTION OF CIVIL ENGINEERS TO MESSRS. R. E. CROMPTON AND CO.'S WORKS.—The students of the Institution of Civil Engineers, accompanied by Mr. James Forest, visited Messrs. Crompton's Electric Light Works, at Chelmsford, on the 7th inst. They commenced their inspection of the works in the heavy machinery department, where they had opportunities of examining the various parts of dynamos of all sizes, and also of armatures in all stages of construction. Among the various large tools was a circular saw used in cutting up 8in. square bars of cold wrought iron; a large new milling machine, manufactured by Messrs. Kendall and Gent; also a large planing machine used for all heavy dynamo bed-plates. The visitors next passed into the testing department, which was found to be well fitted with all the most modern appliances, including large rheostats, a large number of measuring instruments, photometers, &c. Passing out of this, attention was drawn to a three-cylinder compound Willans engine, driving direct a large Crompton dynamo. This set was of the type exhibited at the International Inventions Exhibition, and was here used for doing all electrical work required in the works for shop lighting, both arc and incandescent lamps, and also for driving motors working the fans in the smiths' shops, and all the shafting in the pattern shop. Ascending to the second floor, or bobbin shop, the visitors were enabled to examine armatures of every size and description in various stages of completion, the sizes of these varying from an armature able to work twelve lamps at 2000 revolutions, to one capable of generating 100,000 watts at 400 revolutions. On this floor also projectors of all sizes, and hand-lamps of English and other patterns, were on show. Proceeding to the next floor, instruments, switches, and minor fittings of every sort and description were seen in progress. Returning to the ground floor, the visitors were shown through the erecting shop and stores, and thence to the pattern shop, foundries, painting, and smiths' shops. In this latter a high-pressure steam hammer was seen, used for forging, shearing, and punching. In the new erecting shop was seen three complete combined plants, each capable of giving 100,000 watts at about 400 revolutions, one of these being specially put under steam for the inspection of the visitors. Prominent among other features of interest, which cannot be detailed at any length, were the fittings for a complete set of gear necessary for a light-ship. These embraced dynamos, engines, boilers, glazed lantern containing four arc lamps suspended on gimbals, &c. &c. The whole works, which employ upwards of 400 men, show in every department the steady progress which this branch of engineering is now making.

RAILWAY MATTERS.

On the 4th inst., the Nizam of Hyderabad opened, with great ceremony, the new railway between Secunderabad and Warangol. The line is 87 miles in length.

The Pontypridd and Caerphilly line now runs into the Alexandra Docks from the junction with the Brecon and Merthyr at Bassaleg, and thus takes Aberdare coal without hitch or change.

Our Birmingham correspondent writes: "It is understood here that the Metropolitan Railway Company is the latest English line which has determined to adopt the steel sleeper, and that Messrs. Bolckow, Vaughan and Co., and a Welsh firm, are the concerns who have shared the first order for that line. It is gratifying that native steel-masters can now offer metal sleepers at prices more favourable than those of the German and Belgian makers, and of a superior quality."

The Lieutenant-Governor of the North-West Indian Provinces, and Mr. Hope, the Minister of Public Works, recently opened the first section of the Indian Midland Railway from Cawnpore to Kalpi, a distance of 42 miles. This section, as well as the further section from Kalpi to Jhansi, is to be constructed out of the provincial funds, but will be taken over by the Midland Company, which will eventually carry on the line from Jhansi to Itarsi, on the Great Indian Peninsula line.

Railway intercommunication between the Australian colonies is rapidly extending. It is expected that the South Australian portion of the Intercolonial Railway will be completed about the end of April. Two new engines for the line have arrived from Messrs. Dubs and Co., Glasgow. They are very powerful engines, specially suited for hill traffic. The four sleeping cars were, at date of recent mail, expected to arrive shortly from America. They are described as large, handsome carriages, with every accommodation for travellers overland to and from Victoria.

A new "Alphabetical Time Table" is published at 13, York-street, Covent Garden, for 2d. It is intended to refer to trains in the United Kingdom, and is useful as far as it goes; but it is not yet complete for the secondary roads. For instance: Many Welsh places best reached from Oswestry are mentioned as reached only from Shrewsbury. A 10 a.m. train from London to Oswestry will catch trains that can only be caught by 9 o'clock trains to Shrewsbury. Moreover, instead of stating four trains or three trains daily from a junction to a small place—which is not sufficient—the times should be given.

The Midland Railway Company is about largely to extend its works at Hunslet. The business of wagon repairing has for a long time been carried on by this company in the repairing shops, which are situate in the goods yard, Hunslet-lane. To carry out the necessary extension a suitable site has been obtained in Wakefield-road, Hunslet, adjoining the railway, and the contract for the work has been secured by Messrs. Nicholson and Son, builders, South Brook-street, Hunslet. The dimensions of the new building, which is to be of brick, will be 200ft. by 140ft., and it will be one storey high. There will be a machine shop, 74ft. by 10ft. 8in.; a spring-makers' shop of the same dimensions; a store room, 39ft. 3in. by 80ft.; and the necessary offices. The remaining portions of the site will be devoted to the repairing of wagons, &c.

At St. Petersburg it is now said to be certain that the new line to Merv will be completed early next month, and that the Amu Daria will be reached at the end of July. At present the line extends to eighty-six English miles from Sarakhs, whence the distance to Herat is about 125 miles. There will be no stations except at a few of the larger towns. Refreshments will be served on the train, and the measures of safety usual on European lines will generally be dispensed with. Every fifteen miles there will by a guard-house for workmen, who will inspect the line on horseback. About 20,000 workmen are employed, chiefly Turkomans, who are very clever in earthworks. Their daily wages are only a few pence, so that the line will be the cheapest on record. The *Novoe Vremya* publishes a letter from General Tchernajeff, contesting the military or commercial value of the Transcaspian Railway, and declaring the proposed continuation of the line from Merv to Bokhara to be impracticable, owing to the sandy deserts lying between these places. The General lays stress upon the necessity of an efficient steamship service on the Amu Daria.

There is an old engine, numbered 14, now doing duty on the Alleghany Iron Mountain Railroad, whose voice used long ago to waken the shrill echoes in the valleys and mountains of Central Virginia. A thing whose history includes thirty years seems ancient to an American, and of this engine the *Alleghany Sentinel* says:—"Way back in 1855 this old engine was the pride of the then Virginia Central Railroad, running from Richmond to Louisa, and latter to Gordonsville. Even after the new order of things since the war No 14 held a proud position among the fast passenger engines on the Chesapeake and Ohio Railway, but for years the once monarch of the road has been relegated to the obscure position of yard engine, until procured by the Alleghany Company, and burnished up by one of its old masters, Mr. James Pelter, its sphere of usefulness is enlarged. If engines could only talk, what a volume of important events would this old fellow narrate. What precious freight has been committed to his care. How many old Virginians have waited on narrow platforms for the "keers." What mighty state secrets have been discussed behind its steaming smokestack. Covering a period of the most intense interest in the history of Virginia, the old engine still survives, while many, aye, perhaps all the human actors in those scenes have boarded the long train, by which no return tickets are sold. Engineer Ally, a veteran on the road, well known to Chesapeake and Ohio men, was for many years the man who pulled the throttle of No. 14 on the Virginia Central road. The son of this old engineer runs an engine on the road now. The old man is side-tracked by the Dispatcher of the Universe. Mr. Pelter, the present engineer, used to stand in the cab, and, with the fidelity of a hero, still stands by his old friend. The old engine does effective work in its present position, and, under the careful management of Mr. Pelter, years of service may yet be left the hero of other days."

A report on the collision which occurred on the 7th January at Manor Park Station, on the London and Colchester line of the Great Eastern Railway, when, during a dense fog, the 5 p.m. express passenger train from London for Norwich, while stopped by the bursting of a Westinghouse brake tube near the down advanced starting-signal at Manor Park Station, was run into at the rear by the 5.3 p.m. passenger train from Liverpool-street for Chelmsford, has been published, and the conclusion is that this very serious collision between two down fast passenger trains, timed to leave Liverpool-street Station within three minutes of each other, was primarily caused by the mistake of one fog-signal-man, and by the want of proper knowledge of his duties on the part of another. One immediate cause of the collision was the mistake made by the fog-signalman on duty at Manor Park down distant-signal. This man states that after the 5 p.m. train had passed he put down two fog signals on the rails, and went and stood by his hut, where there was a fire, till he heard the 5.3 p.m. train approaching, that he then went up close to the signal-post, saw, as he thought, the distant-signal light showing white, consequently removed the fog-signals from the rails, and showed the driver a white light as he passed. There is no reason whatever to suppose that the signalman had lowered the Manor Park down-distant signal after he had put it up to protect the 5 p.m. train, or that the arm had not responded to the action of the lever in his cabin, but the fogman's mistake was probably caused by his seeing the white light showing between the spectacle and the lamp when he looked up at it from a point about a yard from and on the London side of it. It did not occur to him to examine the position of the balance weight, which was about 4ft. from the ground; had he done so this would have told him whether or not the signal was at danger. But for this unfortunate mistake of his, the engine of the 5 3 p.m. train would have exploded the fog-signals, and the driver would have been prepared to stop at Manor Park home-signal.

NOTES AND MEMORANDA.

To counteract the formation of blowholes in mild steel castings, Nordenfelt adds a small quantity of aluminium to the molten metal; and it is reported that this addition increases the fluidity of the metal while favouring the disengagement of gas, without impairing the quality of the casting.

According to the communication of the mining engineer, L. P. Dolinski, to the Society of Natural Science of Odessa, a very important discovery of cinnabar mines has been recently made in the mining region of the Don in Russia. The ore is said to contain from 69 to 80 per cent. of pure mercury.

Mr. H. S. Brown, of New York, employs the following method for making large castings, such as steam cylinders, which is said to effect a considerable saving in time and expense. In a pit, tubbed like a mine shaft, a platform is moved up and down by means of a hydraulic press. After the mould is constructed on the platform at the floor level, the press is lowered for pouring the metal, and again raised for removing the casting.

The official statistics of the coal production of the United Kingdom for 1885 show that the total output during the year was 159,351,415 tons, with 520,632 colliers employed, compared with 160,757,779 tons and 520,360 colliers employed in 1884. Owing to the strike in Yorkshire, which lasted two months, the production of the coalfields in that county was diminished by 722,366 tons as compared with the preceding year. The adjoining coalfields of Derby and Notts profited by the stoppage and increased their output by 883,002 tons.

Experiments of Herr J. Koeing on self-purification of rivers, act on the fact that water possesses the power of rapidly absorbing oxygen when presented to it in the state of spray or a thin layer. The author had an apparatus constructed of finely perforated metal, over which he caused a stream of water to flow, most of it descending in fine rain and being largely in contact with the air. Ordinary potable as well as sewage waters were experimented with, and the results were very satisfactory, the oxygen absorbed being considerable in amount. It is recommended that when sewage water is discharged into rivers such should be chosen as have a long course and a rapid flow, presenting considerable surface to the atmosphere.

A new method for producing hydrogen gas has been described. Superheated steam is passed through red-hot coke in a retort. The result is a mixture of hydrogen and carbonic oxide, or what is known as water gas. These gases are then passed on into a second retort, strongly heated, in which a quantity of some refractory substance, such as firebrick, is placed. At the same time jets of steam superheated to the point of dissociation are passed into the retort, the result being a mixture of carbon dioxide and a double amount of hydrogen. The carbon dioxide can be absorbed by passing through milk of lime, and thus pure hydrogen be obtained and collected in a gas holder. One ton of coke is stated to correspond to 3200 cubic metres of gas, and the cost is given as 0 015 franc per cubic metre.

A very interesting paper on the irrigation of the oases of Merv and Akhal-Tekke was recently read by M. Pokrovski-Kozel at St. Petersburg, before the Society for the Assistance of Russian Trade and Commerce, Count Ignatieff being in the chair. The lecturer considers the Merv oasis as one of the most fertile spots on the earth. Wheat, rice, and other cereals cultivated by natives for home consumption, yield beautiful crops. The oasis includes about 900,000 acres of cultivable land. But in order to cultivate them it would be necessary to colonise the oasis with civilised pioneers, and to spend about £120,000 on the restoration and extension of the splendid system of canals built up by the Arabs a thousand years ago, and preserved until now in some parts—as, for instance, at the mouth of the river Murhab, about fifty miles from Merv. These canals are 14ft. deep and 70ft. wide, and partly used even now by the Merv Turcomans for the irrigation of their fields, though in a primitive manner. The Akhal-Tekke oasis is not so rich as that of Merv, but still it has about 900,000 acres of land suitable for culture. It covers the space of seven miles along the railway line from Mikhailovsk Bay to Khizil Arvat, and could be irrigated by the water from the river Tejen.

At a recent meeting of the Paris Academy of Sciences a paper was read on "The Constitution of the Earth's Crust," by M. Faye. It is argued that the surface of the globe cools more rapidly and to a greater depth under the oceans than on the continents, because heat radiates more freely through liquid than through solid bodies. And as this discrepancy has existed for millions of years, the crust of the earth must now be denser under the waters than under dry land. Hence, in the pendulum observations and other calculations made relative to the figure of the globe, no account should be taken of the attraction of the continental masses lying above sea-level, this excess of matter being compensated lower down by a corresponding diminution of density. In the same way no account should be taken of the feeble attraction of the oceans, because this also is compensated a little lower down by the greater density of the solid crust under the oceanic basins. The same conclusion is pointed at by the now completed triangulation of India, Col. Clarke remarking that it would seem that these pendulum observations have established the fact—previously indicated by the astronomical observations of latitude in India—that there exists some unknown cause, or distribution of matter, which counteracts the attraction of the visible mountain masses.

Mineral lubricating oils are often adulterated by the addition of cheap oils. The following tests by Herr P. Falke, published in the *Journal of the Society of Chemical Industry*, may serve for ascertaining their purity:—(1) Colour. The oil must be perfectly clear, and as light as possible. It should not be turbid, which may be caused by the presence of water or other substances. If the oil be turbid by water, it froths on heating, whereas a turbidity produced by solid matters, such as paraffin, disappears on warming, and reappears on cooling. The characteristic feature of all mineral oils is their blue fluorescence. (2) Smell. The smell must be as little perceptible as possible, and should not increase on warming the oil. It mostly smells like petroleum. (3) Behaviour on shaking with water. If three parts of oil be shaken with one part of water in a test tube, warmed, and allowed to stand in a water-bath for some time, no emulsion must appear between water and oil, but the latter should stand clear above the water, which should opalesce only very faintly, and be perfectly neutral. (4) Behaviour to caustic soda. The oil should not be attacked by a caustic lye of 1·40 sp. gr., neither in the cold nor on warming. Saponification is a certain evidence of the presence of animal or vegetable fat. (5) Behaviour to sulphuric acid. On mixing the oil with sulphuric acid of 1·60 sp. gr. it must not be coloured brown, but yellow at the most; otherwise resins have not been carefully removed. (6) Behaviour to nitric acid. On mixing oil with nitric acid of 1·45 sp. gr. a rise of temperature takes place, which should not exceed a certain limit. (7) Specific gravity. Although the specific gravity of oils suitable for lubricating purposes varies from 0·875 to 0·950, only a very small latitude—0·003 at the most—is permitted in contracts. It is invariably taken at 15 deg. C. (8) Behaviour on exposure to the air and heat. Spread in a thin layer and exposed to the air for some time, its consistency must not change, nor should it become acid on being heated continuously above 150 deg. Heated in open vessels it should not give off combustible vapours, except at a high temperature, which is usually specified in contracts. Its flashing point should be ascertained in Abel's apparatus. (9) Behaviour at a low temperature. It should bear a low temperature without losing its lubricating power, nor should it become solid even at a very great cold, but it should rather assume the appearance of an ointment. (10) Test for consistency. This determination is most important. The velocity of efflux of pure rape-seed oil is taken as a standard, and that of the mineral oil compared with it. 100 cc. of the sample are allowed to flow out of a burette with tap, while the time which is required is noted down.

MISCELLANEA.

Messrs. Dick Kerr and Co. have received orders to construct ten tramway engines for the North London Tramway Company.

The Barrow Shipbuilding Company has been honoured with instructions from her Majesty's Government to construct for it a set of twin screw engines of 2000 indicated horse-power to be fitted on board H.M.S. Buzzard towards the end of the year.

The moulders in the iron foundries of Staveley, Claycross, and Chesterfield have accepted a reduction of from 1s. to 2s. a week. In the engineering departments of the Sheffield district the movement for a reduction of wages by 7½ per cent. is being pressed forward.

If the postal authorities would force their stampers to use a little more care and provide them with india-rubber stamps, it would be unnecessary that they should smash light parcels, post boxes, as is now often the case; some boxes having the bottoms smashed in and the contents damaged.

A large International and Colonial Exhibition—Mining, Engineering and Industrial—is proposed to be held in Newcastle-on-Tyne in the summer of 1887, under the patronage of the Duke of Northumberland and presidency of the Earl of Ravensworth. The first general meeting of the vice-presidents and members of the various committees was held in the Literary and Philosophical Society's lecture room, Newcastle-on-Tyne.

Although Melbourne is regarded as a healthy city, its inhabitants are often puzzled to account for its epidemics. The city has recently been visited by typhoid fever, and as many as eleven cases reported in one day. The health authorities were doing their best to mitigate the outbreak and to discover its source. Sanitary engineers and biological sanitarians might find something more to do abroad than some of them are finding at home just now.

Such of our readers as are interested in artillery matters have probably noticed a paragraph in the *Times* stating that the New Krupp guns placed in the Dardanelles forts have signally failed "some bursting, killing several gunners, and others being utterly unfit for their intended use as to range and precision." We have made inquiry, and cannot find any substantial foundation for this report. Officers remaining in Constantinople on their way back from the Bucharest trials know nothing of it. It does not appear likely that Krupp guns would suddenly be found to fail in three totally different respects, namely, in strength, range, and in accurate shooting. Probably some accident may have occurred which has given rise to this report, but the report in the above shape may be safely rejected.

The French Minister of Commerce, M. Lockroy, has submitted his project for a universal and International Exhibition at Paris in 1889 to the Council of Ministers, who have unanimously approved of it. Before bringing the matter before the Chambers, however, the definite reply of the Paris Municipality as to its participation has to be received. In accordance with the project, the Minister of Commerce is to act as general commissioner; and three engineers are to be charged, one with the construction, a second with the classification, and a third with the management of the Exhibition. A general committee of 200 members, chosen from the most eminent men in political, artistic, commercial, and industrial circles, is to constitute the jury. Among the general committee will be comprised the controlling committee of forty-three members—eight for the Paris Municipality, which will guarantee eight million francs; seventeen for the Government, which will guarantee seventeen millions; and eighteen for a company, which will guarantee the remaining eight millions.

Consequent on a survey of the main sewer under the Palace of Westminster, an interim report of the committee on the subject has been presented by Sir Henry Roscoe. "The committee are convinced that the air of the Palace of Westminster is subject to contamination by sewer gas emanating from the low level sewer of the main drainage of the metropolis with which the system of drainage of the palace is in direct connection. Undoubted evidence has been obtained that sewer gas from this source passes into the drainage system of the palace in times of flood, and under the circumstances, owing to the absence of proper ventilation in the low level sewer above referred to and to other causes, the committee are convinced that a complete reconstruction of the main drain passing under the Houses of Parliament and an entire alteration of the means of discharging the sewage from the palace into the main low level sewer are urgently required for the safety of the members of the Legislature and of the officers residing within the precincts of the palace. The committee therefore beg to recommend to the House that the Board of Works be instructed at once to carry out certain remedial measures which the committee are now prepared to suggest, and which in their opinion will effect the desired result."

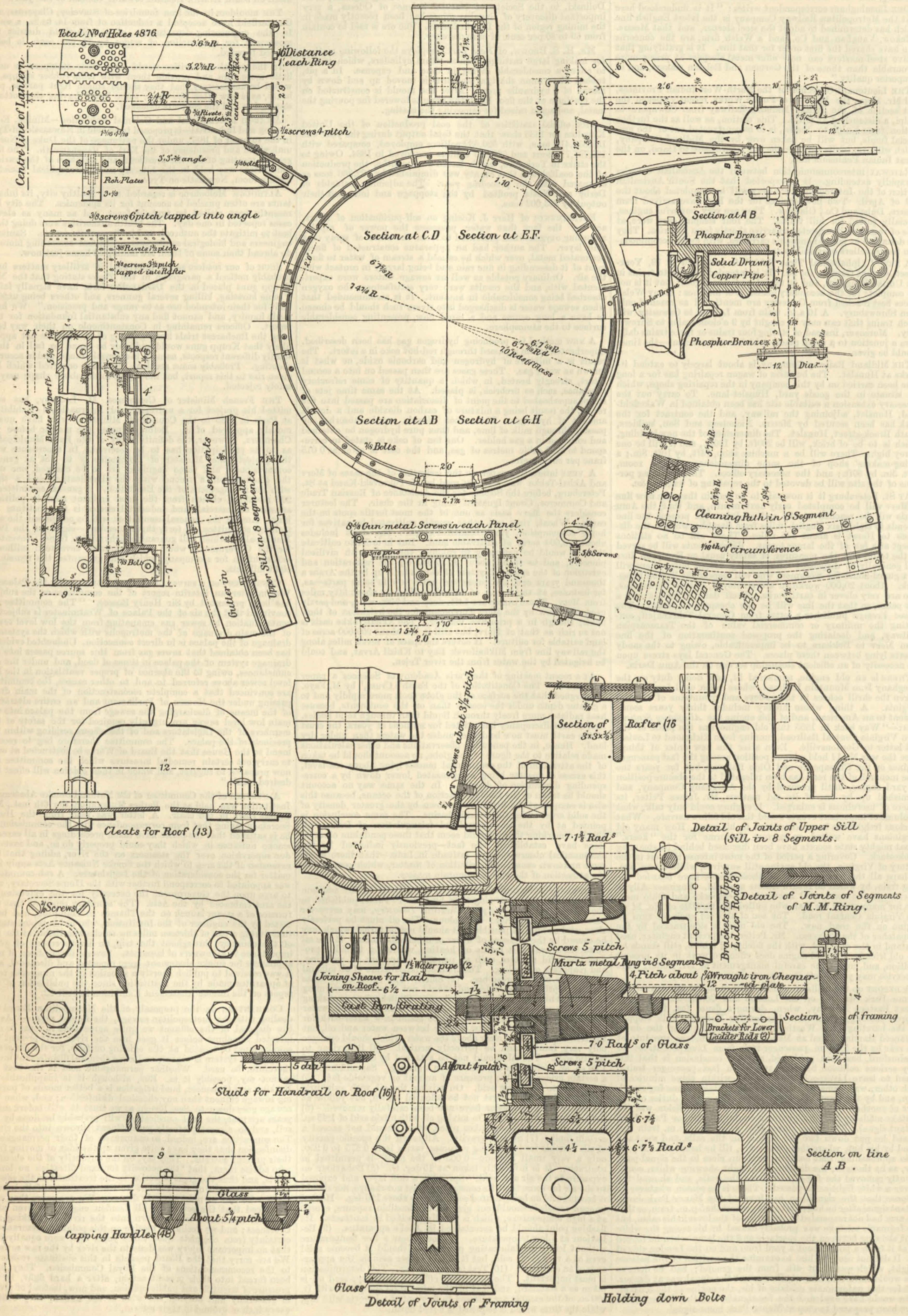
A meeting of the Committee of the National Smoke Abatement Institution was held at the Parkes Museum on the 6th inst., Mr. Ernest Hart in the chair. A letter was read from the Home Secretary saying that from correspondence with the commissioners he is satisfied that the police have taken proceedings in all cases of smoke nuisance in which they could properly do so, and exercise due supervision over the steamers on the river, adding that the extension of the area to which the Smoke Nuisance Acts apply is a matter for the consideration of the Legislature. A sub-committee was appointed to correspond further with the Home Secretary, and to urge upon the Government the necessity for the extension of the area embraced by the Acts. The secretary reported that the furnace of a steam launch on the Thames at Hampton, had been tested by the engineer of the Institution, who in his report stated that during a run of thirteen miles no smoke was visible at the top of the chimney throughout the trip, an improvement of great importance to all owners of launches. Several descriptions of new appliances for smoke abatement were reported and discussed, and it was resolved to publish shortly a selection of the numerous tests of apparatus made by the Institution since the publication of the report on the Smoke Abatement Exhibition in 1881-82.

Commenting on the proposals of the Metropolitan Board for dealing with the metropolitan sewage, the *Lancet* says:—"As to the disposal of the effluent we quite agree that it must be disinfected somehow before it goes into the river. At present the sewage must be treated at the existing outfalls, for the danger of the present system is urgent, and some chemical disinfectant must, therefore, be used. Whether permanganic acid is the best we cannot say, possibly it is. But, although it is inapplicable at Barking and Crossness, land irrigation is a better means of purifying sewage effluent than any chemical disinfection; and, when the sewage goes down to Sea Reach, as we trust it will before many years are past, the final purification will probably be done by the soil, and an almost perfectly pure effluent thrown into the river. The committee are, indeed, so enamoured of their permanganate disinfection that they have quite given up the idea of moving from their present outfalls. They say, on the authority of the chemists who advise them, that 'the necessity for land filtration no longer exists, and thus the great objection to the treatment of the sewage and the discharge of the effluent at the present outfalls is overcome. To this we most strongly demur. We are more than ever convinced that the sewage of all London ought not, even after chemical treatment, to be thrown into the river at Barking and Crossness; and we decline to receive on this point the assurance of certainty from chemists who, three years ago, were equally sure that no important injury was done to the river by the raw sewage. We are sorry that the Board persists in this obstinate resistance to the recommendations of the Royal Commission. They have been forced into their present action, after a hard fight, by the pressure of scientific and public opinion, and now, instead of giving in gracefully and obeying the wish of the nation, they contest every inch of ground in their retreat."

LIGHTHOUSE LANTERN, BISHOP'S ROCK.

SIR JAMES DOUGLAS, ENGINEER.

(*For description see page 296.*)



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PUBLISHER'S NOTICE.

**** The Publisher begs to announce that next week* THE ENGINEER *will be published on* THURSDAY *instead of* GOOD FRIDAY. *Advertisements intended for that Number must be forwarded not later than Six o'clock on Wednesday evening.*

****** With this week's number is issued as a Supplement, a Two-Page Engraving of the 750-H.P. Triple Expansion Engines of the s.s. Coot. 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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TO CORRESPONDENTS.

Registered Telegraphic Address—"ENGINEER NEWSPAPER, LONDON."

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

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

LOG CHIP.—*The scheme has been tried in an Atlantic steamer and given up.*

J. D.—*Your letter only reached us on Thursday morning—too late for publication.*

L. K.—*You can solder lead with lead by using chloride of lead instead of chloride of zinc as a flux.*

ORIENTAL (Japan).—*The problem has been solved long since, and nothing would be gained by the publication of your letter.*

QUININE MACHINERY.

(*To the Editor of The Engineer.*)

SIR,—Will any of your readers kindly give me the names of the manufacturers of machinery for quinine preparation from the bark? Either Continental or English makers will do. JOHNS.

Penarth, April 9th.

CUBIC AND HEATING CAPACITY OF SIEMENS REGENERATORS.

(*To the Editor of The Engineer.*)

SIR,—Can any reader of THE ENGINEER give me the following information, or where it can be obtained from books or papers? What is the cubic capacity—total in the four—in the Siemens steel melting regenerators to take up the heat per lb. of coal gasified per hour. W. S.

Guisbrough, April 8th.

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

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MEETINGS NEXT WEEK.

THE INSTITUTION OF CIVIL ENGINEERS, 25, Great George-street, Westminster, S.W.—Friday, April 16th, at 7.30 p.m.: Students' meeting. Paper to be read, "Experiments on the Relative Strength of Cast Iron Beams," by Ed. de Segundo and Leslie S. Robinson, Students Inst. C.E. Mr. M. am Ende, M. Inst. C.E., in the chair. Tuesday, April 20th, at 8 p.m.: Ordinary meeting. Paper to be read with a view to discussion, "Brickmaking," by Mr. Henry Ward, Assoc. M. Inst. C.E. There will be no meeting on the Tuesday in Easter week.

ROYAL METEOROLOGICAL SOCIETY, 25, Great George-street, Westminster, S.W.—On Wednesday, April 21st, at 7 p.m., the following papers will be read:—"The Climate of Killarney," by the Ven. Archdeacon Wynne, M.A., F.R. Met. Soc. "Note on the Probability of Weather Sequence," by Lieut.-Colonel C. K. Brooke, F.R. Met. Soc. "Account of the Cyclone of June 3rd, 1885, in the Arabian Sea," by Captain Maurice T. Moss. "Results of Solar Radiation Observations in the Neighbourhood of Birmingham, 1875-1884," by Mr. Rupert T. Smith, F.R. Met. Soc., M. Inst. C.E "Results of Meteorological Observations made at Kwala Lumpor, Malay States, 1884," by Mr. A. W. Sinclair, L.R.C.P.

THE ENGINEER.

APRIL 16, 1886.

HEATING FEED-WATER AT SEA.

SPEAKING broadly, an economy of about 13 per cent. can be effected by raising the temperature of feed-water from 60 to 212 deg. Fah. The calculation is very simple. Let the pressure be 120 lb., and the temperature of the water 60 deg. Each pound of steam will contain 1160 units, measured from 60 deg. That is to say, each pound of water pumped into the boiler at 60 deg. will carry away with it, in the shape of steam, 1160 deg., which it must obtain from the furnace. If now, by means of heat otherwise wasted, we raise the temperature of the feed to 212 deg., then each pound of steam will still carry away 1160 deg.; but of this, 212 − 60 = 152 deg. will have been obtained, not from the furnace direct, but from the waste heat, and the saving will be $\frac{1160}{152} = 7·63$. That is to say, more than one-seventh of all the fuel burned, or nearly 13 per cent., will be saved. If the temperature of the water supply is lower, or that of the feed-water higher, then the saving effected will be augmented. Now about the maximum economy claimed for the triple expansion, as compared with the double expansion system, is 15 per cent. Hence it follows that if the temperature of the feed-water at sea were raised from 50 deg. to 212 deg. by waste heat, the double-cylinder compound engine would be as economical as the triple-cylinder engine, provided the latter worked with cold feed. This deduction does not apply, however, in practice, for the feed-water is usually delivered into a marine boiler at about 120 deg. from the hot well; and our figures will stand thus:—Taking the pressure at 120 lb., as before, each pound of steam carries away—measuring this time from zero, which simplifies our figures and comes to the same thing in the end—1220 deg., of which 120 deg. are supplied by the feed-water and 1100 by the furnace. That is to say, $\frac{1220}{120} = 10$, or about one-tenth of the whole heat required comes in with the feed-water. If the temperature of this last had been that of the sea, or say 50 deg., then we should have $\frac{1220}{50} = 24$, or only $\frac{1}{24}$ part of all the heat required would be supplied with the feed-water. If the feed had been pumped in at 212 deg., then $\frac{1220}{212} = 5·75$. Under ordinary circumstances 10 per cent. of all the heat needed comes from the hot-well. If the feed were raised to 212 deg., then about 17 per cent. of all the heat would come in with the feed, and the saving to be effected as compared with the ordinary method would be about 7 per cent., or, say, one-half that got by tripling expansion.

At a time when economy is so much studied at sea, it seems at first sight strange that more attention than it has yet received has not been directed to the heating of feed-water. There are, however, many difficulties in the way, none of which seem, however, to be insurmountable. Two methods suggest themselves. The first is to pass the exhaust steam through a subsidiary condenser, so to speak—that is to say, a box containing a nest of tubes through which the feed-water pumped from the hot well shall be forced while on its way to the boiler. The idea involved is that the steam will be hotter in this box than it will be subsequently on the surface condenser. The fact is, however, that the temperature in the exhaust pipe is very little, if at all, above that of the condenser; certainly not enough to make the adoption of the device we have just named worth having. Nor can it be otherwise. The temperature of steam in an exhaust pipe or anywhere else cannot exceed that due to its pressure. To begin with, the steam in a compound engine has a terminal pressure far below that of the atmosphere, so that the jet could not possibly heat the feed-water to 212 deg.; and in the second place, the pressure in the exhaust pipe assimilates itself to that in the condenser the moment after the slide valve opens the port to the exhaust pipe. Nothing whatever is to be had from waste steam. The second plan consists in pumping the feed-water through a set of pipes arranged in the smoke-box. There is always plenty of heat available here; but it is not easy to get in all the heating surface needed without interfering with the draught and with access to the tube ends. It does not appear, however, that there would be any insuperable obstacle in the way of mounting the feed heating tubes in a swing frame, which could be turned right out of the way just as the smoke-box doors are when necessary; indeed the frames might be secured to the smoke-box doors. Of course cocks would be placed in the line of the hinges, to cut off the feed when the doors were opened. A clever draughtsman would have little difficulty in working this suggestion into a practical shape. There would remain, however, the objection that the tubes would soon become coated with soot, and would lose efficiency. The only way out of this would lie in the use of moving scrapers, such as those employed on shore under somewhat similar conditions; but scrapers would no doubt be intolerable nuisances at sea. A very feasible arrangement was, however, suggested by Mr. Foley at a recent meeting of the North-East Coast Institution of Engineers. In the discussion on a paper on "Forced Draught," which will be found in another page, he proposes to do away with the back uptake, in the ordinary sense, placing it, so to speak, outside of the boiler instead of inside, and pumping the feed-water into a casing surrounding it. No doubt this would effectually raise the temperature of the feed-water, but it would do this not with waste heat, in the ordinary sense of the word; and the efficiency of the tube surface would no doubt be somewhat reduced. Heaters round funnels and in the funnel casing have been found very efficient. They have, however, an evil reputation as sources of danger, and consequently may be put out of consideration.

There is a system of heating feed-water at sea about which we have as hitherto said nothing, because the results obtained are so flatly opposed to what would have been anticipated, that we held our peace about them until we could satisfy ourselves that the statements made concerning these results are true. In the steamers of the Peninsular and Oriental Company Weir's system has been in use for some years and given great satisfaction. Steam is drawn from the intermediate receiver and blown into the feed-water, the temperature of which is raised very nearly to that of the steam in the receiver, or, say, to about 250 deg. The practical result at sea is a saving of 8 per cent. effected by raising the temperature of the feed, and calculation shows that about 4 per cent. is lost by the withdrawal of steam which would otherwise have gone to augment the work done in the low-pressure cylinder, thus leaving a net saving of 4 per cent. There appears to be no doubt whatever that this astonishing result is obtained. But more startling results have been obtained by Mr. Kirkaldy, of West India Dock-road. He takes steam direct from the boiler, employs it to heat the feed-water, and secures an economy of over 7 per cent. At first this statement seems to be incredible. We find, however, a concensus of opinion among engineers and shipowners who have tried it. The result obtained was not anticipated. Mr. Kirkaldy held that it would be a good thing in the case of cargo boats, usually pressed for time, if their boilers, after being emptied in port, were filled up with hot water instead of cold. To this end he arranged apparatus by which the donkey or steam winch boiler could supply steam to heat the cold feed before it was pumped into the boiler. This worked very well, and he extended his operations so that the feed might always go in hot, not to save fuel, but to prevent the injurious strains which cold feed-water is likely to set up in a boiler. He argued, of course, that the steam can give up no more heat to the feed-water than it withdraws from the boiler, and that, as a matter of course, there could be no economy. It turned out, however, that the boilers to which the arrangement was fitted steamed better and held their pressure more steadily than before; and the result of careful trials leaves no doubt in our mind that the Kirkaldy heater does effect a very considerable saving in fuel. The result seems to be due, in some yet-to-be-explained way, to an augmentation in the efficiency of the heating surface of the boiler, probably due to better circulation. Of course, as we have said, as nothing can be taken out of the boiler that has not been first put into it, no direct economy can result from the use of steam drawn from the boiler to heat feed-water. Secondary influences are at work, and to these the economy effected is no doubt due. Mr. Kirkaldy's experience thus bears out Mr. Weir's. The whole subject is very curious and interesting, and deserves further consideration and investigation.

THE CHEMICAL TREATMENT OF THE LONDON SEWAGE.

THE Metropolitan Board has boldly decided on treating the whole sewage of the metropolis by the chemical process which has been undergoing elaboration under its auspices during the last two years. In the resolution thus arrived at, the Board has the warrant of two reports, signed by Sir F. Abel, Dr. Odling, Dr. Alexander W. Williamson, and Dr. Dupré. These are high authorities; and, although it may be said that three of them were not originally disposed to admit that the Thames was in an offensive condition, yet there is the remarkable fact that one of the four—Dr. Williamson—was himself a member of the Royal Commission presided over by Lord Bramwell. Since that Commission took evidence, the chemical operations at Crossness have doubtless thrown further light on the subject, so as to justify some modification of the views previously entertained. The second, and final, report of the Royal Commission bears the date November 27th, 1884, whereas the first report from the four chemists is dated eleven months later. The interval was one of activity at Crossness, and the Metropolitan Board wished to know whether the process devised by Mr. Dibdin would work satisfactorily. Mr. Dibdin, the Board's chemist, was then using 3·7 grains of lime and 1 grain of protosulphate of iron per gallon of sewage. The chemical referees, if we may so term them, expressed their opinion that the result would be "a very great gain over the discharge of untreated sewage;" and they further declared that the process, apart from the precipitating action, did exert "a distinct purifying effect upon the liquid part of the sewage." On the other hand, they considered that the effluent retained a sufficiently unpleasant odour to prohibit its discharge into the river during warm weather at all states of the tide. Had the report ended here, the verdict would have been a little discouraging; but there was an important supplement. The referees saw reason to believe, from what they had witnessed in the way of experiment, that the addition of manganate of soda and sulphuric acid to the effluent would so far deodorise and purify it as to allow of its being afterwards discharged into the river "at all states of the tide." It was, at the same time, a question whether this supplementary treatment would be necessary in the winter months. In their second report the referees decided that the deodorising process would be unnecessary during a considerable part of the year. For the purpose of deodorising the effluent during warm weather they recommended crude commercial manganate of soda, ranging in quantity between 0·5 grain and 1·5 grain per gallon of effluent, with a proportion of sulphuric acid equal to about one-third of the crude manganate.

The report of the Works Committee of the Metropolitan Board in reference to this subject explains that the evidence given before the Royal Commission was of so conflicting a character, that it was felt nothing short of a prolonged series of experiments on a tolerably large scale, extending over some months, and including day and night, would afford the information necessary before working plans could be drawn up for the erection of plant for the treatment of the whole of the sewage. Thus the Board went seeking for new light, and if the report, which includes Dr. Williamson as a signatory, is to be allowed any weight, we must believe that the Board found the object of its search in the experiments conducted by Mr. Dibdin. But behind the precipitation and the deodorisation there was the *bête noir* of the sludge. To purify the sewage was one thing, but to get rid of the sludge was another. Reckoning the daily volume of the sewage at about 150 millions of gallons, the resultant sludge is estimated at 3000 tons. This, when pressed, is reckoned at 850 tons of cake. It is well that Mr. Dibdin is able to use a comparatively small quantity of chemicals. The lime which he introduces will add about 40 tons per diem to the actual sewage residuum, which is considerably less than the bulk which most chemical processes would leave to be dealt with. Still, there is the sludge, and no small quantity either. If some enterprising individual would take the lot, with all its virtues, he might have it for nothing, even though the Board had previously borne the expense of pressing it. The stuff cannot be burnt, for the fumes of its combustion are found to be objectionable, even in the not very savoury neighbourhood just outside the metropolitan boundary. Digging it into land is not an easy matter. Giving it away to the farmers is not altogether hopeful, considering the depressed state of agriculture. It might be used to raise the level of the low-lying lands bordering on the Thames; but the Board contemplates the contingency of flinging it all into the German Ocean. What effect this would have, it may interest some of the experts to determine. The sludge may feed the fishes, it may create shoals, it may go ashore, or it may happily disappear altogether. Some experience on this point has been gained at New York and Boston, but the London sludge will be on a scale pre-eminently large. We have already dealt with the proposal of Mr. J. Orwell Phillips, who elaborated a plan whereby the Beckton screw colliers would be made available for carrying off the sludge in the form of compressed cakes to be thrown overboard at sea. The Board has since invited designs for ships specially constructed to carry away the sludge, and have received as many as twenty-three designs in response. In respect to other arrangements, the Works Committee state that the contract drawings for the enlargement of the Barking sewage reservoir, and arranging it for precipitation and purification works, are in a forward condition, so that the contracts may be let in the course of the coming summer. The works may be completed and brought into full operation in the summer of 1888. Until then reliance is placed on the deodorising works already provided, and which, it is believed, will prevent any nuisance at the Barking outfall. Throughout the approaching summer nine millions of gallons of sewage are to be precipitated daily at Crossness, the remainder being deodorised until the process of precipitation has been extended to the whole of the southern sewage. With regard to the sludge, so much of it as nobody will accept gratuitously is to be sent in lighters out to sea, both in the liquid and in the cake condition, in order to ascertain the cost and effect of this mode of getting rid of it.

The cost of all these operations is, of course, a serious matter. Yet there is encouragement even in that direction. The capital expenditure for dealing with the sewage at the present outfalls is reckoned at about £750,000. The annual cost, including interest on capital, depreciation of plant, wear and tear, and all other expenses, is estimated at £118,000 per annum. When we referred to the subject some time ago, the annual cost was a trifle below this amount, but the first cost, including £131,000 for barges to carry the sludge, was £1,140,000. The Royal Commissioners reckoned that the chemical treatment of the London sewage would cost £200,000 per annum; but in so doing they were aiming at a higher degree of purification than that which is considered necessary by the Metropolitan Board. At Barking and Crossness there is no need to fear any pollution of a drinking supply, and hence a different standard of purity is permissible than would be proper in a part of the stream situated above the intakes of the water companies. Associated with the treatment of the sewage at the outfalls is another operation, which as yet has attracted but little notice. Commencing in July last year, the Board has proceeded to apply manganate of soda and sulphuric acid to the sewage *in transitu*. At more than a dozen stations on the lines of the great intercepting sewers these purifying re-agents have been introduced, the effect being, not to occasion precipitation of the solids, but to deodorise the sewage and prevent the escape of noxious gases from the ventilators. A further advantage consists in the fact that the sewage will arrive at the outfalls in a deodorised condition—a circumstance which, the Works Committee remark, will materially assist in the production of an effluent of a far better character than would otherwise be attainable. The character of the occasional discharge from the storm overflows will also be improved. Anything that can assist the difficult process of sewer ventilation is especially to be valued, and the plan thus commenced by the Metropolitan Board will strike most persons as a happy expedient, the sewage being dealt with before it has time to become putrescent. The principle may be capable of extension, and so long as there is no increase of deposition in the sewers, the deodorising process may simply be limited by the question of cost. If the District Boards and Vestries will each, in their own respective localities, imitate the example of the parent Board, the result will be so much the better. Another incident in this history is the extraordinary cheapening in the price of manganate of soda, in consequence of the development in the manufacture of this article by Mr. Dibdin. Owing to the limited supply and great cost of the manganate, Mr. Dibdin undertook to manufacture the article on a large scale. This so far stimulated the action of the manufacturing chemists that they now come into the market with large quantities of manganate of soda; and whereas some time back the price was £40 per ton, and the supply altogether inadequate, the figure has fallen to £11 per ton, and the supply is practically unlimited. The real use of the manganate of soda, in conjunction with sulphuric acid, is the production of permanganic acid. It is represented by the Board that the purifying agency of this compound is such as to render filtration through land unnecessary. This may be called the turning-point of the whole controversy. It is urged in certain quarters that the Board should implicitly observe the recommendations of the Royal Commissioners. But the reply of the Board is that, by means of this cheap and extensive supply of manganate of soda, it is practicable to apply permanganic acid on a scale which provides an equivalent for land filtration. Probably it is to this consideration that we may mainly attribute the approval which Dr. Williamson now accords to the treatment of the sewage at the existing outfalls. According to the available light on the subject at the time when the Royal Commissioners drew up their final conclusions, they advised that if the sewage were chemically treated at Barking and Crossness it should only be as a temporary measure, unless the effluent were subjected to intermittent filtration through a sufficient area of land. If the same result can be produced by chemical means, and at a greatly reduced cost, there is fair ground for the argument that the Board should not be forced to comply with the mere letter of the law, while amply fulfilling its spirit.

It is impossible to look at the plans of the Metropolitan Board, admirable as these may be, without remembering that another project has been brought forward, based on ample details, and possessing many features of merit. Of course, we are alluding to the Canvey Island scheme of Mr. Bailey Denton and Lieut.-Colonel Jones. In the last report of the Works Committee of the Metropolitan Board in reference to this subject, the Canvey Island plan is discussed in a manner which seems hardly fair. The report of the Committee states that one element in the plan thus brought forward was that the Board should deliver the whole of the London sewage over to the projectors, accompanied by an annual payment of £110,000. The report goes on to say, "The view taken by your Committee, and also by the Board itself, upon this part of the scheme was that it would not be consistent with the Board's duty to hand over the sewage to be dealt with by other persons in consideration of a very large annual payment, and that the Board could not rid itself of its responsibility in that manner." A reply on this basis was sent to the Home Secretary, through whose department the Canvey Island project was in the first instance forwarded to the Metropolitan Board. The report ought to go on to say that to meet this objection Messrs. Denton and Jones offered to transfer their interest in Canvey Island to the Metropolitan Board, so that the latter body might keep the sewage under its own control, and carry out the plan without further reference to the original promoters. No doubt the Committee's report is correct so far as it goes. The first proposals were rejected for the reason assigned. But why do we hear nothing of the amended offer? As the report stands, the reason given for rejecting the Canvey Island scheme is inconclusive, seeing that it merely refers to a past phase of the question, and makes no allusion to the form which it now assumes, this latter phase being entirely free from the objection urged against the first. It may be very true that in its amended form the project is not such as the Board feels called upon to accept. But due respect to all parties, even to the Board itself, demands that the true reason should be specified. We apprehend that the final objection to the Canvey Island scheme is really its costliness. Here, however, we touch a debated point, Mr. Bailey Denton contending that the plans of the Metropolitan Board will prove more expensive than the project which he has brought forward. The Board has evidently a different view of the case, and if the question is pressed, perhaps we shall hear more on that point. The Works Committee put into their report a statement based on information derived from Sir Joseph Bazalgette, that if the outfalls were removed to Hole Haven, the capital cost would not be less than £3,725,000, while the annual expenditure, including the treatment of the sewage there by precipitation, would be £215,000. As this latter amount is nearly £100,000 more than the annual cost of the scheme which the Works Committee have recommended, and which the Board has adopted, it might be inferred that carrying the outfalls still further on, so as to reach Canvey Island, would exhibit a yet greater excess. A subsidiary topic is that which relates to the proposal of Mr. John Orwell Phillips to carry the sludge out to sea in the Beckton colliers, on their return voyage to the North. The *Times* has complained that no reference to this proposal is to be found in the report of the Works Committee. Had such reference been made, it is to be expected the Committee would have stated that Mr. Phillips' proposal proved to involve a much greater outlay than was anticipated. Here again is a question of estimates, and the Board will justify itself by saying that it has to guard the pockets of the ratepayers, and therefore has to do its work in the cheapest fashion it can devise. Relative cost thus comes under consideration, and if it should yet appear that the Beckton scheme is cheaper than any other for the removal of the sludge, we shall doubtless hear more about it, and we cannot say that we quite despair on that point. At all events, something must be done with the London sewage beyond what has yet been accomplished, and the Metropolitan Board is addressing itself to the task in a manner which shows that it has decided upon a plan which it will carry out without loss of time, unless prevented by some interference from without.

WAGES REDUCTIONS.

MANUFACTURERS have only two ways of meeting foreign competition—reducing the cost of production and lowering wages. The first can only be accomplished by using the most perfect appliances which engineers can produce; and perhaps there never was a time when the ingenuity of man has been so severely taxed in that direction as at present. Lowering wages goes steadily on, but it is becoming painfully evident that there is not much more to be obtained from the workmen. Employers complain of "Saint Monday" being still observed, and say the Belgian, French, and German artisans work longer hours and are more diligent while at their employment than the English workman. The latter is now beginning to ask why all the reductions should be made at the tail end. He wants to know why managers and secretaries should not have a turn of the screw as well as himself. One company tried to revise all salaries over £100 a-year, and the result was not encouraging. Yet there must be establishments where there are cats which catch no mice, particularly in limited companies, where waste is more frequent than in private concerns. It is only fair if a stand-up fight is to be made against the foreigner that all the sinews for it should not be drawn from one class. Economical production is only possible where all lend a hand, and we should certainly be sorry to see any of our artisans reduced to the position of those foreign workers who are stated to make scythes for fourpence a day, and live on black bread and pudding. That is the point—the starvation point—from which spring disorder and revolution.

LITERATURE.

The Cost of Manufactures and the Administration of Workshops, Public and Private. By Captain HENRY METCALFE, Ordnance Department, U.S.A. New York: John Wiley and Sons. 1885.

THIS book is interesting to English readers because it gives a glimpse at the manufacturing departments of American arsenals, and because also it touches on questions of administration which affect all manufactories, whether public or private. The author, an officer who seems to have had charge from time to time of different workshops, and who dates the present book from Benicia Arsenal, California, is evidently one of those men who take a keen pleasure in abstracting and tabulating the various incidents and expenditures of factory working, and he has now published for the benefit of his countrymen the system of store vouchers, time-sheets, piece-work, and ledger accounts which he has elaborated and established. This he has done lucidly, not only by description, but by giving in his book facsimiles of the various time-cards, order-tickets, ledger entries, and other forms by which labour is saved and comparison facilitated. But in applying to private factories rules which may have served their purpose in a Government arsenal there are, *inter alia*, two main points of difference, which must qualify any conclusions drawn from one to the other. One of these is the greater repetition of similar operations which generally pervades an arsenal as compared with a private factory; and the other is that the Government establishment is not working for profit, and therefore lacks that keenest of checks on wasteful or fraudulent administration which the self-interest of proprietors affords. The author himself remarks on both these circumstances, and some of his checks and safeguards are directed towards points where the systems of private and public factories diverge. Thus there are the much vexed questions of how to allot to each article manufactured a proper share of general expenses, and how much to allow for the depreciation of plant. In regard to the provision for general expenses, the choice among various methods must depend upon the nature of the work. Thus in America, as in England, some manufacturers allow so much per ton of materials or finished goods, and others so much per cent. on the wages paid. The former plan may be best where the cost of material is the chief item, but in engineering factories it is generally safest to allow for expenses a percentage on the wages, and those who investigate this method for the first time are sometimes surprised to find how large the additions must be. But the author adopts a third method which he has borrowed from Messrs. Sellers, the eminent tool makers, of Philadelphia. He adds for expenses according to the time employed on the job, whether the time be that of men or boys, high or low priced, on the assumption that the running expenses of a factory are a function of time. This theory needs care in application, for we can see that if used indiscriminately it might lead to absurd results. In regard to deterioration of plant, although the author points out the necessity of an allowance on this head so as to prevent too heavy a charge coming on particular years, no system is suggested, and in a public factory where no liquidation or cessation of business occurs, the necessity for a precise method does not arise.

Although the author's ideas are often novel, and are all of them interesting, some of his methods appear over-elaborated and cumbersome, and we think he might learn as well as teach if he had an opportunity of visiting Enfield and Woolwich. Among the illustrations in the book is a wages table given graphically by lines representing days and hours intersecting other lines representing rates of wages in dollars and cents. This plan will doubtless save time to those who are used to it, as compared with mental calculation with or without the aid of a ready-reckoner; but we do not think it so good as that on the tabulated and revolving wages cylinders used and sold by Messrs. Tangye Bros., of Birmingham.

MILAN CATHEDRAL COMPETITION.—Full particulars are being officially published by Sig. Hoepli, of Milan, of the conditions under which the international competition for designs for a new façade of the Milan Cathedral is to be conducted and the character of the work. He is also publishing explanatory plates for the use of competitors. The first prize of 40,000f. will be awarded to the design considered best if it is also decided to be worthy of execution. Several other prizes of 5000f., 3000f., and 2000f. will also be awarded.

THE INSTITUTION OF NAVAL ARCHITECTS.

THE twenty-seventh annual meeting of the Institution of Naval Architects commenced on Wednesday, under the presidency of Lord Ravensworth, in the Hall of the Society of Arts, John-street, Adelphi. There was a fair attendance. The report of the Council was read. From it we learn that the financial condition of the Institution continues to be satisfactory. The Council records with great regret the death of a most esteemed colleague, the late Mr. J. D'A. Samuda, who was for many years the vice-president of the Institution, and had been treasurer since its foundation. He always took the deepest interest in the affairs of the Institution, and endeavoured to further its prosperity by every means in his power. A biographical notice, containing a sketch of his career and an account of his services, is published in the last volume of the "Transactions." The Council endeavoured to show their respect for his memory by appointing a deputation, consisting of the President and Sir Edward Reed, accompanied by the secretary, to represent the Institution at his funeral. The new regulations for the correction of the reports of discussions, announced last year, have worked so well that the Council was enabled to issue the last volume of "Transactions" in two months after the meetings. The regulations will in consequence be continued in future. In December, 1883, the Council received an invitation from the Board of Trade to nominate a member to serve on the Load Line Committee. As was announced in the Annual Report for 1884, the choice of the Council fell upon Professsor Elgar, LL.D., who kindly consented to act, with the result expressed in the letter received from the Chairman of the Load Line Committee, which is appended to this report. The Committee sat for about a year and a half, and after taking evidence in London and at the principal outports, it finally reported to the President of the Board of Trade in August last. The tables of freeboard submitted with the report received the sanction of the Board of Trade and of Lloyd's Register Society, and now form the standard by which the freeboard of ships is officially regulated. It is gratifying to know that the Committee's tables appear also to have been favourably received by the shipowners throughout the country, and that an important step has at length been taken towards the settlement of the load line question.

After routine business had been transacted, Lord Ravensworth addressed the meeting. He congratulated members on the satisfactory report of the Council which had just been read. He referred in feeling and suitable terms to the loss which the Institution had sustained by the death of Mr. Samuda, and went on to consider the depression which existed in the shipping trade, which was probably due in a large measure to the great number of ships built in 1881, at a time when trade was falling. We carry, however, now as large a proportion as ever of the world's merchandise, the returns of traffic in the Suez Canal last year showing that quite 75 per cent. of all the shipping passing through the canal was British. The falling off in the shipping business was not so much in quantity as in price. Freights were so low that it was nearly impossible to make shipping pay, but he might add that a natural law was at work which would soon have its effect. Thus, in the month of January this year no less than 10,000 tons had been taken off the register, and in February as much as 20,000 tons. He added that a gleam of light came from the United States; trade was improving there, and this would react, as it always did, on Great Britain. There was a chance, too, that the American Government would permit the purchase by Americans of ships in this country without prohibitive duties, and this would do good. On this point, however, we may say that although the purchase of ships by the United States might be of service to British shipbuilders, it would be a bad thing for British shipowners. He then touched on the extending employment of steel, which he very aptly styled an "irritable" metal, and he expressed a fear that too much was being expected of it. Bad times always stimulated science, and at no time had science done so much for shipping as during the last few years. He ventured to hope that Lloyd's would see their way to modify the standard for basic steel, which was at its best when of the 24 to 27 tons quality, while ordinary steel was 28 to 32 tons. Referring to the triple expansion system, he said that 142 sets of engines have been built, and 100 sets are in progress. In the Royal Navy the triple system was adopted in three new types, namely, first, the Nile and Trafalgar class; secondly, in the belted steel cruisers of the Aurora type; and lastly in the Rattlesnake class of torpedo catchers of 450 tons displacement, 2700-horse power, and 19 knots speed. Forced draught he felt certain was coming to the front, and would be universally adopted in a short time. He also alluded to the use of petroleum. The drawback to its use was that while it was more efficient than coal by 60 per cent., it was 100 per cent. more expensive. He hoped it would never be used in men of war, as the explosion of a shell in a petroleum tank would lead to the most awful results. With references to the use of hydraulic machinery in shipbuilding yards; the Load Line Committee, and the loss of the Oregon, he concluded a very admirable address, which was warmly received by his audience.

The first paper read was by Mr. W. H. White,

ON THE SPEED TRIALS OF RECENT WAR SHIPS.

The purpose of this paper is to place on record certain facts respecting the performances of some recent warships, and to illustrate the remarkable advances which have been made of late in the speeds attained by battleships, as well as in the design and construction of their propelling machinery. From the time of the Warrior onward for twenty years, the measured mile speeds of the swiftest armoured ships varied from 14 to 15 knots; now there are a considerable number of battle-ships afloat having measured-mile speeds of 16 to 17¼ knots, and still higher speeds are contemplated in the very large ships building by Italy, as well as in some armoured vessels of smaller dimensions building for European navies. Vessels of the cruiser classes recently completed have attained speeds of 18½ to 19 knots when fully laden. In the Royal Navy, the new departure for battle-ships may be said to date from the period—1878—when the design of the Colossus and Edinburgh was prepared. It was then decided to adopt a form of ship differing greatly from any that had been previously used. As the result of a careful investigation, it was anticipated that without exceeding the length of 325ft., which by common consent had been accepted for first-class ships, a steam performance would be secured equal in economy to that obtained on the Warrior with a length of 380ft., when steaming at full speed. The selection of the form finally adopted, and the estimate of the engine power required were entirely based upon an analysis of the steam trials of earlier ships. After the sheer draught had been prepared, the usual model experiments were made at Torquay, the results extending, in a very remarkable manner, the results obtained in the Edinburgh. Table 1 gives the principal dimensions and particulars of the Warrior, Bellerophon, and Hercules, together with those of four recent ships: the draughts and displacements are those corresponding to an average on the steam trials, which will be mentioned hereafter. The Warrior, Bellerophon, and Hercules have single screws. The others are twin-screw vessels. The Edinburgh, Collingwood, and Howe are identical in underwater form. The Howe was tried at her designed load draught, but the other two were at light draught. In Table 2 appear the principal particulars of the speed trials of the ships mentioned in Table 1; and in Table 3 appear particulars of their machinery and screws.

The relative performances of the Howe, Collingwood, and Edinburgh deserved brief consideration. They were proving somewhat better than had been previously estimated. No change was suggested in consequence of the model experiments, which amply confirmed the anticipation that the form selected, besides being as easily driven as the Warrior up to 14½ knots, would also be very well adapted for much higher speeds. After careful consideration, it was decided to hold in reserve for the new ships any gain in power and increase in speed obtainable with forced draught or assisted combustion. This decision has had the result of giving to all the ships thus treated speeds exceeding by a knot, or a knot and a-half per hour, the speeds with which they were publicly credited at the time of their design. The form selected for the Colossus and Edinburgh was adopted also for the Collingwood and five other vessels of the Admiral class, before there was a possibility of making any speed trials by which to verify the estimate. It would be seen, therefore, that the experiment made was on a very large scale; and there were not wanting those who anticipated possible failure. The matter was placed beyond doubt by the trials of the Edinburgh made in September, 1883, and the trials which have followed with the Colossus, Collingwood, Rodney, and Howe, have been equally satisfactory, confirming and tried at different draughts and displacements, and in the case of the Howe there was a further important change in the diameter and blade area of the propellers. The Collingwood and Edinburgh were practically identical in their performances up to the maximum speed—16 knots—attained by the latter ship. The Colossus on her trial practically repeated the maximum performance of the Edinburgh, but being a sister-ship she was not tried progressively. The Collingwood had been designed to be a knot faster than the Edinburgh, with natural draught, and forced draught fittings had been applied to her, so that it was anticipated she would develope about 9000-horse power with her stokeholes under pressure. On the first trials with the screws set to a pitch of 18ft. 10¾in. the maximum power indicated was rather under 8400-horse power, with eighty-nine revolutions and a speed of 16 6 knots. It was evident, however, that a change in the propellers was necessary if the full steam-producing power of the boilers was to be utilised by running the engines faster. As an experiment the pitch was reduced to 17ft. 6in., the revolutions increased to 95·57, and the indicated power to 9573-horse power, but the speed was only increased to 16·84 knots. It became obvious, therefore,

TABLE I.—*Particulars of Vessels.*

	Length between perpendiculars.	Breadth extreme.	Mean draught.	Area of midship section.	Displacement.	Wetted surface.
	feet.	feet.	ft. in.	square feet.	tons.	square feet.
Warrior	380	58	25 11½	1219	8852	30,200
Hercules	325	59	24 8	1313	8676	28,000
Bellerophon	300	56	24 2	1200	7319	25,560
Edinburgh	325	68	22 9½	1287	7750	28,000
Collingwood	325	68	23 9	1354	8200	28,700
Howe	325	68	26 8	1557	9637	31,000
Imperieuse	315	61	24 10	1276	7573	28,480

TABLE II.—*Particulars of Steam Trials.*

	Mean draught.	Displacement.	Indicated horse-power.	Revolutions. Mean per min.	Speed.	$\frac{M.S. \times V^3}{I.H.P.}$	$\frac{D^{\frac{2}{3}} \times V^3}{I.H.P.}$
	ft. in.	tons.			knots.		
Warrior	25 11½	8852	5469	54·25	14·356	659·4	231·5
	25 11½	8852	2867	44·5	12·174	767·1	269·3
	25 11½	8852	1988	38·0	11·04	824·9	289·6
Hercules	24 8	8676	8529	71·51	14·691	488·1	157·0
	24 8	8676	4045	55·29	12·123	578·3	186·0
Bellerophon	24 2	7319	6000	72·92	13·874	534·1	167·8
Edinburgh	22 9½	7750	6754	87·23	15·991	779·0	237·0
	22 8	7690	2537	62·33	11·961	862·0	262·8
	22 8½	7710	1508	51·19	9·849	811·6	247·3
	22 8½	7710	815	41·05	8·097	834·4	254·2
Collingwood*	23 6	8080	9573	95·57	16·844	666·4	201·0
	23 9	8200	8369	89·05	16·602	740·3	222·3
	23 10	8240	7071	85·47	16·051	795·3	238·6
	23 11	8280	3040	65·67	12·621	903·3	270·6
	23 11	8280	1597	52·18	10·236	917·2	274·8
	23 11	8280	803	41·31	7·988	867·2	259·8
Howe...	26 8½	9658	11,613	107·24	16·923	651·0	189·3
	26 8	9637	8230	97·22	15·873	756·6	220·1
	26 8	9637	4099	79·15	13·386	911·1	265·0
	26 8	9637	1709	59·91	10·250	981·1	285·4
	26 8	9637	1150	50·93	8·938	966·7	281·2
Imperieuse	25 0	7645	10,184	87·97	17·213	644·5	194·3
	24 10	7573	1567	47·89	10·096	837·9	253·2

* The pitch of the propeller was reduced from 18ft. 10¾in. to 17ft. 6in. on the trial at the highest power, viz., 9573 I.H.P.

TABLE III.—*Particulars of Machinery and Screw Propellers.*

	Indicated horses power.	Description of engines.	Load on safety valves.	Diameter and number of cylinders.	Length of stroke.	Piston speed.	Revolutions.	Propeller. In twin-screw ships these particulars are given for one screw only. Diameter.	Pitch.	Number of blades.	Total blade surface.	Slip per cent.	Weight of Machinery.	Indicated horses per ton weight of machinery.
			lbs.	Inches.	ft. in.	ft. per min.	Mean per min.	ft. in.	ft. in.				Tons.	
Warrior ...	5,469	Single screw horizontal trunk jet condenser.	22	2=104	4 0	435	54·25	24 6	30 0	2	116	10·62	884 (present weight, 1016 tons.)	6·1
Bellerophon	6,000	Single screw horizontal trunk surface condenser.	30	2=104	4 0	583	72·9	23 6	20 1	2	105	4·01	895 (present weight, 1022 tons.)	6·6
Collingwood	9,573	Twin-screw vertical compound 3 cylinders each set	90	2–52 4–74	3 6	669	95·57	18 0⅞	17 6 (Originally set at 18ft. 10¾in.)	4	88·3	2·05 Neg	1244	7·7
Imperieuse...	10,184	do. do.	90	2–55 4–77	4 0	704	87·97	18 2	22 0¾	4	87·04	10·12	1266	8·04
Howe	11,613	do. do.	90	2–52 4–74	3 9	804	107·24	15 6	19 5	4	72·5	17·64	1152	10·08

that a radical change in the propellers of the Howe was required, if the much greater steam-producing power of the boilers in that vessel was to be utilised in adding to the speed of the ship. It was hoped, as the result of experience, that by running the engines at a higher speed over 11,000-horse power would be indicated on the Howe, and from the Collingwood's trials it was evident that smaller screws must be employed. The change made is indicated in Table 3. The diameter was decreased from 18ft. to 15½ft.; the blade area was diminished by about 18 per cent.; the pitch was slightly increased. With these propellers the engines of the Howe ran at 107 revolutions, and indicated nearly 12,000-horse power, driving the vessel at a speed of 17 knots. On reference to Tables 2 and 3 it appears that the Collingwood's larger screws as first tried were rather superior in performance to those of the Howe for speeds of 13½ to 16½ knots; but at the higher speeds the Howe has the advantage, and this is true also for lower speeds than 13½ knots. For all practical purposes, therefore, the change made in the Howe was a decided improvement. Table 3 contains some interesting data showing how the ratio of weight to indicated horse-power on the measured mile trial has altered from the time of the Warrior onward. Since the time of the Warrior there has been a constant series of additions to the items of auxiliary machinery, pumping appliances, &c., included under the head of machinery in H.M. ships, so that the actual reduction in weight per indicated horse-power is greater than would appear from the tables. Each ton of weight gave 6-horse power in the Warrior, 6¾ in the Bellerophon, 7¾ to 8 in the Imperieuse and Collingwood, and 10 in Howe. I know of still greater developments of power in relation to weight as having been actually realised, and in many ships now building for the Royal Navy more sanguine expectations are likely to be fulfilled. Merchant ships are built and engined for the purpose of steaming continuously at certain maximum speeds. War ships, on the contrary, ordinarily cruise at very low speeds, and yet must possess power to attain high speeds when desired. The performances of the Howe contained in Table No. 2 will illustrate these remarks. At her full speed of 17 knots on the measured mile, this ship, with 107 revolutions, developed 11,600 indicated horse-power. Her engines, boilers, and propellers had to be made such as would enable these conditions to be fulfilled. On ordinary service the Howe would probably steam at from 9 to 10 knots an hour. Her engines make 51 revolutions, and develope 1150-horse power for 9 knots, the corresponding figures for 10½ knots being 60 revolutions and 1700-horse power. As a rule, therefore, the Howe would not require to use more than one-tenth of the full power which her boilers are capable of producing. It is clearly of the greatest importance that the power necessary to give her the high speed, at long intervals and for comparatively short periods, should be secured with the least expenditure of weight consistent with assuring the maximum performance under special circumstances. The maximum power obtained with forced draught and an air pressure not exceeding 2in. of water has varied from 40 to 50 per cent. of increase above the maximum power obtained with natural draught. The rate of consumption of coal per indicated horse-power with this type of boiler has been about 10 per cent. greater than the rate of consumption with natural draught and full power. The increase of power, averaging about 45 per cent., has been obtained by burning about 60 per cent. more coal than with natural draught. With the steam blast as formerly fitted, about 20 per cent. increase on the natural draught power was obtained for an expenditure of 40 per cent. more coal. On the basis of the measured mile performances, the Warrior, with a coal stowage of 800 tons, could steam a little less than 3000 knots at 10 knots in smooth water. The Howe starting with 800 tons could steam twice as far as the Warrior at that speed. At 14 knots the Warrior could cover about 1100 knots; the Howe about 2500. As a matter of fact, the coal bunker capacity in the Howe is 50 per cent. greater than that in the Warrior, and the figures just given, therefore, have to be increased 50 per cent. in favour of the Howe's "coal endurances." Speaking generally, the Howe can average about three times the distance which the Warrior could cover before her coal supply is exhausted. These facts are stated simply as indications of the great progress which has been made in coal endurance concurrently with increase in speed. The sources of economy in the modern ship are too well known to need comment.

It might be interesting to add in connection with the performances of these high speed twin screw ships, that a comparison of the results of model experiments with those of measured mile trials, shows the ratio of effective to indicated horse-power to vary from 48 to 53 per cent. at the maximum speeds attained. The effective horse-power is taken on the naked hull, excluding the resistance due to shaft tubes, struts, &c. Without entering into any discussion of the relative efficiency of single or twin-screw propellers, it may be stated that these percentages show a high degree of efficiency in recent twin-screw ships.

The discussion which followed was not worthy of the paper. Sir Nathaniel Barnaby expressed his opinion that speed could be purchased too dearly in large ships, which would never have to run away from an enemy, while it was of vital importance in small men-of-war. He was followed by Admiral Sir John Hay, who disagreed with him. Admiral Freemantle followed Sir John Hay, and also held that speed was essential. When an attack was made by torpedo boats on an ironclad, the latter should run away, pelting the torpedo boats with her machine-guns. He found that if the torpedo boats began their attack at 1500 yards, if the ironclad could steam 15 knots while the torpedo boat steamed at 20 knots, the latter would be kept under fire for no less than six minutes before they could attack. Mr. White having replied, a vote of thanks was passed, and the meeting adjourned for luncheon.

On resuming, Mr. J. H. Heck, of Lloyd's, read a paper

On an Improved Mechanical Method for Finding the Stability of a Vessel.

The system devised by Mr. Heck consists in making a wooden model of the ship by cutting out twelve boards representing twelve cross sections to scale, and screwing them together as in the diagram. This is then secured

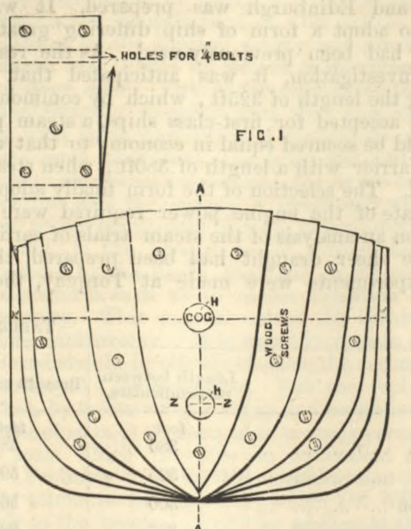
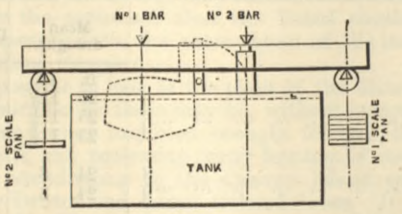


FIG. 1

under a scale beam; inclined at different angles to the beam, and immersed in a tank of water, as shown in the diagram, where the model is seen upright. The author explained by the aid of his apparatus how calculations were made. The time required to make a model is about six hours, and to make a complete set of calculations with its aid about

FIG. 2



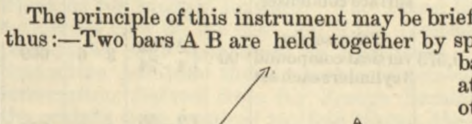
nine hours. The author said that he hoped greatly to simplify his apparatus. He had, indeed, obtained very satisfactory results with a cardboard model, and a small balance weighing only a few ounces.

The discussion was opened by Mr. Denny, who paid a high and well-deserved compliment to Mr. Heck's ingenuity. The whole history of the elaborate methods of making such calculations as those simply effected by Mr. Heck's apparatus, was rendered useless by that apparatus, since these methods would no longer be used. An almost unskilled man could make in nine hours calculations, which, conducted in the ordinary way, would occupy a skilled mathematician not less than a fortnight. It was worth notice that French shipbuilders relied entirely on numerical methods, while practical England was always scheming something which would save time and figures. Mr. Martell spoke highly of Mr. Heck's instrument, and urged that it should be supplied to captains of ships, who ought to be taught its use. He was followed by Mr. Benjamin, who urged that an error of 2 per cent. might be caused by the circumstance that the model was made up of a series of steps or thicknesses of wood instead of having a uniform contour. It would be of no use to captains, because it could not take account of cargo, the centre of gravity varying with the nature of the cargo. Mr. Shönheyder made the suggestion that the apparatus could be improved by making the fulcra to shift instead of having to shift the whole balance end for end, which was now necessary.

In replying, the author stated that a continuous model had been tried, but that its use introduced errors of greater magnitude than those it was intended to avoid, and that, as a matter of fact, the calculations of the old kind, of any two individuals equally skilful, seldom agreed within 2 per cent, what might be termed the personal equation affecting the result. A vote of thanks having been passed, a paper was read by Mr. C. E. Stromeyer, of Lloyd's, on

A Strain Indicator for use at Sea.

The principle of this instrument may be briefly described thus:—Two bars A B are held together by springs. One bar A is fixed at one end; the other B by its opposite end. Between the two is interposed a wire at C, to which is fixed a light pointer.



If the bars move on each other under strain, the wire is caused to rotate on its axis, and the pointer goes round on a dial. The wires are of hard steel, much finer than a cambric needle. With this apparatus the inventor had made many investigations which led to some very startling results, which, if they are confirmed, will throw a good deal of light on steel failures. The author referred to an instrument now about five years old, based on a phenomena called the interference of light. A similar method had been adopted by M. Fizean to determine the coefficients of expansion of solids; so sensitive was it found to be that he could easily measure the different rates of expansion of the various axes of crystals with an accuracy which reduced probable errors to 1 per cent. This extreme sensitiveness compelled the author to use only very short spanned instruments—½in. to 3in.—and they could therefore not be used to ascertain the average strains over long spans, but only to investigate local changes of strains. But for this purpose no other method could give more accurate results. The discoveries he made are the following:—The circumferential strains are not uniformly distributed over the lengths of boiler shells, they are less near circumferential seams than in the centres of plates, and are considerably less near the ends where the shell is rivetted to the flat end plates. A little reflection would show that this is only natural, and he thought that some engineers who, independently of his experiments, had arrived at the same conclusions, argued that the circumferential seams should be looked upon as strengthening rings, and that therefore a shell is really stronger than the ordinary calculations would show it to be. Now although he granted the correctness of these views, further experiments had shown him that these circumferential seams are a source of weakness, for he had found that the local strains in the solid plates on either side of a lap joint are four to five times greater than the ordinary calculations suppose them to be, or about eight times greater than in the other parts of the solid plates, so that one could almost expect these points—adjoining the lap joints—to tear long before the joints have been strained to their utmost. This probably accounted for the tearing of solid plates when boilers were burst experimentally. It usually happened that both the lap joint and the solid plate tear instead of only the former. In future cases it would be interesting to know whether the fracture commenced in the centre of the seam, where it is unsupported by the adjoining strakes, or whether it started in one of the adjoining solid plates. An examination of the fracture would show in which direction it travelled. Feathery groupings of the crystals would indicate that direction. The same phenomena of severe local strains were observed on a ship's side; it was found that they were about twelve times greater just above or below the butt straps than anywhere else. The reason was not far to seek. The seams, especially single butt strap joints, were far more elastic than the adjoining solid plates, and the greater part of the strains naturally got thrown on the latter. Reverting to the case of the boiler, it had often occurred to him whether the shells would not be stronger if the longitudinal seams were carried from end to end, as is sometimes done in donkey boilers.

He had been forcibly reminded of this on one occasion while measuring the strains on an arched wrought iron rib of a bridge while it was being tested with proof loads. Nine instruments in all, viz., three at three different cross-sections, were attached to the top, bottom, and centre of the web—the section was I—but all on one side, so as to guard against interference from the wind which was blowing on the other. The span of each instrument was 10ft., and as vertical angle irons were fitted to the web the instrument had to be fixed 3in. away from it. Consequently any slight tendency to buckle, due to the centre of web and effort not being identical, would be greatly exaggerated. This would chiefly affect the mean stresses. This had not occurred to him while making the experiments, and he was therefore greatly surprised to find that although the readings of the three instruments at each section agreed amongst themselves, and although the centres of efforts at these three sections agreed absolutely amongst each other, the total thrust was decidedly different at the three sections, and differed seriously from the calculated one. The author described at length the results he had obtained concerning the launching strains of the s.s. Ida and Albatross, and the method of measuring strains in a ship at sea.

The discussion which followed was of little interest. Mr. Biles considered the instrument one of great value, giving as it did real information about strains, instead of leaving us depending on calculated results. Mr. Ramage took occasion to say that the question raised only concerned Lloyd's, as shipbuilders had nothing to do with strains; they had only to satisfy Lloyd's and their part was done. Mr. Corry, of Lloyd's Committee, very naturally protested against this theory. He pointed out that shipbuilders ought to aid Lloyd's in every way in their power. Mr. Inglis held that the instrument would prove useful, as enabling calculations to be tested for accuracy. Mr. Denny availed himself of the opportunity to attack Lloyd's, and to protest against the shipbuilders of Great Britain permitting Lloyd's to attain a supremacy over them. In the talent of very young men he saw their hope of protection from Lloyd's.

After a vote of thanks had been passed the meeting adjourned; the annual dinner taking place in the evening at the Holborn Restaurant. Yesterday—Thursday—morning, three papers were read on steel, and followed by an interesting discussion. In the evening "Forced Draught," papers by Mr. Sennett and Mr. Howden were read.

LAUNCHES AND TRIAL TRIPS.

On April 3rd Messrs. Oswald Mordaunt and Co. launched, at Southampton, an iron sailing ship of about 2730 tons net register, built for the Ellesmere Shipping Company, and of the following dimensions:—Length, about 307ft.; breadth, 45ft. 3in.; depth of hold, 24ft. 11in. The vessel is full-rigged, having four masts, the top masts and lower masts being in one; built to class 100A Lloyd's. She has a turtle back aft, long bridge deck amidships for accommodation of first-class passengers, captain, and officers, sail room, apprentices and crew being in fore end of same; whilst on bridge deck a large deck-house is fitted for chart-room and wheel-house, having flying bridge extending to ship's side. Large deck-house is fitted forward for engine-house and galley. Two steam winches are fitted for the rapid loading and discharging of cargo; long monkey forecastle for working anchors, with lighthouses at after end of same, with lockers, &c., underneath. Four water-tight bulkheads are fitted, and two sets of main pumps. The vessel has been built under the superintendence of Mr. Jackson.

On Wednesday, April 7th, Messrs. Head and Riley, Groves Shipyard, Hull, launched an iron steam trawler, the Camenes, length 95ft., breadth 20ft., depth of hold 11ft. Mr. Wales, of Hull, is supplying her with engines and a steel boiler; size of cylinders 17in. and 34in., with a stroke of 21in., and a boiler pressure of 90 lb. per square inch. The vessel, which has been built for Messrs. Hall, Leyman, Cook and Co., will be fitted out for deep sea fishing; a powerful steam trawling winch will be supplied by Messrs. Good and Menzies, of Hull. Emerson, Walker, and Thompson Bros.' patent windlass will be fitted on the forecastle, and Archer's patent steering gear on the bridge.

Barbed Fencing.—The manufacture of this fencing is one of the most remarkable of trades, inasmuch as in a very few years it has grown from nothing into a prodigious output. In their catalogue relating to this fence Messrs. Richard Johnson and Nephew, of the Bradford Ironworks, Manchester, say that while in 1873 the first defensive wire fence was made by an Illinois farmer who fastened to his wire fence strips of wood with wire points, this being improved by another farmer, and 300 tons made in 1875, no less than 120,000 tons of this barbed wire fence produced by automatic machinery was made in 1883, and has vastly exceeded this the last two years.

FORCED DRAUGHT.*

By JAMES PATTERSON and MAGNUS SANDISON.

THIS paper is intended to bring before the Institution the advantages, as they present themselves to the writers, to be gained by the use of forced draught, more especially in its application to the merchant navy, and to show that economy is not incompatible with, but, on the contrary, should follow from its use. The subject has already occupied considerable attention, and much of the ground gone over may lack freshness. It is hoped, however, that a brief outline of forced, contrasted with natural draught, in its theoretical and practical aspects as applied to the naval and mercantile marine, will open a wide field for interesting and instructive discussion.

The quickening or strengthening of the natural draught of the funnel by mechanical means is no new idea, but has long been in use in one form or other. It is here proposed to consider that system in which a fan, or other blowing engine, is employed to force the air through the furnaces, whether the method of closed stokehole or closed ashpit be that adopted. It will be seen at the outset that, so far as the strength of the draught is concerned, there is no hard-and-fast line between forced and natural draught, but that, as a matter of fact, they may and do overlap each other. Broadly speaking, however, the force of the draught is the distinguishing feature.

The fiercer combustion obtained is attended by many advantages, varying in number and importance with the different methods of applying the draught. These advantages are so great that it has been predicted, and the writers believe, that forced draught, in some one of its forms, is destined ere long to supersede almost entirely the use of natural draught. Indeed, the improvement of the boiler as a steam generator, by the use of forced draught, bids fair to eclipse what has been done of late years, by increased pressures and expansions, to improve the engine as a steam user. The advance from the single-cylinder engine and atmospheric pressure to the triple expansion engine and 150 lb. pressure has been gradual, but, in the end, increased economy has been attained with decreased weight. The design of boiler also has developed to meet the requirements of the higher pressures, but, as compared with the engine, little has been done to increase its efficiency or reduce its weight.

Foremost in the effects of forced draught is the increased rate of combustion per square foot of grate per hour, so that the same power may be developed from a much smaller grate. Again, as the heat passes from the products of combustion to the water, in virtue of the difference of their temperatures, the greater this difference the greater the amount of heat which will pass through a unit of surface in a given time. Consequently, as the temperature of the fire with well-arranged forced draught is very much greater, it is evident that the products of combustion, passing over the same surface as in a natural draught boiler, will give up much more of their heat. In other words, while the potential efficiency of the heating surface due to the material, thickness, and construction of the plates and tubes remains unaltered, the actual efficiency has been very much increased by the higher temperature of the fire, and, to keep the same funnel loss, a much smaller surface is required.

The economy to be gained by the use of forced draught lies mainly in the proper application of these two principles—increased rate of combustion and increased efficiency of heating surface—either by themselves, or in combination with a third, viz., the heating of the incoming air by the waste products of combustion.

Following immediately upon this reduced grate and heating surface we have a smaller boiler, with a corresponding decrease in weight both of boiler and water, and a corresponding increase of cargo-carrying or bunker capacity, which, of course, implies not merely a reduction in first cost of machinery, but an additional gain in dead-weight carried. No doubt, against this must be placed the first cost and cost of maintenance of the fan engine, and, also, in the case of stokeholes worked *in plenum*, the shipwork involved in fitting air-locks, and in making the stokeholes air-tight; but it will be shown that, making all due allowance, there is still a large margin in favour of forced draught. At the same time, closed stokeholes, with their attendant dirt and discomfort, and the necessary trouble involved in hoisting ashes or passing from engine-room to stokehole, may be said to be impracticable in the merchant service, and is it only some system of closed ashpit, with the fan engine in some accessible position under the eye of the engineer, that will answer the requirements of the mercantile marine. Another gain resulting from the adoption of artificial draught, which is well worth the attention of shipowners at any rate, is the possibility of burning an inferior and consequently cheaper class of fuel. In these days of commercial depression, a system which produces good results from the combustion of a fuel at less than half the cost of good ordinary bunker coal cannot long remain in the background. The air necessary for the combustion of such fuel, which with natural draught could not be obtained, will with forced draught be readily supplied, and the boilers will be rendered capable of doing full duty, whether the direction of the wind tends to help or hinder the draught.

The general outline of the advantages to be expected has thus been briefly pointed out. Their quantitative values will next be considered.

Two well-known formulæ have been given for the efficiency of the heating surface of boilers under various conditions by Professor Rankine and Mr. D. K. Clarke. These have been shown by their authors to be practically accurate in a certain number of cases, as published in their respective manuals. The force of the draught does not outwardly appear as a factor in Mr. Clarke's formula. Professor Rankine, on the other hand, separates forced from natural draught by the introduction of distinguishing constants, and bases his formula on the two fundamental principles that:—(1) The smaller the quantity of air used per pound of fuel the higher the temperature of the fire; and that (2) the greater the difference between the temperature of the fire and that of the water the greater the efficiency of the heating surface.

For facility of reference the formulæ are subjoined:—

D. K. Clarke.

$$W = a r^2 + B c$$

Where

W = lb. of water evaporated per square foot of grate per hour.

c = lb. of fuel consumed " " "

r = ratio of heating surface to grate area

a = a constant, specific for each kind of boiler = ·016 for marine boilers

B = a constant, specific for each kind of boiler = 10·25 for marine boilers

Thus the lb. of water evaporated from and at 212 deg. F. per lb. of fuel $= \frac{W}{c} = w$

$$\therefore w = \frac{a r^2}{c} + B$$

$$\text{and the efficiency} = \frac{w \times 100}{\text{calorific value of fuel.}}$$

Rankine.

$$\text{Efficiency} = \frac{B S}{S + A F}.$$

Where S = total heating surface,

" F = total fuel in lb. per hour,

" A = ·5 for ordinary convection and chimney draught,

" " = ·3 " " and forced draught,

" B = $\frac{11}{12}$ " " and chimney draught,

" " = $\frac{16}{23}$ " " and forced draught.

A graphic representation of this formula is given on Diagram No. 1, where the abscissæ represent ratios of heating surface in square feet to fuel per hour in lb., and the ordinates percentages of efficiency. The upper curve is for forced and the lower for natural draught. Each of these curves represents a condition of combustion in which considerably more air is used than is chemically necessary for the combustion of the fuel, the air of dilution being given by Rankine at 6 lb. and 12 lb. respectively, making 18 lb. and 24 lb. of air supplied per lb. of fuel for forced and natural draught. The forced draught is that due to the blast of a locomotive, and, unfortunately, there is a dearth of experiments on fan draught to compare with it.

A number of experiments, principally natural draught, have been tabulated, showing the percentage of error by both formulæ, in which it will be seen that there is a close agreement in many, but in others a considerable error.

Table No. 1 is compiled from a series of experiments made at Philadelphia, in 1865-6, on a horizontal return-tube boiler, a report of which is to be found in Weisbach's *Manual of the Mechanics of Engineering*. Table No. 2 is from the experiments made in 1881 on the boilers for the Kimberley Waterworks, and reported in *Engineering* of 3rd March, 1882. Table No. 3 is from the well-known experiments by Mr. Fletcher on the Lancashire stationary boilers in 1867-68. The table is short, but is of exceptional value, inasmuch as it represents the mean of the best results of a large number of trials. The experiments from which Table No. 4 has been compiled are also well known, being the Admiralty trials of Thornycroft's torpedo boat boiler in 1880. Table No. 5 is from the same series of experiments as Table No. 1, but is separated from it, a steam jet or fan having been used.

To arrive at the efficiency in column 12 the calorific value of the fuel had to be assumed, except in the case of Table No. 2. It has, however, in each case been taken with due regard to the quality of coal, as published with the experiments. Another point to be noted is that in Tables 1 and 5 combustible is taken instead of coal. No doubt this is the more correct comparison, but, as in the others the coal used was of good quality, the percentage of refuse would be small, and the error consequently inconsiderable. Columns 13 and 14 are percentages of error by Rankine's and Clarke's formulæ respectively. It occurred to the writers that the error in some of the cases might be explained were the quantity of air used per lb. of fuel known. Unfortunately this has not been recorded, except in the case of Mr. Fletcher's experiments. This quantity has accordingly been approximated from the temperature of the products of combustion on leaving the boiler, and the results thus obtained are given in column 11 of the tables. The total heat of the fuel is supposed to be divided into three portions, viz.,—(1) that which is absorbed by the water in the boiler; (2) that which is carried up the funnel by the products of combustion; and (3) a loss from radiation and other causes, assumed in the calculations at 5 per cent.

On these assumptions, the funnel temperature being given, and the specific heat of the products of combustion being taken at ·242 throughout, the weight of air has been calculated. Thus, take for example experiment 10 in Table 1—

Here Efficiency = ·72

" Miscellaneous loss = ·05

" Funnel loss = ·23

Total heat of combustible = 1·00

Let x = lb. of air per lb. of combustible,

then $(x + 1)\ ·242 \times (630\ \text{deg.} - 50\ \text{deg.}) = 966 \times 16 \times ·23,$

$\therefore \quad x + 1 = 25·3,$

and $\quad x = 24·3$ lb.

tabulated as $24\frac{1}{2}$ lb. of air per lb. of combustible.

It will now be seen that the percentage of error in the main is greatest where the air supply per lb. of combustible departs furthest from the normal quantity.

Let us now examine those experiments—also from Table 1—in which the ratio of heating surface to fuel is constant and equal to, say, 1·5; thus eliminating the effect of that ratio on the efficiency in making our comparison. It is seen at once that almost invariably the efficiency falls with increase of air. The effect of air supply on efficiency is still further corroborated by the Kimberley experiments. In these the ratio of square feet of heating surface to lb. of fuel consumed was never less than 3·6 and rose to 16·1. The efficiency, however, was not proportionately increased, and indeed was diminished, which seems to be amply accounted for by the excess of air in each of the cases.

There are few recorded experiments on fan draught, and these are under unfavourable conditions; two sets have been tabulated in Tables 4 and 5. In these the percentage of error is calculated by the natural draught formula, and it will be noticed that although the efficiency of most of them is higher than that given by the curve, yet it is not nearly so high as that which would be expected from the forced draught curve. This may unquestionably be attributed to the quantity of air used per pound of fuel; and it follows, that unless forced draught can be so supplied as to reduce this quantity of air to 18 lb. per pound of fuel, or even less, there will be no marked increase of efficiency of heating surface due to it. This can only be attained by proper proportions of thickness of fire to force of draught. Refer, for instance, to the well-known experiments on Thornycroft's boiler, on Table 4. The air per pound of fuel is in each of them considerably more than 18 lb., and the efficiency is comparatively low, and in the case of Experiment A, lies on the natural draught curve. On comparing columns 11 and 12 it might at first sight be thought that the increased air supply was advantageous. This is not so. The efficiency given in column 12 is total efficiency, and includes the effect of the amount of heating surface per lb. of fuel which must be eliminated before the effect of the increased air supply can be obtained. If now it

TABLE NO. I.—*Natural Draught Experiments on a Horizontal Return-tube Boiler at Philadelphia.*

Reference No.	Heating surface in square feet.	Grate in square feet.	Heating surface. / Grate area.	Total combustible fuel, less refuse, = in lbs.	Refuse °/o of fuel.	Lbs. of combustible per foot of grate.	Square feet of heating surface. / Lbs. of combustible.	Lbs. of water per lb. of combustible from and at 212 deg.	Funnel temperature.	Lbs. of air per lb. of combustible.	Efficiency, taking calorific value of combustible at 16.	Per cent. of error. Rankine.	Per cent. of error. D. K. Clarke.	Remarks.	Date.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
59	638	36	17·7	417	21	11·57	1·53	12·77	Lead melts ..	16	·798	–13·5	–16·3	4 upper rows of tubes plugged.	1865-66
47	950	"	26·4	536	21·5	14·88	1·77	12·75	" ..	16	·797	–10·4	–13·7	Boiler as built	"
63	326	"	9·1	88	21·3	2·43	3·7	13·6	383	18	·85	– 5·1	–20·6	8 upper rows of tubes plugged.	"
61	482	"	13·4	310	21·4	8·62	1·55	12·28	Lead melts ..	19	·767	– 9·6	–13·8	6 " "	"
48	950	"	26·4	549	20·3	15·24	1·73	12·17	" ..	20	·760	– 6·6	– 9·8	Boiler as built	"
16	"	"	"	256	19·6	7·12	3·7	12·71	510	$20\frac{1}{2}$	·795	+ 1·5	– 7·1	" "	"
64	"	"	"	507	19·5	14·09	1·87	11·72	Lead & zinc melt	21	·733	– 1·3	– 5·8	Ferrules in tubes	"
19	"	"	"	601	18·6	16·69	1·58	9·96	Lead melts ..	$21\frac{1}{2}$	·748	– 7·0	+ 9·5	Boiler as built	"
60	560	"	15·5	403	18·7	11·28	1·40	11·81	" ..	$22\frac{1}{2}$	·738	– 8·8	–10·3	5 upper rows of tubes plugged.	"
7	950	"	26·4	282	23·7	7·84	3·36	12·45	512	$22\frac{1}{2}$	·778	+ 2·4	– 6·2	Boiler as built	"
66	"	"	"	519	18	14·42	1·83	11·75	Lead melts ..	23	·734	– 2·0	– 6·21	Ferrules in tubes	"
37	"	"	"	628	22·2	17·44	1·51	11·26	Zinc melts ..	$23\frac{1}{2}$	·704	– 2·2	– 3·4	Boiler as built	"
58	716	"	19·9	482	18·9	13·4	1·48	11·67	Lead melts ..	$23\frac{1}{2}$	·729	– 6·0	–81	3 upper rows of tubes plugged.	"
24	950	21·6	44	400	22·5	18·51	2·375	11·62	" ..	$23\frac{1}{2}$	·726	+ 4·1	+ 2·6	Grate reduced	"
57	804	36	22·3	505	20·2	14·03	1·59	11·58	" ..	24	·724	– 3·8	– 6·6	2 upper rows of tubes plugged.	"
65	950	"	26·4	546	18·9	15·18	1·74	11·55	" ..	24	·722	– 1·5	– 4·93	Ferrules in tubes	"
10	"	24	39·5	424	22	17·68	2·24	11·52	" ..	$24\frac{1}{2}$	·720	+ 4	+ 1·2	Grate reduced	"
23	"	28·8	33	438	20·9	15·2	2·16	11·52	" ..	$24\frac{1}{2}$	·72	+ 3·3	– 1·1	" "	"
9	"	30	31·7	260	18·9	8·65	3·65	12·2	510	25	·762	+ 5·9	– 0·7	" "	"
18	"	36	26·4	135	13·5	3·75	7·03	13·08	371	25	·818	+ 4·5	– 2·1	Boiler as built	"
32	"	"	"	669	16·2	18·58	1·42	10·78	Zinc melts ..	26	·673	+ 0·6	+ 0·6	Ferrules in 4 upper rows of tubes	"
12	"	18	52·8	344	22·8	19·1	2·76	11·52	570	27	·720	+ 7·6	+ 9·2	Grate reduced	"
8	"	30	31·7	535	21·7	17·82	1·77	10·79	Lead melts ..	29	·675	+62	– 3·2	" "	"
26	"	36	26·4	663	17	18·43	1·43	10·44	Lead & zinc melt	30	·653	+ 3·8	+ 3·9	Boiler as built	"
22	"	"	"	565	19·4	15·68	1·68	10·6	Lead melts ..	$30\frac{1}{2}$	·662	+ 6·6	+ 3·4	" "	"
73	"	"	"	370	13·6	10·26	2·56	11·81	477	31	·738	+ 3·8	– 4·06	Ferrules in tubes	"
21	"	"	"	635	17·6	17·64	1·5	10·45	Lead melts ..	$31\frac{1}{2}$	·653	+ 5	+ 4·1	Boiler as built	"
13	"	18	52·8	152	20·3	8·43	6·25	12·29	399	$32\frac{1}{2}$	·768	+10·4	+26·4	Grate reduced	"
15	"	13·5	70·4	109	23·3	8·08	8·7	12·53	360	$33\frac{1}{2}$	·783	+10·6	+60·1	" "	"
72	"	36	26·4	244	13·6	6·79	3·9	11·96	427	$33\frac{1}{2}$	·747	+ 8·5	– 0·59	Ferrules in tubes	"
28	"	"	"	668	15·7	18·56	1·42	9·47	Zinc melts ..	34	·592	+ 1·4	+15·7	Boiler as built	"
17	"	"	"	645	16·1	17·92	1·47	9·99	Lead melts ..	35	·624	+ 9·8	+ 8·8	" "	"
14	"	13·5	70·4	257	20·4	19·02	3·69	11·26	478	36	·704	+14·5	+28	Grate reduced	"
11	"	24	39·5	209	16·4	8·71	4·78	11·65	431	36	·728	+13·3	+12·6	" "	"
20	"	36	26·4	437	16·7	12·15	2·17	11·05	478	38	·690	+ 7·8	+ 1·1	Boiler as built	"
27	"	"	"	733	18·1	20·35	1·295	7·51	Zinc melts ..	46	·47	+40·4	+44·6	" "	"
29	"	"	"	772	18·2	21·43	1·23	7·41	" ..	48	·463	+40·6	+47·9	" "	"
71	"	"	"	123	15	3·42	7·71	11·25	337	54	·703	+22·3	+20·09	Ferrules in tubes	"

TABLE NO. II.—*Natural Draught Trials on Boilers for Kimberley Waterworks.*

Reference No.	Heating surface in square feet.	Grate in square feet.	Heating surface. / Grate area.	Total coal in lbs.	Refuse per cent. of fuel.	Lbs. of coal per foot of grate.	Square feet of heating surface. / Lbs. of coal.	Lbs. of water per lb. of coal from and at 212 deg.	Funnel temperature.	Lbs. of air per lb. of coal.	Efficiency, taking calorific value of coal at 14·805.	Per cent. of error. Rankine.	Per cent. of error. D. K. Clarke.	Remarks.	Date.
1	2	3	4	5	6	7	8	9	10 deg.	11	12	13	14	15	16
C1	644	15	43	120	—	8	5·36	11·23	529	24	·758	+10·5	24	10 hours' trial	20/10/81
D5	"	$22\frac{1}{2}$	28·6	150	—	6·70	4·3	11·17	509	24	·754	+ 8·7	9·2	9 "	2/1/82
D1	"	"	"	176	—	7·84	3·64	10·87	547	25	·734	+ 9·8	9·7	9 "	28/10/81
D3	"	"	"	100	—	4·44	6·44	11·18	444	$28\frac{1}{2}$	·755	+ 2·6	18	10 "	30/10/81
	"	$10\frac{1}{2}$	61	80	—	7·62	8·05	10·78	454	$31\frac{1}{2}$	·728	+18·4	67	8 "	16/10/81
C2	"	15	43	100	—	6·7	6·44	11·49	368	$31\frac{1}{2}$	·776	+ 9·5	28	10 "	21/10/81
D4	"	$22\frac{1}{2}$	28·6	80	—	3·56	8·05	11·25	392	32	·760	+13·4	23·8	6 "	31/10/81
C3	"	15	43	80	—	5·3	8·05	11·52	349	33	·778	+10·8	37	10 "	22/10/81
B3	"	$10\frac{1}{2}$	61	120	—	11·43	5·36	10·47	460	34	·707	+18·5	47	8 "	15/10/81
C4	"	15	43	60	—	4	10·73	11·07	313	$44\frac{1}{2}$	·747	+17·1	59	10 "	23/10/81
B5	"	$10\frac{1}{2}$	61	60	—	5·71	10·73	10·02	310	61	·676	+29·4	106	8 "	17/10/81
B6	"	"	"	40	—	3·81	16·1	8·15	261	111	·550	+61·4	217	8 "	19/10/81
C5	"	15	43	45	—	3	14·31	8·32	256	$131\frac{1}{2}$	·562	+57·4	57·4	7 "	24/10/81

TABLE NO. III.—*Average of Best Results of Fletcher's Experiments on Stationary Boilers at Wigan.*

	Heating surface in square feet.	Grate in square feet.	Heating surface. / Grate area.	Total coal in lbs.	Refuse per cent. of fuel.	Lbs. of coal per foot of grate.	Square feet of heating surface. / Lbs. of coal.	Lbs. of water per lb. of coal from and at 212 deg.	Funnel temperature, deg.	Lbs. of air per lb. of coal.	Efficiency, taking calorific value of coal at 14·6.	Per cent. of error. Rankine.	Per cent. of error. D. K. Clarke.	Remarks.	Date.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
	751	21 & 31·5	35·8 & 33·8	526	—	20·05	1·427	10·77	—	21	·737	- 8·7	Not calculated.	—	1867-8

* Read before the North East Coast Institution of Engineers and Shipbuilders, March 3rd, 1886.

be allowed that Rankine's curve fairly represents the increased efficiency due to the greater heating surface, column 13 will show the effect of the air supply. It will thus be seen, that as the air per lb. of fuel diminishes, the efficiency rises above the curve, or, in other words, is increased. In Experiment D the increase is as much as 16½ per cent., and there is no doubt that had the designers been able to provide for a fire two or three times the depth of that used—namely, 5½in. to 14in. in the thickest and 3½in. to 9in. in the thinnest fire—the air per lb. of fuel might have been still further diminished, and the efficiency correspondingly increased. Table 5 gives a set of experiments in which, judging from the coal consumed per square foot of grate, the force of the draught has been very much less than in the preceding; and a glance at the results will show that the same conclusions may be drawn from them, while, at the same time, the range of air supply is very much greater.

This question of air used per lb. of fuel for different thicknesses of fire and force of draught is one of so vital importance in connection with the economical introduction of forced draught that it may be here suggested that this Institution undertake some experiments to determine their proper relations. These would not necessarily entail any extravagant outlay, no boiler being required. If, however, a boiler were available, the investigation might be profitably extended to embrace the evaporative efficiency.

The best combination of the foregoing principles, viz., smaller grate, increased efficiency of heating surface, and the utilisation of the waste heat to heat the incoming air, can only be determined by direct experiment.

For the purpose of comparison, four steamers have been chosen, alike in hull, fitted with the same engines, and differing only in that in the first natural draught is used; in the second it is replaced by forced draught, retaining the same boilers, and making the necessary reduction in the grate, which would obtain in the application of forced draught to an existing steamer; in the third, advantage is taken of the smaller grate area required, and the use of smaller tubes to reduce the weight of boiler and water, keeping the heating surface and steam space as before; and in the fourth, the heating surface has been reduced and air supplied to the fans has passed through a heating arrangement in the funnel and uptake.

The steamers are each 285ft. long by 37ft. beam, by 25ft. 9in. moulded depth, with a displacement of 4500 tons at load draught. They are fitted with triple expansion engines of 1000 indicated horse-power with a working pressure of 150 lb. per square inch, it being of course desirable to make the comparison with the most modern and economical type of engine.

The boilers are each 13ft. diameter, by 10½ft. long, with a total weight for boilers and water of 98 tons; other particulars being given in Table No. 7. The efficiency of these boilers by Rankine's formula is 74·4 per cent., as follows:—

$$E = 1\tfrac{1}{4} \times \frac{34 \cdot 6}{34 \cdot 6 + (\cdot 5 \times 16)} = 74 \cdot 4 \text{ per cent.}$$

Allowing other 5 per cent. for miscellaneous losses, 20·6 per cent. remains to be carried away by the products of combustion, giving a funnel temperature of 510 deg., as follows:—

$$(24 \times 1) \cdot 242 \times x = 14 \times 966 \times \cdot 206$$
$$\therefore x = 460 \text{ deg. rise of temperature.}$$

Add 50 deg. for temperature of atmosphere,

460 deg. + 50 deg. = 510 deg. funnel temperature;

probably as low a temperature as should be aimed at for the gases leaving the boiler, being only 145 deg. in excess of the temperature of the steam.

The boilers of the second ship are the same as the preceding, excepting the reduction of the grate area to 45·5 square feet. The efficiency by Rankine's formula for forced draught is 84·4 per cent. being 13·4 per cent. increase. This, however, has been taken at only 10 per cent., including 1 per cent. for driving the fan—being equal to 10 indicated horse-power—leaving 81 per cent. net efficiency. The funnel temperature calculated as before, but taking 18 lb. of air instead of 24, is—

$$(18 + 1) \cdot 242 \times x = 14 \times 966 \times \cdot 14,$$
$$\therefore x = 412 \text{ deg. rise of temperature.}$$
and $x + 50$ deg. = 462 deg. funnel temperature;

a temperature to obtain which by natural draught would necessitate a heating surface of 4064 square feet instead of 3460 square feet.

The boilers for No. 3 ship are 11¾ft. diameter, by 10½ft. long; the heating surface and steam space being practically the same as before. Ample grate area, with a consumption of only 32 lb. per square foot, is obtained in four furnaces with bars 4ft. long, so that the firing is done under most favourable conditions. The tubes also are reduced from 3¾in. to 2¾in. outside diameter. These modifications have reduced the weight of boilers and water from 98 tons to 82·4 tons. At first sight it may be thought that the tube area has been too much reduced, being 17½ square feet, as against 21½ square feet in the natural draught boiler. But as the quantities of the products of combustion are as 19 to 25, the restriction is inappreciable. The heating surface in these boilers being practically the same as in the preceding, the efficiency and funnel temperature are the same. The boilers for No. 4 ship are each 11ft. diameter by 10ft. long. Here the heating surface as well as the grate has been reduced, and the total weight of boilers and water is 65½ tons, being a reduction of 32½ tons from the natural draught boiler. If the surface of this boiler had been reduced as much as would have brought its efficiency down to 76 per cent. on Rankine's forced draught curve, the ratio $\frac{H\,S}{C}$ would have been 1·2; it is however, 1·41, which is an excess of 17·5 per cent. of heating surface, so that the efficiency may be safely taken at 76 per cent. To this, however, has to be added the beneficial effect of heating the incoming air by the outgoing gases. At 76 per cent. efficiency the consumption is reduced to 1·565 from 1·6 lb. per indicated horse-power per hour. Then, the funnel temperature, taking this efficiency and 18 lb. of air per lb. of fuel, is 610 deg. If this be reduced to 250 deg., which is still 200 deg. above the atmosphere, and not an extravagant assumption, then the heat saved is—

$$(18 + 1)\,(610 \text{ deg.} - 250 \text{ deg.}) \times \cdot 242 = 1650 \text{ thermal units.}$$
$$= \cdot 122 \text{ lb. of coal}$$
$$\therefore \text{coal per indicated horse-power per hour} = 1 \cdot 565 - \cdot 122$$
$$= 1 \cdot 443 \text{ lb.}$$

An efficient arrangement for heating the air supply to the fans in the funnel or uptake presents no practical difficulty, and the incoming current of air would tend to prolong the life of the plates. The comparative performance of the steamers is given in Table No. 6. The vessels are supposed to make four double voyages of thirty days per annum, and it will be seen that on a moderate computation No. 2 steamer gives a net return of over £600 per annum more than No. 1, while in No. 3 it is almost £800, and in No. 4 no less than £1044. This gain is due to lighter machinery and greater efficiency of boiler; and whatever saving is to be effected by the use of an inferior class of fuel in the forced draught boats is left out of consideration.

To complete the comparison it is necessary to consider the weight and first cost of the fan and its fittings. It will be sufficient to do this for Nos. 1 and 4 ships, the others being intermediate types. Taking the boilers at £30 per ton, there is a balance of £645 in No. 4 ship to pay for the fan and its accessories, which is about double what would be required. At the same time, the fire-bars have been reduced about 1¼ tons in weight, which will compensate for the weight of the fan. Further, the weight and cost added to the uptake, in the form of heating surface, would probably not be greater than that saved by the reduced size of smoke-box and funnel that would be used. Thus the £1044 may be taken as a clear gain.

It will be seen that the reduction of weight is obtained without any wide departure from the ordinary marine type of boiler. After the reduction of the number of furnaces, the most, and perhaps only noticeable feature in the boiler No. 3, is the reduction in diameter and number of tubes. This, of course, restricts the flue area much more than in the case of the boiler No. 2, so that the remarks made upon it do not apply; on the contrary, there will in this case be an increased resistance to the passage of the gases through the tubes which will have to be overcome by increasing the power of the fan. The additional power required does not, however, seem likely to be great. The whole weight of gases to pass through the tubes per minute is $\frac{1413 \times 19}{60} = 457$ lb., and the area through the tubes is 1630 square inches, so that there are 3·6 square inches for every pound of gas per minute. Now, in the experiments on Thornycroft's boiler, the area per lb. of gas is very much smaller. Take Experiment A:—The weight of gas is $\frac{925 \times 26 \cdot 5}{60} = 400$ lb. per minute. The area through the tubes is 389 square inches, or less than 1 square inch per lb. of gas, and the pressure required to force the gas through the tubes was 1·35in. of water. In B the weight of gas is $\frac{1177 \times 26}{60} = 500$ lb. per minute, giving about ·8 square inches per lb., the air pressure required being 1·87in. of water. In C the weight of gas is 625 lb., giving about ·62 square inches per lb. and 3in. of water pressure.

Similarly in D, 700 lb. of gas gave ·55 square inches of tube area per lb., which required 4·33in. of water pressure. If the area be 3·6 square inches per lb. of gas, the air pressure required is ½in. for the same length of tube as in the above experiments—viz., 6ft. long—and for the same diameter. But the tubes we have to deal with are 7ft. long, and if the diameter were the same the resistance would probably be increased as 7 to 6, giving ⅝in. water pressure. However, the tubes are 2¾in. diameter instead of 1¾in., so that, for each unit of flue area, the surface of tube to offer frictional resistance to the passage of the gases is reduced in the ratio of 5 to 3; the air pressure would then probably be $\frac{\frac{5}{8}\text{in.} \times 3}{5} = \frac{3}{8}$in. of water pressure.

This question of tube resistance might also easily be determined by a few direct experiments at no great cost, and would place valuable information at the disposal of anyone called upon to design a boiler for use under forced draught.

The method of driving the fan deserves careful consideration from an economical point of view; and where it cannot be driven off the main shafting by suitable gear, and a separate engine is provided, it should preferably be a compound engine expanding the steam to a low pressure, many of the high-speed toys frequently used being, it is to be feared, little better than steam eaters. In war vessels the question of economy is made altogether subservient to the necessity of obtaining great power from a light weight of boiler during a limited period. Steaming under natural draught is the normal condition for these vessels, and forced draught is employed only when on special service, or to meet the exigencies of naval warfare. In fact, the British Admiralty in their contracts stipulate for a forced draught trial of four hours' duration only, and the six hours' trial of the cruiser Giovanni Bausan, recently built for the Italian Government by Messrs. Sir W. G. Armstrong, Mitchell, and Co., and engined by Messrs. R. and W. Hawthorn, is probably the longest and one of the most successful forced draught trials on record.

The system usually adopted in the Navy is that of closed stoke-hole; and it has yet to be proved that this can be successfully carried out over a lengthened period. If, however, the system of *closed ashpits* be adopted, and the incoming air heated, it might be—and in the merchant navy has been—used continuously, reducing the consumption of fuel in ordinary working, as already indicated, and thus reducing the amount to be carried—a point of vital importance in this class of vessel. The reduced consumption will be still more marked at the high powers. The temperature of the gases leaving the boiler will be very high—say 1200 deg.—and thus nearly 40 per cent. of the heat in the fuel would pass away through the funnel, so that, if the incoming air carried back one-half of this to the boiler, a saving of 20 per cent. would result.

In conclusion, the writers would again direct the attention of the members to the desirability of having some carefully conducted experiments on the lines already indicated. This is surely not beyond the scope of an Institution with a membership of upwards of 500, amongst whom are representatives of all the leading firms on the north-east coast.

TABLE No. IV.—*Forced Draught Experiments on Thornycroft's Torpedo Boat Boilers.*

Reference letter.	Heating surface in square feet.	Grate in square feet.	Heating surface. / Grate area.	Total coal in lbs.	Refuse per cent. of fuel.	Lbs. of coal per foot of grate.	Square feet of heating surface. / Lbs. of coal.	Lbs. of water per lb. of coal from and at 212 deg.	Funnel temperature.	Lbs. of air per lb. of coal.	Efficiency, taking calorific value of coal at 16·11.	Per cent. of error. / Rankine.	Per cent. of error. / D. K. Clarke.	Force of draught in ins. of water.	Fire in inches. Front.	Fire in inches. Back.	Duration of trial.	Date.
1	2	3	4	5	6	7	8	9	10	11	12	13	14					16
D	618	18·9	32·6	1815	—	96·03	·340	7·15	1444°	22½	·444	−16·4	Not calculated.	6	5½	14	1h. 27m.	April, 1880.
C	„	„	„	1472	—	78·9	·420	7·60	1260°	24½	·472	−11·7		4	4	11	1 39	
B	„	„	„	1177	—	62·2	·525	7·90	1192°	25	·490	− 4·3		3	5½	14	2 7	
A	„	„	„	925	—	49	·668	8·49	1073°	25½	·525	0		2	3½	9	2 0	

TABLE No. V.—*Forced Draught Experiments on a Horizontal Return-tube Boiler at Philadelphia.*

Reference No.	Heating surface in square feet.	Grate in square feet.	Heating surface. / Grate area.	Total combustible = fuel, less refuse, in lbs.	Refuse per cent. of fuel.	Lbs. of combustible per foot of grate.	Square feet of heating surface. / Lbs. of combustible.	Lbs. of water per lb. of combustible from and at 212 deg.	Funnel temperature.	Lbs. of air per lb. of combustible.	Efficiency, taking calorific value of combustible at 16.	Per cent. of error. / Rankine.	Per cent. of error. / D. K. Clarke.	Remarks.	Date.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
50	950	27	35·2	513	22·4	19	1·85	12·92	Zinc melts.	13	·808	−10·8	Not calculated.	Fan, grate reduced	1865-66
45	„	36	26·4	797	18·9	22·15	1·19	11·36		22½	·710	− 9·1		Fan, boiler as built	„
49	„	„	„	780	24·2	21·66	1·22	11·18		23½	·699	− 7·1		„ „ „	„
51	„	„	„	659	18·2	18·3	1·44	11·23		23½	·702	− 3·1		Jet, „ „	„
44	„	„	„	778	20·8	21·62	1·22	11·06		24½	·691	− 6·1		Fan, „ „	„
41	„	„	„	805	16·3	22·37	1·18	10·0		31	·625	+ 2·9		Jet, „ „	„
42	„	„	„	780	18·5	21·67	1·22	9·88		31½	·618	+ 5·0		Fan, „ „	„
43	„	„	„	783	17·7	21·76	1·22	9·25		35½	·578	+12·3		„ „ „	„

TABLE No. VI.—*Comparative Performance of Steamers.*

	No. 1. Tons.	No. 1. Rate.	No. 1. £.	No. 2. Tons.	No. 2. Rate.	No. 2. £.	No. 3. Tons.	No. 3. Rate.	No. 3. £.	No. 4. Tons.	No. 4. Rate.	No. 4. £.
OUTWARD.		s. d.			s. d.			s. d.			s. d.	
Dead weight	2840	—	—	2840	—	—	2855	—	—	2872	—	—
Less coal for 30 days ..	514	—	—	468	—	—	468	—	—	462	—	—
Cargo delivered	2326	20 0	2326	2372	20 0	2372	2387	20 0	2387	2410	20 0	2410
Less bunker coal	514	8 6	218	468	8 6	199	468	8 6	199	462	8 6	196
Gross balance	—	—	2108	—	—	2173	—	—	2188	—	—	2214
HOMEWARD.												
Dead weight	2840	—	—	2840	—	—	2855	—	—	2872	—	—
Less coal for 15 days ..	257	—	—	234	—	—	234	—	—	231	—	—
Cargo delivered	2583	30 0	3874	2606	30 0	3909	2621	30 0	3931	2641	30 0	3961
Less bunker coal	257 257	28 6 24 0	674	234 234	28 6 24 6	613	234 234	28 6 24 6	618	231 231	28 6 24 0	606
Gross balance	—	—	3200	—	—	3296	—	—	3318	—	—	3355
Gross balance on double voyage	—	—	5308	—	—	5469	—	—	5506	—	—	5569
Gross balance per annum ..	—	—	21,232	—	—	21,876	—	—	22,024	—	—	22,276
Gain per annum over No. 1.	—	—	*Nil.*	—	—	644	—	—	792	—	—	1044

TABLE No. VII.—*Boilers.*

	No. 1.	No. 2.	No. 3.	No. 4.
Diameter of boilers	13ft. 0in.	13ft. 0in.	11ft. 0in.	11ft. 0in.
Length „	10ft. 6in.	10ft. 6in.	10ft. 6in.	10ft. 0in.
No. of furnaces	6	6	4	4
Mean diameter of furnaces ..	3ft. 0in.	3ft. 0in.	2ft. 10in.	2ft. 10in.
Length of grate..	5ft. 6in.	2ft. 6in.	4ft. 0in.	3ft. 11½in.
No. of tubes	384	384	540	332
Diameter of tubes	3¾in.	3¾in.	2¾in.	2¾in.
Length „	7ft. 6in.	7ft. 6in.	7ft. 6in.	7ft. 0in.
Total heating surface. sq. ft.	3460	3460	3400	2028
„ grate area.. .. „	100	45·5	45·5	45
Weight of boilers .. tons.	62	62	53·6	41·5
„ water .. „	36	36	28·8	24
H.S. per I.H.P... .. sq. ft.	3·46	3·46	3·4	2·03
H.S. per lb. of coal .. „	2·16	2·38	2·33	1·41
H.S. to grate	34·6	76	74·7	45
Coal per sq. ft. of grate .. lbs.	16	32	32	32
Coal per I.H.P. per hour.. „	1·6	1·456	1·456	1·443
Funnel temperature.. deg. F.	510	462	462	610

THE PHYSICAL SOCIETY.

AT the meeting of this Society on March 27th, Professor W. G. Adams, vice-president, in the chair, Mr. A. R. Wright was elected a member of the Society.

The chairman read a letter from Dr. Alex. Wright, secretary to the Tribe Fund Committee, in which reference was made to the scientific work of the late Mr. Alfred Tribe, and an appeal made for funds to aid in the maintenance and education of his family, which, owing to his early death, have been left in straitened circumstances.

The following communications were read:—"On an Arc Lamp Convenient for Use with the Duboscq Lantern," by Professor S. P. Thompson. The old Duboscq lamp, though working well with a series of Grove's cells, is very unsuitable for use with currents from dynamos. Professor Thompson has employed as a substitute in the Duboscq lantern a lamp commonly known as the Belfast arc lamp. The result is all that can be desired as regards steadiness and regularity. The focussing—that is, the adjustment of the arc so that it shall remain unchanged in position—is effected by a wheel below the lantern, which is moved by hand.

"On a Modified Maxwell's Galvanometer," by Professor S. P. Thompson. The galvanometer consists of a light frame of copper upon which is a coil of wire. This is suspended between the poles of a horseshoe magnet, and a piece of soft iron is placed within the coil but free from it, which concentrates the magnetic force between the poles. The coil is suspended by two silver wires, by which it is in connection with two binding screws on the base of the instrument. This galvanometer is extremely simple in adjustment and very dead beat; it has also the advantage of being affected to an inappreciable extent by neighbouring magnets and currents, with a current in its own coils. When no current is in it, it is of course quite unaffected. The reading is effected by the ordinary lamp, mirror, and scale arrangement.

"On the Expansion of Mercury between 0 deg. and − 39 deg. Cent.," by Professors W. E. Ayrton and John Perry. On November 14th, 1885, Mr. G. M. Whipple gave the Society the results of the examination of thermometers down to the melting point of mercury. There was, however, no evidence as to whether the contraction of the mercury continued uniform, as the thermometers were only compared with mercurial ones. The authors have therefore examined this point, and have made a series of comparisons of a mercurial thermometer lent them by Mr. Whipple, with a constant volume air thermometer, both immersed in a bath of frozen mercury, which was allowed to gradually become warm. The result obtained was that no certain deviation from a linear law could be detected in the expansion of mercury when temperature was measured by the increase of pressure required to keep a volume of air constant. Hence temperatures down to − 39 deg. Cent. may be correctly measured by a mercury thermometer the stem of which is graduated for equal volumes.

"On the Expansion Produced by Amalgamation," by Professors W. E. Ayrton and John Perry. It has been accidentally observed by the authors that the amalgamation of brass is accompanied by great expansive force. If one edge of a straight thick brass bar be amalgamated, it will be found that in a short time the bar is curved, the amalgamated edge being always convex and the opposite concave. The authors imagine that a similar action may be the primary cause of the phenomena presented by the Japanese magic mirrors. Japanese mirrors are made of bronze, and have a pattern cast upon the back, and although to the eye no trace of it can be discovered upon the polished reflecting surface, yet, when light is reflected by certain of these mirrors on to a screen, the pattern is distinctly visible in the luminous patch formed. In a paper before the Royal Society, they have shown that this is due to the polished side opposite the thinner parts of the casting being more convex than the others—a conclusion verified by the fact that the pattern is reversed when formed by a convergent beam of light. Such a condition of things would evidently result from a uniform expansive stress taking place over the reflecting surface, the thinner, and consequently the weaker, parts becoming more convex or less concave than the others. The authors have hitherto attributed this inequality of curvature to a mechanical distortion to which the mirrors are intentionally submitted during manufacture to produce the general convexity of the polished service, but they now think it possible that the use of a mercury amalgam in the process of polishing may have an effect in the production of this inequality of curvature.

THE CARRON COMPANY'S AWARD SCHEME.

THE Carron Company has matured an award scheme something like that of Messrs. Denny, of Dumbarton, to develope and encourage inventive talent amongst its workmen, and to utilise it for improvement in quality of work and economy of production. The rules are:—

I. Any workman or number of workmen, with the exception of those in charge of a department, or a chief foreman in the employment of Carron Company, may claim an award on the following grounds:—(*a*) That he has either invented or introduced a new machine or hand tool into any department of Carron Company's Works. (*b*) That he has improved any existing machine or tool, or adapted it to a new class of work. (*c*) That he has invented, introduced, improved, or rendered more useful, any of Carron Company's manufactures. (*d*) Or, generally, that he has discovered or introduced any method or arrangement by which the work of the company is rendered superior in quality or more economical in cost.

II. When any new idea occurs to a workman or workmen, on which he or they may intend to base any claim, he or they shou'd, without delay, give notice to the secretary, in writing, signed by the claimant, with the view of establishing priority of claim in case of dispute. The secretary to submit the idea to the first meeting of committee for consideration, and if approved of, facilities will be afforded him or them to carry out his or their idea—if unable to do it himself or themselves.

III. On the establishment of a claim under the conditions above specified, the committee are to make an award, at their discretion, of not less than £1 nor more than £10. A workman or workmen accepting the award of the committee, the improvement or invention becomes the property of Carron Company. In the event of the committee considering any invention or improvement worthy of a higher reward, or protection by letters patent, they shall report the same to Carron Company for their special consideration, and if it is agreed upon to take out letters patent for said invention or improvement, Carron Company shall have the first offer of accepting the absolute right to use or manufacture such improvement or invention on payment of a lump sum or royalty, as may be mutually agreed upon.

IV. After the committee have completed their investigation of a claim, the secretary shall intimate their decision to the claimant, and if it is favourable, enclose an order on Carron Company, signed by himself, and countersigned by the company's manager, for payment of the amount awarded, and this order shall be payable on presentation to the cashier.

V. When any workman has received since the commencement of the scheme as many as five awards, the total amount of the awards being under £10, he shall receive a premium of £5. When the total amount of awards is from £10 to £25, a premium of £10. When the awards amount from £25 to £50, he shall receive a premium of £20. This being repeated every five succeeding awards.

VI. The committee will meet on the first Monday of each month for the transaction of business.

VII. The committee may call before them, as evidence on the claims made to them, any person they may think proper.

VIII. The committee shall, in case of difference of opinion, decide the matter by vote, the majority ruling. The chairman to have a casting vote.

IX. The secretary shall, under the direction of the president, keep full minutes of the proceedings and decisions of the committee which must be approved by the committee at the first meeting after that to which the minutes refer.

X. The committee reserve to themselves the right to modify, change or annul, any or the whole of the foregoing rules.

Note.—Copies of these rules may be had from the secretary to the committee. Price threepence each copy.

It is suggested (1) That no workman should hesitate to send in a claim for any invention or improvement he has made, as by so doing he not only deprives himself of the award to which he is justly entitled, but he also prevents the committee from acquiring a complete record of all inventions made in the works, including the names of the inventors. (2) That no workman should present a claim before giving it his most careful consideration and satisfying himself of its validity. By neglect of this precaution his claim may be rejected, and he thereby discouraged from making further efforts.

The committee will at all times be pleased to give any information for the guidance of workmen.

NAVAL ENGINEER APPOINTMENTS.—The following appointments have been made at the Admiralty:—William Bromleigh, engineer, to the Tamar; and James Brown, engineer, to the Avon.

AMERICAN NOTES.

(*From our own Correspondent.*)

NEW YORK, April 3rd.

BUSINESS has been obstructed all the week at Boston, New York, and Philadelphia, on account of the uncertainty as to the outcome of the strikes in the West. A great deal of activity prevails among manufacturers of all kinds of special machinery, locomotives, engines, car work, hydraulic machinery, electric light machinery, and boilers and engines large and small. A large amount of capacity is to be erected during the next sixty days, and additional contracts for special machinery are to be placed this month. The exceptional active demand for machinery at this time is the outcome of a very busy winter. The improvement has taken place in the iron and steel mills, and in the textile establishments of New York and the New England States, and in the larger mills of some of the Western States. Four or five large iron and steel making mills are to be built this season—one in Alabama, two in Western Pennsylvania, one in Ohio, besides the completion of some large establishments in other States, begun last fall; among them the large establishment at Troy, New York, where two of the most complete blast furnaces are being placed. The blast furnace capacity of Pennsylvania has been very greatly improved during the past six months, and three new furnaces are being erected in that State.

Large contracts for lake ore have been placed during the past week for delivery at Cleveland, and over three-fourths of the entire production of the mines is substantially contracted for. A large amount of ore and copper territory will be opened this season in the Lake Superior regions. About one hundred and fifty miles of lumber road also are to be built, which will develope some valuable territory and increase the available supply of white pine for Eastern markets.

The receipts of yellow pine from Gulf ports, and from one or two southern ports, have largely increased during the week, but prices are very firm under the enlarging demand for railroad and building demands. In railroad supply departments everything is quiet. A few good-sized contracts have been placed for steel rails at 35 dols. It is now evident that the total productive capacity of the country, which is 1,500,000 tons, will be engaged to meet the demands which are coming forward. Projection of several new roads is announced, amounting during the past week to between 600 and 700 miles—most of it west of the Mississippi River. Very little bridge work has been placed for two weeks, but a large amount of work will be wanted, and will be placed early in April or late in May. Forge iron is selling at from 16 dols. to 17 dols.; No. 1 foundry, 19 dols.; English Bessemer, 19 dols.; English speigeleisen, 26 dols. The bar mills have been closing down on account of the bituminous coal strike, which involved over 20,000 men. The anthracite coal trade is very firm, and prices have advanced from 25 to 50 cents per ton since last Monday, on account of the agreement of the presidents of the various companies as to the amount to be produced this year, namely, 33,500,000 tons. On next Monday a meeting will be held at which the percentages of production to each of the roads will be determined upon.

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

(*From our own Correspondent.*)

THE reports brought to 'Change at Wolverhampton yesterday, and in Birmingham this—Thursday—afternoon, did not indicate that orders upon ironmasters' books had been largely increased, as the result of the quarterly meetings. Merchants seem to have no big orders to place for export, and for those that are offered, the competition of other districts nearer the shipping ports continues severe.

Orders are being received for cotton tie and baling hoops on United States account in fair numbers. The competition of Lancashire and other ironmasters, however, keeps prices at a very low level. Orders for hoops of the general merchant description are arriving from Australia, South America, and some other markets in moderate quantities. Common hoops are priced at £5 to £5 5s. per ton, superior sorts being £5 15s. to £6. The demand for gas tube strip is quiet at £4 15s. to £5.

The sheet mills are only running part time, and numbers of them have been put wholly to a stand. A few makers, however, keep fully employed, and such firms ask £6 2s. 6d. for doubles and £7 2s. 6d. for lattens, with £1 per ton additional for steel sheets. Prices of galvanised iron are weak. Merchants are offering £10 for sheets of 20 gauge f.o.b. Thames, and a little over £10 for 24 gauge, f.o.b. Mersey. Strong makers will not, however, consent to accept these rates, and certain of them demand 10s. per ton more. The competition of steel sheets is increasing daily, and assists to keep iron prices at their present level. Thin sheet firms are best employed, American, Canadian, Continental, and Australian orders helping out home orders.

Messrs. John Knight and Co. quote: Working-up sheets, £10 10s.; soft steel sheets, £12 10s.; and charcoal sheets, £19 10s. Doubles are 30s. extra, and lattens 60s. extra. Crown bars they quote £7 10s.; plough bars, £9 10s.; angles, up to 3½in., £7; and charcoal bars, £15 10s. Tin-plates, the same concern quote, charcoal i.c. 23s. per box Liverpool, and coke sorts 19s. 6d. Messrs. Crowther Brothers and Co., of the Stour Vale Works, quote their Vale sheets £10 10s.; S.B. brand, £11; best best, £12; and treble best, £13; semi-charcoal, £14; charcoal, £15; and best ditto, £16 6s. Their steel sheets vary from £11 to £12 10s., and on to £13 10s., according to quality.

Although Messrs. Knight and Co. have now started their new works at Brierley Hill, their Cookby Works will also be carried on for some little time longer until the transition has been completed. The Cookby Works have been established nearly 200 years, and are dependent entirely upon water communication. The new works have the advantage of railway and canal communication, and are situated in the centre of the Earl of Dudley's thick coalfields.

The present prices of the Pelsall Coal and Iron Company are as here:—P.C. bars, £5 5s.; P.C. hoops, £5 10s.; crown bars, £6; crown hoops, £6 5s.; crown sheets, £6 15s.; charcoal sheets, £13 15s.; hinge strip, £6 5s.; gas strip, £5 5s.; nail strip, 24in. wide to 13 g., £5 5s.

Messrs. William Barrows and Sons quote:—Bars, round, square, and flat, £7 10s.; best bars, suitable for chain making and other purposes, £9; double best, suitable for superior chain bars and the like, £10; plating bars, £8; best angle, tee, and rivet iron, £9 10s.; and double best, £10 10s. Boiler-plates the firm quote £9, £10, £11, and £15, according to quality; and sheets, £9 for 20 gauge, £10 10s. for 24 gauge, and £12 for 27 gauge. Hoops they quote £8; best, £9 10s.; and wide strips, £9.

Mr. Benjamin Talbot, of the Haybridge Iron Company, Shropshire, has bargained for the purchase of the Castle Ironworks in the same locality, belonging to Nettlefolds, and will take them over when the latter firm remove their business to the new works at Newport, Mon.

Steel of splendid quality is just now being made by the Patent Shaft and Axletree Company. This concern has given a trial to many varied steel processes, and it has come to the conclusion that it is best to still give the preference to the Siemens-Martin process, with some modifications and additions. They are now turning out bars which will stand a tensile strain of 33 tons to the inch.

Some of our steel-masters are hoping by-and-bye to share in the orders for steel sleepers.

Basic steel, rolled by the Staffordshire Steel and Ingot Iron Company, is quoted this week £4 15s. for blooms, £7 for bridge and girder plates, and £8 for boiler plates. Welsh steel tin-bars, blooms, and billets are quoted £4 10s. delivered, and Welsh steel plating bars £5, with an increasing sale.

The prices at which Derbyshire, Northampton, and other Midland pigs are selling are most discouraging. These vary from 35s. delivered to railway stations in this district, while Lincolnshire pigs are quoted 39s. to 40s. Native pigs are 52s. 6d. for hot blast all-mines, though a few makers stand out for 57s. 6d. Part-mines are 35s. upwards, and common cinder pigs are 27s. 6d. to 30s. Some Derbyshire firms have practically retired from the market at 37s. per ton, being unprepared to continue selling at a loss.

Business in hematites is quiet. West Cumberland and good Welsh hematites are mostly quoted 52s. 6d. to 53s. delivered here, though some buyers talk of lower rates. The Tredegar Company is firm at 52s. 6d. for best qualities, and 43s. for second qualities. Spanish hematites of the Vizcaya brand are offered here, but the price is at present too high to effect sales to other than the ironfounders. The representatives quote 55s. 6d. to 57s. 6d., according to quantity, and for foundry sorts 60s. per ton.

Ironmasters have this week a further slight relief afforded them in railway rates. The Midland Company announces as from the 1st inst., a drop of 10d. per ton on the carriage of undamageable finished iron to Hull, the new rate being 12s. 6d. per ton as against 13s. 4d. previously existing. The reduction is fenced about with the provision that the new tariff applies only to 10-ton lots and upwards, instead of 2-ton lots as heretofore. Some years ago Staffordshire ironmasters could get to Hull by canal for 10s. per ton.

The ironworkers have just held a meeting at Old Hill, and determined to give their best support to Mr. Mundella's Railway Bill, and to call upon the Staffordshire Members of Parliament to vote for the measure subject to the alterations which the Staffordshire members suggest. Statistics were quoted by the ironworkers showing that whilst the three railway companies serving the South Staffordshire district had been charging 15s. 2d. from Birmingham to London, for the same distance in Germany the charge was 8s. 6d., in Belgium 8s. 11d., in Holland 8s. 2d.; from Birmingham to Liverpool, 12s. 2d., the German rate, same distance, 7s. 8d.; the Belgian rate, same distance, 8s. 6d.; the Dutch rate, same distance, 7s. 9d.

Constructive engineering firms have, during the past week, submitted tenders for some valuable work which has been in the market, but replies are not yet to hand. Meanwhile the works are fairly well occupied upon former contracts.

The wrought iron tube trade keeps quiet, and makers are watching with much interest the issue of the strike at Wednesbury.

One of the leading Birmingham brassfoundry firms, viz., Mr. Arthur Chamberlain—Smith and Chamberlain—has been converted into a limited liability concern with a capital of £100,000.

The importation of Belgian machine-made nails is having a deleterious effect upon the South Staffordshire and East Worcestershire horse-nail trade. This week the operatives have been called upon to submit to a further reduction in wages of 3d. per thousand, thus bringing the remuneration down from 4s. 3d. five years ago to 2s.

The Shrewsbury Corporation has under consideration a new scheme for the supply of water to the town. As at present proposed, the wells, tanks, filtering bed, and pumping station are to be constructed on the opposite side of the river near the town, and the water pumped to an elevated service tank. The total cost of the works is estimated at £25,675, towards which the Water Committee have £6000 in hand, saved out of the profits from the present supply. It is calculated that £258 a year will be saved by the new scheme, and that the amount of storage will avoid the necessity which now exists of pumping on Sundays.

NOTES FROM LANCASHIRE.

(*From our own Correspondent.*)

Manchester.—The condition of the iron trade in this district remains very much the same as last reported. Business still drags on in a lifeless manner, and to effect sales prices are taken which are lower than anything that has been known in this market before, whilst the listless, indifferent attitude of buyers indicates a continued want of confidence in the future which has so depressing an effect upon the market. In fact, so despondent has the whole outlook become, that the persistent efforts which are being made to bring about a restriction of the output utterly fail to galvanise the market into any semblance of life, and the break up of the Steel Rail Makers' Association, which ought, under any reasonable supposition, to be the opening of the door to a large accession of new business, has apparently no appreciable effect. This long-continued depression, and the serious loss under which business has for a considerable time past in many instances been conducted, has given rise to very disquieting rumours as to the position of a number of houses in the iron trade, and one hears very frequently such remarks as "the end is getting very near," or "some of the makers will soon be compelled to stop," and what is regarded as the inevitable collapse of the weakest of the iron-making firms is indeed looked forward to as the only practicable relief from the present ruinous depression of over production.

The Manchester iron market on Tuesday brought together a very fair attendance; but there was no weight of business doing, and prices all through were excessively low. For pig iron there was only a very poor inquiry, and prices were very much cut up by the keen competition of some of the district brands. Lancashire makers, with their present restricted output, are kept about going with renewals of contracts from regular customers, and they do not attempt to meet the competition of the low-priced district brands; for local brands the minimum quoted figures remain at about 37s. 6d. to 38s., less 2½ per cent., delivered equal to Manchester, and one or two of the Lincolnshire makers hold to pretty near the same prices, but some of the Lincolnshire brands have been sold as low as 35s. 6d., less 2½ per cent., delivered here, and buyers seem to have been making this the basis for any offers they have had to put forward. Outside brands have lost all the advance which the temporary spurt in Glasgow warrants recently gave to the Scotch and North of England markets, and makers' prices for both Scotch and Middlesbrough iron delivered into this district are now quite as low as ever.

Hematites still meet with very little inquiry, and prices continue extremely low, No. 3 foundry qualities being obtainable, where buyers are prepared to take anything like quantities, at about 50s. 6d. to 51s., less 2½, delivered into this district.

In the manufactured iron trade there seems to have been a little more work giving out since the commencement of the quarter, and one or two of the local forges which were previously very slack have got on to full time. The condition of the market, however, shows no perceptible improvement, and prices remain on the extremely low basis of £5 for bars, £5 7s. 6d. for hoops, and £6 10s. for local-made sheets delivered into the Manchester district.

In the condition of the engineering trades, although the returns for the country generally issued for the last month by the trades union societies connected with this branch of industry would seem to indicate a slightly better state of things, so far as this district is concerned, there is no improvement. The Amalgamated Society of Engineers have in the district still about nine to ten per cent. of their members on the books in receipt of out-of-work support, and the Steam Engine Makers' Society are about in the same position. Their returns, as a whole, show a slight decrease in the number of out-of-work members, the number in receipt of donation benefit being now about 5½ per cent., but none of this decrease applies to Lancashire, where there is no improvement perceptible, except in odd cases. Where there is any actual improvement reported, it is confined chiefly to the North of England. So far as this district is concerned, where inquiries recently were reported to be coming forward more freely, there seems to be a falling off, and very little actually new business has resulted. The stationary engine trade continues very dull, and the new work in prospect which was talked of a short time back has not yet found its way into the shops. Tool-makers are kept fairly employed, and firms engaged on heavy ordnance work, iron ship material, and Government contracts, have plenty of work in hand.

The announcement of the death of Mr. Spencer H. Bickham, in his 74th year, has been received with deep and general regret throughout all branches of the commercial community in this district. Mr. Bickham has filled the post of one of the directors of the well-known firm of Messrs. Sharp, Stewart, and Co. ever since it was formed into a limited company, and although not directly connected with the engineering trade, he has taken an active interest in the commercial management of this important concern.

The proposed amendments of the Employers' Liability Act, 1880, contained in the Bills of Mr. Burt and Mr. A. O'Connor now before Parliament, are to be met with strenuous opposition on the part of the various employers' organisations throughout the country. In this opposition the lead is being taken by the Iron Trades Employers' Association, whose head-quarters are in Manchester, and which represents the master engineers, shipbuilders, iron and brass founders, and other kindred trades of Great Britain. This Association has issued a circular, requesting that all of its members should look carefully into the very startling proposals embodied in these two Bills, and as in due course it will be the duty of the Association to tender evidence in the interests of its members before the Select Committee of the House of Commons, to which the entire question has been referred, it is suggested that meetings of members in every district should be held to consider to what extent they can offer such rebutting evidence as will meet the objectionable clauses of Mr. O'Connor's Bill, to which their attention is specially directed. The Association has also prepared a carefully drawn up petition against the two Bills, which so fully takes up and deals with the objectionable points contained in these proposed enactments that it has been adopted as the basis for similar petitions that are to be presented to the House of Commons by other employers' organisations throughout the country. After stating in detail the various proposed amendments of the Employers' Liability Act, to which objection is taken, the petition sets forth that, considering the fact that the principal Act will expire at the end of the session of 1888, it is inexpedient to amend the same or to interfere with the working thereof till it ceases to be operative by the efflux of time. That if employers and workmen are prevented by the Legislature from contracting themselves out of the Act, it will be a direct interference with the freedom of contract, and that no cause for such interference has been shown in any shipbuilding, engineering works, or machinists' shops known to the petitioners. That there are many cases where both employers and workmen feel that it is to their mutual interest that the Act should not apply, and it is submitted that in such cases it is unwise and inexpedient compulsorily to make the Act applicable. That such interest especially arises to the workman injured, or, if he is killed, to his representatives, if no proof of the negligence of the employer or superintendents is forthcoming, as in such case compensation would not be obtained under the Act, and mutual arrangements for compensation would almost certainly be prevented by the Bill. That in cases where the custom and economic practice of any given trade involve the sub-letting of certain work as an unavoidable element in the sub-division of labour, it will be a great injustice to the employer or contractor in the first instance to fix upon him a responsibility in operations where he has no direct control, and that to remove all responsibility from the sub-contractor will seriously increase the risks and dangers which it is the declared object of the principal Act of 1880 to limit or remove. That the proposal to repeal that portion of the eighth section of the principal Act which relates to and defines the person in command, or who has superintendence entrusted to him, is in the highest degree dangerous to the workmen themselves, as it would destroy the discipline of all workshops, and would leave no definite source of authority in any operations whatever, whilst it would expose the employers to the most serious consequences growing out of the actions of ignorant men devoid of authority and incapable of exercising any controlling or directing power in the discharge of their duties, or in operations at which they might be called to assist as ordinary workmen. The petition also objects to the proposed amendments for absolutely preventing the removal of any action into a superior court unless the amount claimed exceeds £200; for enabling an action to be maintained notwithstanding that the notice required by the Act of 1880 has not been given; and for giving discretion to the court to fix the sum for compensation to be awarded in certain cases, which sum is greatly in advance of the amount which can now be claimed under the third section of the principal Act of 1880 now in force.

A generally quiet tone prevails throughout the coal trade of this district. The better qualities of round coal still meet with a fair demand for house fire consumption, but common round coals for steam and forge purposes are in extremely poor demand, and engine classes of fuel meet with only a slow sale. There is no general quotable alteration in prices, but in most cases sellers are prepared with slight concessions to meet the market, and in some instances there is a giving way of 3d. to 6d. per ton on late rates. The average quoted rates at the pit mouth remain at about 8s. 6d. to 9s. for best coals, 7s. to 7s. 6d. for seconds, 5s. to 5s. 6d. common coals, 4s. to 4s. 6d. burgy, and 3s. up to 3s. 9d. per ton for slack, according to quality.

Barrow.—There is nothing new to report in the hematite pig iron trade. There is very little doing, although it is expected that the rail trade will soon so improve as to bring about a better demand for pig iron. Prices of hematite pig iron remain steady at late rates which are represented at 42s. per ton net. at works for prompt deliveries. In the steel trade a further reduction is noted of 2s. 6d. per ton on steel rails, and although this has not yet resulted in any accession of orders, it is more than probable that in the course of a few days some heavy contracts will be booked. Several tenders have been sent out to British railway companies, Colonial and American users, and commencing with this week, so far as British users are concerned, there will be several orders given. Foreign consumers continue to beat down prices. Heavy sections of steel rails are now 15s. per ton below the prices which formed the basis of the now defunct Steel Railmakers' Association. Shipbuilders have booked no new orders. Iron ore finds a very quiet market. Coal and coke in limited consumption. Shipping very quiet. The Barrow Shipbuilding Company has been entrusted by her Majesty's Government with the order to construct a set of twin screw engines and boilers of 2000 indicated horse-power to be fitted by them on board H.M.S. Buzzard at Sheerness Dockyard towards the end of this year, The Maryport Iron Company is exploring for iron ore with every chance of success at Pallaflat, near their works. Iron ore has been found at Bigrigg in Cumberland at Messrs. Lindow's St. John's pit. Another furnace has been blown in by Messrs. Cammell and Co., Workington, and the Solway Iron Company, and the West Cumberland Iron and Steel Company, have each blown out a furnace. The furnaces in blast in the West Coast district are 44. Owing to the improvements which are being made for the navigation of the Ribble, the launching ground and the shipbuilding yard of Mr. Smith at Marsh End is likely to be left high and dry. He has, however, bought three acres of land at Lytham, where he intends putting down works and appliances for the building of ships and steamers up to 1000 tons burthen.

THE SHEFFIELD DISTRICT.

(*From our own Correspondent.*)

YORKSHIRE collieries have done a much-diminished business with Hull for export during March last than for the corresponding month of 1885. The quantity brought to Hull from each colliery makes up a total of 96,408 tons, as compared with 101,056 tons for March, 1885. For the quarter the weight is 269,616 tons, against 286,160 for the first quarter of 1885. The exports from Hull also show a large falling off, 24,259 tons having been sent to foreign countries last month, against 32,914 for March, 1885. The quarter ending March last sh wed a total of 71,689 tons, against 100,415 tons for the first quarter of 1885. At home, Denaby Main, having recovered from its prolonged strike, takes its place at the head of the list, that colliery sending last month 10,285 tons, against 1008 for March, 1885. Manvers Main comes second with 7240 tons, against 9688; Wharncliffe Silkstone, 6464, against 3496; and Allerton Main, 5680, against 5904. To California only 6 tons were exported last month, against 2471 for March, 1885; the principal continental customer was Germany with 6692 tons, against 8772 tons for March, 1885.

Sheffield trade with the United States of America is decidedly improving in the two staple industries of steel and cutlery. Dr. C. B. Webster, the Consul for the Sheffield district, informs me that the exports of steel to the United States for the quarter ending March last reached a value of £62,272, against £46,976 for the corresponding period of 1885. In cutlery the value for the last quarter was £36,181, as compared with £28,608 for the first quarter of 1885. The total exports from the Sheffield consular district during last quarter were £121,971, while the value for the opening quarter of 1885 was £98,166. These figures are still far short of the business done with the United States in former years, such as 1868 to 1874; but it is gratifying to note that trade seems to have again taken an upward turn with this important market.

A statement which appeared in THE ENGINEER some time ago, and was contradicted on its reproduction elsewhere, turns out, as I anticipated, to be correct. It was mentioned that two leading firms of steel rail manufacturers had given notice of their intention to terminate their connection with the Steel Railmakers' Confederation, which would probably collapse. A meeting was held last week, and though it was arranged that further steps might be possible, I am informed that practically the ring was felt to be at an end. The two large firms who gave notice to leave the combination are believed to have been Messrs. Bolckow, Vaughan, and Co., Middlesbrough, and Messrs. Charles Cammell and Co., of Sheffield, Penistone, Barnsley, and Workington. The effect will be to instantly bring steel rail quotations to a lower level. When bottom is touched, improved values may probably be possible.

THE NORTH OF ENGLAND.

(*From our own Correspondent.*)

DULNESS was the ruling feature of the Cleveland pig iron trade during the whole of last week. There appears to be little probability of success for any scheme having for its object a general restriction of output, and consequently buyers are everywhere holding back. The market held at Middlesbrough on Tuesday last was but thinly attended. Few sales were made, and prices fell to the extent of 3d. per ton. Buyers were offered 29s. 10½d., but only in one or two cases was that figure accepted, and the quantities sold were but small. For forward delivery 30s. 6d. to 31s. per ton was demanded. Forge iron is in poor request, the market price being about 29s. per ton.

There is no demand for warrants. Quotations are nominally 30s. 3d. to 30s. 6d. per ton.

The stock held by Messrs. Connal and Co. at Middlesbrough was on Monday last 213,984, which represents an increase of 2246 tons during the week.

Pig iron shipments show a slight improvement. The quantity sent away this month up to Monday last was 25,508 tons, as compared with 19,190 tons during the corresponding portion of March, and 23,203 tons of April, 1885.

The general condition of the finished iron trade is as unsatisfactory as ever, the firms who have hitherto kept their mills at work having the utmost difficulty in getting specifications. Prices are the same as last quoted.

The value of exports from Middlesbrough during March—exclusive of coal and coke—was £144,098, being a decrease of £39,002 as compared with March, 1885. The exports from Newcastle were valued at £171,979, being a decrease of £19,696.

The average net realised price of No. 3 Cleveland pig iron during January, February, and March has been declared as 31s. 9·65d. per ton, which involves a reduction of 1 per cent. in the wages of ironstone miners.

Messrs. Bolckow, Vaughan, and Co., of Middlesbrough, have received an order for a large quantity of steel sleepers from the Metropolitan Railway Company. This would seem to indicate a new departure, and of a kind fraught with no small interest to steel makers. Although shipload after shipload of steel sleepers have been sent out to India, English railway companies have hitherto hesitated to use anything but timber for the purpose, except by way of experiment. The London and North-Western and the Midland Railway Companies have certainly commenced lately to make their experiments on rather a large scale. But even they cannot be said to have entered into contracts except tentatively, and with a certain amount of fear and trembling, lest they should be making a mistake. This new order from a new company, and on a larger scale, may mean that engineers are now at last satisfied that steel sleepers are more economical in the long run than timber, and are as applicable to British as to Indian and colonial lines.

The price of steel rails has fallen 10s. per ton since the collapse of the International Syndicate. Heavy sections may now be had for £4 5s. per ton.

Notices have been posted up at all the blast furnace works in the North of England, setting forth the amount of reduction proposed to be made in the wages of furnacemen and mechanics. The reduction varies from 5 per cent. at some works to 12½ per cent. at others. The men are naturally much excited, and at a meeting held at South Bank on the 12th inst. they passed the following resolution, viz.:—"That we are prepared to accept 1½ per cent. which the ironmasters are entitled to by the selling price of pig iron, but beyond that we cannot go."

The first meeting of the General Committee of the Newcastle-on-Tyne Industrial Exhibition for 1887 is to be held in the afternoon of the 15th inst., at the Literary and Philosophical Institution in that city. Lord Ravensworth will preside, and most of the rather numerous body of vice-presidents are expected to attend. The indefatigable secretary, Mr. Theo. W. Bunning, has for some time been hard at work organising and "wire-pulling," and it is to be hoped that the enterprise will achieve the full amount of success which it certainly deserves. It is by such means that there is the best chance of combating successfully the present tendency to despondency but too apparent in every industrial centre. By taking part in them men imbibe fresh hope and vigour, and contribute to set going those waves of confidence which must precede a general return to prosperity. The promoters are extremely fortunate in having been able to interest Lord Ravensworth at the outset, and secure his services as president. Unlike some of his predecessors, the present Earl seems most sociably disposed, and is ever anxious to promote the welfare of the great industries of the district in which he resides. His genial manner and great tact in dealing with others have won him universal respect, and his presidentship will go far to ensure the success of the exhibition. It is not yet announced where it will be held. The large and commodious edifice built some years since for the Tynemouth Exhibition still exists at that favourite watering place, which is easily accessible by rail or steamboat from Newcastle. The committee could, perhaps, not do better than localise it there.

NOTES FROM SCOTLAND.

(*From our own Correspondent.*)

THE pig iron market has been depressed this week, with less speculative business than during the past fortnight. Still there is an expectation that the volume of business may improve somewhat in succeeding weeks. As it is the shipments of pig iron are rather better than of late. During the past week they amounted to 7031 tons, as compared with 5655 tons in the preceding week, and 9870 tons in the corresponding week of 1885. Since last report an additional furnace has been put in blast at the Govan Ironworks, and there are now ninety-seven in operation, compared with ninety at this date last year. This state of matters looks somewhat anomalous in view of the reduced consumption and the efforts that are being made to limit production; but it arises from the circumstance that, while some makers undoubtedly hold large stocks, others are disposing of their iron. This is the chief difficulty that has to be faced in any scheme of restriction. The addition to stocks has not been quite so large this week, but yet much above what has been usual until within a recent period.

Business was done in the warrant market on Friday at 38s. 7½d. On Monday transactions occurred from 38s. 7d. to 38s. 3d. cash. Tuesday's market was quiet in the forenoon at 38s. 2½d. to 38s. 4d. and 38s. 3d. cash, the afternoon prices being 38s. 2½d. to 38s. 1½d., closing with buyers at 38s. 3d. cash. On Wednesday business was done at 38s. 3d. to 38s. 4d. cash. To-day—Thursday—transactions occurred at 38s. 8d. to 38s. 5½d., closing at 38s. 6½d. cash.

The current values of makers' iron are easier as follows:—Gartsherrie, f.o.b. at Glasgow, per ton, No. 1, 43s. 6d.; No. 3, 41s. 6d.; Coltness, 47s. 6d. and 43s.; Langloan, 44s. and 42s. 6d.; Summerlee, 46s. and 42s.; Calder, 47s. and 41s. 6d.; Carnbroe, 43s. and 40s. 6d.; Clyde, 43s. and 40s. 3d.; Monkland, 39s. and 36s. 6d.; Quarter, 38s. 6d. and 36s.; Govan, at Broomielaw, 39s. and 36s. 6d.; Shotts, at Leith, 45s. and 44s. 6d.; Carron, at Grangemouth, 48s. 6d. and 45s. 6d.; Kinneil, at Bo'ness, 43s. and 42s.; Glengarnock, at Ardrossan, 43s. and 40s.; Eglinton, 39s. and 36s. 6d.; Dalmellington, 41s. and 38s. The total shipments of pigs to date are 93,503 tons, against 122,263 in the same period of last year.

The dissolution of the Steel Railmakers' Association will evidently not produce much effect upon that section of business in Scotland, one reason for this being that hitherto our steel makers have not given very much attention to the manufacture of rails. One or two orders are in the Scotch market at present, but there has been some difficulty in placing them in consequence of makers not being inclined to accept them at terms so low as was expected.

During the past week there was shipped from Glasgow locomotives to the value of £1625 for Tasmania, £6560 worth of machinery, £1804 sewing machines, £11,000 steel goods—of which £5883 were plates and bars for Italy—and £26,000 general iron manufactures, including £10,420 worth of pipes, bars, and sheets for Yokohama, and £6810 sheets, pipes, and tubes for Bombay.

Merchants quote iron bars, flats, rounds, and squares, at £5 2s. 6d., less 5 per cent.; steel, £6 10s.; nail rods, £5 10s.; angles, £5 5s.; steel, £6 2s. 6d.; sheets, £6 15s.; ship plates, £5 5s.; steel, £7; boiler plates, £5 15s. to £6 15s.; steel, £7 10s.

The coal trade is not opening out so well as was expected.

The smallness of the timber freights offering home from Quebec are so unsatisfactory that Clyde vessels are proceeding in very small numbers to the St. Lawrence. In other directions the shipments do not compare well with those of this time last year. The quantities despatched in the past week were 18,097 tons from Glasgow, as compared with 19,530 in the corresponding week of 1885; Greenock, 4103, against 4744 tons; Ayr, 8351, against 8678; Irvine, 1396, against 2221; Troon, 682, against 2329; Grangemouth, 7184, against 8530; and Bo'ness, 3076, against 1515. The household inquiry has materially slackened in consequence of the mild weather.

About 100 German workmen have arrived in Glasgow for the purpose of executing the cabinet fittings in the German Lloyd's steamers now building at the Fairfield Shipyard, it having been one of the terms of the contract that German operatives should perform this portion of the work.

Mr. James Smith, late of Messrs. Smith and Wellstood, the American stove manufacturers, died at his residence in Glasgow on Sunday in the 70th year of his age, having been predeceased by Mr. Wellstood only a very short time. After being some time in business in America, Mr. Smith returned to this country in 1854, and established the firm in Glasgow, which originated and was for many years the only one producing stoves of the American pattern.

WALES AND ADJOINING COUNTIES.

(*From our own Correspondent.*)

THERE was a large attendance and spirited competition at the Gadly's, Aberdare, iron plant sale on Tuesday, and a good deal was disposed of. As showing the estimation in which the old-fashioned make of Welsh iron is held, I give a few particulars. A lot of iron rails, 250 tons, averaging from 16 lb. to 12 lb. the yard, realised £3 5s. per ton. This was a good price, as the best steel rails can now be had from £4 to £4 10s. Cast iron lots fetched about £1 7s. per ton; wrought iron ranged from £1 17s. 6d. to £2. A double horizontal high-pressure engine, 25in. cylinder, 4ft. stroke, with driving-wheel, &c., was keenly contested, and brought £182 10s. It was bought by Mr. Davies, Port Talbot. Several heavy things were reserved in the engine line. This was strange, as the large gathering was in a good mood to buy, and numbers had come from London, Leeds, Manchester, and Birmingham.

I have noted the fall in steel rails incidentally. This was caused by the break up of the syndicate, and it is thought may lead to more brisk times. I note that in the North there is a movement out of the utter stagnation into which things have fallen, and the same may be said here, though only slightly. Cyfarthfa steel works were restarted this week, and on a personal visit there I was pleased to see a good deal of dash and energy. The men worked with a will, only too glad of an opportunity. Things had begun to look dark, and as wages have been low for a length of time no provision had been made for a rainy day. Dowlais, Cyfarthfa, and Tredegar, may now be said to be in competition for the steel sleeper trade, but times must improve before there is a large demand.

Should home railways look up orders will come in. The expense of course is considerable. Steel costs about three times that of timber. A steel sleeper comes to about 9s., while a good creosoted timber one will cost 3s.

Good progress is being made by the new industry near Newport, Mon., Messrs. Nettlefold, at Rogerston and Tydu. They are pushing on well, and have begun the viaduct connecting the line with the Great Western, as well as taking down the old buildings.

Messrs. Nixon are understood to have entered into arrangements with the Rhymney Railway for conveyance of the whole of their coal. A connecting viaduct is now being formed from their colliery at Merthyr Vale to the joint line of the Rhymney and Great Western.

The coal trade shows no signs of looking up. At a few collieries the owners are helping their men; and this is commendable, as the depression tells severely on both. The dead work at the large collieries must be attended to—road-men, firemen, engines, horses—and for all this there is no output to recompense.

I had an interview this week with one of the largest tin-plate manufacturers at Swansea, and his summary of business was a cheerless one. "Plenty of demand, but no price." The struggle is to maintain anything like a price. My informant testified to sales at 12s. 6d. or 13s., delivered in Liverpool, for ordinary cokes. This he and others are endeavouring to resist, and contend for 6d. to 9d. more; but trade at the higher prices is slack. Present quotations are: Ordinary cokes, 13s. 3d. to 13s. 6d.; Bessemer steels, 13s. 9d. to 14s. 3d.; Siemens, 14s. to 14s. 9d.; charcoals, 15s. 6d. to 17s. German orders are fairly plentiful. Of Germans the Swansea makers are becoming suspicious. They believe that Germany is going to be a close competitor, and hence a stranger need not attempt to try and see the inside of a Swansea works.

Another good find of coal, of the 4ft. seam, is reported from the Phœnix Colliery, Rhondda.

All the tin-plate forges, with the exception of Beaufort and Yspitly, have resumed work.

NEW COMPANIES.

The following companies have just been registered:—

Boundary Engineering Company, Limited.

This is the conversion to a company of the business of engineer and millwright carried on by Wm. Rolandson at Boundary-street, Liverpool. It was registered on the 6th inst. with a capital of £5000, in £5 shares. The subscribers are:—

	Shares.
J. Ireland Booker, Everton, Liverpool, engineer	1
G. W. Weddle, 60, Conyer-street, Liverpool	1
T. Evans, 152, Boundary-street, Liverpool, moulder	1
F. Cooper, 167, Scotland-road, Liverpool, tobacco manufacturer	1
G. Lloyd, Anfield, Liverpool, clerk	1
E. Berry, 97, Newsham Drive, Liverpool, solicitor	1
R. M. Dennis, 9, Chirkdale-street, Liverpool, engineer	1

The number of directors is not to be less than three nor more than five; qualification, 30 shares; the subscribers are to appoint the first; the company in general meeting will determine remuneration.

British Manufacturing Corporation, Limited.

This company was registered on the 6th inst. with a capital of £20,000, in £5 shares, to trade as manufacturers of dubbin, curriers' grease, railway grease, soap, and other articles. An agreement of the 16th January provides for the purchase by the company from Mr. Henry Goodson of a secret process for the manufacture of dubbin and the refining of lubricating grease, together with the stock, plant, and machinery used in connection with such process, and tenancy of the premises, 4, Blundell-street, Caledonian-road. The purchase consideration is £10,000 in fully-paid shares and £2000 in debentures, the latter forming part of an authorised debenture capital of £20,000. The subscribers are:—

	Shares.
Thomas Frost, 223, Queen's-road, Dalston, cashier	1
A. S Jackson, 67, Amhurst-road, Hackney, clerk	1
E. J. T. Digby, 36, Sinclair-road, Kensington, chemist	1
W. Morgan, 70, Stoke Newington-road, accountant	1
E. Wright, 34, Queen Victoria-street, merchant	1
J. Price Rees, 2, Great St. Helen's, engineer	1
Henry Goodson, 4, Blundell-street, Barnsbury, fitter	1

The minimum number of directors is to be three and the maximum five; the first are to be the Rev. Philip Howard Moneypenny and such other persons as the subscribers may appoint; qualification for subsequent directors, 50 shares or £250 in debentures. Mr. Smith, of the firm of Gordon Smith and Co., of Abchurch-lane, is appointed managing director. The remuneration of the board will be determined by the above signatories.

E. T. Syndicate, Limited.

This company proposes to adopt an agreement of the 25th ult. (unregistered) relating to the British patents for the "Immisch Motor and Tatham's Secondary Batteries," and to acquire inventions referring to the employment of electricity as a motive or other agent in tramways, railways, ships, boats, buildings, mines, &c., and to carry on business as manufacturers and contractors for the supply of electrical power of all kinds. It was registered on the 3rd inst. with a capital of £6000, in 40 shares of £150 each. The subscribers are:—

	Shares.
G. Hubel, Rose Villa, Rochester-road, N.W.	1
R. Macpherson, Cricklewood, coal factor, &c.	1
F. M. H. Jones, Perren-street, Kentish Town, merchant	1
C. A. Allison, 52, Chancery-lane, patent agent	1
E. F. Hunt, 16, Goldsmith-gardens, Acton	1
W. C. Slaughter, Holmwood, Streatham, solicitor	1
C. T. Whinney, 21, Francis-street, W.C.	1

The subscribers are to appoint the first directors. Messrs. Wm. David Gooch and Wm. Lyster are appointed engineers.

Great Yarmouth and Norfolk Ice Manufacturing Company, Limited.

The company proposes to manufacture ice in Great Britain, especially under a concession for the working of Messrs. Pontifex and Wood's patent process, and to provide storage for perishable articles. It was registered on the 7th inst. with a capital of £50,000, in £10 shares, with the following as first subscribers:—

	Shares.
H. Stonehewer Cooper, Church-end, Finchley, author	1
T. C. Blanchflower, Great Yarmouth, manufacturer	1
C. Eley, 201, Mansion House-chambers, chairman Thames Steam Tug and Lighterage Company	1
J. Best, 39, Moorgate-street, analytical chemist	1
C. Winstanley, 1, Cousin-lane, E.C., shipping agent	1
R. W. Bilby, 77, Gresham-street, accountant	1
M. Murray, 6, Beech View Villas, Croydon-road, accountant	1

The number of directors is not to be less than three nor more than five; qualification, 20 shares. The remuneration of the board will be determined at the statutory meeting, and the above subscribers will act as directors until such meeting.

Kington Water Company, Limited.

For supplying the town of Kington, county of Hereford, with water, this company was registered on the 7th inst. with a capital of £5000, in £10 shares. The first seven subscribers are:—

	Shares.
Rev. M. Wood, Kington Vicarage	30
F. Parker, Kington, draper	10
T. Hall, Kington, grocer	10
H. Smith, Kington, grocer	3
S. Passey, Kington	5
T. G. Sprague, Kington, accountant	5
A. Temple, Kington, solicitor	10

Registered without special articles.

Burns, Taylor, and Co., Limited.

This is the conversion to a company of the business of agricultural and general engineers and millwrights carried on by Messrs. Robert Burns and John Howells Taylor, at Rugeley, Stafford. It was registered on the 7th inst. with a capital of £2000, in £10 shares. The subscribers are:—

	Shares.
R. Burns, Rugeley, engineer	1
J. H. Taylor, Rugeley, engineer	1
T. James, Rugeley, printer	1
J. Robinson, Rugeley, station-master	1
W. Neeld, Rugeley, shoe dealer	1
W. Williams, Rugeley, miller	1
S. S. Nevill, Rugeley, yeoman	1

Table A of the Companies' Act, 1862, will apply.

New Gum and Rubber Company, Limited.

This company was registered on the 7th inst. with a capital of £100,000, in £10 shares, to purchase letters patent dated 21st May, 1884, for an improved process of hardening balsams, resins and resinous compounds or products, fats, oil, tar, pitch, and bituminous products, and to carry on business as manufacturers of india-rubber, gutta-percha, and all kinds of varnishes, &c. The subscribers are:—

	Shares.
C. C. Gruneberg, 18, Billiter-street, clerk	1
F. J. Bailey, 18, Billiter-street, clerk	1
R. C. Doux, 12, Rainford-street, Liverpool, merchant	1
A. Hartmann, 18, Billiter-street, merchant	1
C. Lange, 18, Billiter-street, clerk	1
G. Hartmann, 18, Billiter-street, merchant	1
G. C. Doux, 4, Cullum-street, merchant	1

The number of directors is not to be less than three nor more than seven; qualification, £200 in shares or stock; the subscribers are to appoint the first; remuneration, £1200 per annum, with an additional £200 in respect of each director over five in number.

R. and W. Hawthorne Leslie and Co., Limited.

This company was constituted by deed of settlement dated 4th ult., and registered as a limited company on the 7th inst., with a capital of £600,000, in 6000 shares of £100 each, 3813 of which are taken up and fully-paid. The object of the company is to take over and carry on the business of the amalgamated firm of R. and W. Hawthorne Leslie and Co., of Forth Banks and St. Peter's, Newcastle-on-Tyne, engineers, contractors, shipbuilders, colliery proprietors, &c. The members are:—

	Shares.
*B. C. Browne, Newcastle-on-Tyne, manufacturing engineer	429
*F. C. Marshall, Newcastle-on-Tyne, manufacturing engineer	571
*J. H. Ridley, Newcastle-on-Tyne, manufacturing engineer	571
*C. E. Straker, Newcastle-on-Tyne, manufacturing engineer	571
*W. Cross, Newcastle-on-Tyne, manufacturing engineer	142
*A. Coote, Hebburn, Newcastle-on-Tyne, iron shipbuilder	1270
R. Clayton, Wylam Hall, Northumberland, banker	1
T. Coote, St. Ives, Hunts	1
C. W. Bigg, Newcastle	1
B. C. Browne, F. C. Marshall, J. H. Ridley, C. E. Straker, W. Cross,	256

The number of directors is not to be less than three nor more than nine; qualification, the holding for seven years of shares of the nominal value of £5000; the company in general meeting will determine remuneration. The members to whose names an asterisk are prefixed are the first directors.

Three Towns Patent Steam Carpet-Beating Company, Limited.

This company proposes to carry on in Plymouth, and elsewhere in England, the method of carpet-beating patented by Messrs. Sydney Simmons and Joseph Tullidge, of London. It was registered on the 3rd inst. with a capital of £1000, in £5 shares. The subscribers are:—

	Shares.
J. Shawdon, Plymouth, marble merchant	20
J. Popplestone, Plymouth, draper	20
J. D. Collins, Devonport, draper	20
W. Shawdon, Stonehouse, cabinetmaker	20
J. Greenway, Plymouth, solicitor	20
S. Simmons, Belle Isle, London, N., steam carpet-beater	15
J. Tullidge, Belle Isle, London, N., steam carpet-beater	15

Registered without special articles.

Coventry Gas Fittings Company, Limited.

This is the conversion to a company of the business of gas engineers, gas fitters, and bell-hangers, carried on by Messrs. Robinson Brothers, of Coventry. It was registered on the 1st inst. with a capital of £5000, in £1 shares, with the following as first subscribers:—

	Shares.
W. L Robinson, Coventry, gas engineer	1
A. L. Newbold, Coventry, collector of gas rents	1
F. Baker, Coventry, gasfitter	1
J. Hepworth, Coventry, bookkeeper	1
J. A. Noble, Coventry, clerk	1
J. Morton, Coventry, coal merchant	1
T. Reynolds, Coventry, gasfitter	1
A. E. Willdigg, Coventry, engineer	1

Registered without special articles.

Smith and Chamberlain, Limited.

This company proposes to take over the business of Mr. Arthur Chamberlain, brassfounder in all branches, including the manufacture of bedsteads, chandeliers, gas, water, steam, and electric light fittings, lamps, and appliances. It was registered on the 5th inst. with a capital of £100,000, in £10 shares. The subscribers are:—

	Shares.
Walter Chamberlain, Harborne Hall, Stafford	1
Arthur Chamberlain, Moor-green Hall, Birmingham	1
Agnes S. Coane, 3, New Bartholomew-street, Birmingham, spinster	1
J. Brown, 22, Loveday-street, Birmingham, clerk	1
A. S. Bowler, Edgbaston, Birmingham, clerk	1
Richard Chamberlain, M.P., Birmingham	1
Herbert Chamberlain, Edgbaston, Birmingham	1

The number of directors is not to exceed ten; qualification, 10 shares or £100 stock. Mr. Arthur Chamberlain is appointed sole director. The company in general meeting will determine the remuneration of the board.

THE PATENT JOURNAL.

Condensed from the Journal of the Commissioners of Patents.

Applications for Letters Patent.

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

6th April, 1886.

4752. Printing Presses, A. G. Brookes.—(*T. S. Nowell, United States.*)
4753. Bats for Racquets, &c., Games, C. B. Townsend, Birmingham.
4754. Children's Chairs or Cots, J. T. B. Bennett, Birmingham.
4755. Switches for Making or Breaking Electric Circuits, R. Cornthwaite and R. Ingham, Bradford.
4756. Lawn Tennis Court Marker, J. H. Bullard, Birmingham.
4757. Bolt and Fastener for Windows, &c., W. Swain, Birmingham.
4758. Twist Indicator for Ships' Cables, E. Hunt.—(*J. Scotland, Miquelon.*)
4759. Fasteners for Driving Machinery, J. Whitehead, Newcastle-upon-Tyne.
4760. Athletic, &c., Boots and Shoes, M. Frankenburg, Leicester.
4761. Rope and Twine, A. James and H. Shipley, Nottingham.
4762. Brushes, W. Fryer, Birmingham.
4763. Speeding the Cylinders and Doffer of Carding Engines, E. Tweedale, Halifax.
4764. Thread Guides of Spinning and Doubling Frames, S. Tweedale, Halifax.
4765. Locks for Sliding Doors, &c., J. Kaye, London.
4766. Preventing the Rattling of Glass in Vehicles, &c., J. S. Robertson, Ecclefechan.
4767. Handles for Tools, A. C. Wells and E. Grube, Manchester.
4768. Scouring Dredges, A. Harrison, London.
4769. Steam Tar Injector and Tar Burner, J. Laycock and J. Baldwin, Keighley.
4770. Water Meters and Water Motors, B. D. Healey, Liverpool.
4771. Preparing Infusions from Tea, &c., G. H. and A. Hobbs, Longton.
4772. Steel Headed Frost Nail for Horseshoes, H. Wooldridge, Lye.
4773. Preventing the Bulging of Linings of Boilers, G. Fry, London.
4774. Coffins, R. McC. Fryer, London.
4775. Shovels, Spades, and Hoes, J. W. Calef, London.
4776. Artificial Ear Drums, H. A. Wales, London.
4777. Cutting Cork, J. Liston, Glasgow.
4778. Mixing Machine, T. Maxwell, J. Young, and J Crawford, Glasgow.
4779. Discharge Apparatus for Water-closets, J. Bolding and Sons, London.
4780. Preparing Fur for Felting, E. Tweedy, H. L. Brevoort and I. L. Roberts, London.
4781. Preparing Fur for Felting, E. Tweedy, H. L. Brevoort, and I. L. Roberts, London.
4782. Artists' Drawing-boards, T. C. Roussel and B. Rouxel, London.
4783. Folding Chess and Draught-board, H. Haes, London.
4784. Water Gauge, W. A. Barlow.—(*A. Donneley, Germany.*)
4785. Propelling Locomotives, &c., R. Hutchinson, London.
4786. Boilers, F. B. Bramham, Liverpool.
4787. Preventing Horses from Slipping, R. H. Radford.—(*J. B. E. Lacombe, France.*)
4788. Utilising the Kernel of the Fruit of the Mauritia Vinifera, &c., E. de Pass.—(*F. Kugelmann, France.*)
4789. Chain Padlocks, E. Jones, London.
4790. Delivery Mechanism for Web Printing Machines, W. Conquest.—(*Messrs. R. Hoe and Co., U.S.*)
4791. Coating Paper, T. Bolas, London.
4792. Single-acting Compound Steam Engines, J. H. Eickershoff, London.
4793. Boiler Cleaners and Feed-water Heaters, E. W. Van Duzen, London.
4794. Explosives, H. Schöneweg, London.
4795. Window Flower Box, F. W. Hudson, London.
4796. Arc Lamps, R. Kennedy and R. Dick, Glasgow.
4797. Distributing Artificial Manures, P. Wilson, Glasgow.
4798. Kitchen Ranges, W. Dick, Glasgow.
4799. Galvanic Finger Rings, &c., W. Schuller, London.
4800. Cores in use for Casting Metal, R. Applegarth, London.
4801. Desaccharification of Molasses, &c., C. D. Abel.—(*P. Schwengers Söhne, Germany.*)
4802. Construction of Surfaces for Skating, J. A. Calantarients, London.
4803. Fire-grates, C. J. Bellamy, London.
4804. Curling, &c., Hair, W. Bown and G. Capewell, London.
4805. Curling, &c., Hair, W. Bown and G. Capewell, London.
4806. Lids or Covers for Sanitary Vessels, I. Greenbury, Glasgow.
4807. Umbrellas, B. B. Cox, London.
4808. Obtaining Motive Power, M. M. Tergatian, London.
4809. Electric Furnaces, W. P. Thompson.—(*The Cowle's Electric Smelting and Aluminium Co., U.S.*)
4810. Electrically Controlled Lock, W. P. Thompson.—(*M. Gillet, France.*)
4811. Wheels, W. P. Thompson.—(*H. M. Horrne and J. C. Rutherford, United States.*)
4812. Wedges for Breaking-down Stone or Coal, R. Thompson, Liverpool.
4813. Apparatus for Forcing Down or Breaking up Coal, &c., F. Robinson, London.
4814. Rope Guides for Pulleys, A. J. Boult.—(*L. Dyer, G. S. Sawyer, and C. H. Dyer, United States.*)
4815. Combined Spoon and Scraper, E. J. Averill, London.
4816. Gun Carriages, A. J. Boult.—(*C. E. Creecy, United States.*)
4817. Gun Carriages, A. J. Boult.—(*C. E. Creecy, United States.*)
4818. Dress Shields, A. J. Hiscott, London.
4819. Teaching Apparatus, A. J. Boult.—(*C. R. Viehofer, Germany.*)
4820. Grain Binders, A. J. Boult.—(*The Milwaukee Harvester Company, United States.*)
4821. Bolts, &c., A. J. Boult.—(*G. Coulon, France.*)
4822. Gas-burners, G. W. Smiley.—(*T. J. L. Smiley and C. H. Stombs, United States.*)
4823. Copying Letters, &c., A. M. Clark.—(*C. W. Benedict, United States.*)
4824. Ventilating and Warming Buildings, B. Verity, London.
4825. Governors for Gas or other Fluids, T. C. Hopper, London.
4826. Improving the Condition of Rivers, &c., J. H. Johnson.—(*L. M. Haupt, United States.*)
4827. Wheels, S. T. Williams, London.
4828. Magazine Fire-arms, H. H. Lake.—(*I. N. P. Stokes, United States.*)
4829. Converting Reciprocating or Oscillating Motion into Rotary Motion, H. H. Lake.—(*C. Hammelmann, United States.*)
4830. Tungsten Compounds, C. L. J. Bech, London.
4831. The Rule of the Road at Sea, P. J. D. Hawker, Lymington.

7th April, 1886.

4832. Labelling Plants, &c., D. Storrie, Dundee.
4833. Testing the Moisture of Damp in Yarns, W. Noton, Oldham.
4834. Furnaces and Flues of Steam Boilers, O. Meredith, London.
4835. Looms for Weaving, J. Jucker, Manchester.
4836. Traverse Motions for Machines for Winding Thread, &c., J. M. Cryer and J. T. Wibberley, Bolton.
4837. Wrench, H. Lucas and A. H. Bishop, Birmingham.
4838. Steam Engine and Governor, G. Pickin, Stoke-on-Trent.
4839. Washing, &c., Fabrics, W. Birch, Manchester.
4840. Sliding Cover or Guard for Rifles, A. and W. Jenkins, London.
4841. Picking Motion of Looms, E. and W. Rothwell, Manchester.
4842. Lathes for Turning, &c., Studs, A. Muir Manchester.
4843. Measuring, &c., Apparatus, A. Hitchon, Accrington.
4844. Cotton Velvets, &c , A. Dux, Manchester.
4845. Postal and other Envelopes, E. Restieaux, Llanelly.
4846. Castors, W. G. Edgehill, Birmingham.
4847. Exhaust or Ventilating Fans, E. W. Collier, Leyton.
4848. Selvage Motions Combination, N. Cocker and B. Lees, Oldham.
4849. Writing Pens, G. Murray, Glasgow.
4850. Driving Machinery for Spinning Wool, &c., J. Cockroft, near Halifax.
4851. Lubricating Shafting in Land or Marine Engines, H. Brough, London.
4852. Balance Lever, J. A. Footitt, Sudbury.
4853. Artificial Palates, W. Lederle, London.
4854. Brakes, W. L. Wise.—(*A. Argo, Germany.*)
4855. Printers' Quoins, P. Lawrence.—(*R. W. Peach United States.*)
4856. Lamps for Painters', &c., Use, W. H. Burdock, London.
4857. Machines for Manufacturing Horseshoes, O. Imray.—(*W. M. Mooney, United States.*)
4858. Extracting Corks from Bottles, J. Harriss, London.
4859. Steam and other Engines, H. Moehring and A. Pflüger, London.
4860. Sash Fasteners for Windows, A. Cross, Glasgow.
4861. Stowing of Ships' Boats, J P. Wilson, Glasgow.
4862. Folding Packing-cases, &c., H Greene, London.
4863. Permanent Way of Railways, J. Colquhoun, London.
4864. Adjustable Spanner or Wrench, E. J. B. Lowdon, Dundee.
4865. Gauges for Indicating the Strength of Air Currents, E. J. B. Lowdon, Dundee.
4866. Holder for Rolls of Paper, W. W. Colley, London.
4867. Stand for Holding Plants in Pots, A. Blackie, London.
4868. Cowls, W. Bradford, London.—*6th April*, 1866
4869. Valves for Hot and Cold Water, D , D. C., and A. H. Hancock, Stratford.
4870. Coupling or Connecting Tubes, J. Richards, London.
4871. Grinding and Triturating Machine, G. F. Redfern.—(*M. H. Simonet, France.*)
4872. Producing Imitations of Stone, &c., D. Cottier, London.
4873. Candle-moulding Machines, A. R. Cowles, London.
4874. Machines for Breaking, &c., Flax, J. C. Mewburn.—(*S. G. Brookes, France.*)
4875. Lamps for Burning Oil, &c., W. P. Catterson, London.
4876. Bottle Stoppers, S. J. Hersee, J. D. and D. Campbell, and C. S. Western, London.
4877. Combined Table Candle Lamp and Bracket Lamp, R. F. Heath and W. Crook, London.
4878. Filter Presses, W. F. B. Massey-Mainwaring, London.
4879. Hansom Cabs, W. F. B. Massey-Mainwaring, London.
4480. Employing Electricity for Curative, &c., Purposes, R. Durling, London.
4881. Gas Engine and Fluid Pump, P. M. Justice.—(*F. B. Taylor, United States.*)
4882. Rotary Dynamometers, D. Bánki, London.
4883. Rotary Cutting Tools, R. Haddan.—(*T. D. Cook, United States.*)
4884. Dynamo-electric Machines, J. Platt and J. and E. Hopkinson, London.
4885. Vessels for Subaqueous Navigation, H. W. C. Tweddle, London.
4886 Fixing Laths, &c., to Iron Roofs, S. Worsnop, Leeds.
4887. Decorating Lincrusta-Walton, &c., Tapestry, S. G. L. Giles and W. J Petrie, London.
4888. Indicating the Depth of Liquids, F. R. de Wolski, London.
4889. Applying Taps to the Mouths of Bottles, W. Reynolds, London.

8th April, 1886.

4890. Looms for Weaving Cotton, &c., W. Pennington, Blackburn.
4891. Needles for Repairing Driving Belts, W. A. M. Brown, London.
4892. Cleaning, &c. Textile Fibres, R. B. Goldworthy and R. Wild, Manchester.
4893. Bedsteads, H. Bouttell, Halifax.
4894. Dobbies for Looms, J. Hollingworth, Halifax.
4895. Brake for Perambulators, &c., A. W. Orr, Dublin.
4896. Angle Iron Frames for Mangling Machines, S. Crompton, Lincoln.
4897. Attaching Handles to Coffins, J. Gordon, Birmingham.
4898. Spades, &c., J. Hatton, Birmingham.
4899. Acoustic Telephone, S. Vyle, Glasgow.
4900. Looms for Weaving, J. Clark and J. Whitson, Glasgow.
4901. Hinges, T. Whittaker, Oldham.
4902. Hats, W. H. Blackwell, near Manchester.
4903. Cleaning the Rails of Tramways, A. Dickinson, Birmingham.
4904. Forming and Shapeing Pork Pies, &c., J. H. Marston and W. Dunmore, Leicester.
4905. Stopping Roving Frames, J. Tasker, Halifax.
4906. Leggings, L. E. Emmet, Sheffield.
4907. Ensuring Uniform Pressure on Yarn, A. Hargreaves, London.
4908. Turnscrews, S. Hill, Sheffield.
4909. Spring Cutlery, T. R. Ellin, Sheffield.
4910. Cutting Shovel Plates, G. Clark and W. H. Shephard, Sheffield.
4911. Straight-steering Tricycles, T. Hawkins, London.
4912. Bending Canes to form Handles, O. Muller, London.
4913. Umbrellas, S. H. McKenzie, Liverpool.
4914. Manufacturing Fleece Fabrics, E. Ross, London.
4915. Electric Burglar Alarms, J. May and G. J. Hatton, London.
4916. Fastenings for Gloves, W. A. and W. J. Bancroft, Birmingham.
4917. Frameless Arresene, M. E. Noel, Tottenham.
4918. Imitation Caoutchouc, O. Imray.—(*A. K. Kissel, Germany.*)
4919. Treatment of Yeast, G. Epstein, London.
4920. Show Case for Pictures, W. McCall and A. Smith, Glasgow.
4921. Fittings for Water, &c., C. H. Taylor and A. Ross, London.
4922. Making Carbonate of Soda, &c., C. F. Claus, Wimbledon.
4923. Arctic Cycle Auxiliary, T. A. Moryson, London.
4924. Winding Yarns, &c., W. T. Stubbs and J. Corrigan, Manchester.
4925. Making Wrappers for Bottles, K. Giese, London.
4926. Fixing Bands to Metal Tubes, W. Bayliss and R. Howarth, London.
4927. Strippers of Carding Engines, S. Beaumont, London.
4928. Circulating, &c., Pump Valve, J. S. Wyndham, London.
4929. Repeating Magazine Guns, &c., G. Rowell, London.

4930. Oscillatory Engines, S. Butler, London.—*9th July*, 1885.
4931. Blind Cord Pulleys, G. F. Guyon, London.
4932. Food for Animals, T. King, London.
4933. Safes, S. Chatwood, London.
4934. Making Paper for Cigarettes, J. B. Scammell, London.
4935. Padlocks, A. H. Bremner, London.
4936. Marking Soap, T. E. Gardner, London.
4937. Converting Heat Energy into Electrical Energy, W. R. Lake.—(*W. E. Case, United States.*)
4938. Horseshoes, F. Lebacq, London.
4939. Fire Alarms, G. A. Mason, London.
4940. Walking Stick, &c., C. Reddick and J. W. Rider.—(*P. C. Leclerq, Belgium.*)

9th April, 1886.

4941. Ships' Steering Apparatus, G. D. Davis, London.
4942. Cheese-cutting Apparatus and Stand, S. T. Lauder, Mere.
4943. Closet Basins, T. W. Twyford, Longport.
4944. Loading Cartridges, J. A. Scotcher and G. E. Bond, Thetford.
4945. Attaching Cars to Balloons, W. N. Hutchinson, Wellesbourne.
4946. Telephonic and Telegraphic Call Apparatus, C. L. Baker, Manchester.
4947. Closing Breech-loading Cartridge Cases, J. Dixon and Sons and G. Simpson, Sheffield.
4948. Separating Postage Stamps, &c., J. J. Allen, Halifax.
4949. Weighing Grain, J. D. and C. Tomlinson, Rochdale.
4950. Securing Scales to Cutlery, S. V. Wheatley, Sheffield.
4951. Planes, J. Chapman, Sheffield.
4952. Spindles for Spinning Machines, J. Jucker, Manchester.
4953. Flushing Water-closets, M. Cleary, Dublin.
4954. Trenching or Slotting Out Wood, J. and T. Harrison, Blackburn.
4955. Driving Band, H. B. Hartley, Whittlesey.
4956. Metallic Alloys, H. Kesterton, Birmingham.
4957. Fulling, &c., Woollen Fabrics, H. Ainley and G. W. Tomlinson, London.
4958. Packing Pistons, H. Turner, Liverpool.
4959. Automatic Meter for Grain, &c., L. A. Couteau, London.
4960. Watches, &c., V. and L. Weber, London.
4961. Curtain Rod, T. Crossley, London.
4962. Draught and Dust Excluder, T. J. Porter, Fleetwood.
4963. Spoons, R. N. Helme, Lancaster.
4964. Hosiery, J. Hall, London.
4965. Applying Photographic Emulsion, E. J. Palmer, London.
4966. Fire-guards, W. F. B. Massey-Mainwaring, London.
4967. Brass Bedsteads, E. Lawson and R. G. Hodgetts, London.
4968. Stoves for Heating Rooms, J. R. Crosthwaite, London.
4969. Lawn Mowing Machines, J. R. Stoney, London.
4970. Pressure Escape Cheque for Breech-loading Arms, W. M. Call and A. Lancaster, London.
4971. Provision Safes, &c., J. Jolley and W. Jones, London.
4972. Safety Letter Boxes, W. Rayner, London.
4973. Frames for Buckles, &c., A. Bullows, London.
4974. Mirror and Lamp Bracket, C. Kempton, London.
4975. Stop for Doors, G. Cooper, London.
4976. Securing Door-mats, J. W. Roe, London.
4977. Bricks, G. Spink, London.
4978. Clock and Watch Mechanism, H. J. Haddan.—(*J. Pallweber, Germany.*)
4979. Hydraulic Apparatus, F. Neukirch, London.
4980. Sweeping or Brushing Lawns, E. J. Taylor and J. Parker, London.
4981. Torpedo Boats, J. H. W. Stringfellow, London.
4982. Boxes for Containing Stationery, L. W. Stone, London.
4983. Torpedo Boats, J. H. W. Stringfellow, London.

10th April, 1886.

4984. Ventilator for Railway Carriages, &c., R. Bradshaw, Swinton.
4985. Cocks, J. Dewrance and G. H. Wall, London.
4986. Capstans, G. Thompson, E. J. Eyres, and H. Eastcott, Gateshead-on-Tyne.
4987. Stoves for Heating and Ventilating, C. J. Henderson, Edinburgh.
4988. Electric Apparatus, A. Wright, Brighton.
4989. Food for Cattle, &c., F. W. Wendenburg, London.
4990. Engine, J. Roots, London.
4991. Filters, A. J. Bell, Manchester.
4992. Reel, J. B. Whiteley and W. Whiteley, Halifax.
4993. Communicating Power or Motion, J. Roots, London.
4994. Soap, J. Higson, Manchester.
4995. Preparing, &c., Cotton, &c., H. Stevenson, J. Webb, and S. Hallam, Manchester.
4996. Grinding Wheat, &c., J. Collins and F. Spencer, Manchester.
4997. Turbine Water Wheels, C. L. Hett, Brigg.
4998. Distribution Valves for Steam Engines, K. D. Noble, Glasgow.
4999. Saddles for Velocipedes, &c., H. Halladay, Birmingham.
5000. Farmers' Label, G. Lewis, Berkley, and T. Workman, Thornbury.
5001. Watering and Oiling Apparatus, M. Cross, Bristol.
5002. Calenders for Glazing and Finishing Paper, &c., W. Hartley, Salford.
5003. Measuring Liquids, W. Cowan, London.
5004. Trimming Ships' Cargoes in Bulk, I. A. Mack, Liverpool.
5005. Advertising, W. Pope, Hampstead.
5006. Weighing Grain, &c., W. H. Baxter, London.
5007. Window Sash Fasteners, C. F. Hengst and J. Thake, London.
5008. Preventing Collisions between Railway Trains, C. T. Jones and G. Wetmon, London.
5009. Gas Engines, A. Treeton, London.
5010. Engines of Steam-worked Winches, &c., W. Clarke, London.
5011. Holders for Thread, &c., J. C. Mewburn.—(*G. P. V. St. Leger, France.*)
5012. Spray Baths, J. Kirkwood, Glasgow.
5013. Railway Chairs, &c., T. Barbour, Glasgow.
5014. Removing Scale from Boilers, W. G. Wrench, Glasgow.
5015. Waterproof Mantles, R. Thomson, Glasgow.
5016. Expelling Sulphuric Acid from Sulphates and Bisulphates, J. H. Johnson.—(*J. L. Kessler, France.*)
5017. Oiling Machinery, T. Haslam and J. Moorcroft, Liverpool.
5018. Spring Apparatus, T. Haslam, J. Moorcroft, and J. Liddiard, Liverpool.
5019. Damper Mechanism for Pianofortes, H. Billeter, London.
5020. Manufacturing Soap, A. J. Boult.—(*J. Montermbio, Spain.*)
5021. Washing Machines, M. Rodda, London.
5022. Stove, H. H. Lake.—(*L. Cline, United States.*)
5023. Preventing Water from Entering the Hulls of Ships, H. H. Lake.—(*C. Wiley and H. C. Roome, United States.*)
5024. Artificial Fuel, H. H. Lake.—(*L. Cline, United States.*)
5025. Controlling the Speed of Engines, J. Richardson and R. H. C. Nevile, London.
5026. Sifting Cement, &c., I. B. Warwood and J. Wallis, London.
5027. Points for Tramways or Railways, G. J. Chapman, London.
5028. Stands for Photographic Cameras, &c., G. L. Johnson, London.
5029. Metallic Label or Ticket, G. F. Redfern.—(*E. Guiraudeu, France.*)
5030. Lamps, W. Bown and G. Capewell, London.
5031. Water-closet Apparatus, R. Weaver, London.
5032. Forcing Liquids, &c., A. M. Clark.—(*H. F. L. Worme de Romilly, France.*)
5033. Cigar Rolling Machines, A. M. Clark.—(*D. J. Boehm, United States.*)
5034. Treating Phosphatic Earths and Rocks, N. B. Powter, London.
5035. Supporting the Sliding Sashes of Railway Carriages, T. Crumpton, London.
5036. Sections for the Supers of Beehives, S. Allen, London.

12th April, 1886.

5037. Distributing Farmyard Manure, &c., W. Davidson, Glasgow.
5038. Fasteners for Window Sashes, C. A. Ewing, Chester.
5039. Securing Handles to Brooms, T. Firth, Huddersfield.
5040. Wrapper or Protector for Fragile Goods, E. Sherring, Manchester.
5041. Bicycles, &c., J. Parr, Leicester.
5042. Metallic Torsion Springs, M. Finlayson, Edinburgh.
5043. Opening Carriage Heads, T. Swinton, Glasgow.
5044. Operating Back Draught of Dust-collectors, M. Martin, London.
5045. Stowing Boats, J. P. Wilson, Glasgow.
5046. Tie, A. Jack, Motherwell.
5047. Roller Milling, J. Ward and J. Aizlewood, Sheffield.
5048. Felted Netting, T. B. Burns, Cornwall.
5049. Grounding Skins, H. S. Barrow, Nottingham.
5050. Brakes, T. Suchland, London.
5051. Shuttles, J. T. Hargreaves, Yorkshire.
5052. Ropes, &c., G. J. Booth, Manchester.
5053. Railway Keys, S. W. Smith, Coventry.
5054. Flat Steel Square, A. Stribling, Bournemouth.
5055. Racks for Goods, F. T. Schmidt and R. C. Douglas, Bradford.
5056. Shuttles, &c., E. Shepherd, F. Rothwell, J. E. Hough, and T. Rothwell, Oldham.
5057. Stop Valves, C. H. Ancill, Birmingham.
5058. Cruet Bottles, J. Watts, Birmingham.
5059. Ships' Canal from Barmouth, P. P. Brownrigg, Liverpool.
5060. Bars and Plates of Steel, &c., Direct from the Molten Metal, C. M. Pielsticker, London.
5061. Gas Ovens, S. Leoni, London.
5062. Aerated Liquids, H. T. Cook, Walthamstow.
5063. Telegraphing Apparatus for Engines, W. Chadburn, Liverpool.
5064. Carts for Spreading, &c., Manure, E. Chadwick and M. Wells, London.
5065. Blacking used for Moulding, A. Crumblehulme, London.
5066. Pins for Curling Hair, F. Bosshardt.—(*A. Marin, France.*)
5067. Buttons or Studs, W. Boothby, Liverpool.
5068. Carding Machines, D. Proctor, jun., and H. McPherson, London.
5069. Rotary Brushes, F. Richardson, London.
5070. Mock Boot Tree, A. Savage, London.
5071. Bottling Beer, W. T. Ramsden, London.
5072. Hand Rest, W. Davidson and W. A. Martin, London.
5073. Securing Plate, &c., in Baskets, &c., G. Scott, London.
5074. Drum Attachments for Pin-rails, A. F. Spear, London.
5075. Washing Photographic Prints, E. J. Pound, Richmond.
5076. Sashes of Railway, &c., Doors, W. S. Lockhart, London.
5077. Roller Presses for Shaping Metals, W. Lorenz, London.
5078. Electric Lighting Apparatus for Vehicles, R. Weber, London.
5079. Ascertaining Escape of Gas, C. Schmidt, London.
5080. Locks and Latches, A. T. Tucker, London.
5081. Cricket, H. Richardson, London.
5082. Locking Wheels of Carriages, &c., G. Nobes, London.
5083. Mixing, &c., Dough for Bread, G. Elsey, London.
5084. Cock, P. Dronier, London.
5085. Registering and Cancelling Pre-paid Tickets, A. Warner, W. H. Davis, and J. P. Rock, London.
5086. Boring Holes in Rocks, H. Sladden, Glasgow.
5087. Gas Stove for Cooking Ranges, W. Moffatt, Glasgow.
5088. Pantaloon Stretchers, W. G. Davis, London.
5089. Electric Arc Lamps, F. Fesquet and C. S. J. Ostrorog, London.
5090. Measuring the Consumption of Electricity, H. Serrin and F. Fesquet, London.
5091. Electrical Governors, A. M. Clark.—(*E. A. Wahlström through Messrs. Wirth and Co., Germany.*)
5092. Thermo-electric Generator, A. Rust, London.
5093. Telegraph Transmitters, G. W. Baldridge, United States.
5094. Pianofortes, B. J. B. Mills.—(*F. C. Baruth, France.*)
5095. Ointment, H. H. Leigh.—(*E. Gillett, Oxfordshire.*)
5096. Waxed Ends, &c., H. J. Haddan.—(*W. B. Arnold, United States.*)
5097. Preventing Leakage in Ships, E. C. Taylor, London.
5098. Lamps, T. C. J. Thomas, London.
5099. Ladies' Collars, G. N. March, United States.
5100. Stoppering of Bottles, H. H. Lake.—(*W. Stewart and E. C. Webb, United States.*)

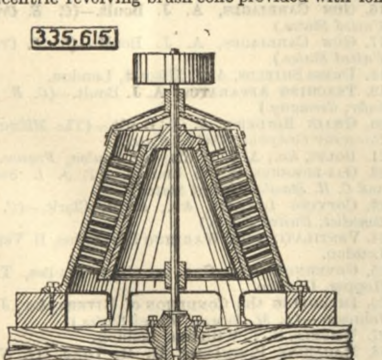
SELECTED AMERICAN PATENTS.

(*From the United States' Patent Office official Gazette.*)

335,615. Disintegrator, *John W. Parmelee, Englewood, Ill.—Filed August 21st*, 1884.

Claim.—The combination of the exterior imperforate conical vertical shell, open at the top and bottom and a concentric revolving brush cone provided with long

335,615.

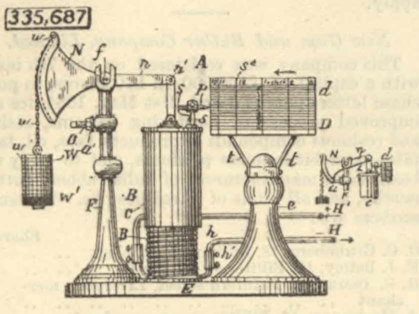


flexible wire bristles, adapted to whip instead of cutting the gravel, &c., and driving mechanism for operating the cone substantially as specified.

335,687. Electric Meter, *John I. Drake, Providence, R.I.—Filed May 15th*, 1885.

Claim.—(1) In a recording time and electric current meter the combination, with the helix and its armature having a pencil or tracer adapted to move in unison with the armature, of a suitably mounted lever having one end thereof connected with said armature, and the other end having a flexible connection carrying counter weights, substantially as shown and for the purpose set forth. (2) In a recording electric meter the standard F, having an adjustable stop *a*, in combination with the weighted beam N, fulcrumed to the standard F, and the cup armature C, connected with the beam, substantially as shown and described. (3) The paper carrying cylinder D, adjustably secured to the centre moving spindle *m* of a clock train, and completely encasing said train, the latter being supported by means of the standard *e*, substantially as shown and set forth. (4) In combination with a base E, standards F *e*, and helix B^1, all secured to said base, the counter weighted lever N, pivotted to the standard F, a cup armature C, carrying a pencil or tracer P, connected with said lever, and the clock train T, operating the paper-carrying drum or barrel D, the whole constructed and arranged substantially as shown and for the purpose hereinbefore set forth. (5) In a

335,687

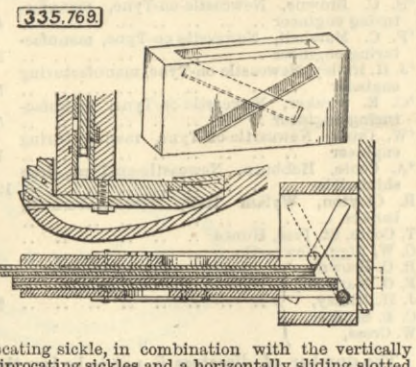


self-recording electric meter the combination with a helix or solenoid connected in an electric circuit, an armature having a pencil or tracer and mechanism for moving a piece of paper *d* against the point of said tracer, of the suitably mounted lever N, having its inner end *n* connected with said armature, the outer portion of the lever having a series of counter weights connected therewith adapted to move in a straight line or parallel with the vertical axis of the standard or other support in which the lever is mounted, all constructed and arranged substantially as shown and set forth.

335,769. Track Clearer for Mowers, *James M. Patterson and Eli A. Himebauch, Tipton, Cal.—Filed August 7th*, 1885.

Claim.—(1) In a mowing machine, a horizontal finger bar with reciprocating sickle, and a vertical standard secured at its outer end and having two sickles or cutters guided to move vertically upon its front edge, in combination with pitmen secured centrally to said cutters extending downward through guides in the standard and the horizontal sliding block having oppositely inclined diagonal grooves upon its opposite sides into which pins from the lower ends of the pitmen project, substantially as herein described. (2) A horizontal finger bar with its reciprocating sickle, in combination with the vertically reciprocating sickles and a horizontally sliding slotted block with a diagonal bar or rod connecting said block with the horizontal sickle substantially as herein described. (3) A horizontal sliding block having a vertical slot made through it to receive and guide the two pitmen by which the vertical sickles are driven, said block having diagonal slots made upon each side of the vertical channel and inclined in opposite directions, substantially as herein described. (4) The horizontal finger bar and reciprocating sickle of a mowing machine, and the vertical standard having

335,769



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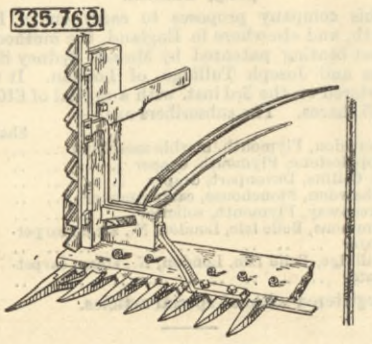
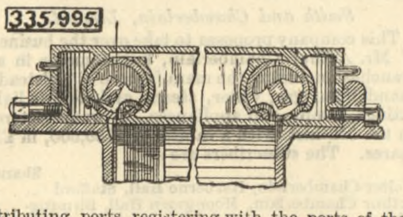


sickles or cutters guided to reciprocate in opposite directions upon its forward edge, with channels made in its opposite sides to receive and guide the pitman by which the sickles are reciprocated, in combination with swinging plates or covers by which these channels are inclosed and protected, substantially as herein described. (5) The vertical reciprocating cutters moving in close proximity with each other, the blades of said cutters having one edge bevelled and sharpened, and the edge which passes and opposes the bevelled edge of the opposite cutter made straight, substantially as herein described.

335,995. Cut-off Valve, *Delano H. Dugar, Cedartown, Ga.—Filed November 13th*, 1885.

Claim.—The combination of a cylindrical valve casing having the distributing ports at one side, and having a channel communicating with the live steam chamber at the diametrically opposite side, a hollow cylindrical valve fitting within the casing and having

335,995

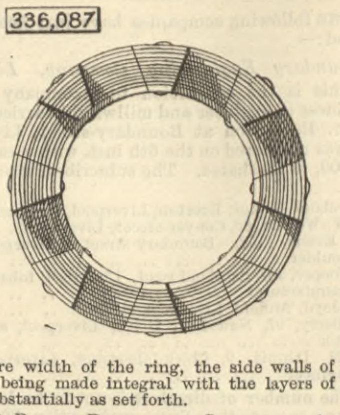


distributing ports registering with the ports of the casing, and having perforations registering with the channel communicating with its interior, and a cut-off valve having a semi-cylindrical face formed with distributing channels or apertures registering with the apertures in the hollow valve and bearing against the apertured inner surface of the said valve, as and for the purpose shown and set forth.

336,087. Armature for Dynamo-electric Machines, *Chas. F. Brush, Cleveland, Ohio.—Filed May 13th*, 1884.

Claim.—An armature composed of superposed layers of band iron wound one upon another, the opposite faces of which are provided with radial grooves situated directly opposite one another and extending

336,087

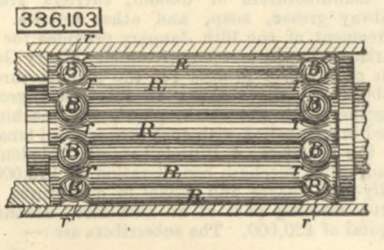


the entire width of the ring, the side walls of the grooves being made integral with the layers of the band, substantially as set forth.

336,103. Roller Bearing for Shafts and Axles, *John Gibbons, West Troy, N.Y.—Filed December 7th*, 1885.

Claim.—(1) In an axle or shaft bearing, the combination, with the rollers R, made with the recesses *r* in revolution thereon, of the balls B, having the same diameter as the rollers, and placed between said rollers within the grooved recesses relatively to the axle-box and axle or shaft, substantially as and for

336,103

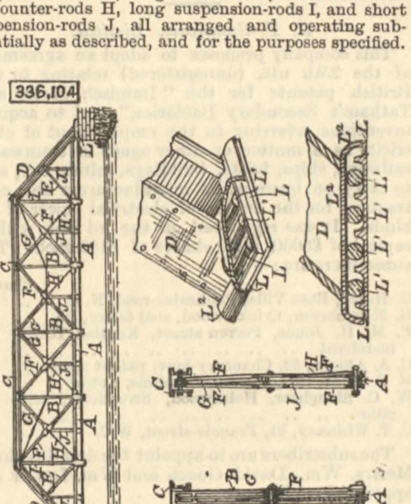


the purposes set forth. (2) In an axle or shaft bearing, the combination of the rollers R, made with the recesses *r* in revolution therein, of the balls B, having the same diameter as the rollers, and arranged within the grooved recesses, as shown, and a collar on the axle or shaft, and a threaded cap on the box, substantially as and for the purposes set forth.

336,104. Bridge, *Solomon H. Godman, Indianapolis, Ind.—Filed June 12th*, 1885.

Claim.—(1) In a bridge, the combination, with the upper and lower chords and end posts thereof, of diagonal struts extending from said end posts to the lower chord, the upright struts, long truss-rods extending from the corners formed by the connection of the end posts and top chord, or from the top of the vertical struts to the foot of the next vertical strut, the short truss-rods connecting the central portions of said long truss-rods to the top chord or top end of the vertical strut nearest it, and suspension rods supporting the floor beams, substantially as set forth. (2) In a bridge, the combination, with the lower chord A, upright struts B, top chord C, and end posts D, of the diagonal struts E, long truss-rods F, short truss-rods G, counter-rods H, long suspension-rods I, and short suspension-rods J, all arranged and operating substantially as described, and for the purposes specified.

336,104



(3) The combination, with the upper and lower chords, upright struts, and end posts of a bridge, of the long double truss-rods F, having pin-holes provided in the centre thereof, the short truss-rods G, secured at one end to said central portion and at its other end to the top chord at the top of the next strut, and the counter-rod H, connected at one end to the central portion of said long truss-rods, and at its other to the lower chord at the foot of the next strut, all substantially as set forth. (4) The combination, with a bridge, of the supports L, for carrying the ends of said bridge, consisting of the bed-plate provided with transverse grooves, the rollers L^1 mounted loosely in said grooves, and the top piece L^2 mounted on top and bearing on said rollers, substantially as set forth.

336,143 Water Meter with Revolving Piston, *Lewis H. Nash, Brooklyn.—Filed October 19th*, 1885.

Claim.—The combination, in a water meter, of a revolving non-rotating piston having circumferential projecting points and inlet and discharge ports concentric with each other, with a case having an equal number of joint-forming points and head ports operated by the concentric inlet and outlet valve ports of the piston, substantially as described, for the purpose specified.

336,143

750-H.P. TRIPLE EXPANSION ENGINES OF THE S.S. COOT.

THE CENTRAL MARINE ENGINEERING COMPANY, WEST HARTLEPOOL, ENGINEERS.