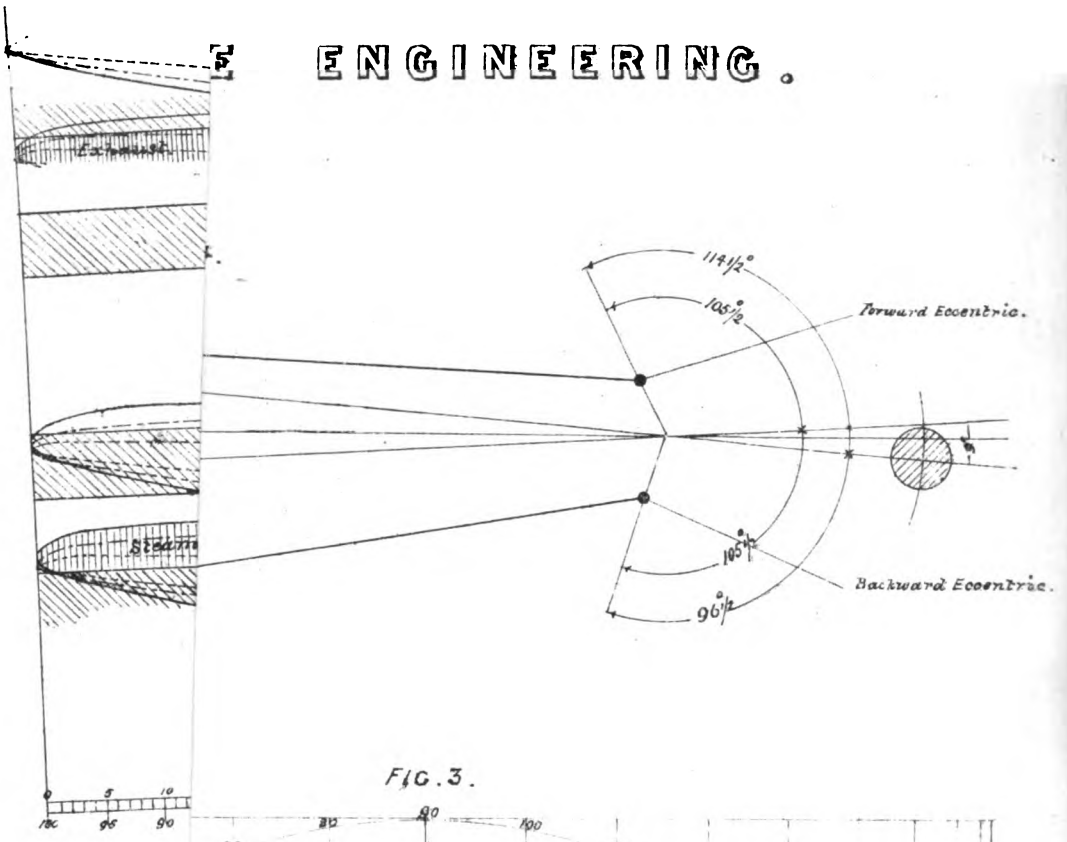
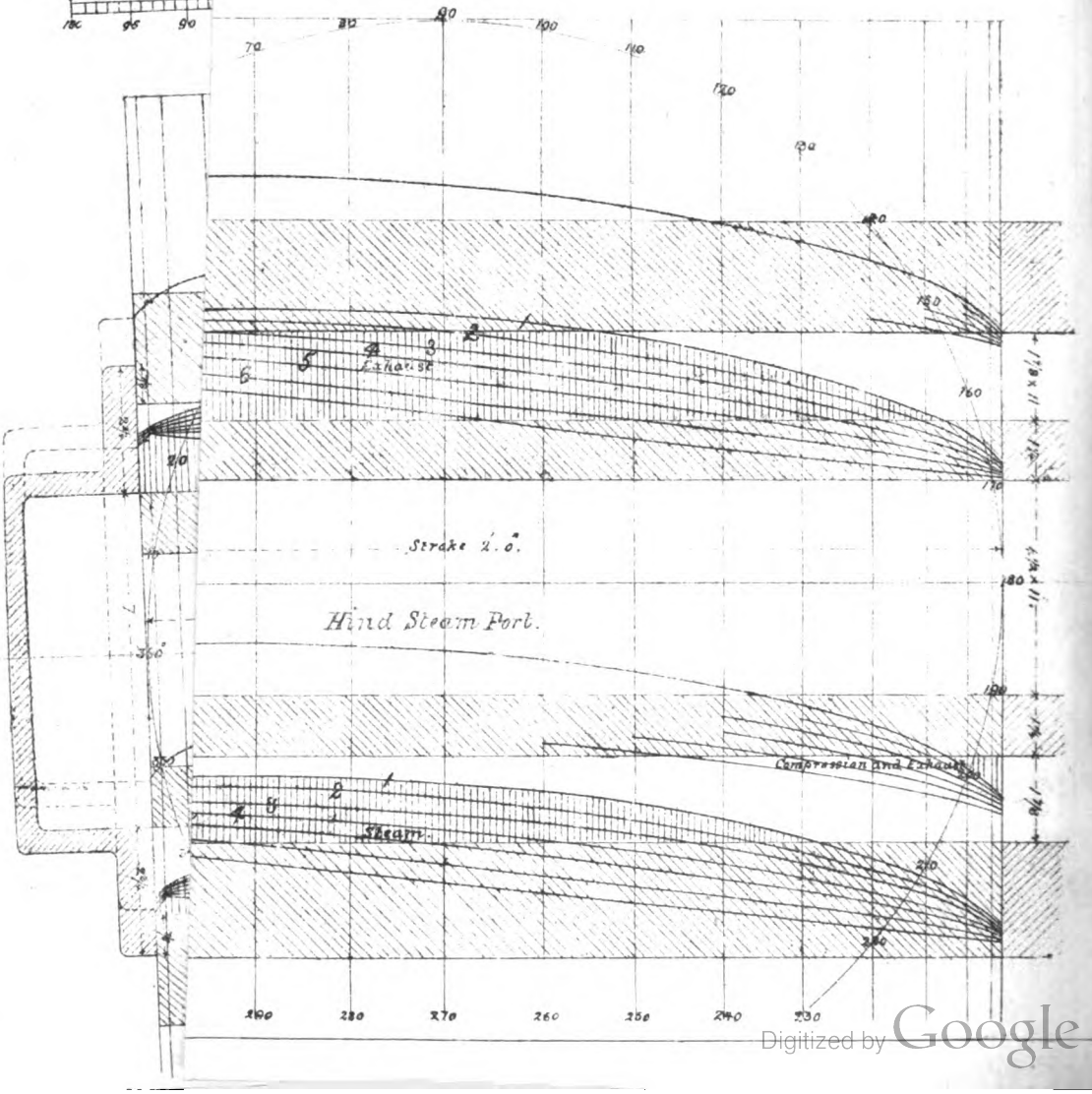
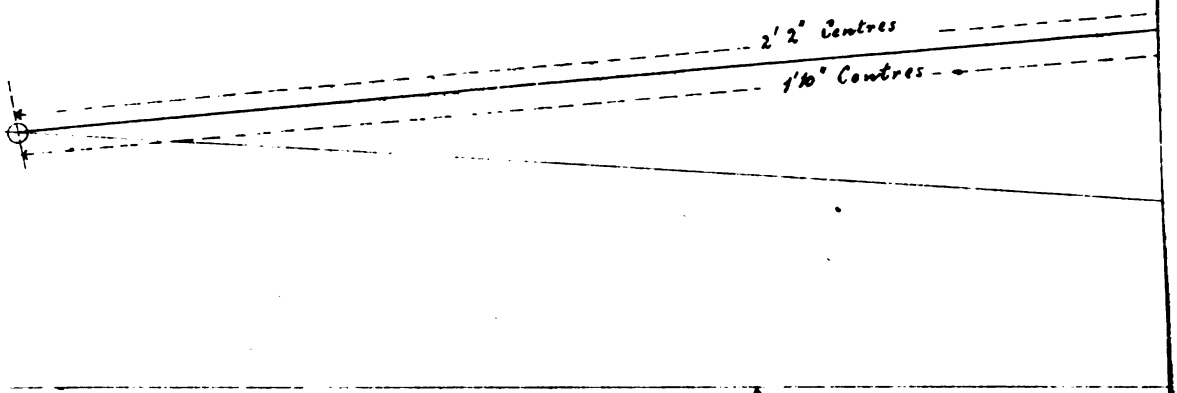



FIG. 3.




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FIG. 1.




| (FIG. 1.) | Ins. |
|---|---|
| Travel of Valve | 5½ |
| Lap | 1¼ |
| Lead | ¼ |
| Extreme Opening | 1½ |
| Breadth of Steam Ports | 1½ |
| " " Exhaust | 3 |
| " " Bars | 1 |
| Length of Ports | 12 |

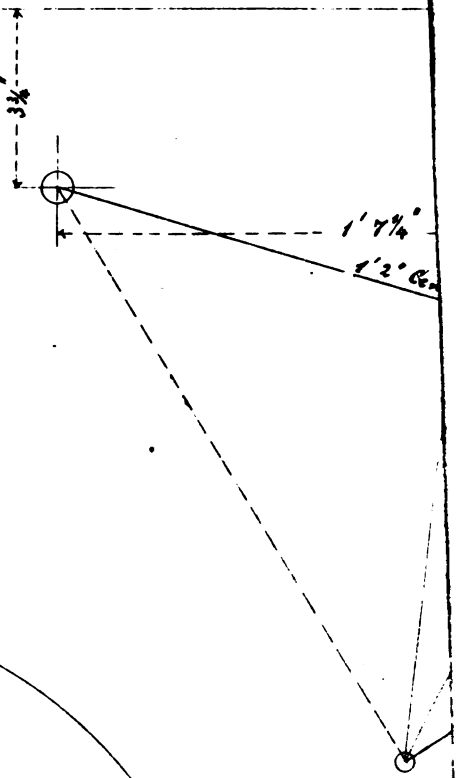
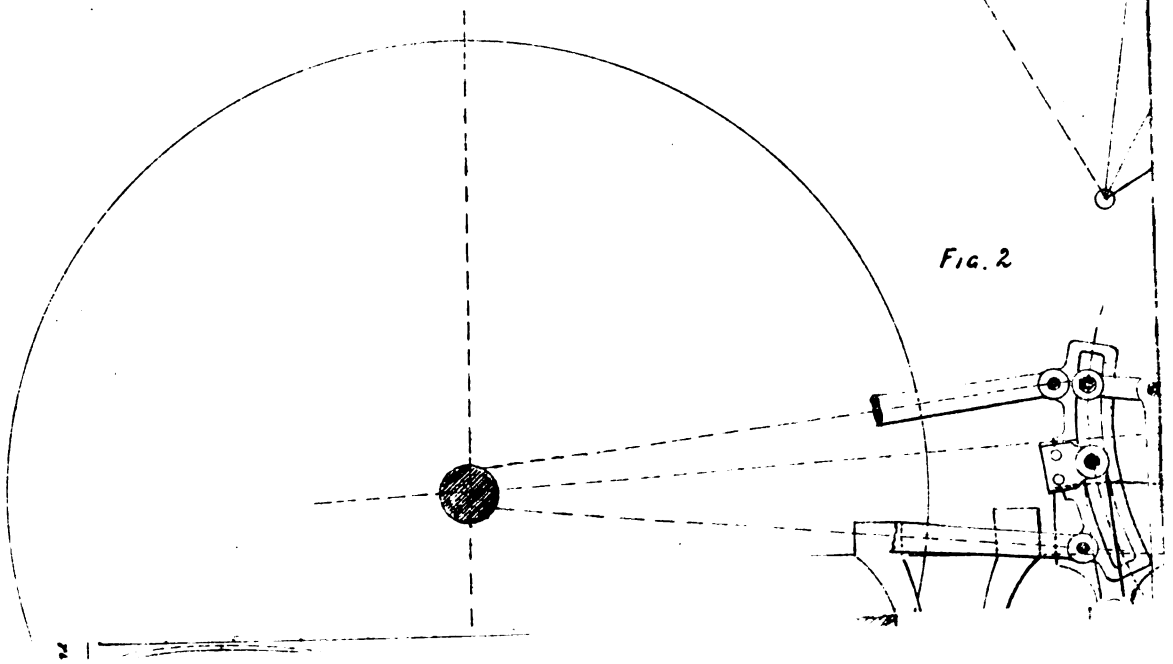



FIG. 2



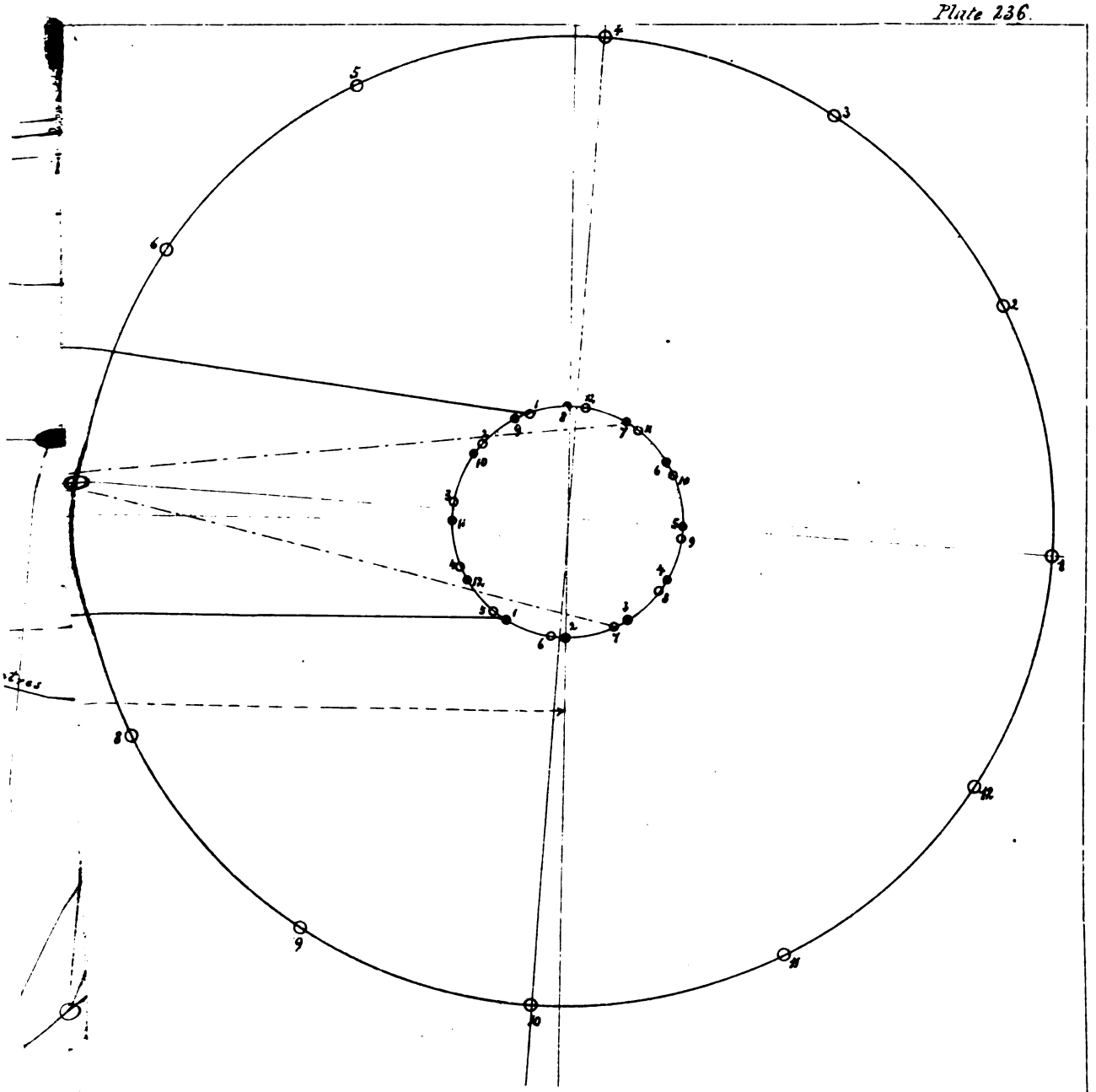
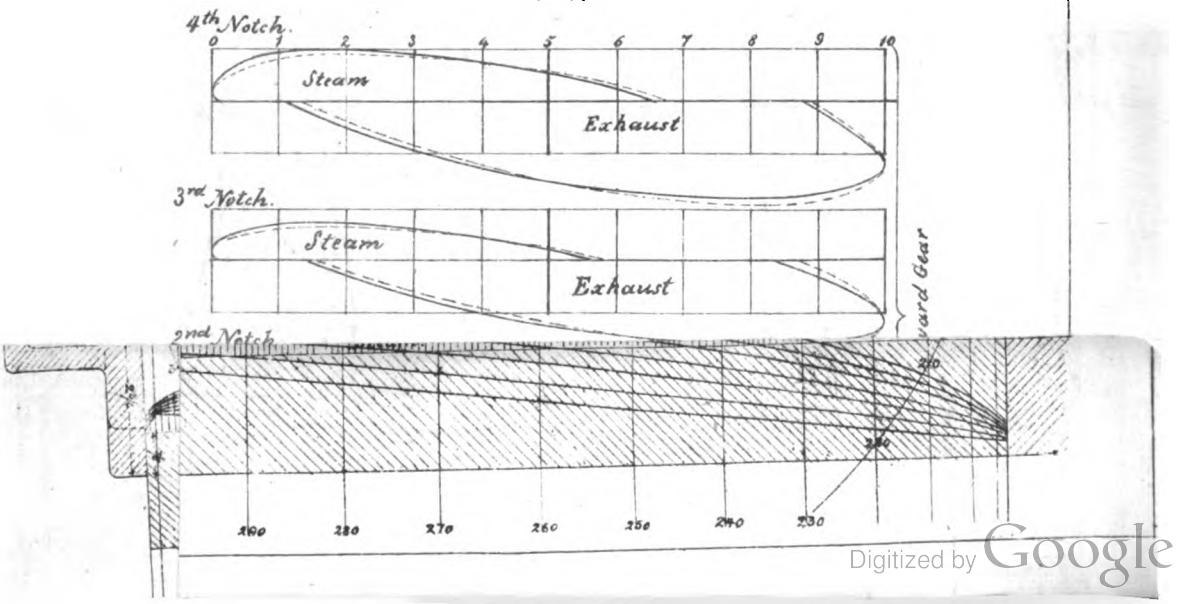


FIG. 4.




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# THE ARTIZAN.

No. 3.—Vol. 1.—Third Series.

MARCH 1st, 1863.

## GOODS LOCOMOTIVE "STEIERDORF."

### Constructed at the Works of the I. R. Austrian State Railway Company, Vienna.

*(Illustrated by Plate 233.)*

In The Artizan of December last we gave a plate illustration and description of the express locomotive "Duplex," constructed at the Works of the Imp. R. Austrian State Railway Company, Vienna. The plate with this number illustrates, in side elevation and by a sectional plan, a goods locomotive, constructed at the same works, and designed to run on the line of railway between Oravicza and Steierdorf, being a portion of the Austrian Suedostbahn. This line attains as high a gradient as $\frac{1}{50}$, and contains curves of a radius of 370ft. within a length of 10·6 miles, the maximum weight of the trains on the gradient being about 110 tons; the speed not to exceed 7 to 9 miles per hour. The aggregate tractive power required under these conditions had been computed at 103·4 cwts. = 5·17 tons, viz.,

| | |
|---|---|
| The tractive power on a level at 2200 : 260 | = 8·4 cwt. |
| The tractive power required for passing over curves of 370ft. radius supposed to be 2·5 × the tractive power on a level | = 21·0 cwt. |
| The tractive power required to overcome the relative weight of the train 2200 : 50 | = 44·0 cwt. |
| Ditto, to overcome the relative weight of the locomotive and tender 900 : 50 | = 18·0 cwt. |
| Total | 91·4 cwt. |
| To be added the power required by the engine to move itself on the horizontal curved line $\frac{900}{260} \times 3{\cdot}5$ | = 12·1 cwt. |
| Aggregate tractive power | = 103·5 cwt. |

Supposing the coefficient of friction to be = 1 : 7 the weight of adhesion of the engine would be 724·5 cwts.; and taking into account the various impediments, it would amount to 800 cwt. = 40 tons. The maximum load on each axle being 190 cwt., 5 driving axles were required for the motion. The aggregate weight to be dragged being 91·4 cwts., the speed for a gradient of 1 : 50 being 7·5 miles per hour, or 660ft. per minute, the strength required for the engine is

$$\frac{10237 \times 660}{33000} = 204{\cdot}74 \text{ say } 205 \text{ H.P.} \quad \ldots\ldots\ldots (1.)$$

Taking 6·454 square feet as the heating surface for 1 H.P., we have

6·454 × 1322 square feet aggregate heating surface.
Diameter of driving wheels D = 3·2ft.; stroke of piston $l$ = 2·07ft.

Calling $p$ the working pressure on each piston, after deducting the resistance of the working parts of the engine to overcome the resistance Z of the train, we have

$$2p \times 2l = \pi \, D \, Z,$$

and hence,

$$p = \frac{\pi}{4} \times \frac{D}{l} \times Z = 12{,}429\text{lbs.} \quad \ldots\ldots\ldots (2.)$$

If $d$ denotes the diameter of the cylinder in inches,
$n$ the pressure in atmospheres of 14·71lbs. per square inch.
$k$ = 0·46 the average useful pressure of steam in cylinder,

we have

$$p = 0{\cdot}46 \times 14{\cdot}71 \times n \frac{d^2 \pi}{4} = 5{\cdot}3145 \, n \, d^2$$

Taking

$$n = 7, p = 12429,$$

$$12429 = 5{\cdot}3145 \times 7 \times d^2$$

$$d = \sqrt{\frac{12429}{37{\cdot}2015}} = 18{\cdot}2 \text{ inches} \quad \ldots\ldots\ldots (3.)$$

The following is the list of dimensions of the several parts of this locomotive:—

| | |
|---|---|
| **Fire Grate.** | |
| Length | 4ft. 9⅛in. |
| Width, fore | 2ft. 10⅛in. |
| „ aft | 3ft. 3⅛in. |
| Area | 15·06 sq. ft. |
| Number of grate bars | 23 |
| Distance of grate bars from each other | ½in. |
| **Fire Box.** | |
| Internal length, at the bottom | 4ft. 9⅛in. |
| „ „ at the top | 4ft. 7⅛in. |
| Internal breadth at the bottom, front | 2ft. 10⅛in. |
| „ „ „ back | 3ft. 3⅛in. |
| „ „ top | 3ft. 8 7/16in. |
| Internal height, front | 4ft. 4⅛in. |
| „ „ back | 3ft. 11⅛in. |
| Height from fire door to bottom of fire box | 1ft. 6 3/16in. |
| Thickness of copper plate | ⅜in. |
| „ of the tube plate, top | 1in. |
| „ „ „ bottom | ⅜in. |
| Diameter of copper stay bolts | 1in. |
| Distance of „ „ | 4in. |
| **Barrel.** | |
| Length to the tube plate in the smoke box | 14ft. 2 1/16in. |
| Largest diameter | 4ft. ⅜in. |
| Smallest „ | 3ft. 10 13/16in. |
| Thickness of plate | ⅜in. |
| Diameter of rivets | ⅝in. |
| Distance of same from each other | 1 3/16in. |
| Number of tubes | 158. |
| Internal length of tubes | 14ft. 6½in. |
| External diameter of tubes | 2 1/16in. |
| Thickness of copper of tubes | 3/16in. |
| Distance of tubes from centre to centre | 2¾in. |
| Number of safety valves | 2 |
| Diameter of „ | 4⅜in. |
| **Heating Surface.** | |
| Heating surface of the tubes | 1244·5 sq. ft. |
| „ „ of the fire box | 78·5 sq. ft. |
| Aggregate heating surface | 1323· sq. ft. |
| **Chimney.** | |
| Diameter of funnel | 1ft. 4 3/16in. |
| Height of mouth of funnel above the rails | 14ft. 8 5/16in. |
| **Blast Pipes (Moveable Valves).** | |
| Area of largest opening | 24·9 sq. in. |
| „ of smallest „ | 4·7 sq. in. |
| **Feed Pumps.** | |
| Two patent Giffard injectors, No. 9. | |
| **Regulator.** | |
| Area of aperture | 7·8 sq. in. |
| **Steam Cylinders.** | |
| Diameter of cylinders | 1ft. 6⅛in. |
| Length of stroke | 2ft. ⅛in. |
| „ of steam ports | 1ft. ⅛in. |
| Width of „ „ | 1 3/16in. |
| „ of exhaust ports | 3⅛in. |
| **Slide Valves and Reversing Gear.** | |
| External length of the slide | 10⅛in. |
| Internal „ „ | 5⅛in. |
| External width | 1ft. 3 1/16in. |
| Internal „ | 1ft. 1/16in. |
| Area of the slide valve | 168·8 sq. in. |
| Exterior lap of slide | 1⅛in. |
| Interior „ „ | 1/32in. |
| Lead of the slide | 1/8in. |
| Largest opening for inlet of steam | 1 3/32in. |
| „ „ for exhaust of steam | 1 5/16in. |



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| | |
|---|---|
| Shutting off of steam in cylinders | 66 per cent. |
| Largest travel of slide | 4⅝in. |
| Throw of eccentrics | 6⅞in. |
| Angle of lead, forward | 15°. |
| „ „ backward | 12°. |
| Length of eccentric rod | 4ft. 6⅛in. |
| Radius of link segment in the middle | 3ft. 6½in. |
| Length of link segment | 1ft. 4 1/16in. |

Connecting and Coupling Rods.

| | |
|---|---|
| Length of connecting rod | 6ft. 4½in. |
| „ of front draw bar | 3ft. 1⅞in. |
| „ of back draw bar | 3ft. 7 9/16in. |
| „ of draw bar for tender | 7ft. 3⅛in. |

Coupling of the two Trains.

| | |
|---|---|
| Length of coupling shaft from centre of bearing | 5ft. 1/16in. |
| Total length of „ „ „ | 7ft. 6½in. |
| Diameter of „ „ „ | 5 5/16in. |
| Length of the vertical link between the first tender axle-tree and coupling shaft | 2ft. 0⅝in. |
| Largest section of ditto | 16·1 sq. in. |
| Length of oblique coupling rods between driving shaft and coupling shaft | 5ft. 2½in. |
| Largest section of ditto | 5·5 sq. in. |
| Length of the vertical draw bars between the first tender axle-tree and the coupling shaft | 2ft. 0⅞in. |
| Largest section of ditto | 4·8 sq. in. |

Wheels.

| | |
|---|---|
| Number of wheels | 10 |
| Diameter of „ | 3ft. 3⅝in. |
| Width of Tyres | 5½in. |
| Taper of „ | 1/16in. |
| Total length of wheel base | 19ft. 3½in. |
| Distance from first to central axle | 3ft. 7 9/16 |
| „ Central to driving axle | 3ft. 7 9/16 |
| „ Driving to first tender axle | 4ft. 9in. |

Tender.

| | |
|---|---|
| Capacity for water | 160 cub. ft. |
| „ for fuel | 60 cub. ft. |

Buffers.

| | |
|---|---|
| Height above the rails | 3ft. 6½in. |
| Distance from centre to centre | 5ft. 9in. |

Main External Dimensions of Engine.

| | |
|---|---|
| Length between surfaces of front and back buffers | 33ft. 10 9/16in. |
| Largest width of engine (measured on the cylinders) | 9ft. 8 1/16in. |

Total Weight of the Engine in Working Order.

| | |
|---|---|
| Load on rails from the 1st axle-tree | 9·153 tons. |
| „ „ 2nd „ | 8·267 „ |
| „ „ 3rd „ | 9·694 „ |
| „ „ 4th „ | 6·791 „ |
| „ „ 5th „ | 12·106 „ |
| Total | 46·011 tons. |

We also purpose presenting our readers in our next issue with another plate engraving, containing sectional views of the "Steierdorf," accompanied with a series of woodcuts and descriptive particulars.

## A CRITICAL AND HISTORICAL REVIEW OF LOCOMOTIVE ENGINEERING.

By J. J. Birckel.

(*Continued from page* 29.)

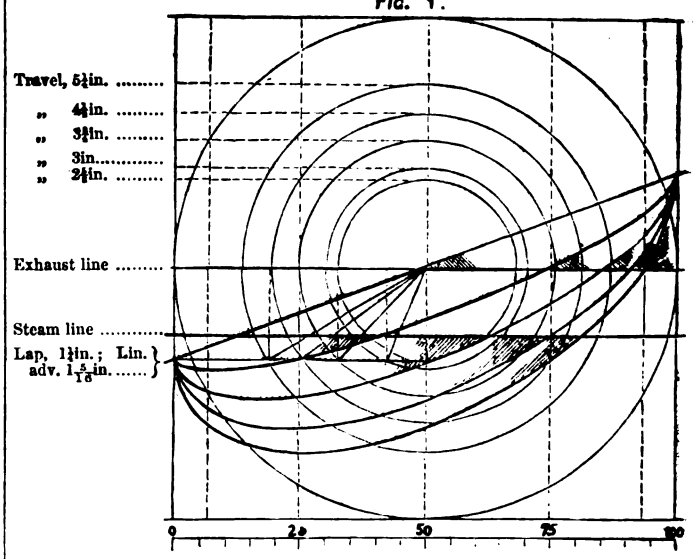
(*Illustrated by Plates Nos.* 234, 235, *and* 236).

We have seen that the distribution of the steam by means of the slide valve, so far as regards the periods of admission, suppression, and release, is regulated by the lap and the lead; and having stated also that variable and long expansion is obtained by great lap, accompanied with variable travel, we now give a graphic demonstration of this statement for the satisfaction of our readers by the annexed motion diagrams (Figs. 1, 2, 3, &c.) of a valve supposed to have one inch lap, and 5/16 lead with a travel varying from 5¼ to 2⅜ inches. These diagrams show that the points of suppression keep shifting at a rapid rate towards the beginning of the stroke as the travel is reduced, but the ratios, as given in the following table, will perhaps render the fact much more apparent.

| Travel. | | Period of Admission. | |
|---|---|---|---|
| Inches. | Per centage of Maximum Travel. | Per cent. of Stroke. | Per cent. of Max. Admission. |
| 5¼ | 100 | 81·5 | 100 |
| 4½ | 85·7 | 73·5 | 90·1 |
| 3¾ | 71·4 | 60· | 73·6 |
| 3 | 57·1 | 39 | 47·8 |
| 2⅜ | 50 | 12 | 14·7 |

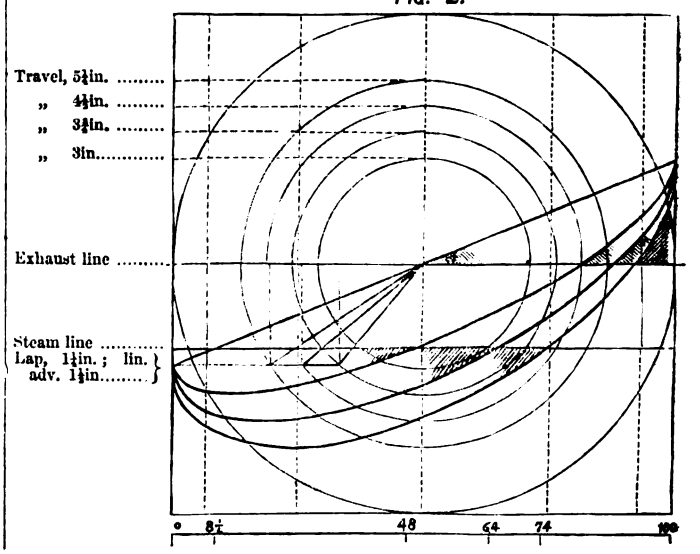
These figures, we think, strongly support the opinion already expressed in favour of a great initial travel of valve, since it is evident that with constant lap and lead it affords a greater range for variation in the rate of expansion.

Fig. 1.




The object of the link motion is to obtain variable expansion by means of variable travel with constant lap, and the amount of lap, so far at any rate as we have been able to ascertain, is subject to no other law in actual practice than the particular fancy of each designer, and ranges from

Fig. 2.



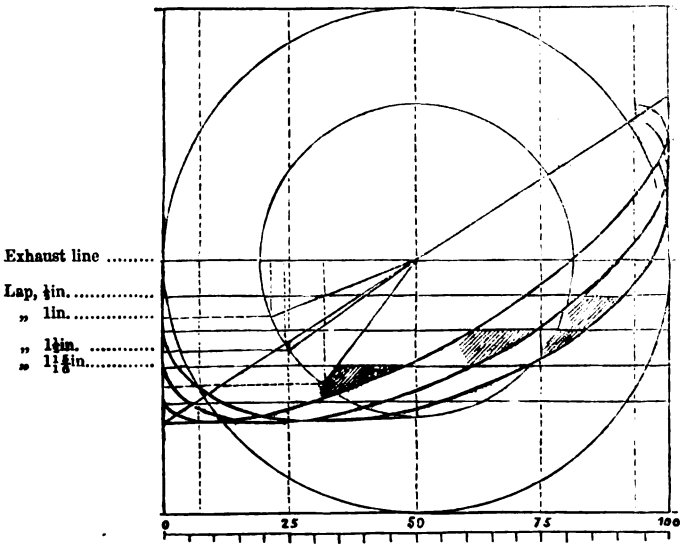

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¼ to 1¼ inch in locomotives of the same power or description. We think it somewhat strange that there should be such a large margin for variation in a matter like this, the relative results of which are so easily compared by diagrams representing the motion of the valve; the accompanying diagram (Fig. 2) for instance, being that of a valve having 1¼in. lap, with the lead nearly as before, shows that the sole addition of ¼in. to the lap reduces the periods of admission to 74, 64, and 48 per cent., being an increase of 7½, 9½, and 12 per cent. of the stroke in the expansive action of the steam, as compared with the results obtained by the corresponding amounts of travel in the previous example; this comparison, we think, is sufficient to show that the large lap has a claim to preference, if increased expansion is a guarantee of economy. It is true that the periods of release of the steam calculated from the opposite end of the stroke increase very rapidly with the decrease of the period of admission, but the loss of useful work thus occasioned is really too small, especially in the case of engines running at very high speeds, to be taken into account, when it is remembered how great is the gain upon back pressure due to this same circumstance.

The foregoing comparison naturally leads to the inference that variable expansion may be obtained also by varying the lap, and this virtually is the case in Meyer's expansion gear, illustrated by Fig. 9, plate 231, of THE ARTIZAN of last month, in which the removal of the expansion blocks from the centre of the valve face amounts to an increase of lap.

The annexed diagram (Fig. 3), illustrates the motion of a valve with lap

FIG. 3.




varying from ¼in, to 1⅛in., and from comparison with Figs. 1 and 2, it may be ascertained that the period of expansion does not increase at the same rapid rate as with varying travel, while at the same time, the period of release is considerably retarded, especially with the shorter laps; this circumstance, which is certainly favourable to engines working at low speeds, may be very unfavourable to engines working at high speeds, and upon the whole variable expansion by means of variable travel with constant lap is to be preferred.

With reference to the link motion and to its history, no sooner had it found its way into practice than human ingenuity applied itself to the task of modifying and improving it, and as a consequence, we have to make known to our readers three distinct types of link motions, namely: 1st. Stephenson's original motion known as the *shifting link*; 2nd. *The stationary link*, originated by Mr. Gooch, of the Great Western Railway: 3rd. The *straight link*, originated by Mr. Allan, of the Scottish Central Railway, and we shall proceed upon our investigation in the order just named, because this is the chronological order of their appearance, and of their recognition as mechanical entities.

The arrangement of the shifting link may be generally illustrated by Fig. 1 (plate 235,) which happens to be a representation of the valve motion of Mr. Ramsbottom's engine "Lady of the Lake," and consists of a slotted motion link curved to the radius of the eccentric rods and suspended from the arms of the reversing shaft; the points of connection of the eccentric rod ends with the link, vary according to convenience or necessity, and the engine is reversed or the rate of admission altered by lowering or raising the link through the medium of contrivances to be described hereafter,—the effect of thus lowering or raising the link is to cause the valve rod to be commanded either by the forward or backward eccentric, and the valve rod itself is either guided in a bush as in the case illustrated, or is suspended from some fixed point in such manner that it may move in a horizontal plane with as little vertical vibration as possible; it will be noticed, also, that the system of eccentric rods and links suspended on one side of the reversing shaft is balanced on the other side by a suitable counterweight for easiness of reversing. The link in each of the three types of motions is generally of two kinds, namely, the open link as illustrated by Figs. 5 and 6, and the box link as illustrated by Fig 4. The choice in the use of either kind

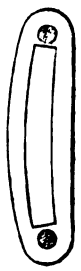
FIG. 4.



FIG. 5.



FIG. 6.



s often made by considerations of economy and sometimes y considerations of expediency r of local necessity, although, s we shall have occasion to how, the relative positions of the points of suspension and of connection with the eccentric rods have a material influence upon the distribution of the steam, and it will be seen on reference to the illustrations, that the box link affords the better means of variation in the position of the points of connection.

Referring now to the general illustration of the shifting link motion (plate 235) it is easy to perceive that when the link stands in its middle or neutral position, if the forward and backward eccentrics were placed exactly opposite each other, both having the same radius or throw, it would pivot upon its point of suspension, which would remain stationary, and as in this position of the link the head of the valve rod is either exactly or nearly concentric with that point, the valve also would remain stationary; if on the contrary the link was raised or lowered a certain extent, the valve would receive motion either from the backward or forward eccentric and the ratio of that motion, to the throw of the eccentrics, would be exactly the same as the ratio of the distances of the centre of the valve spindle and of the centre of the eccentric rod ends to the point of suspension of the link which would still remain stationary. From these considerations we learn that the motion of the valve as received through the medium of the link remains similar to and isochronous with the motion which it would receive directly from a single eccentric, so long at any rate as the two eccentrics remain diametrically opposite each other; this condition, however, becomes an impossibility when, with a view to obtaining long expansions, the valve is to have a certain amount of lap, and when, to ensure the easier working of the moving parts of the engine, it is to have a certain amount of lead; for as under these circumstances the valve must have travelled beyond its middle position by the whole amount of lap and lead when the piston is at the end of its stroke, it follows that the eccentric must stand at such an angle with the crank, that its normal projection upon the straight line passing through the two extreme positions of the crank, referred it need be to the centre line of motion of the valve, and measured from the centre of the crank, be equal to the sum of lap and lead. This projection is called the *linear advance* of the eccentric. Hence in reality the smallest motion of which the valve is capable is equal to twice the sum of lap and lead, and from the study of the motion diagrams of the link, Figs. 2 (plates 325,) it may be ascertained that the motion of the valve is the same exactly that it would be if it was driven from two eccentrics, the one remaining in the position above described with its present throw, and the other applied to the centre of the link but placed exactly opposite the crank and with a throw equal to twice the sum of lap and lead only; it may be seen also that the motion of the valve when the link stands in its middle or neutral position is exactly like that derived directly from the latter named fictitious eccentric, and that the valve is at one end of its stroke when the crank is at the opposite end; but the closer the point of the link to which the end of the real eccentric rod is applied, is shifted to the centre line of motion of the valve, the nearer becomes the motion of the valve, like that derived from the original single eccentric. We have dwelt at some length upon this point because it had been held for a long time that there was something very mysterious and incomprehensible in the cinematical manifestations of the link motion taken from the motion of the valve, and we doubt whether even Mr. Clark, who has dealt with the subject in a manner fully befitting its importance, has thoroughly understood the nature of that motion, for the following is all that he says on the subject:—

"The motion yielded by the link is apparently not so simple in its character as that of the single eccentric; throughout the whole length of the link it is a compound of the motions imparted separately by each eccentric, excepting only at the points where it joins the eccentric rods. Though the motion of every other point of the link is so compounded, the motion of each eccentric nevertheless predominates in its own half of the link above and below the point of suspension, and results in a motion com-

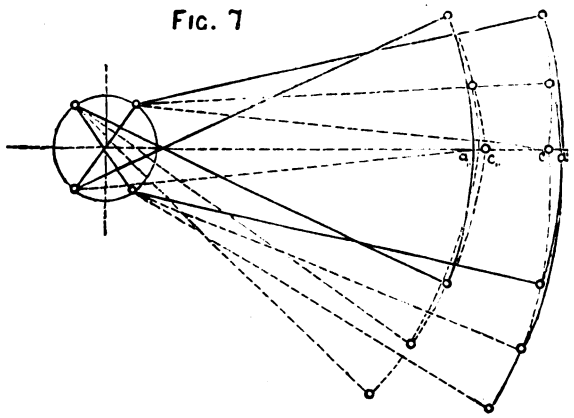
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municated to the valve of which each reciprocation has a varying velocity accelerated and retarded like that yielded by the single eccentric."

This, no doubt, is correct, but it leaves the reader in the dark as to the nature of the motion yielded by the middle of the link, whereas the introduction of the fictitious eccentric as has been done above, solves that question altogether, and besides, has the advantage of teaching us that the motion of the valve, as the middle of the link is shifted towards the centre of the valve rod, does gradually merge from that yielded by a single eccentric placed at the proper angle of advance, to that yielded by a single eccentric of smaller radius and placed right opposite the crank. The motion diagrams of both the shifting and the stationary link teach us still more; upon careful examination it may be ascertained that the motion of the valve in its relation to that of the crank always corresponds to that yielded by a single eccentric whose radius is measured from the centre of the crank, to a certain point lying upon the straight line which joins the points 1, Fig. 2 (plate 235), of the real eccentric and of the fictitious one supposed to be applied to the middle of the link, and the angle of which, with the crank, is defined by the line drawn from the centre of the crank to that certain point; the points 1 it should be stated, indicate the positions of the eccentrics (real and fictitious), when the crank is at the end of its stroke. Such being the case, it is always possible to define the relative motions of the crank and of the valve, as due to any intermediate point of the link, when the diagram of the various positions assumed by the latter during one revolution of the crank is set out, and may be accomplished in the following manner:—with half the distance $a_1$ $b_1$ (Fig. 2, plate 235) draw the path of the fictitious eccentric, supposed to be applied to the middle of the link; the diagram itself indicates that it is placed exactly opposite the crank, its point 1 is, therefore, upon the diameter passing through the two extreme positions of the crank and the straight lines 1, 1 may at once be drawn; if now it is desired to define the position of the eccentric to which the motion of the valve, as derived from that $a$, $b$ of the link may be referred, with one-half the distance $a$, $b$ draw the path of this new fictitious eccentric and from its point of intersection, $d$, with the line 1—1 draw the radius $d$ $o$, which will define the angle of this eccentric with the crank; a similar construction would answer for any other intermediate point of the link. These various considerations may be perhaps of little practical value, but looked upon from a purely abstract point of view, they are not without considerable interest.

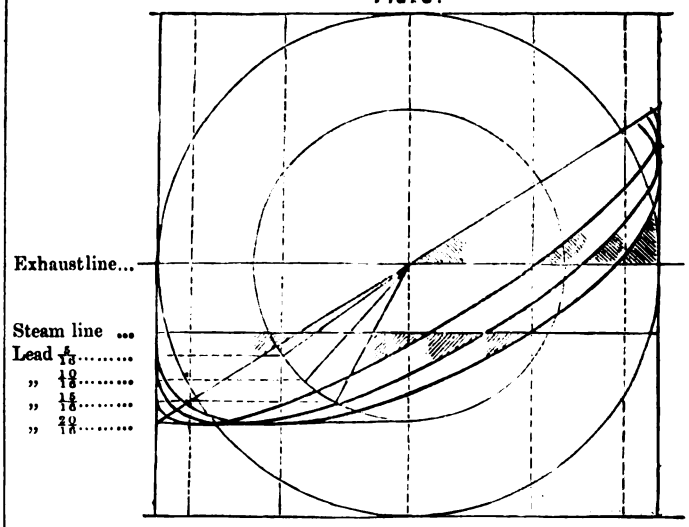
We have stated, previously, that the angle of the eccentric is defined by the sum of lap and lead measured horizontally from the centre of the crank, and we have stated also that the smallest motion of the valve is equal to twice the sum of lap and lead, two statements from which it might be reasonably inferred that the smallest motion of the valve is equal to twice the linear advance of the eccentric; such would be the case if the length of the eccentric rods remained unchanged during the whole period of one revolution of the crank, but as this length is materially affected by the obliquity of the rods, as illustrated by the adjoining sketch (Fig. 7.), it follows that the smallest motion of the valve

FIG. 7



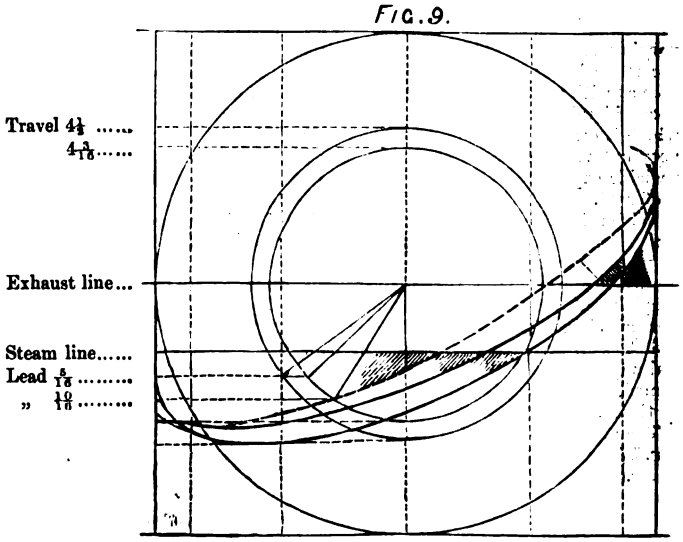
is equal to twice the linear advance of the eccentrics, augmented by twice the maximum difference of length of the eccentric rods occasioned by their obliquity. But as we have seen that in the case of minimum travel of the valve it has reached the end of its stroke when the crank is at the opposite end, since it is evident also that the lap remains unchanged, it is to be inferred that the lead must have increased at each end of the cylinder by the whole amount of the difference of length of the eccentric rods due to their obliquity; this fact is plainly illustrated (Fig. 7.) Where the distances $a$ $c$, $a''$ $c''$ represent the difference of lead which occurs; the same sketch also shows that the lead increases gradually as the link is raised from the position of full gear to that of mid gear, and that the sum of lap and lead in full gear is equal exactly to twice the linear advance of the eccentric as has been stated already. We have adopted this demonstration of the difference of lead, because by it the fact necessarily forces itself upon the reader's mind that in order to avoid great variations of lead it is essential to have very long eccentric rods. This variation in the lead has been a great grievance against the shifting link, and the advocates of other systems have not failed to make the most of this apparent defect; even Mr. Clark himself, who in other respects seems to have been animated by a most unbiassed spirit throughout his work, has taken for the normal pattern of his link motion the stationary box link, evidently on account of its fulfilling the condition of constant lead; for, in speaking of the range of variable expansion by means of the link he says that "a condition necessary to its most successful operation, is the preservation of constant lead for all degrees of expansion;" and yet in the chapter

FIG. 8.




immediately preceding he demonstrates that variable expansion may be obtained, to a considerable extent, by the increase of lead, with constant lap or travel, a fact which is illustrated by the annexed diagram (Fig. 8) taken from his work. He also demonstrates, conclusively, that when lap, lead, and travel increase at the same time, in equal proportions, the events of the distribution remain unchanged, and since it has been shown that the effects of variation of lead and variation of travel are similar,

FIG. 9.




though not quite identical, it follows that increase of lead with decrease of travel must be favourable to the expansive action of the steam; this may be seen from the annexed (Fig. 9), where the dotted line indicates the

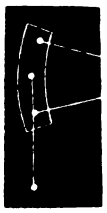
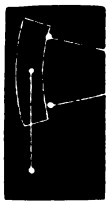
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motion of the valve with reduced travel and with the lead doubled, whereas the full line indicates the motion of the valve with reduced travel simply.

The only objection that we can see to the increase of lead is the corresponding increase in the period of admission of steam before the piston has reached the end of the stroke; but when it is remembered that the link is used in those of its points yielding long expansions, when the engine is running at great speeds, that is, when the reciprocations of the parts in motion are more frequent and more violent, it may be inferred, with reason, that this increased pre-admission of the steam is a circumstance rather favourable to the preservation of those parts, and, consequently, that the slight increase of lead, far from being a defect, is a decided advantage; it should be remarked, besides, that the engine never can be worked from mid gear, and that the increase of lead is more rapid towards mid gear than towards full gear, both which circumstances militate in favour of the opinion which we have just expressed.

We have stated that the positions of the points of connection with the eccentric rods and of the point of suspension have a material effect upon the events of the distribution; and, we believe, that for the knowledge which we possess on this subject, we are chiefly indebted to the experimental researches of Mr. Gooch of the Great Western Railway. It is true that local, or individual causes, often lead to peculiar modes of connection and suspension, not quite conformable with the requirements of correct distribution of the steam, notwithstanding this, however, it may prove both interesting and useful to be acquainted beforehand with the results obtained by various arrangements adopted in practice, and we, therefore, reproduce some of them from Mr. Clark's work in the table below:

TABLE OF DISTRIBUTION, WITH VARIOUS ARRANGEMENTS OF THE SHIFTING LINK, CORRECTED FOR A SIX LENGTHS ROD.

| Arrangement of Link. | | Admission per cent of stroke. Front. | Back. | Arrangement of Link. | | Admission per cent of stroke. Front. | Back. |
|---|---|---|---|---|---|---|---|
|  | Full gear | 79 | 72 |  | Full gear | 78 | 72 |
| | Half gear | 51¼ | 44¾ | | Half gear | 48¼ | 45¾ |
| | Mid gear | 17 | 15½ | | Mid gear | 17 | 15½ |
|  | Full gear | 78 | 65½ |  | Full gear | 77¼ | 66½ |
| | Half gear | 52¾ | 37 | | Half gear | 54¼ | 39½ |
| | Mid gear | 22¾ | 12½ | | Mid gear | 21½ | 12 |
|  | Full gear | 74 | 73 |  | Full gear | 78 | 77¼ |
| | Half gear | 47 | 47¾ | | Half gear | 52¼ | 52 |
| | Mid gear | 18½ | 16½ | | Mid gear | 19½ | 20 |

This table shows how great is the influence arising from the mode of arranging the links, upon the distribution of the steam, a fact which, in badly arranged motions, is very audible when the engine is on duty from the inequality of the beat, or, in other words, from the inequality in the periods of release of the steam at each end of the cylinder; this evil is sometimes remedied by providing unequal lap at the opposite ends of the valve, but it is quite evident that this is not the legitimate mode of correction, since by pure accident the valve may just be put the reverse way into its place; sometimes also the correction is made by a difference in the width of the steam ports and to this we can see no practical objection.

'Fig. 1 (plate 234) is a diagram of the valve motion of the "Lady of the Lake," taken from a full size model, and in the following table we give the numerical results, corrected for a seven lengths rod, which, compared with those taken from the engine itself, placed in juxtaposition with them show what a great influence a slight difference in the position of the centres may have; in this case there is a great probability that the model was not fitted up with the same accuracy as the motion itself whose results may, indeed, be said to be practically correct:

ABSTRACT OF RESULTS OF VALVE MOTION OF ENGINE "LADY OF THE LAKE."

| | Taken from Diagram. | | | | Taken from Engine. | | | |
|---|---|---|---|---|---|---|---|---|
| | Steam cut off. | | Exhaust begins. | | Steam cut off. | | Exhaust begins. | |
| | Up. | Down. | Up. | Down. | Up. | Down. | Up. | Down. |
| Full gear ... | 69½ | 65¾ | 85½ | 88 | 72½ | 68½ | 90 | 87 |
| Half gear ... | 51½ | 54¾ | 81¼ | 81½ | 50 | 49 | 80 | 77 |
| Quarter gear. | 22 | 27½ | 66 | 61 | 25 | 23½ | 62 | 60 |

We have stated, in an earlier part of this paper, that the choice in the kind of the link, and the general arrangement of the link motion is, sometimes, subject to considerations of local necessity, a statement which will be very easily understood when it is mentioned that the greatest available space to hold the cylinders never exceeds 4ft. 1½in. upon the narrow gauge (the inside cylinder engine, of course, is here alluded to), which, for cylinders of large dimensions, scarcely leaves room for the link motion. This fact, indeed, was one of the great grievances against the narrow gauge during that memorable episode in the history of railway engineering, known as the "battle of the guages, and in it the advocates of the broad gauge found, undoubtedly, a good argument at that time, for, we believe that no cylinder, exceeding 16in. in diameter, was then to be found on the narrow guage, while the broad guage could boast of the *Great Britain* with cylinders 18in. diameter. So far as we are able to ascertain the problem of finding room for a commodious arrangement of the link motion, with 18in. cylinders. lodged in the narrow space of 4ft. was first solved by Messrs. Sharp, Stewart and Co., in the "Sphynx," 1847, and as we have every reason to believe that at the time it was a triumph of perseverance and skill in locomotive engineering, we give a section through the cylinders of that engine (Plate 235, Fig. 3), and an illustration of the link motion (Figs. 4 and 5, Plate 235) with a diagram of the motion of the valve (in Figs. 2, 3, 4, Plate 234), Fig. 2 showing the periods of the front stroke; and Fig. 3 those of the back stroke. Here the increase of the lead, amounting to ¼in., is somewhat considerable, but it arises from the fact of the link being very long, and this latter circumstance has the advantage of yielding long periods of admission in full gear; in other respects the results of this motion are very good indeed, the periods of admission corrected for a six lengths rod being as follows:—

| | Per cent. of Admission. | |
|---|---|---|
| | Front. | Back. |
| Full gear ..... | 83¾ | 81 |
| Half gear ..... | 54 | 50 |
| Quarter gear..... | 27¼ | 25 |

Since that date, however, it has been found possible to put the valves

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into their usual place between the cylinders and to cram the link motion into the very narrow space available in the case of 18in. cylinders; but we venture to affirm that such arrangements are anything but an improvement upon the one here illustrated, because they leave no room for repairing the valve faces and invariably lead to awkward and unmechanical modes of connection between the several parts of which the link motion consists, nor admit of those dimensions which provide the amount of wearing surface, so essential to ensure a long continued efficient working of the motion.

The stationary link may be generally illustrated by Fig. 2 (Plate 236), representing the link motion of Mr. J. V. Gooch's engine "Snake;" and upon the same plate (Fig. 1), we have illustrated the motion diagram of a stationary link as fitted to some engines lately constructed for the Great Eastern Railway by Messrs. Fairbairn, and which we are enabled to furnish to our readers through the kindness of Mr. Sinclair. It differs from the shifting link in that it is suspended from a fixed point, and where it is used the act of reversing or of altering the rate of expansion is performed by raising or lowering the valve rod. The link is curved to a radius equal to the length of that rod and has its concave side turned towards the cylinder, by which arrangement the condition of constant lead is effectually realised. The nature of the motion yielded by the stationary link is identical with that yielded by the shifting link, and all that has been said on this subject applies to the three types of link motions. With the stationary link, however, the linear advance of eccentrics is not equal exactly to the sum of lap and lead, for since the position of the link referred to the centre of motion of the valve remains unchanged, it is evident that the effect of the obliquity of the eccentric rods is transmitted to the valve in an equal degree by all the points of the link from full gear to mid gear, and consequently the linear advance of the eccentrics must be less than the sum of lap and lead by the full amount of the variation of length of the eccentric rods occasioned by their obliquity. From the remarks which we have made, when discussing the peculiarities of the shifting link, we would by no means be understood to detract from any of the real merits of the stationary link, which, in our opinion, however, may simply be stated as follows. The reversing gear required by the use of it is less heavy and compendious, requiring but very small, or no balance weights, and, proportionately also is the labour of reversing made easier; but in opposition to this it is argued that the obliquity taken by the valve rod occasions great vertical pressure upon the glands of the valve spindle, and wears them out very soon, and be it prejudice, or be it a well grounded cause for rejection, certain it is that the stationary link is patronized only by Mr. Gooch, and by Mr. Sinclair.

The straight link may be generally illustrated by Fig. 3 (plate 236); it consists of a reversing shaft having two short levers forged upon it, and placed on opposite sides of the shaft, to one of which the motion link is suspended, and to the other the valve rod. The lever to which the motion link and the eccentric rods are suspended, is made shorter than the one which carries the rod, and this being lighter than the former is thus made to counterbalance them. As a result of this arrangement, in which, during reversal the motion link and the eccentric rod ends are lowered while the valve rod and the motion block are raised, a straight link has to be used, because the versed line of the arc which one portion of the gearing describes, is counteracted by that described by the opposite portion. This construction of the link motion carries along with it several important and undisputable advantages; in the first place, the working surfaces of the straight link are much easier got up and kept in repair; secondly, as the length of the suspending levers seldom exceeds 4 inches, and as the spaces through which the respective parts of the motion have to travel, are very small, a much greater purchase can be obtained with the reversing lever than in the other types of link motions and the labour of reversing, or of altering the degree of expansion is considerably easier, a feature of the utmost importance in cases of emergency; and lastly, another great advantage is, that much less vertical space is required, in consequence of which, the boiler can be kept proportionately lower, the difference amounting often to three or four inches; it may be stated also that it keeps the lead equal for all degrees of expansion. Fig. 4, plate 236, illustrates the motion of a valve having 1⅛in. lap, the period of the front stroke being indicated by the full lines, and those of the back stroke by the dotted lines, and corrected for the obliquity of the connecting rod, they would be almost equal. In the table below we give the results obtained with a valve having $\frac{7}{8}$ in lap, the ports being so arranged as to have $\frac{1}{4}$in lead to the front, and $\frac{5}{16}$ to the back.

Since in this motion the lead remains unaltered as previouely stated, it follows that the linear advance of the eccentrics is equal to the sum of lap and lead diminished by the whole amount of the difference of length of the eccentric rods occasioned by their obliquity. Some engineers object to this arrangement of link motion on the ground of its causing the glands of the valve spindle to wear out very soon, by reason of the obliquity of the valve rod; we believe, however, that in this case, the objection is without foundation,

Results of Straight Link Motion in per cent of Stroke.

| | Suppression. | | Release. | | Compression. | |
|---|---|---|---|---|---|---|
| | Front. | Back. | Front. | Back. | Front. | Back. |
| Full gear ..... | 72 | 72 | 90 | 90 | 10 | 10 |
| 4th notch..... | 60 | 60 | 85 | 85 | 15 | 15 |
| 3rd „ ..... | 50 | 50 | 81 | 80 | 19 | 20 |
| 2nd „ ..... | 37 | 38 | 74 | 72 | 26 | 28 |
| 1st „ ..... | 23 | 25 | 64 | 62 | 36 | 38 |
| Mid gear ..... | 14 | 15 | 51 | 49 | 49 | 51 |

We shall not follow the example set by Mr. Clark, to give rules, or prescribe methods for setting out link motions, for we have occasion to know from our own observations that every engineer or every draughtsman finds out a method best suited to himself; all that can be said in the shape of advice on this subject, is as follows: In the case of the shifting link, the reversing shaft and levers should be so placed as to cause the working point of the link in its various positions to move in the straight link, passing though the centre of motion of the valve; in the case of the stationary link the reversing shaft should be so placed as to cause the motion block in all its positions to move in a line parallel to that passing through the centre of motion of the valve; in the case of the straight link, when once its position is decided upon, it may be said that the position of the reversing shaft is given, and the only care to be taken is to have the suspension rods as long as possible, in order to reduce their arcs of vibration as near as possible to a stright line. As for the position of the eccentrics upon the axle, that is generally determined by actual trial underneath the engine, when the link motion complete is in its place, and is afterwards fixed by template for every engine of the same description. Some foremen erectors, however, have sufficient confidence to define that position upon paper, and to set the eccentrics permanently without previous trial. Mr. Clark gives some trigonometrical rules and formulæ to define their position, as well as that of the periods of suppression and release in terms of the stroke; such rules, however, have no practical value whatever, for we can confidently affirm that no practical engineer ever yet set to work in search of any of those quantities with a table of natural sines in his hands, and since in abstract science they teach nothing, we look upon them as being only so much waste paper.

In order to complete our review and study of link motions, we have yet to lay before our readers the apparatus by means of which the engine is reversed, or the rate of admission altered to suit the continually changing wants of the train upon the road.

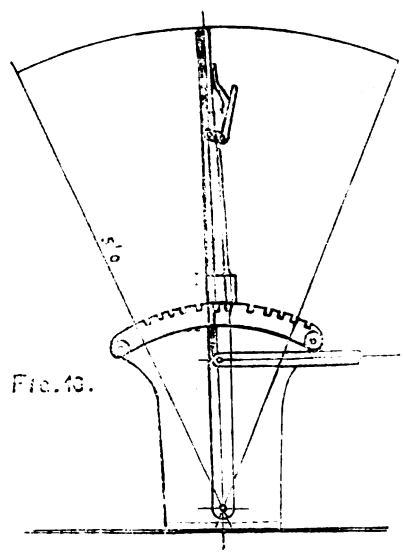


Fig. 10.

The apparatus which, until lately, has been in almost exclusive use, may be generally illustrated by the accompanying woodcut, Fig. 10, and consists of a quadrant or sector notched upon its outer circumference; of a lever or handle pivoting upon a fixed centre as a fulcrum, and carrying the reversing rod at a suitable distance from this fulcrum in such manner as to have sufficient leverage to enable one man easily to overcome the combined resistances of all the parts of the link motion; a guide plate notched like the sector is fixed upon the latter, and the reversing handle in its angular motion slides between them; the handle carries a catch provided with a trigger to be worked with the hand during the act of reversing. The whole system is generally so arranged that the handle stands upright when the link is in mid gear, — that it leans forward *towards* the engine

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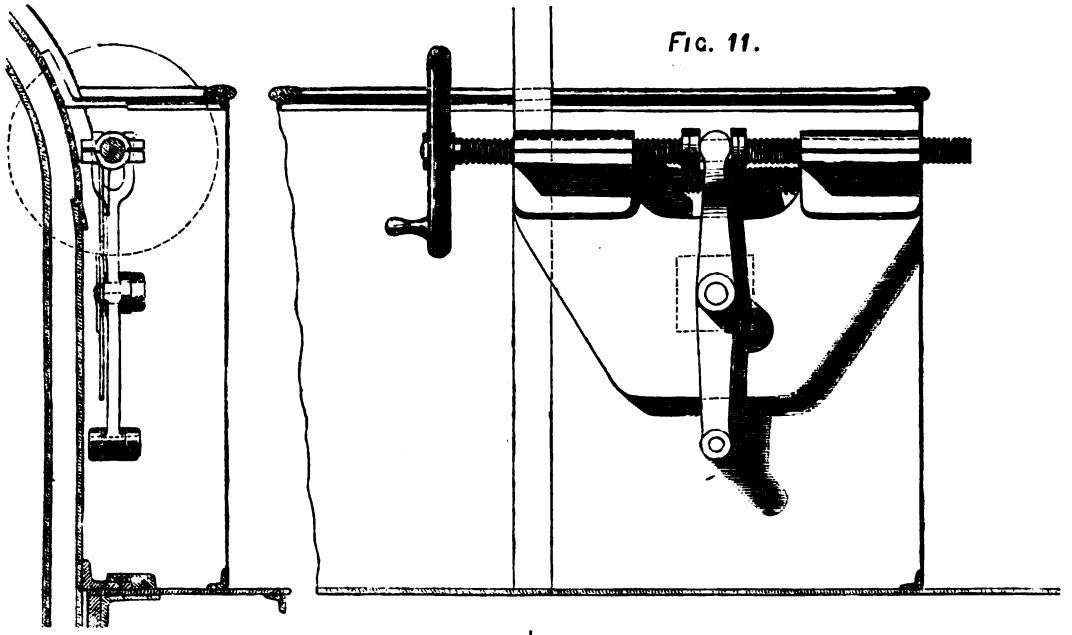


FIG. 11.

when the motion is in forward gear, and backward *from* the engine when it is in backward gear.

Mr. Ramsbottom has adopted, and has used for some time, the scheme illustrated by Fig. 11, and consisting as before, of a lever pivoting upon a fulcrum, and carrying the reversing rod at a suitable distance from that fulcrum, but here the lever is forked at one extremity, and made to engage between the collars projecting upon a screw shaft moving in the two nuts *n n*; the screw is three threaded and is set in motion through a hand-wheel *h*, pushing the lever either forward or backward according as the wheel is turned to the right or to the left. The peculiar advantage of this reversing apparatus is, that it can be worked with much greater ease than the one previously described, and what is of still greater importance, it can never permit the link, of its own accord, to change its position, say from mid gear to full gear, or from backward to forward gear, a circumstance of frequent occurrence when the catch is bad, and which has been the cause of many serious accidents.

*(To be continued.)*

## USEFUL NOTES AND FORMULÆ FOR ENGINEERS.

*(Continued from page 31.)*

### TABLE 1.

LEAST DIAMETERS OF WROUGHT IRON MAINSHAFTS FOR PRIME MOVERS.

| H.P. of Prime Mover. | Number of Revolutions of Shaft per Minute. | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 15 | 20 | 25 | 30 | 35 | 40 | 45 | 50 | 55 | 60 |
| 3 | 4·00 | 3·63 | 3·34 | 3·16 | 3·00 | 2·88 | 2·76 | 2·66 | 2·60 | 2·50 |
| 5 | 4·74 | 4·30 | 4·00 | 3·76 | 3·56 | 3·46 | 3·28 | 3·18 | 3·06 | 2·98 |
| 8 | 5·44 | 5·04 | 4·66 | 4·40 | 4·18 | 4·00 | 3·88 | 3·70 | 3·58 | 3·48 |
| 10 | 5·70 | 5·42 | 5·04 | 4·74 | 4·50 | 4·30 | 4·14 | 4·00 | 3·86 | 3·76 |
| 12 | 6·34 | 5·76 | 5·28 | 5·02 | 4·78 | 4·56 | 4·40 | 4·24 | 4·10 | 4·00 |
| 14 | 6·68 | 6·06 | 5·64 | 5·30 | 5·02 | 4·80 | 4·62 | 4·46 | 4·32 | 4·20 |
| 16 | 6·98 | 6·34 | 5·88 | 5·54 | 5·26 | 5·02 | 4·84 | 4·66 | 4·52 | 4·40 |
| 18 | 7·26 | 6·60 | 6·12 | 5·76 | 5·48 | 5·24 | 5·02 | 4·86 | 4·70 | 4·56 |
| 20 | 7·52 | 6·82 | 6·34 | 5·96 | 5·66 | 5·42 | 5·22 | 5·02 | 4·88 | 4·74 |
| 25 | 8·10 | 7·36 | 6·82 | 6·64 | 6·10 | 5·84 | 5·62 | 5·42 | 5·25 | 5·10 |
| 30 | 8·60 | 7·82 | 7·26 | 6·82 | 6·48 | 6·20 | 5·96 | 5·76 | 5·58 | 5·42 |
| 35 | 9·06 | 8·24 | 7·64 | 7·20 | 6·82 | 6·54 | 6·28 | 6·06 | 5·88 | 5·70 |
| 40 | 9·48 | 8·60 | 8·00 | 7·52 | 7·14 | 6·82 | 6·56 | 6·34 | 6·14 | 5·96 |
| 45 | 9·96 | 8·96 | 8·32 | 7·82 | 7·42 | 7·10 | 6·82 | 6·60 | 6·38 | 6·20 |
| 50 | 10·20 | 9·28 | 8·60 | 8·10 | 7·70 | 7·36 | 7·08 | 6·82 | 6·62 | 6·42 |
| 55 | 10·54 | 9·58 | 8·88 | 8·36 | 7·94 | 7·60 | 7·30 | 7·06 | 6·82 | 6·64 |
| 60 | 10·84 | 9·86 | 9·14 | 8·60 | 8·18 | 7·82 | 7·52 | 7·26 | 7·04 | 6·82 |
| 65 | 11·14 | 10·02 | 9·40 | 8·84 | 8·40 | 8·04 | 7·72 | 7·40 | 7·22 | 7·02 |
| 70 | 11·42 | 10·32 | 9·64 | 9·06 | 8·60 | 8·24 | 7·92 | 7·64 | 7·40 | 7·20 |
| 75 | 11·68 | 10·61 | 9·86 | 9·28 | 8·80 | 8·42 | 8·10 | 7·82 | 7·58 | 7·36 |
| 80 | 11·94 | 10·84 | 10·06 | 9·48 | 9·00 | 8·60 | 8·28 | 8·00 | 7·74 | 7·52 |
| 85 | 12·18 | 11·09 | 10·18 | 9·66 | 9·10 | 8·70 | 8·40 | 8·10 | 7·90 | 7·60 |
| 90 | 12·40 | 11·30 | 10·40 | 10·00 | 9·30 | 8·90 | 8·60 | 8·30 | 8·00 | 7·70 |
| 95 | 12·60 | 11·50 | 10·60 | 10·10 | 9·50 | 9·10 | 8·70 | 8·40 | 8·20 | 7·90 |
| 100 | 12·80 | 11·70 | 10·80 | 10·10 | 9·80 | 9·20 | 8·90 | 8·60 | 8·30 | 8·10 |

### TABLE II.

ULTIMATE STRENGTH OF PILLARS CAST FROM LOW MOOR IRON, IN POUNDS AVERDUPOIS PER SQUARE INCH OF SECTIONAL AREA.

| Length ÷ Diameter. | Solid Columns. | Hollow Columns. |
|---|---|---|
| 80 | 4,000 | — |
| 78 | 4,000 | — |
| 76 | 4,000 | — |
| 74 | 4,100 | — |
| 72 | 4,500 | — |
| 70 | 4,750 | — |
| 68 | 5,000 | — |
| 66 | 5,400 | — |
| 64 | 5,900 | — |
| 62 | 6,200 | — |
| 60 | 6,900 | — |
| 58 | 7,300 | — |
| 56 | 8,000 | — |
| 54 | 8,600 | — |
| 52 | 9,500 | 12,000 |
| 50 | 10,500 | 13,000 |
| 48 | 11,500 | 14,000 |
| 46 | 12,500 | 15,000 |
| 44 | 14,000 | 16,700 |
| 42 | 15,000 | 18,600 |
| 40 | 16,800 | 20,000 |
| 38 | 18,500 | 22,100 |
| 36 | 20,000 | 24,500 |
| 34 | 22,000 | 27,000 |
| 32 | 24,500 | 30,000 |
| 30 | 27,000 | 33,000 |
| 28 | 29,500 | 35,500 |
| 26 | 32,000 | 38,000 |
| 24 | 35,000 | 41,500 |
| 22 | 38,000 | 45,500 |
| 20 | 41,000 | 50,000 |

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## TABLE III.

STRAIN ON CHAINS AND ARCHES.

| $\frac{c}{v}$ | At Centre. | At Support. | Length of Curve. |
|---|---|---|---|
| 50 | W.6·250 | W.6·270 | c. 50·04 |
| 45 | 5·625 | 5·650 | 45·04 |
| 40 | 5·000 | 5·025 | 40·06 |
| 35 | 4·375 | 4·403 | 35·08 |
| 30 | 3·750 | 3·783 | 30·10 |
| 25 | 3·122 | 3·163 | 25·10 |
| 20 | 2·500 | 2·549 | 20·12 |
| 19 | 2·375 | 2·423 | 19·14 |
| 18 | 2·250 | 2·305 | 18·14 |
| 17 | 2·125 | 2·181 | 17·15 |
| 16 | 2·000 | 2·062 | 16·16 |
| 15 | 1·875 | 1·913 | 15·17 |
| 14 | 1·750 | 1·820 | 14·18 |
| 13 | 1·625 | 1·695 | 13·20 |
| 12 | 1·500 | 1·581 | 12·21 |
| 11 | 1·375 | 4·468 | 11·23 |
| 10 | 1·250 | 1·345 | 10·26 |
| 9 | 1·125 | 1·230 | 9·29 |
| 8 | 1·070 | 1·120 | 8·32 |

c = chord of arc or span.
v = versine or deflection.
W = total load on chain or arch.

RULE.—Find the value of $\frac{c}{v}$ in first column; the number opposite it in the second column × W = strain at centre; the number on the same line in the third column × W = strain on chain or arch at either point of support; the number in the fourth column × the versine = the length of the arc.

## TABLE IV.

CO-EFFICIENTS OF FRICTION AND ANGLES OF REPOSE.

| NAME OF MATERIAL. | Co-efficient of Friction = tan. $\phi$. | Angle of Repose = $\phi$ |
|---|---|---|
| Dry Masonry and Brickwork | 0·60 to 0·70 | 31½° to 35° |
| Masonry and Brickwork with damp Mortar | 0·74 | 36½° |
| Timber on Stone | 0·40 | 22° |
| Iron on Stone | 0·70 to 0·30 | 35° to 16¾° |
| Timber on Timber | 0·50 to 0·20 | 26½° to 11½° |
| Timber on Metals | 0·60 to 0·20 | 31° to 11½° |
| Metals on Metals | 0·25 to 0·15 | 14° to 8½° |
| Masonry on dry Clay | 0·51 | 27° |
| Masonry on moist Clay | 0·33 | 18¼° |
| Earth on Earth | 0·25 to 1·00 | 14° to 45° |
| Earth on Earth, dry Sand, Clay, and mixed Earth | 0·38 to 0·75 | 21° to 37° |
| Earth on Earth, damp Clay | 1·00 | 45° |
| Earth on Earth, wet Clay | 0·31 | 17° |
| Earth on Earth, Shingle, & Gravel | 0·81 to 1·11 | 39° to 48° |

## TABLE V.

THE ULTIMATE STRENGTH OF MATERIALS USED IN CONSTRUCTION.

*The breaking weights are stated in lbs. avoidupois, per square inch of sectional area.*

| Name of Material. | Tension. | Compression. | Shearing. | Modulus of Elasticity. |
|---|---|---|---|---|
| Ash | 17,207 | 9,000 | | 1,600,000 |
| Brass, Cast | 17,968 | 10,300 | | 9,170,000 |
| Brick | 280 | 807 | | |
| Copper, Cast | 19,072 | | | |
| —— Wire | 61,228 | | | 17,000,000 |
| —— Bolts | 48,000 | | | |
| Deal, Christ. | 12,400 | | | 1,672,000 |
| Fir, Riga | 11,549 | 6,000 | | 1,130,000 |
| Hornbeam | 20,240 | 7,289 | | |
| IRON, WROUGHT. | | | | |
| —— Bar | 60,000 | 36,000 to 40,000 | 50,000 | 29,000,000 |
| —— Russian | 60,000 | | | |
| —— Swedish | 71,000 | | | |
| —— Sheet | 50,000 | | | |
| —— Chain | 52,460 | | | |
| IRON, CAST. | | | | |
| Hematite, No. 1 | 14,233 | 52,136 | 18,915 | 7,541,000 |
| —— 2 | 17,751 | 82,265 | 20,455 | 10,455,000 |
| —— 4 | 17,566 | 82,583 | 24,335 | 10,145,000 |
| Weardale, No. 1 | 18,080 | 52,771 | 27,558 | 9,911,000 |
| —— 3 | 21,859 | 90,046 | 28,520 | 10,830,000 |
| —— 4 | 23,513 | 109,286 | 31,050 | 12,375,000 |
| Southbank | 18,425 | 86,886 | 32,285 | 12,375,000 |
| Stockton, No. 1 | 25,810 | 99,524 | 28,715 | 13,315,000 |
| —— 3 | 22,271 | 87,063 | 30,810 | 12,265,000 |
| Butterley, No. 1 | 23,388 | 88,488 | 35,870 | 12,200,000 |
| —— 2 | 18,970 | 74,743 | 29,315 | 11,591,000 |
| —— 3 | 23,265 | 91,661 | 33,900 | 12,020,000 |
| Ilkeston, No. 1 | 22,107 | 82,220 | 30,585 | 10,815,000 |
| —— 2 | 29,840 | 119,483 | 39,655 | 13,012,000 |
| —— 3 | 30,115 | 120,321 | 38,960 | 13,993,000 |
| —— 4 | 19,847 | 75,318 | 37,660 | 12,245,000 |
| Goldendale | 25,430 | 113,459 | 33,430 | 12,943,000 |
| Netherton, No. 1 | 20,517 | 73,977 | 29,960 | 10,350,000 |
| —— 2 | 26,012 | 86,473 | 35,145 | 11,165,000 |
| —— 4 & 5 | 30,344 | 108,285 | 36,960 | 12,945,000 |
| Parkhead | 27,033 | 95,787 | 29,835 | 12,080,000 |
| Old Hill, No. 2 | 14,593 | 50,499 | 22,705 | 9,737,300 |
| —— 3 | 23,815 | 80,991 | 34,918 | 12,022,000 |
| —— 4 | 22,918 | 80,213 | 28,112 | 12,075,000 |
| Lays Works | 31,480 | 119,631 | 24,800 | 12,135,000 |
| Parkend | 17,019 | 56,116 | 21,878 | 8,680,500 |
| Blænavon, No. 1 | 26,766 | 91,897 | 26,820 | 12,017,000 |
| —— 3 | 23,903 | 87,358 | 27,750 | 11,795,000 |
| Pontypool | 26,302 | 99,618 | 25,535 | 11,735,000 |
| Larch | 10,220 | 5,568 | 1,300 | 879,600 |
| Oak, English | 17,300 | 9,509 | 2,300 | 1,451,200 |
| —— Canada | 10,250 | 9,509 | | 2,148,800 |
| —— Dantzic | 12,780 | | | 1,191,200 |
| Pine, Pitch | 7,818 | 6,790 | | 1,225,600 |
| —— Red | | 5,375 | 650 | 1,840,000 |
| —— Yellow | | 5,445 | | 1,600,000 |
| Steel | 110,000 to 130,000 | | | 29,000,000 to 42,000,000 |

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## ARE GAS HOLDERS LIABLE TO EXPLOSION?

BY T. W. KEATES, F.C.S.

During the progress of a recent conflagration which occurred in the immediate neighbourhood of one of the largest of the metropolitan gas works, considerable excitement and alarm were experienced by many of those living in the adjoining streets, or present in the crowd, from the idea that if the fire extended to the gas holders, which at the time were filled with the gas required for the supply of the public and private lights, an explosion of unexampled force and destructiveness would be the result. It was stated that many persons hastened away from the locality when they heard that there was a probability of the flames reaching the gas works; some thinking that if an explosion occurred, even the dome of St. Paul's might be endangered; others that at least Blackfriars Bridge would be destroyed; and, indeed, the public mind was filled at the moment with that vague and unreasoning sense of danger, which, operating upon great masses of people, effectually prepares the way for the most dangerous panic.

It is very desirable, both in the interest of the gas companies and of the public, that the erroneous ideas which gave rise to these really absurd, although in some respects natural, fears, should be corrected. There is but one way in which this can be done, that is, by affording information concerning the agents and forces involved in the question; so that a clearer conception of their nature may be acquired, and the undefined terrors, which in this, as in other similar cases, are engendered and fostered by ignorance, may be removed by a rational consideration of the physical and chemical laws to which such agents are subject. In accordance with this view, there are, then, to be considered—first, the character of coal gas with reference to the question of explosion; secondly, whether explosive mixtures of coal gas can be produced by circumstances attendant upon a fire extending itself to the gas holders. With regard to the first part of the inquiry, it must be remembered that the gaseous mixture, which we know as coal gas, is not *per se* an explosive, although it is an eminently combustible, material. When ignited, it burns with the greatest rapidity, evolving an immense flame, and producing a very great amount of heat; but there is no more tendency to explosion than when coals, or any other combustible substance, are burning in a furnace. Certain constituents of coal gas require a very high temperature to inflame them; others are readily inflamed at a red heat; but the lowest point at which any one of its constituents may be inflamed must be taken as the index of the point of inflammation of the mixture, and this may be, perhaps, set at a red heat. When coal gas burns in the air, it is, of course, at the expense of the atmospheric oxygen, the process simply consisting in the oxidation of the carbon and hydrogen of the gas; and this action is necessarily confined to the exposed surface. Under such circumstances, the oxidation goes on gradually, and a certain time is required to bring in contact the combustile atoms and the oxygen; we have then burning, but no explosion. To effect complete oxidation, coal gas consumes, or rather combines with, about two and a half times its bulk of oxygen, which are equal to more than twelve times its bulk of atmospheric air. If, however, the required quantity of oxygen, or of air containing the oxygen, be mixed with coal gas before the latter is inflamed, and means of inflaming the gas be then applied, combustion will not progress gradually, as it does when the gas alone is inflamed, but will occur atomically as it were,—that is, each atom of gas finding in its immediate proximity an atom of oxygen, the union between the two will take place throughout the whole volume of the gaseous mixture instantaneously, and a violent explosion will be the result. To produce this explosion, oxygen, in certain proportion, must be mixed with the gas before ignition. In the absence of oxygen, previously so mixed, there can be no explosion.

Sir H. Davy, in his important and interesting experiments upon this subject, found that light carburretted hydrogen, the most powerfully explosive of the gases, required about seven times its bulk of atmospheric air to be mixed with it to produce the greatest explosive effect; practically, it may be calculated that from eight to nine times its bulk of air will produce the most explosive mixture with coal gas: but, as was remarked before, the air and gas must be mixed previously to inflammation. No matter how rapidly the air may be supplied when the gas is burning, it will merely increase the fierceness of the combustion: there will be no explosion. To form an explosive mixture the gas must be present in quantity varying from about 7 to 25 per cent. of volume; if it fall short of or exceed that proportion, it will burn away quietly, and not explode. So it will be perceived that, in the contents of the gas holders, we have to deal with a material which is combustible in the highest degree, but which in itself, even when burning, has no tendency to explode, and which cannot be made to explode excepting by changing its normal state by previous admixture with a foreign gas, viz., oxygen.

There is another property of coal gas which relates to this inquiry, and which it possesses in common with all matter,—that is, expansibility under increased temperature. When a gas is heated, its volume is augmented. For every degree of Fahrenheit's thermometer this augmentation equals $\frac{1}{480}$th part of the bulk of the gas at 32°, so that the volume of a gas being 480 cubic inches at 32°, it would be 481 at 33°, 482 at 34°, and so on. The qualities of coal gas, then, which relate to the question of explosion of gas holders are—combustibility, capability of forming explosive mixtures with oxygen gas or air, and susceptibility of having its bulk or volume increased by rise of temperature. It remains to see how far circumstances arising from the application of heat or flame to the exterior of a gas holder could so affect or modify its contents as to produce explosion, as many persons have seen cause to dread. In the gas holder itself we have an apparatus very well calculated to preserve the gas which it contains from any admixture with the external atmosphere; and, indeed, under all ordinary circumstances, such admixture is impossible. It must be remembered, that the gas holder, formed of strong plate iron, is so arranged that it is only capable of moving vertically, under the guidance of firmly constructed iron rods and pillars, and that, during all its movements, its lower edge remains immersed in a tank of water; were it not so its contents could not be preserved at all, as it must be remembered that gas holders *rise* in consequence of the elastic raising force of the gas which is forced into them, and are not *suspended*. The moment the gas is removed by any means from the holder the latter sinks by virtue of its weight, which operates as a powerful expulsive force, and is, in fact, the only force which sends the gas through the almost endless ramifications of pipes by which it is distributed for public consumption. Are there, then, any conditions in which the gas in the holder could become mixed with a sufficient quantity of air to be rendered explosive; those conditions, of course, being produced by the action of heat applied externally to the holder?

Some years since it happened, at one of the London gas works, that a portion of the upper part of the heavy iron framework which guides the holder became detached, and, falling upon the top or crown of the holder, crashed through, making a large hole in the iron plate. The weight of the holder caused the gas to rush through this opening with great velocity; reaching a light which was burning near, it became ignited, and, as may be supposed, a flame of immense size and force—a sort of gigantic blow-pipe flame—was produced; as the aperture was of considerable size, the whole of the gas was, however, expelled from the holder in a very short time, and no damage was done,—nothing in the remotest degree resembling explosion having occurred. Suppose, during a great fire at a gas works, that, by any means, a gas holder became perforated, the only result would be that just described; and even if the perforation were made in a part of the holder from which the flame might prove a means of extending the conflagration, there would be no danger of explosion, unless, as we have seen before, the gas holder contained a mixture of gas and atmospheric air or oxygen. Is there, then, any probability of such an explosive mixture being produced in a gas holder through the effect of an external fire?

If a gas holder, filled with gas, were exposed to the action of violent flame, it is evident that, in accordance with the law of expansion already explained, the volume of the gas would be rapidly increased. It is scarcely in the nature of things that a large gas holder should be uniformly heated on every side; but, for the sake of illustration, let it be supposed that the whole mass of the gas was raised to 1000°, a very high temperature, about equal to bright-red heat; under these circumstances, the volume of the gas would be nearly tripled, so that from a gas holder capable of containing 3000 cubic feet, nearly two-thirds of the contents would be expelled by mere expansion,—that is, if the holder were at first filled to its full capacity. As the holder cannot rise out of the water of the tank, owing to the iron framework by which it is held, the excess of gas—that is, 2000 cubic feet—would be forced under the edge of the holder, and would bubble up through the water, a thing which not uncommonly happens on a limited scale in gas works when the holders are over-filled: as the gas thus escaped, it would, of course, inflame, and a succession of irregular fierce combustions, so to speak, would be the consequence; but, as the gas could not previously have been mixed with air, there would be no explosion. Now, let us suppose the source of heat to be removed, the fire about the gas holder to be subdued, for example, the contained gas would cool, and, in cooling, would contract to its natural density; this being so, it would only be capable of occupying one-third of the capacity of the holder, which would, of course, descend as the contraction progressed, and the result would be, not that any mixture of air and gas had been produced in it, but that the gas holder would be found less elevated from the tank by two-thirds of the height which it reached when first subjected to the action of the heat. Let us, however, take an extreme case, in which the holder, filled with gas, expanded to three times its normal volume, is suddenly cooled, and in which, from the action of the fire, the guides or pulleys of the holder itself have been so deranged that the holder cannot descend upon the contracted gas; it is obvious that the gas, in cooling, will, as in the former case, be only capable of filling one-third of the holder; the water of the tank cannot rise to fill the vacant space; atmospheric air would therefore pass under the edge of the holder, or blow through the water seal; and very shortly the contents of the holder



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would consist of about one-third of gas and two-thirds of atmospheric air; even then the mixture would not be explosive. Davy's experiments show that, when the gas present in the mixture exceeds from 20 to 25 per cent., it burns quietly, and does not explode; and in the above case, a most unlikely one to occur, the gas is present in the proportion of 33 per cent. If a gas holder became fixed by any means, in the manner spoken of, and by accident the side of the tank were broken down, so that the water flowed away from the holder, the contained gas would be in communication with the atmospheric air; in that case, however, the mixture of the two would be but a slow operation, as, by its superior levity, the gas would continue to occupy the suspended holder until sufficient time had elapsed for diffusion of the gas and air to take place.

If flame were to be brought into contact with the contents of the gas holder shortly after the occurrence of such an accident, which would, of course, happen if the injury to the tank were caused by fire, there would be still no explosion, but burning of the gas from the surface upwards, as in a common lecture table experiment, where combustible gas, contained in an inverted jar, is ignited at its inferior surface, and extinguishes a lighted taper plunged into its mass. As to the gas holder itself being so much damaged by the action of the heat or flame, as to be rendered incapable of containing the gas, such a thing is scarcely possible. It is well known that rivetted sheet iron vessels will bear a lengthened exposure to a red heat before they are so much injured as to become leaky; and if, in the case of the gas holder, the sudden action of powerful flame, striking on its exterior, were so to twist or warp the plates, that the gas could escape, there would be simply combustion of the gas as it issued from the openings, as in the case of the perforated gas holder first discussed.

A little consideration of this subject seems to show, then, that the explosion of a gas holder, from circumstances created by the influence of a conflagration in a gas works is an event, not perhaps beyond the bounds of possibility, but so far removed from anything like probability, that any serious fears in connection with it must be looked upon as entirely groundless. Such an occurrence seems never to have taken place in the whole course of gas-making practice; and if we reflect upon the natural laws which operate in the matter, it is to be presumed that it could scarcely be made to happen under the influence of any external circumstances. It cannot be denied that a conflagration may be increased to a fearful extent by the contents of a gas holder becoming ignited, but it may be safely questioned if, in any case, there is the slightest danger to be apprehended from explosion.—*Newton's London Journal.*

## SCOTTISH SHIPBUILDERS' ASSOCIATION.

### THE PRINCIPLES OF THE NEW MEASUREMENT TONNAGE.

By Mr. J. G. Lawrie.

By the "Merchant Shipping Act, 1854," the measurement of ships for tonnage is made by one of the two following rules; and the tonnage so ascertained is deemed the register tonnage in all ships except those propelled by steam:—

"Throughout the following rules the tonnage deck shall be taken to be the upper deck in ships which have less than three decks, and to be the second deck from below in all other ships; and in carrying such rules into effect all measurements shall be taken in feet and fractions of feet; and all fractions of feet shall be expressed in decimals:

"Rule I.—The tonnage of every ship to be registered, with the exceptions mentioned in the next section, shall, previously to her being registered, be ascertained by the following rule, hereinafter called Rule I.; and the tonnage of every ship to which such rule can be applied, whether she is about to be registered or not, shall be ascertained by the same rule.

"(1.) Measure the length of the ship in a straight line along the upper side of the tonnage deck from the inside of the inner plank (average thickness), at the side of the stem to the inside of the midship stern timber or plank there, as the case may be (average thickness), deducting from this length what is due to the rake of the bow in the thickness of the deck, and what is due to the rake of the stern timber in the thickness of the deck, and also what is due to the rake of the stern timber in one-third of the round of the beam; divide the length so taken into the number of equal parts required by the following table, according to the class in such table to which the ship belongs.

"Table.

"Class 1. Ships of which the tonnage deck is, according to the above measurement, 50 feet long or under, into four equal parts:

"Class 2. Ships of which the tonnage deck is, according to the above measurement, above 50 feet long and not exceeding 120, into six equal parts:

"Class 3. Ships of which the tonnage deck is, according to the above measurement, above 120 feet long and not exceeding 180, into eight equal parts:

"Class 4. Ships of which the tonnage deck is, according to the above measurement, above 180 feet long and not exceeding 225, into ten equal parts:

"Class 5. Ships of which the tonnage deck is, according to the above measurement, above 225 feet long, into twelve equal parts.

"(2.) Then, the hold being first sufficiently cleared to admit of the required depths and breadths being properly taken, find the transverse area of such ship at each point of division of the length as follows:—Measure the depth at each point of division, from a point at a distance of one-third of the round of the beam below such deck, or, in case of a break, below a line stretched in continuation thereof, to the upper side of the floor timber at the inside of the limber strake, after deducting the average thickness of the ceiling which is between the bilge planks and limber strake; then, if the depth at the midship division of the length do not exceed sixteen feet, divide each depth into four equal parts; then measure the inside horizontal breadth at each of the three points of division, and also at the upper and lower points of the depth, extending each measurement to the average thickness of that part of the ceiling which is between the points of measurement; number these breadths from above (*i.e.*, numbering the upper breadth one, and so on down to the lowest breadth); multiply the second and fourth by four, and the third by two; add these products together, and to the sum add the first breadth and the fifth; multiply the quantity thus obtained by one-third of the common interval between the breadths, and the product shall be deemed the transverse area; but if the midship depth exceed sixteen feet, divide each depth into six equal parts instead of four, and measure as before directed the horizontal breadths at the five points of division, and also at the upper and lower points of the depth; number them from above as before; multiply the second, fourth, and sixth by four, and the third and fifth by two; add these products together, and to the sum add the first breadth and the seventh; multiply the quantity thus obtained by one-third of the common interval between the breadths, and the product shall be deemed the transverse area.

"(3.) Having thus ascertained the transverse area at each point of division of the length of the ship as required by the above table, proceed to ascertain the register tonnage of the ship in the following manner:—Number the areas successively 1, 2, 3, &c., No. 1 being at the extreme limit of the length at the bow, and the last No. at the extreme limit of the length at the stern; then, whether the length be divided according to the table into four or twelve parts, as in Classes 1 and 5, or any intermediate number as in Classes 2, 3, and 4, multiply the second and every even numbered area by four, and the third and every odd numbered area (except the first and last) by two; add these products together, and to the sum add the first and last if they yield anything; multiply the quantity thus obtained by one-third of the common interval between the areas, and the product will be the cubical contents of the space under the tonnage deck; divide this product by one hundred, and the quotient being the tonnage under the tonnage deck shall be deemed to be the register tonnage of the ship, subject to the additions and deductions hereinafter mentioned.

"(4.) If there be a break, a poop, or any other permanent closed-in space on the upper deck, available for cargo or stores, or for the berthing or accommodation of passengers or crew, the tonnage of such space shall be ascertained as follows:—Measure the internal mean length of such space in feet, and divide it into two equal parts; measure at the middle of its height three inside breadths, namely, one at each end and the other at the middle of the length; then to the sum of the end breadths add four times the middle breadth, and multiply the whole sum by one-third of the common interval between the breadths; the product will give the mean horizontal area of such space; then measure the mean height, and multiply by it the mean horizontal area; divide the product by one hundred, and the quotient shall be deemed to be the tonnage of such space, and shall be added to the tonnage under the tonnage deck, ascertained as aforesaid, subject to the following provisoes: first, that nothing shall be added for a closed-in space solely appropriated to the berthing of the crew, unless such space exceeds one-twentieth of the remaining tonnage of the ship, and in case of such excess the excess only shall be added; and, secondly, that nothing shall be added in respect of any building erected for the shelter of deck passengers, and approved by the Board of Trade.

"(5.) If the ship has a third deck, commonly called a spar deck, the tonnage of the space between it and the tonnage deck shall be ascertained as follows:—Measure in feet the inside length of the space at the middle of its height from the plank at the side of the stem to the lining on the timbers at the stern, and divide the length into the same number of equal parts into which the length of the tonnage deck is divided as above directed; measure (also at the middle of its height) the inside breadth of

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the space at each of the points of division, also the breadth of the stem and the breadth at the stern; number them successively 1, 2, 3, &c., commencing at the stem; multiply the second and all the other even numbered breadths by four, and the third and all the other odd numbered breadths (except the first and last) by two; to the sum of these products add the first and last breadths; multiply the whole sum by one-third of the common interval between the breadths, and the result will give in superficial feet the mean horizontal area of such space; measure the mean height of such space, and multiply by it the mean horizontal area, and the product will be the cubical contents of the space; divide this product by one hundred, and the quotient shall be deemed to be the tonnage of such space, and shall be added to the other tonnage of the ship ascertained as aforesaid; and if the ship has more than three decks, the tonnage of each space between decks above the tonnage deck shall be severally ascertained in manner above described, and shall be added to the tonnage of the ship ascertained as aforesaid."

"Ships which, requiring to be measured for any purpose other than registry, have cargo on board, and ships which, requiring to be measured for the purpose of registry, cannot be measured by the rule above given, shall be measured by the following rule, hereinafter called Rule II.:—

"(1.) Measure the length on the upper deck from the outside of the outer plank at the stem to the aftside of the stern-post, deducting therefrom the distance between the aftside of the stern-post and the rabbet of the stern-post at the point where the counter plank crosses it; measure also the greatest breadth of the ship to the outside of the outer planking or wales, and then, having first marked on the outside of the ship on both sides thereof the height of the upper deck at the ship's sides, girt the ship at the greatest breadth in a direction perpendicular to the keel from the height so marked on the outside of the ship on the one side to the height so marked on the other side, by passing a chain under the keel; to half the girth thus taken add half the main breadth; square the sum; multiply the result by the length of the ship taken as aforesaid; then multiply this product by the factor ·0017 (seventeen ten-thousandths) in the case of ships built of wood, and by ·0018 (eighteen ten-thousandths) in the case of ships built of iron, and the product shall be deemed the register tonnage of the ship subject to the additions and deductions hereinafter mentioned.

"(2.) If there be a break, a poop, or other closed-in space on the upper deck, the tonnage of such space shall be ascertained by multiplying together the mean length, breadth, and depth of such space, and dividing the product by 100, and the quotient so obtained shall be deemed to be the tonnage of such space, and shall, subject to the deduction for a closed-in space appropriated to the crew as mentioned in Rule I., be added to the tonnage of the ship ascertained as aforesaid."

In ships propelled by steam an allowance or deduction is made from the tonnage, ascertained by these rules, for the space occupied by or on account of the machinery, and the remainder is deemed the register tonnage. This allowance is measured in the following manner, by an order of the Commissioners of Customs, dated 23d October, 1860:—

"In pursuance of the powers granted by the 29th section of the 'Merchant Shipping Act, 1854,' the Board, with the approval of the Board of Trade, direct, with a view to the more accurate and uniform application of the principle of granting a certain allowance to steamers for their propelling power, that in lieu of the rules set forth in the section 23rd of the 'Merchant Shipping Act,' and in paragraphs 4, 5, 6, 18, and 20, of instructions to measuring surveyors of 1865, the following rule be adopted in future, viz.:—

"*Rule.*—In every ship propelled by steam or other power requiring engine room, an allowance of space or tonnage shall be made for the space occupied by the propelling power, and the amount so allowed shall be deducted from the gross tonnage of the ship, and such deduction shall be estimated as follows (that is to say):—

"(1.) Measure the mean length of the engine room between the foremost and aftermost bulkheads or limits of its length, excluding such parts, if any, as are not actually occupied by or required for the proper working of the machinery; then measure the depth of the ship at the middle point of this length, from the ceiling at the limber strake to the upper deck in ships of three decks and under, and to the third deck, or deck above the tonnage deck, in all other ships; also the inside breadth of the ship, clear of sponsing, if any, at the middle of the depth; multiply together these dimensions of length, breadth, and depth for the cubical contents; divide this product by 100, and the quotient shall be deemed to be the tonnage of the engine room, or allowance to be deducted from the gross tonnage on account of the propelling power.

"(2.) In the case of ships having more than three decks the tonnage of the space or spaces betwixt decks, if any, above the third deck, which are framed in for the machinery or for the admission of light and air, found by multiplying together the length, breadth, and depth thereof, and dividing the product by 100, shall be added to the tonnage of such space.

"(3.) In the case of screw steamers the tonnage of the shaft trunk shall be deemed to form part and added to such space, and shall be ascertained by multiplying together the length, breadth, and depth of the trunk, and dividing the product by 100.

"(4.) In any ship in which the machinery may be fitted in separate compartments the tonnage of each such compartment shall be measured severally in like manner according to the above rules, and the sum of their results shall be deemed to be the tonnage of the said space."

Diagrams 1 and 2, page 60, are explanatory of these rules.

These diagrams represent a ship with two decks, the upper one of which is of a length, measured in the manner pointed out in the rules, greater than 180ft., and less than 225ft., and a depth of hold greater than 16ft. By the rules the length of this ship, from 1 to 11, is divided into 10 equal parts, at the points 2, 3, 4, 5, 6, 7, 8, 9, 10. At each of the points of division, and also at the extremities, 1, 11, of the length, sections are made as in diagram No. 2. These sections being of a length 1 to 7, measured as pointed out in the rules, greater than 16ft., are divided into six equal parts, at the points 2, 3, 4, 5, 6, diagram No. 2. The area of each of these cross-sections (Figs. 5 and 6), is calculated, as pointed out in the rules, by adding together the breadth at one, the breadth at 7, twice the breadth at each of the other odd numbers, and four times the breadth at each even number. The sum of these breadths is multiplied by one-third of the distance betwixt the breadths, and the product is the area of the section. Having obtained in this way the area of the cross-sections at the points 1, 2. . . . 11 of diagram No. 1, the cubical internal capacity of the ship is calculated in the same way as the area of the cross-sections, and as follows:—The area at 1, the area at 11, twice the area at each of the other odd numbers, and four times the area at each even number, are added together; and the sum of the areas so obtained being multiplied by one-third of the distance betwixt the areas, the product is deemed the cubical capacity of the ship. The cubical capacity being divided by 100, the quotient is the tonnage of the ship.

Whether the tonnage of a ship so ascertained gives a correct measurement of the internal capacity, depends plainly upon whether the areas at the points 1, 2, . . . . . 11 of the length are correctly measured in the manner pointed out in the rules, and also upon the use made of these areas in the calculation by which the cubical capacity is evolved.

The areas of the sections are calculated upon the principle that each section is composed of six parts, as shown in diagram No. 6, and that the area of each of these component parts, say of the part A B C D, is obtained by adding the breadths A B, C D, to four times the breadth E F, and multiplying the sum by one-third of the distance from A B to E F.

The theorem upon which this mode depends of calculating an area bounded by the three straight lines A B, D C, A D, and the curved line B C, is correct, if the curved line be of a form which possesses certain known characteristics. If the curved line be of the form called by mathematicians a curve of the second order, or a conic section, the area is, as is shown in the note,* correctly calculated in this way; but if the curved line be of any other form, the area is not correctly measured in that way, and the amount of error depends on the form of the curved line, and on the extent to which it differs from a curve of the second order.

The areas of the several cross-section at the points 1, 2, . . . . . 11, measured in this way, are used in the mode of calculation prescribed by the rules, to form a curve of areas, as in diagram No. 3, in which the perpendiculars at the points 1, 2, . . . . . 11 are drawn of a length proportional to the areas of the sections at these points, and the surface of this curve of areas is assumed to be the internal capacity of the ship. The surface of this curve is calculated in the same way as the surfaces of the various cross-sections are calculated. The widths of the curve at the points 1, 11, twice the width of each of the remaining odd numbered widths, and four times the widths of each of the even numbered widths are added together. The sum is multiplied by one-third of the distance betwixt the cross-sections, and the product is deemed the internal capacity. It is plain that this mode of calculation assumes the curve of areas to

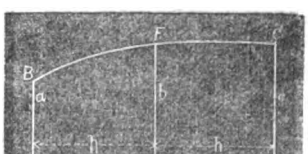
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* If B F C be a curve of the second order, its equation is

$$y = A + B.x + C.x^2,$$

resolving this equation with the values $a, b, c, h$,

$$A = a \quad B = (c - 4b - a)\frac{1}{2h} \quad C = \frac{c + a - 2b}{2h^2}.$$

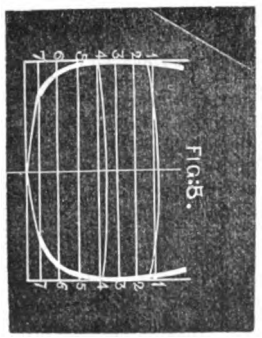



The differential of the area of a curve is $y\,dx$; and therefore the differential of the area of this curve $= y\,dx = A\,dx + B\,x\,dx + C\,x^2\,dx$.

$$\therefore \text{Area of the curve} = \int y\,dx = A\,x + \tfrac{1}{2}B\,x^2 + \tfrac{1}{3}C\,x^3 + C.$$

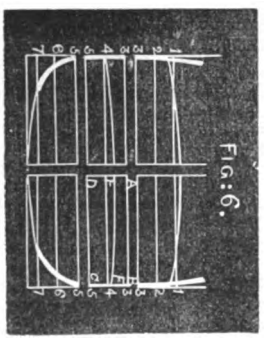
By introducing the values of A, B, C, and putting successively $x = 0$ and $x = 2h$, the area from A B to D C is found to be $= (a + c + 4b) \times \frac{1}{3}h$.

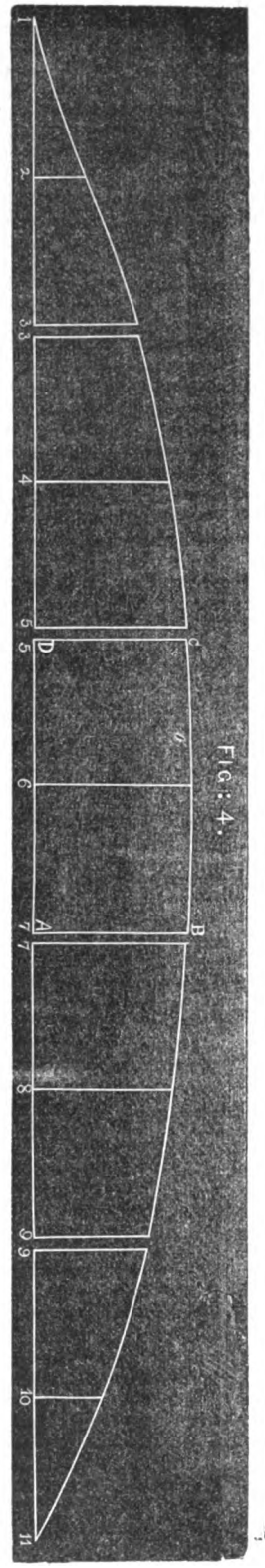
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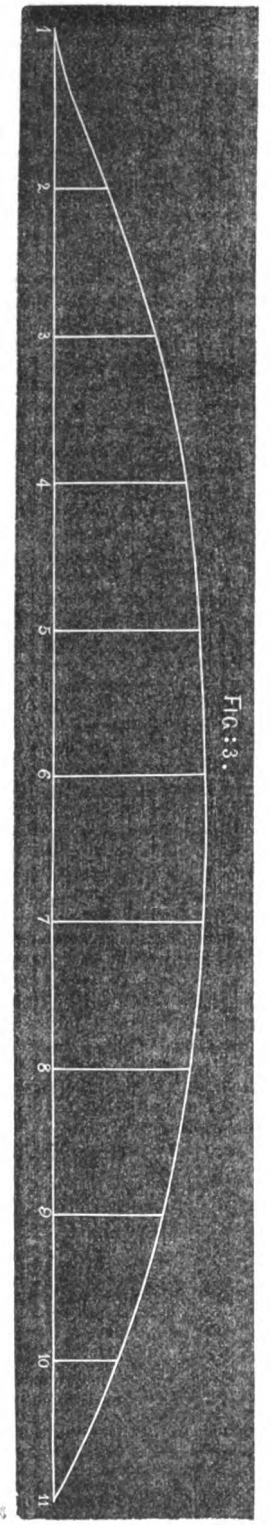


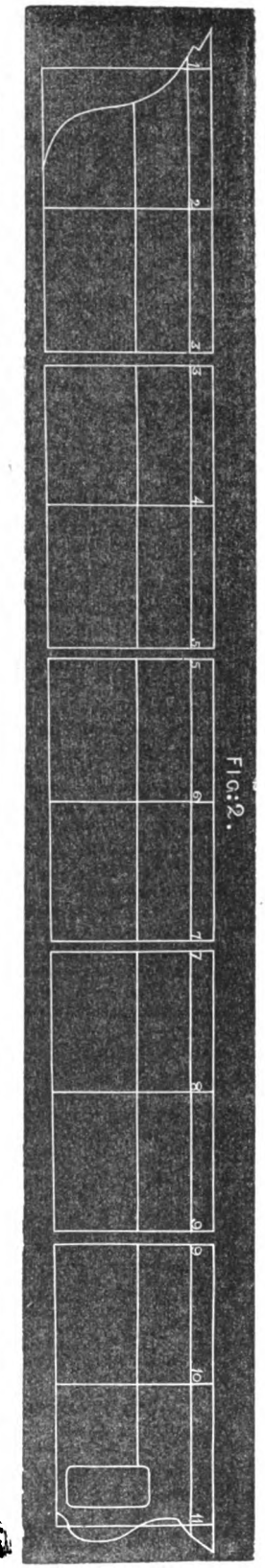

# THE PRINCIPLES OF THE NEW MEASUREMENT TONNAGE.

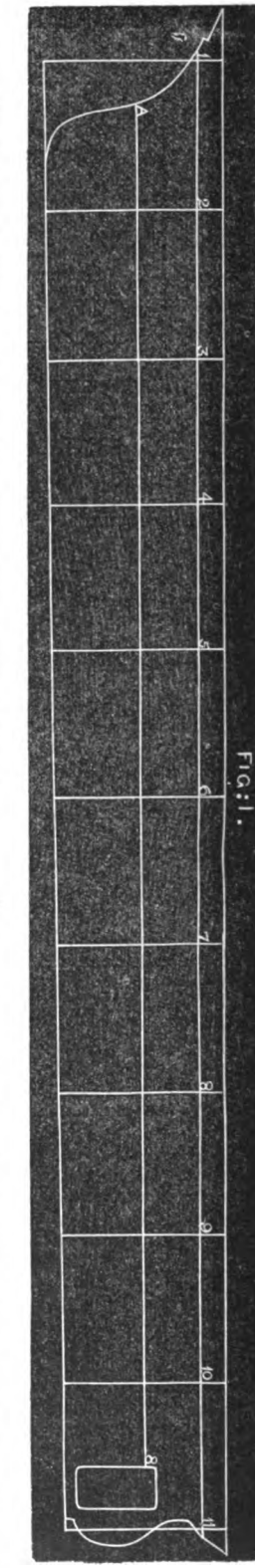
BY MR. J. G. LAWRIE.




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consist of five component parts, as in diagram No. 4, and that the surface of each of these component parts, as, for example, A B C D, is obtained by adding the breadths A B, D C to four times the breadth E F, and multiplying the sum by one-third of the distance from A B to E F. As already stated, the accuracy of this mode of ascertaining the surface of the curve of areas depends upon the form of the curved line B C. If this line be a curve of the second order, the measurement is correct; but if it be a line of any other form, the calculation of measurement so made is incorrect, and the amount of error depends upon the form of the line.

It thus appears that the mode prescribed of calculating the internal capacity of a ship is not necessarily exact, unless the ship be of a particular form—unless it be of such a form that the various cross-sections are conic sections, and also that the line called the curve of areas, relating to that ship, be a curve of the second order. There is, besides, an element of inaccuracy in the calculation of the internal capacity of the ship due to the way in which the measurements are directed to be taken. The length from 1 to 11, in diagram No. 1, is plainly greater to a considerable extent than the body of the ship; and in the case of screw steamers, which have a propeller aperture, is greater to an extent of material importance. In consequence of the excessive length taken, the curve of areas in these ships must always be considerably different, and more particularly at the after end of the ship, from the form, consistent with accuracy in the calculations; at the bow, the fore end of the length taken being at 8, the length is greater than the body of the ship by the amount which the point 1 overhangs the various water-lines; and at the stern, the after end of the length taken being at 11, it extends considerably beyond the greater part of the ship, which terminates at the fore side of the propeller aperture. This error in the mode of taking the measurements would be avoided if the length was taken at half the depth of hold, as on the line A B, diagram No. 1, and calculating separately the capacity of those parts of the ship beyond the extremities of this line, A B, in the same way as the tonnage of quarter-decks, poops, and roundhouses is measured.

To measure, however, the tonnage of a ship in a manner which will afford no inducement to the builder or owner to adopt a form of ship unsuitable for the performance of duty was the material object sought to be attained at the time the existing mode of measurement was established; and that object is, undoubtedly, sufficiently accomplished by the rules adopted. There is occasionally an indefiniteness in the measurement of the width at 7, the floor width of the midship cross-sections, arising from the flatness of the floor. In the writer's opinion it would be more satisfactory than the present mode to make this width a certain proportional part of the width next above it—that is, of the width at 6—leaving the shipbuilder at liberty to form the floor of his ship as he may conceive to be desirable. This would no doubt be not a rigorous mode of measuring the surface of a cross-section; but while absolute accuracy is practically unattainable in such operations, it would be sufficiently near the truth for the purpose, and would be without any element to induce an injudicious form of ship.

At the time the present mode of measuring the tonnage of ships was under discussion considerable diversity of opinion existed on the question, whether the register tonnage of ships should be proportioned to the internal capacity or to the external volume. In the writer's opinion, the proper answer to this question depends materially on the purpose for which ships are measured at all. If ships are measured for the purpose of providing means by which the work they are capable of performing can be compared; and if that work consists in carrying dead weight, the measurement for tonnage should plainly be external. But if the work consists in carrying what is technically called measurement cargo, the measurement should be internal. Whether dead weight or measurement capacity is of greater importance depends somewhat on the trade in which the ship is to be employed; but in the greater number of instances capacity for dead weight is the more important of the two elements. The writer is not aware of a single instance of a contract for building a ship in which measurement capacity has been stipulated for irrespective of dead weight, while many contracts have been made providing for dead weight irrespective of measurement capacity,—showing that in these instances external measurement was of more importance than internal capacity. If ships are measured for the exaction of harbour dues, lights, &c., the measurement should certainly be proportioned to the external volume, considering that the accommodation received in a harbour, and the benefit derived from lights, depend more on the external dimensions of a ship, and particularly on the draft of water, than on the internal capacity. It has been urged that, because iron ships are lighter than those built of timber, and, therefore, with the same external dimensions, capable of carrying greater cargoes, the measurement should be internal, instead of external, so as to deprive iron ships of this advantage, and raise wooden ships more nearly to the level of those of iron; but it appears to the writer that this fact is rather another reason why the measurement of ships should be external—the fact that, with the same external dimensions, there is a difference in the performance of wood and iron ships—in order that the best ship should be known, without reference to the material of which it is built.

A wood ship and an iron ship of 1000 tons, built for 12 years A, measured externally, will have respectively an internal capacity of* 820 tons and 890 tons, and will weigh respectively 820 tons and 690 tons. Thus, with external measurement, an iron ship of 1000 tons will carry † ten per cent. more dead weight than a wood ship of the same tonnage, measured externally, both being loaded to a draft of water leaving three inches of side for each foot in the depth of hold, and will have eight and a half per cent. greater measurement capacity; while with internal measurement, as at present practised, the iron ship will possess the same measurement capacity, and will have only‡ two per cent. greater dead weight capacity.

With internal measurement the iron ship draws less water than a wood ship of the same tonnage, and occupies less harbour accommodation, yet is made to pay the same dues as the larger wood ship drawing more water and requiring greater harbour accommodation; while, with external measurement, ships paying the same dues would draw the same water and occupy the same harbour accommodation. For these reasons the writer is of opinion that external measurement would have been the more equitable; although any change is now manifestly altogether out of the question.

Another question in the measurement of ships has been, whether in measuring steamers an allowance should be made in the exaction of dues for the space occupied by the machinery and fuel. To make a deduction from the tonnage of a steamer on which dues are levied is virtually a protective duty upon the application of steam; and although earlier in the history of that most valuable invention such a protective duty may have been desirable, no reason is now apparent why it should be continued. The object of the dues levied on tonnage is to support harbours, lights, &c.; and if the payments made by one part of the tonnage benefited by these harbours, lights, &c., is reduced, the payments made by the remainder of the tonnage must be so much greater. To reduce therefore, the dues paid by steamers is to increase the dues upon sailing ships; and the writer can see no reason why steam in navigation should be supported on principles now so much out of date, and so foreign to the policy of this country, except it be a reason that in the competition betwixt steam-ships and railways there may be a justifiable policy in giving steam-ships this relaxation.

The question remains, whether on tonnage there should be any allowance whatever to make the register tonnage upon which dues, &c., are levied different from the actual tonnage of a ship. So far as the writer can see, there is, with the exception of the allowance in the tonnage of steam-ships for the competition betwixt steamers and railways, no abstract reason why the register tonnage of a ship should be different from the actual tonnage, unless an allowance is deemed to be desirable to stimulate the sanitary construction of ships in the use of round-houses for the protection of deck passengers, and the adoption of improved accommodation for the crew.

The register tonnage of ships, both steam and sailing, for the purpose of levying dues, &c., may be, and probably ought to be, different from the tonnage used in the application of Lloyd's Rules to define the strength of ships. A ship with a spar deck, for example, or with a house amidships, extending from side to side, is a very different ship in point of strength from one of the same tonnage built with a poop, or quarter deck, or round-house, which does not extend from side to side. It may be that in ships constructed with a poop, quarter deck, or round-house, the tonnage used in the application of Lloyd's Rules should be not the net gross measurement of the ship, but a greater tonnage, in which the poop, quarter deck, or round-house would be taken at a tonnage beyond the exact measurement in a determinate ratio, to compensate for the weakness inherent to a ship so built. The question is, however, beyond the scope of this paper, and need not now be considered.§

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* An iron ship of 1000 tons internal measurement will carry a dead weight cargo of = 1,500 tons, which, added to 775 tons, the weight of the ship, gives a displacement of 2,275 tons. A wood ship of the same internal measurement has a greater displacement in the ratio of 1·319 to 1·221, and has therefore a displacement of 2·473 tons. This displacement, reduced by the weight of the ship, 1000, leaves a dead weight cargo of 1·473 tons, being within two per cent. of the cargo of the iron ship.

† In timber ships the internal capacity is 82 per cent. of the external volume, while in iron ships it is 89 per cent. The weight of timber ships is taken at 20 cwt. per ton of internal capacity, and the weight of iron ships is taken at 15½ cwt.

‡ An iron ship of this size (1000 tons externally and 890 tons internally), and loaded to this draft, will carry 1½ × 890 tons of dead weight = 1335 tons; while a wooden ship of the same external measurement will carry only = 1335 + 690 − 820 = 1,205 tons. The internal capacity is, as already stated in the text, in the ratio of 820 to to 890, in the favour of iron ships.

§ From what has been said it will be apparent that if it be required to build ships capable of carrying the greatest amount of dead weight cargo, the capacity of the ship should be as much as possible under the load draft line. Ships built with poops, quarter decks, or measurable round-houses, cannot carry as much dead weight as ships of the same tonnage built without these measurement spaces. The sheer of ships diminishes the dead weight carrying capacity, and plainly the sides built with a considerable amount of tumble home increases it.

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## ROYAL SCOTTISH SOCIETY OF ARTS.

### NOTICE OF A SIMPLE IMPROVEMENT ON SHIPS' ANCHORS.

By Heriot Currie, Engineer to the Northern Lights steamer *Pharos*.

Much attention has of late been called to the ground tackle of ships, from the appalling wrecks which so frequently occur on our coasts being too often traceable to defective mooring.

While probably little can be done for cables, except making them of the best materials and in the most careful manner, the anchor is susceptible of considerable modifications, and it is now constructed in various ways which the several inventors consider the best for obtaining the strength and bite rendered necessary by the large size of modern ships without unduly increasing its weight and size.

Without attempting to express any opinion on the merits of the various patent anchors which are now more or less commonly to be met with, I may mention that the anchor, with flukes of the form patented by Trotman, and connected with the shank by a pin or joint, has come into very general use; and it is to this anchor, or any other with moveable flukes, that the improvment which I have invented is adapted.

FIG: 1.

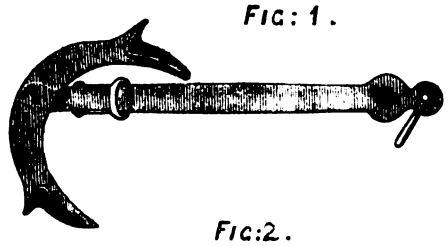


FIG:2.



There appears to be little doubt that the pin or axis on which the flukes turn is the part of the anchor which is most liable to failure, and besides the possibility of its giving way from unperceivable defects in the metal of which it is made, there is also a danger of the cutter, which keeps it in its place, dropping out, or of the end of the pin through which the cutter passes being broken off by its accidentally coming in contract with a projecting point of rock. In either way, the pin would become loose and might work out, either from a varying strain on the cable, or from the vessel swinging to wind or tide. On board the Northern Lights steamer *Pharos* alone, it has happened on two occasions that the shank came home and left the flukes at the bottom, while at another time it was found, when the anchor was brought on board, that the cutter had been lost, and the pin itself had nearly dropped out. On the very day before one of the occasions on which the flukes were lost, the *Pharos* was anchored on a dangerous lee shore, and had the anchor given way then, instead of the very next time of anchoring, the vessel would in all probability have been totally wrecked.

FIG. 3.

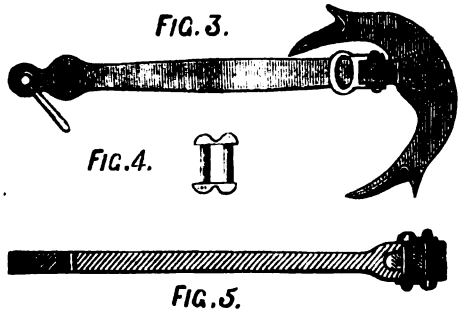


FIG. 4.



FIG. 5.



The improvement which I propose, and which would entail little additional expense, is to have two pins to connect the anchor flukes with the shank—one made as at present, and serving as a centre on which the flukes turn—the other fitting tight in the shank and working in a circular slot in the flukes. The pins, as shown in the drawing, have their heads so formed as to lock each other in, so that should one of the cutters drop out, or should the point of a pin be broken off (an accident much less likley to happen than before, as the rounded head of the one pin protects the point of the other from injury), the damaged pin will still be of service, as it will be prevented from dropping out by the head of the other; while, should one of the pins even give way entirely, the anchor will still be as secure as any of those at present made with flukes moving on one pin.

Fig. 1 is an elevation of anchor with flukes turning on one pin, as at present constructed, part of the shank being shown in section to show the shape of the flukes and the position of the pin.

Fig. 2 is a longitudinal section of the present anchor through the joint.

Fig. 3 is the elevation of anchor of the form I propose, with two pins; the shank partly cut away to show the arrangment.

Fig. 4 shows the pins detached, and with the locking part of the head of each pin forged with a rounded swell, so as more effectually to protect the point of the other. Each cutter in this arrangement passes through the head of one pin and the point of the other.

Fig. 5 is a longitudinal section of the anchor with two pins through the joint, showing the manner in which one pin locks the other.

## INSTITUTION OF CIVIL ENGINEERS.

### ON RAILWAY TELEGRAPHS, AND THE APPLICATION OF ELECTRICITY TO THE SIGALLING AND WORKING OF TRAINS.

By Mr. W. H. Preece, C.E.

In the two papers on "Railway Accidents," by Mr. Brunlees and Captain Galton, read at the Institution during the last session, it was shown that 27 per cent. of the accidents arising from preventible causes were due to a want of the electric telegraph. No mention was then made of accidents attributable to the presence of the telegraph, of which several instances could be cited, and which had even led to an argument being maintained against its utility; but it was contended, experience had proved that, in particular localities, such as the Victoria Station (Pimlico), the New-street Station (Birmingham), the Lickey, and other steep inclines, and long tunnels, its employment was imperative. The author did not, however, advocate the general and indiscriminate adoption of the telegraph, as a primary power, in the working of railways. It was, like many mechanical arrangements, and uncertain agent, and its chief advantage lay in its secondary or auxiliary character, in which capacity it was invaluable.

The Author then proceeded to discuss the various systems that had been introduced in working long tunnels, single lines, steep inclines, drawbridges, and other exceptional cases; alluding incidentally to the supposed superiority of working lines by an interval of space in preference to an interval of time.

The first application was that of Mr. Cooke, the original introducer of the electric telegraph into practical use for railway and commercial purposes. He suggested and established on the Eastern Counties Railway, between Norwich and Yarmouth, in 1844, what was now known as the 'block' system. A line of railway was divided into sections, each having its own telegraph, which regulated the line signals, and prevented the admission of a second train upon the same length of line. For this purpose a needle instrument was employed, which showed the presence of a train upon any particular section. The author pointed out that, by making the out-door signals a representation of the indications of the needle, distant stations could be worked like distant signals; and, consequently, that instead of these signals being confined to distances of about 1000 yards, by the aid of the telegraph the distance could be increased *ad infinitum*. Most railway companies, in working long tunnels, &c., employed simply a single needle speaking instrument, which, by a momentary deflection of the needle on one side, gave 'train in,' and on the other 'train out.' Only these two signals were used on the entry and exit of trains. This plan was condemned as being faulty and inefficient.

Mr. Edwin Clark (M. Inst. C.E.) perfected the scheme of Mr. Cooke, in the system he introduced upon the London and North-Western Railway, which was fully described. The needle instrument was employed, but its indications were made permanent by the use of continuous currents of electricity. It not only showed when the line was clear, and when there was a train on the line, but also the occurrence of an accident This last signal was produced by rupturing wires that descended every alternate pole on the line; but this plan was thought to be dangerous. The London and North-Western Railway Company did not strictly adhere to the 'block' system. They allowed two, three and sometimes four trains to be on the same length at the same time. The 'train on line' signal was only accepted as a caution, and not as a danger signal. This was a partial expedient, which provided a certain amount of safety, but it was not considered sufficient under all circumstances to prevent collision. A somewhat similar, but less complete, system was adopted on the Great Northern Railway; permanent signals were not used, but carefully kept record books were maintained in which all signals were entered.

The advantages and disadvantages of speaking telegraphs in connection with signalling apparatus were considered, and it was maintained that a speaking telegraph should never form a portion of a signalling system, but be a separate and independent agent. The objections to the needle instrument, as regarded its transitory signals, and its liability to reversal, demagnetization, and injury by lightning, as well as its capability of being converted into a conversational medium, were stated to be partially avoided in Mr. Tyer's, and in Mr. Bartholomew's systems. The former was used on the North London and several other lines; the latter on the London, Brighton, and South Coast Railway. Mr. Walker's system of bells, on the South Eastern line, by which an indicator was dispensed with, and dependence placed solely on sound, was mentioned. The French system of M. Regnault, which did not differ essentially from Mr. Clark's—excepting that the "block" was maintained by self-acting mechanism, and not by hand—a questionable alteration—was described. The French "appareils de demande de secours" and the German bell system were deemed to be impracticable in England.

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It was shown that, in all these systems, the two signals, danger and safety, were not sufficiently opposite in their indications to be unmistakeble, and that this was obviated in an instrument invented by Mr. Highton, in 1854, and recently applied on the Great Western line by Mr. Spagnoletti. Written words were given in place of the deflection of a needle. Moreover, the signals in all these systems were so dissimilar to those used out of doors, that the signalman had to master and to retain on their mind two systems, the one line signals, to regulate the trains, the other electric signals, to regulate those of the line. The author then proceeded to describe how he had assimilated, on the London and South Western railway, the electric to the line signals. The instrument used by him was an exact counterpart, on a small scale, of the signals employed on the line, whether semaphore, disc, or otherwise, and it was worked in a precisely similar manner. The electric signal was simply a distant signal; and it was contended that, if a system of signalling was found sufficient to work the trains by manual power, the same system must be equally efficient when manipulated by electrical agency.

The North-Western, Mr. Tyer's, and the South-Western systems—as embracing the principle of all those in use—were compared and their relative superiority discussed. It was argued, that, while the North-Western and the South-Western systems met nearly all the conditions laid down, Mr. Tyer's system failed to do so, and, under some circumstances, had been proved to be objectionable.

Various self-acting arrangements for communicating between two trains, or a train and a station, or signals and an engine, or signals and a station, &c., were alluded to, and their impracticability shown.

The danger of using the telegraph as a medium of converstion, without carefully writing down everything sent and received, and the necessity of repeating every important message, were adverted to. The use of record books, as a check upon the telegraph, was also advised.

The method of working single lines by telegraph was then discussed. This could be done in two ways, either in a primary manner, by means of a signalling apparatus, or in a secondary manner, to give notice of the delay of trains, to hurry on one train, to stop another, to alter the authorised passing places, and to prevent the unpunctuality of one train affecting all the rest. The system in use on the London and South Western line, and in America, in which the latter plan was employed, was descrided. It was argued that single lines, properly worked, would be sufficient to meet a great portion of the traffic of this country; and that large sums of money had been uselessly expended, in consequence of Parliament compelling railway companies to make double lines, where a single line would have been ample for the requirements of the district. This had been owing to the absence of a reliable signalling apparatus, and the want of confidence in, or knowledge of, the telegraph by railway managers. With a well-managed speaking telegraph to regulate the trains, and a reliable signalling apparatus to regulate the signals, safety and regularity were assured; and single lines might be worked as securely and as rapidly as double lines.

The low estimation in which the telegraph was held, and the little consideration it received on the part of railway officials, were regretted; and while it was admitted that where indiscriminately used, the telegraph might become a positive source of danger, yet when carefully applied it would be found to be the greatest element of security.

## ON THE WOODS USED FOR SLEEPERS ON THE MADRAS RAILWAY.

By Mr. Bryce McMaster, M. Inst. C.E.

The native wood sleepers having hitherto been found for the most part to fail,—on the Madras Railway between 30 and 40 per cent, requiring to be renewed annually,—the Author undertook an investigation with a view of ascertaining the causes of this deterioration, and whether those causes could be overcome, so as to render available the vast resources of India. Thirteen hundred sleepers, of sixteen different woods, were submitted to careful examination and scrutiny twice at an interval of twelve months. The sleepers were variously placed, both on embankments and in cuttings; in some cases they were entirely covered with ballast to a depth of 4 inches, while in others they were as much as possible uncovered, and completely so from the rails to the ends, the ballast being only raised 2 inches in the middle of the way, and sloped off so as to carry away the water under the rails. From these observations it appeared, that only five woods,—Chella Woonjay, Eloopay, Kurrah Murdah, Palay, and Karavalum,—were sound at the end of two years, the other eleven not lasting even that time. Also, that when the sleepers were uncovered, decay was less rapid than when they were buried in the ballast. The plan of leaving the sleepers partially uncovered had many advantages; it effected a saving in the ballast, allowed the defects to be more quickly detected, and kept the sleepers drier. It had been urged, that the heat of the sun would split the sleepers, and cause the keys and trenails to shrink; but from experience the Author was enabled to state that, while amongst the "uncovered" sleepers there was a larger proportion "beginning to split," or "useless from being split," there was, on the other hand, amongst the "covered" sleepers, a still larger proportion "beginning to rot," or "useless from being rotten.' It was also noticed, that of the sleepers "beginning to rot," 19 per cent. had commenced under one or both chairs. This was due to the retention of moisture under them, and might be remedied, the Author believed, by tarring the seats of the chairs. As regarded the trenails, where the sleepers were rotten, the trenails were invariably found to be in the same state; while when the heads were exposed to the sun, he never found them loosened by shrinking. Another objection was, that the road would be more liable to buckle and twist, but this was not found to be the case on the 40 miles of line, thus ballasted and opened for traffic, on the division under his charge. Trenails made in India cost £2 10*s.* to £4 per thousand, and the woods generally used for the purpose were Vengay, Kurrah Murdah, Erool, Porasa or satinwood, and Trincomalee. The three woods first-named were also extensively employed for keys, which were considerably larger than usual; but Teak keys seemed to be the best, and their cost did not exceed £6 per thousand. From personal observation and enquiry, the Author thought the following woods would make really good sleepers, to be used plain:—Teak, Saul, Sissoo Pedowk, Kurrah Murdah, Aucha, Vengay, Chella Woonjay, Erool, Karavalum, Dud Eloopay, and Paulay.

The sleepers which had failed on the Madras Railway might be divided into two classes—those which were originally of perishable woods, and were therefore unfit for the purpose, and those which, although of good woods, had been cut from young trees, and not been allowed to stand till old enough. The first arose from want of experience in Indian woods, the second to the absence of a proper system of working the jungles. The conditions under which the sleepers were supplied to the Railway Company, either through native contractors possessed of capital, or by purchase direct from the wood-cutters or others, having been found to fail, the Author suggested that in future the Company should send their own agents, with sufficient establishments, into the jungles to cut down the wood, that the wood-cutters should be furnished with proper appliances, and their operations be carefully superintended. This was done in one or two instances on the Madras Railway, with great success. In particular from the Palghaut Jungles, Mr. Ross, one of the resident engineers, was able to furnish sleepers for nearly eight districts, while on other portions of the line the supply required for one district of 25 miles could only be obtained from a great variety of sources. But as the Indian Jungles abounded in woods of too perishable a nature to allow of their being used plain, the Author recommended that the sleepers should be creosoted on a much larger scale than had yet been attempted in that country, and those so preserved which had been sent from England, answered admirably. The process had not yet been fairly tried in India, as only Saul, Teak, Soondry, Sissoo, and other hard close-grained woods had been submitted to it; while the cheaper, more easily procured, lighter and more open-grained woods had been neglected. English creosoted sleepers, led, say, 100 miles by rail and 50 miles by road, cost 9*s.* 6*d.* each; while good, native wood, plain sleepers delivered at the works averaged 6*s.* each. If establishments and apparatus for creosoting were erected in convenient positions near to each extensive jungle, it was believed sleepers of common wood might be procured for 4*s.* 6*d.* each, and be creosoted for about 1*s.* each.

In proof that the resources of India were likely to be equal to the demand, reference was made to the Report of the Conservator of Forests for the official year 1859-60. From this it appeared that from the Salem Jungle alone—one probably of twenty in the Madras Presidency—about 246,000 sleepers, or sufficient for 133 miles of railway, had been cut during that year. Of this number about 62 per cent. could not be used plain, and were practically useless, owing to the want of artificial means for preserving those of a perishable nature. But as a supply from each jungle of 2000 sleepers per month would provide for the construction of 500 miles of railway in that Presidency within the next five years, and for a renewal of 33 per cent. of those already laid, it might be confidently anticipated that the supply would not fail, if means were taken to make the naturally perishable sleepers last a reasonable time.

In conclusion, the Author recommended that a fair trial on a new footing be made with the native wood sleepers; that all woods now known, or hereafter found to be good, be used plain, and that others be avoided; that proper care be taken in the selection, felling, and seasoning of the timber; that the sleepers be tarred under the seats of the chairs, and that they be laid in dry ballast, raised slightly in the middle, and sloped off so as to throw the water under the rails.

## MANCHESTER LITERARY AND PHILOSOHPICAL SOCIETY.

### ON THE BURNLEY COAL FIELD.

Mr. T. T. Wilkinson, F.R.A.S., said that, in the paper upon this subject, prepared by Mr. Joseph Whitaker, of Burnley, and himself, and read before the Geological Section of the British Association, at Manchester, they gave a sketch of the principal mines in this district, but they purposely omitted all mention of those whose thickness did not exceed one foot. There are, however, one or two of these thinner mines which may hereafter become worthy of notice, and hence he offered the present note as an addition to Mr. Hull's valuable synopsis in pp. 133–4 of his *Coal Fields of Great Britain.*

Section of Strata near Worsthorne, Burnley.

| | feet. |
|---|---|
| Strata composed principally of blue clay, followed by light metals | 102 |
| 1.—Coal, the "China Bed" | 2 |
| Strata, consisting chiefly of grey rag and metal | 39 |
| 2.—Coal, the bed not named, and overlaid by about three inches of cannel, together | 1½ |
| Strata, composed mainly of dark rag and metal seating | 73 |
| 3.—Coal, the "Danby Bed" | 2¾ |
| Strata, consisting of rag, light blue rock, metals, and black shales | 126 |
| 4.—Coal, the Arrey, or Habergham mine | 4½ |

The bed (2) is the one which has been hitherto omitted; and; if of no other value at present, it may be useful for co-ordination and identification with the seams of coal in other localities.

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## ON THE NEW RED SANDSTONE AND PERMIAN FORMATIONS AS SOURCES OF WATER SUPPLY FOR TOWNS.

By Edward Hull, B.A., F.G.S.

The paper commenced by pointing to the advantage enjoyed by most of the large towns of the central counties from their geological position, when built on the new red sandstone. First, from being in proximity to coal; second, from having a dry foundation; third, from having easy access to building stone; and fourth, from the fact of their resting upon natural reservoirs of water stored up in the sandstone itself. The Author considered that many of these towns had not taken full advantage of this last-named source of water supply, partly from a distrust of the resources of the rock, and partly from the failure sometimes sustained in consequence of the positions for the wells having been selected without a proper regard to the geological structure of the country.

The excellence of the new red sandstone and the lower permian sandstone as sources of water supply, was shown to depend upon three qualities. I. Their porousness; Homogenity, or uniformity of structure and composition; 3. Filtering powers. Each of these were treated of in detail, and with examples from several wells in Lancashire and Cheshire. The Author then referred to the failure of the attempts to obtain fresh water at Rugby, and a sufficient supply at Wolverhampton; and he maintained that an abundant supply might have been found at the latter town had the position for the well been selected with due regard to the geological structure of the country.

The Author then proceeded to lay down certain rules of general application for the selection of proper sites for wells, and illustrated the subject by reference to a well now being sunk under his direction at Whitmore, for the supply of the railway works and town of Crewe. The position of the well is in a trough, both geographically and typographically, and on a four-inch bore hole being sunk to a depth of 148ft. the water ascended to the surface with a head of four feet, and has continued to flow without diminution for the last six months. The well, which is being made within 100 yards of the bore hole, has only reached a depth of 60ft., but already yields 250,000 gallons per day.

In conclusion, the Author expressed his conviction that the question of water supply from the strata was becoming every day more a geological one, just as was the discovery of coal beneath the formations which overlie the coal-measures.

## NOTICE OF A COMPRESSING AIR PUMP.

By Dr. J. P. Joule.

The Author referred to the difficulties of realising in practice the theoretical advantages of the air, or the superheated steam engine. The abrasion which takes place when metal rubs against metal, without an intermediate lubricator, speedily destroys the cylinder. He believed that the necessity of using elastic packing would not exist if the length of the channel along which the elastic fluid must pass, in order to arrive at the opposite side of the cylinder, were sufficiently increased. This might be accomplished by increasing the depth of the piston, or by placing on the rim of the piston concentric rings to enter, at the beginning and end of each stroke, corresponding concentric grooves in the covers of the cylinder.

The principle of great depth of piston, as a substitute for packing, had been successfully carried out in the pump which was the subject of this communication. The cylinders, two in number, are twenty inches long and two inches in diameter. The pistons are solid cylinders of iron, ten inches long, fitting as accurately to the cylinders as is consistent with freedom of motion. The depth of each piston, as compared with its diameter, renders the usual guide or parallel motion unnecessary, so that the connecting rod is simply jointed to the top of the piston. Air is readily compressed to sixteen atmospheres, the quantity passing the sides of the cylinders being very trifling.

## ON SWELL OBSERVED AT SEA, PARTICULARLY IN THE REGIONS OF THE SOUTH-EAST TRADE WIND.

By Mr. Thos. Heelis.

The Author, after examining the causes of swell and giving instances and especially alluding to the rollers at Ascension, St. Helena, and Tristan d'Acunba, gave some instances of the observed succession and order of the undulations in altitude and of the speed of translation of the crests, which in one instance he had found to attain twenty-two miles per hour; and after setting forth a table of different instances of swell, chiefly in the Atlantic and Indian Oceans, and Bay of Bengal, addressed himself to the consideration of the swell which is frequently observed in tropical latitudes in the southern hemisphere to roll up from the southward. This he attributed to the action of currents setting especially in the Indian Ocean from the neighbourhood of the southern tropic, towards the great connecting current which extends from the Cape of Good Hope to Australia. The Author gave instances of these currents experienced in

| | | | | | |
|---|---|---|---|---|---|
| 30°47′ S. | 79°10′ E. | running south | 27 | miles in | 24 hours. |
| 28°22′ S. | 81°13′ E. | „ | „ 27 | „ | „ |
| 26°42′ S. | 81°45′ E. | „ | „ 23 | „ | „ |
| 23°38′ S. | 83°10′ E. | „ S. 50° E. | 42 | „ | „ |

And called attention to the difference between them as actually experienced, and the set of the water as laid down upon general current charts, the peculiar circulation which they shewed to exist at times in the Indian Ocean, and the meteorological disturbances which the causes which set such currents in motion cannot fail to originate.

## NOTES ON THE INTRODUCTION OF STEAM NAVIGATION.

By Mr. Dyer.

Mr. Dyer stated that this subject, being of great importance, had engaged many able pens in tracing the origin of the several inventions and experiments that preceded the final triumph of steam power over that of wind for navigating ships; each writer claiming the honour of priority for his own country. It may be useful to state the order in which, and the parties by whom the principal attempts were made to realise that object. Several letters lately appeared in the *Times*, and were thence transferred to the pages of the *Engineer*, giving a graphic account of the "first steamer in English waters," the "*Margery*, built at Dumbarton, by the late William Denny, for William Anderson, of Glasgow, and passed through the canal to the Forth and thence to the Thames, where she arrived on the 23rd January, 1815." On the authority of Mr. Anderson, then, this date is fixed when the first steamboat was seen on English waters. The first steamboat, the *Claremont*, was started as a regular packet on the Hudson River, in the spring of 1807; so that the first steamer seen on the American waters was fifty-five years ago, a lapse of time that should now insure a calm view of the steps that led to this first actual success in steam navigation. It will be shown that, by a long course of persevering labours, the honor of that success must be conceded to Robert Fulton, by whom it was achieved.

Whilst admitting the merits of other ingenious men long engaged in the same pursuit, it is clearly proved that, either from good fortune, or by the exercise of superior judgment and skill, the race was won by 8 years' priority of steam navigation, by Fulton, on the Hudson River.

In 1793, Mr. Fulton sent his plan for a steamboat to Lord Stanhope, who approved of, and thanked him for the communication. Shortly after, Fulton went to Paris, and made experiments on the French waters, with the chain floats, the duck's-foot paddles, the screw or smoke-jack propellers, and with the paddle wheels, to which latter he gave the preference, and constructed a boat with them in 1803, which was the model adopted in building the *Claremont*, in 1806.

Mr. Dyer had sailed in the *Claremont*, and remembers the sensation created by her appearance, and the high admiration bestowed on the author of so great an enterprise. That sensation in 1807 was precisely the same as the *Margery* created among the vessels on the Thames in 1815.

All attempts at steam navigation were fruitless before the invention of Mr. Watt's steam-engine, his engine being the first that could be usefully applied to rotative machines on land, and therefore for propelling ships. The principal claims put forth by other inventors of steamboats, are the following:—

In France, the Marquis de Jauffroy constructed a steamboat at Lyons, in 1782, "with paddle wheels," but that this boat did not succeed is obvious, because she was not heard of until 1816, when the first Fulton boat was started to run on the Seine.

In 1783, Daniel Bernoulli proposed a plan which consisted of forcing water throug a tube, out of the stern of the boat. This scheme has been tried many times since, but fails on account of the defective principle of applying the force. Endless chains, with float propellers, have been many times tried and have failed on the same ground,

In 1795, Lord Stanhope made experiments with a boat on the Thames, using the reciprocating or "duck's foot" paddles, which also failed, from the loss of time and power by the return stroke.

In 1785, James Rumsey, of Virginia, tried a boat on the Potomac, and afterwards in London, both without success; and about the same time Mr. Fitch, of Philadelphia, tried one with paddle wheels, on the Delaware, but this boat also did not succeed and was given up as a failure. J. C. Stephens, of New York, made experiments in 1804, with a "boat 25ft, long and 5ft. wide," which of course did no good, and was stopped as a failure, though again brought to notice as preceding Mr. Fulton's.

In 1788 and 1789, William Symington, in conjunction with Patrick Millar and James Taylor, made experiments with their patents for navigating by steam, and in 1802 commenced running a boat on the canal at Glasgow which made three miles an hour, but after many changes of propellers and trials, the scheme was given up, and no more was heard of the steamboat of Mr. Symington until long after those of Fulton were widely spread over the American waters.

In 1816, the Marquis de Jauffroy complained that the Fulton steamboat on the Seine had taken the "paddle wheels" invented by him and used at Lyons thirty-four years before, but also abandoned by him. To this charge Mons. Royou replied in the *Journal des Debats*, thus:—"It is not concerning an invention, but the means of applying a power already known. Fulton never pretended to be an inventor in regard to steamboats in any other sense. The application of steam to navigation had been thought of by all artists, but the means of applying it were wanting, and Fulton furnished them."

The first ocean steamer was the *Fulton*, of 327 tons, built in 1813, and the first steamer for harbour defence was built under Fulton's direction, 2470 tons, launched in 1814. This became the model ship for the iron-clad batteries and rams since constructed with many changes. It will be seen by the drawings of Fulton's plans, that he had tried the several other kinds of propellers—the chain float, duck's foot, and the screw fan—before adopting the paddle wheel, for though the screw was good in principle, it was many years before it could be constructed to act efficiently. The *James Watt* was the first boat with the screw running between London and Havre, about ten years after the advent of the *Margery*.

In 1811 I endeavoured to introduce steam navigation into England, but I found a strong conviction that it would not answer in this country, our most eminent engineers saying, "We don't doubt the success of steam-boats in the wide rivers and harbours of America, but in our comparatively small rivers and crowded harbours they will never answer." Even such scientific engineers as the late John Rennie, sen., and Peter Ewart, a Vice-President of this Society, both advised me to relinquish the attempt to introduce steamboats, as sure to prove a waste of time and money to no purpose. However, when conviction came over the

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public mind that steam navigation would answer here—but not until after more than 5000 tons of steamboats had been launched on the Hudson in 1816, did it so come—then began the spread of steam navigation, since extended with such marvellous rapidity and perfection as to atone for the sluggish beginning. Since nations are indebted to the genius of Watt for success in using steam power, to that of Fulton for its successful application to navigation, to Stephenson for the like success on railways, the meed of praise due to each of their names should be cheerfully awarded by all who are so largely benefited by the result of tneir labours. In doing this we should bear in mind, that inventions do not spring into existence perfect from their birth, like Pallas from the brain of Jupiter, but they come from the prior labours of many brains, and he is the true inventor who first collects the essence of and gives the stamp of vitality to those labours. In this sense the invention of steam navigation will for ever illustrate the name of Robert Fulton.

## ROYAL GEOGRAPHICAL SOCIETY.

### ON OCEAN CURRENTS ON THE NORTH-EAST COAST OF SOUTH AMERICA.

By J. A. MANN, F.R.G.S.

The object of the paper was to present an account of the voyage, in July and August, 1862, of the *Monte Cristo* from Cayenne, in Guiana, to Paranahiba, in Brazil, in which some extraordinary phenomena connected with the Guiana current were experienced. The popular idea is that this current always runs in a north-west direction, at a rate varying from one to four knots per hour; but in this voyage of the *Monte Cristo* it was found that the current was entirely reversed, running at a rate of 4¾ knots per hour—a circumstance which, if proved, would upset the received ideas not only on the subject of this particular current, but of the entire ocean streams. Much evidence was adduced, and well authenticated, to prove the phenomena described, and although, as Mr. Mann stated, he was not able to secure as satisfactory observations as he could wish, it seemed that there was no good reason to doubt its existence.

Captain Maury (formerly of the U.S. navy, but now a well-known Secessionist,) remarked that when he was at Bermuda, on his way to England from South Carolina, he met some officers of her Majesty's Navy who had been on the North American station several years, and they told him that on the passage from Halifax to Bermuda, they found the Gulf Stream actually running to the southward and westward, and that they observed precisely the same condition of the current on their return to Halifax. It showed that there were exceptional cases, of which the one detailed by Mr. Mann was an instance which was well known to all Brazilian navigators. Mr. Capello, of the Meteorological Observatory at Lisbon, had established the existence of a well-marked current on the north of the Equator setting to the east, and of an equally well-marked current just to the south of the Equator setting to the west. He had also found that a little to the south of the De Verd Islands, taking the form of an ellipse, there is a region in which the north-east trade-winds blow with the greatest force; and, in like manner, he had found in the neighbourhood of St. Helena towards Cape St. Roque, a region where the south-west trade-winds blow with the greatest force. If, therefore, there were so many exceptions with the winds, which have so much to do with currents, we might well find exceptions in the currents themselves.

### ON THE QUESTION OF A SURVEY OF THE PHYSICAL CONDITION OF THE ATLANTIC, PRELIMINARY TO THE LAYING DOWN OF ANOTHER ELECTRIC CABLE CONNECTING EUROPE WITH NORTH AMERICA.

By DR. G. C. WALLICH.

The author began by pointing out that both the amount and kind of information we now possessed regarding the deep-sea bed of the Atlantic were altogether inadequate to meet the requirements of oceanic telegraphy. Referring in proof of this to the line of soundings taken by Captain Dayman, in 1857, on board her Majesty's ship *Cyclops*, he observed that these, though as perfect as circumstances then allowed, furnished data necessarily incomplete; inasmuch as only 41 soundings were taken at depths exceeding 250 fathoms, across an area of 1300 miles of ocean, leaving a mean interval of 32 miles between each two soundings. Having assigned his reasons for disbelieving that the entire central basin of the Atlantic is, as many have supposed, a vast plateau unbroken by alternations of level as great as those existing on land, he observed that in the intervals between the previous measurements of the depth of the ocean-bed, some of the largest mountain ranges might very well be included—a matter obviously most important, as bearing upon the safe laying of a telegraphic cable. True, no such submarine slopes had hitherto been detected in the mid-Atlantic, but the data on which it was assumed that they did not exist there were, he maintained, purely arbitrary. A sounding of 100 fathoms had been taken by Lieutenant Sainthill, R.N., within about 32 miles of one of 3000 fathoms, taken by Captain Dayman. Dr. Wallich then enumerated the various kinds of observations that he thought essential to a trustworthy telegraphic survey, among which was a method of probing the deposits of the sea-bed, with a view to determine their geological character. He exhibited an ingenious instrument, designed by him to effect this object, besides other new apparatus for raising specimens of water from any desired depth, and for gauging the pressure at all depths. Passing to the means requisite for carrying out his survey, Dr. Wallich recommended that the Government should equip two steamships for the work; the great novelty of his plan consisting in the two vessels sailing in parallel courses, removed only 2 miles from each other, and the soundings being taken alternately on each line of the longitudinal belt thus defined. While, therefore, there would be an interval of 5 miles at the utmost between any two soundings on the same line (that was, taken by the same ship,) there would be an interval of only 2½ miles between those on alternate lines. Having indicated how a minuter inspection of doubtful or dangerous areas might easily be effected, he suggested that Captain Dayman's line of soundings should form, as it were, the base of operations, and be taken as the centre of the 2-mile longitudinal belt which he proposed to have surveyed. The entire work might, he thought, be finished in five or six months. Summing up the advantages of his plan, he remarked that it would furnish no less than 640 reliable observations, extending across the entire deep water of the Atlantic, and affording a basis upon which its old sea-bed might ultimately be mapped out. In conclusion, he said the task was unquestionably arduous. Its execution might prove costly and tedious. But there it was, staring us in the face—a task which we must either manfully grapple with and master, or leave unfulfilled to our successors the accomplishment of the grandest international project that human sagacity had heretofore suggested.

Sir R. Murchison reminded the meeting that Dr. Wallich accompanied Sir Leopold M'Clintock in his North Atlantic explorations, and had since published a valuable work on the natural history part of the exploration. In his elaborate paper he had thrown some light on the nature of the animals existing at the bottom of the sea, and on the varieties of soils, and even subsoils, that were to be found there; for with the ingenious apparatus which he had explained, he was able not only to tap the soft strata, but even to bore into the solid rock. The survey which he proposed was a preliminary one, and essential before any attempts were made to lay down a telegraph cable across the Atlantic. At all events, whether any adventurous persons chose to undertake that preliminary survey, it became us, as a great maritime nation, to ascertain as accurately as possible the condition of the bed of the ocean between England and America, with the view to telegraphic communication being established.

Sir Edward Belcher, R.N., as the senior surveying officer present, thought it his duty to answer some portion of the paper. Such a project as Dr. Wallich proposed would answer very well across the Irish Channel; but from his experience in searching for shoals even within 100 yards of his own ship, for six weeks and fourteen hours a day, he knew the difficulty of finding a rock, not much larger even than the President's chair. Any such survey, therefore, would cost an immense sum of money, would incur more labour than the men would like and would be attended with innumerable difficulties, which would render the carrying out of such a project absolutely impossible. For a telegraph cable, it was not the deepest water that was wanted, but a line of bottom which would give mud and avoid mountains: nor did he think many scientific men were of opinion that it was desirable to carry a cable straight across the Atlantic. If they carried the line from the Hebrides or the Orkneys to the Faroe Islands, and so on in that direction, a simple mode of being sure of what they were about would be secured: they would know, with such small lines, positively what bottom the cable would lie upon. To carry a cable from point to point might be done at a small expense, and in that way they could feel their way across the ocean. With reference to the apparatus explained by Dr. Wallich for sounding the bottom of the ocean, he might state that in the soundings which he carried on in 1835 and 1836 a very accurate instrument was used, not only for sounding, but also for determining the temperature at different depths and bringing up the water. He explained the construction of that instrument, and stated that it was in use for a period of twelve years without the slightest derangement of even the delicate thermometers that were attached to it. He thought, before the Government was moved to incur the cost and labour of carrying a line of soundings across the Atlantic, the opinions of scientific men should be taken as to whether it would not be better to have several stations for the cable, instead of one long line.

Admiral Elliott doubted whether the survey proposed by Dr. Wallich would render them any wiser with regard to the laying down of the Atlantic cable, because it was impossible to thread their way across the ocean in the way Dr. Wallich supposed, and avoid mountains and hollows that might be found to exist. Nor did he think such a method of sounding practicable; and to keep the laying of the cable in abeyance till it was accomplished would be inexpedient.

Professor Tyndall said, as far as the physical objects indicated in the paper were concerned, he did not think they were of sufficient importance to justify any great outlay. He confessed he had arrived at a conclusion somewhat in accordance with that of Sir Edward Belcher and Admiral Elliott. Even if Dr. Wallich's survey were carried out, it could not, with five miles intervals, give an accurate view of the bed of the ocean; knowing what we did of the variations that occur within five miles on the earth's surface, how easily such a projection as that of the Matterhorn might be missed.

Captain Selwyn, R.N., said the diagrams of soundings taken by Captain Dayman, R.N., not having been thoroughly understood, had given rise to the supposition that there was a precipice off the shores of Iceland. He had been engaged, in company with an officer of the Admiralty, to measure the exact distance between the soundings and the depths, and they ascertained that the fall on the bank in question was not greater than that of Holborn Hill. No one would imagine that a cable would be injured by such a descent as that, nor that there were precipices so abrupt as to hold the cable on the stretch between them. Again, it was utterly impossible to find out whether abrasion would be caused, and it would be combating with theoretical difficulties to delay laying the cable until the exact character of the bed of the ocean between England and America had been thoroughly determined. With respect to the best route, he could suggest a shorter one by 300 miles, by taking the cable to the Flemish Banks, 300 miles this side of Newfoundland, where the depth varied from 30 to 200 fathoms. He also thought that the proper method of survey would be to adopt the system of triangulation.

Mr. Webster argued that the laying of the cable would of itself enable us to obtain a knowledge of the bed of the ocean much more effectually than by any survey.

Dr. Wallich briefly replied, defending his plan from the objections that had been urged against it, and adducing further reasons against the adoption of the counter telegraph-route suggested by Sir E. Belcher.



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## REVIEWS AND NOTICES OF NEW BOOKS.

*The Year Book of Facts in Science and Art, &c.* By John Timbs, F.S.A. London: Lockwood and Co., Stationers' Hall Court, 1863.

This Annual, always highly interesting, appears to us to possess this year a larger collection of interesting scientific jottings than any of its predecessors. The steel engraving of Sir Charles Lyell, D.C.L., is a life-like portrait of the illustrious Savan.

[We are reluctantly obliged at the last moment to omit several notices of books. Editor of The Artizan.]

## NOTICES TO CORRESPONDENTS.

X.X.—The specimen of pig iron is of good quality, but it is evident that it would be improved by mixing with a good Staffordshire brand.

Hydraulic (Brazil).—Write to Mr. R. Roberts, C.E., of Adam-street, Adelphi, London, or send your name and address here, and we will obtain the information.

Alexis.—We must, under the circumstances, decline to recommend any one.

D., S., & P.—Address the Secretary of the Admiralty, Whitehall, London. You are all too young.

Superheater.—1. Do not waste your money on the idea. It has already been patented four or five times. 2. How's Salinometer is, we believe, the best. 3. It is Messrs. Lamb and Summers (of Southampton) to which your third question refers. 4. Declined.

S.—"Swedish piston." We do not know of any locomotive piston known by this name. The buckets or Swedish pumps for mining and other purposes, are made up of ⩤ shaped pieces of bark, and work well. The wooden pistons of the Swedish air blowing cylinders are built up in pieces; each piece has a groove around it, having, however, no packing; the theory of its action being that before the emerging air passes from groove to groove, and has reached the opposite side of the piston, is again on its return stroke, and the air is changed back again from grove to grove.

Mr. J. (Canonbury).—Apply to Weale, Atchley & Co., and Spon the Engineering book sellers, for a catalogue of books on railway construction.

R. H. T. (Newcastle).—1. We do not undertake to supply such information as you seek in detail, either in The Artizan or by letter. 2. As a rule it is better to address such questions to the author of a paper read at a Society, you are then pretty certain to get his own views. 3. We cannot find the figures quoted by you in our number for March, 1860. 4. The last edition of Bournes' works gives the most recent formulæ. 5. Read Mr. Atherton's paper in The Artizan.

R. J.—In answer to your inquiry with reference to the new bridge at Blackfriars we give the following:—

The designs for a granite bridge were those submitted by—

| | |
|---|---|
| Sir John Rennie, of three arches, the centre span being... | 236ft. 10in. |
| Mr. George Rennie, of five arches, the centre span being... This design appears to have been prepared in 1858. | 150ft. |
| Mr. George Rennie, of five arches, each span being ..... | 125ft. |
| Mr. R. W. Mylne, of five arches, the centre span being ... | 156ft. 6in. |

The designs for a wrought-iron arched bridge were those submitted by—

| | |
|---|---|
| Mr. John Fowler, of three arches, the centre span being... | 275ft. |
| Mr. John Fowler, of five arches, the centre span being ... | 184ft. |
| Mr. John Hawkshaw, of three arches, the centre and other spans being ..... | 200ft. each. |
| Mr. John Hawkshaw, of five arches, the centre and other spans being ..... | 145ft. each. |
| Mr. P. W. Barlow, of three arches, the centre span being... | 250ft. |

The design for a wrought-iron girder bridge was that submitted by—

| | |
|---|---|
| Mr. R. P. Brereton, of five openings, the centre opening being ..... | 220ft. |

The designs for a cast-iron arched bridge were those submitted by—

| | |
|---|---|
| Mr. Thomas Page, of three arches, having a centre span of | 280ft. |
| Mr. Thomas Page, of five arches, having a centre span of | 156ft. |
| Messrs. George P. Bidder and Edwin Clark, of five arches, each span being ..... | 172ft. |
| Mr. George Rennie, of five arches, having a centre span of | 160ft. |
| Mr. George Rennie, of five arches, having a centre span of | 175ft. |
| Mr. George Rennie, of five arches, having a centre span of This design appears to have been prepared in 1852. | 180ft. |
| Mr. Robert William Mylne, of five arches, having a centre span of ..... | 163ft. 6in. |
| Mr. Joseph Cubitt, of five arches, having a centre span of | 150ft. |
| Mr. James Brunlees, of five arches, having a centre span of | 172ft. |

The remaining design for an iron bridge was that submitted by—

| | |
|---|---|
| Mr. Thomas Greenhill, of seven arches, having a centre span of ..... | 120ft. |

with a tube for a railway; and he mentions it may be converted into a five-arched bridge.

The "Flora" Iron Screw Steamer.—In the Artizan of December last, we gave an account of the trial trip of this steamer; and we are glad to learn that her performance at sea is also highly satisfactory. At the end of December the *Flora* made the voyage home from Madeira, under steam, in heavy weather, in 5½ days. She was heavily laden, the screw being 2ft. immersed. The *Flora* was chased on the voyage by the U.S. steamer *Tuscarora*, during a whole day, during which she encountered a strong N.E. trade wind, and a heavy sea. The *Tuscorora* being under sail and steam dead before the wind. The *Flora* succeeded in getting away from her pursuer and was making during this time 109 revolutions with steam at 17lbs. The *Flora* also, we understand, recently made the passage from Madeira to St. Thomas in 4 days, using alternate screws alternate days, making 7½ knots with either screw.

Manganese in Iron.—It is well known that iron reduced from spathic ore, and other ores containing manganese, not unfrequently contains a considerable percentage of manganese. In the variety of pig-iron called by the Germans Spiegeleisen (mirror-iron), the manganese has been estimated by different chemists to be from 4 to 7 per cent. In 1860, Dr. R. List published an analysis of a white-iron from Rüblinghausen, made from a mixture of ores containing from 20 to 25 per cent. of oxyde of manganese, in which he found but 3·80 per cent. of manganese. As the ore was so rich in manganese, List concluded that the iron obtained from its reduction must contain the maximum amount of manganese—that iron could not take up more than 3·80 per cent. manganese, and that the earlier analyses giving more than this must be incorrect. (*Polytechnisches Journal* clv. 119.) Professor Richter, of Leoben, has, however, reviewed List's results, and shows that the differences in the manganese content of iron smelted at different furnaces, or at different times, does not necessarily depend upon the quantity of this substance in the ore, but upon the temperature of the furnace, and the relative amount of coal used in the reduction. The higher the temperature, and the larger the proportion of coal in the charge, the greater will be the relative amount of manganese reduced. The basic or acid nature of the slag has also an important influence on the amount of the reduced manganese—it is easily reduced from a basic slag, but with considerable difficulty, from an acid slag. Richter gives analyses of Spiegeleisen from Jauerburg in Carniola and Theresienthal in Bohemia:—

| | Jauerburg. | Theresienthal. |
|---|---|---|
| Sulphur ... ... ... | 0·073 | — |
| Silicon ... ... ... | 1·902 | 2·732 |
| Manganese ... ... | 7·579 | 22·183 |
| Carbon ... ... ... | — | 2·311 |

The extraordinary amount of manganese found in the specimen from Theresienthal so influenced the properties of the iron, that it was not magnetic, and had not the power to throw down copper from a solution of chloride of copper; it simply reduced it to subchloride. Richter further remarks that the same mass of iron may contain more manganese in one part than another; this is due to the tendency manganese has to separate from the fused mass, and the upper portion of a "pig" may thus contain more manganese than the lower portion.

Croll's Treatment of Ammoniacal Liquor of Gas Works.—Mr. A. Croll, of Coleman-street, proposes to avoid the inconvenience and annoyance arising from the treatment of ammoniacal liquor of gas-works in the following manner:—Steam from a suitable boiler is conveyed into ammoniacal liquor contained in a suitable closed chamber, and the combined vapour and steam resulting are conveyed from the upper part of this chamber into other ammoniacal liquor contained in another closed chamber placed somewhat higher than the preceeding, in order that as the ammoniacal liquor in the previous chamber becomes spent it may be supplied from the second, and if desired other number of such ammoniacal chambers may be employed. From the last ammoniacal chamber the vapour resulting, combined with particles of steam, is conveyed into a closed compartment or chamber of a vessel containing acid adapted to the salt of ammonia desired to be obtained. Thus, supposing the salt desired is sulphate of ammonia, then the last chamber will contain sulphuric acid, and it is at its upper part divided into two compartments, one open at the top, the other closed by a cover, and a partition dipping below the surface of the acid liquid therein and below the mouth of the pipe conveying the vapour and steam thereto from the last ammoniacal chamber. Any vapour arising from the closed compartment of this vessel is conveyed into similar acid in another closed chamber used as a reservoir. From the upper part of this last closed chamber the sulphuretted hydrogen liberated is conveyed to the furnace supplying a vitriol chamber. By these means economy and the avoidance or great mitigation of the inconvenience and annoyance arising from the treatment of the ammoniacal liquor of gas-works is secured.

## RECENT LEGAL DECISIONS
### AFFECTING THE ARTS, MANUFACTURES, INVENTIONS, &c.

Under this heading we propose giving a succinct summary of such decisions and other proceedings of the Courts of Law, during the preceding month, as may have a distinct and practical bearing on the various departments treated of in our Journal: selecting those cases only which offer some point either of novelty, or of useful application to the manufacturer, the inventor, or the usually—in the intelligence of law matters, at least—less experienced artizan. With this object in view, we shall endeavour, as much as possible, to divest our remarks of all legal technicalities, and to present the substance of those decisions to our readers in a plain, familiar, and intelligible shape.

Spencer v. Jack.—His Honour said that in this case a motion for a new trial of certain issues, directed by the Court, which resulted in favour of the plaintiff, had been made, and he considered the matter of so much importance that he had taken time to look through the voluminous evidence which had been adduced on both sides. The case was tried before the Lord Chief Justice of the Court of Common Pleas and a special jury, some time since, at Guildhall. The trial occupied three days, and the main question involved was whether a patent obtained by the plaintiff in the year 1860 for alleged "improvements in steam engines, for propelling steam ships and other vessels," was a novelty and the proper subject of a patent. His Honour said he was sorry to say that he did not consider the result of the last trial satisfactory to his own mind, and if the motion was pressed, he should feel bound to direct a new trial. A new trial was ultimately ordered.

Hyde v. Palmer.—This was an action tried in the Court of Queen's Bench on the 9th ult., and was on a patent obtained by one Bersham in 1849 for improvements in separating the fibre from cocoa-nut husks. The plaintiff had become assignee of the patent, and sued the defendant for the breach of it. At the trial before Mr. Justice Blackburn the novelty of the alleged invention was disputed on the grounds, first, that there had been previous patents by Logan and also by Berry. The jury at the trial found a verdict for the plaintiff. Mr. Hindmarsh, Q.C., subsequently obtained a rule for a new trial on the ground of misdirection by the learned judge. Mr. Grove, Q.C., and Mr. Aston now appeared to show cause against the rule; and Mr. Hindmarsh, Q.C., and Mr. Rascher to support it. The Court made the rule absolute for a new trial.

Clare v. the Queen.—This was "a petition of right," the first tried under Bovill's Act. It was an action brought by Mr. J. Clare, jun., formerly a produce broker in Liverpool, and the patentee of certain "improvements in the construction of iron houses, vessels, &c." The patent was dated the 5th September, 1853. The action was tried in the Queen's Bench, before Lord Chief Justice Cockburn, and a mixed special and common jury. The action was brought for the infringement of Clare's patent by the Admiralty in the construction of the *Warrior*, and some other iron vessels. The part of the plaintiff's invention, which he in particular complained had been infringed, was the use or employment of an independent framing, or structural arrangement of materials, in which vertical and longitudinal framing pieces were combined so as to form a stable structure, to which the plating was afterwards attached. The plaintiff now claimed to be compensated for the use of his plans, and so much of his invention as had been used by the Admiralty. The Admiralty resisted the claim, alleging that they had not infringed his patent, that the invention was not new, and that the patent was void. The case occupied the court five days, and notwithstanding the admirable manner in which the plaintiff's counsel conducted the case, the jury returned a verdict for the Crown, under the direction of the Lord Chief Justice.

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# NOTES AND NOVELTIES.

## OUR "NOTES AND NOVELTIES" DEPARTMENT.—A SUGGESTION TO OUR READERS.

We have received many letters from correspondents, both at home and abroad, thanking us for that portion of this Journal in which, under the title of "Notes and Novelties," we present our readers with an epitome of such of the "events of the month preceding" as may in some way affect their interests, so far as their interests are connected with any of the subjects upon which this Journal treats. This epitome, in its preparation, necessitates the expenditure of much time and labour; and as we desire to make it as perfect as possible, more especially with a view of benefiting those of our engineering brethren who reside abroad, we venture to make a suggestion to our subscribers, from which, if acted upon, we shall derive considerable assistance. It is to the effect that we shall be happy to receive local news of interest from all who have the leisure to collect and forward it to us. Those who cannot afford the time to do this would greatly assist our efforts by sending us local newspapers containing articles on, or notices of, any facts connected with Railways, Telegraphs, Harbours, Docks, Canals, Bridges, Military Engineering, Marine Engineering, Shipbuilding, Boilers, Furnaces, Smoke Prevention, Chemistry as applied to the Industrial Arts Gas and Water Works, Mining, Metallurgy, &c. To save time, all communications for this department should be addressed "19, Salisbury-street, Adelphi, London, W.C." and be forwarded, *as early in the month as possible*, to the Editor.

## MISCELLANEOUS.

BROWNING IRON AND STEEL OBJECTS.—Gun barrels and other objects in iron and steel are browned, either to improve their appearance, or to preserve them from rust, by giving them at first a thin but entire coating of oxide of iron. The following process is successfully employed in Prussia for browning steel barrels:—Dissolve two parts of crystallised ferric chloride, two parts of butter of antimony, and one part of gallic acid, in the smallest possible quantity of water (about four or five parts); with this moisten a sponge or cloth, and rub the object to be browned. Leave it to dry in the air, and repeat the operation several times. Then wash with water, dry, and rub with boiled linseed oil. Objects browned in this way have a very agreeable dead grey appearance, and the shade deepens according to the number of times the operation is repeated. It is essential to the success of the operation, that a solid butter of antimony be used,—that is to say, a chloride of antimony containing as little free hydrochloric acid as possible.

DOCKYARD EXPENDITURE.—A blue book has been issued containing balance sheets showing the cost of manufacturing articles in the workshops of the several dockyards and steam factories for the year 1860-61. The dockyards and steam factories from which accounts are presented are Deptford, Woolwich, Chatham, Sheerness, Portsmouth, Devonport, and Pembroke. Taking the first table, under the head of mast houses, it will be found that in the year 1860-61, the total debit for these was £110,042 15*s.* 9½*d.* The highest was Portsmouth, £44,051 8*s.* 4*d.*; the lowest Deptford, £178 7*s.* 3*d.* Devonport figures for £20,111 10*s.* 6½*d.* In boathouses the expenditure is not very large, commencing with £2359 3*s.* 6*d* at Woolwich, and ranging to £7172 4*s.* 3*d.* at Portsmouth, Devonport coming in for £5351 19*s.* 3*d.* In capstan houses Chatham stands for the highest, £3782 16*s.* 8½*d.*; Devonport comes next with £3064 18*s.* 7*d.*; Pembroke is the lowest, £521 7*s.* 5*d.* In joiners' shops Devonport stands first, £3976 4*s.* 7½*d.*; Deptford is the lowest, £897 4*s.* 6*d.* From two of the dockyards, Deptford and Pembroke, no separate accounts were received from the plumbers' shops, and in none of the establishments from which these were sent was the amount large. At Chatham it was £3976 15*s.* 11½*d.*; at Portsmouth, £53 6*s.* 11*d.* The total debit for wheelwrights' shops in all the dockyards was £1827 5*s.* 10½*d.* Four of the dockyards spent £17,681 0*s.* 10*d*, in their millwrights' shops; three, Deptford, Woolwich, and Pembroke, send no return. This is the same in the roperies' department; but in Chatham, Sheerness, Portsmouth, and Devonport, £371,671 5*s.* 0½*d.* was expended under this head. As in the joiners, here also Devonport takes the lead—£169,281 3*s.* 0½*d.*, Chatham stands for about £37,000 less; Portsmouth, £58,848 18*s.* 10*d*; Sheerness about one-fiftieth part of that sum. An extensive business has been done in sail lofts: Portsmouth £17,260 16*s.* 9*d.*; Devonport about £1700 less; Pembroke the lowest, £86 14*s.* 2*d.* For colour lofts the total debit was £2299 14*s.* 2½*d.* Devonport was the highest; Sheerness the lowest. Sheerness stands first in the rigging house department, Woolwich the last, the figures varying from £10,822 19*s.* 5*d.* to £16,131 5*s.* 10*d.* In the lead, paint, metal, and cement mills, the items are unimportant. Coming, then, to blacksmith's shops it will be found that there are returns from only Portsmouth and Devonport; the former £27,699 10*s.* 4*d.*, the latter £736 12*s.* 11½*d.* The expenditure in the trenail houses was small; Pembroke was the highest; Deptford the lowest; whilst from Portsmouth no account was received. Oarmakers' shops show a total of £6243 9*s.* 6½*d.*; from Deptford, Woolwich, Sheerness, and Pembroke, no returns were sent. For caulkers and pitch heaters the expenditure was £11,379 12*s.* 4*d.*; Portsmouth, £5989 4*s.* 6*d.*; Devonport, £2647, 14*s.* 2*d.* Passing over the turners' shops, which do not show for much, next is presented locksmiths', timmen's and braziers' shops; these are somewhat over £2,000. The charge for foundries is scarcely what might have been expected—£5,632 4*s.* 9½*d.*; from Deptford, Woolwich, Sheerness, and Portsmouth, there are no returns. For painting in the several dockyards, £5,170 3*s.* 7½*d.* The only condensers' shop is at Portsmouth, where £15,881, 18*s.* 9*d.* was expended; here, also, is the only pump house, which goes down for £840 10*s.* 0½*d.* The only dockyard from which a fire-engine account was received was Devonport, where the expenditure was £145 6*s.* 4*d.* "Smitheries" is a heavy item, no less than £211,606 18*s.* 5½*d.* being put down for them. Of this, £55,000 was spent at Portsmouth; £49,000 in the north and south smitheries of Devonport; £32,000 at Chatham; £27,000 at Woolwich; £18,000 at Sheerness; £14,000 at Deptford; and £13,060 at Pembroke. In steam-hammer shops, Portsmouth stands for £13,302 16*s.* 1*d.*; Devonport, £11,089 12*s.* 7*d.*; Deptford, £3102 9*s.* 7*d.* At Portsmouth, nearly £7000 was expended in the iron-foundries, and at Keyham £4481 14*s.* 6*d.* Brass-foundries—Portsmouth, £45,532 12*s.* 7*d.*; Keyham, £13,674 12*s.* 4*d.* Copper-smiths' shops—Portsmouth, £4851 19*s.* 10*d.*; Keyham, £4234 17*s.* Engine Smitheries—Portsmouth, £5959 15*s.* 4*d.*; Keyham, £5659 10*s.* 3*d.* Boiler smitheries—Keyham, £5394 9*s.* 10*d.*; Portsmouth, £5148 8*s.* 4*d.* The total expenditure in the dockyards for the year 1860-1 was £1,382,506 3*s.* 8*d.*; and in addition to this, under the head of shops in the steam factories, there is £144,981 3*s.* 4*d.*

THE NAVY ESTIMATES.—The estimate of the sums required to meet the expenses which may be incurred in the naval department in the year 1863-64 has recently been issued, and is as follows:—The total amount required for the naval service is £10,465,882, whilst for the financial year 1862-63 it was £11,606,655; and for the army department (conveyance of troops), the amount required for the current year is £270,180, against £188,650 for the past year, thus showing a net decrease of £1,058,373.

NEW MODE OF GENERATING STEAM.—Mr. J. L. Linton, a gentleman from America, has lately visited Paris for the purpose of submitting to the French Government his new method of generating steam. Instead of the ordinary fuel he uses petroleum oil; or, should that be wanting, ordinary coal oil; and, as the machinery which he employs can be easily applied to the steam engines in general use, he claims the merit of effecting a very considerable saving. It is reported that this plan has been examined by a Government Committee in Paris.

A NEW PETROLEUM TRADING COMPANY is announced, with a capital of £100,000, in shares of £10 each. The object is to import petroleum from the natural wells in America, in iron tank vessels specially constructed, which vessels will class A1 for 17 years. By this proceeding a large per centage will be saved in freights. The demand for petroleum is yearly increasing for lighting purposes, and it is a cheap and efficient agent for the rapid generation of steam.

VOLTAIC BATTERIES FOR STEAMERS.—The Emperor of the French is superintending the construction of one of three batteries, intended to replace fuel. In this country it has been proposed to our Admiralty to make a trial of a voltaic battery of 2000 double plates, each containing 30 square inches, the whole surface being 128,000 square inches. Charcoal points, connected with the two poles, are ignited to whiteness, on withdrawing the points from each other, an arch of light, 4in. in length, is produced between them. When any substance is introduced into this arch, it instantly ignites. Platinum melts as readily as wax in a common candle. Quartz, the sapphire, &c., with equal facility.

BAROMETER FOR MEASURING ATMOSPHERIC DISTURBANCES.—At the last meeting of the Manchester Literary and Philosophical Society, Dr. Joule described a barometer for measuring small atmospheric disturbances. It consists of a large carboy connected by a glass tube with a miniature gasometer formed by inverting a small platinum crucible over a small vessel of water. The crucible is attached to the short end of a finely suspended lever multiplying its motion six times. When the apparatus was raised two feet the index moved through one inch; hence he was able in the serene weather to observe the effect corresponding to the elevation of less than one inch. The barometer is placed in a building, the slated roof of which affords, without perceptible draught, free communication with the external atmosphere. In this situation it was found that the slightest wind caused the index to oscillate, a gale occasioning oscillations of two inches, an increase of pressure being generally observed when the gusts took place.

SHIPBUILDING ON THE CLYDE.—The number of iron ships built on the Clyde, during the last seven years, has been as follow:—

| Year. | Ships finished. | Tonnage. | Building at close of year. |
|---|---|---|---|
| 1856 | 102 | 39·330 | 62 |
| 1857 | 98 | 37·416 | 56 |
| 1858 | 90 | 40·922 | 34 |
| 1859 | 78 | 35·705 | 52 |
| 1860 | 88 | 47·833 | 46 |
| 1861 | 88 | 46·901 | 62 |
| 1862 | 123 | 69·969 | 86 |

PRIVATE BILLS.—The Speaker laid upon the table of the House of Commons, on the the 20th ult., a report from the Examiners of Petitions for Private Bills, that in respect of the bills comprised in the list reported by the Chairman of Ways and Means as intended to originate in the House of Lords, they have certified that the Standing Orders have been complied with in the following cases:—Albert Bridge; Anglesey Central Railway; Banff, Macduff, and Turriff Extension Railway; Banff, Portsoy, and Strathisla Railway; Barnes, Hammersmith and Kensington Railway; Bishops Waltham Railway; Blackburn, Chorley, and Wigan Railway; Buckley Railway; Carmarthen and Cardigan Railway (No. 1); Carmarthen and Cardigan Railway (No. 2); Carnarvonshire Railway; Cork and Kinsale Junction Railway; Cowes and Newport Railway; Dare Valley Railway; Dublin Metropolitan Railway; Dulas Valley Mineral Railway; Dundalk, Carlingford, and Greenore Railway; East Gloucestershire Railway; East London and Rotherhithe Railway; Edinburgh Water; Esk Valley Railway; Fochabers and Garmouth Railway; Fulham Bridge: Grand Surrey and Commercial Docks Railways; Great Eastern Railway (New Metropolitan Station and Branches); Great Eastern Railway (Steam-boats); Great Grimsby Water; Greenock and Wemyss Bay Railway; Hammersmith and City Railway; Hoylake Railway; Ilfracombe Railway; Irish North-Western Railway; Isle of Wight Railways (Extensions); Lands Improvement Company; Launceston and South Devon Railway; Law Life Assurance Society; London, Chatham, and Dover Railway (No. 1); London (City) Traffic Regulation; London Railway (Victoria Section); Londonderry Railway (Seaham to Sunderland); Lowestoft Water, Gas, and Market; Merthyr, Tredegar, and Abergavenny Railway; Metropolitan Bridges; Metropolitan Railway; Metropolitan, Tottenham, and Hampstead Railway; Newry and Greenore Railway, Pier, and Wet Dock; North British Railway (Steam-boats); North London Railway; Northumberland Central Railway; Okehampton and Lidford Junction Railway; Pontypridd Water; Putney and Fulham New Bridge and Pier; Ringwood, Christchurch, and Bournemouth Railway; Ripley's Hospital; Rotherhithe Railway; St. Ives and West Cornwall Junction; Sidmouth and Budleigh-Salterton Railway; Solicitors' and General Life Assurance Society; South London and Greenwich and Woolwich Railway; South London Market; Stokes Bay Railway and Pier, and Isle of Wight Ferry Companies; Surrey Gas; Thames Bridges; Tottenham and Hampstead Junction Railway; Uxbridge and Rickmansworth Railway; Van Diemen's Land Company; Victoria Station and Pimlico Railway; Watford and Rickmansworth Railway; West Cork Railways; West London Docks and Warehouses; West London Extension Railway; Wicklow Copper and Hibernian Mines Companies; Yarmouth Gas. The standing orders have not been complied with in the following cases, viz.:—Cardiff, Caerphilly, and Aver Valley Railway; Cardiff and Caerphilly Railway; Cardiff Consumers' Gas; Colne Valley and Halstead Railway; Cookstown and Pomeroy Railway; Corris, Machynlleth, and River Dovey Tramroad; Morayshire Railway; Putney, Balham, and City Junction Railway; Rumney and Brecon and Merthyr Tydfil Junction Railways; Sligo and Ballaghaderreen Junction Railway; South Mayo Railway; Wandsworth and Fulham Bridge; Wexford and Enniscorthy Railway.

TRIAL OF A NEW TRACTION ENGINE.—On the 21st ult., a number of engineers and scientific men assembled at Rochester for the purpose of witnessing some experiments made with a new traction engine, manufactured by the firm of Messrs. Aveling and Porter, of Rochester, the patentees. The engine selected for the trial was one of several which are now being manufactured for the Yudanamutana Copper and Mining Company, Australia. Shortly after 1 o'clock the engine started from the factory at Strood with four heavy waggons attached, each laden with baulks of timber, the total weight of each wagon, with its freight, being close upon five tons. With this load the engine traversed the narrow streets of Strood, turning the sharp angle at the turnpike and ascending a long incline of about 1 in 12, for upwards of a mile, at a speed of five miles an hour. The engine was then turned towards a hill with a rise of 1 in 8—the steepest of the kind in the neighbourhood—and, nothwithstanding the exceedingly soft, sloppy state of the road, ascended to the top with the train of waggons at the rate of about three miles an hour. After travelling some distance at speeds varying from three to six miles an hour, the engine and train descended the long inclines, and again reached the turnpike roads, where two more heavily laden waggons were attached, swelling the weight, with the engine, to upwards of 40 tons. Again the engine was started, and, without the least apparent difficulty, it dragged its load over every variety of ground and through the streets, arriving at the factory at about 5 o'clock, after an absence of upwards of three hours. The engine experimented upon was one of nominally 10-horse power, and was the first traction engine which ever ascended a gradient of the steepness of that passed over on this occasion with such a heavy weight. It is the intention of the company to send out 20 similar engines to Australia for the purpose of transporting the copper from their mines to the port, a distance of 120 miles, over an unbeaten tract of land. The cost of carriage is now £10 per ton, but by the use of these engines it will be reduced to £2 per ton.

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Semaphores.—M. Felix Julien publishes an article on the semaphores now established or in course of construction along the coasts of France. Their number is upwards of 150; each consists of a small white house roofed with red tiles, and surmounted by a tower. From this there rises a vertical mast, 10 metres in height, provided with three moveable fan-shaped wings, by means of which signals are made to ships passing even at a distance of six miles. The ship replies by its flags, and thus news may be instantly transmitted from the vessel to any part of the country, thanks to the telegraphic wire with which each semaphore is now provided. The semaphore is essentially an instrument of attack or defence in times of war; but even during peace time it may perform valuable service, if, as M. Julien justly suggests, its communications of the state of the weather be received at a central office, established at Paris, and thence made to radiate to all the points of the French coast—a plan perfectly in accordance with that now conducted in England by Admiral Fitzroy. The signals used by French vessels for great distances consist of the three primitive figures of geometry, viz., a square or ordinary flag; a triangle or flame; and a circle, or ball. The combination of these three signals taken two by two, gives the first ten figures of our numeral system; which may be combined so as to express any number between 1 and 10,000. This is, indeed, the number of articles contained in the French code of signals for the mercantile navy. The semaphore replies to these signals by its three wings, each of which can assume six different positions. Each of these positions represents one of the first six numbers. The first wing represents the units, the second the tens, and the third the hundreds. But to render the system more simple, the semaphore first telegraphs the page of the signal-book, and then the line of the page separately.

The Pneumatic Dispatch.—The Postmaster General and the Secretary to the Post Office, have officially inspected the working arrangements of the branch tube from the Euston Station to the North-Western Post Office in Eversholt-street, previous to the transmission of the mails between these two places; the Post Office authorities having conceded this privilege to the Pneumatic Dispatch Company. After the working arrangements had been fully explained, trains of cars were rapidly propelled backwards and forwards through the tubes, the cars containing heavy weights; being principally loaded with stout planks, and on the signal being given by Wheatstone's telegraph, they were despatched to the other end of the tube with a pressure of about 4 ounces, in a few seconds over a minute; the average up the incline being about 1 minute 12 seconds, returning by vacuum in 1 minute 5 seconds. The mail bags, upwards of 120 per day, will be blown through the tube in 55 seconds, to the Post Office, Eversholt-street; the usual time occupied by the mail carts being at present about 10 minutes. The next step of the company will be to lay tubes connecting the markets of London with the Camden Goods Station, with a tube to the General Post Office, and Pickford's depôt in Gresham Street.

Trial of New Iron Sheers.—On the 11th ult. a number of gentlemen assembled in the Southampton Docks, for the purpose of witnessing the tests applied to the monster iron sheers just erected for the company, under contract, by Messrs. Day and Co., of the Northam Ironworks. They are of the following dimensions:—Length of the front legs, 110ft.; length of the back leg, 140ft.; power of the engine to work them, 20 horse-power; proof strain to be 100 tons, vertical lift, and 80 tons with an overhang of 35ft. from the dock wall. The enormous bundles of rail iron, forming the testing weights of 100 tons, were raised from the railway trucks, which run under the sheers, and deposited on the quay; after which 80 tons were lifted and run out 35ft. from the dock wall, and brought back again in a remarkably quick and satisfactory manner. This is effected by an improvement introduced by Mr. Thomas Summers, of the above named works, in the construction of sheer legs, which renders them simpler and more easy to work than those on the ordinary plan. In the new sheers the back leg is made to act both as a prop and a guy to the front legs, and its bottom end slides in an iron groove strongly bolted to its foundation. The movement of the back leg along this groove is affected by a powerful wrought-iron screw, 43ft. long and 8in. diameter, and worked by the same engine as is used to work the hoisting gear. The length of the groove is 48ft., and the sheers are run either in or out in about four minutes. The rate of hoisting for weights up to 20 tons, is about 12ft per minute, and for heavier weights a more powerful purchase is used, giving a rate of from 4ft. to 6ft. per minute.

## NAVAL ENGINEERING.

Trial of the Lyrian, Screw Gunvessel.—The *Lyrian*, commenced her official trials of speed at the measured mile in Stokes Bay, on the 27th January last, and completed them on the following day. The *Lyrian* is one of the new description of gunvessels, of an intermediate size, between the small Haslar class and the despatch boat. She is fitted with engines of 60 horse-power, nominal, by Messrs. Maudslay, on the high-pressure principle; but since her completion, a condenser has been added by the Admiralty Department. She has a Griffiths screw of 8ft. pitch, and 8ft. diameter, working with a draught of water in the ship's hull of 8ft. aft. and 7ft. 6in. forward. On the first day the trials were at high pressure. The wind was at a force of about 4, and in a W.N.W. direction. Six runs were made with the following results:—1st, 6·371 knots; 2nd, 10·055 knots; 3rd, 6·509 knots; 4th, 10·198 knots; 5th, 6·070 knots; 6th, 9·863 knots: thus giving a mean speed of 8·214 knots; the average pressure of steam was 60lb.; and the average number of revolutions, 165. On the second day the low-pressure trials were made at the measured mile. The weather was unusually favourable for the time of year. The first trials were made with six runs at full power, as follows:—1st, 7·438 knots; 2nd, 8·695 knots; 3rd, 7·531 knots; 4th, 8·780 knots; 5th, 7·438 knots; and 6th, 8·845 knots; giving a mean speed of 8·120 knots; average pressure of steam 38lb.; revolutions of engines 152. One boiler out of the two with which the ship is fitted was next cut off, and six runs made with one boiler, yielding results as follows:—The 1st, 5·825 knots; 2nd, 7·114 knots; 3rd, 5·598 knots; 4th, 6·593 knots; 5th, 5·891 knots; and the 6th, 5·479 knots, giving a mean speed of 6.192 knots; the average pressure of steam, 37lb., and the average number of revolutions, 121. In testing the mechanical working of the engines, they were stopped dead from the time of giving the signal in 9 seconds; they were started ahead in 8 seconds, and turned astern in 3 seconds. The trial of the *Lyrian* was considered most favourable. The chief novelty connected with the engines of the *Lyrian*, consists in her being fitted with two short boilers, with return tubes, taking up less space than the ordinary mode of gunvessel fitting, steam being got up in less time, and also kept up with greater ease to the *maximum* point.

The "Emerald," screw frigate of 34 guns, 2913 tons, and 600-horse power, Captain Arthur Cumming, commenced her series of experimental speed trials with various forms of screw propellers, at Portsmouth, on the 19th ult. The trials will be conducted by Captain H. Broadhead, commanding her Majesty's ship *Asia* and the reserve at the port, and his staff will consist of Mr. Ward, Assistant Engineer of the dockyard, and Mr. Murdoch, the Inspector of Machinery of the Steam Reserve. The following were the results of the trial:—No. 1 trial.—Screw, common Admiralty pattern, with a diameter of 18ft., a pitch of 28ft., and a length of 3ft. 6in.; the leading corners of the screw cut. The ship drew 21ft. of water forward and 22ft. aft. Coals on board, 300 tons; state of weather, a calm. Runs:—1st run, time, 5 min.; speed in knots, 12·000; steam, 20lbs.; vacuum, 24; revolutions, 53·5; 2nd run, time, 5 min. 29 sec.; speed, 10·942; steam, 18½; vacuum, 24; revolutions, 53·5; 3rd run, time, 4 min. 46 sec.; speed, 12·587; steam, 18; vacuum, 24; revolutions, 53·5; 4th run, time, 6 min. 3 sec.; speed, 9·917; steam, 19; vacuum, 24; revolutions, 54; 5th run, time, 4 min. 31 sec.; speed, 13·284; steam, 19½; vacuum, 24; revolutions, 54; 6th run, 6 min. 8 sec.; speed, 9·783; steam, 19½; vacuum, 24; revolutions, 54·5. The mean speed of the ship is 11·529 knots. The circles were made:—Port—half circle, 4 min. 22 sec.; full circle, 8 min. 40 sec.; starboard, half circle, 4 min.; full circle, 8 min. 29 sec.; port—helm put up in 19 sec.; starboard, 18 sec.; port—angle of under 15 deg., starboard, 16 deg.; port—turns of wheel, 1½; starboard, 1¾; port revolutions of engines, 51·5; starboard, 52. There were six men at the wheel. It is intended to carry an uniform "pitch" of the screw throughout. The *Emerald*, on the 21st ult., resumed her experimental screw trials. The screw tested on this occasion was of the same pattern as on the last, the common, or Admiralty screw, with an increasing pitch of from 27ft. 6in. to 29ft. 6in.; diameter, 18ft.; length, 3ft. 6in.; and immersion, 10½in. Six runs were made at the measured mile, the mean of the whole giving the ship a speed of 11·524 knots, with a mean revolution of engines of 53. The ship turned a full circle to port in 8 min. 49 sec., and to starboard in 10 min. 1 sec.

The "Royal Sovereign."—On the 14th ult. Lord Clarence Paget arrived at Portsmouth, and visited the *Royal Sovereign*, converting to a turret ship in the dockyard, under the direction of Capt. C. P. Coles, R.N. Six of her armour plates, three on each side, are being bolted on, and, so far as the external work of the ship's conversion is concerned, she is now ready to receive the whole of her armour plating from below her water line to her topsides. To receive this part of her armour the ship has been strengthened outside with two layers of diagonal teak planking, the inner being of three and the outer of four-inch. This diagonal strengthening extends 11ft. 8in. below that part of her topsides to which she was originally cut down. The lower ends of this diagonal planking rest in worked rabbits of longitudinal planking added to the original bottom of the ship, which project sufficiently far beyond the level of the diagonal ends to form a shelf on which will rest the lower edges of the lower tier of armour plates. The lowest part of this longitudinal planking is 14ft. 10in. from the point to which the ship was originally cut down. The ship was cut with a sheer forward and aft, which Capt. Coles afterwards disapproved. The result was that the ship's topsides were filled in and raised, the greatest extent being amidships, where it is about 18in. Sloping downwards from the centre in all directions, to allow of the required depression of the guns in the turrets, the appearance of the *Royal Sovereign's* upper deck, when complete, will be as nearly as possible like the under part of a butcher's tray, thus forming the glacis of the gun towers or turrets. Where the towers stand, or rather are to stand, the original wooden beams have been removed, and their places taken by short rolled-iron beams from the Butterly Works, which extend from the ship's side to the crown of the glacis at its junction with the tower. Where the removal of the original beams has not been necessitated by the fitting of the towers they have been retained, and to give the necessary slope outwards to the deck they have been doubled over by other beams. As an instance of the size of and distance between the beams thus doubled over, it may be mentioned that the beams forward of the foremost turret and abaft the aftermost one are 3ft. 3in. in depth and 1ft. 5in. in width, of solid timber. Six of these double beams, in addition to massive inner strengthenings, are between the vessel's stern and forward turret, the distance between each beam being about 2ft. 4in. Amidships the beams are even closer, and are alternated with rolled-iron beams secured to longitudinal iron beams, clear of the turrets amidships, where not extending right acsoss the deck, by stout U-shaped knees. The height of the original wooden beams from the deck below is exactly 6ft., but where the old wooden beams have been removed altogether and short iron ones substituted, as in the make of the turrets, an additional height is gained of 18in. at the combings of the hatchways and 14in. in at the ship's side. The *Royal Sovereign* has not been built expressly for a turret ship, and therefore, when tried, allowances must be made for certain qualifications which she will possess and which she would have done much better without. The Admiralty have also decided that she is not to be masted, and consequently she will be unable to steady herself at any time by her canvas. With all the faults that can possibly be summed up against her, the *Royal Sovereign* will solve the problem as to whether guns of much heavier calibre can be worked better on the central than on the broadside principle,—in fact, whether a gun of 20 tons cannot be worked more efficiently and with greater ease from a turret, than a gun of 7 or 8 tons can ever be expected to be worked through a broadside port. The water was, on the 20th ult., admitted into No. 3 dock at Portsmouth, and the *Royal Sovereign* was floated off her blocks. On the water rising in the dock to a sufficient height, the ship was lifted off her blocks at a draught of 13ft. 8in. forward, and 17ft. 5in. aft., the water line being just below the lower portion of the added longitudinal planking which supports the 7in. of crossed diagonal teak planking which has been added to the ship's external topsides to strengthen her, and assist in carrying her 5½in. armour plates, and also supports in a rabbit the lower edges of the bottom tier of armour plates. At this draught of water, therefore, the embryo turret-ship was floating, the only weights in addition to the wooden hull being her machinery complete as an 800 horse power screw steamship, ten of her huge 5½in. iron armour plates on her sides partially completed in their bolt fastenings, and 30 of the 1in. iron plates on the upper deck beams underneath her 8in. wooden deck planking, which lay on the beams of her upper deck. In measuring round her topsides to ascertain their exact height from the water line, it was found to be as follows:—Amidships, 15ft. 2in., on the quarters, 15ft. 5in.; and on the bluff of the bows, 16ft. Her estimated draught of water when ready for sea, with everthing on board, is 20ft. 3in. aft, and 21ft. 9in. forward, which leaves, at the ship's present draught, an additional immersion of the hull of 7ft. aft and 6ft. 4in. forward, to carry the undoubtedly enormous weight which has yet to be put on and into the ship. This weight will be comprised chiefly in the following items:—Four turrets of 80 tons each, 320 tons; armour for sides, fastenings, and deck-plating, 1000 tons; anchors 27, and cables 72 tons, 99 tons; messengers and fittings, 6 tons 13 cwt.; boats, 12, and firehearth 8, 20 tons; men and effects (280), 44 tons; boatswain's and carpenter's stores, 85 tons; armament, say (what it ought to be), 100 tons; shot, shell, and gunner's stores, 170 tons; powder, 30 tons; water and tanks, 30 tons; coals, 600 tons; and provisions and victualling stores, 72 tons. The whole weight will thus be 2576 tons 13 cwt. There are the steam capstans, auxiliary engines for working them, the internal fittings of the ship, and many other smaller items, all amounting to a goodly total, that are not included, of course, in the above, but which will materially add to the weight to be carried by the turret-ship. The extra displacement the ship will gain by her increased section from her diagonal and longitudinal planking and armour-plating to 5ft. below her water line, will of course give her additional carrying power; but this will, no doubt, injuriously affect her speed, not only by the increased size of the hull to be driven through the water with a given power, but also by all want of relative proportions in the bottom of the hull, owing to the abrupt ending of the additional planking at between 7ft. and 8ft. below the line of flotation.

Trial of the "Leander."—This screw frigate, 2760 tons, 400 porse-power, was taken to the measured mile, on trial of her machinery and engines, on the 4th ult.; but owing to the excessive priming, she was unable to complete her trial. Since then her boilers and pipes had undergone a thorough overhauling and cleaning, and the vessel was again taken out on trial on the 17th ult. During the period of four runs the trial was successful, the engines working satisfactorily, with an entire absence of hot bearings. The average speed attained in the four runs was 10¾ knots, with 60 revolutions per minute vacuum, 18½; mean pressure of steam, 23lbs. While the fifth run was being made, the padding in the junctions of the relief valve, which it is thought had become decayed, was forced out of its place, and, owing to the excessive leakage, the trial had again to be postponed.

The "Caradoc," paddle-wheel despatch, has returned to Woolwich from an engineer's trial of her machinery, after repairs. The trial was prolonged beyond the usual test, in order to ascertain the merits of Mr. Humphrey's new superheating steam apparatus, fitted to the boilers. The maximum speed attained by the engines of the *Caradoc* was only 10¼ knots per hour; becoming overheated, the apparatus burnt away a portion of the woodwork before the foremost funnel.

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TRIAL OF THE "HIMALAYA" TROOPSHIP.—The *Himalaya*, screw troopship, 700 horse power, on the 2nd ult., made her official trial of speed, on the conclusion of extensive repairs to her machinery, at the measured mile in Stokes Bay. The weather was most unfavourable for developing the ship's highest rate of speed, a strong south-west gale blowing at the time. Four runs were made with full boiler power, the mean of which gave a speed of 11·88 knots. Two runs were next made with half boiler power, giving a mean speed in knots of 9·550. The maximum number of revolutions of the engines was 58, and the minimum 55; the propeller being a Griffiths, having a diameter of 18ft., a pitch of 27ft. 9in., and an immersion of its upper blade of 4ft.

THE "ALFRED."—This iron screw turret-vessel, building for the Government at Messrs. Samuda's, in their yard at Blackwall, is making rapid progress. Her armament, consisting of five deck guns only, will be protected by four cylindrical armour-plated turrets, three of which will contain a single gun each, and the fourth two guns, making the total amount of her armament. The construction is exactly that of the Confederate invention, and is intended for similar purposes. The turrets will be built up after the principle of the *Warrior's* sides, with 4½in. plates, backed by solid teak timbers. The revolving platforms and general woodwork of the turrets have been cut out and the work commenced by the shipwright department at Woolwich.

THE "CALEDONIA."—The plating of this vessel is advancing rapidly in dock at Woolwich. A new system practised in armour-plating the ships of the French navy has been introduced, which it is expected will have the effect of warding off the dry rot, and preventing decay. It is effected by carbonising with a flame of gas the surface of the timber before receiving the plates. In order to obtain a satisfactory test of the effect of this system, an equal number of the plates has been laid on without the carbonising, and the system will be applied to the remainder of the strakes to obtain the necessary result.

THE BRITISH NAVY.—A return issued on the 16th ult. gives in detail the number of steam ships afloat and building, together with the number of effective sailing ships, on the 1st February, 1863. There were then afloat a total of 522 vessels, of which 414 were screw and 108 paddle. There were building 44, and of effective sailing ships afloat the number was 103—grand total, 669. Of the ships afloat 2 are armour-plated (iron) second rates; and 3 armour-plated (iron) third rates; and 3 are armour-plated (wood) third rates. There were 56 screw ships of the line afloat, and 38 screw and 16 paddle frigates; 26 corvettes and 65 sloops; 7 floating batteries, 209 gunboats and gunvessels; the remainder of the ships afloat carrying smaller armaments. There are building 8 armour-plated ships, of which 4 are iron second rates, 1 iron third rate, and 3 wood third rates. There are also 2 turret ships in progress, third rates, 1 iron new, and 1 wood converting. The building of 3 ships of the line, and 6 frigates, 4 corvettes, 5 sloops, and 6 gunboats, all screw, is suspended. Of the effective sailing ships afloat 9 are screw ships of the line, and 13 are frigates, 7 are sloops, and 73 mortar vessels and floats.

NAVAL FORCE.—The number of 76,000 men to be voted for the navy is made up thus:—5784 officers, subordinate officers, and warrant officers; 33,216 petty officers and seamen, 9000 boys, 9000 Coastguard, 1000 officers and men employed in the Coastguard Civil Service, and 18,000 marines. The Estimates propose £40,000 for Royal Naval Coast Volunteers and for victualling and clothing them when afloat, provision being made for 8000 in number. The sum to be voted for the Royal Naval Reserve is £193,060; the provision is made for 16,000. The ships in commission on the 1st of December were as follows:—Line-of-battle ships, 13; iron-cased ships, 4; frigates and corvettes, 46; sloops, small vessels, and gun-boats, 92—making in all 155 sea-going steam vessels, being 5 less than on the 1st of December, 1861. The guard-ships, stationary ships, surveying, troop, and store ships, and tenders, brought the total fleet and Coastguard up to 90 sailing and 237 steam vessels on the 1st of December last, a number 10 less than on the 1st of December, 1861.

IRON MORTAR VESSELS.—Admiralty orders have been received at Chatham for another of the fleet of mortar vessels laid up in Yantlett Creek to be handed over to the Controller of the Coastguard for use in that service, the Admiralty having determined on bringing the whole fleet of mortar-boats into use as opportunities occur, instead of allowing them to remain rotting in inactivity at their present berths. Beside the numerous mortar-vessels at Yantlett Creek, there is likewise a large squadron of iron mortar-boats, built during the Russian war, laid up at Chatham Dockyard, costing the country a considerable sum to keep them in repair, and to prevent rust eating into their iron plates. Each vessel is housed over with a covering of wood to protect it from the weather, but, although every precaution is adopted in this respect, nothing can prevent their undergoing a certain amount of injury. The number of these iron mortar-vessels cannot be much less, if it does not exceed, 100.

STEERING BY TELEGRAPH.—The iron-cased frigate *Royal Oak*, 34, 800 horse-power, preparing for sea at Chatham, has been selected by the Admiralty as the first vessel in the navy on board which Gisborne's code of steering and engine-room electric telegraph signals are to be fitted. Since the former order for applying the invention to the *Royal Oak* was issued a second Admiralty order has been received at Chatham dockyard directing the steering signals in addition to being placed in the engine-room and on deck, to be fitted within the armour-plated turret which is now being erected on the upper deck, and also to the two lower deck wheels, thus enabling the officer stationed within the turret to communicate his orders simultaneously to the engineer and also to the men at the wheel. This arrangement is most important. During intricate navigation, such as entering or leaving harbour, or in foggy or stormy weather, it is frequently of vital importance that the captain's orders should be conveyed quickly and unmistakably to the helmsmen and engineers, and the invention enables every movement of either the helm or the engines to be apparent to the commanding officer.

THE SPANISH FLEET.—The following is a list of the Spanish frigates now afloat or building:—Screw ironsides. *The Sagunto*, 30 guns; *Zaragoza*, 30; *Humannia*, 40, all building; *Arapiles*, 30; *Navas de Tolosa*, 50; *Gerona*, 50; *Principe de Asturias*, 50; *Principe Alfonso*, 30; *Victoria*, 30. Screw steamers; *Villa de Madrid*, 50, building *Almansa*, 50. Sailing vessels: *Espenanza*, 42; *Triumfo*, 42; *Resolucion*, 42; *Nuestra*, 42; *Senora del Carmee*, 42; *Lealtad*, 42; *Concepcion*, 38; *Beranguela*, 38; *Blanca*, 38; *Petronilla*, 38. Of the ten corvettes in the Spanish navy, five are sailing vessels, and five screw. Of the 22 goelettes, only one is a sailing vessel, the others are screws, seven of which are building.

NAVAL APPOINTMENTS.—The following appointments have taken place since our last:—H. W. Elgar, Chief Engineer, to the *Buzzard*; J. Neil, Chief Engineer, to the *Cumberland*, for the *Mars*; J. Walsh, Engineer, W. Nicholson, First-class Assist. Engineer, and J. G. Sampson, Acting Second-class Assist. Engineer to the *Buzzard*; T. S. Gissing, First-class Assist. Engineer, to the *Asia*, for the *Foam*; D. Langlands, First-class Assist. Engineer to the *Caradoc*; T. Barker, in the *Foxhound*, promoted to Acting First-class Assist. Engineer; W. Tempest, Second-class Assist. Engineer, to the *Fisgard*, for the *Baun*; H. H. Tomkin, promoted to Chief Engineer; J. Staley, First-class Assist. Engineer, to the *Asia*, as supernumerary; M. A. Fothergill, Acting Second-class Assist. Engineer, to the *Cumberland*; J. W. Carpenter, in the *Firefly*, promoted to Acting Chief Engineer; J. Lawson, Engineer, qualified for charge, to the *Racoon*; W. White, supernumerary, in the *Cumberland*, promoted to First-class Assist. Engineer; S. J. Bird, and W. Ray, Second-class Assist. Engineers, to the *Racoon*; T. H. W. Ramsay, Acting Second-class Assist. Engineer, to the *Indus*, as supernumerary; A. Clarke, in the *Defence*, promoted to Engineer; H. Woolley, Engineer, to the *Indus*, for the *Alert*; J. Murdock, Acting Second-class Assist. Engineer to the *Asia*, as supernumerary; C. Icely, Chief Engineer, to the *Fisgard*, for the *Caledonia*; J. Gillies, Chief Engineer, to the *Cumberland*, for the *Scylla*; J. Francis, in the *Shannon*, J. Purdie, in the *Petrel*, J. Russell, in the *Fisgard*, and W. Kelly, in the *Satellite*, promoted to First-class Assist. Engineers; C. M. Johnson, in the *Forte*, J. Gibson, in the *Firefly*, A. Templeton, in the *Euryalus*, G. Whitting, in the *Ardent*, W. Taylor, in the *Barracouta*, and W. Brock, in the *Alacrity*, promoted to be Acting First-class Assist. Engineers; J. Copplestone, Acting Second-class Assist. Engineer, to the *Indus*, as supernumerary; G. Booth, Engineer, and J. Russell, First-class Assist. Engineer, to the *Racoon*; W. R. Leeson, in the *Snake*, promoted to Acting Engineer; J. C. Gray, First-class Assist. Engineer, to be borne supernumerary of the *Fisgard* from the date of his arrival in England; W. Galr, in the *Stromboli*, promoted to Acting First-class Assist. Engineer; J. A. Lodge, Engineer to the *Fisgard*, as Supernumerary; W. Tempest, in the *Fisgard*, for the *Baun*, and G. Murray, in the *Asia*, promoted to First-class Assist. Engineers; W. H. Brunfield, Acting First-class Assist. Engineer to the *Fisgard* as Supernumerary; J. A. Cawlay, Second-class Assist. Engineer, to the *Cumberland*, as Supernumerary; A. M. Boumage, J. W. Haves, G. J. Weeks, W. T. Pover, and G. H. Barnes, Acting Second-class Assist. Engineers, to the *Asia*, as Supernumeraries; S. J. Rock, Acting Second-class Assist. Engineer, to the *Narcissus*; F. Brockton, T. Clark, W. Gentles, and J. F. Hughes, Engineers, to the *Vigilant*; J. Knight, Engineer, to the *Cumberland*, for the *Cochin*; W. W. Williamson, promoted to be Inspector of Machinery afloat; P. Steel and R. J. Hay, Chief Engineers, to the *Cumberland*, for the *Atlas* and *Bristol* respectively; J. F. Channon, Engineer, to the *Indus*, as Supernumerary; T. Rose, First-class Assist. Engineer, to the *Indus* for the *Fervent*; M. J. Sprake, Acting Second-class Assist. Engineer, to the *Asia*, for the *Frederick William*; S. Swan, Engineer to the *Victory*, for the *Sprightly*; R. E. Davison, in the *Petrel*, promoted to Engineer; W. B. Trenwith, Second-class Assist. Engineer, to the *Megara*; W. Crichton, Acting Second-class Assist. Engineer, to the *Russell*.

## MILITARY ENGINEERING

RESIGNATION OF SIR WILLIAM ARMSTRONG.—Sir William Armstrong has sent in his resignation of the official position he has held for the last three or four years as ordnance engineer and superintendent of rifled ordnance construction in the War Department. The causes assigned for the step are, it is stated, wholly unconnected with the forthcoming experimental trials between the Armstrong and Whitworth guns, and Sir William only retires that he may attend more closely than his duties permitted him, to the extensive works of the Elswick Ordnance Company, in the success of which he has so large an interest. That company will, as hitherto, continue to manufacture rifled ordnance, both for the army and navy.

## LAUNCHES OF STEAMERS.

LAUNCH OF AN AUSTRALIAN AND NEW ZEALAND MAIL STEAMER.—On the 7th ult., the *Paulet*, destined to convey the mails between Australia and New Zealand, was launched from the building yard of Messrs. Charles Mitchell and Co., at Low Walker, on the Tyne. She is an extremely handsome vessel. No expense has been spared in fitting her up for the extensive passenger trade between the two colonies; and among the modern improvements introduced into the cabin arrangements of this vessel is one that will be very acceptable aboard steamships in warm climates. A separate steam engine is to be erected on board this vessel for the purpose of thoroughly ventilating the holds, cabin, engine-rooms; and so completely will the system be carried out, that each private cabin will be provided with a ventilating tube, so that each passenger will have the opportunity of regulating the draught to suit his individual convenience. The machinery to drive the *Paulet* is of 150 horse-power, and has been manufactured by Messrs. R. Morrison and Co., Newcastle. By the use of surface condensers, there will be a considerable economy in the consumption of fuel.

LAUNCH OF THE "LOTUS."—On the 21st ult., this fine screw steamer was launched from the building yard of Messrs. C. and W. Earle, Hull. She is intended for the Mediterranean trade, and is owned by Messrs. J. Moss and Co., Liverpool. The registered tonnage of the *Lotus* is 500 tons; her actual burden, however, will be about 800 tons, and her dimensions are—Length over all, 220ft.; breadth, 24ft.; and depth, 15ft. 2in.

## TELEGRAPHIC ENGINEERING.

THE TELEGRAPH TO INDIA COMPANY.—The half-yearly general meeting of this company has been held. The directors in their report, after referring to previous transactions in connexion with the Persian Gulf line, and stating that the directors had found it necessary to discontinue for the present the station at Jubal, proceeded to state that they considered it the best course in the interests of the company to make arrangements with Messrs. Glass, Elliott, and Co., the lessees of the Malta and Alexandria cable, for working the Alexandria and Suez line for four years from 1st January, under which the line is to be worked and maintained in good condition, without any charge upon the company, by the lessees, who are to pay the company, so long as the Malta and Alexandria cable continues in working order, £2500 a year during the term of the lease. This will enable the board, unless any unforseen accident arises, to pay a dividend to the shareholders during the next four years of from 4 to 5 per cent. per annum. With regard to the Persian Gulf Telegraph the directors have applied for and obtained the sanction of his Highness the Viceroy of Egypt to construct a line to El Arish, with a view to completing the further communication to Beyrout, Iscanderoon, or Aleppo, and so connecting this company's line with Constantinople by one about to be constructed by the Ottoman Government from Diarbekir, on the direct line from Constantinople to India, and also by the Persian Gulf Telegraph with India. By this short and inexpensive addition the value of the company's property, in the opinion of the directors, will be materially increased, but they are advised that it would not be competent to the Company to make the line to Beyrout.

AN ELECTRIC TELEGRAPH ACROSS THE MERSEY.—In consequence of the frequent accidents to the submarine cable across the Mersey, through the fouling by ships' anchors, the cable has been taken up, and at present messengers perform the communications. It is, however, intended to erect on each side of the river two iron pillars, of about 240 feet in height, and on these to extend a strong steel wire, to which will be fastened the telegraph wires. The distance across the Mersey, where it is to proposed to erect these pillars, is about 1300 yards. In connection with the proposed alteration—which seems a very feasible one—we understand that there will be a submarine cable laid between the different lightships outside the port and the shore, which will be of immense service to the mercantile community, as it will accelerate the reporting of vessels off the port, and, in cases of storm, the position of vessels in distress, &c.

SUBMARINE TELEGRAPHY.—Although submarine telegraphy is an industry which only dates from 1851, it appears that the length of cable submerged to the present date is calculated at 15,176¼ miles. The following is a list of the principal cables laid by English firms up to 1857:—From Dover to Calais, 27 miles, laid in 1851 by Messrs. Wilkins and Wetherley, Messrs. Newall and Co., Messrs. Ruper and Co., and Mr. Crampton; from Holyhead to Howth, 73 miles, laid in 1852 by Messrs. R. S. Newall and Co.; from Denmark across the Belt, 18 miles, laid in 1853 by Messrs. R. S. Newall and Co.; from Dover to Ostend, 80¼ miles, laid in 1853 by Messrs. R. S. Newall and Co. and Messrs. Ruper and Co.; across the Firth of Forth, five miles, laid in 1853 by Messrs. R. S. Newall and Co.; from Portpatrick to Donaghadee, 25 miles, laid in 1853 by Messrs. R. S. Newall and Co.; from England to Holland, four separate cables of 120 miles each, laid in 1853 by Messrs. R. S. Newall and Co.; from Portpatrick to Whitehead, 27 miles, laid in 1854 by Messrs. R. S. Newall and Co.; from Sweden to Denmark, 12 miles, laid in 1854 by Messrs. Glass, Elliott, and Co.; from Holyhead to Howth, 73 miles, laid in 1854 by Messrs. Newall and Co.; from Italy to Corsica, 110 miles, laid in 1854 by Messrs. Glass, Elliott, and Co.; from Corsica to Sardinia, 10 miles, laid in 1854 by Messrs. Glass, Elliott, and Co.; from Varna to Constantinople, 172 miles, laid in 1855 by Messrs. R. S. Newall and Co.; from Varna to Balaklava, 356 miles, laid in 1855 by Messrs. R. S. Newall and Co.; a cable, 10 miles

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in length, laid off the Egyptian coast in 1859 by Messrs. Glass, Elliott, and Co.; from Italy to Sicily, five miles, laid in 1855 by Messrs. Glass, Elliott, and Co.; from Newfoundland to Cape Breton, 85 miles, laid in 1856 by Messrs. Glass, Elliott, and Co.; from Prince Edward's Island to New Brunswick, 12 miles, laid in 1856 by Messrs. Glass, Elliott, and Co.; in Norway across Fiords, 40 miles, laid in 1857 by Messrs. Glass, Elliott, and Co.; from Sardinia to Malta and from Malta to Corfu; 760 miles, laid in 1857 by Messrs. R. S. Newall and Co.; across the mouths of the Danube, three miles, laid in 1857 by Messrs. Glass, Elliott, and Co.; from Ceylon to the mainland of India, 30 miles, laid in 1857 by Messrs. Glass, Elliott, and Co.; from Sardinia to Bona, 125 miles, laid in 1857 by Messrs. R. S. Newall and Co. In 1858, 1859, 1860, 1861, and 1862, the submersion of telegraph cables proceeded in an accelerated ratio, only 2467 miles out of the 15,784½ miles indicated above having been thus far recapitulated.

Telegraphs Bill.—The object of the bill brought before Parliament by the Board of Trade is to make general regulations in respect to all telegraph companies, existing and future, but not to affect existing companies in respect of a past exercise of powers. No telegraph, above ground, is to be placed within 10 yards of a dwelling house worth £20 a year, or across an avenue, or approach to such house, without the consent of the occupier of the house. But a subsequent provides that, where the body having the control of a street consents to a telegraph being placed along it, that consent is to be sufficient authority for placing the telegraph along or over any land or building "adjoining to, or near the street," but not directly over any building if the owner or occupier objects. Any person in the employment of a telegraph company wilfully or negligently delaying a message, or improperly divulging its purport, is to be liable to a penalty not exceeding £20. Every telegraph is to be open to all persons without favour, or precedence, except that messages on her Majesty's service are to have precedence if required by any department of the Government. Telegraphs also may be taken possession of for Her Majesty's service, if the Secretary of State is of opinion that an emergency has arisen in which it is expedient for the public service that the government should have control over the transmission of messages; the company to be compensated according to the average profits of the previous three months.

## RAILWAYS.

Spanish Railways.—The Madrid, Saragossa, and Alicante Railway Co., have opened another section of their wide network, which, when completed, will control over 700 miles. The section now made available lies between Murcia and Carthagena, and is 40 miles in length. The receipts of the system are steadily extending, and when the Saragossa division, which will open communication between France and Spain is completed, the earnings, it is calculated, will be at least £1,000,000, per annum.

A Barcelona paper announces that the construction of the railway of San Juan de las Abaderas has been conceded to M. Bengoechea, the representative of a London house, who offered to take it for a term of ninety years without any subvention from the Government. There were eight tenders in all.

The Toulon and Nice Railway.—It is announced that the section of this railway between Arc and Cagnes is ready for traffic, as a first experimental journey, made by a train carrying the engineers and principal officials, has been attended with perfect success.

Double-acting Ventilator for Railway and other Carriages.—An ingenious and simple apparatus for this purpose has been patented by Mr. H. Wignell. It is intended to be inserted in a convenient position, such as above the glass slide in the door of the carriage, and may be briefly described as consisting of a double tube, put together in a T form, and inserted horizontally, so that the mouth of the inlet-tube will open forward on the route of the carriage, while the mouth of the outlet-tube opens in the opposite direction. There are, of course, intetior openings, one for admitting the fresh air, and the other for egress of the foul.

The Midland Railway.—This company are about to ask for Parliamentary powers to construct a line of 51½ miles, giving them an independent entrance into London. The line is to extend from Bedford by way of Ampthill, Luton, and St. Albans, to London. Its estimated cost is £1,750,000. The Midland Company also propose to raise £1,140,000 this session for other purposes.

Great Western Capital Expenditure.—The expenditure on capital account to the 31st of December, 1849, amounted to £10,917,378, including £1,016,582 for working stock; and from the latter date to the 31st December last, the expenditure on branch and extension lines, including £650,752 for new station at Paddington; £874,036 for additional rolling stock; and £817,684 expended on joint account, amounted to £11,247,371; and in addition to this, the aggregate sum of £2,208,567 had been subscribed towards twelve other undertakings, connected with Great Western railways, making the total expenditure on capital account by the Great Western Company £24,378,316, leaving a balance of £598,873.

Locomotives.—It appears that the number of locomotives possessed by English railway companies at the close of 1861 was 4966. The Scotch companies had 848 and the Irish 352, making a total of 6156. At the close of 1860, the number possessed by the companies was only 5801, showing an increase in 1861 of 355. Having regard to the depreciation of existing stock, and the demand for engines for new lines, it is probably within the mark in estimating that 500 additional locomotives will be required in the British Isles alone for the next ten years.

Railways in Bavaria.—At the end of 1861 the entire length of railway opened in Bavaria was 703 English miles. The cost of construction has been on an average 224,570fl. per kilometre (⅛ of a mile). The rolling stock consisted of 298 locomotives, 590 carriages, and 4059 waggons and trucks for merchandise, &c. The carriages contained 20,747 places: 1159 first class, 5708 second, and 13,880 third. The locomotives cost 7,356,224fl., the carriages 1,326,184fl., and the waggons and trucks 7,074,966fl., making a total of 15,757,374fl., or 33,785,800f. The net profit of the working, deducting all expenses, amounted to 4,011,123fl., or 7292f. per kilometre.

Railways in India.—The length of railway now opened in British India is as follows:—On the Great Indian Peninsula system, 495 miles; on the East Indian, 750½ miles; on the Madras, 448 miles; on the Bombay, Baroda, and Central India, 167½ miles; on the Scinde, 105 miles; on the Punjaub, 32 miles; on the Eastern of Bengal, 110 miles; on the Calcutta and South Eastern, 28½ miles; and on the Great Southern of India, 79 miles; making an aggregate of 2235½ miles.

French Railway Traffic.—The traffic receipts on the principal French lines were as follows:—On the Paris and Mediterranean for the year 1862 the traffic receipts amounted to 155,462,973f. (£6,218,513), against 144,473,601f. (£5,778,944) in 1861, showing an increase of 10,989,371f (£439,569). On the Eastern of France to 67,139,427f. (£2,685,577) in 1862, against 69,632,617f. £1,785,305) in 1861, showing a decrease of 2,496,190f (£99,728). On the Paris and Orleans to 75,624,900f. (£3,024,996) in 1862, against 76,683,428f. (£3,027,337) in 1861, showing a decrease of 58,528f. (£2341). On the Northern of France, 68,452.833f. (£2,738,113) in 1862, against 65,333,627f. (£2,613,345) in 1861, showing an increase of 3,119,204f. (£124,768). On the Western of France to 53,210,542f. (£2,068,422) in 1862, against 55,213,554f. (£2,208,542) in 1861, showing a decrease of 3,003,012f. (£120,120). On the Southern of France to 33,572,809f. (£1,342,912) in 1862, against 30,063,648f. (£1,202,546) in 1861, showing an increase of 3,509,161f. (£140,366). On the Lyons and Geneva to 6,914,641f. (£276,585) in 1862, against 7,026,795f. (£281,072) in 1861, showing a decrease of 112,154f. (£4,486). And on the Ardennes to 5,954,688f. (£238,188) in 1862, against 4,115,520f. (£164,621) in 1861, showing an increase of 1,839,169f. (£73,567). The aggregate receipts for the year 1862 on these lines, 10,941 kilometres in length (6814 miles), amounted to 465,332,813f. (£18,613,312), and for the year 1861, on 9630 kilometres (5985 miles),[1] to 451,548,789f. (£18,061,712), with an increase of 629 miles and of 13,790,024f. (£551,601) in the receipts, of which increase, 13,003,835f. (£520,113) was on 1072 kilometres (1288 miles) of new lines of railway included above.

## RAILWAY ACCIDENTS.

Railway Accident on the Blackwall Line.—A serious accident, unattended with loss of life, occurred on the Bow Extension of the Blackwall Railway, on the 9th ult. A heavy goods train was sent down from Camden-town to Haydon-square, and while passing over a viaduct not far from the Regent's-canal, a truck near the centre of the train got off the rails, and dragged all behind after it. The couplings held with more than usual tenacity, and the waggons became heaped up, one on another, in inextricable confusion. Before the engine-driver discovered the accident, and could bring the train to a standstill, the waggons had dashed against the parapet of the viaduct, knocking down a large part of the brickwork, and some portions of the train itself went over into the road below. There was a great destruction of property, and the traffic was stopped for the greater part of the day.

Railway Accident at Preston.—On the night of the 4th ult., an accident occurred on the Lancaster and Carlisle Railway Company's line at Preston. About eleven o'clock the train from Scotland and the North of England to London, &c., which was due at Preston at 10.40, but which had been delayed on the road, was proceeding along the line near Maudland Bridge, when a goods waggon, which had been placed in a coal siding, by some means broke loose and ran into the latter portion of the train, smashing four or five carriages and a van, and seriously injuring many of the passengers.

Accident at the Crewe Station.—The passengers by the Irish "limited" mail train on the London and North-Western Railway had a very narrow escape on the 18th ult. The train, which is due at Crewe about 2·30 a.m., but does not stop there, dashed though the station at its usual speed, and had not proceeded very far beyond the bridge that crosses the line, when, from some cause, several of the carriages ra off the line and were much broken, and the passengers much shaken, but none were seriously injured.

Destruction of the Kidderminster Railway Station by Fire.—About half-past twelve o'clock on the night of the 14th ult., it was discovered that the Kidderminster railway station of the West Midland line, was on fire. Assistance speedily arrived, but a sufficient supply of water could not be obtained for the engines, which, after some delay, made their appearance, and the station, telegraph office, and all Messrs. Smith and Sons' books, papers, newspapers, &c., were destroyed. After levelling the whole of the station to the ground, the flames next extended to the refreshment rooms (which, had the water been plentiful, might have been saved), and this shared the same fate as the rest. The telegraph wires were also destroyed.

## ACCIDENTS TO MINES, MACHINERY, &c.

Fatal Colliery Accident at Leeds.—On the 9th ult. an accident of an alarming character took place at the Neville-hill Colliery, Leeds. For some time past, workmen have been engaged in deepening and repairing an old shaft, and at the time of the accident, two men were employed upon a "cradle," about seventeen yards from the bottom, when, without the slightest warning, the sides of the shaft collapsed, breaking down the scaffolding, and burying the two men beneath from eight to ten tons of *debris*.

Colliery Explosion at Aberdare.—An explosion took place in the Navigation coal-pit at Mountain Ash, on the 7th ult. It would seem that there was no night shift, fortunately, and only a relay of men went down, after the day men ascended, to repair the pit. It was when they were at work that the explosion occurred. Two miners only met with their death, the remainder being soon rescued.

The East Cowes Gasometer exploded at four o'clock on the afternoon of the 29th January last. The manager, Mr. G. S. Bellows, and a son of the steward of Parkhurst Prison, were killed. [We have since been informed that it was not the gasometer, but the station meter which exploded.]

## GAS SUPPLY.

Gas Dividends.—The Worcester Gas Company have declared a dividend of 10 per cent. for the past half year. The Chester United Gaslight Company have also declared the same dividend; and have reduced their price so far as by granting 2½ per cent. discount on speedy payments. The Stoke, Fenton, and Longton Company have declared a dividend of 8 per cent., and state that an enlargement of their works has become necessary. The Collingham Company have declared 6 per cent., besides a reserve. The Crowle Gas and Coke Company have declared a dividend of 10 per cent., leaving a balance in hand. The Alnwick Company have declared a dividend of 10 per cent., and resolved to reduce the price of gas 6d. per 1000 cubic feet, making it 5s. per 1000.

The Manchester Gas Committee have recommended the following reduced scale of charges in townships beyond the city on the near side of the Mersey, viz.:—When the quarterly consumption is under 500,000ft., 4s. 3d. per 1000ft.; 500,000ft. and under 1,000,000ft., 4s. 2d.; 1,000,000ft. and under 1,500,000ft., 4s. 1d.; 1,500,000ft. and upwards, 4s. In the district beyond the Mersey they recommend that the present price, 4s. 6d., should be continued.

## SEWERAGE WORKS.

The Fleet Sewer.—The extensive works in connection with carrying the Fleet sewer over the eastern curve of the Metropolitan Railway at King's-cross, which for some time has been in course of construction for the junction of the Metropolitan Railway with the Great Northern are completed. The water is carried through an iron channel, which is let into the top of the arch of the railway. The channel is 40ft. in length, 8ft. wide, and 9ft. high; and so important was the work considered, that the Metropolitan Board of Works sent Mr. Raeburn, clerk of works, to superintend its construction. Before the water was allowed to pass through, the channel was tested, both by Mr. Raeburn and Mr. Cordell, the manager for Mr. Jay, the contractor. The weight of the test was no less than 35 tons—a far heavier weight than the channel will ever be called upon to bear; but so substantial is the work, that the deflection was found to be only one-eighth of an inch.

## CANALS.

Irrigation and Canal Works in India.—A contract has been executed by the Governor General of India and the above Company, for the construction of their scheme of works in Orissa, and the adjacent districts towards Calcutta. This is the first instance in which clauses of arbitration have formed part of the contract between the Government of India and a private company. The plans and estimates of a canal from the Hoogly to Balasore, 95 miles in length, are now complete, and its construction has been or is about to be immediately entered upon. The Government view this line from Calcutta to Balasore, as one of great importance, and express a strong wish for its completion as quickly as possible, so that there is every probability of the work progressing very rapidly.

## BOILER EXPLOSIONS.

The Manchester Association for the Prevention of Steam Boiler Explosions.—A special meeting of the executive committee of this association was held on January 20th, 1863; in order to take into consideration a retrospect of the transactions of the association during the past year of 1862; when Mr. L. E. Fletcher, chief engineer, presented his annual report relating to matters of an engineering character, from which the following facts are extracted:—"The defects discovered in boilers are mainly of two classes

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one relating to their construction and the other to their condition. Under the first head, namely, that of construction, 196 recommendations had been made, which are as follows:—In 153 boilers the internal flue tubes have been recommended to be strengthened by hooping. In 18 boilers the shells have been recommended to be strengthened at the steam domes by stays of angle iron, &c. In 9 boilers the shells have been recommended to be strengthened at the ends. In 16 boilers the load on the safety valves have been recommended to be reduced. Under the second head, namely, that of condition, 85 defects have been discovered, all of which were considered dangerous, they are as follows:—Fracture of plates and angle irons, 13; blistered plates, 1; furnaces out of shape, 12; corrosion, 37; defective safety valves, 5; defective water gauges, 9; defective blow-out apparatus, 7; others not actually dangerous, but still unsatisfactory, were then given, which need not here be repeated. The report then went into a detailed consideration of the defects discovered under each of the above heads; some of the remarks on corrosion may be given. Corrosion is found to be going on in all boilers, more or less, and it will be seen that the greatest number of dangerous defects in the preceding table are to be found under this head. In one case a boiler set upon a mid-feather wall 15in. thick, had a channel eaten right along it about 8in. wide, which ran down the centre of the seating, while the plates at the edges of the brickwork appeared quite sound, and the danger consequently passed for some time unsuspected. In a second instance, with a mid-feather 2ft. wide, the plate was found to be eaten almost through from nearly one end of the boiler to the other—while in a third, where lime had been allowed to come in contact with the boiler at the mid-feather, the plate was completely pulverised and could be carried away in handfuls. In a fourth case, a vertical tubular boiler had been placed close to a wall, one part being in actual contact. Damp in the brick-work set up corrosive action in the plate, which being concealed by the position, went on undetected until the metal was completely eaten through, and a piece blown out by the pressure of the steam. The original plating of the boiler was thick, the pressure low, and the corrosive action local, only affecting a surface of about 12in. square, so that the rent did not extend. Examples of corrosion might be multiplied indefinitely; enough, however, has been said to show the importance of having all parts of the boiler accessible to examination, the flues sufficiently capacious, and the seatings as narrow as possible, and also of having the brickwork removed occassionally, at all events in places, so as to ascertain the condition of the plates, since to conclude that the parts concealed are in the same condition as those in view has been found in practice to be fallacious. Under the head of explosion it was stated:—It is to be regretted that no means exist of ascertaining the whole number of steam boiler boiler explosions that occur throughout the United Kingdom, and there can be no doubt that many are never recorded at all. There are known, however, to have occurred during the last year, no less than 31 explosions, from which at least 87 persons have been killed, and 88 injured. Of the number of lives lost by some of the above, no account could be obtained; while from one of them, as many as 29 persons were killed and 12 injured; from a second, 12 were killed and 24 injured; and from a third, 6 were killed and 8 injured. The following list gives the description of boiler to which the explosions have occured, with the number of each class, as well as of the persons killed and injured:—4 haystack boilers—12 persons killed and five injured; 6 plain cylindrical egg-ended boilers—6 persons killed and 6 injured; 3 iron works boilers—47 persons killed and 44 others injured; 3 plain single-fued cornish boilers—2 persons killed and 2 others injured; 2 plain double-flued Lancashire boilers—4 persons killed; 3 locomotive boilers—4 persons killed and 2 others injured; 1 agricultural boiler of tubular portable construction—4 persons killed and 4 others injured; 1 kitchen range boiler—1 person killed. Also 8 other boilers, of the construction of which no reliable information could be obtained, but from the explosion of which 27 persons were killed and 22 others injured. An analysis of the causes of explosion then followed, the summary of which only can be given:—Of 31 explosions which have happened during the year 1862, 11 occured to externally fired boilers, from failure of the plates exposed to the action of the fire; 3 resulted from internal corrosion, and 3 from external; in addition to which, 4 were due to improper original construction, one to shortness of water, and another to accumulated pressure through want of a safety valve; while 7 occurred at a distance which precluded a personal investigation of their causes, at the same time that no reliable information could be obtained with regard to them.

CEMENTATION OF STEEL.—An invention has been patented by a gentleman in Paris, according to which he claims the application of wood divided into small parts, such as sawdust, the leaves of trees, and the envelopes of certain fruits for the cementation of the pieces of cast or forged iron to form steel suitable for the manufacture of cutlery, rails, tyres of wheels, and other articles.

## MINES, METALLURGY, &c.

LEAD MINES.—The number of lead mines worked in Cornwall in 1861 was 44; in Devonshire, 11; in Cumberland, 79; in Northumberland and Durham, 39; in Westmoreland, 6; in Cheshire, 1; in Shropshire, 9; in Yorkshire, 30; in Somersetshire, 4; and in Staffordshire, 1; making a total for England of 224. As regards Wales, the county of Cardigan had 43 mines at work in 1861; Carmarthenshire, 3; Denbighshire, 14; Flintshire, 48; Montgomeryshire, 14; Merionethshire, 3; Pembrokeshire, 1; Radnorshire, 2; Carnarvonshire, 19; making a total of 147. The Isle of Man at the same time had 5 mines worked; Scotland, 7; and Ireland, 7; making a total for the United Kingdom of 390, as compared with 380 in 1860. and 264 in 1859. The quantity of ore raised does not show a corresponding increase. The metallic lead produced from this aggregate of ore was 65,634 tons in 1861, against 63,317 tons in 1860, and 63,233 tons in 1859.

TWELVE YEARS OF PIG IRON.—The computed make last year was, in round figures, 1,080,000 tons, as compared with 1,010,000 in 1861, 990,000 tons in 1860, 960,080 tons in 1859, 980,800 tons in 1858, 910,080 in 1857, 820,000 in 1856, 692,800 tons in 1825, 775,000 in 1854, 710,000 in 1853, 770,000 tons in 1852, and 775,000 tons in 1851. The production, last year, therefore, showed an increase of 305,000 tons or 30·35 per cent., as compared with 1851,—an astonishing advance in so brief a period. The total consumption scarcely kept pace with the production, having amounted to 978,000 tons last year, as compared with 935,000 tons in 1861, 917,000 in 1860, 910,000 tons in 1859, 833,000 in 1858, 840,000 tons in 1857, 830,000 tons in 1856, 842,000 tons in 1855, 885,000 tons in 1854, 935,000 tons in 1853, 680,000 tons in 1852, and 695,000 in 1851. The consumption last year, therefore, showed an increase of 283,000 tons, or 42·72 per cent. as compared with 1851, the deliveries last year having been in excess of any former 12 months, notwithstanding the general depression of trade. The stock, however, increased 102,000 tons last year; 75,000 tons in 1861, 73,000 tons in 1860; 50,000 tons in 1859, 147,000 tons in 1858, 70,000 tons in 1857, 90,000 tons in 1853, and 80,000 tons in 1851; in 1856 it decreased 10.000 tons; in 1855, 20,000; in 1854, 60,000; and in 1853, 225,000; but the general result was to increase the stock, December 31, 1862, to 637,000 tons, as compared with 350,000 tons, December 31, 1851. The shipments last year amounted to 871,000 tons, and the local consumption to 407,000 tons; in 1861 the shipments were 585,000 tons, and the local consumption 350,000 tons; in 1860 the shipments were 567,000 tons, and the local consumption 343,000 tons; in 1859 the shipments were 567,000 tons, and the local consumption 343,000 tons; in 1858 the shipments were 559,000 tons, and the local consumption 275,000 tons; in 1857 the shipments were 538,000 tons, and the local consumption 312,000 tons; in 1856 the shipments were 595,000 tons, and the local consumption 325,000 tons; in 1855 the shipments were 542,000 tons, and the local consumption 300,000 tons; in 1854 the shipments were 542,000 tons, and the local consumption 300,000 tons; in 1853 the shipments were 635,000 tons, and the local consumption 300,000; in 1852 the shipments were 434,900 tons, and the local consumption 245,100; and in 1851 the shipments were 452,700 tons, and the local consumption 242,300 tons. The average number of furnaces in blast last year was 120, as compared with 123 in 1861, 121 in 1860, 124 in 1859, 129 in 1858, 138 in 1857, 117 in 1856, 117 in 1855, 116 in 1854, 111 in 1853, 110 in 1852, and 114 in 1851. The increase in the number of furnaces in blast was consequently only 5·26 per cent. last year, as compared with 1851, while the production increased in the same period as before indicated 39·35 per cent.; this discrepancy is to be attributed to the large increase in the results obtained from each furnace of late years. Notwithstanding the growth of the stock the average price realised last year was 53s. per ton as compared with 49s. 3d. per ton in 1861, 53s. 6d. per ton in 1860, 51s. 9d. per ton in 1859, 54s. 5d. per ton in 1858, 69s. 3d. per ton in 1857, 72s. 6d. per ton in 1856, 70s. 9d. per ton in 1855, 79s. 8d. per ton in 1854, 61s. 5d. per ton in 1853, 45s. 3d. per ton in 1852, and 40s. per ton in 1851. The increase experienced in the demand last year, and the consequent firmness in prices is attributed to the large demand for iron for shipbuilding purposes.

## APPLIED CHEMISTRY.

ZINC WASH FOR ROOMS.—Mix oxide of zinc with common size and apply it with a brush, like lime whitewash to the ceiling of a room. After this apply a wash in the same manner of the chloride of zinc, which will combine with the oxide and form a smooth cement with a shining surface.

THE PRESENCE OF ARSENIC IN THE SO-CALLED PURE COMMERCIAL HYDROCHLORIC ACID, BY M. GLÉNARD.—So-called pure hydrochloric acid, sold by the manufacturers of chemical products, is often as arseniferous as the crude acids. Twice has M. Glénard, at a year's interval, examined numerous specimens of hydrochloric acid considered as pure. In two specimens very recently examined he found 2·5 grammes of arsenious acid per kilogramme. According to M. Glénard, the presence of arsenic in hydrochloric acid may prove very injurious in the preparation of certain pharmaceutical products. It is, then, important that pharmaceutists should be aware of this fact, and abstain from employing hydrochloric acid which they have not previously tested carefully. The examination is attended, fortunately, with no difficulty. It is only necessary to mix the acid to be tested with its volume of a solution of hydrosulphuric acid, or to pass into it, during a few minutes, a current of this gas; or, better still, to throw into it a few morsels of artificial sulphide of iron. Under these three conditions, the acid, if it contains arsenic, will become troubled, owing to the separation of the yellow sulphide of arsenic. But how to obtain pure hydrochloric acid? M. Glénard proposes:—1st. The direct preparation of this acid; 2nd. The purification of commercial acid. In the direct preparation, the first step is to ascertain that the sulphuric acid is free from arsenic; otherwise, the arsenic, transformed during the preparation of the hydrochloric acid into very volatile chloride of arsenic, will escape with the acid, and with it become condensed in the water. The first thing to do is to eliminate the arsenic from the sulphuric acid. To effect this, the acid is diluted with half its weight of water, and to it is added a little hydrochloric acid, and then a current of hydrosulphuric acid gas is passed into it. The arsenic soon separates in the form of sulphide. It is next filtered through a funnel packed with amianthus, then heated in a capsule, to expel the excess of sulphurretted hydrogen, and to bring it to 60° of Baumé's areometer. The sulphuric acid thus purified is employed in the ordinary way, and furnishes perfectly pure hydrochloric acid. After describing the simple and ingenious process which consists in disengaging, by means of concentrated sulphuric acid, the hydrochloric gas contained in commercial acid, and in condensing this gas in distilled water, M. Glénard proposes the following method:—Into the crude acid to be purified a current of hydrosulphuric acid is passed until all the arsenic is precipitated. The sulphide of arsenic is separated either by letting the acid stand or by filtering it through a funnel packed with amianthus. Should the filtered liquid contain excess of sulphuretted hydrogen, some grammes of a concentrated solution of perchloride of iron are added, which destroys the hydrosulphuric acid, becoming reduced to protochloride. As the hydrochloric acid would then contain only fixed matters, it could then be rectified. Hydrochloric acid gas is displaced by means of sulphuric acid freed from arsenic.

PROCESS FOR EXTRACTING SODA FROM CRYOLITE.—Take eight tons of cryolite to eleven tons of chalk or calcareous stone, and pulverise separately, as fine as possible, by vertical mill-stones, and sift, still separately, through movable tammies; then mix, and re-grind by vertical mill-stones. (The portions of cryolite and chalk remaining in the tammies are again ground and sifted separately, then mixed and re-ground as in the first operation.) The mealy powder produced in this way is placed in furnaces constructed for the purpose, wherein it is baked and constantly stirred with iron instruments. During baking, the material must be carefully watched, to prevent it from fusing. When at white heat, it is taken from the furnace, and, when sufficiently cooled, to be sifted through an iron sifter; the lumps which may have agglutinated during the baking are separated. (After eight days, when, from the influence of the air, these morsels have lost some of their coherence, they are ground before being re-baked.) The calcined product is sifted and put into washing-tubs, and boiling water poured upon it, until no more soda remains to be extracted. The lixivium is conveyed into reservoirs intended to receive the carbonic acid destined for the saturation. The carbonated lixivium is directed into receivers, at the bottom of which clay is deposited. After clarification, the supernatant liquid is pumped, either into evaporating pans, to be reduced to the point necessary for crystallisation, or into calcining vessels, if salt of soda is to be produced. Carbonic acid is obtained from the furnaces used to calcine the mixture, whence it is conducted by canals into a purifying apparatus, and thence into its reservoirs (iron cylinders; the boilers of a steam-vessel will answer the purpose.) This operation, during which three tons of coal are burnt, produces 175 kilog. of crystals of soda, and 16 kilog. of pure alumina per 100 kilog. of cryolite. Theoretically, the 100 kilog. of cryolite ought to yield 204 kilog. of crystals of soda, and 24 kilog. of alumina. The alumina is used in manufacturing alum, sulphate of alumina, aluminate of soda, or aluminium.

METHOD OF DECOMPOSING ROCK SALT.—Sea salt in the state of rock salt, and sulphate of lime in the state of anhydrite, gypsum, or plaster stone, are always found in proximity in the mineral kingdom, particularly in variegated marls. Of this we have a striking example in the lower strata of the department of the Meurthe. Sulphuric acid, lime, chlorine, and sodium, when associated, are arranged so as to form on one side sulphate of lime, and on the other chloride of sodium. It will be admitted that it is under these forms that the above substances manifest the greatest degree of stability, and not as sulphate of soda and chloride of calcium. An inverse arrangement has been in vain attempted. *A priori*, the thing is not feasible when the operation is confined exclusively to these substances. A different result altogether is obtained by calcining the mixture of these two salts, after adding to them a certain amount of peroxide of manganese. In this case sulphate of soda is always produced. In this operation the theory which guided M. Nicklès is exceedingly simple: he counted on the possibility of displacing the chlorine of chloride of sodium by the oxygen of a peroxide; for instance, peroxide of manganese, to obtain the soda necessary for the production of sulphate of soda. This, in fact, takes place; the displaced chlorine is disengaged, the crucible retains sulphate of soda, lime, and any excess of the manganese and sulphate of lime employed. The maximum of sulphate of soda which M. Nicklès has been able to obtain, under these conditions, is 15 per cent. It would, no doubt, be difficult to exceed this quantity, on account of the volatilisation of the chloride of sodium, —volatilisation which takes place just about the temperature at which the above decomposition is effected.

CARBONIC ACID AS AN ANESTHETIC.—M. Oznum has given a mixture of three parts carbonic acid with one part atmospheric air with success as an anæsthetic. After breathing it for ten minutes the patient became insensible, and an operation was performed without his evincing any sign of pain.

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## LIST OF APPLICATIONS FOR LETTERS PATENT.

We have adopted a new arrangement of the Provisional Protections applied for by Inventors at the Great Seal Patent Office. If any difficulty should arise with reference to the names, addresses, titles given in the list, the requisite information will be furnished, free of expense, from the office, by addressing a letter, prepaid, to the Editor of, "The Artizan."

### Dated January 27th, 1863.

232 H. H. Henson—Fabrics.
233 C. Davies—Preserving provisions.
234 W. Gilpin & J. Hiatt—Fastenings of umbrellas and parasols.
235 C. F. Ash—Cornices, joints, and laths of bedsteads.
236 C. Askew—Railway chair and joint for rails on railways.
237 W. Rollason—Metallic boxes
238 R. A. W. Green—Light rowing boats.
239 J. Edmondson & T. Ingram—Looms and apparatus for weaving.
240 T. Gordon — Damping and affixing postage stamps to letters.
241 D. E. Hughes—Apparatus for effecting telegraphic communications.
242 W. C. Wilkins—Lamps.

### Dated January 28th, 1863.

243 H. B. Barlow—Preserving timber.
244 H. Watson—Heating arrangements of stoves for drying woven fabrics.
245 T. Parkinson—Carding engines
246 W. E. Gedge—Fastening by screws boots, shoes, and other articles composed of leather.
247 E. F. Prentiss & J. C. Sellars—Treating rock oil, petroleum, paraffine oil, coal oil, and paraffine and other mineral oils and products therefrom.
248 J. Oglesby, J. Dickinson, W. M. Dickinson, & J. Dickinson—Steaming, cooking, and generating gas.
249 H. O. Cook & E. G. Terrey—Propelling ships and vessels.
250 C. Mace—Steam engines for propelling vessels.
251 R. Ward—Locking-up or fastening forms of type or other printing surfaces.
252 F. W. Wymer—Steam engines.
253 J. Platt—Rotatory engine.
254 W. Considen—Cylindrical chromo-lithographic printing machines.
255 S. W. Francis—Revolving shutters
256 W Clark—Copying and reproducing sculpture and other objects of art
257 J. H. Johnson—Braid.
258 C. P. Stewart & J. Robinson—Giffard's injector, and the adaptation of it to locomotive and other boilers.
259 E. G. Munts—Securing axles and axle boxes.
260 H. Crichley—Reaping and mowing machines.
261 B. J'Anson Bromwich—Obtaining and applying motive power.

### Dated January 29th, 1863.

262 H. A. Bonneville—Construction of granaries.
263 T. A. Weston—Coupling and break for transmitting regulating, or arresting motion.
264 J. B. E. Louit—Glass chimneys.
265 J. Mackenzie—Shaping machines for curvilinear surfaces.
266 R. A. Brooman—Candles.
267 J. Powney—Obtaining, transferring, and printing from photographic pictures or images.
268 W. Ball & J. Wilkins—Looped fabrics.
269 J. Nadal—Fountains.
270 N. Clayton & J. Shuttleworth — Thrashing machines.
271 C. H. G. Williams—Red colouring matter.
272 A. Pritchard — Preserving the contents of packages from air, water, or damp.
273 G. Blake—Apparatus for heating and warming.
274 W. Clark—Condensation of steam.
275 J. Sainty—Feeding troughs for sheep and other cattle.
276 F. G. Stuber—Air-tight boxes, cases, cupboards, and similar vessels.

### Dated January 30th, 1863.

277 J. W. Branford—Longitudinal and transverse hoe.
278 W. E. Gedge—Cleansing chimnies and other flues.
279 W. E. Gedge — Cones for moulding refined sugar.
280 J. Cocker—Turnstile.
281 N. P. C. Lloyd—Engines.
282 W. F. Newton—Couplings for railway carriages.
283 W. E. Gedge—Hair nets.

### Dated January 31st, 1863.

284 M. Smith—Looms for weaving.
285 J. Lightfoot & F. Trachsel—Distillation of certain substances.
286 T. Bennett—Obtaining pictorial back-grounds, fore-grounds, and perspectives when taking photographic portraits or sun pictures.
287 J. Grossmith—Producing the aura electric gas.
288 F. Tolbausen—Cleaning the beams of mules and spinning frames, collecting the dust and waste thereof, and also for cleaning the flooring underneath the mule carriages.
289 W. Drummond—Stopping the supply of gas to burners when the light is put out.
290 W. A. Lytle — Cigar and tobacco smoking appliances.
291 R. B. Wilson—Supplying air, gases, steam, or fluids to iron and other furnaces, and to engines and vessels.

### Dated February 2nd, 1863.

292 F. G. Grice—Bolts, spikes, rivets, and screw blanks.
293 E. H. Massey—Compositions for coating and colouring the walls, ceilings, and other parts of buildings.
294 J. Gibson—Looms for weaving.
295 A. Forbes—Soldering together parts of vessels formed of tin or tinned plate.
296 W. C. Barnes—Shaping, rolling, or compressing metal.
297 R. H. Frith—Paper.
298 E. B Wilson—Gas.
299 W. Clark—Armour plated and other ships.

### Dated February 3rd, 1863.

300 C. & G. L. Smithies—Preparing and bleaching Rhea.
301 T. Raworth—Looms for weaving.
302 G. Holeroft—Preparing cotton for spinning and weaving.
303 S. Oddy & E. Oldfield—Carding engines.
304 J. Fletcher—Injector for feeding boilers with water.
305 A. T. Blakely & J. Vavasseur—Projectiles for ordnance.
306 T. L. Jacobe—Cleaning casks.
307 W. G. Valentin & F. Levick—Generating combustible gases.
308 W. E. Newton—Reflectors.

### Dated February 4th, 1863.

309 G. Harton—Wood paving.
310 J. Mellor—Distilling, subliming, and drying.
311 T. E. Tallent—Leather.
312 T Bradford—Washing, wringing, and mangling clothes.
313 G. Haseltine—Uniting metallic surfaces
314 G. T Bousfield—Postage, revenue, and other stamps, and apparatus for post marking and cancelling postage and other stamps.
315 J. J. Hays—Hot-air stove for purifying or filtering the gaseous products of combustion.
316 L. J. H. Marville—Covering for the ears.
317 Z. M. Parkes—Iron and other metal bond for use in building.
318 W. T. Weston, Spring Catch for windows, etc.
319 B. Russ—Iron ships or vessels.
320 C. & D. Faulkner, J. Fairley & W. C. Stiff—Gun barrels.
321 J A. Manning—Treatment of night soil.
322 W. Stokes—Window sashes.

### Dated February 5th, 1863.

323 W. T. Mabley & W. T. Cheetham—Blowing organs.
324 J. Gill & J. Parkin—Polishing yarn, twine, and threwis.
325 W. Betts — Applying metallic capsules to bottles.
326 H. Direks & J. H. Pepper—Apparatus for the exhibition of dramatic and other performances.
327 E. Ingham—Dyeing wool in the sliver.
328 R. A. Brooman—Supplying and spreading wool and other filamentous materials on belts, tables, and other surfaces, to be afterwards carded and otherwise acted on.
329 J. Paterson—Buckle and hook fastenings.
330 R. A. Brooman—Tuning pianofortes.

### Dated February 6th, 1863.

331 B. F. Bates—Cannon and projectiles to be used therewith.
332 A. Heintzmann & T. A. Rochussen—Boring bench for gun barrels.
333 T. Blakeley & B. Meakes—Lead and stone pencil sharpener.
334 A. Johnston—Propulsion of vessels.
335 G. Stevens—Effecting a regular supply of air or aeriform fluids for various purposes.
336 A. Clarke—A. Clarke—Knife-cleaning.
337 R. A. Brooman—Carding engines.
338 W. Robins—Fire lighters.
339 J. Price—Signal lanterns.
340 R. D. Tirnann—Holster boxes.
341 A. Ellissen—Treating sheeting and iron plates.

### Dated February 7th, 1863.

342 J. Cameron—Iron and alloys of iron.
343 J. Siron—Medicinal preparation for internal and external application.
344 J. Mallison—Dyeing yarns.
345 G. Turner—Mincing meat.
346 W T. Cooper—Distilling apparatus.
347 C. Parigot & A. Grivel—Eccentric locks.
348 W. Clark—Application of gas for the preparation of wood work generally and iron ships for their better preservation and reception of paint or other protecting coating, and for disinfecting ships, hospitals, and other places.
349 J. James—Covering for hooped skirts.
350 J. Miller & W. Struthers—Securing the corks, stoppers, or lids of jars and bottles.
351 M. Hackforth—Shades or reflectors.
352 G. Redrup—Cutting chives, bungs, corks, spiles, and vent or other pegs.
353 D. Groucutt—Iron for making nails.

### Dated February 9th, 1863.

354 B. Dobson & E. Barlow—Carding engines.
355 H. G. Williams & R. Price—Crushing and amalgamating auriferous quartz, and pulverizing and washing ores.
356 J. Macintosh—Obtaining and applying motive power.
357 D. Law & J. Downie—Traction engines or common road locomotives.
358 J. Goucher—Regulating the admission of air into the furnaces of steam boilers.
359 H. & J. Smith—Depositing seed and manure.
360 W. B. Roof—Respirator.

### Dated February 10th, 1863.

361 J. Crosby & J. B. Smith—Carding engines.
362 T. Hill—Protection of markers at rifle butts.
363 R. Burley — Handles for hammers, mallets, picks, and mattocks.
364 M. Wigzell—Candles, tapers, and other lights.
365 M. Cartwright—Combining plastic substances with metals.
366 J. F. Bottom—Dressing lace.
367 W. Whitaker & W. Tongue—Steeping, boiling, washing, bleaching, and dyeing fibrous materials or slivers, slubbings, rovings, yarns, or woven fabrics of the same.

### Dated February 11th, 1863.

368 A. Corneau—Hot-air stove.
369 H. Donald—Shearing, punching, and riveting metals.
370 E T. Hughes—Drilling wood, stone, iron, or other materials.
371 J. Duckworth—Paper.
372 D. Radcliffe—Valve taps.
373 C. P. Carter—Road making.
374 R. Saunders—Pavements and floors.
375 W. Symington—Weaving.
376 R. A. Brooman—Photographic apparatus.
377 E. Humphrys—Steering ships.
378 H. Wycherley—Applying wings or dirt screens

### Dated February 12th, 1863.

379 F. Oppenheim—Plastic compounds for dental purposes.
380 E. Kemp, J. Needham, & O. Robinson—Self-acting mules for spinning.
381 A. Morton—Lawn mowing machines.
382 W. Clark—Bearing surfaces of shafts and other axles.
383 S. H. Phillips—Fastening for purposes, portemonnaies, pocket books, bags, reticules, and such like purposes.
384 S. Lumb—Machinery for tenoning, grooving, sawing, and otherwise cutting wood.

### Dated February 13th, 1863.

385 G. H. Birkbeck—Extracting silver or other metals from lead.
386 S. M. Innes—Pianofortes
387 W. E. Gedge—Table apparatus for promoting the comfort of persons at sea.
388 J. Jones—Lead, tin, and other metals.
389 J. F. Spencer—Steam engines.
390 J. Robertson — Printing woven fabrics by blocks.
391 J. Grantham—Hydraulic presses.
392 W. Robertson—Machines for spinning and doubling.
393 G. Wrigley & S. Morris—Machines for spinning and doubling.
394 O. H. Hodge—Hat brims.
395 J. A. Schlumberger—Heating coal tar dead oils, and for producing phenic or carbolic acid.
396 S. Whitaker—Indicating the positions or conditions of railway signals and points.

### Dated February 14th, 1863.

397 G. Haseltine—Lever horse powers.
398 R. Begsley—Creels for warping machines.
399 J. C. Jeffcott—Production and generation of gases.
400 W. C. Paul & A. T. Shore—Spring mattresses and other articles for sitting and reclining upon.
401 J. S. Gisborne & W. Simpson—Rendering ships and other compasses insensible to local attraction.
402 H. Dembinski—Motive apparatus and processes for giving to it a continuous motion and unlimited strength.
403 W. Baylis & T. H. Hopwood—Tongs.
404 W. Wood—Cutting screws or threads.
405 J. Lewis—Driving sewing machines.
406 J. H. Walsh—Breech-loading fire arms and cartridge cases.
407 T. Thorne—Disengaging ships' boats.
408 W. Clark—Separating the fibres of straw, wood, and other vegetable substances, and extracting the gummy and colouring matters therefrom.
409 A. J. Fraser—Window furniture.
410 J & H. Higgins—Carding engines.
411 F. E. Walker—Breech-loading fire-arms.
412 J Morgan—Embalming and preserving from decay human bodies and bodies of other animals, also pickling, curing, and flavouring animal bodies.
413 J. H. Johnson—Wrought iron casements.

### Dated February 16th, 1863.

414 M. Ohren—Self-acting gas holders.
415 J. W. Crossley—Drying press papers.
416 C. D. Abel—Omnibus.
417 W. C. McEntee & G. and T. Withers—Locks.
418 J. R. Watts—Matches and swords.
419 H. Smith—Feeding horses.
420 R. A. Brooman—Protection for steel and other metal springs, ribbands, and hoops.
421 W. Jackson—Pumps.
422 J. H. Haywood & W. Vernon—Packing bonnet fronts, and rouches.
423 S. W. Clough—Signalling on railways.
424 W. Nalder—Rotatory screens.
425 T. Wilkinson—Singeing pigs.

### Dated February 17th, 1863.

426 T. W. Salmon—Washing machines.
427 J. Lee—Ploughs and harrows.
428 W. T. Dibb—Brewing.
429 W. C. Ford—Paddle-wheels.
430 J. Gunson—Punching or cutting out leather and other substances.
431 E. Deville—Floating or life preserving coats or garments.
432 J. Durant—Chimney tops.
433 G. Home—Projectiles.
434 J. W. Lane—Fasteners for studs, sleeve fasteners, solitaires, bracelets, brooches, and other uses.
435 S. Pluchart—Food for horses.
436 H. Tomlinson—Stoves or fire-places for warming apartments.
437 D. Tassin—Preventing the explosion of steam boilers.
438 E. Strawson—Finishing with greater facility articles of dress manufactured either by hand or sewing machines.

### Dated February 18th, 1863.

439 G. K. Gerelin—Perfect combustion of the various components of coal in open fire-places.
440 M. Siegrist—Atmospheric brake.
441 J. Barker and F. Moss—Portable and stationary cranes or cranes.
442 J. F. Spencer—Regulating and working the valves of steam and other engines.
443 J. H. Bly—Cooking stoves.
444 F. Johnston and R. Heatley — Looms for weaving.
445 J. Platt and W. Richardson—Cleaning cotton from seeds.
446 G. T. Bousfield—Breech-loading fire arms.
447 F. J. Reed—Traversing guns.
448 G. T. Bousfield—Boots and shoes, and preparing india-rubber for such and other uses.
449 J. Puntis and G. Cox—Appliances for displaying in the open air or indoors illuminated designs, devices, mottoes, or announcements, and in which jets of gas are employed as the illuminating agent.
450 J. Gray and J. Hudson—Treatment of steatite, and its application to certain purposes.

### Dated February 19th, 1863.

451 R. P. Roberts—Axle boxes for carriages or vehicles.
452 F. Markland and J. C. Dickinson—Warping or beaming yarns or threads.
453 W. Sherwood—Wine glasses.
454 L. A. Pouget—Oil lamps
455 R Pinkney—Metallic pens.
456 J. J. Badart—Preparation of cotton seed cake.
457 W. Trustrum—Oiled silk.
458 N. Thompson—Shaping bottles, jars, and other vessels.

### Dated February 20th, 1863.

459 H. B. Barlow—Weaving.
460 W. Marsden—Envelopes.
461 W. Marsden—Buttons.
462 C. Billingsley—Saddlery, harness, and driving straps.
463 J. Bentley and H. Booth—Looms for weaving.
464 C. W. Siemens—Insulating and supporting telegraph line wires.
465 W. Hainsworth—Cast iron pipes, columns, or any description of tubing.
466 R. Bell—Armour plating for protecting ships and vessels.
467 W. Clark—Boilers for disintegrating and pulping vegetable substances.
468 W. Clark—Projectiles for ordnance.
469 F. W. Bennoorf—Governors for regulating steam engines.
470 W. Husband and J. Quick—Raising sewage and water.

### Dated February 21st, 1863.

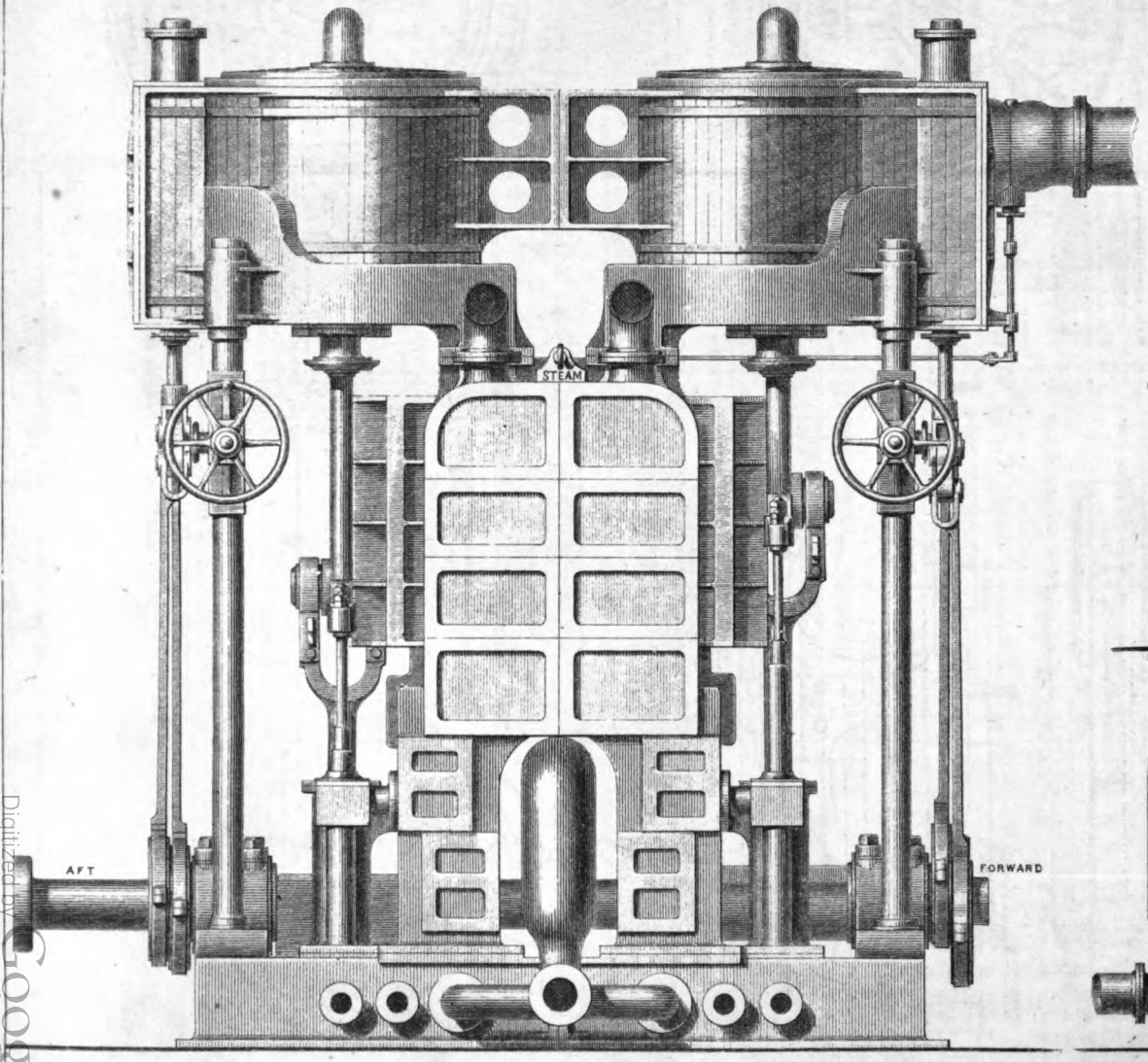
471 C. Malpas—Kilns for firing, burning, or baking pottery, bricks, tiles, and other earthen or ceramic articles.
472 R. Thompson—Moulding.
473 H. Kilshaw and T. Elce—Preparing and doubling cotton.
474 F. J. Manceaux—Fire-arms.
475 E. T. Hughes—Treatment of colouring matters derived from tar for the purpose of making them applicable for painting.
476 R. V. Dodwell—Preventing the destruction of plants by insects.
477 A. H. Remond—Preserving provisions.
478 A. Cetleur—Taking photographic impressions or likenesses by means of the camera.
479 W. Wood—Pomfret or liquorice cakes, rolls, sticks, and pipes.
480 H. Mackinder—Separating potatoes into different sizes.
481 J. Brown—Armour plates for ships.
482 A. Dugdale—Throttle valves.
483 W. E. Newton—Wind instruments of music.
484 N Wiard—Ordnance and artillery.
485 W. H. Gauntlett—Heating the blast in the manufacture of iron.
486 E. T. Hughes—Cleaning organic matter.
487 J. Eckersley—Spinning and doubling silk.
488 R. A. Brooman—Dressing millstones, ornamenting or engraving on glass, pottery, and other similar substances.
489 J. P. F. Datichy—Steam engines.
490 J. D. and A. P. Welch—Blocking and pressing hats and bonnets.
491 R. Marsdale—Lamps and burners.
492 T. R. Harding—Carding and combing flax, wool, and cotton.
493 T. and A. L. Dickens and H. Heywood—Ornamenting plush.
494 J. Tatham—Preparing cotton and other fibrous materials for spinning.
495 J. Erwood—Producing imitation gilding in paper hangings.

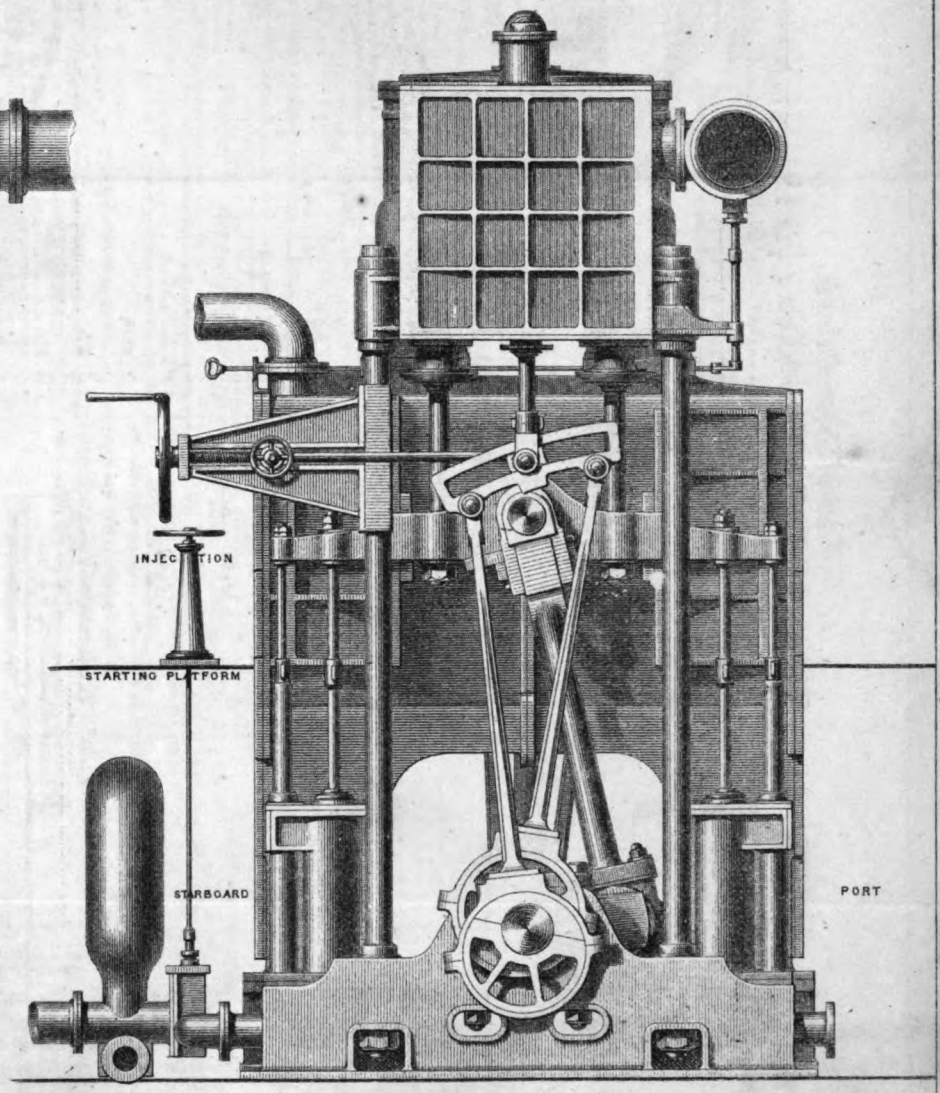
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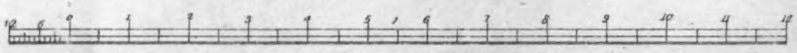
# J.F. SPENCER'S PATENT SURFACE CONDENSING SCREW ENGINES OF 200 H.P.

## FOR A 1500 TON STEAM SHIP.

*BY MESSRS DENNY & CO ENGINEERS, DUMBARTON.*



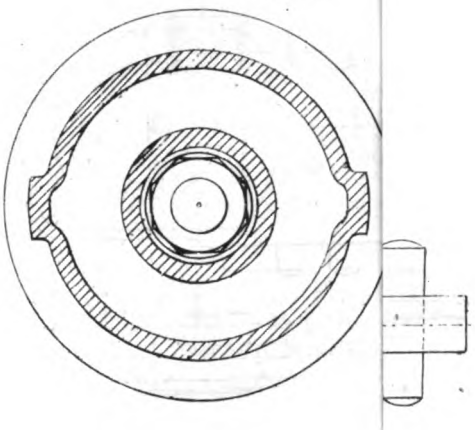




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Fig. 8



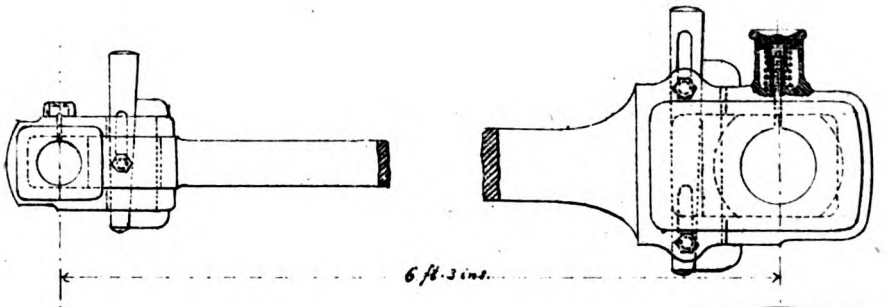



Fig. 9.

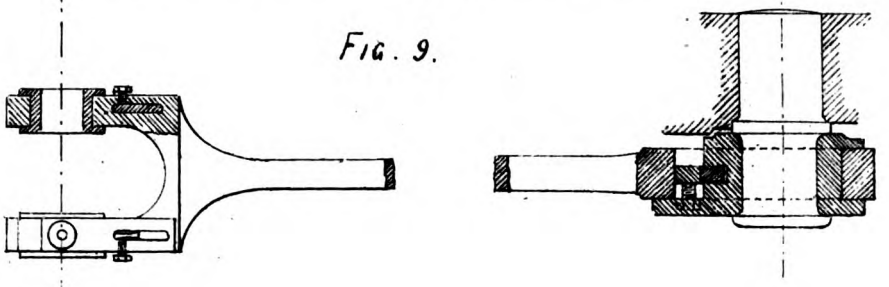
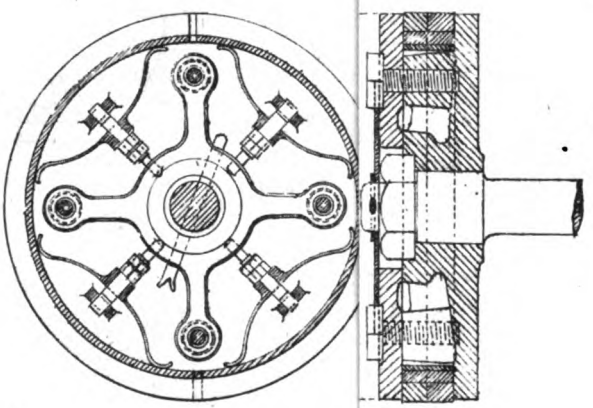


Fig 3



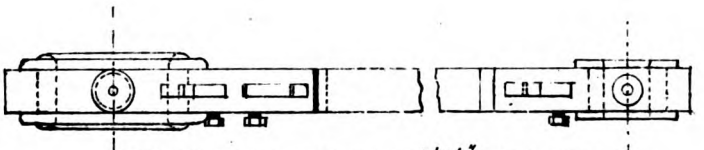



Fig 10.

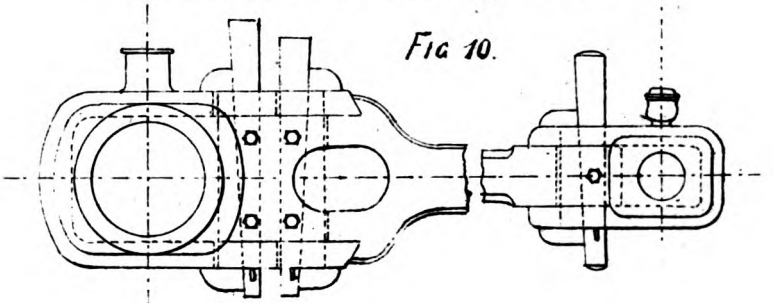


Fig. 11.

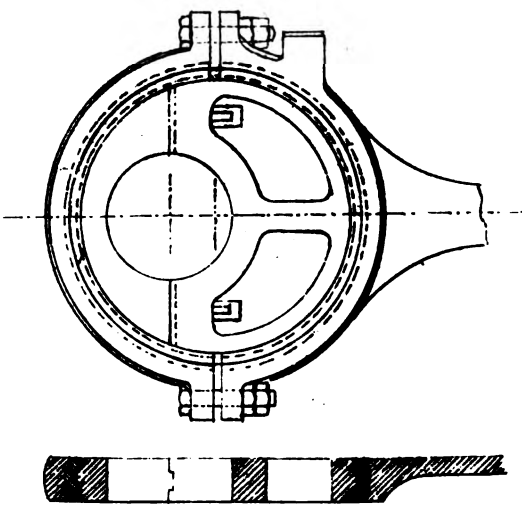
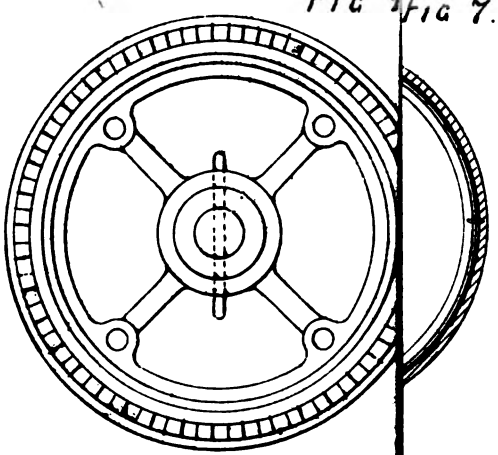
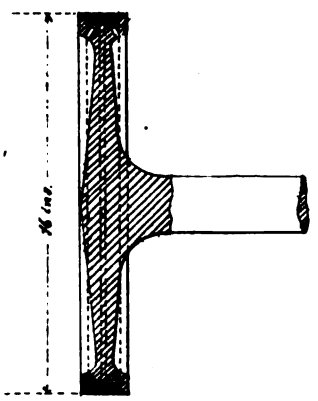


Fig 1 Fig 7.






Scale to Figs 9, 10, 11.




W. Smith, C.E. direx.

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# MOTIVE ENGINEERING.

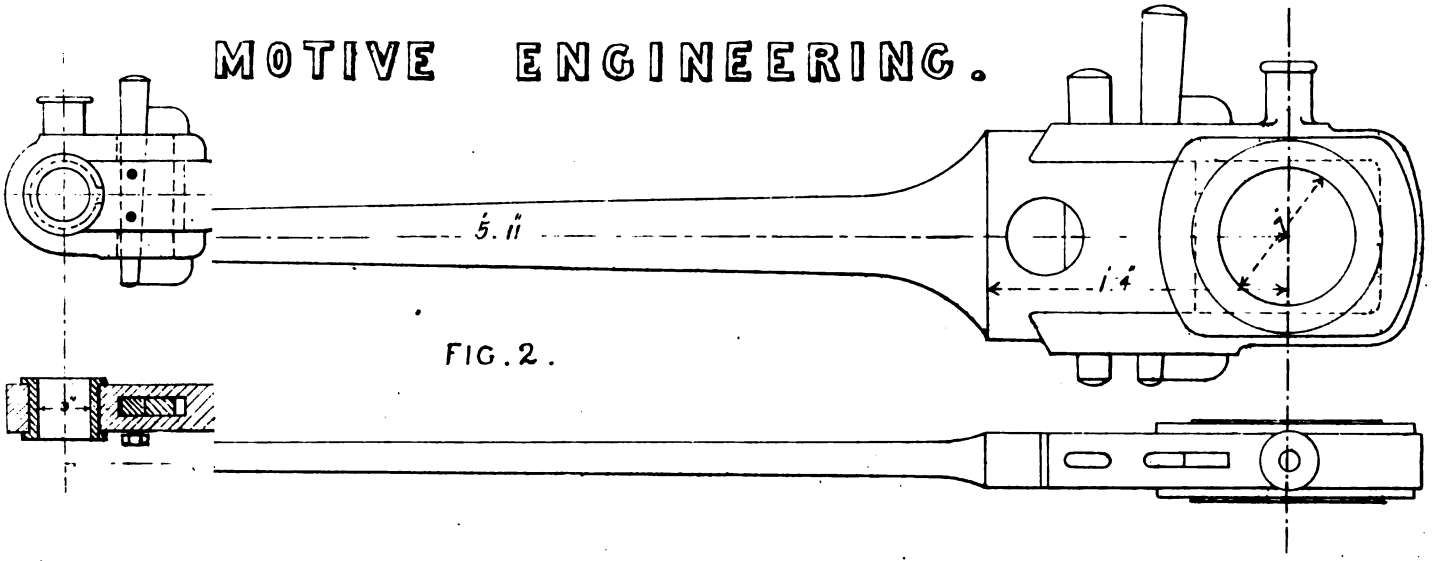
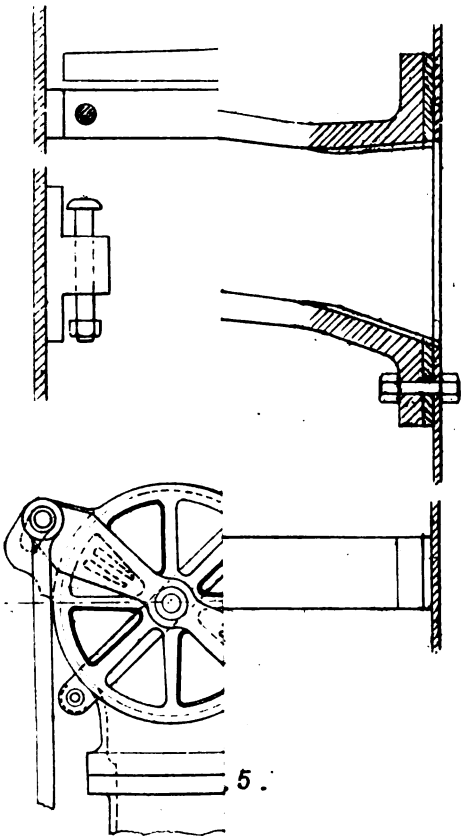



FIG. 2.



5.

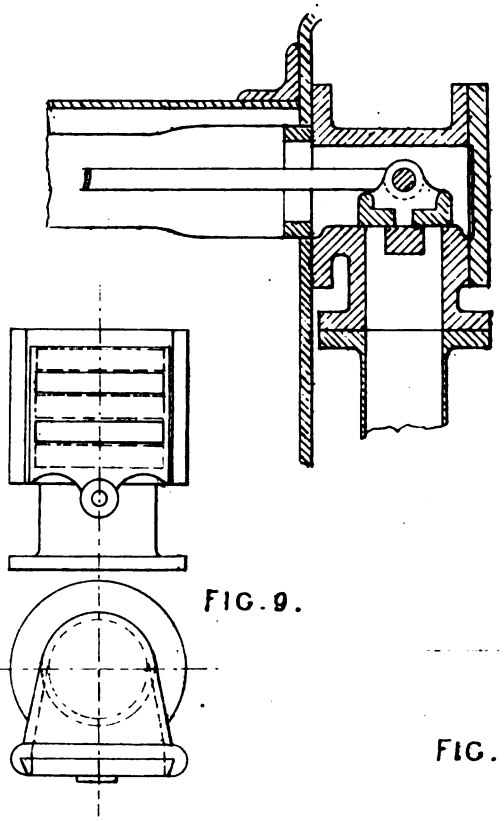


FIG. 8.



FIG. 9.

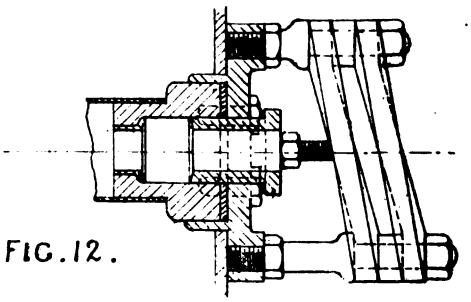


FIG. 12.

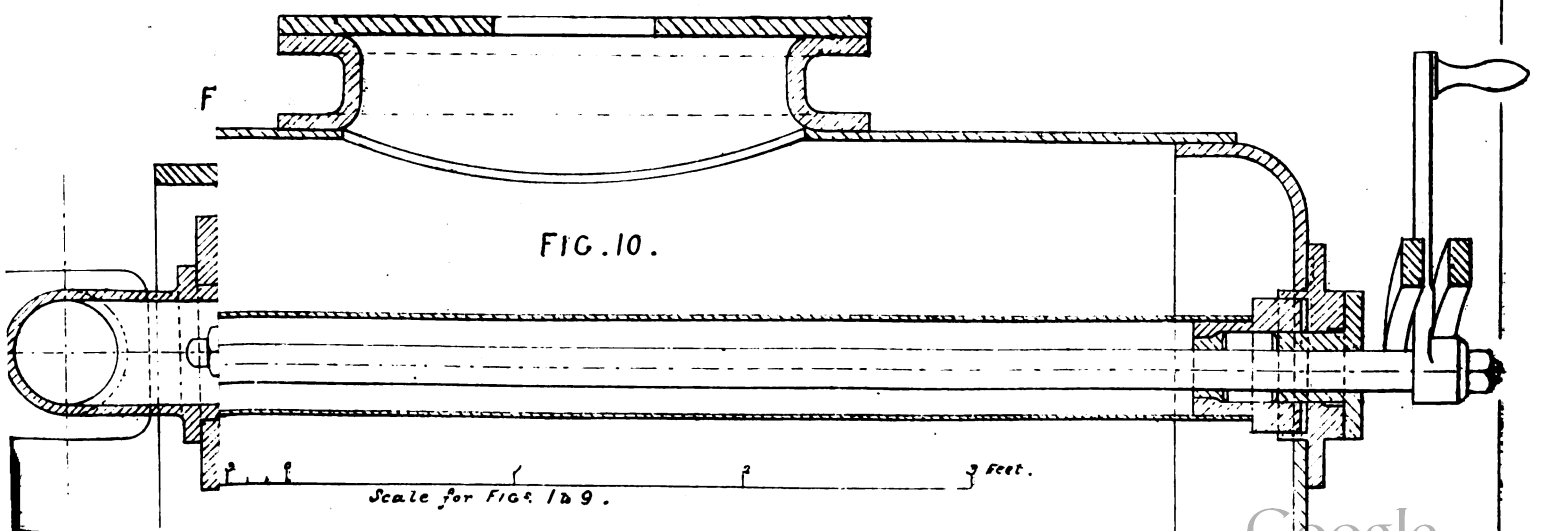



FIG. 10.

Smith. C.E. direx.

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# THE ARTIZAN.

No. 4.—Vol. 1.—Third Series.

APRIL 1st, 1863.

## A CRITICAL AND HISTORICAL REVIEW OF LOCOMOTIVE ENGINEERING.

By J. J. Birckel.

(*Illustrated by Plates* 238 *and* 239.)

(*Continued from page* 56.)

We should here observe that Dr. Rankine, in his work on "Prime Movers," also shows that the motion of the valve, as derived from the link, may always be referred to a single eccentric; and the method which he gives for defining the throw and position of that eccentric for any point of the link is very nearly identical with that given in the last number of the Artizan. There is, however, this difference, viz., that the rule given in the work on "Prime Movers" does not provide for the obliquity of the eccentric rods.

Having thus completed our study of the steam distributing apparatus, we now proceed to treat of the remaining questions appertaining to the steam engine proper, the first of which being those which relate to the apparatus for the transmission of power, namely, the piston, the piston rod, the connecting rod, the crosshead, and the slide bars: and, in order to render our review as complete as possible, we will cast a rapid glance at the construction and the proportions of each of these parts.

The duty imposed upon the piston is to retain the steam in its front, while the latter, by virtue of its expansive force, causes the former to perform its alternate backward and forward motion. Any leakage occurring between the body of the cylinder and the packing of the piston gives rise to a twofold loss; it is a *direct* loss of power through waste of so much steam from which no duty is obtained, and it is an *indirect* loss of power through increase of back pressure. At the same time, a piston packing may be made so tight as to absorb the greater part of the power of the engine by friction, and here, therefore, is a problem essentially experimental in its nature, the satisfactory solution of which is of the highest importance. Piston packings may generally be divided into three kinds, namely:—

1st. Those which are made tight by means of springs.

2nd. Those which are intended to be made tight by the pressure of the steam itself.

3rd. Those which are tight by virtue of their own elasticity.

Pistons and packings of the first kind are illustrated by Figs. 1 to 5 (Plate 238), among which Fig. 1 is Goodfellow's patent, we believe one of the oldest in use; its construction is very simple, and, being made wholly of cast iron, it is very cheap; Fig. 2 is Critchley and Elston's patent, and the others (Fig. 3, 4, and 5), so far as we know, are public property.

Those of the second variety (Wakefield's patent) are illustrated by Figs. 6 and 7; here small holes admit the steam upon the back of the packing where it is expected sufficient pressure will be applied to make the packing tight; but we are of opinion that when these pistons have been found to be steam tight it was only by virtue of the elasticity of the packing itself.

For the two first varieties of pistons (Figs. 1 to 7) the body is generally of cast iron, keyed or screwed upon the piston rod, and the packing made of brass; sometimes, however, the piston rod and the body of the piston are forged solid in one piece, with the especial object of reducing the weight. This arrangement is, however, open to one very serious drawback, which militates against its general adoption, for, whenever the piston rod breaks or is permanently injured so as to require renewing, the piston itself must be renewed also, and the expense of repairs is thereby greatly increased.

Among pistons of the third kind, Fig. 8 illustrates Mr. Ramsbottom's patent, in which the body is made of cast iron, keyed upon the piston rod, there being three steel rings $\frac{1}{16}$ broad let into the body, and forming the packing. The adoption of this design of piston was most unquestionably one of the boldest attempts made at the simplification of the working details of the steam engine, but we can also say that its success is as complete, as it must have been unexpected to many. We have seen cylinders worn almost as bright as a mirror by the use of this piston without showing a single scratch, and, as it has been at work now for some seven years with similar results, this is ample proof of its efficiency; taking also into consideration its great simplicity and cheapness, we think that it should ere long find its way into general use. The secret of its tightness seems to us to be satisfactorily explained in the opinion advanced by some engineers, that a thin ring of condensed steam maintains itself between the walls of the cylinder and the piston, and serves to act as a packing; for, if this be really the case, the construction of the piston under consideration is evidently correct, since the two spaces between the three rings afford room for two such annular packings of condensed steam. Another description of piston of the third kind is Mather's, with helical packing; it is, however, only used in stationary engines, where, we believe, it is found to answer very well.

Piston rods, until very lately, were generally made of Yorkshire iron, and in some instances have been casehardened; they are now, however, very frequently made of steel; and should Krupp's cast steel become much cheaper, we do not doubt that they will then be made of steel invariably, though their diameter will not be much reduced on that account. We shall not attempt to give rules or formulæ for defining the diameter of piston rods; but in the table below we give a series of dimensions of piston rods, with corresponding diameters of cylinders, from the actual practice of various makers.

| Designation of Engine, and Maker. | Diameter of Cylinder. | Diameter of Piston Rod. |
|---|---|---|
| | inches. | inches. |
| Sharp's London and Chatham Express | 17 | 2¼ |
| Sharp's Great Western Express | 16 | 2¼ |
| Ramsbottom's Express | 16 | 2¼ |
| Ramsbottom's common Passenger | 16 | 2¼ |
| Sharp's Dublin and Belfast Tank | 12 | 2 |
| Fairbairn's Wolverton Passenger | 16 | 2¼ |
| Sharp's London and Chatham Goods | 17 | 2¼ |
| Sharp's Dublin and Wicklow Goods | 16 | 2¼ |
| Ramsbottom's Crewe Goods | 17 | 2¼ |
| M'Connell's Wolverton Goods | 16 | 2¼ |
| Fairbairn's Wolverton Goods | 18 | 2¼ |

Connecting rods are generally illustrated by Figs. 9 and 10, Plate 238, and Figs. 1, 2, and 3, Plate 239; Fig. 9 being that for outside cylinder passenger engines; Fig. 2, Plate 239, that for inside cylinder goods engines, as made by Mr. Ramsbottom; Fig. 10, Plate 238 is the connecting rod as made by Messrs. Fairbairn in their common passenger engines and Fig. 1, Plate 239, that of Sharp's heavy goods engine "Sphynx." The smallest area of the rod proper is generally a little larger than that of the piston rod, and increases gradually towards the crank end. Connecting rods, and more especially coupling rods, are now generally made flat rather than round in section, on account of their greater elasticity, and of the greater facility possessed by them to yield when passing round sharp curves, or when they have to sustain and transmit severe concussions, either from unevenness of the road, or from sudden reversal of the engine. The brasses at the crank end are now generally lined with Babitt's metal, which has the advantage of keeping very cool during long journeys and at great speeds.

Crossheads and slide bars for outside cylinders, used by Mr. Ramsbottom for inside cylinders also, with a view, no doubt, of reducing the number of types, are illustrated by Figs. 4 and 5, Plate 239; those more generally used for inside cylinders are illustrated by Fig. 3. The slide blocks are generally made of cast iron, sometimes lined with Babitt's metal, and the slide bars are made of solid shear steel—very seldom of iron faced with steel.

The diameter of crank pins for coupling rods and outside connecting rods has increased gradually, as locomotive engineers have become better acquainted with what was really required, namely, large wearing surfaces. They generally range between 2¾in. to 3½in.; but we perceive that Mr. Ramsbottom has made the working surface as much as 4in. diameter in his outside cylinder express engines.

The feed pump, which forms an integral part of the steam engine proper, is now gradually superseded by Giffard's injector, which is more handy; and when the driver is well acquainted with its peculiarities it is less liable to failure upon the road than the pump with its train of clack boxes. The



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injector is capable of performing not only the work of the ordinary feed pump, but also does away with the necessity for the donkey pump, which of late years had been a frequent adjunct to the locomotive engine.

Steam regulators also form part of the steam engine proper, and are generally of four kinds, viz.:—

1st. The regulator, with disc valve (illustrated by Fig. 6), which, until lately, has been used by Messrs. Sharp, Stewart, and Co. almost exclusively; it has, however, the defect, inherent to all disc valves, of wearing its faces convex, and of becoming leaky very soon; besides this, it is very expensive, being made wholly of brass, and for these reasons it is being gradually abandoned.

2nd. The regulator, with slide valve (illustrated by Figs. 8 and 9), of which the horizontal one is used in engines having no dome, the steam being collected in a long copper pipe, having a series of perforations on the top. In these regulators the head or body is generally of cast iron, and the slide valve of brass; they are very simple, require but little labour in fitting them up, and answer their purpose very well.

3rd. The regulator, with piston valve (illustrated by Figs. 10, 11, and 12), used chiefly by Messrs. Allan and Sinclair. They are worked from a handle, moving in two helical guides, and certainly have the advantage of not being subject to open or shut of their own accord; they are, however, a most expensive piece of workmanship, and that especially so because they require to be made wholly of brass.

4th. The regulator, with double-beat valve (illustrated by Fig. 7), first introduced, we believe, in some engines made for the Lancashire and Yorkshire Railway, by Mr. Fairbairn. They are now invariably employed by Mr. Ramsbottom, we presume especially on account of their non-liability to wear out. These regulators also require to be made wholly of brass, but are comparatively inexpensive in fitting up.

Before dismissing this portion of the subject, it remains for us to make a few remarks about the eccentrics. These may be generally illustrated by Fig. 20, Plate 238, and are from 2¾in. to 2¾in. broad, the sheaf of cast iron, in two pieces, bolted together with cottered bolts, and the straps of wrought iron, about 1¼in. thick, with a brass lining about ⅜in. thick, fitted into them. Mr. Ramsbottom, however, now makes the lining of Babitt's metal, cast in an iron mould, and, we believe, does not put them into the lathe at all. These are found to wear much longer, and to run cooler.

(*To be continued.*)

## J. F. SPENCER'S IMPROVEMENTS IN SURFACE CONDENSING MARINE ENGINES.

(*Illustrated by Plate* 237.)

We have at various times alluded in THE ARTIZAN to Mr. Spencer's improvements in marine engines, and particularly his construction and arrangement of surface condensers, and their adaptation to marine engines.

Amongst the numerous competitors for success in the application of surface condensation, the most successful is Mr. Spencer, and his success is not due to mere pushing business habits or puffing, but solely to the sound practical and scientific intelligence which he has brought to bear upon this branch of engineering, hence almost every step he has taken has been successful, and an improvement upon that which preceded it.

The subject which we have selected for illustration is a pair of 200 horse power inverted cylinder screw engines, constructed by Messrs. Denny and Co., engineers, Dumbarton, for the "City of Cork," a 1500 ton steam ship, and one of Inman's Philadelphia line. These engines have been designed by Mr. Spencer, in accordance with his latest patent, and for compactness and accessibility of parts, they are unequalled; and for steadiness and perfection of working and economic performance they cannot be surpassed.

We may observe that in consequence of each of the four pumps being both an air and a cold water pump; the strain on the piston is equal instead of being one sided, as is the case when there are only one cold water, and one air pump, worked direct from the main piston of each engine.

The pumps are greatly reduced in diameter, as 150 horse power engines require pumps of only about 9in. diameter to maintain a good working vacuum. The air pumps are well below the condenser; thus ensuring a free flow into them. The feed and bilge pumps are worked from the main cross head, instead of requiring extra space and gear or apparatus at the end of the crank shaft.

The total athwart ship's space occupied by engines on this plan of 200 horse power, is about 9ft.; and of 300 horse power, about 11ft.

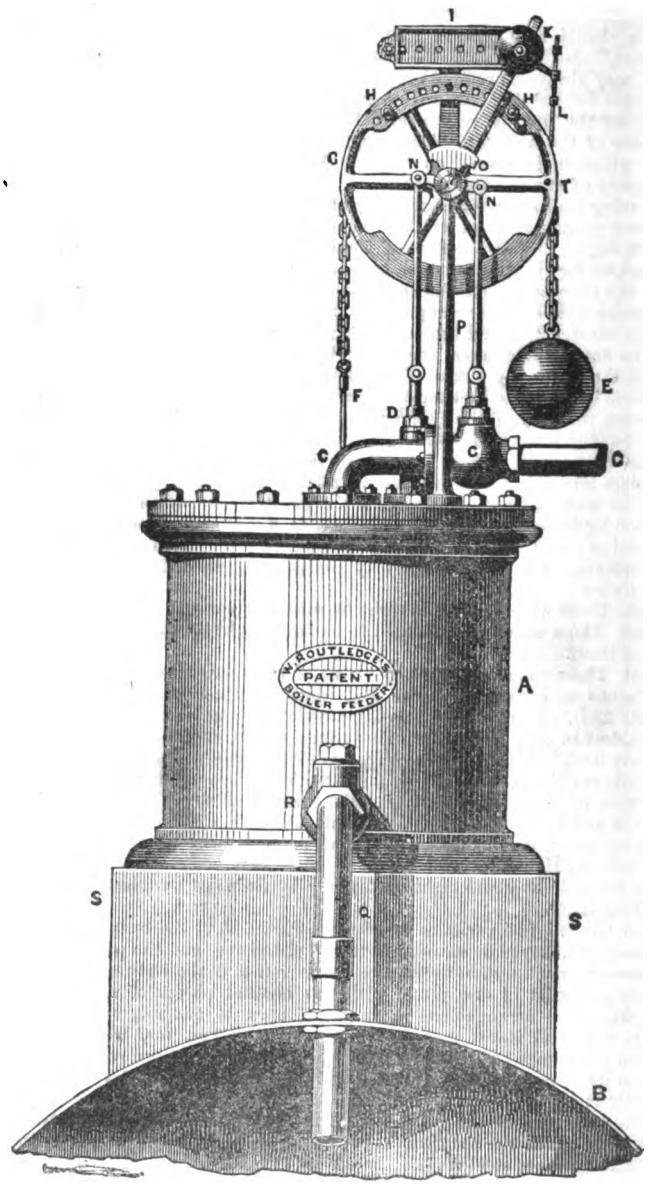
The surface condenser, which is constructed upon Mr. Spencer's patent plan, admits of ready access to the interior, and of the withdrawal and replacing of one or more tubes with the greatest facility, and without breaking a steam or vacuum joint. Whilst from the central position in which the condenser is fixed, great economy of space is effected, the condenser casing being employed in supporting the cylinders in combination with four wrought iron columns or pillars.

## ROUTLEDGE'S PATENT SELF-ACTING BOILER FEEDER.

Continuing our notices of the contents of the late Exhibition, the accompanying engraving illustrates Routledge's Patent Self-Acting Boiler Feeder, manufactured by the firm of Routledge and Ommanney, of New Bridge Foundry, Salford, Manchester. Several of these self-acting feeders have, we understand, been at work for some time in the manufacturing districts and in London, and have been found to give very satisfactory results.

In our illustration, A is a closed vessel, containing a float. B, the boiler. C C C, Water supply pipe and valve. D, steam valve connected to boiler. E, balance weight. F, float wire. G, float wheel. H H, two studs in float wheel. I, a register. K, tumbler lever. L, link, connecting float wheel to register. N N, levers connected to water supply and steam valves. O, quadrant, keyed fast on lever shaft. P, standard. Q, feed pipe. R, feed valve. S S, feeder support. T, stud attached to link L to work the register.

Should the boiler require water, the float attached to the float wire F descends, putting in motion float wheel G, which brings the stud H in contact




with the tumbler lever K, which, falling over, shuts the steam valve D and opens the water valve C, allowing the cistern to re-fill with water causing the float F to rise, and again opening the steam valve D, at the same time shutting the water valve C. When the pressures become equalised, the water descends of its own gravity into the boiler. The action of the apparatus is continuous. The position in which the float

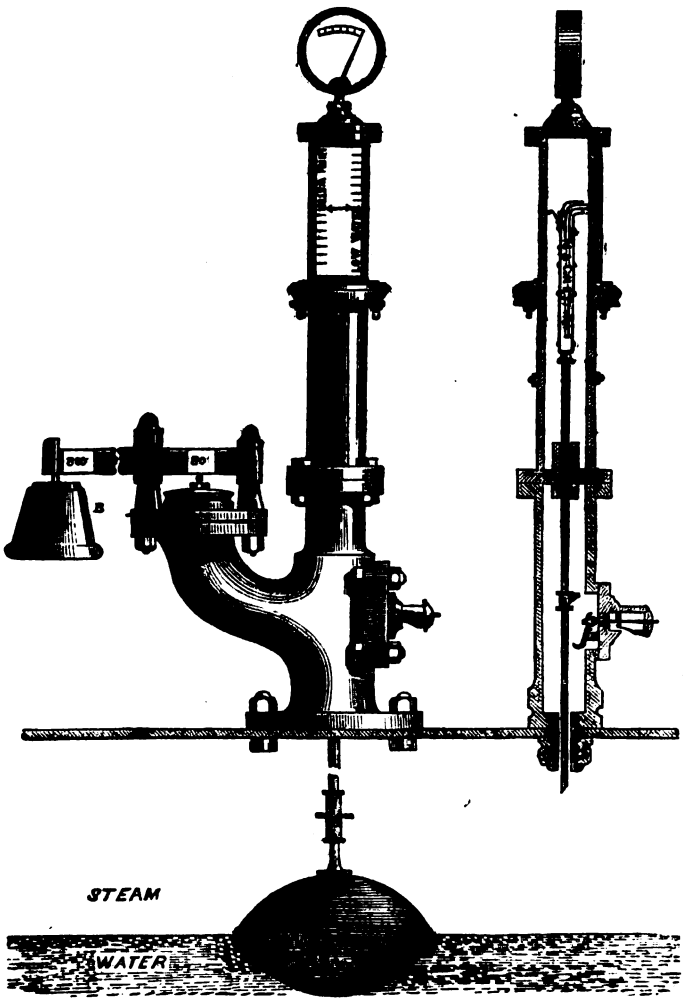
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wheel is represented in the annexed engraving shows the water to be descending into the boiler.

Amongst the advantages claimed to be derivable by the use of the self-acting Patent Feeder are the following, viz., that it will feed a boiler under any pressure of steam, and, when applied to two boilers, it will, when one is let off, fill it again by taking steam from that in work, the water being taken from the usual supply. It will feed with water at 212 degrees, and will fetch water from a depth of 20ft. below the feeder, if cold water, and warm water at 90 degrees, from a hot well or other source, 15ft. below the feeder. With a register attached it will show the quantity of water used. It possesses simplicity of construction, durability, and non-liability of derangement. It will work through the night, and keep a uniform height of water in the boiler. It also gets rid of the foul air, so that none can enter the boiler. The economy in fuel by using the feeder is found to be equal to 15 per cent. in the quantity used—that is, when cold water has been used to feed the boiler previous to the application of the feeder. The head of water required to form the vacuum is about one quarter of the quantity used, the remainder can be fetched by the vacuum from the hot well of the engine or any other source. The usual vacuum formed is 13lbs. An extra valve can be attached when the water is required to be fetched from a well or other source by the vacuum.

The Jury of Class 8 of the late Exhibition awarded a prize medal to Messrs. Routledge and Co. for the practical utility of this apparatus.

FIG. 1. FIG. 2.




MAGNETIC INDICATOR OF WATER LEVEL.

The accompanying woodcut, illustrates the Magnetic Indicator invented by M. Lethuillier-Pinel, of Rouen, and for which he received the award of Honourable Mention at the late Exhibition. Fig. 1 shows the Magnetic Indicator with alarm whistle, pressure gauge, and safety valve complete; Fig. 2 being a sectional view, showing the position of the magnet. In the latter figure we have not considered it necessary to repeat the view of the float in position.

The Magnetic Indicator establishes a communication between the interior and the exterior of the boiler, through the brass collar shown in Fig. 2, leaving the rod free, and rendering unnecessary conical and packed joints, and also avoiding the inconvenience and necessity of constant watching to see that the float acts.

A float proved to stand the pressure of fifteen atmospheres is joined to an iron rod, to the other extremity of which is attached a strong magnet which rises or falls in a brass box with the rise or fall of the water in the boiler. On the exterior of one of the sides of the box is placed horizontally an iron index or pointer, without any support, and held on the brass merely by the attraction of the magnet, which it follows in all its movements, running as it rises and falls on the face of the box, which is graduated to correspond with the proper height of water.

The superior or inferior limit of the float's course cannot be attained without operating upon the catch which opens the whistle, and immediately makes known the want, or excess of water.

Mr. Pinel's apparatus has already been very extensively used on the Continent, with very satisfactory results; and though, until last year, it was not known much in England, it is deserving of the attention of the users of steam power, as being an apparatus that will constantly and with certainly mark the height of the water in the boiler, and give warning when, through neglect or forgetfulness, it varies from its proper height.

## R. GIBBON'S IMPROVED MACHINE FOR SEPARATING, CLEANING AND CRUSHING MALT.

This machine has been invented by Mr. R. Gibbon, a practical brewer of many years experience, with a view to overcome the disadvantages attend- the present comparatively rude and inadequate mode of crushing malt, as in consequence of malt in bulk containing at least three recognisable sizes of kernel, which it is impossible to crush effectually at the same time, and with such means, all the larger and most valuable kernels must either be crushed to atoms, and cause considerable waste, or the smaller ones entirely escape and go into the mash-tun useless. It being found that when malt is placed in a hopper in large quantities, the small kernels will, to some extent, get together, and come to the rollers in much larger proportions, at times, than the bulk shows, and thereby cause the irregularity noticed.

When a grist of malt is to be crushed, and on examination is found to be in a sensible proportion, hard and steely, if an adjustment of the rolls is provided, by which the setting can be matched to the average size of the steely grain, whether large, middle, or small, and this is at all times properly attended to, and a judicious mashing heat applied, these hard steely kernels will become thoroughly crushed and afterwards dissolved in the mash-tun.

It is a well known fact that malt cannot be reasonably crushed too fine for profitable purposes, provided the worts pass through the *goods* freely and quite bright, and one great object of this machine is to *thoroughly and effectually* crush every kernel, but *powder none*—a matter which, hitherto, it has been most difficult to accomplish. Indeed, it never has been accomplished effectually by one, or even two pair of rollers, and it appears to us that Mr. Gibbon's machine is admirably adapted for this purpose.

By this combined machine the malt is separated, in its descent through the upper small hopper, from its coarse impurities. It then passes a feed roll, which supplies the whole of the crushers. From the feed roll it falls through a gentle blast of air (which carries off all the dust) on to a couple of sieves, rapidly, but smoothly shaken, where a further separation of the malt from fine flints and small stones takes place; it then passes on, in its dressed state, to three separating sieves, smoothly shaken by the same machinery, by which it is sorted into three sizes, small, middle, and large and led into three small hoppers, conducting to the three pair of rolls, each adjusted to the size of malt it has to crush, these rollers being actuated by toothed wheels, keyed on one end of their axes, the whole series deriving motion from large spur wheels keyed on the axis of some of them, and primarily from ordinary fast and loose pulleys attached to a prolongation of the axis of one of the rollers. After passing the rollers, the crushed malt falls into small hoppers, either to be conducted into one large receptacle, or separate bins, as may be desired.

We may state that a grist of malt crushed as described by this machine, is calculated to produce from one to three per cent. more extract, at the least, than when crushed by one pair of rolls only, and we do not contemplate that a grist of malt, crushed by Mr. Gibbon's machine, will choke the false bottoms of the mash-tun, provided a proper mashing heat is first applied.

The rolls are chilled in casting and rendered almost as hard as steel, which gives them the power of crushing the small flints and stones which pass with the malt, without any indentation or injury, such as occurs to

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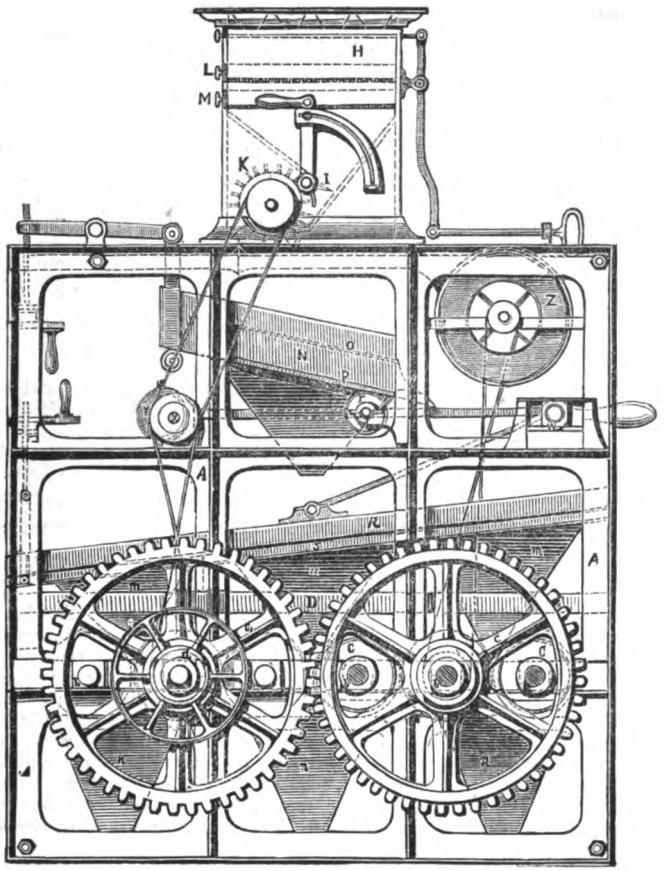



Fig. 1.—Side Elevation.

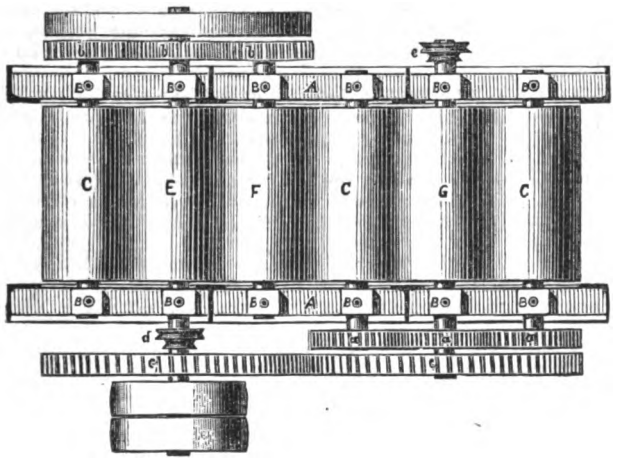



Fig. 2.—Sectional Plan.

the common soft rolls hitherto generally used. The journals are also hardened, and the bearings of cast steel. An improvement is also added for guarding against the back lash or jerking of the rollers when running empty. It is well known, that by the present mode of resting the journals of the rolls on the open brass bearings, a most disagreeable and injurious back lash takes place when running empty, the rolls striking each other with great force and injury, but which in the machine under notice, is entirely guarded against, so that they may run empty with as much safety as when at work. The easy shaking motion given to the sieves by an eccentric, is so arranged that it can be thrown on or off at any moment, with the rolls and machinery in motion, without the slightest injury. We have lastly to call attention to the valuing appendage, or malt balance, attached to Mr. Gibbon's machine, and consisting of an adjustable balance such as an ordinary steelyard, by which the actual weight per bushel and quarter, as also the specific gravity of the grain can be at once determined, and thence its real value to the brewer.

Fig. 1 shows a side elevation of the machine, and Fig. 2 a sectional plan thereof. A is the cast-iron frame, having suitable receptacles for the bearing blocks B, and caps over each pair of rollers marked C, and which are moveable at pleasure. A cast-iron plate, D, is placed at the back of these caps, which extends the whole length of the frame, and fits over the necks of the gudgeons and against the ends of the rollers. The rollers marked E, F, and G are fixed in place, the other three being movable and adjustable by means of set screws. Wedges are driven in behind each of the movable rollers to prevent the back lash, and are kept in place by set screws tapped into the back plates of the caps C. H is the upper hopper box containing the regulator valve I, the feed roller K, and the two sieves L and M, the latter being fixed in frames, so as to be readily withdrawn; N is the frame under the feed roller, containing two sieves O and P, the top one being coarse and the lower one fine, as before described. The spout, Q, is here shown fixed, and conducts the grain to the separating sieves, which are placed in the frame R. This frame travels on the bars S, which are secured at the upper ends to the frame of the machine, their lower ends being supported by an adjusting screw for altering the inclination. These bars carry rods, upon which the cleaners revolve, and which consist of thin discs of metal placed between the wires of the sieves. These sieves are shaken by means of a lever, keyed or otherwise attached to the shaft V, which latter is worked by the eccentric Y on the shaft X, which also carries an eccentric for working the sieve frame N. This eccentric is connected with the slide bar W, a plan of part of which is shown in Fig. 3. Z is an ordinary fan for driving off the refuse from the grain as it falls from the feed roller. The dust is driven out of the spout Z, which has a slot in it for the grain to pass through on to the sieve O. Three pinions (*a a a*) for driving the rollers are placed on one side of the frame, and three (*b b b*) on the other, as they would not gear well if all placed on the same main driving wheels *c c*, one of which it is preferable to make a mortice wheel. The hoppers for supplying the rollers are fixed in a frame *m*, and those for receiving the crushed grain in a frame *n*; they may all, however, be separate. The frame N rests upon small wheels, which are carried by vertical bars to place the frame at any convenient angle. The weighing machine may be placed anywhere convenient.




Fig. 3.

Mr. Gibbon has compiled a series of comparative tables to be used in connection with the valuing appendage, and by the aid of which the value of malt and barley may be readily deduced; the following is an example of these tables.

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Barley, weight per bushel in lbs. ... | 51·5 | 52·5 | 53·5 | 54·5 | 55·5 | 56 | 57 | 58 |
| Barley, weight per sack or comb in in stones of 14lb. | 14·10 | 15 | 15·4 | 15·8 | 15·12 | 16 | 16·4 | 16·8 |
| Barley, weight per quarter ..... | 412 | 420 | 428 | 436 | 444 | 448 | 456 | 464 |
| Malt, weight per bushel ..... | 38 | 38·75 | 39·5 | 40·5 | 41·75 | 43 | 44 | 45 |
| Malt, weight per quarter ..... | 304 | 310 | 316 | 324 | 334 | 334 | 352 | 360 |
| Malt, specific gravity or solid extract, per quar.. | 1·205 | 1·216 | 1·226 | 1·240 | 1·253 | 1·270 | 1·283 | 1·297 |
| Malt, density of wort obtainable, per quarter ..... | 76 | 80 | 84 | 89 | 94 | 100 | 105 | 110 |
| Malt and barley, increase in value per quarter to brewers..... | 0 | 6*s.* | 12*s.* | 19*s.* 6*d.* | 27*s.* | 36*s.* | 43*s.* 6*d.* | 51*s.* |

A modification of the arrangement illustrated in the annexed wood-cuts, may be made by placing three rollers on the same spindle, these rollers working opposite to a second set of three rollers fixed to a second spindle. In this arrangement, each pair of opposite rollers is made of a different diameter (about the twenty-fifth part of an inch), so that when the largest rollers are working close together, or nearly so, and thus allowing the smaller grains to be properly crushed, the next pair of rollers would be slightly separated so as to properly crush the medium sized grain, whilst the third pair of rollers would be still further separated so as to properly crush the larger grains. The three rollers instead of being cast separately, may be cast together so as to form a single roller, and be afterwards turned to the required diameters. And instead of the rollers of each pair being the same size, as just described, the difference of diameter to allow for the different sized grains, may be made in the roller or rollers upon one of the spindles only, the roller or rollers on the other spindle being parallel

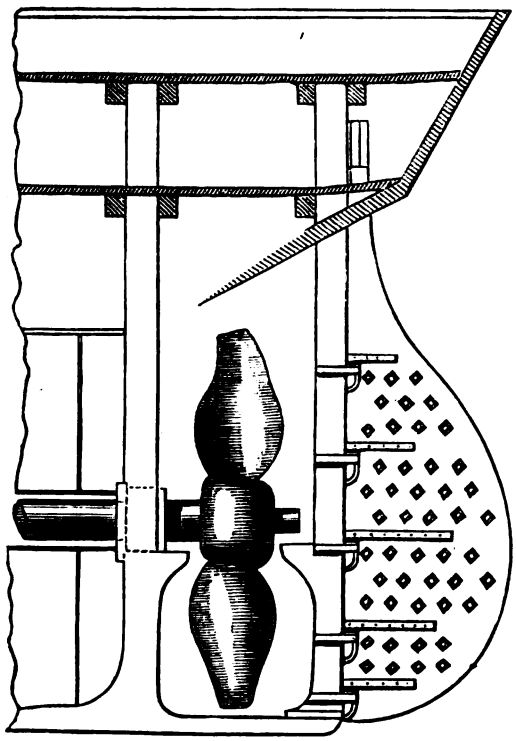
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throughout; or lastly, part of the difference may be made in the rollers upon one spindle, and part in the rollers upon the second spindle, either of these latter arrangements giving a slight rubbing action to the grain as well as crushing it.

## PERFORATED RUDDERS.

Commander T. E. Symonds, R.N., lately submitted to the Admiralty a very simple, yet valuable improvement in rudders. The object to be attained more especially being to render the rudders of screw ships of war and armour-plated vessels, more easily worked and manageable, as considerable difficulty has hitherto been experienced in steering this class of vessels, and which is attributed no doubt in a very considerable measure to the imperfect proportions of the rudders at present in use.

Capt. Symonds proposes to make a series of perforations in the rudder, as shown in the accompanying woodcut. The orifices increase in size from the centre of the thickness of the rudder on either side, and expose a series of surfaces when the helm is over. These openings allow of a free passage of the water through the rudder, at the same time preserving a more effectual surface for steering, when the rudder is by these means got over



more readily to a greater angle; the water impinging on the rudder in a horizontal direction, and acting on the faces of the holes or slots. Again, it may safely be assumed that in case of a ship gathering sternway before the helm could be righted, or in the event of the rudder being struck by a heavy sea, the shock and damage which would ensue in a vessel fitted with the ordinary rudder is averted, and thus the ship may be kept steadily to her bearings in the heaviest weather.

The plan is certainly one which possesses considerable merit, and is worthy of the attention of those entrusted with the designing and construction of our costly, and it is also to be feared, experimental vessels of war. (We are informed by Capt. Symonds that junks and large vessels in the Chinese waters are now, and have been for numbers of years back, fitted with these perforated rudders.)

## DR. NORMANDY'S APPARATUS FOR THE DISTILLATION OF SALT WATER.

The annexed woodcuts (p.p. 80,81 illustrate the very useful apparatus invented by Dr. Normandy, for the production of aërated fresh water from sea-water.

The apparatus under notice is the result of very considerable study, and a series of most carefully conducted experiments undertaken by Dr. Normandy, with a view to arrive at a comparatively simple and efficient plan of producing distilled water from sea water, which should not possess the disadvantages attending, to a greater or lesser extent, all methods previously adopted for the production of distilled water from sea water. We allude to the intolerably nauseous and empyreumatic taste and odour which it retains for many weeks, and which is, moreover, insipid, flat, and vapid, owing to its want of oxygen and carbonic acid, which water in its natural state possesses, and of which it has been deprived by the process of distillation.

The problem which Dr. Normandy undertook to solve was the following, viz., to obtain, with a small proportion of fuel, large quantities of fresh, inodorous, salubrious, aërated water, without the help of machinery or of chemical re-agents, by means of a small, self-acting, and compact apparatus, capable of being worked at all hours, under all latitudes, in all weathers and conditions compatible with the existence of the ship itself, and incapable of becoming encrusted, or otherwise going out of order. That the problem, through necessarily a difficult one, has been satisfactorily solved in the apparatus before us is best evidenced in the general use into which the apparatus has gradually come, after having been submitted to the most severe competitive trials, made in 1859, against the ordinary condensers used in the Navy.

Referring to the annexed illustrations, the apparatus, it will be seen, consists mainly of two parts—an evaporator and a condenser, joined so as to form one compact and solid mass, screwed and bolted, without solderings or brazings of any kind. The evaporator is a cylinder, partly filled with sea water, into which a sheaf of pipes is immersed, so that on admitting steam at a certain pressure into these pipes, it is condensed into fresh, though non-aërated water, by the sea water by which the pipes are surrounded, the sea water being thus heated and a portion of it evaporated at the same time. This non-aërated fresh water becomes aërated by an arrangement which we will afterwards explain.

The steam at a pressure being of course hotter than ordinary boiling water, serves to convert a portion of the water contained in the evaporator into ordinary steam, which, as it reaches the pipes in the condenser, is resolved therein into fresh aërated water without pressure. By thus evaporating water under a slight pressure, one fire performs double duty; and thus the first condition, that of economy, is fulfilled; for while, in the usual way, 1lb. of coal evaporates 6 or 7lbs. of water, the same quantity and quality of coals, burnt under the same boiler, but in connexion with this apparatus, is thus made to evaporate 12 or 14lbs. of water, or in other words, from the same amount of steam or of coals employed, this machine will produce double the quantity of fresh water that can be obtained by simple or ordinary distillation—that is to say, double the quantity produced by the ordinary condensers.

The steam issuing from the evaparator, and which is condensed by the water in the condenser, imparts, of course, its heat to the sea water in it; and as this water is admitted cold at the bottom, whilst the steam of the evaparator is admitted at the top of the condenser, the water therein becomes hotter and hotter gradually as it ascends, and when it finally reaches the top, its temperature is about 208° Fahr.

As water begins to part with its air at a temperature of about 130° Fahr., therefore, the greater portion of the air condensed in the water which flows constantly and uninterruptedly through the condenser is thus separated, and led through a pipe into the empty space left for steam-room within the evaparator, where it mixes with the steam. And as about six gallons of sea water must be discharged for every gallon of fresh water which is condensed, and as each gallon of sea water contains five cubic inches of air, and whereas the utmost quantity of it that fresh water can naturally absorb is fifteen cubic inches per gallon, it follows that the steam in the evaparator, before it is finally condensed, has been in contact with twice as much air as water can take up, the result being a production of fresh water to the maximum of aëration.

The agent employed for the destruction and removal of the empyreuma of distilled water thus aërated, is charcoal, Dr. Normandy having found, from carefully conducted experiments, that two cubic feet of charcoal are sufficient to remove entirely the empyreumatic odour and taste of distilled water, produced at the rate of 500 gallons per diem, and that the charcoal never wants removing. And the water issuing from the apparatus is perfectly sweet, tasteless, inodorous, and completely saturated with a large quantity of oxygenised air and of carbonic acid.

The apparatus represented in the accompanying drawings is intended for sailing ships; that is to say, when it is placed on deck, or above the level of the sea, on deck or on land—in which case it must be provided with a lift-pump, and of course with a steam boiler.

Fig. 1 is a section showing the construction of the apparatus without reference to the real position or actual form of its constituent parts.

Fig. 2 is a front view of the apparatus, one sixteenth of the real size, and of the normal power of 500 gallons per day of 24 hours.

Fig. 2 is a back view of the same apparatus.

The action and mode of working the apparatus is as follows:—Get steam up in the boiler, start the pump, and fill the apparatus with sea water by opening the cock A; the sea water pumped up will then enter the condenser at B, and pass through feed-pipe C into the priming box, D, and thence into the evaporator, E, where it should be allowed

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NORMANDY'S APPARATUS FOR DISTILLING SALT WATER.

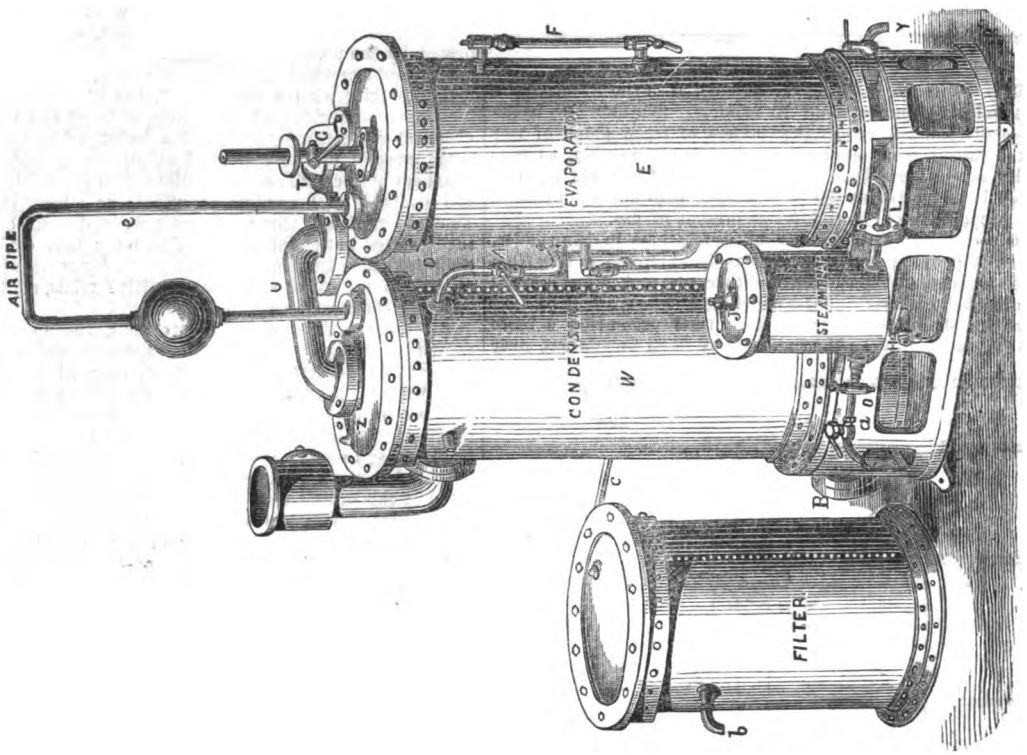



Fig. 3.

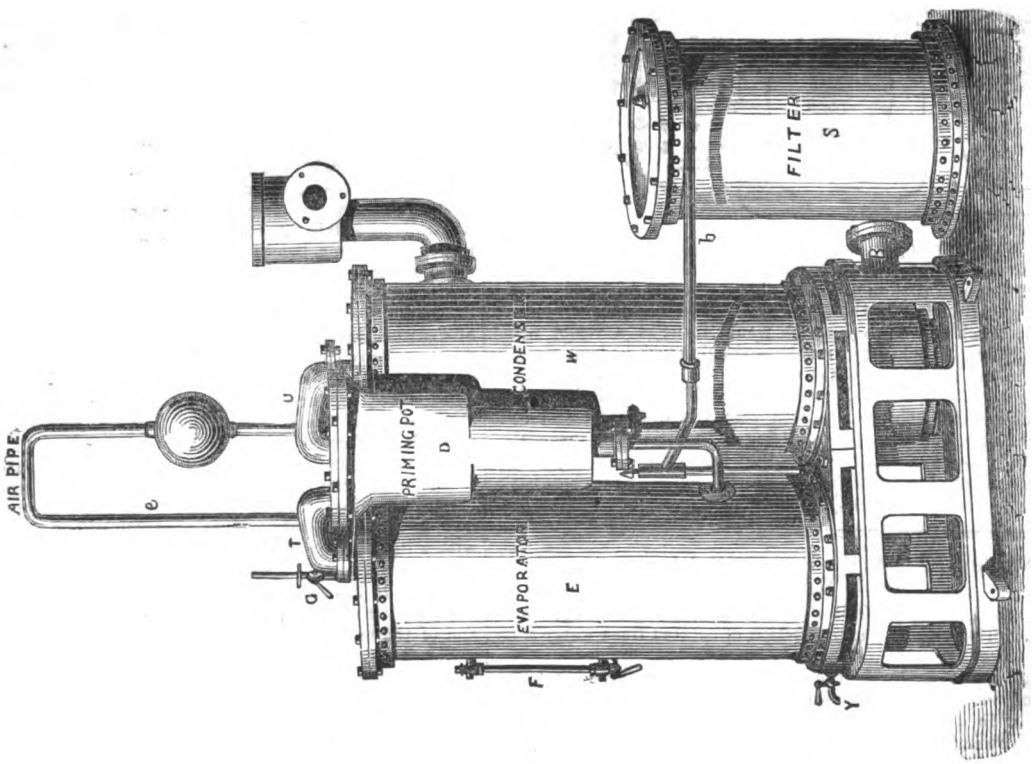



Fig. 2.

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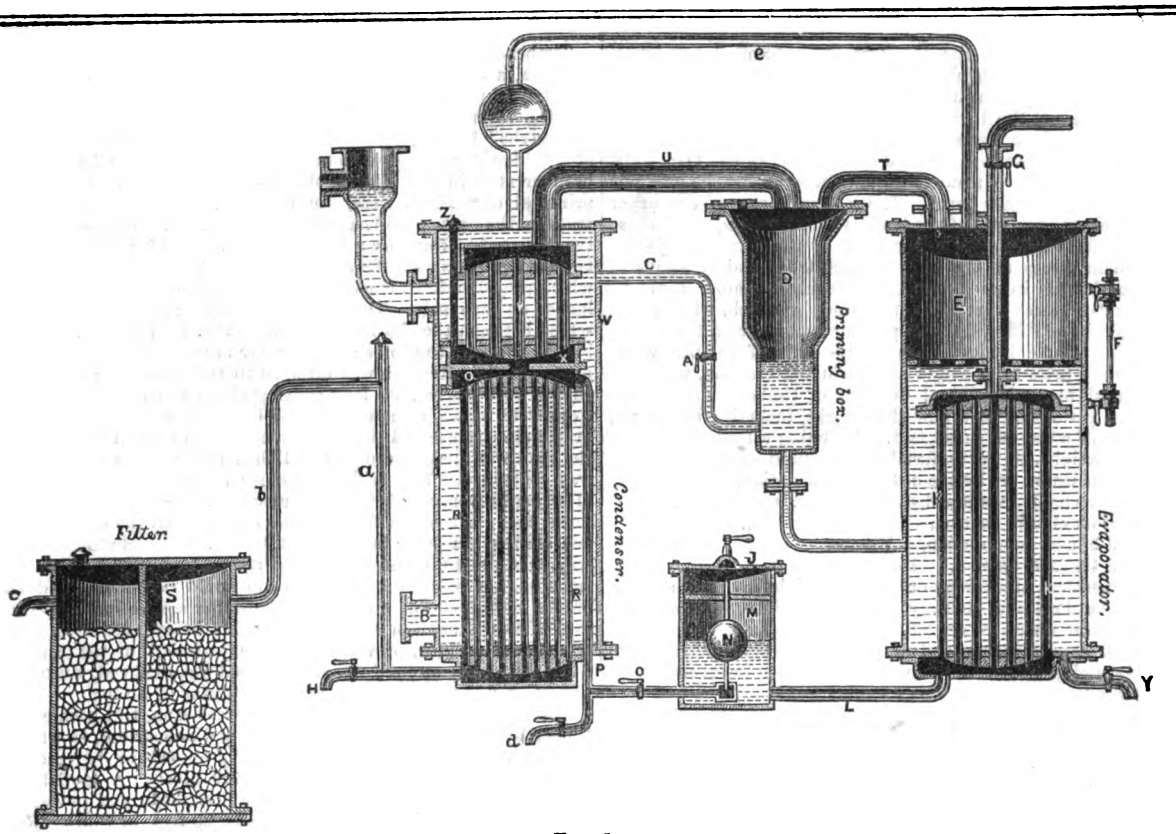



FIG. 1.

to rise half-way in the glass gauge, F, when the cock, A, should be shut. The apparatus having its proper quantity of sea-water, open the steam cock, G,* and likewise the clearing cock, H; after a short interval open also the small cock, J. On opening this cock, J, some water will perhaps be projected for a few seconds; but, presently, air and steam only will issue from it; as the steam is seen issuing from it, it should then be closed gradually, and eventually be left almost shut, so as to leave only room for the smallest possible wreath of steam slowly to issue from it. As soon as the steam-cock, G, is open, the steam from the boiler will rush through that cock into the sheaf of pipes, K, of the evaporator, in which pipes it will be condensed by the sea water which surrounds them, and then flow through the pipe L into the steam trap, lift up the float, N, pass through the cock O, ascend the pipe P into the upper cap, Q, of the refrigerating sheaf of pipes R, and flow out at the waste cock H. If the apparatus has been left for some time without working, the water issuing from the waste cock will have a rusty colour, wherefore it (the condensed water) should be left running until it flows out clear, in order not to foul the filter. As soon, however, as the water flows in a clear state, shut the cock, that the water may pass into the filter S.

The steam within the sheaf of pipes K of the evaporator E soon brings the sea water round them to the boiling point, and the attendant may know that it begins to boil by a slight up and down motion of the water in the water gauge. Steam passes then from the evaporator through the pipe U into the priming box L, where any salt water which may have been carried with the steam is deposited and returned into the evaporator, while the pure steam passes from the priming through the pipe U into the sheaf of pipes V of the condenser W, and being there condensed falls into the lower cap X, and thence from the upper cap of the refrigerating apparatus mixes with the water from the condensation of the steam of the boiler brought by the pipe P, and both waters pass into the filter S. As soon as the water of the evaporator begins to boil, open the brine cock Y, but only to such an extent as to permit a quantity of brine to be constantly flowing from it. Open also the feed cock A, from time to time as the sea water in the glass gauge sinks, or adjust it so that no more sea water may flow through it than is sufficient to keep the gauge glass about half-full.

* This steam cock should be opened gradually, and only to such a degree as will not cause the sea water in the boiler and in the evaporator to boil furiously, which might produce extraordinary priming. Priming can always be easily prevented both in the boiler and in the evaporator by shutting the steam cock more or less.

Attention to this is absolutely necessary; for, if too much or too little sea water be allowed to run out, the apparatus in the first case will not produce its proper quantity of fresh water, and in the second case earthy matter would be formed, which would impair the apparatus, or even put it altogether out of service. If, however, the attendant take care to adjust the brine cock X, so that the flow of the brine is at the rate indicated, that is to say, about one-third at least of the whole fresh water produced, there will be no chance of diminishing the evaporation, nor danger of incrustation.

If the fresh water produced is not sufficiently cool, work the donkey pump faster.

If any steam or water is seen to issue from the breathing pipe Z, it is a sign that too much steam is admitted into the apparatus, wherefore the steam cock should be shut off, more or less, so as to reduce the quantity of steam to the proper degree.

On board steamers, or when the apparatus is placed below the level of the sea, the stand pipe is suppressed, as well as the lift-pump; the large pipe and the upper pipe to which the stand pipe is bolted are then put in communication, through the walls of the ship, with the sea water outside, by means of the ordinary Kingston or ground valves of the ship, and in that case the air-pipe must of course be raised several feet above the sea level.

We may add that this apparatus was exhibited in Class B of the late International Exhibition, and that the exhibitors received a prize medal for it.

## INSTITUTION OF CIVIL ENGINEERS.

### ON AMERICAN TIMBER BRIDGES.

By Mr. J. R. MOSSE, M. Inst. C.E.

It was stated that the early common road bridges for spans of 100ft. and upwards were generally built on the lattice plan. The sides and the top and bottom chords were formed of planks, usually 12in. wide by 3in. thick, fastened together by oak treenails, 2in. in diameter. For road traffic with moderate spans this kind of bridge answered tolerably well, and several of the early railway bridges were constructed in a similar way. But this structure, having been found insufficient for heavy trains, had long since been abandoned, though it was sometimes, but erroneously, thought in England to be the general style of American bridges.

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The next design noticed was the Howe bridge, a detailed description being given of one on this principle on the Danville Railway, over the James River, at Richmond, Virginia. This bridge consisted of eleven openings, each 121ft. span, the total length being about 1800ft., with a width of 18ft. For each span there were two trusses, the greatest depth of which was 20ft. Each truss was divided into several panels 11ft. wide, and the bottom chords were so arranged that there should be only one joint in the chord pieces in each panel. The sectional area of the upper chords was 396 square inches, and of the bottom chords 528 square inches; the greater area of the latter being on account of the numerous joints. There were four main braces at the ends of each truss, and by means of three vertical iron tie-rods in each panel, any required camber could be easily given. Counter-braces were also introduced, by which, when keyed up, the bridge could be so stiffened that a passing load was said to produce no additional strain. These bridges were always built of the best white pine, and the ordinary price for a single line, including erection, was from £4 to £5 per lineal foot. The usual quantity of timber employed was about 30 cubic feet per lineal foot, and the weight, including iron work, a little more than half a ton per lineal foot. Assuming a load of 3000lbs., including its own weight, to be uniformly distributed over the bridge alluded to, the strains would be, by the ordinary calculation,

On the upper chords, compression, 729 lbs. per square inch.
„ bottom chords, tension, 547 lbs. „
„ end braces, compression, 735 lbs. „
„ end tie-rods, tension, 15,125 lbs. „

The ordinary dimensions of a bridge on this principle having a span of 150ft. as built on the Portland Railway, were then given, from which it appeared that the lower chord pieces of the two trusses had together a sectional area of 676 square inches, and of the upper chord pieces of 520 square inches. Assuming the same weight of 3000lbs. per lineal foot to be equally distributed over this structure, the strains would be,

On the upper chords, compression, 901 lbs. per square inch.
„ bottom chords, tension, 694 lbs. „
„ end main braces, compression, 750 lbs. „
„ end tie-rods, tension. 18,750 lbs. „

These strains were greater than in the first example, and the compression of 901 lbs. per square inch on the upper chords was the limit of safety; but it was not probable that the bridge would ever be loaded to the amount assumed.

Owing to the increased weight of the trains and the greater span of railway bridges, it was afterwards found necessary to strengthen this form of bridge, by the addition of arches on the sides of the trusses. This "Improved Howe Truss," as it was usually called, came into general use. A bridge on this plan was described, which was built for a double line on the Philadelphia and Reading Railway, where it was subject to the heaviest traffic in America, the coal conveyed over it alone, exceeding 5000 tons daily, besides the ordinary passenger and goods trains. This bridge had a clear span of 160ft. There were three trusses, each 23ft. deep, and six arches. The sectional area of the three upper chords was 1215 square inches, of the bottom chords 1620 square inches, and of the six arches 1530 square inches. The arches were formed of the best pine, in pieces about 24ft. long by 4½in. wide and 15in. deep. Timber arches had not unfrequently been built of pieces 6in. square; but very rarely of laminated plank, in the manner formerly practised in England. Supposing a load of 3 tons per lineal foot, including the weight of the structure itself, to be equally distributed over this bridge, and to be borne both by the upper chords and the arches, then the compressive strain per square inch would be 292lbs. on the former, and 237lbs. on the latter; while if sustained by the arches alone, the pressure would only amount to 468lbs. per square inch. As American engineers usually considered 900lbs. per square inch as the safe limit of compression on timber framing, the strength of this bridge appeared, by calculation, to be greatly in excess of what might be deemed necessary.

The approximate quantities of materials in this bridge, exclusive of the roof, were, per lineal foot, 58 cubic feet of timber, 270lbs. of wrought iron, and 76lbs. of cast iron; and the cost of the superstructure amounted to £10 3*s.* per lineal foot.

These bridges were usually built with a camber of about 1 foot; but owing to decay at the joints, and the unseasoned state of the timber when framed, they soon deflected, and did not last in good condition longer than from twelve to fifteen years. When, however, they were roofed in and boarded at the sides, and were properly cared for, their duration might be taken at twenty-five years.

Some American engineers did not approve of the arch in combination with the truss, believing that a structure composed of two systems, neither of which was strong enough by itself, was wrong in principle, and that it was almost impossible so to proportion the strains, as to make each system bear its due share. These engineers thought it better, either to add to the truss the material used in the arch, or to depend entirely upon the arch, and to have a light truss merely to stiffen the roadway.

Timber-bridge building had become a special branch of engineering in America, and one firm alone—that of Mr. D. C. McCallum,—had constructed 15 miles on length of bridges upon different railways, in spans varying from 30ft. to 260ft. These bridges were built on what was termed the "Inflexible Arched Truse" principle; and a description was given of a bridge, for a single line of railway, 200ft. span, of which several had been erected in the States of New York, Ohio, and Mississippi. The principal dimensions were; total length, 210ft.; span, 200ft.; depth of truss in the centre, 26ft. and at the ends, 21ft. The arched tops of the two trusses had together a sectional area of 814 square inches, and the two bottom chords of 468 square inches. There were four main braces, which projected 32ft. from the piers, having a sectional area of 704 square inches on each side. The posts, of which there was a double row, inserted between the chords, varied from 9in. by 13in. at the abutments to 9in. by 6in. at the centre; the counter braces being 9in. by 6in. throughout. Special attention was directed to the manner in which the bottom chords were scarfed, by long splicing pieces and combination keys, so as to prevent them, as much as possible, fron stretching. The spur arch braces also transferred the load directly on to the abutments, by which the span was directly reduced to 136ft., so far as the strain on the truss was concerned. This bridge contained 7360 cubic feet of timber, 6958lbs. of wrought iron, and 5997lbs. of cast iron. Its total cost was £5 4*s.* per lineal foot; the rough timber being delivered on the site of the works at one shilling per cubic foot. The total weight, including the permanent way, was 109 tons, and with an additional load of 205 tons, equally distributed, the pressure on the arch top would be 862lbs., and the tension on the bottom chords would be 1500lbs. per square inch. With an actual load of nearly one ton per lineal foot, this bridge deflected nearly three-quarters of an inch, previous to the adjustment of the counter braces; these were then screwed up, and the load was removed, when a permanent deflection was found to be nearly five-eighths of an inch.

Several railway swing bridges of 120 feet span, had been constructed of timber by Mr. McCallum, and the principal dimensions, as well as detailed drawings, of one on a similar plan, proposed to be erected over the Mississippi river, at Clinton, Ohio, were given. A McCallum common road bridge, of 150 feet span, was then described; and it was stated that the quantity of timber in such a bridge, 29 feet in width, did not exceed 23 cubic feet per lineal foot, its entire cost amounting only to £3 2*s.* 6*d.* per lineal foot, the rough timber delivered on the ground being estimated at ninepence per cubic foot.

As an illustration of the adaptation of the Howe truss for large roofs, a description was given of that erected at the Dunkirk station of the New York and Erie Railway, the span of which was 80 feet. This roof was chiefly remarkable for the lightness of the scantlings, only two pieces of timber being as large as 6 inches by 7 inches, and most of them were about 5 inches by 7 inches. A principal of this roof contained 280 cubic feet, and would cost, at the ordinary price for timber framing, including erection, about £36.

In conclusion, the author expressed the hope that these specimens of timber work, the result ot many years' experience, and the adaptation of the only available resources of a new and comparatively poor country, would be found interesting; as, whatever their merits or faults, the bridges had undoubtedly produced good practical results, and would bear investigation.

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## ON THE RECONSTRUCTION OF THE DINTING AND THE MOTTRAM VIADUCTS.

By Mr. W. Fairbairn, F.R.S., M. Inst. C.E.

After alluding to the many advantages resulting from the application of a tenacious but flexible material, like wrought-iron, either in the tubular girder, or other forms in which it was now employed, as being probably the most suitable for bridges and viaducts of great width and span, where strength and durability were required, the author remarked, that at the present time there did not appear to exist any inducement, on the score of economy, for the introduction of a perishable material, such as timber, into structures intended to be of a permanent character. He then briefly described the original condition of the Dinting and the Mottram viaducts, on the Sheffield and Manchester railway, which were erected in the year 1843-44, under the direction of the late Mr. Joseph Locke. The former consisted of five arches of 125 feet span, and the latter of one arch of 150 feet and two of 125 feet span, constructed of timber ribs on the laminated principle. As was generally the case with similar structures, within ten or twelve years after their erection, the timber was so much decayed as to endanger their security, and to render considerable repairs indispensable. It was then contemplated to substitute iron work, but this step was not finally determined upon until the year 1858, when the viaducts were again in such a state as to alarm the passengers. It was stated that, the restored portions for each viaduct, consisted of two longitudinal and continuous tubular iron girders, fixed to the middle piers, and free to

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expand and contract in the direction of the abutments. To the top of these girders iron cross-beams were rivetted, on which were laid the ongitudinal sleepers for supporting the rails. There was nothing new in the construction of the girders. They were one-thirteenth of the span in depth, and the areas of the top and bottom flanges were in the proportion of 7 to 6, the breaking weight, equally distributed, amounting to 12·58 tons per lineal foot. The chief novelty was in the mode of erection, and in the method of substituting iron for wood; the Directors of the Railway Company having insisted on the condition, that the traffic should not be interrupted during the progress of the works. Several plans were proposed, but that which was ultimately adopted was to construct the girders on the old existing platforms, to cut down the piers and the abutments, and then, by a simple mechanical apparatus, first to suspend and afterwards to lower the girders into their places. A strong wooden frame, about 16 feet high, was erected on the pier at each end of the girder, and on the top of this was inserted a cast-iron plate, with a hole in the centre, through which a square-threaded screw, 4½ inches in diameter, was passed. Centered on this screw, and resting on the cast-iron plate, was a bevil wheel, which received motion from a pinion, in connection with spur gearing, worked by crank handles in the ordinary manner. On the lower end of the large screw was forged an eye, to receive a cross-bar, having links at each extremity, which hooked under the angle irons at the sides of the girder. With six men at the handles, each girder was raised and lowered into its place in one hour. When one line of girders was thus completed—the whole of the traffic having in the meanwhile been carried by a single road—a temporary way was laid upon this line of girders, and the traffic was transferred to it. The girders on the other side of the viaduct were next constructed, and when they were finished, the iron cross-beams were rivetted to these girders, and the permanent way for this line was made good. The trains were again passed on to this road, the permanent way on the other side was laid, the timber arches and the framing were removed, and the viaduct was complete.

## ON THE PERENNIAL AND FLOOD WATERS OF THE UPPER THAMES.

By the Rev. J. C. Clutterbuck, M.A.

The object of this communication was to draw attention to the nature of that portion of the water-shed of the Thames comprising the oolitic district, and containing a computed area of 1500 square miles, situated between the range of chalk hills bounding the Vales of Aylesbury and of White Horse, and the Cotswold Hills bounding the Vale of Evesham and the Valley of the Severn. It was shown that, the Thames ran almost entirely over a clay bed from its source, about 4 miles west of Cirencester, to its junction with the Thame stream, the limit of the district under consideration; and that it was the mere carrier of waters, whether perennial, or flood, brought in by its tributaries, a description of which, in the order they joined the main river, was given. Those running from N. to S. and from N.W. to S.E.,—as the Churn, the Coln, the Leach, the Windrush, the Evenlode, and the Cherwell,—received their perennial waters from oolitic strata. Those flowing from S. to N. originated in the chalk hills, from the escarpment of which they conveyed the back drainage, slightly augmented by that of the upper greensand, and then passed over the gault and kimmeridge clays, either to the main stream, as the Ray and the Cole, or as affluents of the Ock and the Thame, from which the principal supply was derived.

The geological condition of the source of the main stream was next noticed; and it was stated that the whole natural bed of the river, from Somerford Keynes to Sandford, below Oxford, was an excavation in the Oxford clay, flanked to the south by the escarpment of the coralline oolite, which rested on a ridge of the clay. As a rule, the lower levels of the valley, including also in many places the oolitic rock, outcropping to the north at a very slight angle beneath the Oxford clay, were covered with drift gravel. Whenever the floods had extended, sand, silt, or argillaceous loam, had been deposited on this gravel; and this action was still going on, governed by the number and character of the floods. Thus, the bed of the river was as a rule gravel, and the banks a warp, the accumulation of ages. There were instances of the change of bed to the extent of several chains in width; and indeed there appeared to be no limit to these deviations, but the physical features of the valley. These facts had an important bearing on any improvement, so much needed, in the drainage, or condition of the Thames valley.

The perennial waters were either used for mills, or for navigation. The mills on the tributaries were numerous. Between Thames Head and Cricklade they were, however, virtually deprived of water. From Cricklade to Lechlade the water was not applied to any economical use; and again from Lechlade to Wolvercote, 3 miles above Oxford, there were no mills. The gaugings of the numerous tributaries, where they joined the main stream, would give the aggregate of the water that it carried; but such observations had been neglected, and as the watersheds were very varied, any estimate of the volume of these streams at different seasons would be difficult. Most of these tributaries were immediately affected by heavy rains, and were subject to flood. The gauging of the main stream was beset with other difficulties; as the height and passage of the water was divided between the mills and the navigation, controlled, indeed, by stringent regulations, but too often disregarded. Though it was not the purpose of this communication to deal with absolute quantities derived from the various sources, yet it was believed the following gaugings, the result of several years' observations, by Mr. Stacy, the manager of the mills at Wolvercote, would be received with interest, and would, if carried in out in other places, lead to valuable results. There were no mills for 30 miles above Wolvercote, and the navigation, though 'flashes' were still sent down, had virtually ceased. Mr. Stacy had found that, in the summer months, the river had a mean velocity of 58ft. per minute, when the total yield was 8120 cubic feet per minute, exclusive of the quantity brought down twice a week by "flashes," which it was difficult to estimate. During the winter months, in fine weather, without frost, or rain, the river had a mean velocity of 94·9ft. per minute, and taking the section area as 181·5 square feet, this gave a volume of 17,224 cubic feet per minute. In moderate rainy weather, without floods, when the level of the river just reached the high-water navigation mark, the total quantity of water passing through the mill was 28,189 cubic feet per minute. At the end of December, 1862, under similar conditions, the total yield was 35,498 cubic feet per minute, of which 7738 cubic feet might be taken as the water passing from the main stream to Wytham. These data suggested the necessity of adopting a standard at various stations, so that the results might be compared with the rainfall when the gaugings were taken. At the same time, observations were made on the river below the influx of the Cherwell and the Ock, when the yield was found to be 50,995 cubic feet per minute, being an excess of 15,497 cubic feet as compared with Wolvercote, and of which excess it was estimated that 7689 cubic feet were brought in by the Cherwell, and the remainder by the Ock and the smaller perrennial streams. The verification of these quantities was prevented by a fall of rain of nearly half-an-inch, in a few hours, which, at the expiration of thirty-six hours, doubled the volume of the Thame stream, and added about 30 per cent. to the volume of the main river. At Wolvercote, on the 5th of January, 1863, after about 1 inch of rain, the increase was from 27,986 to 48,418 cubic feet per minute. The rainfall from the 1st to the 7th January, 1863, inclusive, produced a flood in the Thames under circumstances peculiarly favourable for observation. The rain recorded during this period averaged 1·61 inch over the whole water-shed; Dalton's gauge, at Hemel Hempsted, showing a fall of 1·52in., and a percolation of 1·10in. The gaugings of the main river at Wolvercote then amounted to 82,500 cubic feet per minute, and at Clifton Hampden, below Abingdon, to 181,832 cubic feet per minute. Of this latter quantity 44,755 cubic feet were delivered by the Cherwell (or an increase of 37,066 cubic feet as due to the flood), 24,864 cubic feet by the Ock, and 29,713 cubic feet by the many smaller streams, water-courses, and land drainage outfalls, issuing into the river between Wolvercote and Clifton Hampden, a distance of about 20 miles by the river, with an average fall of 2ft. per mile, from a computed water shed of 80 square miles. It should be stated, that the rainfall on this occasion, on the southern part of the district, was in excess of the average more than half an inch.

The state of the navigation between Lechlade and Oxford was then described. It was remarked that from running on one stratum, the Oxford clay, and from other causes, it ceased to be; although the physical condition of the river bed, and its easy gradients, offered facilities for navigation, for the whole fall in this distance, 31 miles, was only 51ft. 3in., or about 1ft. 7½in., on average per mile.

The highest recorded floods on the Thames, since January 8, 1734, were then alluded to, and details were given of that which occurred March 29-31, 1862. The action of land drainage on flood-water was next considered. It was generally admitted, that the floods in the main river and its tributaries rose more rapidly than formerly; there being in some localities an advance of twenty four in seventy two hours within twenty years. There was a difference of opinion as to the subsidence of the water. As yet, however, it was believed, that land drainage had produced little apparent practical effect on the volume of the flood or perennial waters of the Upper Thames.

There was great scope for improvement in the valleys of the Thames and its tributaries, especially the Thame, the Ock, the Cherwell, and the Evenlode. With a view to prevent injury by floods, Mr. Bryan Wood had successfully carried out several important works, based on a system in which the local drainage was separated from the flood. If, by some such plan, the floods were brought under control, and the water prevented from remaining stagnant on the land, property would be improved, and the sanitary condition of the Valley of the Upper Thames would be greatly benefited,



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## INSTITUTION OF ENGINEERS IN SCOTLAND.

### ON A STEREOMETRIC TABLET FOR THE COMPUTATION OF EARTHWORK.

By Mr. John Warner, of Pennsylvania, U.S.

This is an instrument intended to assist the computation of earthwork by the method of transverse ground slopes. The measurements taken on the field are—the length of the work; and, at each end, the centre-height, C H, C T (Fig. 1); and the inclination to the horizon of the surface line, D E, K M, of each cross section. To simplify the explanation, the surface of the ground is assumed to be plane.

*Plane Surface.*—The problem, then, is to find the solidity of a prismoid included between the end planes, A B K M, A B D E, the side slopes, B D, A E, and the plane surface joining M K, D E. The elements necessary for computation are—the sum of the whole end heights, H N, T N, and the difference of those heights; the slope or inclination to the horizon of K M or D E; also the width of the road bed, A B, and the rate of the side slope; that is, the inclination of B K or A E to the horizon.

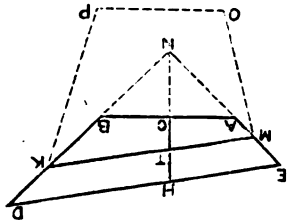



Fig. 1.

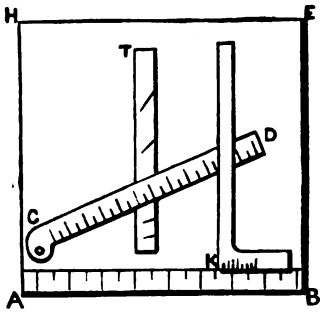



Fig. 2.

Suppose C H = 28·7, C T = 14·5, the slope of K M or D E = 15°, the width of road bed, A B, = 24 ft., the side slope 1½ to 1, and the length of the work 100 ft., we shall then have the sum of H N and T N = 43·2, and their difference = 14·2.*

The Stereometric Tablet is represented in Fig. 2. It consists essentially of a flat tablet, A B E H, with three scales, A B; C D, upon a pivot at C; the scale, T; and and a movable square, K. The back of the square contains a vernier, by aid of which distances can be taken upon A B in feet and tenths.

The scale, A B, is called the radius scale; C D, the secant scale; and T, the tangent scale. Both C D and T require a peculiar graduation, of which we shall hereafter speak particularly. At present it is sufficient to say that C D represents length, and T represents the slope of the ground surface.

The Stereometric Scale, (Fig. 4), is used in conjunction with the tablet. Before proceeding to exemplify the use of the tablet, it would be proper to show the use of this scale. It is employed to find the equivalent sum of heights, that is, the double whole end-height (or twice the height corresponding to T N, Fig. 1) of a prism standing on a triangular base similar to N K M, of the same length as the given prismoid contained between A B K M and A B D E, and having the same solidity.*

To find the equivalent sum of heights by the scale, the method will be best shown by an example. Take the dimensions given in figure 1.

The sum of the end heights is 43·2, and their difference 14·2. On the first side of the scale, marked "sums," take 43·2, and extend the dividers to the difference, 14·2, on the scale of "differences." Keeping the dividers set, go to the second side of the scale, place one point at the mark of the surface slope 15,° as nearly as can be estimated, on the scale of "degrees," and read the number to which the dividers reach on the scale of "depths," say 58 ft.: this is the equivalent sum of heights required.

*To find the Solidity by the Tablet.*—Take the same example. The scales C D and T of the tablet (Fig. 2) are supposed to be proper for the given side slope, 1½ to 1. We must now go on to the tablet with the equivalent sum of heights, 68, as above found, and with the surface slope 15°.

Set the square, K, to read 68 upon A B, and set the scale, C D, at 15° upon T. We then read upon C D as marked by the blade of the square, say 109·7. With the quantity, 109·7, we enter a suitable table,† where, opposite 109 feet, and under 7-tenths, we find the content of the work, say 5571 yards.

If desirable, questions of the following kind may be resolved by the tablet:—

Suppose O P ‖ (Fig. 1) to represent the road bed, and suppose a piece of rock cutting, as O P K M, to begin above by an earth cut, M K D E. How is the computation to be performed?‡

The cross-section of one end of the work only (as the figure now viewed represents) will be sufficient to illustrate the method of proceeding.

Compute, by the tablet, the rock cutting in the manner just described, taking care that the scales, C D and T, are suitable for the side slope of the rock cutting. It then remains to compute the earth cutting, M K D E.

Produce the side slopes, D K, E M, to meet in N, and perform this on each end cross section; then proceed, as before, to find the content res-

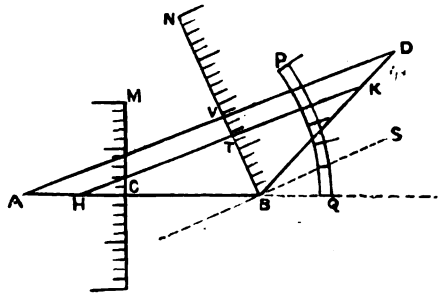



Fig. 3.

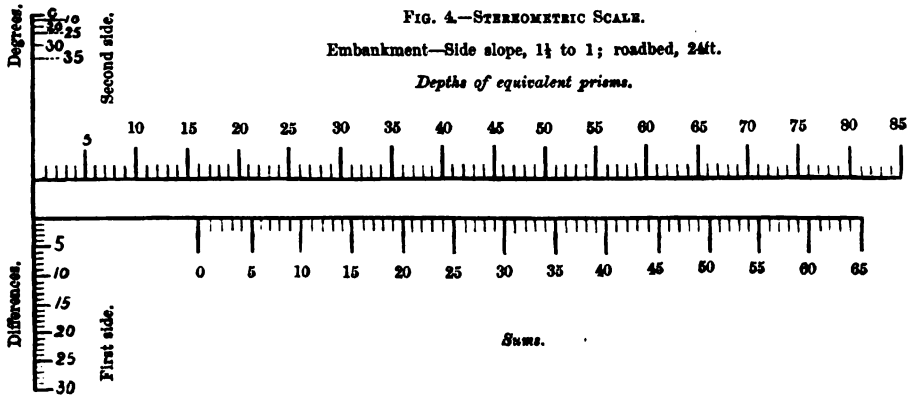



Fig. 4.—Stereometric Scale.

Embankment—Side slope, 1½ to 1; roadbed, 24ft.

*Depths of equivalent prisms.*

* The scale is easily prepared for any given width of road bed and rate of side slope, but we cannot here enter on further explanation of this point. See Treatise, Article 97, p. 48; and Article 12, section 3, p. 301.

* These dimensions will be easily found by the reader. In the author's treatise on earthwork an easy system of obtaining these elements is taught; but it would divert attention from the main subject to enter now on further explanation of this point. See Treatise, Article 59, p. 31:—*New Theorems, Tables, and Diagrams, for the computation of Earthwork: designed for the use of engineers in preliminary and final estimates of students in engineering, and of contractors, and other non-professional computers. Illustrated by original engravings, and a series of lithographic drawings from models, showing all the combinations of solid forms which occur in railroad excavations and embankments.* 8vo. pp. 316. Philadelphia, J. B. Lippincott & Co., 1861.

† Table XV. of the Treatise. This table contains the eighth-parts of square prisms 100 ft. long. The side of the square base of such a prism, multiplied by $\sqrt{8}$ would give the number 109·7 above used to enter the table. See Article 25, section 5, p. 312. We may, if desired, compute by tablet the whole ground inclosed between the surface and intersection of side-slopes, and then subtract the redundant prism standing. (Article 85, p. 41, and 13, p. 302.)

‡ As a similar question was proposed when the tablet was exhibited, the answer then given may be appropriately repeated here. Compare Article 92, p. 46.

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pectively of the solids on N D E and N K M. The difference of these solids is the earth cutting, K D E M.

Where the end cross sections, if complicated in form, can be reduced to equivalent triangular cross sections, having side slopes to which the tablet applies, an approximate result can generally be obtained. But the writer will not now elaborate this suggestion.

The pyramids, and truncated pyramids, which frequently occur in benching upon hill-sipes, may be computed by the tablet.

Suppose H B K and A B D (Fig. 3) to be the end cross sections of a truncated pyramid. Bisect the side-slope, D B Q, by the line B S, and draw B N perpendicular to B S; B N will then bisect A B D. By drawing a scale of feet on C M at the centre of the road bed, and also on B N, and by appending a graduated arc, P Q, of which the centre may be placed at C, a diagram will be formed on which various cross sections may be drawn in pencil, and erased when no longer needed. The scale C M will be convenient for taking centre-heights, the arc P Q will give the surface slope, and the scale B N will measure new heights, which are to be used in computation by the tablet. It is evident that these new heights, such as B V, correspond entirely with such heights as H N in (Fig. 1); and that if a prism standing on a triangle similar to N D E can be computed from heights similar to H N, so can in Fig. 5, a prism standing on a triangle similar to A B D, be computed from heights similar to B V. It will only be necessary to take care that the scales, C D, and T of the tablet, are adapted to the angle, D B S, as the side slope, and to the angle between A D and B S, as a new surface slope. Let us take an example:—

*Example.*—Suppose the width of road-bed to be 28ft., that is, B C 14ft.; the centre height of A B D = 4·0, of H B K = 2·1, the surface slope 20°, the side slope 1 to 1, the length of the work 100ft. The line, B V, will be found to measure, say 8·6; B T to measure, say 6·7. The sum and difference of these new heights will be 15·3 and 1·9. Then by scale* we shall find the equivalent sum of heights, say 15·4. Then on the tablet (Fig. 2, the scales C D and T, being adapted to the work), take 15·4 upon A B, set C D at 20°, and read on C D, say 34·0. Then, in Table XV., opposite 34ft. and under 0 tenths, find the content, say 535 yards.

In the case of a pyramid, one of the new heights, as B T, will be nothing; and this value must be used in taking the sum and difference. Then work as before.

If the length of the work differs from 100ft., the solidity as above found is to be taken proportionally according to the real length.

*Warped Surface.*—We have assumed the surface slope at both ends, (Fig. 1), to be the same, and the surface a plane. If the slope is different at the two ends, or if it is in opposite directions, the surface will be warped. In this case, if a solid can be found with a plane surface, and containing exactly or nearly the same solidity as the work under the warped surface, the content of such a solid can evidently be computed by the tablet. The writer has shown that a good approximation may be obtained, by computing as for a prism standing on the mid cross section of the work.† If desired, this approximation may be corrected by means of a small second term, which can also be found by aid of the tablet.‡ If the computor chooses to assume any particular height and surface slope under plane ground for the base of a prism, he may work by the tablet.

*Curves.*—It is usual, at least for preliminary estimates, to compute on curves as if for straight work. But when it is judged desirable to take curvature into account, the writer's method is to compute as if for straight work, of the given end dimensions, and 100ft. in length; this may be done by the tablet. The content thus found is then corrected for curvature, after which, if the length differs from 100ft., the corrected content is taken proportional to the length.§

*Graduation of the Scales C D and T.*—For cross sections, such as Fig. 3, we may take A B on a scale of 20ft. to the inch; then divide 10in. by the square root of twice the rate of side slope. The result will correspond to 10in. on A B—that is, the length thus found will contain 200 parts or feet upon C D. Thus, for the side slope 1½ to 1, twice the rate of slope is 3; then, 10 divided by $\sqrt{2}$ gives 5·7735. This length is divided into 200 parts on C D.‖

To find the mark on the scale, T, which corresponds to any given degree of surface slope, make radius equal to the rate of side slope, draw from the centre a line inclosing with radius an angle equal to the surface slope, and find the natural tangent of this angle for the assumed radius. Then, with radius equal to unity, take the tangent thus found for a sine, and construct the angle corresponding to this sine. This angle is the angle included between A B and C D, upon (Fig. 2), for the given surface slope. The construction is simple in practice.*

For pyramids and truncated pyramids, proceed to graduate the scales as before, only taking care to use the half of the angle D B Q—that is, D B S (Fig. 3), to obtain a new rate of side slope; also instead of the real surface slope, D A Q, to use the angle included between D A and B S. The point on the scale T, (Fig. 2) however, which has been thus obtained, must be marked with the degree of the real surface slope, D A Q. Two graduations will arise, one counting up the scale, T, and the other down it; for it will be noticed that when D A Q = S B Q, the *new* surface slope of D A is nothing—that is, the mark is at the bottom of the scale, T. The graduation will begin, on one side of the scale, with the marks for the lower numbers of the real surface slope running down until the real surface slope is equal to S B Q, when the bottom of the scale is reached, and the graduation will proceed upwards on the other half of the scale.

*Construction of the Tablet in Practice.*—The body of the tablet may be made of wood not liable to warp. The scales, A B and C D, and the square, K, made be made of metal. The scale, C D, adapted to a particular side slope, may be changed for another adapted to another side slope, by simply lifting off and putting over the pivot, C. If desirable, four scales may be engraved on the four edges of C D, and four pivot holes placed at the four corners. The scale, T, for any particular side slope, may be placed upon one of the faces of a polygonal roller let into the tablet. Several such rollers may be made if desired.

An expert draughtsman may, however, prepare his own tablet. A paper scale, A B, can be pasted on the edge of a drawing table. The square, K, may be supplied by a T-square applied to the edge of the table; or the scale, A B, may be pasted on the edge of a flat rule, and a right-angled triangle applied to the rule. The scale, T, may be graduated on paper, when means will readily be devised to fasten this scale, or to exchange it for another when necessary. The scale, T, should have its zero upon a line drawn through through the pivot, C, parallel to A B. The vernier of the square, K, must show zero upon A B when the edge of the blade is at the centre of the pivot, C.

The writer has thus shown that all ordinary problems occurring in the method of transverse slopes can be expeditiously solved by the tablet, with the aid of a single table. If it is considered sufficient for preliminary estimates to assume the ground to be level transversely, the tablet is simplified. It will then only be necessary to keep the scale, C D, permanently set at 0°—that is, to draw the scales, A B and C D, side by side, on the same paper. The square, K, and scale, T, may be dispensed with. Or an instrument may be constructed, by inserting between the scales a movable slide, instead of the square, K. This slide may be set to the proper mark upon A B, when the required distance upon C D can be at once read. If desired, instead of reading the distance on C D and then going into Table XV., the numbers corresponding to the divisions of C D may be extracted from the table, and placed on this scale; the difference for tenth-parts may also be recorded. The instrument may be of sufficient size to permit the requisite numbers to be thus placed.†

*Of the Nature of the Ground Surface.*—Whether or not it is sufficient for preliminary estimates to assume the surface to be level transversely, will be regarded by some as a matter of opinion, which cannot be decided by the dictum of any one writer. The present writer does not consider this assumption sufficiently accurate. It may at least be said, in favour of taking the ground slope into account, that the labour of measuring the slope is not great, and that estimates which take account of this slope will approximate to the truth considerably nearer than estimates which disregard this element of computation. This may be exemplied in the following manner:—

Let the length be 100ft., the end heights 13ft. and 9ft., the road bed 24ft., the side slope 1½ to 1, the surface slope 9°. The content will be found to be 1777·9 yards. Had we, with these dimensions, assumed the ground to be level transversely, we should have found for the content 1657·4 yards, which is too little by 120·5 yards, or about 7 per cent. The mean height of the given section is 11ft., and the content for this mean height under 9° slope is 1770 yards. Under level ground we should find 1770 yards to correspond to a mean height a little over 11¼ft.

Again, suppose a mean height of 5ft. with the other dimensions as before. Under 9° we find the content to be 639·5 yards; this quantity under level ground corresponds to a mean height a little less that 5$\frac{1}{10}$ft.; the actual content under level ground for a mean depth of 5ft. is 583·3 yards, which is too little by 56·2 yards, or about 9 per cent. too little.

It therefore appears, that with the not unusual dimensions of these examples, the error of computation is from 7 to 9 per cent., and this error corrresponds to an error of about ¼ foot in taking the levels. Such errors in levelling for preliminary estimates would not, the writer thinks, be

* See treatise, Article 96, p. 47, and Article 12, section 2, p. 301. The width of road-bed on the stereometric scale (Fig. 6), is now 0.

† See Treatise, Article 104 p. 52, and Articles 6, 7, 8, pp. 293—294, for the necessary details.

‡ The height and the surface slope of the secondary prism (Article 6, p. 293) may be measured, and the prism computed.

§ See Treatise, Article 105, p. 53.

‖ See Treatise, Article 25, sec. 5, p. 312.

* The Tablet is a mechanical exhibition of diagrams similar to that of Plate XIV. (Treatise). The scale, A B, corresponds to C K; the scale C D to C Φ; the scale, T, to the graduation on the margin of the Plate, and the square, K, to the line K Φ. For further details see Articles 23, 24, 25, pp. 309—313.

† Such an instrument may be seen in the Engineering School of the Glasgow University.

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tolerated even by engineers who might consider it sufficient in practice to neglect the transverse slope.* It was asked at the meeting, whether computation by transverse slopes is not going out of use in America. The writer is not aware that this is the case.† The true question to be settled, however, is whether or not this mode of computation ought to be retained. To settle this, we should look rather to the necessity of the case than to indirect proofs founded on a supposed disuse of the method. In the writer's opinion, it is as necessary to attend to the transverse slope in computation, as it is to take into account single tenths of feet in the end heights.‡ It has long been held by American authorities to be necessary, and it is still their practice to take the tenths into account.§

The writer will not here enter into a formal discussion of the most probable hypothesis concerning the form of the ground surface. It is sufficient to express his belief that, at least for preliminary estimates, the computer may use the tablet with advantage, because he can, either according to some hypothesis he may adopt, or by an empirical estimate,‖ find centre heights and serface slopes which will give a good approximate result. The faciliity and expedition in the employment ot the tablet will, he thinks make it a valuable instrument, not only to professional engineers, but to contractors and other non-professional computers, who may either desire to test the computations of engineers, or to prepare for duty in a field corps.

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## RESULTS OF AN EXPERIMENTAL INQUIRY INTO THE COMPARATIVE TENSILE STRENGTH AND OTHER PROPERTIES OF VARIOUS KINDS OF WROUGHT IRON AND STEEL.

By Mr. David Kirkaldy.

Mr. Kirkaldy exhibited several cases of the fractured specimens upon which his experiments were made; and, by way of introduction to the discussion, there were read from his treatise the following conclusions arrived at by Mr. Kirkaldy in the course of his inquiry:—

1. The breaking strain does not indicate the quality, as hitherto assumed.
2. A high breaking strain may be due to the iron being of superior quality, dense, fine, and moderately soft, or simply to its being very hard and unyielding.
3. A low breaking strain may be due to looseness and coarseness in the texture, or to extreme softness, although accompanied by very close and fine quality.
4. The contraction of area at fracture, previously overlooked, forms an essential element in estimating the quality of specimens.
5. The respective merits of various specimens can be correctly ascertained by comparing the breaking strain jointly with the contraction of area.
6. Inferior qualities show a much greater variation in the breaking strain than superior.
7. Greater differences exist between small and large bars in coarse than in fine varieties.
8. The prevailing opinion of a rough bar being stronger than a turned one is erroneous.
9. Rolled bars are slightly hardened by being forged down.
10. The breaking strain and contraction of area of iron plates are greater in the direction in which they are rolled than in a transverse direction.
11. A very slight difference exists between specimens from the centre and specimens from the outside of crank-shafts.
12. The breaking strain and contraction of area are greater in those specimens cut lengthways out of crank-shafts than in those cut crossways.
13. The breaking strain of steel, when taken alone, gives no clue to the real qualities of various kinds of that metal.
14. The contraction of area at fracture of specimens of steel must be ascertained as well as those of iron.
15. The breaking strain, jointly with the contraction of area, affords the means of comparing the peculiarities in various lots of specimens.
16. Some descriptions of steel are found to be very hard, and, consequently, suitable for some purposes; whilst others are extremely soft, and equally suitable for other uses.
17. The breaking strain and contraction of area of puddled-steel plates, as in iron plates, are greater in the direction in which they are rolled; whereas in cast-steel they are less.
18. Iron, when fractured suddenly, presents invariably a crystalline appearance; when fractured slowly, its appearance is invariably fibrous.
19. The appearance may be changed from fibrous to crystalline by merely altering the shape of the specimen so as to render it more liable to snap.
20. The appearance may be changed by varying the treatment so as to render the iron harder and more liable to snap.
21. The appearance may be changed by applying the strain so suddenly as to render the specimen more liable to snap, from having less time to stretch.
22. Iron is less liable to snap the more it is worked and rolled.
23. The skin or outer part of the iron is somewhat harder than the inner part, as shown by appearance of fracture in rough and turned bars.
24. The mixed character of the scrap-iron used in large forgings is proved by the singularly varied appearance of the fractures of specimens cut out of crank-shafts.
25. The texture of various kinds of wrought-iron is beautifully developed by immersion in dilute hydrochloric acid, which, acting on the surrounding impurities, exposes the metallic portion alone for examination.
26. In the fibrous fractures the threads are drawn out, and are viewed externally, whilst in the crystalline fractures the threads are snapped across in clusters, and are viewed internally or sectionally. In the latter cases the fracture of the specimen is always at right angles to the length; in the former it is more or less irregular.
27. Steel invariably presents, when fractured slowly, a silky fibrous appearance; when fractured suddenly, the appearance is invariably granular, in which case also the fracture is always at right angles to the length; when the fracture is fibrous, the angle diverges, always more or less from 90°.
28. The granular appearance presented by steel suddenly fractured is nearly free of lustre, and unlike the brilliant crystalline appearance of iron suddenly fractured; the two combined in the same specimen are shown in iron bolts partly converted into steel.
29. Steel which previously broke with a silky fibrous appearance is changed into granular by being hardened.
30. The little additional time required in testing those specimens whose rate of elongation was noted had no injurious effect in lessening the amount of breaking strain, as imagined by some.
31. The rate of elongation varies not only extremely in different qualities, but also to a considerable extent in specimens of the same brand.
32. The specimens were generally found to stretch equally throughout their length until close upon rupture, when they more or less suddenly drew out, usually at one part only, sometimes at two, and, in a few exceptional cases, at three different places.
33. The ratio of ultimate elongation may be greater in short than in long bars in some descriptions of iron, whilst in others the ratio is not affected by difference in the length.
34. The lateral dimensions of specimens form an important element in comparing either the rate of, or the ultimate, elongations—a circumstance which has been hitherto overlooked.
35. Steel is reduced in strength by being hardened in water, while the strength is vastly increased by its being hardened in oil.
36. The more highly steel is heated (without of course running the risk of being burned) the greater is the increase of strength, on its being plunged into oil.
37. In a highly converted or hard steel, the increase in strength and in hardness is greater than in a less converted or soft steel.
38. Heated steel, by being plunged into oil instead of water, is not only considerably *hardened*, but *toughened* by the treatment.
39. Steel plates hardened in oil and joined together with rivets are fully equal in strength to an unjoined soft plate; or the loss of strength by rivetting is more than counterbalanced by the increase in strength by hardening in oil.
40. Steel rivets fully larger in diameter than those used in rivetting iron plates of the same thickness being found to be greatly too small for rivetting steel plates, the probability is suggested that the proper proportion for iron rivets is not, as generally assumed, a diameter equal to the thickness of the two plates to be joined.
41. The shearing strain of steel rivets is found to be about a fourth less than the tensile strain.
42. Iron bolts, case-hardened, bore a less breaking strain than when wholly iron, owing to the superior tenacity of the small proportion of steel being more than counterbalanced by the greater dutility of the remaining portion of iron.
43. Iron highly heated and suddenly cooled in water is hardened, and the breaking strain, when gradually applied, increased, but at the same time it is rendered more liable to snap.
44. Iron, like steel, is softened, and the breaking strain reduced, by being heated and allowed to cool slowly.
45. Iron subjected to the cold-rolling process has its breaking strain greatly increased by being made extremely hard, and not by being "consolidated," as previously supposed.
46. Specimens cut out of a crank-shaft are improved by additional hammering.
47. The galvanizing or tinning of iron plates produces no sensible effects on plates of the thickness experimented on. The results, however, may be different should the plates be extremely thin.
48. The breaking strain is materially affected by the shape of the specimen. Thus the amount borne was much less when the diameter was uniform for some inches of the length than when confined to a small portion—a peculiarity previously unascertained and not even suspected.
49. It is necessary to know correctly the exact conditions under which any tests are made, before we can equitably compare results obtained from different quarters.

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* In these comparisons we may assume a plane surface both for the level and the sloping ground.

† This method is still practised by eminent engineers in that country. Both during the preparation of his work and since its publication, the writer received the testimony of high American authority as to the value of this mode of computation.

‡ Tables VII. and IX. afford the means of comparing, by inspection of the Table the difference in content caused by a change of one-tenth foot in mean height under the same degree of slope, and the difference due to a change of one degree of slope with the same mean height. Such a comparison will, the writer thinks, support the opinion of the text.

§ See Ellwood Morris, C.E., in *Journal of Franklin Institute*, vol. xxv., second series, p. 23. Mr. Morris objected to the Tables of Macneil, not only that they did not extend to tenths of feet in height, but that they were restricted to level ground.

‖ Although the writer will not assume the responsibility of recommending empirical processes yet it must be observed that those who, for the sake of expedition, resort to empirical processes, cannot consistently object to the following passage:—Empirical processes here must be compared with other empirical processes for facility and approximate accuracy. A small empirical increase of the equivalent sum of heights, in order to make up for neglecting the differences, would probably lead to closer results than disregarding the surface slope and assuming the ground to be level transversely, although known to be considerably inclined. Such an empirical process would simplify the operation of the stereometric scale. (Compare Article 101, p. 50.)

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50. The startling discrepancy between experiments made at the Royal Arsenal, and by the writer, is due to the difference in the shape of the respective specimens, and not to the difference in the two testing machines.

51. In screwed bolts the breaking strain is found to be greater when old dies are used in their formation than when the dies are new, owing to the iron becoming harder by the greater pressure required in forming the screw thread when the dies are old and blunt, than when new and sharp.

52. The strength of screw-bolts is found to be in proportion to their relative areas, there being only a slight difference in favour of the smaller compared with the larger sizes, instead of the very material difference previously imagined.

53. Screwed bolts are not necessarily injured although strained nearly to their breaking point.

54. A great variation consists in the strength of iron bars which have been cut and welded; whilst some bear almost as much as the uncut bar, the strength of others is reduced fully a third.

55. The welding of steel bars, owing to their being so easily burned by slightly over-heating, is a difficult and uncertain operation.

56. Iron is injured by being brought to a white or welding heat if not at the same time hammered or rolled.

57. The breaking strain is considerably less when the strain is applied suddenly instead of gradually, though some have imagined that the reverse is the case.

58. The contraction of area is also less when the strain is suddenly applied.

59. The breaking strain is reduced when the iron is frozen; with the strain gradually applied, the difference between a frozen and unfrozen bolt is lessened, as the iron is warmed by the drawing out of the specimen.

60. The amount of heat developed is considerable when the specimen is suddenly stretched, as shown in the formation of vapour from the melting of the layer of ice on one of the specimens, and also by the surface of others assuming tints of various shades of blue and orange, not only in steel, but also, although in a less marked degree, in iron.

61. The specific gravity is found generally to indicate pretty correctly the quality of specimens.

62. The density of iron is decreased by the process of wire-drawing, and by the similar process of cold-rolling, instead of increased, as previously imagined.

63. The density in some descriptions of iron is also decreased by additional hot-rolling in the ordinary way; in others the density is very slightly increased.

64. The density of iron is decreased by being drawn out under a tensile strain, instead of increased, as believed by some.

65. The most highly converted steel does not, as some may suppose, possess the greatest density.

66. In cast steel the density is much greater than in puddled steel, which is even less than in some of the superior descriptions of wrought-iron.

The breaking strain per square inch of wrought-iron is generally stated to be about twenty-five tons for bars and twenty tons for plates. This corresponds very nearly with the results of the writer's experiments, of which the following table presents a condemned summary :—

| | Highest. | Lowest. | Mean. | |
|---|---|---|---|---|
| | lbs. | lbs. | lbs. | Tons. |
| 188 Bars, rolled | 68,848 | 44,584 | 57,555 | = 25¾ |
| 72 Angle-iron, &c. | 63,715 | 37,909 | 54,729 | = 24½ |
| 167 Plates, lengthways | 62,544 | 37,474 | 50,737 | = 21¾ |
| 160 Plates, crossways | 60,756 | 32,450 | 46,171 | |

Although the breaking strain is generally assumed to be about 25 tons for bars and 20 tons for plates, very great difference of opinion exists as to the amount of working strain, or the load which can with safety be applied in actual practice. The latter is variously stated at from a third to a tenth. It will be observed that whilst much discussion has arisen as to the amount of working strain, or the ratio the load should bear to the breaking strain, the important circumstance of the quality of the iron, as influencing the working strain, or the ratio the load should bear to the breaking strain, the important circumstance of the quality of the iron, as influencing the working strain, has been overlooked. The Board of Trade limits the strain to 5 tons, or 11,200lbs. per square inch.

It must be abundantly evident, from the facts which have been produced, that the breaking strain, when taken alone, gives a false impression of, instead of indicating, the real quality of the iron, as the experiments, which have been instituted reveal the somewhat startling fact, that frequently the inferior kinds of iron actually yield a higher result than the superior. The reason of this difference was shown to be due to the fact, that while the one quality retained its original area, only very slightly decreased by the strain, the other was reduced to less than one-half. Now, surely this variation, hitherto unaccountably completely overlooked, is of importance as indicating the relative hardness or softness of the material, and thus, it is submitted, forms an esssential element in considering the safe load that can be practically applied in various structures. It must be borne in mind that although the softness of the material has the effect of lessening the amount of the breaking strain, it has the very opposite effect as regards the working strain. This holds good for two reasons: first, the softer the iron the less liable it is to snap; and second, fine or soft iron, being more uniform in quality, can be more depended upon in practice. Hence the load which this description of iron can suspend with safety may approach much more nearly the limit of its breaking strain than can be attempted with the harder or coarser sorts, where a greater margin must necessarily be left.

Special attention is now solicited to the practical use that may be made of the new mode of comparison introduced by the writer, viz: the breaking strain per square inch of the fractured area of the specimen, instead of the breaking strain per square inch of the original area.

As a necessary corollary to what he has just endeavoured to establish, the writer now submits, in addition, that the working strain should be in proportion to the breaking strain per square inch of fractured area, and not to the breaking strain per square inch of original area, as heretofore. He does not presume to say what that ratio should be, but he fully maintains that some kinds of iron experimented on by him will sustain with safety more than double the load that others can suspend, especially in circumstances where the load is unsteady, and the structure exposed to concussions, as in a ship, or to vibratory action, as in a railway bridge.

The writer has not attempted to explain the cause of the mysterious change produced on steel by heating it and plunging it into water, or the no less singular result effected by plunging it, when heated, into oil. Neither has he tried to account for the mysterious change produced by subjecting iron to the processes of cold-rolling or wire-drawing. The explanation offered by some, of this difficult question, that the iron and steel are condensed by the processes to which they are subjected, is completely contradicted by fact, the metal being actually expanded. The aim of the writer being strictly to ascertain facts, and state the conclusions which he considers to be fairly deducible from them, he has not felt himself warranted in attempting to speculate on a subject respecting which so little is yet known.

In conclusion the writer ventures only to express a hope that the experiments on which he has been so long and unremittingly engaged, may not prove wholly unserviceable to practical science and the world at large. The importance of possessing a thorough knowledge of the capabilities and strength of substances on which the lives and property of so many human beings depend, no one will attempt to deny. The only excuse, if indeed excuse it can be called, for employing an inferior description of material in the rearing of structures on the stability of which such momentuous issues are involved, is ignorance or misapprehension of its proper quality. The writer has endeavoured, by a plain statement of facts, to furnish some information on a subject which seems until now to have been denied the attention which its paramount importance demands. Were this question fairly taken up and considered, some security might be afforded against the repetition in future of disasters occasioned by its being so often practically ignored. The necessity of using nothing but the very best descriptions of metal where human life or valuable property is at stake may, he trusts, come soon to be more generally recognised than is at present And an increased demand for the finer varieties may conduce to a generous emulation amongst the manufacturers to improve still further the quality of their productions. Should his labours tend in any, even the smallest degree to diminish the annual sacrifice of life and property occasioned by faulty material and workmanship, he will feel the satisfaction that they have at least not been entirely in vain.

Mr. Kirkaldy exhibited 490 selected specimens, which were contained in five cases, namely—

| | | | |
|---|---|---|---|
| In Case I. | 9 iron bars, showing elongation and lateral contraction. | | |
| | 1 iron plate, | do. | do. |
| | 1 steel plate, | do. | do. |
| In Case II. | 42 steel bars, showing fractures and contraction of area. | | |
| | 105 iron bars, | do. | do. |
| In Case III. | 36 steel plates, | do. | do. |
| | 60 iron plates, | do. | do. |
| | 24 angle-iron, &c. | do. | do. |
| In Case IV. | 36 iron bars, showing fractures and effects of difference of shape. | | |
| | 40 iron bars, showing fractures and effects of difference of treatment. | | |
| | 12 steel bars, | do. | do. |
| | 12 iron plates, | do. | do. |
| | 15 iron bars, showing fractures and effects of strains suddenly and gradually applied. | | |
| In Case V. | 46 iron bars, showing fractures of screwed bolts. | | |
| | 12 iron bars, showing fractures of welded joints. | | |
| | 2 steel bars, | do. | do. |
| | 26 iron bars, showing texture as developed by acid. | | |
| | 8 iron plates, | do. | do. |
| | 1 iron plate, with surface cold-rolled. | | |
| | 4 iron bars, with surface cold-rolled, | | |

## SOCIETY OF ENGINEERS.

### ON THE RELATIONS BETWEEN THE SAFE LOAD AND THE ULTIMATE STRENGTH OF IRON.

By ZERAH COLBURN.

A great number of experiments have been made by many experimenters to ascertain the ultimate resistance of iron to tension and compression, and its strength has thus been determined with perhaps as much precision as is possible in the case of a material presenting almost constant variations of quality. Every engineer is now aware that, as an average result, the tensile strength of good cast iron may be taken as about 8 tons per square inch and its crushing strength as 48 tons. Wrought iron of fair quality will bear not far from 22 tons per square inch in tension, while its crushing strength is variously stated at from 12 or 15

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tons per square inch up to 28½ tons, the last named being given by Mr. Mallet as the result of experiments upon large hammered bars which bore but from 23 tons to 24 tons in tension.

When, however, we come to the question of safe working strength, much difference of opinion exists among engineers, the permanent supporting power of iron being variously estimated at from four-tenths down to one-tenth of its breaking strength. Thus when, some fifteen years ago, a royal commission sat to inquire into the application of iron to railway structures, the late Mr. Glynn, in his evidence, recommended that a cast iron bridge should never be loaded beyond one-tenth of its ultimate strength. The late Mr. Stephenson, with several other engineers, thought a ratio of one-sixth sufficient, while the late Mr. Brunel was satisfied with a ratio of from two-fifths to one-third; or, in other words, if a girder would just bear 100 tons of distributed load, he would put from 33 tons to 40 tons upon it, where Mr. Stephenson would allow not more than 17 tons and Mr. Glynn only 10 tons.

Were we now to have another commission entrusted with the same inquiry, it is not unlikely that as great a difference of opinion would be found still existing. For there is no acknowledged natural principle upon which the safe load of iron has yet been determined, and in the absence or oversight of such a principle each engineer must be governed by his own judgment of what is safe and prudent. It is true that the authority of the Board of Trade has been so far exercised in this matter as to have limited engineers, in the design of wrought iron railway bridges, to maximum tensile strains of 5 tons per square inch; and although it is commonly believed that with wrought iron a compressive strain of from 4 tons to 4½ tons corresponds to a tensile strain of 5 tons, the Board of Trade impose the same limit of strain for both the top and bottom chords of a wrought iron girder. The limit of 5 tons per square inch, it is hardly necessary to say, is an entirely arbitrary one, nor is it modified according to the quality of the iron and workmanship in a structure. Thus, in girder bridges, plate iron is used of which the breaking strength is occasionally not more than 18 tons per square inch. In punching the rivet holes, however, and irrespective of the loss of the metal actually punched out, the solid iron remaining between the holes is injured, so much so that, in a series of experiments made many years ago by Mr. Fairbairn, the mean tensile strength of seven specimens was reduced from 52,486lb. per square inch before punching to 41,590lb. per square inch of solid iron left between the holes after punching,—more than 20 per cent. of the strength of the iron being destroyed by punching, a loss distinct from that of the metal actually punched out. Drilled rivet holes, it is satisfactory to know, are now being adopted in the best class of bridge work, but in bridges already erected and containing plates occasionally no stronger than 18 tons per square inch before punching, the loss of strength ascertained by Mr. Fairbairn would diminish this to about 14½ tons for the net section of metal between the rivet holes. On the other hand the best suspension bridge links have a strength of from 26 tons to 28 tons per square inch of section, and yet the Board of Trade inspecting officers would not probably depart from the arbitrary limit of a maximum strain of 5 tons in either case. As far, therefore, as is necessary to meet the requirements of the authorities, good iron and sound workmanship go for little or nothing; and not only does this remark apply to the interference of the Board of Trade, but, in the case of Chelsea Suspension Bridge, the chains of which are believed to have a tensile strength of upwards of 25 tons per square inch, two of the leading members of our profession have declared that structure to be unsafe until it shall have been so strengthened that the greatest load which the heaviest traffic is likely to bring upon it shall not exceed 5 tons per square inch of the sectional area of the chains. The highest authorities, we are justified in supposing, would, at the same time, be satisfied with the same maximum strain in the chords of a plate girder bridge, even if the actual breaking strength of the solid iron between the rivet holes did not, as we have reason to believe it often does not, exceed 15 tons, or three-fifths that of the links of Chelsea Bridge.

From the illustrations given, the elasticity of solids appears to be no more than the range or play of the attractive and repulsive forces of matter, as variably exerted, but within the limits of rupture or crushing. Thus elasticity is the same in kind whether the repulsive or separating force be externally applied, or whether it be that of heat acting between the molecules of the body. If a bar of good wrought iron be stretched to the one-thousandth part of its length, corresponding, say, to a strain of ten tons per square inch, its elasticity will be fully excited or nearly so, and it will not support a much greater strain without taking a permanent set. It is true that, if the same bar of iron, when not under strain, be heated to from 150 to 200 deg. above its normal temperature, it will also elongate by one-thousandth part of its length, and that without injury. But if this elongation take place under a compressive strain, or, if the iron, first raised in temperature by 200 deg. and thereby elongated, be attached to two fixed points, and thus, while cooling, be made to contract under strain, it will be found that an elongation of not far from one-thousandth of the original length of the bar is the most that can be borne without injury, even when that elongation is due to heat alone. But if the iron be first heated sufficiently to soften it, as railway tyres and gun hoops are heated, the particles will be rearranged, and, within certain limits, without injury; but after the metal has once cooled below the temperature at which the particles have the mobility necessary for this re-arrangement, any further contraction around an unyielding object will be attended with permanent, and, there is reason to believe, injurious strain. Even in setting railway tyres, it is believed to be best to put them on cold, and under graduated pressure, and in the case of gun hoops, Captain Blakely and Mr. Mallet, who appear to be entitled to the credit of the modern system of the ringed construction of artillery, have always insisted upon the importance of a definite degree of shrinkage of each ring, so that the consequent strain shall not exceed the elastic limit of the material. Sir William Armstrong has stated that he does not consider any especial accuracy essential in the distribution of the strains imparted by shrinking his gun hoops upon each other, but it may be questioned how far the failures of so many of the Armstrong guns have been due to neglect in this respect.

It would be interesting to know the precise manner in which a separating strain acts upon the molecules of iron, or rather to know the successive positions of the atoms during the application of the strain. We are, however, without any positive knowledge of the positions which the atoms assume in solidification and under subsequent forging, but the multifarious forms in which all atoms visibly crystallise serve to show us that they cannot all be at equal distances from each other throughout the whole body. If they were, the arrangement would be that of cannon balls in a triangular pyramidal pile. Could we visibly represent the atoms, as occupying the angles of an infinite number of equilateral triangles, we should understand that a linear strain acting to separate any two of the atoms would, at the same time, draw a third atom, if not a number of atoms partly between them. And when, from this intrusion, the repulsive force, or heat, always enveloping the intruding atom, had once overpowered the attractive or cohesive force existing between the two atoms thus strained apart, these would, in turn, cohere anew to the atom which had been drawn in between them, and thus we should have a permanent rearrangement of the atoms, or, in other words, a permanent set, with permanent elongation in one direction, and permanent contraction in a plane at right angles thereto. That the atoms are thus drawn into parallel rows of straight lines, in many kinds of iron at least, seems evident from the appearance of fracture, which presents stringy collections of particles forming what is commonly called fibre, although there is great reason for doubting that anything like fibre existed in the iron before it was broken. Mr. Kirkaldy's recent extensive experiments appear to show, as many others have shown, that iron may be made to break short or to break with an appearance of fibre, just according as it is broken with a sudden blow or a gradual pull. Something like fibre may be imparted, on a coarse scale, by repeated rolling or in wire-drawing, but it is more probable that masses of atoms are thus drawn into strings then that any fibre is really imparted to the atomic arrangement itself.

It is commonly held that, within certain limits of strain, iron is perfectly elastic. There are high authorities, however, who maintain that iron takes a permanent set under even very moderate strains. If we are to understand that the set is exceedingly small, this may be true. The late Mr. Hodgkinson, for example, remarked, on the 381st page of his "Experimental Researches," that two cast iron beams took each a permanent set with weights respectively equal to one fifty-seventh and one-eightieth of the breaking weight. In a discussion at the Institution of Civil Engineers, a Mr. Dines mentioned that he had tested upwards of 8000 cast iron girders for the late Thomas Cubitt, and that he found it hardly possible to apply a weight so small as not to produce some permanent set, one-twentieth of the breaking weight producing a perceptible set. In the experiments of the Iron Commission at Portsmouth a bar of annealed wrought iron 50ft. long was said to have taken a perceptible set with a weight of less than 1¼ tons per square inch. After this weight had been doubled, however, the set was still only perceptible; and notwithstanding that the elasticity of annealed iron is known to be inferior to that of unannealed bars, the whole set of the 50ft. bar was but the $\frac{1}{250}$ part of one inch, after a strain of 8½ tons per square inch had been borne; and the set was but the $\frac{1}{10}$ of an inch in 50ft. after a strain of 11·9 tons per square inch. Mr. Edwin Clark has experimented on a wrought iron bar 10ft. long and 1in. square. Under a strain of 3 tons per square inch he gives a permanent set of nearly the $\frac{1}{1000}$ part of an inch in 10ft. With 8 tons the permanent set is given as about the $\frac{1}{250}$ of an inch in 10ft., and it was not until a strain of 13 tons per square inch had been applied that a set of $\frac{1}{12}$in. in 10ft. became apparent. With such exceedingly minute measurements, we may, perhaps, doubt if there was really any permanent set at all, with strains under 9 or 10 tons per square inch. An increase of temperature in the bar of perhaps a single degree, while the measurements were being made, would more than account for some of the reported sets, even under considerable strains. Thus Mr. Edwin Clark gives the permanent set of his bar, after a strain of 8 tons per square inch, as the $\frac{1}{113,636}$ part of its length, and this is almost exactly what the extension of the bar would have been had its temperature been raised but a single degree between the observations. Iron is heated in the very act of straining it, and a sudden breaking strain will generally leave the broken ends too hot to be handled. Such a slight apparent extension might also have occurred while the shackles by which the bar was strained were coming to their bearings. But even if such a microscopic permanent set really existed, it is one of which no engineer would take the slightest serious notice as affecting the strength of the bar in which it was observed. With the means of measurement commonly employed by engineers, ordinary wrought iron is seldom permanently stretched until after it has borne strains of upwards of 8 tons per square inch. In seven experiments by Professor Barlow, on wrought iron bars 10ft. long, two of them retained their full elasticity under a strain of 11 tons per square inch, three bars bore 10 tons without injury, while one bore 9½ tons, and another, made from old furnace bars, did not retain its elasticity beyond a strain of 8½ tons per square inch. All the links for Pesth Suspension Bridge, upwards of 5000 in number, and 12ft. long from centre to centre, were tested without permanent set up to 9 tons per square inch, and those of Chelsea Suspension Bridge were tested, without permanent elongation, up to 13½ tons per square inch. Mr. Edwin Clark, from the results of his experiments, considers that the limit of elasticity of wrought iron is 12 tons per square inch, and this appears to have been adopted by him both for bars having a breaking weight of 24 tons and for plates having a breaking weight of 20 tons. Every chain cable purchased by the Admiralty is tested up to 11·46 tons per square inch of the metal in each side of the link, the standard test being 6301bs. for each circular ⅛in. of the diameter of the iron of which the cable is made, one half of this strain coming upon each side of the link. The iron of which the cables are made does not, as a rule, take any permanent set when strained to this amount, or to say 11¼ tons per square inch. Mr. Howard has stated that the best iron begins to stretch permanently under about 10 tons per square inch in 10ft. lengths, although he occasionally tests up to 15 tons or 16 tons per square inch, the breaking weight being from 26 tons to 28 tons. Mr. Mallet, about four years ago, presented to the Institution of Civil

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Engineers the results of a valuable series of experiments on wrought iron and puddled steel, from which it appeared that the elastic limit and the breaking strain under tension were, in the case of certain samples, as follows :—

| | Elastic limit. | | Breaking weight. |
|---|---|---|---|
| Hammered slab or bar, 12in. × 4in. | 15·312 tons. | ... | 24·062 tons. |
| Hammered bar | 14·219 „ | ... | 23·969 „ |
| Rolled slab or bar, 12in. × 4in. | 10·937 „ | ... | 22·969 „ |
| Rolled bar | 10·937 „ | ... | 23·969 „ |
| Fagotted forged slab, 4ft. × 4ft. × 1ft. | 8·750 „ | ... | 18·594 „ |
| Original faggot bars, Horsfall gun | 12·031 „ | ... | 21·875 „ |
| Longitudinal cut, forged mass | 9·844 „ | ... | 19·688 „ |
| „ „ „ | 10·937 „ | ... | 17·900 „ |
| Circumferential „ | 6·562 „ | ... | 16·406 „ |
| „ „ „ | 5·470 „ | ... | 16·716 „ |
| Transverse „ „ | 3·281 „ | ... | 6·562 „ |
| Charcoal rolled bar from borings from the Horsfall gun | 5·470 „ | ... | 22·321 „ |

Sir Marc Brunel made a number of experiments on Yorkshire iron, hammered to small dimensions, or from ¾in. to ½in. square. A very high elastic limit was obtained, as follows :—

Mean of ten bars began to stretch with 22·2 tons per square inch, the mean breaking weight being 30·4 tons per square inch. With ten other bars the mean strain at which they began to stretch was 24·4 tons, the breaking strength being 32·3 tons per square inch. It is to be borne in mind, however, that these bars were reduced by the hammer only at the centre of their length, and that, therefore, the stretching could be observed upon but a very small part of their length. Mr. John A. Roebling, the engineer of the Niagara Suspension Bridge, has made experiments upon bars similarly drawn down to ¾in. square at the centre, the breaking weight being 33 tons per square inch; these bars bore a strain of 20¼ tons per square inch with visibly stretching, and when no jar was given to the bars they would support the strain for a week. Upon any vibration, however, the bars immediately took a permanent set.

Under strains, however, considerably within the elastic limit, a gradual rearrangement of the particles of the iron commences; and if the strain be continued sufficiently long, permanent set will after a while take place. The late M. Vicat, whose work on limes and mortars is so well known, began as early as 1830 to investigate the effect of continued strains on unannealed iron wire. He applied various strains to similar wires of a known breaking strength, and continued these strains from July, 1830, to October, 1833. One wire was strained to one-fourth its breaking weight, but beyond the elongation which at once took place no additional stretching occurred in thirty-three months. A second wire was strained to one-third of its breaking weight, and in thirty-three months it stretched at the rate of 2¾ parts in every 1000 parts of its length, this stretching being additional to that which took place as soon as the weight was applied, but which, of itself, was not sufficient to immediately produce any permanent set. Under a strain of one-half of the breaking weight another wire was stretched rather more than 4 parts in every 1000 parts of its length. Under a strain of three-fourths of the breaking weight a fourth wire stretched, in thirty-three months, 6½ parts in every 1000 parts of its length, and then broke, which circumstance terminated the experiments. M. Vicat's account of them appeared in the 54th volume of the second series of the *Annales de Chimie et Physique*. It is to be regretted that, in place of the constantly recurring experiments upon the breaking strength of iron, and which, as is already beginning to be understood, give us but a very partial knowledge of its available working properties, we have not a larger experimental acquaintance with the continued supporting power of iron, as afforded by experiments similar to M. Vicat's. Mr. Fairbairn, it is true, made an extensive series of experiments between the years 1837 and 1842, to ascertain how long bars of cast iron would support weights equal to about nineteen-twentieths of their breaking weight. By taking care to prevent any vibration in or about the bars, several of them continued, for five years and upwards, to support nearly their full breaking weight. Their deflection steadily increased, however, during the whole time, and Mr. Fairbairn has stated that some of these bars afterwards broke with but one-twentieth of their original breaking weight. As bearing upon the last mentioned circumstance, it may be remarked that M. Vicat, writing in 1833, observed that M. Henri, an engineer serving in Russia, had already shown that iron which had once withstood a great proof strain, often broke some time afterwards under a much less strain. This fact must indeed have been known to practical men even earlier than in 1830.

Now, in employing iron in any structure where it is subjected to strain, we seek to keep within its limit of elasticity. Yet not only have we but a comparatively small number of recorded experiments to show us what this limit is, even under a single and temporary strain, but we have at least the result of M. Vicat's experiments to show us that we cannot depend upon anything like this limit under a long-continued strain. What experimental knowledge we have goes to show that the original elastic limit of iron is greater when hammered than when rolled, but we are unable to count with any degree of certainty upon the ultimate superiority of hammered iron, in this respect, after long-continued strain. As a rule, also—the abundant evidence of which it is not, perhaps, necessary to introduce into the present paper—all harsh, hard, crystalline irons have a higher elastic limit, in proportion to their breaking strength, than soft, ductile, highly fibrous irons, like Swedish bar, for example; that is to say, the harder irons will bear a greater strain before taking a permanent set, although, as we shall presently have occasion to inquire, it may not follow that they are really superior to other irons which are more readily stretched, and which, indeed, may have an even less breaking weight. What information we have goes to show that there is no settled relation between the elastic limit and the breaking weight of iron; the former is much more variable than the latter, and can hardly be expressed at all as an average result, ranging, as it does, from less than one-fourth to more than two-thirds of the breaking weight; or if the elastic limit be taken irrespective of the breaking weight, the instances already cited show that the former varies from 3½ tons up to 24½ tons per square inch in different qualities of iron, although the range in ordinary bar iron and plate iron is not nearly as great. Now, no engineer, in apportioning the strains in a structure, would think of working up to or near to the breaking strength of iron. His object is to keep within the elastic power of the iron as exerted through a very long series of years. We ought by this time to have hundreds of trustworthy experiments upon this point where there is now one. If the safe working strength of a metal is limited, as it would appear to be, by its measure of permanent perfect elasticity, we may say that we hardly know, even yet, what is the strength of the materials we are constantly dealing with, notwithstanding that not a year passes without some addition to our stock of knowledge of breaking weights.

While we are about considering the permanent injury which iron suffers when strained beyond its elastic limit, it is to be understood that iron may be strained for a short time almost up to the breaking point without in the least diminishing its strength under a breaking weight subsequently applied. Indeed, in gradually applying the breaking strain to any sample of iron, it is clear that it must have borne 10 tons before it is subjected to a strain of 15 tons, and that it must have borne 15 tons before it is strained to 20 tons, and so on. Not only is this the case, but after a bar of iron has been actually broken under a tensile strain, the two broken portions of the bars will almost always require a still higher strain to break them. The weakest spot in the bar will fail first; and although the breaking strain will at the same time permanently stretch the bar throughout its whole length, the iron on each side of the fracture will still have its original breaking strength. Professor Barlow's treatise on the Strength of Materials contains the results of several experiments made at Woolwich Dockyard, as follow :—

A bolt of Solly's patent iron was nicked at one place, and then broken by a strain of 26·7 tons per square inch. One of the pieces was then tried and broke at 29½ tons. In the next experiment a bar of the same iron was first broken with 23½ tons per square inch, then again with 26½ tons, a third time with 26½ tons, and a fourth time with 25¾ tons.

Mr. Thomas Lloyd, engineer to the Admiralty, made a like series of experiments a few years ago, on ten bars of SC crown iron, 1¾in. in diameter, and 4½ft. long. The mean breaking weight at the first breakage was 23·94 tons per square inch. At the second breakage, with pieces 3ft. long, the mean strength was 25·86 tons per square inch. At the third breakage, with pieces 2ft. long, 27·06 tons per square inch, and at the fourth breakage, with 15in. lengths, 29·2 tons per square inch. Mr. Lloyd's experiments have been held to show that iron was actually strengthened by stretching it; or, in other words, that by destroying the cohesion at one point, the cohesion was everywhere else increased. A more obvious explanation is that the bars first broke at the weakest part, then again at the next weakest part, and so on. A variation of from 23·94 tons to 29·2 tons in the strength of the same bar is undoubtedly large, the greater strength being 22 per cent. more than the lesser: a difference which appeared to exist in each of the ten bars tried. It is well known, however, that hardly any two bars of iron have exactly the same strength, and Mr. William Roberts, manager of Messrs. Brown, Lenox, and Co.'s extensive chain cable works at Millwall, has cut a 12ft. bar of iron into 2ft. lengths, and found on testing that there was a difference of strength of 20 per cent. between the strongest and the weakest of these pieces. In the experiments of the Railway Iron Commission upon the extension of cast iron, the strength of Lowmoor cast bars was 7·325 tons per square inch at the first, and 8·152 tons at the second breakage. Blaenavon iron broke with 6·551 tons per square inch at the first, and 6·738 tons at the second breakage. Gartsherrie iron broke with 7·567 tons per square inch at the first, and 8·475 tons at the second breakage. Other cast iron bars of a certain mixture broke with 6·6125 tons per square inch at the first, and 6·777 tons at the second breakage, the latter being at an unsound place. Upon these results the commissioners remarked that "it would appear that iron, repeatedly broken, becomes more tenacious than it was originally. This erroneous conclusion may be obviated by considering that it would be very difficult, if not impracticable, to obtain cast iron bars perfectly sound and 50ft. long. Fracture may be supposed to take place the first time at the largest defect, and subsequently at those smaller, until, finally, none remain." It is not intended, however, in the present paper, to entirely deny that the breaking strength of iron may be actually increased by being stretched when cold; and this point may be left as an open question. That iron is so strengthened derives some probability from the known fact that its strength is greatly increased by being drawn cold into wire, and also by cold rolling. When heated moderately, or to less than a dull red, and then stretched, iron is strengthened throughout. This treatment is known as thermo-tension, and in an extensive course of experiments made about twenty years ago by Professor Walter R. Johnson, for the United States Government, a total gain of nearly 30 per cent. in strength and length, taken together, was estimated to have been obtained with a variety of irons. A bar of iron, having a strength of 60 tons, was heated to upwards of 500 degrees, and then stretched by 6½ per cent. of its length, when it acquired a strength of 72 tons. Captain Blakely has lately proposed the same treatment of iron, and his experiments, it is understood, corroborate those of Professor Johnson. All the links made for the four great pitch chains employed, with the steamship *Great Britain's* engines, for getting up the speed of the screw, were stretched ½in. while at a dull red heat.

But from what has been said, it is not to be supposed that iron is not injured by excessive strains, notwithstanding that the metal strained may, when tried immediately afterwards, still retain its full breaking strength. The injury will appear when a subsequent working strain is long continued; and even without waiting for this, it will be found that the strained iron has been deprived of a large part, if not the whole, of its natural elasticity. In a paper of great value, read nearly seven years ago before the Royal Irish Academy, and afterwards published in a quarto volume entitled *On the Physical Conditions involved in the Construction of Artillery*, Mr. Robert Mallet has laid down a useful measur

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of the working and ultimate strength of iron. Poncelet had already employed co-efficients which indirectly expressed, not merely the elastic limit and breaking strength of iron, but the range also through which the force acted in each case in reaching these limits. Mr. Mallet has adapted these co-efficients to the English standard of mechanical work, to wit, "foot-pounds," and he represents the structural value of different materials, or of various qualities of the same material, in one case by the product of the elastic load in pounds into half the range in feet or parts of a foot through which it acts, and in the other case by the breaking weight in pounds multiplied also by half the range, in feet or parts of a foot, through which it acts. Mr. Mallet employs Poncelet's co-efficients, as follows:—

$Te$ = foot pounds in reaching elastic limit of tension.
$Tr$ = „ „ to produce rupture by tension.
$T^{1}{}_{e}$ = „ „ in reaching elastic limit in compression.
$T^{1}{}_{r}$ = „ „ to produce crushing.

One half the weight into the whole extension, or, what is the same thing, the whole weight into half the extension, is adopted because the force gradually applied to break a bar must increase from nothing to the breaking weight. Upon Dr. Hooke's law *ut tensio sic vis*, the weight of a grain will in some minute degree deflect or extend the heaviest bar of iron, and the deflection or extension will increase progressively, with the weight applied, up to rupture. Therefore, if a bar be stretched 1ft. and then broken with a weight of 33,000lb., the work done will be the mean of zero and 33,000lb. into 1ft. or 16,500 foot-pounds. This, as has been said, is the work done in the case of a gradually applied strain. If, however, the weight be applied without impact, but at the same time instantaneously, upon the bar, it will, so long as the limit of elasticity is not exceeded, and supposing the bar to have no inertia, produce twice its former deflection, and, therefore, twice the ultimate strain. For the weight, in falling through the distance of the deflection due to the load at rest, will acquire momentum sufficient to carry it through an additional distance equal to that of the static deflection. This may be best demonstrated experimentally with the aid of a spring balance. If, upon the pan of a balance sufficiently strong to weigh up to 40lb., a weight of 15lb. be placed, and this be then lifted to zero on the scale and there released, it will descend, momentarily, to nearly 30lb. on the scale; and if there were no opposing resistances and the spring had no inertia, it would descend to exactly 30lb. In the actual application of strains in practice a weight is never thus applied, but a consideration of what would occur under such circumstances is sufficient to show how important it is that vibratory action be not overlooked in considering the strains on bridges. It is to be remembered that this action of suddenly applied loads is only manifested in the case of the application of weights, for if the strain be produced by the sudden admission of steam or any other practically imponderable body, no additional deflection will take place beyond that due to the pressure acting statically. If steam pressure acted in the same manner in this respect as a weight, the steam indicator would show nearly or quite double the pressure acting effectively within the cylinder of the engine.

It will not be attempted in the present paper to enter fully into the application of the co-efficients adopted by Mr. Mallett, for there are objections against, as well as reasons in favour of, their application. It is evident that $Tr$ may be the same in two cases, in one of which a high breaking weight is exerted through a very short distance, and in the other of which a low breaking weight produces stretching through a correspondingly greater distance. But this co-efficient does possess a value in taking account of the combined cohesive force and extensibility of iron, instead of the breaking strength alone. As Mr. Mallet justly observes, glass has a high cohesive force, and is nevertheless useless under strain, owing to its brittleness, while caoutchouc has great extensibility or toughness with but slight cohesion. The products, therefore, expressed by the co-efficients in question do not afford a complete notion of the practical value of a given material unless the factors whereby these products are obtained are also given. The elastic limit of iron, however low, is not to be exceeded in practical use, whatever its range of elasticity may be; nor does it appear prudent to work into the neighbourhood of a high elastic limit when the elastic range is known to be small. It is not to be understood that the co-efficients in question are intended to apply otherwise than in comparison of bars of equal length, else it would result that the measure of $Te$ in a bar of 50ft. long was one hundred times greater than that of a bolt 6in. long, and of the same material and sectional area. For the purposes of the engineer a long bolt is not only no stronger than a short one, but as it can be no stronger than its weakest part, it will follow that the average strength of 100 bolts 6in. long is likely to be greater than that of a single bolt of the same diameter and 50ft. long. Every engineer must be aware of the importance of toughness in combination with cohesive strength in iron, but we need much more extensive and accurate information as to the former; and a consideration of Mr. Mallett's coefficient should lead to additional experiments being undertaken. Mr. Kirkaldy, proceeding upon an independent course of inquiry, but with the same object as that pursued by Mr. Mallet, has lately published the results of a most important series of experiments, which are the first upon anything like an extensive scale, to take into account the combined cohesive force and extensibility of iron and steel. Mr. Kirkaldy experimented upon many hundreds of specimens, but he did not ascertain their limit of elasticity. He has given both the original dimensions and cross sectional area, and the dimensions and area after fracture, and he has also given the amount of elongation at fracture, although he did not ascertain the extension at the elastic limit. The reduction of diameter of a bar at the point of fracture serves to give a practical man a good idea of the quality of the iron, but it does not admit of an expression of the mechanical work done in producing fracture, as does the combined breaking weight and linear extension. In tearing a bar in two, also, we have to consider the permanent stretch communicated to all parts of the bar alike, and the additional stretch at and near the point of fracture. That part of the stretching which extends uniformly throughout the whole bar would, we may suppose, be exactly proportional to the length of the bar, while that part of the stretch which takes place close to the point of fracture would, we may also suppose, be a fixed quantity, whatever might be the length of the bar. Mr. Kirkaldy's specimens of iron and steel varied from 2·4in. to 8·2in. only in length, and with these the ultimate elongation at fracture varied from nearly nothing to 27 per cent. of the original length, whereas longer bars would have shown a proportionally less elongation. The samples which hardly elongated at all were of puddled steel ship plates. One sample, which bore 63,098lb. per square inch of the original area, stretched before breaking but the $\frac{1}{20}$th part of an inch in a length of 7·6in., or less than $\frac{1}{10}$ths of 1 per cent. of the length. Adopting Mr. Mallet's coefficient, the structural value of such a material would be almost nothing. In fact, Mr. Kirkaldy found the puddled steel plates throughout to have much less extensibility than cast steel plates, while the former also were of very irregular breaking strength.

Mr. Fairbairn communicated some of the results of an important series of experiments to the British Association at the Manchester meeting, 1861, from which it appeared that a large model of a wrought iron plate girder withstood without injury 1,000,000 applications of a load equal to one-fourth its breaking weight, and afterwards 5175 applications of one-half its breaking weight, when it broke down. The model was then repaired, and 25,900 applications of two-fifths its breaking weight, and afterwards nearly 3,000,000 applications of one-third its breaking weight, were made, it was said, without injury, although neither the deflections nor the permanent set were given. We know that iron alters its form, temporarily, during the application of very moderate strains, the elasticity of good iron being generally observable with strains of 1 ton per square inch; and we know that its form is permanently changed both immediately on exceeding the limit of elasticity, and gradually under strains nearly approaching that limit. There clearly must be a rearrangement of the particles of iron always going on where the strain is great; and as we know that when even a more moderate strain is eased off the iron tends to resume its original form, it appears incontestible that final injury must result under what may appear moderate although irregular loads—say one-third, or even rather less, of the breaking weight. Iron, it is still to be remembered, has not been employed long enough for purposes of construction to enable us to compare its endurance with masonry, of which there are abundant examples still perfect after many hundred years. At the same time it must not be forgotten that while we can never know the absolute strength of a bar of iron without destroying it under strain, neither can we always infer its strength from its deflection, or apparent range of elasticity, for we are not yet secure against flaws or those other faults of molecular structure, which Mr. Mallet so well describes as "planes of weakness." A bar of iron may have a general strength of 22 tons per square inch, except at a single point in its length, where, for an almost inappreciable linear distance, the strength may not exceed 10 tons. If the bar be broken, this fault will be detected, but hardly, if at all, otherwise; for under a strain of even 8 tons or 9 tons, the extension at the precise point of weakness would be so slight as to be quite overlooked in a general observation of the total deflection or extension.

The application of iron to bridges, especially to those of large span, necessarily requires the most careful consideration in apportioning the strains, since every pound of metal not brought into effective action is so much dead weight or useless load—being not only mis-applied of itself, but requiring additional material to support it. In considering the strains upon iron, therefore, reference has been more particularly made in the present paper to its employment in bridges, but in the case of boilers, iron ships, cranes, ordnance, railway bars, warehouse girders and columns, roofs, engine beams, and in many other applications, the most careful distribution of material and adjustment of strains is of very great importance. Iron is, perhaps, more severely strained in steam boilers than in any other structures. In the case of locomotive engines, there is a disposition to employ still larger boilers and to carry still greater pressures. With 50in. boilers, formed of $\frac{7}{16}$in. plates double rivetted, and carrying, as is now not unusual, from 130lb. to 150lb. pressure, there is at the higher limit a circumferential strain of 5¼ tons per square inch at the joints and a longitudinal strain of nearly 2 two tons per square inch along the whole length of the boiler: the resulting strain at the joints being nearly six tons per square inch. This strain is constantly maintained with plates ranging from 21 tons to 24 tons in strength, and under all the contingencies of corrosion, incessant vibration, and occasional sudden exaltations of pressure due to the instantaneous production of steam upon overheated tubes or plates. In many cases we have 4ft. boilers with $\frac{3}{8}$in. plates single rivetted and worked at 120lb., corresponding to a strain of at least 6½ tons per square inch at the joints of the boiler when new: the circumferential and longitudinal strains being both taken here into account. Put under this strain when new, many locomotive boilers are worked in all for from ten to twenty years, and often from three to seven years without any internal examination of the plates. It is not remarkable, therefore, that explosions are becoming so frequent.

We may regard with much hope the increasing use of steel in large masses, as produced by Krupp and by Mr. Bessemer, and others whose discoveries have already effected a great economy in the production of that material. Although a departure from the subject of the present paper, it is interesting also to refer to the introduction of phosphorised copper, as now produced by the Birmingham and other coppermasters. It was announced, about three years ago, as a new discovery by Mr. Abel, chemist to the War department, that the addition of from 2 to 4 per cent. of phosphorus to copper greatly increased its density and strength. There is no doubt of the large advantage of this combination, although it was discovered in the last century, and made publicly known sixty years ago. A French chemist, M. Sage, contributed a paper upon this subject to the *Journal de Physique*, and which was translated into the 20th volume of the *Philosophical Magazine*, for 1805. By combining the maximum quantity of phosphorus with copper, the latter acquired the hardness, grain, and colour of steel, and although M. Sage had already kept the compound for fifteen years it had suffered no change from exposure to the air. It was easily turned and took a fine polish. It may yet be found that copper thus treated is the best material for many of the purposes of the mechanical engineer.

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## REVIEWS AND NOTICES OF NEW BOOKS.

*Practical Mechanical Engineering:* With an Appendix on the Analysis of Iron and Iron Ores. pp. 241. By FRANCIS CAMPIN, C.E., &c. London: Atchley and Co., 1863.

This work is neither strictly elementary, nor is it of the high scientific and technical class, but is evidently intended for the use of students advanced beyond the ordinary elementary works, but for whom the very abstruse treatises are not suited. There is scarcely a branch of mechanical engineering upon which the author has not touched, though, of necessity, some of the subjects treated in the articles are very much condensed, and, in fact, conciseness appears to have been attempted by the author rather than literary elegance of expression. The most lengthy chapters are devoted to the general arrangement and practical construction of the steam engine in various forms, the various workshop operations being detailed; the machinery required for carrying these out being previously described. In the more theoretical and elementary parts of the work, the "Physical Basis of the Steam Engine," and the "Principles of Mechanical Construction" are examined, a general law for the action of *levers, hydrostatic presses, pulleys, &c.*, being given in place of the numerous rules in use. The modifications of force produced in the steam engine by the varying positions of the crank, etc., is discussed afresh, and the *moment of pressure* on the main shaft is exhibited by means of diagrams of solids, sections of which at any planes give the *moment of pressure* on the main shaft when the crank is in such places, both for oscillating and fixed cylinder engines. In the appendix are described modes of analysing iron and iron ore in great number, collated with great care. The work is illustrated by twenty-eight lithographs and plates of tools, marine, locomotive, traction, and other engines, some of which are very good, especially those of the Grand Junction Pumping Engine. Numerous woodcuts are also interspersed with the letter-press. In conclusion, we recommend a perusal of this treatise to those intending to follow the engineering profession.

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*A Record of the Progress of Modern Engineering:* Comprising Civil, Mechanical, Marine, Hydraulic, Railway, Bridge, and other Engineering Works, with Essays and Reviews. Edited by WILLIAM HUMBER, Assoc. Inst. C.E., and M. Inst. M.E. London, E. and F. N. Spon, 1863.

The large plates illustrating the works which have been selected by the Editor for the first examples of modern engineering progress, are well executed, and the text is devoted to the specifications issued by the engineers, and upon which the tenders for the execution of the works were based. To make the work complete, the price at which the several parts of the works were executed should be given. The details and minor parts of the structures are drawn on too large a scale, but without doubt the Editor will improve upon the first two numbers, as the issue of the series progresses. A useful selection of good examples will give a high character to the *Record of the Progress of Modern Engineering.*

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*The Management of Steel; including Forging, Hardening, Tempering, Annealing, Shrinking and Expansion; also the Case Hardening of Iron.* By GEORGE EDE. Tweedie, 337, Strand. 1863.

A very excellent shilling's worth. We do not know who or what Mr. Ede is, but infer from the author's preface that he is an artizan; but whatever he may be by trade or calling, he is possessed of a good deal of sound practical experience in the management or treatment of steel. Nothing like the present book has been published since Holtzappfel's very expensive book on "Turning," &c.

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*Pocket Book of Useful Formulæ and Memoranda, for Civil and Mechanical Engineers.* By GUILFORD L. MOLESWORTH, M. Inst. C.E. London: E. and F. N. Spon. 1863.

Mr. Molesworth has done the profession a considerable and lasting service by publishing his very excellent Pocket Book of *Engineering Formulæ.*

What strikes us first is the very convenient size and form of the book adopted by the author; and next, in glancing over its contents, we are pleased to find many really useful things not to be found elsewhere in any engineering pocket book. Mr. Molesworth's treatment of hydraulics and hydro-dynamics, and motive power generally, is excellent. To the latter branch of his subject Mr. Molesworth has evidently devoted considerable attention, and his collection of formulæ will be found most useful. But to stop to detail everything that is good and useful in this book would be nearly equal to reprinting a list of its contents.

The best wishes we can express towards the author and publisher are, that they may speedily sell off the present edition; that (presuming all the corrections have been already made) that they have stereotyped the work; and that the next edition "all sold" may be 50,000. Indeed, we see no good reason why that number may not be sold, if the book is got up in plain style, at half the present price.

## NOTICES TO CORRESPONDENTS.

ALPHA.—Yes. We give you the order *in extenso*, which is as follows:—"As one or more vacancies will probably shortly occur in the junior grade of Engineer officers in the dockyards, my Lords deem it highly desirable that these vacancies should be filled by persons of such age and acquirements that they may be expected, after some years' experience, to become well qualified to serve in the higher grades. This cannot be hoped for if persons of advanced age or low qualifications be selected. With this important object in view, my Lords consider that a somewhat similar course should be adopted in making the selections as obtains in respect of the Shipwrights' officers, and of many others in the Civil Service, namely, by competitive examination. It may be expected that comparatively young men thus selected would be stimulated, by a prospect of promotion, zealously to perform the duties first assigned to them, and to qualify themselves, as far as they may be able, subsequently to perform duties of greater importance. You are therefore to call on the captains of the Steam Reserve and the officers of the factories, to report the names of such candidates, under their orders, as they may consider qualified to fill the situation of Assistant-Inspector of Machinery at the factories. It being intended to subject the candidates to an examination at the Royal Naval College, at Portsmouth, to ascertain the extent of their mathematical acquirements, this qualification need not weigh with the officers in making their selection; they should take into consideration the mechanical abilities of the candidates, their experience and knowledge of steam machinery, and other practical qualifications, as well as their character, conduct, and fitness for the office in question, as far as these may be known to the officers from personal knowledge, or can be ascertained from unquestionable testimonials. Together with the list of names, the age of each candidate (*which must be between 25 and 35 years*), where he was brought up, and where and how he was subsequently employed, should be stated; copies also of such testimonials as the officers consider important are to be forwarded, with any remarks on the several candidates, which, in the opinion of the officers, ought to be known to their Lordships before they make the ultimate selections for appointments.—By command of their Lordships, W. G. ROMAINE."

G.H.—The Water Ram, you refer to, will raise water to the height of 300 feet, or say 30 times the height of the waterfall by which it is worked. It is necessary to state the number of feet fall, which can be obtained at the spring, or brook to work the ram; the perpendicular height from the lower part of the fall to where the water is required to be delivered; the distance horizontally from the spring, or brook, to the house or premises where the water is required, and, if the spring or streams should be small, it is very desirable to ascertain how many gallons it flows per minute. We may add that this society is a very successful and useful institution.

CONDENSEUR PAR SURFACE.—Yes, considerable interest is now being taken by our neighbours on the subject, and we may mention, as an an evidence of this, that the Societé labre d'Emulation du Commerce et de l'Industrie de la Seine Inférienre at Rouen have included in their programme of prizes for 1864, a prize of 300 francs, to the inventor of a surface condenser, the price of which shall not materially exceed that of the ordinary condenser, and the use of which will allow of steam generators being supplied almost exclusively with the distilled water of condensation.

D.L. (permanent way).—The best method we know of is that invented by a Mr. Perry, of Brighton, who employs a *hollow* trenail in conjunction with an iron spike of peculiar shape. The spike being driven into the hollow trenail, which is expanded at its lower end, so as to form a dovetail within the sleeper. The plan is found, in practice, to answer very well, and the trenail is thus prevented from being withdrawn from the sleeper, and the spike, or pin, from being withdrawn out of the trenail.

INGENERO (Milan).—Saxby's system of locking railway points and signals is the most effectual remedy we know of to overcome the difficulty you refer to.

C. B.—For what is known as black malt, the rotary kilns are preferable. But if you require merely to thoroughlydry, or desiccate the grain, and not to *roast* it, we should recommend the employment of an open wire kiln floor, through which, and amongst the kiln charge, currents of heated air are caused to circulate, The apparatus best adapted for this purpose is that known as the Steam Desiccator. Send us further particulars as to the number of quarters, and what power you have at hand, &c.

## RECENT LEGAL DECISIONS
### AFFECTING THE ARTS, MANUFACTURES, INVENTIONS, &c.

UNDER this heading we propose giving a succinct summary of such decisions and other proceedings of the Courts of Law, during the preceding month, as may have a distinct and practical bearing on the various departments treated of in our Journal: selecting those cases only which offer some point either of novelty, or of useful application to the manufacturer, the inventor, or the usually—in the intelligence of law matters, at least—less experienced artizan. With this object in view, we shall endeavour, as much as possible, to divest our remarks of all legal technicalities, and to present the substance of those decisions to our readers in a plain, familiar, and intelligible shape.

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FOWLER'S STEAM PLOUGH.—In the Court of Common Pleas an action has been tried for the infringement of certain patents for steam ploughs. The plaintiff was substantially Mr. John Fowler, of the Steam Plough Works, Leeds, and the defendants were Messrs. J. and F. Howard, the agricultural implement makers, of Bedford. It appears that the original plough was invented, in 1855, by Messrs. D. and T. R. Fiskin, school teachers, in Scotland, and consisted of a new and very peculiar arrangement of the ploughs, and in the mode of lifting them a great stride was made in the progress towards perfection. Subsequently it was thought necessary to find some other means of raising or depressing the ploughs, and accordingly a very ingenious contrivance was adopted by Messrs. Fiskin, consisting of a screw shaft—in other words, an endless screw, which worked upon a cogged wheel, and by turning which around one way the ploughs were raised, and by turning it in another they were depressed. The following year it struck Mr. Fowler that, instead of having separate levers and axles, with the peculiar arrangement in the centre to suite

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them, it would be preferable to place all the ploughs in one frame, so that both the sets should move together. This idea he carried out: the ploughs at each end of the frame were fixed, and the frame made to move with a reciprocating, or see-saw motion, on one axis. The mode of bringing this into action is as follows:—The ploughs being drawn by the motive power to the headland, it became necessary to lift one set out of the earth and to put the others in to cut the next furrow; and all that had to be done was to apply the moving force to a chain or rope attached to the bottom of the machine, and as soon as that was effected the tendency of the draught was to drive the plough at that end into the ground, while it pulled out those at the other end. As one set rises the other falls. In the year 1861 it became perfectly manifest to all agricultural implement makers that Fowler's ploughs, following and improved upon Fiskin's, were the very best ploughs that could be devised. It was, therefore, important to all manufacturers of any note that they should possess the privilege of making those ploughs; accordingly the leading gentlemen in the trade, including Messrs. Clayton, Shuttleworth, and Co., Messrs. Ransomes and Sims, Messrs. James and Frederick Howard (the defendants), and Mr. Charles Burrell, all eminent agricultural implement makers, came to an arrangement that they would take licenses for making these ploughs. For this purpose they agreed to pay Mr. Fowler no less a sum than £30,000, besides a considerable royalty upon each plough, for permission to make and sell such ploughs. The arrangements were completed in September, 1861, and Messrs. Howard signed the agreement with the other gentlemen who were parties to it. In two months after, Messrs. Howard refused to carry out the agreement, and had constructed a plough of their own, which combined both Messrs. Fiskin's and Mr. Fowler's inventions. By so doing it was alleged that the defendants had infringed the existing patents. On their behalf it was contended by Sir Fitzroy Kelly that not only was there no resemblance, but the defendants' machine was totally different to the plaintiff's from one end to the other. Moreover, evidence was called to prove that Messrs. Fiskin were not the real inventors of this machine, but that their brother William had invented the most notorious parts of it. William Fiskin was a Presbyterian minister, and as he had not given his consent when the patent was taken out, therefore the patent was invalid. After a five days' trial the jury found a verdict for the plaintiff on all the issues. Lord Chief Justice Erle, who presided at the hearing of the case, declined to decide technical points raised on behalf of the defendants, and the probability is they will be argued hereafter before the full Court.

## NOTES AND NOVELTIES.

### OUR "NOTES AND NOVELTIES" DEPARTMENT.—A SUGGESTION TO OUR READERS.

We have received many letters from correspondents, both at home and abroad, thanking us for that portion of this Journal in which, under the title of "Notes and Novelties," we present our readers with an epitome of such of the "events of the month preceding" as may in some way affect their interests, so far as their interests are connected with any of the subjects upon which this Journal treats. This epitome, in its preparation, necessitates the expenditure of much time and labour; and as we desire to make it as perfect as possible, more especially with a view of benefiting those of our engineering brethren who reside abroad, we venture to make a suggestion to our subscribers, from which, if acted upon, we shall derive considerable assistance. It is to the effect that we shall be happy to receive local news of interest from all who have the leisure to collect and forward it to us. Those who cannot afford the time to do this would greatly assist our efforts by sending us local newspapers containing articles on, or notices of, any facts connected with Railways, Telegraphs, Harbours, Docks, Canals, Bridges, Military Engineering, Marine Engineering, Shipbuilding, Boilers, Furnaces, Smoke Prevention, Chemistry as applied to the Industrial Arts Gas and Water Works, Mining, Metallurgy, &c. To save time, all communications for this department should be addressed "19, Salisbury-street, Adelphi, London, W.C." and be forwarded, *as early in the month as possible*, to the Editor.

The Water of the Thames.—The principal facts indicated by an examination of the water of the Thames, by Henry Letheby, M.B., M.A., during the years 1861 and 1862, are:—1st. That the water in the middle of the river is invariably charged with a larger proportion of dissolved matter than that near to the shore, but the quantity of suspended matter is greatest in the shore water. 2nd. That the proportion of saline matter in the water is greatly influenced by the rainfall and by the temperature of the river; for when the former is less than two inches in the month and the latter is over 60 deg. Fahrenheit the quantity of saline matter quickly rises from the normal proportion of about 32 grains in the gallon to upwards of 100 grains. 3rd. That when, from evaporation and a diminished rainfall, the supply of water to the river is from the ocean, instead of from the land, the mixture of the sea water with the sewage causes an offensive decomposition, which gives an unpleasant odour to the river. 4th. That during strong winds, and at the proportions of the several constituents of the water during the first six months of the year—namely, from January to June. At that time the amount of saline matter ranges from 22 grains to 34 grains in the gallon, and of this quantity about 3·5 grains are organic. In the summer and autumn months, when evaporation from the river is considerable, the quantity of dissolved saline matter in the water sometimes exceeds 150 grains in the gallon. This shows that at those times of the year there is a strong upward current from the ocean, and it indicates the necessity, at those periods, for a very perfect defœcation of the sewage of the metropolis, which is to be discharged into the river at Barking Creek. If this circumstance is disregarded, the condition of the river in after time, when the main drainage scheme is completed, will be unbearable and absolutely dangerous to health. Finally, it may be said that the result of the constant examinations of the river water has been gradually improving, and that the special manufacturing impurities which were once so constantly present in the water are now no longer there. This is attributable to the careful supervision which is exercised by the officers of the Conservancy in preventing the discharge of such matter into the stream.

Coal and Iron in France.—The official documents which have been recently laid before the French Chambers contain the following returns with regard to the production of coal and iron in France, and the importation of British iron. *Coal.*—The production of pig and cast iron in France was, in 1859, 7,500,000 tons; 1860, 8,039,168 tons; 1861, 8,400,000 tons; 1862, 9,400,000 tons. The price of coal at the pit's mouth was, in 1860, 9*s.* 1½*d.* per ton; 1861, 9*s.* 1½*d.* per ton; 1862, 9*s.* 0½*d.* per ton. *Iron.*—The production of pig and cast iron was, in 1862:—Smelted with charcoal, 285,000 tons; value £1,949,200; per ton, £6 16*s.* 6*d.* With coke, or coke and charcoal mixed, 768,000 tons; value, £3,456,000; per ton, £4 10*s.* Total of all qualities in 1862, 1,053,000 tons; value, £5,405,200. The production of pig and cast iron was, in 1861:—Smelted with charcoal, 299,000 tons; with coke, or coke and charcoal mixed, 590,000 tons. Total of all qualities in 1861, 880,000 tons. The total production of all descriptions of pig and cast iron was, in 1859, 856,152 tons; and the total in 1862 having been 1,053,000 tons, it appears that there has been an increase in the total production in France during three years of nearly 25 per cent. The quantity of bar and other descriptions of wrought iron manufactured in France was, in 1862, with charcoal, 71,130 tons; value, £1,794,800; per ton, £16 16*s.* 1*d.* With charcoal and coke mixed, 29,400 tons; value, £404,000; per ton, £13 14*s.* 10*d.* With coal, 600,000 tons; value, £5,724,000; per ton, £9 10*s.* 9*d.* The total of all descriptions of bar and wrought iron manufactured was, therefore, in 1862, 700,500 tons; value, £7,322,800 The quantities manufactured were, in 1861, with charcoal, 76,600 tons; with charcoal and coke, 32,400 tons; with coal, 493,700 tons. The total quantity manufactured in 1861 was, therefore, 602,700 tons. The quantities manufactured were, in 1859, with charcoal, 90,660 tons; with charcoal and coke, 16,930 tons; with coal, 412,510 tons. The total quantity manufactured in 1859 was, therefore, 520,000 tons; and the total manufactured in 1862 having been 700,500 tons, it appears that there has been an increase in the total production in France during three years of 180,500 tons, or more than 33 per cent. The quantities of British iron imported into France during the first 11 months of 1862 were—pig-iron, 149,551 tons; bar-iron and rails, 41,565; plates, sheets, and tin-plates, 2650; all other descriptions, 7023 tons.

Explosion of Gas on Board a Steamer.—The iron screw steam ship *Battalion*, 500 tons, belonging to Mr. W. Laing, of Newcastle, was blown up by gas, while off Plymouth, on the 8th ult. She left Cardiff on the 5th ult., with a cargo of 800 tons of steam coal, and on her passage round encountered some very heavy weather. About half-past five a.m., when eight miles SSW of the Eddystone, the mate, who was in charge of the watch, sent three of the crew to get up a spare sail from out of a store-room that was parted off from the hold by a wooden bulk-head. On the store-room hatch being taken off one of the men went down for the sail, and had an open lamp passed down to him. During the passage, it appears, a large quantity of gas had evolved from the coal, and the hatches being all fastened down in consequence of the bad weather, and no other means of ventilation provided, had accumulated in the hold. Directly the lamp was passed down the gas took fire, and the explosion was the consequence. The whole of the hatchways were blown out fore and aft, and either blown to pieces or blown overboard, considerable damage being done by the scattering of the *debris*. The mate had a very narrow escape from being blown overboard from the bridge and had his face seriously injured, and three men were severely burnt.

## NAVAL ENGINEERING.

Trial of the "Royal Oak."—The first of the official trials of this armour-clad war vessel took place at Maplin Sands on the 23rd ult., under somewhat unfavourable circumstances of weather. The engines have been constructed by the firm of Maudslay, Son, and Field, and are nominally of 800 horse-power, but can be worked up to 3000 horse-power, and are the horizontal double piston-rod direct-acting, fitted with the improved gear for tightening the piston-rod bands without stopping the engines. The cylinders are 82in. in diameter, and the length of stroke 4ft. The screw is an improved "Griffiths," the blades being bolted to the "boss" with flanges, instead of being fixed with the key and wooden wedges. The diameter of the screw is 19ft., and its weight rather more than 19 tons; by its improved mode of construction the pitch can be readily varied from 22ft. 6in. to 27ft. 6in. Her draught of water was 23ft. 1in. aft, and 20ft. 7in. forward, with her midship ports 11ft. 2½in. from the water. After steaming well out to the Nore, the engines working at little more than half speed, some experiments were made in turning the circle and stopping and starting the engines. The force of the wind at the time was barely 1, and the sea calm. With the helm hard over to starboard, and four men at the wheel, the circle was made in 5 min. 23 sec., with the rudder at an angle of 21½ deg., and the screw making 52 revolutions per minute. The helm was then put hard aport, and with the rudder at 26½ deg. the circle was made in 5 min. 6 sec., the engines making 54 revolutions per minute, the pitch of the screw on both occasions 27ft. 6in., and diameter 19ft. 6in.; vacuum, 2¼; load on safety valve, 20lb. The frigate was found to answer her helm remarkably well, and turned the complete circle in little more than twice her own length. Experiments were then made in starting and stopping the engines. From the time of giving the order from the bridge to the engine-room, the engines were stopped dead on two separate occasions in 6½ minutes and 6 minutes respectively. From the order being given from the bridge the steam was shut off and engines started in 7 seconds. On reaching the Maplins it was found that there was too great a haze prevailing to allow of the experimental runs being made with safety, and the trial was therefore postponed.

Trial of the "Racoon."—The screw steam corvette *Racoon*, 22, was taken from Sheerness harbour for her final trial on the 23rd of February last. The *Racoon* carries an armament of two 110lb. Armstrong guns, one 12lb. Armstrong and one 12lb. smooth bore guns for boats, one 12lb. Armstrong fieldpiece, and one 6lb. smooth bore gun for practice at short ranges on the upper deck; 16 8-inch smooth bore, and four 40lb. Armstrong guns on the main deck. The trial was under the superintendence of Capt. T. P. Thompson, of the Sheerness steam reserve, and took place at the measured mile off Maplin Sands. The engines were in charge of Mr. Lawson, chief engineer of the ship. The vessel attained an average speed at full boiler power of 10·1 knots per hour; revolutions of engines, 54 per minute; pressure of steam, 20lb.; vacuum, 25lb.; while at half-boiler power the average speed was 7·279 knots; revolutions of engines, 42. The circle was turned with full boiler power, helm to port, 17 deg., in 5 min. 21 secs.; with half-boiler power, helm to starboard, 23 deg., in 5 min. 59 secs. The engines were stopped when going at full speed in 16 secs. from the time of moving the telegraph; they were started ahead in 35 secs., and astern in 25 secs. from dead stop. The *Racoon* is fitted with trunk engines, 400-horse power, made by Messrs. Ravenhill, Salkeld, and Co., and common screw with corners cut off; pitch, 26ft.; diameter, 16ft.; length of blade, 3ft. During the trial the draught of water was 18ft. 2in. forward and 19ft. 6in. aft. There was an entire absence of hot bearings or priming, and the trial was pronounced highly successful both as regards the machinery and the qualities of the vessel.

The Emerald, 35, screw frigate, made her third experimental screw trial on the 18th ult., at the measured mile in Stokes Bay. The screw tested on this occasion was one with six common shaped blades, fixed at equi-distant intervals on a "Griffiths" boss. The weather was very favourable for the trial, the wind scarcely exceeding a force of 1 from the N.E., and the sea being perfectly smooth. The ship drew 20ft. 9in. forward and 21ft. 10in. aft, and the mean pressure of steam during the six runs made at the mile was 22lb., the vacuum being 25in., the maximum revolutions of the engines being 52, and the minimum 50. The runs were completed as follows: the first run in 4min. 31sec., or at the rate of 13·285 knots per hour; the second run in 6min. 10sec., or 9·729 knots; the third run in 4min. 24sec., or 13·636 knots; the fourth run in 6min., or 10 knots; the fifth run in 4min. 26sec., or 13·533 knots; the sixth run in 6min., or 10 knots. The mean speed of the ship was 11·725 knots. The circles were made in the usual manner as follows:—To Port.—Helm up in 17 seconds, with six men at the wheel, and with one a half turns of the wheel rope, the angle of the rudder being 11 degrees. The half of the circle was completed in four minutes and two seconds, and the full circle in seven minutes and 54 seconds, the revolutions of the engines being 49½. To Starboard.—Helm up in 19 seconds, with six men at the wheel, and with one and a half turns of the wheel rope, the angle of the rudder being in this instance 17 degrees. The half circle was completed in four minutes and four seconds, and the full circle in seven minutes and 56 seconds, the revolutions of the engines being 50. The six-bladed screw, as had been anticipated from the results of the Shannon's trials, gave a speed superior to that obtained from the common two-bladed screw by about two-tenths of a knot, with a

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rather less indicated horse-power of engine, and a total absence of vibration from the working of the screw, the only motion felt on board being from the movement of the engines.

THE "HECTOR," 32 gun iron frigate, arrived at Spithead on the 15th ult. from the Clyde. The hull, engines, and iron lower masts have all been constructed by Messrs. Napier. The hull is on the principle of the *Warrior* and other iron ships, with the exception that the *Hector* has a heavy bulkhead, or "shield," covered with 4½in. armour plates, fixed across her bows from her lower deck to a level with her bulwarks. This is of semicircular form and is intended to receive the fire of a fort, or that of an enemy's broadside of guns, when using the *Hector* as a ram. Her armour-plating is also continued, from the point at which the *Warrior* now carries her armour-plating, as a belt round her line of gun ports, bow and stern, with additional plating over her outer stern-post and rudder-head. The majority of her armour-plates are rolled, and are from the manufactories of Messrs. Brown, Sheffield; Messrs. Beall, Parkgate, and Messrs. Rigley, Parkhead. The engines have cylinders of 82in. diameter and a stroke of 4ft. The screw is a "Griffiths" of 20ft. diameter and 20ft. 6in. pitch. At the back of each cylinder is fitted a small auxillary engine for starting and stopping the engines, in addition to the ordinary wheel and hand gear, and all is so simply and efficiently arranged that two men, one at each auxiliary, have perfect control over the engines, the action at the same time being almost instantaneous. The castings are excellent, and every part is massive, well finished, and simple in arrangement. The screw alley is unusually lofty and roomy, and the disconnecting aud other arrangements of the shafting have been fitted with great care and strength. The stokehole has six boilers—three on each side. The highest temperature reached here during the voyage round from Greenock was 85 degrees. The means of ventilation appear to be very good, although no patented plans have been applied. The funnel casing is well open on the upper deck, and a square shaft, fitted to hoist out ashes, no doubt contributes in the main to this excellent result, the former acting as an up and the latter as a downcast air-shaft. Above the boilers is fixed a small auxiliary engine, which hoists out the ashes from the stokhole. An auxiliary engine of 40 horse power is also being fitted on board to work the fire-engines, capstans, &c.

NAVAL APPOINTMENTS.—The following appointments have taken place since our last:—J. Knight, Acting First-class Assist. Engineer, to the *Cumberland*, for the *Erne*; A. G. Smith and J. O. Wilson, Acting Second-class Assist. Engineers, to the *Fisgard*, as Supernumeraries; H. Mackavoy, Acting Second-class Assist. Engineer, to the *Cumberland*, as Supernumerary; M. O. C. M'Cartie and Thomas Barnes, Acting Second-class Assist. Engineers to the *Indus*, as Supernumeraries; J. Mercer, Acting Second-class Assist. Engineer, to the *Asia*, for the *Curaçoa*; J. C. Thompson, Acting Second-class Assist. Engineer, to the *Asia*, as Supernumerary; J. Cleland, J. Prebble, J. A. Cowper, and P. Samson, Assist. Engineers, to the *Indus*, as Supernumeraries; E. Rivers and R. Allen, Chief Engineers, to the *Asia*, for the *Melpomene* and *Imperieuse* respectively, when they are paid off; J. Crew, W. J. Wise, T. E. Williams, T. B. Jordan, H. Rawlings, and F. Earnshaw, Assist. Engineers, to the *Rattlesnake*, on the coast of Africa, as Supernumeraries; G. Lynch, Supernumerary in the *Fisgard*, promoted to Engineer; C. Deal, of the *Rattler*, G. M'Leod, of the *Megæra*, E. R. Cockrell, J. M. Page, and L. M. Green, of the *Asia*, W. Russell, of the *Indus*, J. E. Turner, in the *Black Prince*, and J. J. Finch, of the *Industry*, First-class Assist. Engineers, promoted to Engineers; J. Beech, of the *Greyhound*, W. P. Dawe, of the *Liffey*, and J. Peach, of the *Centaur*, promoted to Acting First-class Assist. Engineers; W. C. Beck, engineer to the *Indus*, as Supernumerary; A. Smart, Assist. Engineer, to the *Cumberland*, for the *Snipe*; P. Thompson, Assist. Engineer to the *Pembroke*; T. Duncanson, Chief Engineer, to the *Orpheus*, for disposal; O. A. Davies, Engineer, to the *Pandora*; S. Lawton, T. Murray, and J. Stirling, Assist. Engineers to the *Sparrow*; E. Newman, Assist. Engineer, to the *Indus*, for the *Clinker*; J. Staley and J. Grant, Assist. Engineers, to the *Pandora*; J. West, Assist. Engineer, to the *Cumberland*, as Supernumerary; S. Madden, Chief Engineer, to the *Indus*, for the *Ocean*; J. Steil, Chief Engineer, to the *Indus*, for the *Pelorus*; C. Dickson, Chief Engineer, to the *Asia*, for the *Hector*; J. Turner, Assist. Engineer, to the *Asia*, for the *Hector*.

TRIAL TRIP OF THE "VIGILANT."—The screw steam gun vessel *Vigilant*, 200 horse-power, which, since her accident on the Gunfleet Sands, has received thorough repairs, underwent her final trial trip on the 2nd ult., at the measured mile, off Maplin Sands. She attained an average speed, at full boiler power, of 10·191 knots; and, at half boiler power, of 7·987 knots, everything working most satisfactorily.

## MILITARY ENGINEERING

EXPERIMENTS AT SHOEBURYNESS.—On the 3rd ult. some interesting experiments in gunnery were undertaken on the practice-ground, with the view of testing the resistance offered by Captain Inglis's shield—a most massive and ponderous kind of armour, proposed by that officer as a covering for the exposed portions of fortifications, and generally for casemated batteries facing the sea. Captain Inglis's shield, or rather target, for it is in appearance like any other iron target, with an embrasure in the centre, is as simple in its plan of construction as can well be conceived, consisting of nothing more than very massive double slabs of wrought iron placed transversely. The slabs on the left-side of the embrasure are eight inches and five inches thick respectively, and those on the right seven inches and five inches,—the different thicknesses being purposely adopted to ascertain if possible their relative powers of resistance. These great slabs are bolted on to the iron backing with most massive screw bolts, and the entire mass supported by time of the equinoxes, the quantity of suspended matter in the water is greatly increased. Lastly. It may be said that the normal composition of the river water is indicated by the wrought-iron struts. The whole principle of the target apparently consists in meeting the impact of the shot with masses of iron of such strength and solidity as, when properly made and fitted together, would be virtually indestructible by any battery a ship could direct against it. It is also claimed for this invention, or rather combination of slabs, that it is the cheapest as well as the most efficient way that has yet been tried of covering casemates with armour. For the guns used against it the target was much too strong, and its immense thickness prevented any real estimate being formed of the effect of the shots. It had, however, been to some extent injured and shaken by previous trials, and there is no doubt that the seven shots fired at it at short range and all near the same spot was a more severe trial than it would ever be likely to undergo if forming part of a real series of such batteries actually engaging a fleet of iron-clads; yet in spite of this it stood well, and at the close of the day still remained a formidable defence, though, of course, much bent in parts, with bolts displaced, and, generally speaking, damaged. The first experiment was made with Mr. Whitworth's 7-inch muzzle-loading rifled gun, weighing 7½ tons, and nominally throwing a 120-pounder shot, though in reality made for projectiles of the weight at 150lb. and upwards. This was loaded with 25lb. of powder and a flat-headed hardened projectile, weighing 137lb. It struck on the left or 13-inch side of the target with terrific force, emitting at the moment of contact a sheet of flame as broad and vivid as if another cannon had been fired from the mark in reply. The result, however, proved to be very difficult to ascertain, inasmuch as the head of the shot had quite buried itself in the metal, and what had not penetrated had been shivered to atoms by the tremendous force of the concussion, so that it was quite impossible to say how far it had really gone. Opinions on the subject of its depth varied from 2½ to 7in., but they were all founded on the purest conjecture, and not the slightest impression or disturbance of any kind appeared at the back of the plates to warrant the opinion that it had entered further at most than 4in. or 5in. The velocity at which this projectile struck the target was at the rate of 1240ft. a second. The practice was resumed at the same range and target with Sir William Armstrong's smooth-bored 100-pounder muzzle-loader, The usual service charge of a piece of this kind would be 33lb. of powder, but on this occasion it was loaded with only 25lb., in order to place it on an equality with the Whitworth previously fired. The shot was a spherical wrought-iron 100 pounder, which was made to fit the bore so closely that doubts were expressed whether it would be easy to get it down at all when the gun was fouled after a few rounds of rapid firing. This missile struck full upon the thick side of the target with a velocity of 1470ft. per second, inflicting a tremendous circular dent 2½in. deep, cracking one of the inner plates of the target and knocking off one of the massive bolt-heads. The target was roughly shaken, but, for all practical purposes, was as strong as ever, and, to illustrate the facility with which it could be repaired, a fresh bolt and bolt-head were adjusted in place of those broken in the course of a few minutes. The third shot was fired from Sir William's great 300-pounder muzzel-loading gun rifled on his peculiar shunt principle. This tremendous piece of ordnance weighs no less than 11¾ tons. It is rifled with 10 deep grooves on the shunt principle—that is to say that though the shot enters loosely and easily by the muzzle down one series of grooves, it is regularly shunted into another series, along which it comes out when the gun is fired, and the grooves for exit being shallower than those for entrance, they, as it were, squeeze the shot with sufficient force to make it take the form of rifling, and give it the rotation on its axis so necessary for long range ordnance. This was loaded with a hollow headed conical-shaped shot, 19½in. in length, and weighing 230lb., and with a 45lb. charge of powder behind it. It sent the shot with a velocity of 1,405ft. per second full on the thick part of the target, inflicting a broad damaging indent, shaking the whole structure a good deal, and cracking an outer upper plate. But except the mischief that actually showed itself on the surface it was impossible to say with any certainty how much the butt was really injured. It was in fact much too thick to enable anything but conjectures to be formed as to the comparative results of all the different missiles. The next gun was one of Mr. Lynall Thomas's, a 7-inch muzzle-loading piece, rifled on a very peculiar principle, and capable of throwing projectiles of 150lb., or even 200lb. weight, with charges of powder as low as 25lb. The gun, which is 11ft. 6in. long, is rifled on a new plan of Mr. Thomas's, somewhat in appearance like the *canon rayé* of the French, but with this difference, that instead of three grooves it has three ridges projecting nearly an inch into the bore, the elongated projectiles, which are 2½ diameters long, fitting into and between the ridges. The shot fired was a wrought-iron one of 151lb. weight, with a charge of 25lb. of powder. It was the first time the gun had ever been fired, and it hit the white spot aimed at so truly as quite to obliterate the mark, doubling up the shot itself into the form of a huge cauliflower, and making an indent almost as severe as that of the 100-pounder smooth bore. The target seemed shaken, though not materially so, the shot having only struck at a velocity of 1215ft. per second. Mr. Whitworth's gun was then again fired at the same range, and with the same charge of powder and shot. The shot was aimed at the untouched plate, below the embrasure, and so close to the ground that the projectile struck the earth first, making a deep furrow; and, of course, considerably diminishing the force of its blow. For this reason it made but a very slight impression, and did no injury to the target that was worth speaking of. The 300-pounder Armstrong was then tried with a solid shot weighing 306lbs., and a 45lb. charge of powder. This tremendous missile injured the target considerably, and sent its fragments of cast-iron flying through the air in all directions with a hoarse roar that was terrible to hear. The force of this terrific blow broke some of the plates in fresh places, knocked the head off one of the bolts, and drove out another like a rocket. Mr. Lynall Thomas's gun was the next competitor. At the first fire it had recoiled considerably, and thrown its muzzle high into the air, almost at an angle of 45 degrees, and there is no doubt but that this first discharge injured it fatally, though not in such a manner as could be seen externally. This time it was loaded with 27½lb. of powder, but, instead of wrought iron shot of 151lb., with a steel projectile weighing 133lb. It was fired as usual by electricity, and instantly the whole gun burst into fragments like a gigantic shell. The explosion was so complete and total that the massses were scattered in every direction; one piece weighing nearly a ton being thrown to a distance of 140 yards. Out of the seven shots, too, the last, from Mr. Thomas's gun, can scarcely be reckoned, as, if it ever touched the target at all, which is most improbable, it touched it so lightly as to leave no mark whatever, and of the six shots that did strike, one from Mr. Whitworth's gun grazed the ground, as we have said. Still the victory was with the target. Some most important experiments against floating targets, at 1200 yards' range, against iron embrasures for casemated batteries, and against targets built of unusual size and of the strength of our improved Warriors, will be undertaken this summer at Shoeburyness.

THE RESUMED EXPERIMENTS AT SHOEBURYNESS, which took place on the 17th ult., were arranged to elucidate as much as possible both points in dispute, the guns used being the old smooth-bore 68-pounder, Sir William Armstrong's 110-pounder service gun, with special steel shot cut down at the base to reduce them to 65lb. weight, Sir William's 300-pounder muzzle-loading rifled shunt gun, Mr. Whitworth's muzzle-loading 150-pounder or 7-inch gun, and Mr. Lynall Thomas's 9-inch or 300-pounder rifled muzzle-loading gun. Both these latter were made by Colonel Anderson, at Woolwich, on the built-up coil principle adopted by Sir William Armstrong, and both were admirable specimens of workmanship, though before the experiments commenced, Mr. Whitworth's gun was found to have a crack or flaw in the centre steel tube round which the coils of wrought iron are wound and welded in the course of manufacture. This defect prevented its being used in the course of the experiments except for one discharge with a live shell. Mr. Thomas's gun was an enormous piece of ordnance, nearly 18ft. long, weighing 16 tons, and with a thickness of 17in. of metal round the powder chamber at the breech. Though nominally a 300-pounder, this gun is claimed to be capable of throwing projectiles of various forms and weights from 250lb. up to 400lb. Sir William's 300-pounder weighs less than 12 tons, and was the same short, powerful piece we have already described in our account of previous trials on this ground. The three plates against which this ponderous array of ordnance was directed, at a distance of 200 yards, were bolted up into a target about 12ft. square, the upper plate being 5½in. thick, the middle one 7½in., and the lower plate 6½in. On the right side these plates were backed with 10in. thick of solid teak, behind which again, as representing the skin of an armour ship, were plates of iron, one of 1in. thick and one of 1½in. thick, which rested on the usual upright ribs of wrought iron. The other half of the target was fastened to the iron ribs, but had no teak backing or inner iron skin. The armour plates were made and rolled by Mr. Brown, of Sheffield, and, as the result proved, were beyond all doubt the finest specimens of plates, whether rolled or hammered, which have ever been tested at Shoeburyness. Colonel Taylor conducted the experiments, the arrangements for firing, &c., as usual, being under the care of Captain Alderson. The first shots, three in number, were fired from the old smooth-bore 68-pounder with the usual service charge of 16lb. of powder. These were directed against the 5½, 6½, and 7½-inch plates, and were immediately followed by three shots from Sir William's 110-pounder, loaded with special steel projectiles, weighing 65½lb., and fired with the same service charge as the smooth-bore 68. The result of this experiment proved the inutility, not to say folly, of having comparative trials of rifled guns at so short a range as 200 yards. Where the 68-pounders had struck, the indentation varied from 2½in. to 3in. in depth; where the steel shot of Armstrong's had hit, the mark was in one case deeper, and the plate showed a just perceptible crack about 8in. long, though apparently of very trifling depth. The most careful examination failed to discover any mark on the back of the target, even as much as a disturbance of the paint upon the rivets to show that it had been hit at all. The next shot was fired from Sir William's 300-pounder, loaded with a conical steel shot of 296lb. weight, and fired with 45lb. of powder. This tremendous missile struck with a velocity of 1298 feet per second full upon the centre of the 7½in. plate, where it was backed,

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driving in a circular piece of iron 10in. in diameter quite through the plate, bending in the whole plate itself to a depth of 1¼in., and buckling its ends outwards more than 1in. The massive wrought iron girder which crosses the whole back of the target horizontally was bent out and broken in several places, as were also the inner ribs, the 2½in. skin was bulged and cracked, the rivet heads loosened, and many knocked off altogether. The examination showed that the target, as a target, had received a most serious shake, though, from the wonderfully good quality of the iron, there was little of actual fracture or cracking except in the spot on which the shot itself had struck, where the whole 7½in. piece was driven in, and only held in place apparently by the wooden backing. The next shot was from the 300-pounder, loaded with a cast iron shell weighing 286lbs., and charged with 11lbs. of powder. This was fired with the usual 45lb. charge, and struck full in the centre of the 5½in. backed plate with a velocity of 1330ft. per second. It shattered its way completely through it, leaving a rough round hole about 10in. in diameter, and then burst in the inside, blowing the teak to minute fragments, setting it on fire, breaking off many of the rivet heads, and tearing the inner skins of iron, 2½in. thick, into rough shredded gaps, as if they had been so much cardboard. Altogether, this shell, both for penetration and awfully destructive effects on bursting, was the most successful that has yet been fired against armour-plates of any kind. Mr. Whitworth's 150-pounder was next tried, loaded with a steel flat-headed shell of 151lb. weight, with a bursting charge of 6lb. of powder, fired from the gun with 25lb. of powder. This shell struck within about 5in. of the spot where Sir William's had struck and burst, and destroyed the teak backing. The Whitworth shell passed quite through the plate, and burst among the *debris* of splinters behind. Apparently, most of its charge must have escaped from the front of the target. Certainly the explosion made not the least perceptible addition to the damage already inflicted by Sir William, nor did it even set the timber on fire, though from the smoke that hung about it was at the moment thought it had done so. From the flaw in the breech of the gun already mentioned, no further trials were made with this piece, and Mr. Lynall Thomas's gun was the next competitor. Unfortunately, from some mistake, the gun was not well pointed, and its first 330lb. shot missed the target altogether, and struck the ground on the left, passing through a bank of earth, and then flying off to the right upwards into the air over the river. The next shot, weighing 307lbs., and fired with a 50lb. charge of powder, struck the hollow part of the target, where it was 7½in. thick, and what is termed "dished it," or bent the plate; but, as was remarked upon the ground, for a projectile of such weight, propelled by such a charge of powder, it effected no commensurate damage. The third shot was more successful. It was a steel projectile of 330lbs. weight, fired with the some charge. It struck on the edge of the 7½in. plate—its weakest part—and made a broken indentation to the depth of 10½in. The terminal velocities of both these last shots were lower than any fired, which was attributed to what is believed to be the excessive pitch in the mode of ribbed rifling adopted by Mr. Thomas. The whole effect of this piece, considering its great length of barrel and force of charge, did not realise the expectations formed of its capabilities in the morning. Sir William Armstrong then fired his 300-pounder with an ordinary cast-iron round shot, weighing 144lb., with a charge of 45lb. The terminal velocity with which this struck the 7½-inch plate on the unbacked portion was the highest attained—no less than 1636ft. a second—and almost in exact proportion to its velocity was the damage it inflicted. Not only was its indent larger and deeper than any shot that had gone before, but on the inner side it broke the plate both vertically and horizontally, leaving a cruciform tear nearly two inches wide at the openings, besides shaking the target to its very foundations. This shot and the steel projectile of Mr. Thomas had, in fact, so damaged the whole of the massive structure, both in its plates and fastenings, that further experiments became almost useless. The iron, even where most torn, held together in a manner that was really wonderful, but Mr. Thomas had knocked off several of the massive screw bolt heads, and the effect af the entire day's work had been to so bend the plates and destroy the backing that there was really no part left that afforded the means of a fair test of resistance, while it was evident that a few more shots like the last might bring the whole mass to the ground. The firing, therefore, was discontinued.

ARMOUR PLATE TESTING AT PORTSMOUTH.—The firing at the sample and experimental armour plates on the sides of the *Powerful*, target ship, at Portsmouth, was brought to a close on the 25th February last, after three days' practice. The firing at the sample plates resulted in nothing of particular interest to the general public or calling for any remark further than that the plate supplied by Messrs. John Brown and Co., of the Atlas Steel Works, Sheffield, undoubtedly carried off all the honours. The firing at the experimental plates proved interesting and important as far as related to the testing of the two bent plates. The crossed planks of iron had been tested in somewhat different forms, but on the same principle, on several former occasions, and have utterly failed in resisting the blows of the 68-pounder. The crossed planks or plates of iron fired at on the present occasion were each 6ft. long by 1ft. wide and 2½in. thick. Six of these were bolted on the *Powerful's* side by side in a horizontal position, the remaining six being laid over them in a contrary or vertical position, and the whole 12 thus covering a 6ft. square space. The supposed object of the Admiralty in making this experiment was to ascertain whether any difference existed, and if so, to what extent, in the shot-resisting qualities of plates bent hot and cold, the latter being the cheaper and more expeditious method. For this purpose one of the 4½in. "Royal Alfred plates" was selected from the stock in store in Portsmouth dockyard, and divided into two parts, each being then about 7½ft. long by 3ft. 6in. wide. It had been intended to bend each of these portions of the plate to a curve of 44in. from a centre line, but in bending the one part cold in the hydraulic press the metal began to open on the outer curve when the curve had only reached 1½in. out of the intended 4½. Under these circumstances the plate was only bent further to 2½in., just half the extent originally intended. The other part was bent hot in the wedge press to the same extent, but exhibited no opening of the metal, and was apparently as sound as when first sent in from the contractors. The plates were of rolled manufacture, and had been bent across the grain. The first shot at that part of the plate bent cold decided its fate, the effects produced by the shot proving incontestibly that the very operation of bending the metal cold had completely altered the structure and nature of the metal, rendering it to a great extent crystalline and brittle. The firing at the hot bent plate was attended with as much interest. That bent cold, from the openings exhibited in its bending, was not expected to stand very severe hammering, although the way in which it broke up astonished every one. The hot bent portion, however, represented the sides of our present armoured ships afloat and building. This plate stood but little better than the one bent cold in the hydraulic press, and its structure was also apparently as much changed as that of the cold bent plate by the bending process to which it had been subjected. It may here be stated that the plate selected for this experiment was from the manufactory of one of the best of our armour-plate makers, Mr. John Brown, of Sheffield. With, therefore, this utter destruction by the process of "bending" of all the rigidity and blow-resisting powers of an acknowledged superior description of armour plate, certainly more complete in the "cold" than "hot" process, abundant material is furnished for future and most serious consideration in armouring our ships of war.

ARMOUR-PLATE EXPERIMENTS were resumed at Portsmouth on the 9th ult., under the superintendence of Capt. R. S. Hewlett, C.B. The plates tested on this occasion comprised three of 11in. in thickness of metal from the Elswick Company—two of iron and one of steel, all three made under the steam hammer, but with the additional novelty attending the steel plate, that after its manufacture it had been re-heated to an annealing heat, and then cooled in oil. There were also two hammered plates of 5½in. thickness of metal, from the Thames Ironworks and Shipbuilding Company, one of which was a sample plate for the *Minotaur* iron frigate, building for the Government by the company, and the other was a plate for the *Royal Sovereign's* turrets, bent 2½in. out of a straight line, when heated, by the wedge-press process. The Elswick plates failed utterly in offering resistance to the shot from the 68-pounder gun, one iron plate being destroyed by a single shot, the other by two shots, and the steel plate being broken up in five separate pieces by two shots. The diameter, depth, and general character of the indents from the shot on the two iron plates, were of the ordinary description, but those on the steel plate were considerably less than what is made by the shot on iron plates, the diameter of the indents in this case being only 6in., and their depth only 1 1-10in. The plate possessed all the required hardness, but also the fatal fault of brittleness. It was made from the best Sheffield steel. The two plates from the Thames Ironworks proved to be of an unusually excellent quality, considerably above the average of good "A 2" plates. It is a remarkable fact in connexion with the cast plate for the *Royal Sovereign*, that there were no cracks or openings in the metal after it was bent, and even when the plate was broken eventually across its back, in a known weak part of the forging, by the severe pounding which it received, the metal did not open with the curve, but across it. This plate received five shots in an irregular triangular space, 1ft. by 1ft. 3in. and 10in. Three of these shots struck in a space of 8in., measuring from centre to centre of the extreme indents. There was no penetration of the plate in any part by the shot, nor was any part of the metal detached from the main body. The other plate, made by the Thames Company for the *Minotaur*, received seven shots in a space of 2ft. 6in. by 2ft., and three of these were on the lower left edge, beating the edge of the plate partially into the ship's side, but without any actual penetration, or without any part of the plate being thoroughly separated from the main body. The chord of the arc within which the three blows were struck, measured 23in., and the depth of the arc was 12in.

TESTING OF ENGLISH AND FOREIGN ARMOUR PLATES.—The firing at the English and foreign ships' armour took place at Portsmouth on the 20th ult. The plates consisted of 4½-inch plate, from the Thames Ironworks Company, cut in two parts, one part bent two inches traversely from a straight line, and the remaining part not bent; a 4½-inch plate, from the Mersey Ironworks, and two other plates, one of 5½-inch and the other of 4½-inch, from Mr. Begbie, of London. All the plates were of excellent quality. The bending of the half of the Thames plate did not appear to have injured the metal any further than if it had been rather incautiously heated. The metal in the bent portion had a greater tendency to crumble under the blows of the shot than the unbent portion. The Mersey plate was also excellent, and stood some severe pounding without penetration being made. The two plates furnished by Mr. Begbie, however, beat all the others. The 5½-inch had five shots planted in a space of 17 inches by 12, but no thorough penetration was made, nor were there any cracks of consequence. The 4½-inch plate had seven shots in a space of 3 feet by 22 inches, with only surface cracks. This plate stood magnificently, and the way in which the metal stretched under the blows of the shots without cracking was astonishing. One shot struck the plate on the edge at the upper corner, but instead of breaking or cracking the metal, as is usually the case under such circumstances, it merely bent and expanded it without a sign of crack or flaw of any kind. The incidents on these two plates were rather under the ordinary depth. The metal, where pounded by the shot, had a peculiarly white, silvery, and soft appearance.

KRUPP'S GUNS.—The breech-loading 110-pounder gun (says the *Army and Navy Gazette*) rifled in the Royal Arsenal on the service (Armstrong) system, which was cast solid and then hammered at the works of Messrs. Krüpp, at Essen, has passed the endurance proof as well as the service one, but shows a slight flaw in the interior. This may have been caused by rifling, and would, in the case of a built-up gun, be of no moment, but must be regarded with some suspicion, and can hardly be considered safe in a solid weapon, that would, if burst, fly into fragments. We much question whether any guns without coils or hoops over the breech will be sufficiently safe for use in the 'tween decks on board ship. There must be absolute safety in firing the high charges, by which alone armour-plates can be pierced; and this safety, although the interior tubes fail, has only been obtainable hitherto by building up. The want of a better interior for the guns was clearly pointed out several months since, in a lecture given by Mr. Anderson, at the Royal United Service Institution, and at which he made his proposal to use "steel," rendered tough by the application of oil. At the head of the factories, as Mr. Anderson now is, we may therefore look forward to a superior class of heavy ordnance being produced; but whether the internal portion of the gun will be a steel tube or a Krüpp casting hammered afterwards, seems doubtful. If steel or Krüpp's metal can be produced of sufficient size and toughness to form the whole front and inner breech in one mass, a great advantage will result both in the expense and in the power of the guns to withstand the blows of hostile shot upon their exposed portion; the breech could then have a coil over it, which would always render the gun safe against breaking in pieces, and causing destruction to the ship and crew.

## STEAM SHIPPING.

TRIAL TRIP OF "THE KATE," TWIN SCREW STEAMER.—The trial trip of this new vessel, which has been looked forward to with much interest in nautical circles, came off on February 28th. The *Kate*, built by Messrs. Dudgeon, is an iron vessel of 500 tons B.M., her length between perpendiculars is 165ft., beam 22ft. 6in., depth in hold 13ft. 6in. She is fitted with separate and independent engines of 60 horse-power each, 26in. cylinders, and 21in. stroke; has two three-bladed screws of 7ft. 6in. in diameter, 14ft. 6in. pitch, and 9ft. 6in. apart from centre to centre. Her engines are exactly the same as the *Flora*. She is, however, 15ft. longer, has a long flat floor and tolerably square bilges, is rigged as a fore-and-aft polacca schooner, her masts constructed to lower by a joint near the deck, telescope funnel, and wire rigging. Her draught of water on this occasion was 7ft. 2in. aft, and 5ft. 4in. forward. The blades of her screws were now entirely immersed, exposing about 9in. above the water. At 12.15 she cast off, and, as her head was up the river, afforded those on board an opportunity of judging of the facility of the twin screws afforded for turning from a state of rest, and also for extricating a vessel quickly from a difficult and awkward position. From the time the warps were cast off until she made her half turn, and was under way down the river, about two minutes ten seconds elapsed. A single screw vessel, vainly endeavouring to execute the same manœuvre, just outside of her, appropriately exemplified the vast superiority the double screws impart, and the difference formed a marked contrast that was closely observed by all the naval authorities on board, affording an incident that fully satisfied them as to further results. The day was exceedingly fine, with a light easterly breeze, and the tide on the last of ebb. The *Kate* averaged twelve knots on her passage to the Nore, the engines making 120 revolutions. Upon reaching the Nore light-ship, Mr. Dinnen of the Admiralty, commenced the trials. The first was running from the Nore to the Mouse light-ship, 7¾ nautical miles; this was accomplished in 37 minutes, giving an average speed of 12 knots an hour, the engines, which were also constructed by Messrs. Dudgeon, working beautifully at from 120 to 129 revolutions, with a vacuum of 25in., and the pressure of steam 20lb. It must be remembered in comparing the speed of the *Kate* with the *Flora*, that the former is a much larger, longer, and out of the water loftier vessel, and with but the same power of engines. After reaching the Mouse, the more important trials of manœuvring, with a view of showing the advantages of the twin screw system as applicable to vessels of war, were commenced. The first was describing a circle with both screws working ahead full speed, and the helm hard to starboard; this she accomplished in 3 min. 48 sec.; the circle described was about 980 yards in diameter. The second trial the port engine and screw were stopped, and the starboard driven ahead full speed, and she described the circle in 3 min. 58 sec. At the third trial the starboard engine and screw were driven ahead full speed, and the port astern, when the circle was accomplished in 4 min. 16 sec. Upon the

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fourth trial the starboard engine and screw were driven ahead full speed, the port engine and screw astern full speed, and the helm kept amidships; by means of her screws alone she described the circle upon her own centre in 6 min. 55 sec. The fifth trial was made by turning the port engine and screw ahead, and the starboard astern, with the helm hard-a-port, when she described the circle in 4 min. 17 sec., turning on her centre. The sixth trial consisted in experimentalising upon steering the vessel by her screws alone, without any assistance from the rudder, when it was most satisfactorily proved by going ahead, astern, and turning to port and starboard, that the vessel was under perfect command. In that part of the trial in which she steamed full steam astern, one of the river buoys was selected as the point to steer her for by the screws, and universal satisfaction was expressed at the manner in which she performed this manœuvre. The return trip from the Mouse to the Nore light-vessel was accomplished in 35 min. 15 sec.; so that, taking the state of both wind and tide, twelve knots an hour appears to have been her average speed throughout the day.

TRIAL OF THE GALWAY MAIL STEAMER "COLUMBIA."—This paddle-wheel steamer, one of the Atlantic Royal Mail Company's fleet, underwent her official trial on the 4th ult., in Stokes Bay. The *Columbia* has been thoroughly overhauled and strengthened in every department, and, among other improvements, the whole of the condensers and air pumps are new, and are now worked by large eccentrics. The work connected with the hull has been executed by Messrs. Laird and Sons, of Birkenhead, and that of the machinery department by Messrs. Ravenhill and Salkeld. The following are the results of four runs at the measured mile. First run, 4 min. 16 sec., equal to 14·229 knots per hour, 20½ revolutions; second run, 4 min. 56 sec., equal to 12·162 knots per hour, 20½ revolutions; third run, 3 min. 59 sec., equal to 15·063 knots, 21 revolutions; fourth run 5 min., equal to 12·000 knots, 21 revolutions; giving a mean of 13·487 knots. Pressure of steam, 25lbs.; vacuum, 24½; indicated horse-power, 4000. Her draught of water forward was 19ft. 9½in.; aft, 19ft. 2½in.; the mean draught being 19ft. 6¼in. She had 860 tons of coal on board, and 65 tons of water and spare gear. While at full speed the vessel made a complete turn in 6 min. 55 sec.

THE LIVERPOOL, NEW YORK, AND PHILADELPHIA STEAMSHIP COMPANY have recently added a new steamer to their line, called the *City of Cork*, built by Messrs. Denny, of Dumbarton, of 1550 tons; and the new steamer, *City of London*, of 2580 tons, by Messrs. Tod and McGregor, is expected on the station in about another month.

THE PENINSULAR AND ORIENTAL COMPANY.—A Bombay paper states that the value of the Peninsular and Oriental Company's fleet may be estimated at £3,000,000, their leasehold and freehold property at £1,100,000, and their coal depôts at £340,000. Their gross revenue is about £2,000,000 a year. The company have 20 stations, and their offices, machinery, fuel depôts, and docks at many of these stations rival Imperial establishments for their magnitude and convenience. They have the most lucrative goods and passenger traffic of any carrying company in the world.

## LAUNCHES OF STEAMERS.

LAUNCH OF STEAMSHIPS FOR CHINA.—On the 4th ult. the *Quang Jung*, a fine paddle steamer built for the Anglo-Chinese fleet, was launched from the yard of Messrs. Laird, Birkenhead. Her dimensions are:—Length, 184ft.; baeadth, 24ft.; depth, 13ft.; tonnage, 525 tons; power of engines, 150 horses. The model is designed to made a fast and handy vessel, both at sea and in the rivers. She has a straight stem and elliptical stern. The deck, fittings, &c., will be of the same style and quality as in Her Majesty's service. There was also on the same day floated out from one of the docks of the same works another steamer built for the same fleet called the *Tien-tsin*. Her dimensions are:—Length, 150ft.: breadth, 25ft.; depth, 12ft.; tonnage, 445 tons; power 80 horse. The engines are those for which Messrs. Laird were awarded a medal at the International Exhibition.

THE "SOUTHERNER," a fine model screw steamer, was launched from the yard of Messrs. Pearce and Lockwood, Stockton, on the 8th ult. The *Southerner* is of 1953 tons, O.M.; length over all 294ft., 8in..; breadth, 38ft., 2in.; depth of hold, 22ft. The engines of 300 horse power, constructed by Messrs. Fossick and Hackworth, are fitted with superheating and feed heating apparatus, and other recent improvements. This is the largest vessel ever launched on the Tees.

LAUNCH OF AN ANGLO-CHINESE DESPATCH BOAT.—On the 6th ult. a despatch paddle steamer, ordered by Captain Sherard Osborne for his Anglo-Chinese fleet, was launched from the yard of Mr. J. White, Isle of Wight. Her dimensions are:—length between perpendiculars, 239ft.; breadth of beam, 29ft.; tonnage, builders measurement, 1000 tons. The engines, which are of 300 horse power, are constructed by Messrs. Day and Sons, of the Northam Ironworks.

## RAILWAYS.

COLLISION ON THE MIDLAND RAILWAY.—On the 16th ult. a collision took place which fortunately did not terminate fatally, but which caused serious injury to several persons. The accident occurred on the Midland line, at Sawley junction, half way between Nottingham and Derby. Between eight and nine a coal train between Derby and Leicester broke down near to Sawley. It was followed by the 8.30 train from Derby to Nottingham, which came to a stand behind the coal train. Arrangements were instantly made for the passenger traffic to be worked on the down instead of the up line. Soon afterwards the 8.30 train backed from the place at which the stoppage occurred to Draycott-station, and the pilot guard (who was on the engine) mistook a white light from the engine of the 9.20 passenger train from Derby to Nottingham as a signal from the pointsman to advance, and that all was right. The consequence was, that the two trains dashed into each other violently. None of the carriages were knocked off the line, but it was ascertained there were about ten persons more or less seriously injured.

THE DUBLIN METROPOLITAN RAILWAY, though a small, is one of the most important undertakings that Ireland has seen since the introduction of the railway system into that country. Its object is to connect all the great lines which centre in the capital, and to make extensions to the shipping quays, along which tramways will be laid. The present isolation of the existing lines is thus removed; the interchange of traffic, now difficult and expensive, is facilitated and cheapened, and a thorough communication established for passengers and goods. The project has the support of all the existing railway interests. The capital required is £556,000, divided into £10 shares.

RAILWAY COMMUNICATION WITH ITALY.—At one of the recent sittings of the Italian Chamber of Deputies at Turin, on the occasion of the discussion of the Budget of Public Works, General Menabrea applied that the funds for cutting through Mont Cenis should be carried up to 2,500,000f. instead of 2,000,000f., as fixed by the committee. The Chamber, feeling the importance of that great undertaking, acquiesced, in spite of its desire to effect as much saving as possible, in the application of the Minister. General Menabrea, in a very remarkable speech, summed up the situation of the undertaking, and the present state of the works. The length of the tunnel at Bardonnecche, on the Italian side of the mountain, was, he said, on the 1st January last, 1274 metres (the metre is 39 inches English), of which 724 were executed by the ordinary means from 1857 to 1860, and the remainder—170 metres in 1861, and 380 in 1860—by the new mechanical means. On the side of Modene, on the French slope, the mechanical means had not been adopted up to the 1st January last, but, by the ordinary means, 925 metres had been excavated, making altogether a length of 2199 metres. At the end of January the new means were also brought into operation on the French side. General Menabrea expressed his opinion that the whole of the cutting may be completed in 12½ years, instead of the 25 years at first demanded, and recommended the Parliament to make the necessary sacrifices in order to attain that result, which was the more desirable for the Italian Government, as by the convention with France the latter is to pay a premium of 500,000f. for every year reduced in the maximum of 25 years, and of 600,000f. if the works continue for less than 15 years. While waiting for the tunnelling of the mountain the Italian Government has conceded to Mr. Zell, an English engineer, the construction of a railway on the present road over Mount Cenis, on a system of which he is the inventor, and which is described below. Mr. Zell, who is supported by Mr. Brassey, undertakes the affair at his own risk and peril. The concession of the Italian Government is not, however, valid, unless Mr. Zell obtains that of the French Government, which is equally interested in the undertaking, and he has already left for Paris in order to present his proposals to the French Government.

A RAILWAY ACROSS THE SIMPLON.—The Paris correspondent of the Brussels *Independance* writes:—The scheme for the passage of the Alps by railway over the Simplon, has been submitted to the Emperor, at the Tuileries. The plans are executed by the company of the Italian line, and the president, one of the directors, and M. Lehaitre, the engineer, had the honour of presenting it. The Grand Diana gallery had been placed at the disposal of these gentlemen, for the exhibition of the plans, which are forty metres in length. Some workmen had arranged along the whole length of this celebrated gallery, wooden ascents and cross-roads, by which were shown the general plan and outline of the route, so that the Emperor and the persons who accompanied him, could, in walking, follow upon the maps the projected line from Douro O'Ossola, in Italy, to Brigues, in the Valais, and so effect, in imagination, an actual passage of the Alps, upon a reduced scale, it is true, of two thousand. This great work was commenced on the 1st of August last year, and ended on the 7th. About forty agents, divided into two brigades, one turning to the north and the other to the south of the Alps, under the leadership of two engineers, have during four months explored the mountain, and traced the plan of the future railway, which is to pass over rocks, cross torrents, fill up valleys, gorges, and precipices, before which science does not hesitate. The stimulus of having a great work to accomplish has alone sustained the great men to whom the task was confided. They set up shelters and encampments in woods hitherto unexplored, carrying on their backs, beds, clothing, and provisions, as they had often to live two or three leagues from any dwelling. It was frequently necessary to lower by ropes down the precipices, the men who had to prepare the plans amid empty space, and the snow and avalanches more than once threatened to stop them summarily in their work. The result has been to put before the Emperor eighty kilometres of iron way in the Helvetic Alps, forty-four of which will be covered over, twenty-three in tunnels, and twenty-one in galleries. All these passages are ventilated either by shafts for the tunnels, or lateral openings for the galleries. These openings, cut at different points into arcades, have a startling appearance. They are veritable promenades a thousand metres above the sea, offering the same security as those of the Rue do Tivoli, which they resemble, but presenting a more picturesque and varied panorama. The execution of the plan, according to the author, would occupy less than five years. At the end of this month the complete project of crossing the Alps by the Simplon, will be officially submitted to the governments of France, Italy, and Switzerland. The estimated cost of this great project, including the fixed and rolling material, the interest of the capital employed, &c., is 72,000,000 francs.

THE GREAT RUSSIAN RAILWAY.—From the report of the council of administration of the Great Russian Railway Company for 1861-2, which has recently been published, the following is found:—The undertaking, upon which about £25,000,000 have been expended, on the faith of a 5 per cent. guarantee by the Russian Government, appears to be making good progress, the traffic having doubled in 1862 as compared with 1861. The extent of railway now at work is 1010 miles. Last year seventy-five mixed locomotives, forty-nine goods locomotives, and thirteen locomotives to be used at stations were ordered by the company; and, at the close of 1862, it was calculated that the company had 322 engines, of which 220 were employed on the St. Petersburg and Warsaw, and 102 on the Nijni-Novgorod line. The company had constructed a good deal of its plant, and many of its turntables, switches, &c., at its Leuchtenberg works, and fitting and repairing shops on a great scale were last year brought into operation at St. Petersburg.

SOUTH AMERICAN RAILWAYS.—The Peruvian Government have sanctioned a contract with reference to a line across the Andes, concluded with Messrs. Homberg and Co., of London, and Messrs. Bovan and Co., of Paris. An interest of 7½ per cent. per annum is guaranteed by the Peruvian Government upon the capital employed. The works of a line in progress from Santiago to Valparaiso, in the Republic of Chili, are being pushed forward with great activity, and the rails have been laid for more than half the distance between Santiago and Quillota, from which point a line to Valparaiso has been for some time opened for traffic.

INDIAN RAILWAYS.—The opening of the railway to Benares has so shortened the time taken by the post between Calcutta and Bombay that the direct mail steamer from Calcutta closes only three days, instead of a week, after the Bombay mail. On Lord Elgin's way to Benares, the Governor-General stopped at Nulhattee, and carefully inspected the light railway which has been laid down on an ordinary road from Moorshedabad by Mr. Wilson, C.E., engineer of the Indian Branch Railway Company. The gauge is only four feet, a first experiment in a system of railway construction which may yet revolutionise Indian transit. The same company are about to lay down a similar feeder of the East Indian trunk line from Cawnpore, through Lucknow, to the Gogra, which is at this point more navigable than the Ganges. A third very long feeder will start from a point about 60 miles from Delhi, and at right angles to the line pass through the rich Doab of the Ganges and Jumna to the foot of the Himalayas. But the longest of all will be a line parallel with the East Indian, to start from Buxar on the Ganges, and run direct up through Oude and Rohilcund, probably to Umballa. Instead of £12,000 a mile, the lowest average price of the guaranteed lines, these light railways will be laid down at £3500 a mile, of which the State will contribute £1000 in some shape or other as a subvention. All will be on the uniform Indian gauge of 5ft., and will meet the insuperable difficulty of the want of wood by iron sleepers.

## RAILWAY ACCIDENTS.

EXTRAORDINARY ENGINE CHASE.—An extraordinary occurrence recently took place on the Caledonian Railway, which had very nearly been the cause of a serious accident. An engine was detached from an up luggage train at Beattock station, and shunted on to the down line, for the purpose of taking in water. When this operation was completed, the driver, instead of going to the points and returning to his proper line, put on steam and started for the south alone. The fireman, who was on the platform, seeing that if the engine kept on it would inevitably meet the down limited mail face to face, lost no time in getting ready another engine, which fortunately had the steam up, and started in chase on the proper or up line. After a race of 13 miles he overtook the truant engine near Lockerby, and on getting alongside leaped from one engine to the other, both going at the rate of 15 or 20 miles an hour at the time. He had just time to reverse the engine, wake up the driver, who was asleep, and then run to the adjacent signal post, when the limited mail came thundering along from Carlisle at 40 miles an hour. It was fortunately stopped by the signal in time when within a few yards of the runaway engine. Had the fireman hesitated as to the proper cause to pursue, even for one minute, a very serious accident and loss of life must have occurred.

RAILWAY COLLISION AT WOLVERHAMPTON.—On the 8th ult. a railway collision happened on the Shrewsbury and Birmingham line, near to Wolverhampton. At 7.15 a.m. a local train left the Great Western Station in Wolverhampton for the Madeley and Wellington branch. Through a defect in the feed-valve too much water was taken into the boiler at Wolverhampton, and the train was stopped at the Wolverhampton locomotive works of the Great Western Railway, which are upon the Shrewsbury and Birming-

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ham line, that this defect might be remedied. Care did not seem to have been taken by the persons in charge of the train to apply the stationary signal, which was close at hand, so that a London goods train, which was then due, might be warned off. In consequence, the goods train came on, unapprehensive of danger, and was between 100 and 150 yards only from the passenger train when the driver of the goods saw the tail of the passenger train. He shut off steam, reversed the engine, applied his breaks, and did all in his power to avert a collision; but in vain. Fortunately, the passenger train, when he came upon it, had begun to move; and to this circumstance, added to the promptitude of the goods train driver, is owing the circumstance that the collision has been unattended with fatal consequences. Singularly enough the persons injured were in the carriage the farthest removed from the point of collision, and the one which was coupled to the luggage-van, which followed immediately upon the tender of the passenger train. This was a second-class carriage. Its buffers were broken by the concussion against those of the luggage-van, and then the carriage was reared to the roof of the van, and the first compartment destroyed.

## TELEGRAPHIC ENGINEERING.

The Indian Electric Telegraph Department is about to be thoroughly reformed, and the lines now in use are to be superseded by posts and wires of permanent construction. The reforms are due to the representations of the Bombay Government.

Telegraph in Sweden.—The official Swedish telegraph report states, that the Swedish telegraph (net) has advanced from 10 geographical miles, in 1853, to 689 in 1861; the total amount of wires being 983 geographical miles, while the number of stations has increased from two to sixty eight. In 1861 the number of telegrams was 169,038, the income 513,044, and the clear gain to the state 69,142 Swedish dollars.

Submarine Telegraph Company.—The Submarine Telegraph Company, during the half-year end 31st December last, transmitted 172,881 messages over their wires, against 137,714 for the previous six months, showing an increase of 35,167 messages. The receipts were £23,427 5*s.* 6½*d.*, against £18,517 18*s.* 8½*d.*, or an increase of £4909 6*s.* 10*d.* The returns of the current half-year contrast favourably with those of the corresponding period of 1862—the number of messages conveyed for the first six weeks being 34,680, as compared with 31,783, and the receipts being £4907 13*s.* 5½*d.*, as compared with £4194 19*s.* 5*d.* The proportion of the earnings belonging to this company, after paying the working expenses and repairs to cables, left a profit of £9500 16*s.* 7½*d.*; and deducting the interest paid on debentures and loans, and £1853 18*s.* 11*d.*, being 10 per cent. on the gross receipts for the reserve fund, there remains a sum of £5285 0*s.* 3½*d.*, equivalent to a dividend of nearly 5 per cent. per annum on the share capital. Following the same course for the liquidation of the balance of the suspense account (2300 15*s.* 11½*d.*), as was adopted in the last half-yearly accounts, viz., by applying the reserve fund, £1853 18*s.* 11*d.*, and the balance, £820 5*s.* 9*d.*, of last half-year's revenue, amounting together to £2674 4*s.* 8*d.*, there is available a sum of £5458 9*s.*, from which a dividend at the rate of 4 per cent. per annum was declared, carrying over a balance of £1219 15*s.* placed to the credit of the reserve fund. The cable between Marsala, in Sicily, and Cape Carbonara, in Sardinia, has recently been successfully laid.

## GAS SUPPLY.

The Crystal Palace District Gas Company have reduced their price of gas throughout the district commencing the 1st of January, 1863, and have also declared a dividend of six per cent. per annum, and a dividend of ten per cent. per annum on the ordinary capital of the company.

The Boston Gas Company propose a dividend at the rate of 8½ per cent. for the current year.

In Abergavenny, the price of gas is to be reduced from 6*s.* 10*d.* to 5*s.* 10*d.* per 1000 feet; the 10*d.* also to be deducted for prompt payments.

The Howden Gas Company have reduced their price from 7*s.* 6*d.* to 6*s.* 8*d.*, and have declared a dividend of 6 per cent.

The Bromley Gas Company have declared a dividend of 10 per cent., leaving a balance of £305.

The Kettering Gas Works have deemed it necessary to add a third gasholder to the two already existing, the accepted tender being C. and W. Walker; for £444.

## CANALS.

The Suez Canal.—The efforts of the company are at present almost exclusively directed to the completion of the canal, by which fresh water will be conveyed to Suez. It branches off, near Lake Timsah, from the small canal, previously dug by the company, and which, will be remembered, is a prolongation of the Wadi Toumilat Canal. The watercourse is about 25 feet in width, with a depth of about five feet. It is already completed as far as the Bitter Lakes, and the engineers of the company expect to reach Suez before the middle of the coming summer. Their next task will be the construction of a feeding canal, starting from Cairo, and running along the edge of the Desert, the execution of which, though lately abandoned, has been finally decided upon. Without it, indeed, it would be impossible to maintain a sufficient level in the new canals, even while draining their neighbours, to the grievous injury of the cultivators dependent upon the latter for the irrigation of their lands. The sight of a stream of fresh water, flowing through the still and death-like solitude of the Desert, of itself offers a most singular spectacle. A practical end can also more readily be assigned to this portion of the company's projects. To the inhabitants of Suez the acquisition of fresh water and of the attendant means of vegetation will be a boon of real value, and, although new accessions of arable land are hardly yet an object of necessity to Egypt, yet the canals afford the prospect that many productive spots along their banks may yet be redeemed from the surrounding wilderness. Between the fresh-water canal and the *rigole*, or preliminary trench of the Maritime Canal, runs a small channel, about five feet wide and two to three feet in depth, which serves to supply the labourers with water, and which is lengthened as the work on either side progresses, being, however, always kept a short distance in advance. The cutting for the maritime *rigole*, through the ridge of the Serapeum, which, next to the Gisr, is the highest land on the course of the canal, will for a short time remain in abeyance, while the fresh-water canal is pressed forward. The cutting of El Gisr has been dug to a depth, at its highest levels, of about 70 feet, and it forms a channel containing a width of water of about 25 feet, with a depth of four to five feet. The trench is cut, as elsewhere in the desert, with its sides at an inclination of two feet for every one foot in depth. The ridge terminates towards the north in a plain covered with hillocks of light sand, which about four and a-half miles further on sinks below the level of the sea, and is now covered with a shallow sheet of water, communicating with lake Menzaleh. It is along these four to five miles of the line that the canal appears to be exposed to the greatest danger from land drifts. But it is maintained that the embankments which will be formed when the canal is excavated to its full width and depth will afford ample protection. As a further precaution, hedges of cane and brushwood are put up at various points across the plain. These, it is contended, will serve as barriers against the progress of the heavier particles of sand, which being raised by even the most violent storms at but a slight elevation, and moving at a low velocity, are brought to the ground on meeting with the least obstacle. The lighter particles, being lifted high into the air, are carried away over long distances, and on again falling to the ground are spread so lightly over the plain that it is contended they can be of little or no practical effect. The track of the canal along the greater part of its course through Lake Menzaleh is clearly marked by the embankments, of which the bases have been raised on either side at a distance of 60 mètres across. Two small channels have been formed, one on either side, with a depth of water just sufficient to give passage to a small boat. The central portion of the canal is still untouched, and the mud which forms the bed of the lake frequently shows itself above the surface of the water. The embankments are made of this same mud, which was lifted by hand labour from the bed of the lake. Near Port Said the traces of the embankment become very slight, and in some places boats seemed to cross the open lake. The work is to be continued by means of dredging machines. The mud is raised in almost a liquid state, and is poured into a species of caisson formed of planks, supported by wooden piles driven into the bed of the lake. On rising above the level of the water the mud hardens into a solid mass. This portion of the work, as will be readily believed, has been attended with great difficulties and trouble, but the worst is believed by the engineers to be past. As the canal approaches Port Said it is to attain the width of 80 mètres, terminating in a basin or dock of 800 mètres square. This basin is likewise to be deepened by means of dredging machines. As yet only 16 machines have been put together at Port Said and along the canal, but it was stated that the number will shortly be raised to 50, and that each is expected to excavate an average of little if at all less than 1000 cubic mètres a day. The channel of communication with the sea will be 400 mètres wide, and its entrance is to be protected by a double jetty. The western mole is to be prolonged to a distance of 3400 mètres, or somewhat more than two miles, where it will reach a depth of water of 10 mètres, or about 32 feet. A small islet of stone has been formed at about half the distance as a nucleus to the future pier, and to serve for the discharge of the boats that come to Port Said with stone and other materials and stores. The temporary wooden jetty is about 200 yards in length, and is partially filled in with stone. The accumulation of sand that has been formed on the western side advances the beach to the extent of about 50 yards into the sea; but the engineers are disposed to attach but little importance to the matter. They argue that before the sand can reach the extremity of the mole it must fill up an angle formed by a basis extending to an almost unlimited length along the coast to the westward, and of an elevation of upwards of two miles. The stone required for the works at Port Said has hitherto been brought at an exceedingly heavy cost from the quarries of El Meks, near Alexandria. Future supplies are to be drawn from the hills of Genneffeh, near the Bitter Lakes, and to be brought in flat-bottomed boats along the canal, at an estimated cost of 1*s.* the cubic mètre. At Suez, it will be remembered, the intention of constructing jetties has been abandoned, and it is proposed simply to deepen the channel that leads from the anchorage to the town, a distance of about four and a half miles, and which is practicable for small boats alone. The channel is formed on its western side by a large sandbank, partially uncovered at low tide. At its further extremity the Messageries Imperiales have commenced the foundation of the dry dock, in accordance with their contract with the Egyptian Government. The dock will be connected with the shore by an embankment 2¼ miles in length, already in course of construction, over the sandbank, and which will be surmounted by a railway. It seems a singular thing, considering the implicit confidence with which the success of the Canal Company appears throughout to have been regarded by the French public of all classes, as well as by the late Viceroy, that it should not have been resolved to await the completion of the improved channel, when the dry dock might be constructed close in shore on a far more convenient spot, and, of course, at a very much lighter cost. To return to Port Said. The site of the destined town is a narrow strip of land, which separates the sea from the lake, and, until lately, occasionally washed over by the sea. It is in process of being widened and raised beyond the reach of the waves. A foundry and workships, fitted up with every description of machinery, have been established at Port Said, and, together with the lighthouse, at the foot of the pier, the storehouses, *chdlets*, and other light dwelling places built for the *employés*, impart a town-like appearance to the spot. Nile water is brought across the lakes in boats carrying iron tanks, but the place is before long to be supplied by means of iron pipes, which have already been brought to the Isthmus. The water is to be raised by pumping machinery in the neighbourhood of Timsah to the summit of El Gisr, whence it will flow towards the north, following the embankment of the maritime canal.

## ACCIDENTS TO MINES, MACHINERY, &c.

Colliery Explosion near Newcastle-upon-Tyne.—About six o'clock in the morning of the 7th ult. an explosion of gas occurred in Coxlodge Colliery, by which 19 persons have lost their lives. The colliery is situated at the north edge of the town moor, about a mile and a half from the town, and it is the property of Mr. Joshua Bower, of Leeds. The workings of the mine are very extensive, and it appears that at the time mentioned, 43 persons were working in the north-east division of the pit. Of these 19 were killed, and 24 escaped with their lives.

## BOILER EXPLOSIONS.

Manchester Association for the Prevention of Steam Boiler Explosions.—At the ordinary monthly meeting this Association held on February 24th, 1863, the chief engineer presented his report. This report was a double one, embracing the month of January as well as that of February. Of this report the following is an abstract:—"During the last two months, *i.e.*, from January 1st to February 20th, the ordinary visits of inspection have been made, 2 boilers tested by hydraulic pressure, and the following defects discovered in the boilers examined, viz.:—Fracture, 4; corrosion, 45 (5 dangerous); safety-valves out of order, 8 (1 dangerous); water gauges ditto, 28 (2 dangerous); pressure gauges ditto, 19; feed apparatus ditto, 9; blow-out cocks ditto (mainly from neglect), 37 (1 dangerous); fusible plugs ditto, 1; furnaces out of shape, 3 (1 dangerous); blistered plates, 3. Total, 157 (10 dangerous). Boilers without glass water-gauges, 19; without blow-out cocks, 17; without back-pressure valves, 64. Three explosions have been reported since the commencement of this year, from which, however, no lives have been lost, nor any personal injury done worth mentioning. Not one of the boilers in question was under the inspection of this Association. "No. 1 Explosion.—There has been no opportunity of investigating the cause of this explosion, neither have any reliable reports been obtained, but with regard to No. 2 and No. 3; a personal examination has subsequently been made of the boiler in each instance. No. 2 Explosion.—The boiler in this case was externally fired, and of plain cylindrical construction, the ends being slightly domed. The length was 5ft.; the diameter, 2ft.; and the thickness of the plates, three-eighths in the ends, and one quarter in the remainder. The cylindrical portion of the shell was composed of two plates, about three feet wide, laid lengthwise, and flanged at their attachment to the end plates, which were in one piece. The complement of fittings was most incomplete, the number of those omitted being greater than those supplied. There was no feed stop-valve, no feed back-pressure valve, no steam pressure-gauge, nor any tap for applying the indicator as a test of the actual pressure. The only fittings were, one glass water-gauge, and one safety-valve, the latter stated to have blown off at a pressure of 25lb. per square inch. The boiler had lately been purchased second-hand, and not put into regular work since its re-setting. In consequence of this, the feed pipe was not yet connected, and the boiler had been supplied with water poured in by hand at the safety valve when the steam was down. The engine was standing at the time of the explosion, but had been working about an hour previously. The results of the explosion to the surrounding property were, that the workshop in which the boiler was set, was laid completely in ruins, the chimney levelled to the ground, and the windows of a house on the opposite side of the street broken by the concussion. The boiler was rent into five pieces, one of which was blown across the street, and lodged upon the top of the opposite house, while the manhole cover was thrown upon the roof of a shed in another direction. With regard to the cause of the explosion, the primitive mode

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of feeding the boiler naturally excited the suspicion as to the sufficiency of the supply of water; and with this view, therefore, a particular examination was made of the remaining fragments of the glass-gauge, the colour of the plates, and the position of the fractures; in addition to which, the circumstances attendant on the working of the boiler were inquired into. The result of this investigation was, that shortness of water did not appear to have been the cause of the explosion, and this conclusion was corroborated by further examination, as will be seen from the following particulars. The safety-valve, which was supposed to have blown off at 25lb. pressure, was found, on investigation, to have been loaded to upwards of 100lb.; the diameter being one inch, the proportions of the lever thirteen to one, the weight at the end 5lb., in addition to that of the lever itself. It is impossible to say, however, whether the valve had been free or not, since it, as well as the lever, had been blown away; and, as there had been no steam-gauge, the pressure must always have been a matter of uncertainty, and thus it can only now be concluded, that 100lb. on the square inch was the minimum. A boiler, however, of such dimensions as the one in question would, if well constructed, withstand a much higher pressure than that of 100lb. per square inch; but, in this case, the manhole had not been strengthened with any mouth piece, which consequently made a very weak point in the shell, and from which the explosion appeared to have arisen. Five rents had started from it, while the remaining fractures were all subsidiary to these, and nothing more than the simple development of them. The effect of the manhole would be to throw upon the plates of the shell, in the immediate vicinity of the opening, an extra disruptive strain of about ten tons, added to which, the cover being an internal one, there would be acting it an upward pressure of steam amounting to about five tons, and tending to drive it through the manhole. The cover was a bad fit, being much too rounding, in consequence of which difficulty had always been experienced in making the joint, and it had been severely tightened by a stout bolt, which left the impression of the heels of the bridge in the plates. When it is remembered that the thickness of the plates was only one-quarter of an inch, it will not be surprising that fracture should have occurred at the manhole, under the above circumstances, and the fact of five of the rents emanating from this point, and all the others being explicable upon the view that fracture commenced there in the first instance, it is thought to be conclusive that the mal-construction of the boiler, in not being suitably strengthened at the manhole. was the cause of the explosion. No. 3 Explosion.—The circumstances in this case were very similar to those in No. 2. The boiler was externally fired, and of plain cylindrical construction. The length was 7ft. 6in.; the diameter, 3ft.; while the plates varied in thickness from five-sixteenths to one-quarter. The boiler was made out of an old flue-tube, taken from an internally fired boiler, and the longitudinal seams in line. The fittings consisted of only one float, and one safety-valve, there being as in the previous case, no steam-gauge, nor any means of ascertaining the actual pressure. At the time of the explosion, the engine was not at work, but the steam was being got up in preparation for starting, and the boiler stated to have been amply supplied with water, which an examination of the plates and fractures, afforded no reason to doubt. As to the cause of the explosion, there could be no room for hesitation. The safety-valve, which was stated to have blown off at 50lb. pressure, proved to have been actually loaded to upwards of 200lb., the diameter being only three-quarters of an inch, the proportions of the lever, seven to one, and the weight with which the lever was loaded, 21lb. The manhole in this boiler, as in the previous one, was not strengthened by any mouth-piece, and the rents, as before, had started from this opening. Attention has already been called in these reports to the weakening effect produced upon the shells of boilers by unguarded manholes, as well as by openings cut in the plates at the base of steam domes, and a case of explosions from these causes previously recorded. All modern well-appointed boilers have, as a rule, their manholes strengthened by strong mouth-pieces rivetted to the plates, the surface for the cover-joint being faced; still, it is thought that the weakening effect produced upon the shells of boilers by steam domes has not, as yet, received sufficient attention, and although it may have proved hitherto comparatively harmless, that the gradual increase of pressure, now generally taking place, must shortly force the subject into notice, and thus prominence is given to the details of these two explosions with a view of showing the importance of the subject. The danger of working without steam-pressure gauges will also be apparent from both of the above explosions. The results of this explosion were curious rather than serious, and attested the force of atmospheric concussion produced by steam. A dwelling-house directly facing the boiler, and situated about 50ft. from it, had its four windows, two on the ground and two immediately over them, all dismantled. A shower of bricks had been projected through the lower window immediately opposite the boiler, and had left their scars upon the walls of the room inside, while the two upper windows were also blown in. This will not excite much surprise; but the other lower window was stated not to have been blown in but drawn out, and this was attested by the debris of the sash lying upon the ground in the yard, while it was added that a looking-glass standing in the room had been sucked out along with the window sash, and thrown upon the ground outside. The same apparent anomaly has been noticed with regard to explosions caused by gunpowder,—some objects being thrown away from the seat of explosion, and others drawn towards it. This is accounted for by the double action that takes place, namely, first an expansion, which causes pressure, and then a recoil, which produces exhaustion. Some objects are more susceptible to the effect of pressure than exhaustion, while others are the reverse, and each succumbs to that action to which it is able to offer the least resistance. Thus unguarded windows fall under the first action—viz.: that of pressure consequent upon the expansion, while outside shutters, adapted to resist external aggression, withstand the former, but yield to the exhaustion consequent upon the recoil. There were further signs on the roof of an adjoining shed of the force of atmospheric impact, consequent on the explosion. This shed stood at right angles with the dwelling-house, and extending toward the seat of the boiler, formed, with the buildings immediately adjoining the latter, nearly three sides of a square. A considerable portion of the side of this shed nearest the boiler was open, while the other sides were closed. The effect upon the shed was, that many of the stone flags, with which the roof was covered, were blown up, and, clearing the pegs which hung them to the rafters, slid down upon the lower ones, while others mounted the rafters only, and there remained. The portion of the roof affected was the side of the gable opposite to the open doorway, and most distant from the boiler, since that side presented a surface more nearly at right angles with the direction of the impulse than the other. These particulars, though not important in themselves, afford additional evidence of the high pressure at which the boiler must have been worked."

## MINES, METALLURGY, &c.

PROCESS FOR OBTAINING FINELY-POWDERED METALLIC COPPER, BY M. HUGO SCHIFF.—To obtain finely-powdered metallic copper, mix a certain quantity of a saturated solution of sulphate of copper with some of the same salt in coarse powder, and some granular metallic zinc, and shake the mixture continuously and briskly; the cupric solution is decomposed by the zinc, which is changed into sulphate, and leaves the copper only in the form of a finely-divided powder. As a certain quantity of the excess of sulphate of copper is constantly dissolving, the decomposing action of the zinc continues while cupric salt is in solution. By this means large quantities of powdered metallic copper can be prepared in a very short time. When a certain quantity is formed, it is thrown on a filter and washed several times with distilled water freed from air, and then with alcohol; it is afterwards dried by pressure, guarded from air and heat, as the metal, when so finely divided, is very apt to oxidise. During the reaction heat is developed, and singularly accelerates the decomposition of the cupric salt, and after a few minutes the temperature becomes so intense as to render it impossible to hold the flask in the hand.

THE DESULPHURATION OF IRON IN PUDDLING.—The inferior quality of bar-iron obtained from the puddling of pig-iron reduced from iron ores rich in sulphur, or even, from good ores when reduced with coal containing much pyrites, is well known to ironmasters, and many methods have been devised for the desulphuration of this iron in the puddling process. Among the best of these is the addition of binoxide of manganese; still this is liable to objection as it is infusible, and thus prevents its becoming thoroughly incorporated with the iron; moreover, commercial oxide of manganese often contains impurities which possibly may be taken up by iron in the puddling process, and influence unfavourably the quality of bar-iron produced. This subject has recently been studied by Prof. Robert Richter, of Leoben (Austria). Richter calls to mind the powerfully oxidising effect of litharge (oxide of lead), and its use to promote oxidation in many metallurgical processes. On experiment he finds that litharge will not only remove sulphur in the puddling process, but, what is equally important, it also oxidises the phosphorus contained in the iron, thus affording a most simple means of correcting two sources of the greatest annoyance to the ironmaster. The experiments were made at the forges of Count Donnersmark, at Frantschach, near Wolfsberg, in Carinthia, with pig-iron which contained so much sulphur that it was impossible to make it into puddled bar. The process of puddling was undertaken in two double puddling-furnaces arranged for burning wood. Each furnace was charged with 7 cwt. of this iron. To one of the furnaces there was added 3lbs. of sulphide of iron and ½lb. of phosphide of iron, in order to still further deteriorate the quality of the product. After complete fusion, 3lbs. of litharge was added to the furnace in which the sulphide and phosphide of iron has been placed, and on thoroughly mixing this with the charge, the iron commenced to boil finely—the litharge being deoxidised by the carbon. The reduced lead was immediately re-oxidised by the atmosphere, and by subsequent reduction and re-oxidation it again and again exercised its oxidising influence on the harmful impurities contained in the iron. There was soon formed an easily fusible slag, containing oxide of lead, which also exercised an oxidising influence upon the impurities contained in the iron, while at the same time the oxides thus formed united with the slag. After an hour and a half from the time of charging, the iron was made into balls, these were shingled, and without difficulty rolled into puddled bar. In the other furnace, in which the iron was puddled in the usual manner, it was two and a half hours before the puddled balls could be taken out of the furnace, and, notwithstanding the greatest care was exercised, these crumbled to pieces when struck with the hammer, and rolling into bar was not to be thought of. Besides this, the loss in weight when the litharge was employed was but 11 per cent., while in puddling this iron by the ordinary process the loss was 18 per cent. The puddled-bar obtained from puddling with litharge proved neither hot or cold short, and was of sufficiently good quality to be forged into iron for scythes. A repetition of the experiments gave a confirmation of these results. Richter adds that in some instances the use of metallic lead may, perhaps, be preferable to litharge.

## APPLIED CHEMISTRY.

NEW PROPERTIES OF SULPHUR, BY M. DIETZENBACHER.—A small quantity of iodine, bromine, or chlorine modifies in a remarkable manner the physical and chemical properties of sulphur. It becomes soft and malleable at the ordinary temperature, and maintains this form for a long time. This modification of sulphur, discovered by M. Charles Sainte-Claire Deville, and by him called insoluble sulphur, is almost entirely transformed by this process. 1. By heating a mixture of 400 parts of sulphur and one part of iodine, to about 180°, and then cooling it, a sulphur results remaining elastic for a considerable time. By pouring the sulphur on a glass or porcelain plate, flexible laminæ are obtained. This takes place with even a much smaller proportion of iodine. Iodide of potassium acts in the same manner as iodine. Treated in this way by iodine, sulphur becomes insoluble in sulphide of carbon. The liquor turns violet. 2. The action of bromine on sulphur is analogous to that of iodine; only instead of being black with a metallic lustre, the sulphur is of a wax-yellow colour, and is much softer, and remains soft. This modification is produced with 1 per cent. of bromine, and about 200° of heat. This sulphur is composed of from 75 to 80 per cent. of sulphur insoluble in sulphide of carbon. 3. By passing a current of chlorine on sulphur heated to about 240°, a soft kind of sulphur is obtained, easily drawn out, and the fragments of which readily adhere and unite With sulphide of carbon it behaves in the same way as sulphur treated by bromine. When freshly prepared, however, the sulphur, modified by the chlorine, yields about 10 per cent. more matter soluble in sulphide of carbon. After being worked up for one or more hours, sulphur hardens suddenly, and becomes completely insoluble in sulphide of carbon. These facts may throw light on some of the details of the manufacture of India-rubber vulcanised by sulphur and chloride of sulphur. Some of them confirm the results already obtained by M. Berthelot.

INFLUENCE OF OZONISED AIR UPON ANIMALS.—Dr. Ireland says:—"These experiments were most carefully performed, and all sources of complication avoided as carefully as possible; and, as I felt satisfied of their correctness, I saw no reason to sacrifice the lives of more animals in repeating them. I submit to the reader the following conclusions:—1. Ozonised air accelerates the respiration, and, we may infer, the circulation. 2. Ozonised air excites the nervous system. 3. Ozonised air promotes the coagulability of the blood, probably by increasing its fibrine. In the blood, however, ozone loses its peculiar properties, probably entering into combination with some of the constituents of the circulating fluid. 4. Animals can be subjected to the influence of a considerable proportion of ozone in the air for hours without permanent injury; but in the end ozone produces effects which may continue after its withdrawal, and destroy life."

COAL-TAR COLOURS—PEONINE AND AZULINE.—An additional colouring matter, from coal products, has recently been patented by Messrs. Guinon, Marnas, and Bonnet, of Lyons. The object of the invention is, in the first place, to transform carbonic acid into a red colouring matter, and then to convert it into a fast colour, capable of resisting acids and other agents. They take about 23lbs. of carbonic acid, from 10lbs. to 20lbs. of oxalic acid, and from 7lbs. to 14lbs. of sulphuric acid; this mixture is heated until the colouring matter is formed of the requisite consistence, the excess of acid is then removed with boiling water, when it assumes the state of a light pitch, with a green shade of cantharides. It may be dried and reduced to powder by exposure to the air, or by means of a stove. To convert this into a more solid matter, take 2½lbs. of this less solid matter, and about 5½lbs. of ammonia of commerce. This mixture is then put into a closed metallic vessel, then heated to a temperature of about 270° Fahr. for about three hours. This is allowed to cool, and then the vessel is opened. The matter originally introduced therein becomes completely dissolved in the ammonia, thence yielding a liquor rather thick, and with a considerable colouring power. This liquor, when treated with acids, furnishes a deep red precipitate, which is the new matter modified as required. This "peonine" is applicable to the dyeing of silk, wool, &c., red. By combining five parts of peonine with about six or eight parts of aniline a blue colouring matter is produced. The mixture is heated to a temperature near the boiling point, which is maintained for some hours until the material is completely transformed. The result thus obtained is a blue colouring matter, which is purified by means of successive washings, first with acidulated boiling water, next with heated coal oil, and, lastly, with a dilute solution of caustic alkali. The matter thus obtained is passed into acidulated boiling water, then dried. It is then in the form of a powder, with golden shades, soluble in alcohol, methyle, and other spirits, and the solutions of which may be used directly for dyeing and printing. The inventors designate this new compound "azuline," and the blue produced by it is said to be very fine.

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## LIST OF APPLICATIONS FOR LETTERS PATENT.

WE HAVE ADOPTED A NEW ARRANGEMENT OF THE PROVISIONAL PROTECTIONS APPLIED FOR BY INVENTORS AT THE GREAT SEAL PATENT OFFICE. IF ANY DIFFICULTY SHOULD ARISE WITH REFERENCE TO THE NAMES, ADDRESSES, OR TITLES GIVEN IN THE LIST, THE REQUISITE INFORMATION WILL BE FURNISHED, FREE OF EXPENSE, FROM THE OFFICE, BY ADDRESSING A LETTER, PREPAID, TO THE EDITOR OF "THE ARTIZAN."

### DATED FEBRUARY 24th, 1863.

496 H. Mozers—Spools, bobbins, and rollers.
497 D Spink—Armour plates f r ships.
498 W. & H. Whitehead & H. Barber—Cutlery handles.
499 J. Clay—Saddles.
500 J. Hawthorn—Handles for doors, drawers, and other means of enclosure.
501 G. Davies—Melting and smelting furnaces.
502 W. E. Gedge—Hats.
503 J. W. Burton—Bearings and leashes of axles and shafts.
504 J. Le-Butt—Dressing grain.
505 W. Hooper—Insulating and protecting telegraphic and other wires and rods.
506 D. B. Chatterton—Brick-making machinery.
507 E. R. Walker—Valves.
508 H. S. Willson—War and merchant ships.
509 G. A. Huddart—Imparting heat to fluids.
510 A. Jaeger—Life-preserving garment.
511 T. Mallinson & J. Livingston—Throstle, spinning, and doubling frames.
512 R. W. Thomson — Obtaining and applying motive power.
513 G. Bower & W. Hollinshead—Apparatus for the production and transmission of gas or other fluids.
514 W. Clark—Sewing machines.
515 W. H. Lapthorn—Reefing and furling ships' square sails.

### DATED FEBRUARY 25th, 1863.

516 H. Wilde—Electro-magnetic telegraphs.
517 F. A. Gatty—Printing and dyeing cotton and other fabrics.
518 R. Maynard—Cutting and separating agricultural produce.
519 R. A. Brooman—Lamps for burning petroleum and other similar oils.
520 J. Fiter—Casters for tables, chairs, and other furniture.
521 W. Readman—Carbonate of magnesia and of iodine and kelp salt and other products from kelp.
522 E. B. Wilson—Alloys of titanium and iron.
523 J. B. Green—Paper.
524 B. Lawrence & W. Niblett—Regulating the flow of gas.
525 J. Gailey—Supplying air for mixture with gases and other aeriform fluids.
526 J. Edwards—Buttons.
527 H. H. Henson—Mats.
528 T. V. Lee—Digging, compressing, and moulding peat or turf, and for retorts and kilns for drying peat or turf, and making peat or turf charcoal through the agency of hydro-caloric or superheated steam, and for collecting the products of distillation whilst charring the peat of turf.
529 W. E Newton—Producing stereotype plates for printing purposes.
530 W. Hudson & C. Catlow—Looms for weaving.
531 N Thompson—Sawing wood.
532 J. Inglis—Folding paper and other fabrics or materials.
533 A. Maclvor—Veneering.
534 G. Tomkins—Tin and terne plates.

### DATED FEBRUARY 26th, 1863.

535 H. Edmonds—Ventilation of ships and vessels.
536 H W. Brown—Window frames and glazing windows.
537 C Ritchie—Making spiral lighters or spills from wood or other substances.
538 G H. Lilley—Securing together planks of wood applicable to the building and caulking of ships and other vessels
539 W A. Wilson & J Smith—Furnaces fire-grates.
540 A. Capello—Glazing Morocco leather.
541 A. P. Price—Blue colors
542 J. Yates—Armour plates or blocks for defensive purposes.
543 P Spence—Potash, alum, and other salts of potash.
544 W. Clark—Buttons.
545 M. Puddefoot—Tilling and cultivating land.
546 J. Hunby—Oxide of zinc or zinc white.
547 R. J. Nodder—Hats, caps, helmets, military head dresses, and other coverings for the head.
548 F. H. Twilley—Book slides or holders.

### DATED FEBRUARY 27th, 1863.

549 J. H. Albinson & H. H. Cocker—Spinning, doubling, throwing, and reeling silk.
550 W. Standen—Converting certain fibres into a substitute for human and other hair.
551 H. Febr—Treatment of mineral oils.
552 E T Hughes—Doubling or twisting yarn, thread, braid, and rope.
553 J. Garver—Fixing of combs in machines employed in the manufacture of bobbin net or twist lace.
554 J. A Coffey—Controlling and facilitating locomotion on land and water.
555 J. Fry—Mashing machinery used in making fermented liquors.
556 R. A Brooman—Apparatus for boring into water and gas supply pipes, and fixing branch pipes thereon.
557 A. Dudgeon, G. F. L. Meakin, E. E. Allen—Underground railways or subways, and carriages to be used therein.
558 W. Gray—Beaters for thrashing machines.
559 W. Clark—Pumping and forcing water.
560 V. D. Delahaye—Cleaning and excavating pit coal and rock or earth.
561 J. H. Johnson—Treatment of hemp and other textile fabrics.

### DATED FEBRUARY 28th, 1863.

562 B. West—Metallic pens.
563 G. Reglo—Creasing or making rouches.
564 W. Haddeld—Steam boilers.
565 J W. Friend—Gas meter.
566 T. Farra—Skirtings.
567 J. Maxfield—Brewing.
568 S. Williamson—Furnaces.
569 D. Collinge—Cleaning, steaming, and preparing cotton to be spun.
570 E. Paine—Facilitating the cleaning of vessels' bottoms while afloat
571 T. E. Symonds—Screw-propelled ships.
572 J. Penn—Relief valves to the cylinders of marine and other steam engines.
573 J. Courtenay—Obtaining motive power.
574 E. Hayes—Supplying water to surface condensers of marine engines.
575 S. Bateman—Wire rope and cordage.
576 G. Hasseltine—Sewing machines.

### DATED MARCH 2nd, 1863.

577 O. Murrell—Generating steam in boilers and other vessels.
578 F. Tolhausen—Cloth blankets.
579 J. W. Barton—Refining and purifying oils.
580 A. F. Pegny—Agricultural implement for cultivating tubercles, roots, and all oil plants.
581 G. Hawksley & T. Bissell—Powder chargers.
582 E. Habel & E. Suckow—Preparing, spinning, and doubling cotton.
583 T. Taylor—Fabric, and its application to the formation of ornaments for fire stoves.
584 C. Garton—Applying heat in the manufacture and refining of sugar, malting, hop drying, brewing, distilling, and vinegar making
585 J. S. Wells—Stockings and other looped fabrics.
586 W. Clark — Preparing and obtaining photographic impressions.

### DATED MARCH 3rd, 1863.

587 T. E. Symonds—Steering ships.
588 T. Emmott—Mules for spinning and doubling.
589 R. Saunders—Metal sheathing for ships and vessels.
590 G. P Lyster—Mooring buoys.
591 R. H. Jones & J. Abrahall—Bracelets and brooches.
592 G. Davies—Polishing soap.
593 J. Henderson—Carpets.
594 G. Price & W. Dawes—Burglar proof safes and strong room doors and frames.
595 J. Sibert—Winding and measuring lace.
596 G. Lamb—Recording the revolutions of the propelling shaft of a steam ship or vessel.
597 T. Erich—Pressing pest.
598 D. B. Parsons—Reaping and mowing machines.
599 B. S. Cohen—Protecting the points of pencils.
600 W. Parsons—Dining tables.
601 J. Pollard—Dressing warp yarns in the loom.

### DATED MARCH 4th, 1863.

602 C. M. Palmer & J. Melntyre—Applying and fastening metal sheathing to the bottoms of iron ships or vessels.
603 J. F. Gits—Furnace for the revivification of animal charcoal.
604 A. P. Jeune—Spring bed bottom.
605 J. de Keyser—Producing a greasy substance.
606 T. H. Morrell & J Williamson — Purifying noxious vapours.
607 E. A. Wunsch—Treating sea weed.
608 P. Adie—Measuring angular and actual distances.
609 E. W. Binney—Pressure and pump lamps.
610 E. W. Binney—Lamp burner.
611 W. Clark—Sulphuric acid.
612 W Hamilton—Registering suitable for advertisers' purposes.
613 J. Craig—Detecting and detaining thieves, and indicating the presence of fire.
614 W. L. Tizard—Cuirated armour plates.

### DATED MARCH 5th, 1863.

615 W. Whittle—Nails.
616 T., E., & R. Thornton—Preparing wool for spinning.
617 J. Clinton—Flutes.
618 W. Allen & W. Johnston—Grinding cards employed in carding engines.
619 E. D. Dwyer—Springs for beds and seats.
620 E. P. Plenty & W. Pain—Supporting screens and straw shakers.
621 W. Wells—Horse shoes.
622 W. Jackson & R. Watkins—Steam engines.
623 S. H. Foster, T. Banney, & J. Anderson—Looped fabrics.
624 J. Miller—Horticultural buildings.
625 E. B. Wilson—Steel.
626 T. W. Osborne—Lamps.
627 J. Howie—Crossings of railways.
628 W. Clark—Fire arms.
629 J. Elsey—Winding of lace on to the work roller in bobbin net or twist lace machines.
630 C. Clay—Chain harrows
631 J. Morris & T. Newton—Refrigerators
632 W. H. Buckland—Producing gas for illuminating and heating purposes.

### DATED MARCH 6th, 1863.

633 M. Jourdin—Engraving by electricity.
634 A. Cuthell—Self-acting dampers for steam engine furnaces.
635 A. W. Makinson—Locomotive and stationary engines.
636 A. Wilson—Easy, lounging, and invalid chairs, seats, or settles.
637 W. E. Gedge—Steam engines.
638 G. T. Bousfield—Illuminating gas.
639 D. W. Ransom—Fixing artificial teeth.
640 T Hancock—Receptacle for gold, silver, and other coins.
641 H. R. Spicer—Preserving the bottoms and sides of ships.
642 T. G. Webb—Articles of pressed glass.
643 A. V. Newton—Elastic carriage wheel.
644 W. E. Newton—Metal casks.

### DATED MARCH 9th, 1863.

645 H. Whittles—Collecting the condensed steam or waste water from places where steam is used and returning the same to the boiler.
646 R. Maabet—Treatment of pig or cast iron.
647 J. Cowley—Bricks, pipes tiles, and mouldings.
648 H. A. Bonneville—Removing stains from cloth and other materials.
649 J. Isherwood—Working presses for making up yarn in bundles
650 J. Haworth—Breaks for omnibuses and other carriages.
651 C. H. Lee—Opening and closing the gates of railway crossings.
652 W. Inglis—Steam boilers and engines.
653 P. Hugon—Obtaining and applying motive power.
654 Sir A. Keller—Reeling silk direct from cocoons on bobbins.
655 W. J. Clapp & N. Coats—Armour plates.
656 J R. Gorst—Carriages.
657 W. E. Newton—Laying of wooden floors.
658 J. H. Johnson—Treatment of certain fibrous vegetable substances with a view to the production of textile materials therefrom.

### DATED MARCH 11th, 1863.

659 H. Fletcher—Cleaning and preparing cotton for spinning.
660 R. T. & R Monteith—Making dyes from aniline and its analogues.
661 F. Cooke—Hats or coverings for the head.
662 R. A. Brooman—Voltaic belts and bandages.
663 J. Cassell—Moderator lamps.
664 G. A. Felton & J. Clyde—Dry gas meters.
665 W. E. Mulley—Sheathing iron ships, caissons, and other like structures.
666 H. Wilson—Shaping wood.
667 W. Wood — Ornamentation of pomfret or liquorice cakes, rolls, and sticks.
668 A. Barclay — Locomotive boring and winding engines.
669 A. Barclay—Traction engines
670 J. Werge—Indicating any regulated maximum or minimum degree of temperature.
671 J. Tomlinson—Opening twisted yarns and woven fabrics.
672 J. Renshaw—Dressing, raising, and brushing silk and cotton velvets, velveteens, cords, plushes, and other frilled fabrics.
673 W. Rossetter—Back beam warping machines.

### DATED MARCH 12, 1863.

674 F. Buser-Kraushaar — Winding, cleaning, measuring, serving, doubling, throwing, and reeling silk.
675 H. D. & J. W. Taylor—Finishing woollen, worsted, and other fabrics.
676 L. Desens—Bathing machine adapted for deep water.
677 W. Clark—Breech loading fire-arms.
678 E. H. Lomas—Action of charges or measure for powder flasks, canisters, or other vessels.
679 J. Polkinghorne—Treating tin ores and matters containing arsenic.

### DATED MARCH 13th, 1863.

680 H. B. Barlow—Looms for weaving.
681 J. Harris, J. Butler, & J. H. Fraser—Rolling armour and other plates
682 C. T. & A. Latwyche—Metallic pens.
683 J. Taylor—Fire bars and bearers.
684 J. B. M. A. Bourreiff—Transferring by the means of typography colours and metals on surfaces in general.
685 W. H. Stubbe—Governors for marine and other engines.
686 A. Wydler & C. Thornton—Printing and dyeing woollen fabrics.
687 J. H. Johnson—Fastenings for harness.
688 W. Smith—Cultivating land and sowing seed.

### DATED MARCH 14th, 1863.

689 W. E. Gedge—Plough.
690 F. Rudrum—Apparatus for registering.
691 W West—Valves.
692 J. Page—Taps or valves.
693 J. W. McCarter—Sawing wood.
694 J. Tangye — Portable hydraulic punching machines.
695 R. Alexander—Mariners' compasses.
696 J. C Richardson—Ships.
697 W. Young—Type composing and distributing machines.
698 R. Moreland—Making extracts of hops, and selecting or separating the seeds and pollen from hops.
699 J. Walworth—Cleaning and drying Egyptian wheat, beans, and other kinds of grain or seeds
700 W. Boaler—Colouring matters for dyeing and printing.

### DATED MARCH 16th, 1863.

701 E. Oliver & G. Myers—Lowering and disengaging boats from vessels.
702 F. Hoyos—Stove or fire-grate for heating, cooking, and boiling.
703 T. W. Willett—Reefing and furling square sails of ships and vessels.
704 W. Vernon—Communicating signals or intelligence to or from railway trains or other similar conveyances, whether they be stationary or in motion.
705 G. P. Beley—Discharging projectiles below the water line of navigable vessels and other structures.
706 T. Powell—Chopping block for butchers.
707 J. Smethurst—Construction of ships and vessels, for the purpose of obtaining additional motive power.
708 W. E. Newton—Iron and steel.
709 W. G. Eavestaff—Pianofortes.

### DATED MARCH 17th, 1863.

710 J. H. Brierley & B. Greenwood—Cricketers' clasp.
711 J. H. Brierley & B Greenwood—Album belt.
712 W. H. Atkinson—Stands.
713 W. E. Gedge—Framing pictures and looking glasses.
714 W. H. Emett—Processes for facilitating and combining the art of writing with engraving together on stone.
715 J. Cox—Swimming baths.
716 W. R. Newton—Cure of scab, foot rot, and other diseases of sheep and cattle.
717 G. de Laire—Brown colouring matters.
718 T. N. Miller—Heating horticultural buildings.

### DATED MARCH 18th, 1863.

719 W. Symington—Roasting and treating coffee and other organic substances.
720 W. C. Wild & J. H. Mandel—Inlaying gold and other metals in glass, and a composition suitable for the manufacture of jewellery and other ornaments.
721 W. Dumbavand & D. Crichton—Looms for weaving.
722 J. Robert & R. Nayler—Organs, harmoniums, and pianofortes.
723 S. A Brooman—Spoons and forks.
724 F Richmond H. Chandler, & J. G. Richmond —Washing potatoes and other vegetables
725 W. E. Taylor—Reeling, winding, warping, and beaming yarn.
726 H. Kilshaw—Looms for weaving.
727 B. Wren—Cleansing and treating certain descriptions of wheat and other grain.
728 E. Legris—Thrashing out the seed of flax.
729 T Oldknow—Jacquards employed in bobbin net or twist lace machines.
730 F. Norrington—Girths or bands and knee caps for horses.
731 W. Lorberg—Treatment of rags.
732 A. Morel—Generating carbonic acid.
733 J. D. & A. P. Welch—Bleaching, reducing, and brightening the colour or tone of dyed straw plaits and straw.

### DATED MARCH 19th, 1863.

734 G. Hasseltine—Boots and shoes.
735 E. Lever—Composition for the coating and preservation of canvas and other materials to make them water proof and non-inflammable.
736 H. Wilde—Steam boilers.
737 H. O. Haughton—Drying and cooling grain and seeds.
738 J. Saunders & J. Piper—Tin and terne plates.
739 S L. Crocker—Yellow metal sheathing nail or spike, which by means of a nail cutting engine is cut from yellow sheathing metal.
740 C. Webster and W. Forgie—Clearing out the interior of foul channels or flues when on fire or otherwise.
741 G. H. Smith—Sewing machines.

### DATED MARCH 20th, 1863.

742 W. Reay, jun.—Concentric bell amalgamator.
743 R. Couchman—Supporting or carrying ladies' parasols and bags.
744 A B. and A. Morton—Injecting and ejecting fluids.
745 J. and T A. Nield—Core barrels.
746 R. A. Brooman—Beating and drying wool and other textile and filamentous substances.
747 V. Houghton—Lamps and lamp wicks.
748 G. Wilson—Springs.
749 G. Coles, J. A. Jaques, and J. A. Fanshawe—Washing and wringing cloths or fabrics.
750 C Pryse and D. Kirkwood—Breech loading fire arms.
751 J. Brigham and R. Bickerton—Reaping and mowing machines.
752 F. de Wylde—Manufacture of cement from gypsum.

### DATED MARCH 21st, 1863.

753 I. M. Evans and W. T. Griffiths—Ventilating mines.
754 F. and A. Roberts—Agricultural implements.
755 C. de Groote—Lamps with circular burners or wicks for the combustion of petroleum, schist, and other volatile oils.
756 G. A. Biddell—Traction engines to be used on common roads
757 E Hartley, J. Clegg, and T. and J. Mellodew—Looms for weaving.
758 J. M. Hetherington—Combing cotton and other fibrous materials.
759 F Applegate—Making certain indications in railway carriages.
760 F. Applegate—Time indicators.
761 W. Clark—Separation or obtaining of ammonia from azoted matters in the preparation of manure

### DATED MARCH 23rd, 1863.

762 H. Hancock—Range for making gas, cooking by gas, and lighting.
763 J W. H. and F. J. Rothwell—Heating the feed water of steam boilers,
764 W. Johnston — Apparatus for lighting and heating.
765 T. G. Grant—Ovens.
766 J. Eyles—Chaffcutter bedsteads
767 W. Clark—Agricultural apparatus.

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FIG. 4.

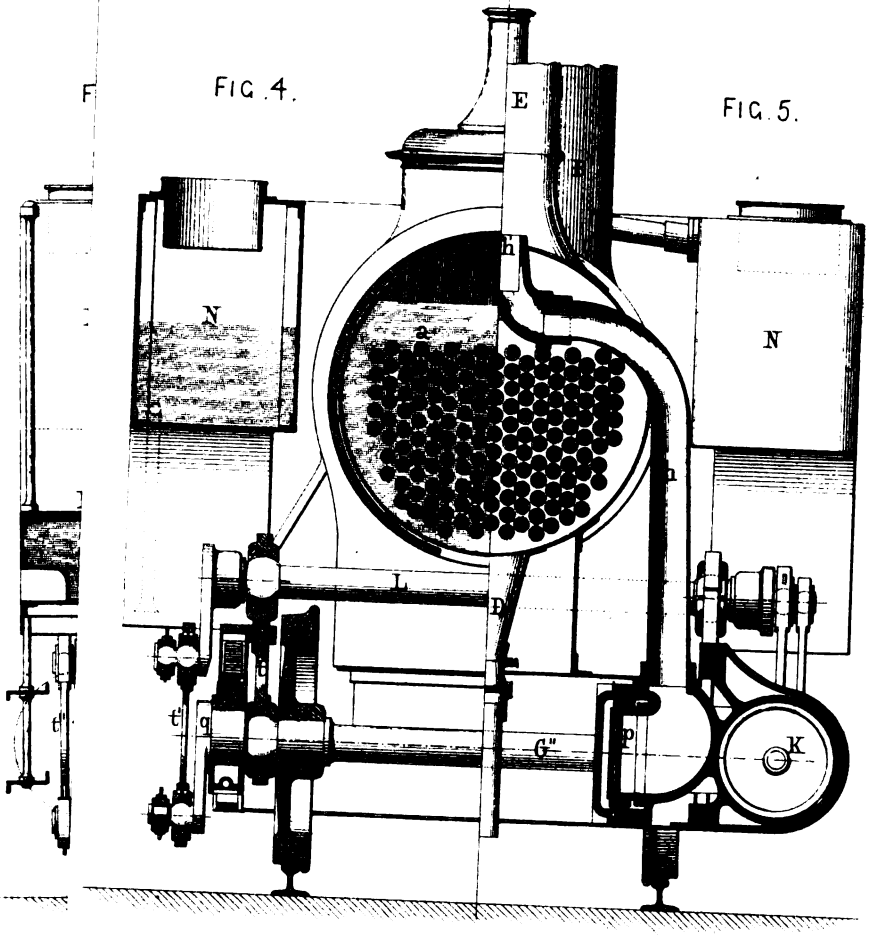
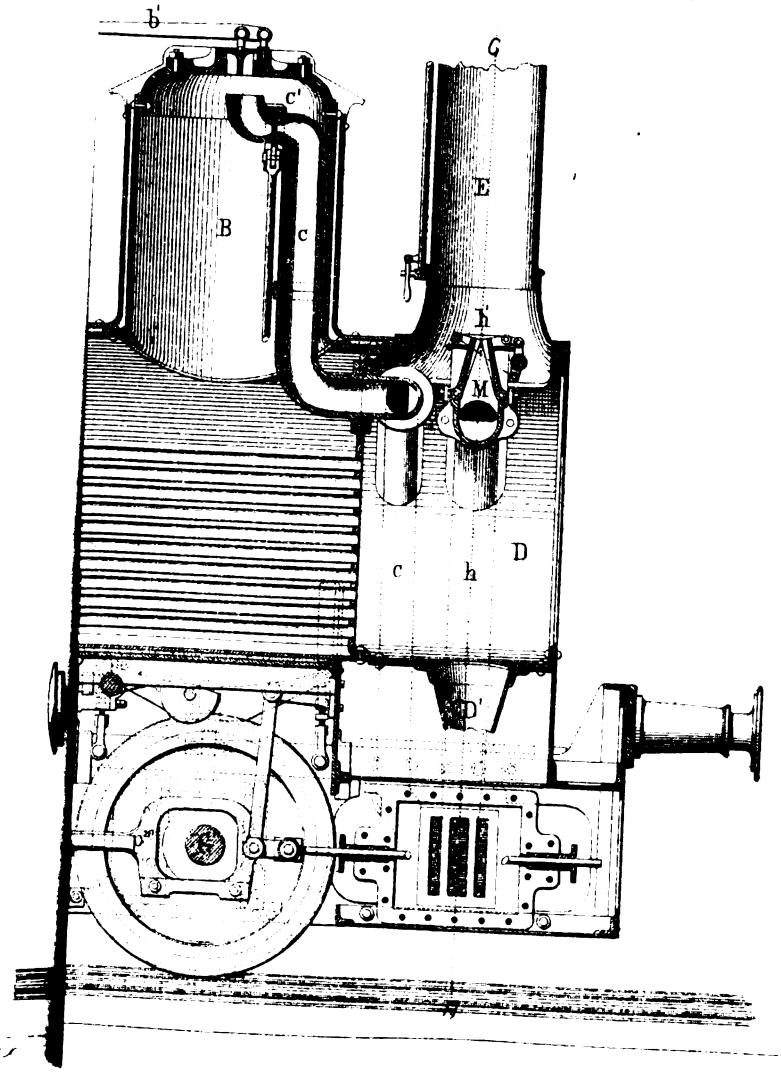



FIG. 5.



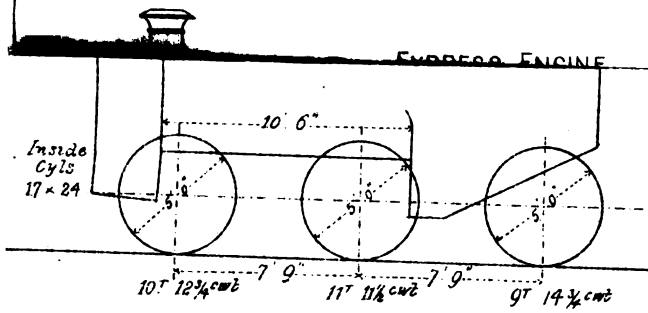

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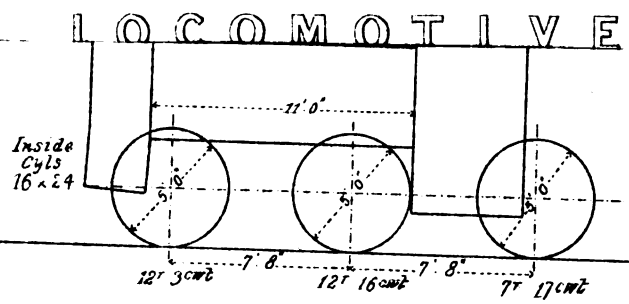
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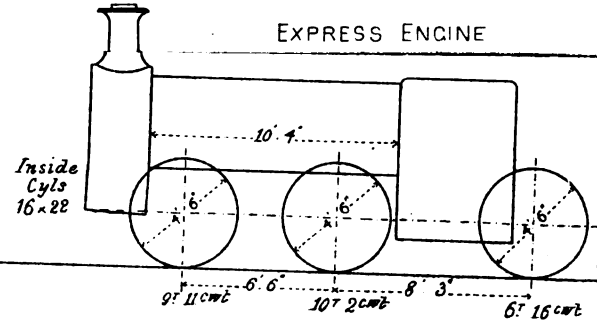
# LOCOMOTIVE

EXPRESS ENGINE

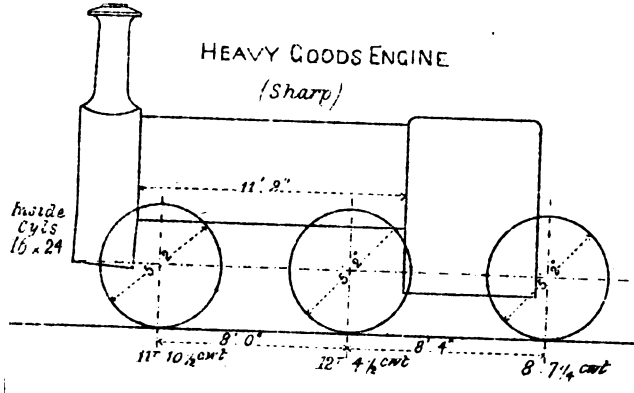


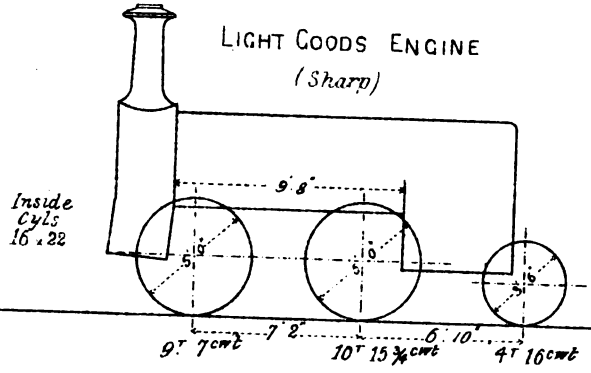

EXPRESS ENGINE



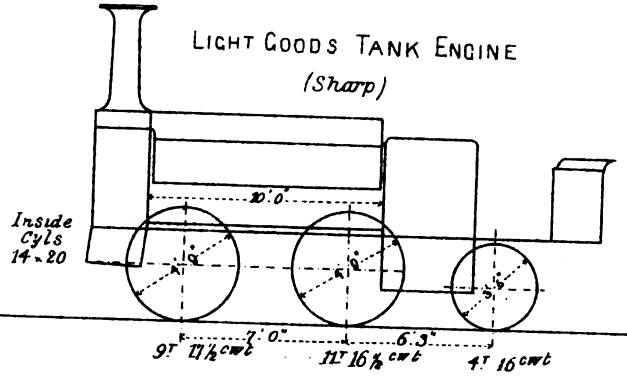

HEAVY GOODS ENGINE
(Sharp)



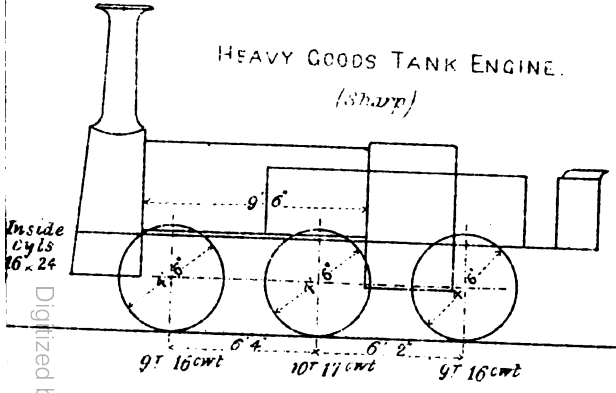

LIGHT GOODS ENGINE
(Sharp)



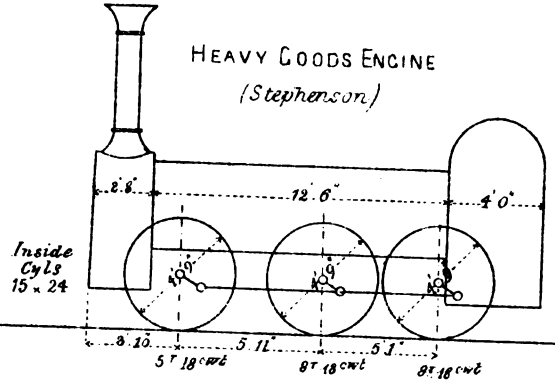

LIGHT GOODS TANK ENGINE
(Sharp)



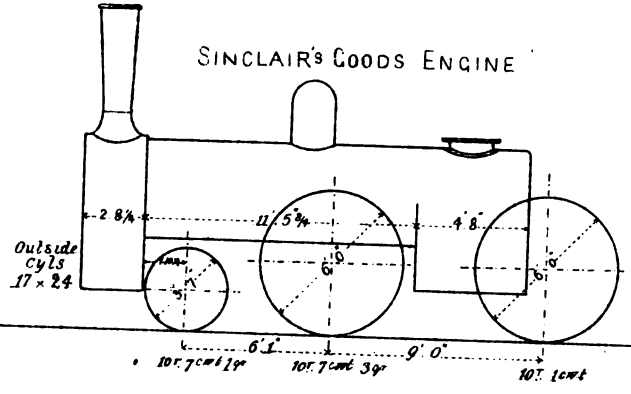

HEAVY GOODS TANK ENGINE.
(Sharp)




HEAVY GOODS ENGINE
(Stephenson)




SINCLAIR'S GOODS ENGINE




Smith C.E. direx

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# THE ARTIZAN.

No. 5.—Vol. 1.—Third Series.

MAY 1st, 1863.

## GOOD'S LOCOMOTIVE, "STEIERDORF."

Constructed at the Works of the I. R. Austrian State Railway Company, Vienna.

(*Continued from page* 50.)

(*Illustrated by Plate* No. 240.)

In The Artizan of March we gave (Plate 233) an elevation and sectional plan of the "Steierdorf," accompanied by a series of descriptive particulars and details as to construction, dimensions, &c.

In Plate 240 with the present number, Fig. 1 is a longitudinal section taken through the barrel of the boiler.

Fig. 2, one-half of a cross section taken on the line A B, Fig. 1.

Fig. 3, one-half of a cross section through the fire-box on the line C D.

Fig. 4, one-half of a section through the fourth axle on the line E. F.

Fig. 5, one-half of a cross section through the cylinders, &c., on the line G. H.

In the following description we refer also to Plate 233; the same letters of reference are used in both plates to denote corresponding parts in the several views. A is the barrel of the boiler; B, the steam chest, containing the steam pipe $c$ with the regulator $c'$, and the safety valve $b'$ above it; the fire-box C is strengthened by the stays $d$ and suspension irons $d'$; its lower fore-end has a slight obliquity inward, so as not to be touched by the wheels of the fourth axle; two Giffard's injectors $g$ $g$ (Figs. 2 and 3, Plate 240) are used as feed pumps; D is the smoke chamber enclosing the inlet and exhaust pipes $c$ and $h$, and the variable blast pipe $h'$; a funnel D' is fitted to the bottom of the smoke-box, to allow of the removal of any cinders which may enter through the tubes. This operation is performed by means of a valve opened from outside. The main frame F rests outside the wheels, on the three forward axles G (G being the driving axle) G' G'', and supports the steam cylinders and moving parts, together with the fore part of the boiler; it is strengthened by means of longitudinal and cross plates Z Z, and by angle irons. The three forward axles each support a pair of driving wheels; they are supported by bearings in the frame F; the wheels are cast iron, and furnished with cast steel tyres, the counterweights being cast with the discs; $k$ $k$ are the springs connecting the main frame with the axles. H is the second or after frame, and rests upon the axles J J; it carries part of the barrel, and the tank for water and fuel. The width of this frame is sufficient to allow of the bearings for the support of the supplementary axle L; the bearings for the axles J and J' are also formed within the lower portion of this framing. $k$ $k$ are the springs connecting the bearings with the after framing H. $o$ is the pivot bolt, and $y$ the cylindrical socket. $l$ $l$, &c., are the struts fixed on the engine framing, and forming a support to the barrel of the boiler. K K are the steam cylinders (which, as will be seen, are outside the framing); $p$ the slide valves, and $p'$ the eccentrics. $p''$ the expansion link suspended on the frame by means of an oscillating rod; $p'''$ are the slide rods suspended to the rods $p''''$; $r$ $r$ are the connecting rods actuating the cranks $q$, which are fixed on the axles according to Hall's method; $q'$ $q'$ are the coupling rods, and $s$ $s'$ $t$ $t'$ parts of the coupling gear connecting the axles of the engine frame with those of the tender, through the supplementary axle L.

The steam break fitted to the "Steierdorf" consists of two vertical steam cylinders, $u$ $u'$ (Fig. 2, Plate 233, and Fig. 1, Plate 240), placed perpendicularly to the engine below the boiler, so as to be acted upon at pleasure by the driver. When the steam is admitted into these cylinders, the levers X X (shown in dotted lines) are actuated, and the brake blocks, $w$ $w_1$, press upon the wheels G G. When the steam is let out, the whole of the mechanism recovers its former position by its own weight. The break blocks and levers on each side of the engine are connected by means of the shafts V V. The effect of the break can be increased by a counter-pressure from M, the exhaust valve in the smoke chamber, which can be readily operated by the driver. (This contrivance was made by Herr Zeh, of the Elisabeth Westbahn, to allow of admitting steam into the cylinders even when descending long gradients, and prevent at the same time the wear of the pistons by working without steam.) N N are the water tanks, Q Q the receptacle for coals, and $n$ the tool-box on the tender. R is the platform for the driver, S that for the stoker.

The reason for connecting the whole of the five pairs of wheels of this locomotive has been explained in our March number.

It had been deemed impracticable to have the five axles on the same frame, on account of the small radius of the curves to be traversed. The arrangement shown in the woodcut, Fig. 1, page 98, was, therefore, made in order to enable the two frames to have a motion independent of each other.

Thus in Fig. 2, supposing $a$ to be the line of the centres of the wheels of the engine frame.

$b$ ditto of the tender frame.

$o$ $m$ = $x$ the distance of the pivoting point $o$ from the axle of the engine frame next to it.

$o$ $w$ = $y$ the distance of same from first axle of tender frame.

$c = x + y$, the distance of the last axle of engine frame from the first of the tender frame.

The position of the point $o$ having to be fixed so that both $a$ and $b$ remain steadily chords of the arc of circle, whenever the two frames turn round $o$, we get the following equations.

$$x \,.\, y :: b + y : a + x$$

$$x + y = c$$

$$\therefore x = \frac{c\,(b + c)}{a + b + 2\,c} \quad y - \frac{c\,(a + c)}{a + b + 2\,c}$$

For the "Steierdorf," $a = b$; therefore,

$$x = y = \tfrac{1}{2}\,c.$$

A four-wheeled carriage running alone when traversing a curve will endeavour to take the direction shown in Fig. 3, when the plane of the back wheels will form an angle with the tangent to the curve. The resistance to the motion of the wheels in a curve is due chiefly to the amount of the angle $\alpha$ and the sliding of the surface of the wheels against the rails. This resistance will be met with also in the arrangement, Fig. 4; in six-wheeled carriages, and when several carriages are connected together by means of a movable link, as shown. The result will, however, be quite different if the coupling, Fig. 5, is used, for in this case the five axles will take up such a position that the exterior wheels can run on their largest, and the interior ones on their smallest diameters. By this means the angle $\alpha$ will be reduced to a minimum, and the slipping of the wheels will be nearly prevented. The trials to which the "Steierdorf" have been subjected have proved very much in favour of this arrangement.

The coupling of the locomotive axles with the tender axles was first contemplated at the time of the construction of the Sömmering railway, (which combines very sharp curves with a gradient of 1 : 40). This principle was first successfully carried out by Herr von Engerth, who connected the engine and tenders by a set of gearings. This method, however, having proved too delicate, the gearings requiring too much time and attention, a Hanoverian engineer, Herr Kirchweger, proposed the scheme illustrated in Fig. 6. In this view, A is the tender frame, B the engine frame, both furnished with the usual draw bars. C is the upper frame, and includes both engine and tender. D is a false or supplementary axle fitted on the frame C, so that both its ends can be raised and lowered independently of each other and of the frame C. This raising and lowering of the shaft D is effected through wedges fitted on C, and acted upon by mechanism fitted on the fire-box and tender-frame. The rods $g$ $g$ connect the bearings of the axles $m$ and $n$ with the bearings of the supplementary axle; $d$ $d$ are the coupling rods between the cranks of the axles $m$ and $n$ and the false or supplementary axle. In this contrivance the distance between the bearings $m$ $n$ will always be the same, and the power can always be transmitted by means of the drawbars. In traversing curves the axle D will rise on one side and descend on the other through the increase of the distance of the axles $m$ $n$. But it has been found that the complication of the mechanism, and its liability to frequent derangement, makes it unfit for practical purposes.

The arrangement proposed by Herr Lippert, in 1854, is based on the same principles as Kirchweger's, the supplementary axle, however, being suppressed entirely. The axles $m$ $n$ (Fig. 7) are furnished with double cranks $b$ $c$, the



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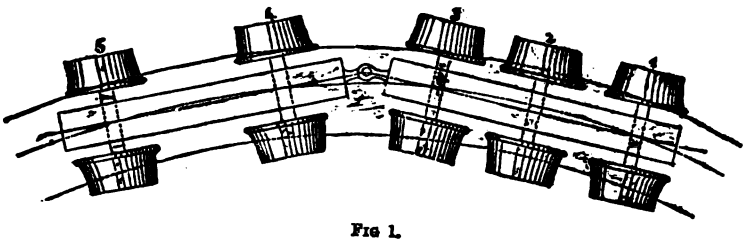



FIG 1.

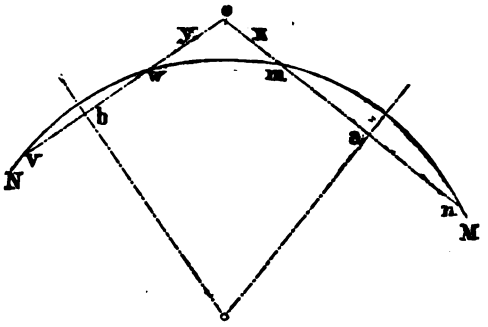



FIG. 2.

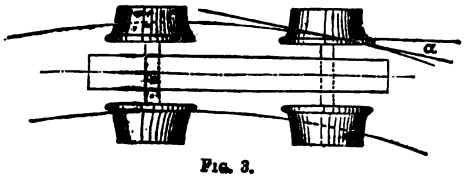



FIG. 3.

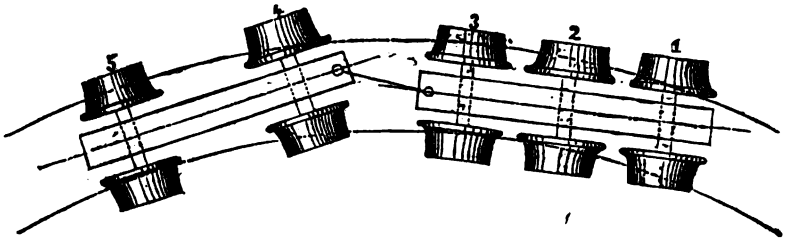



FIG. 4.

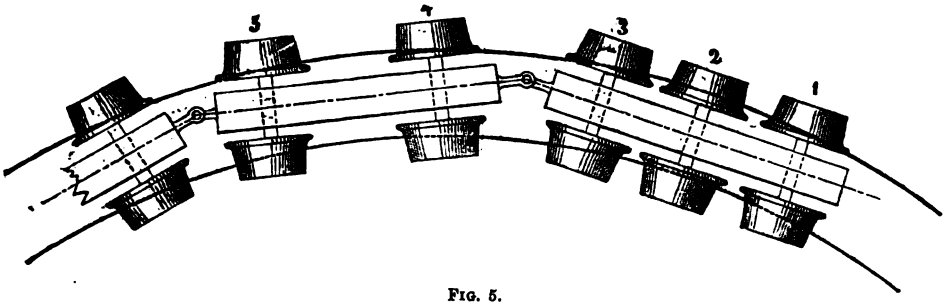



FIG. 5.

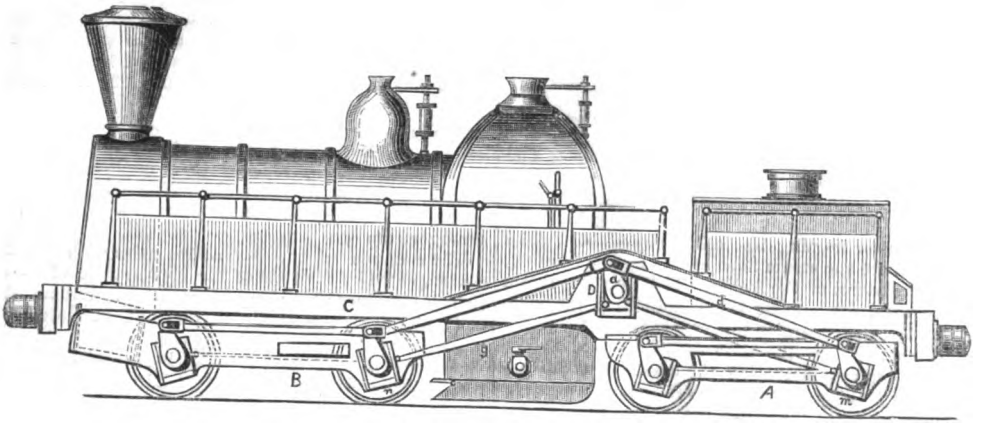



FIG. 6.

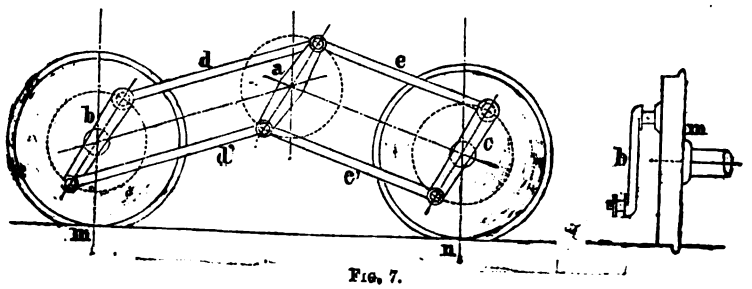



FIG. 7.

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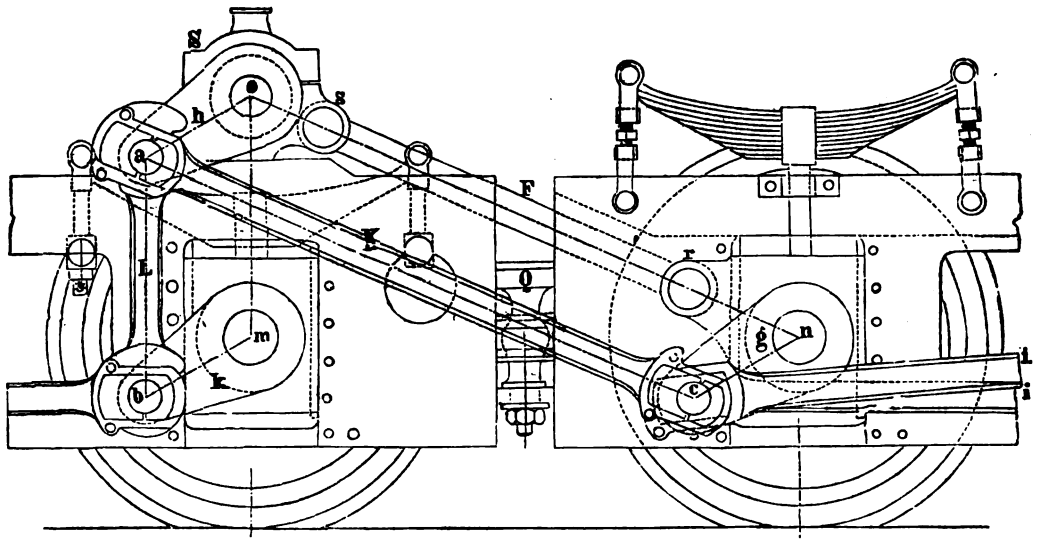



FIG. .

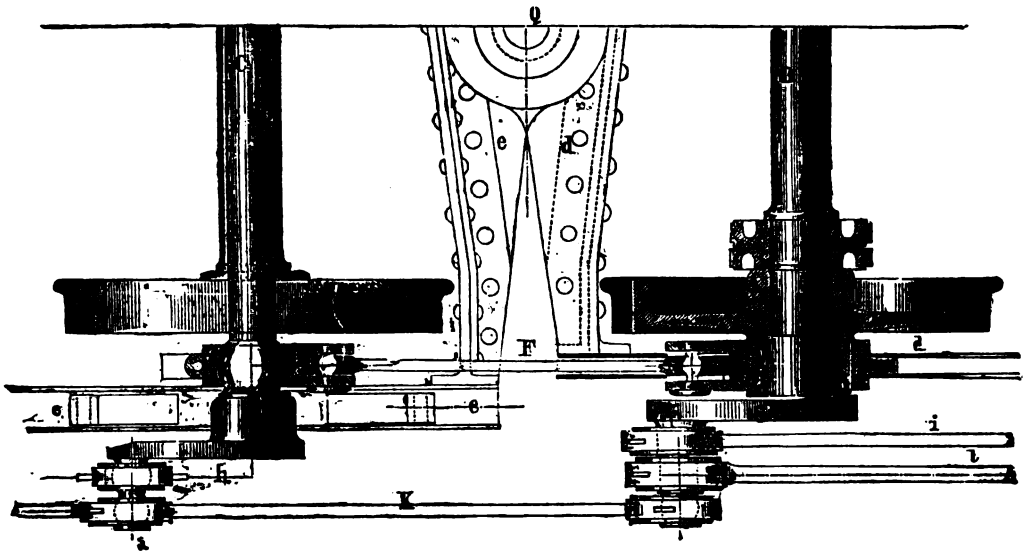



FIG. 9.

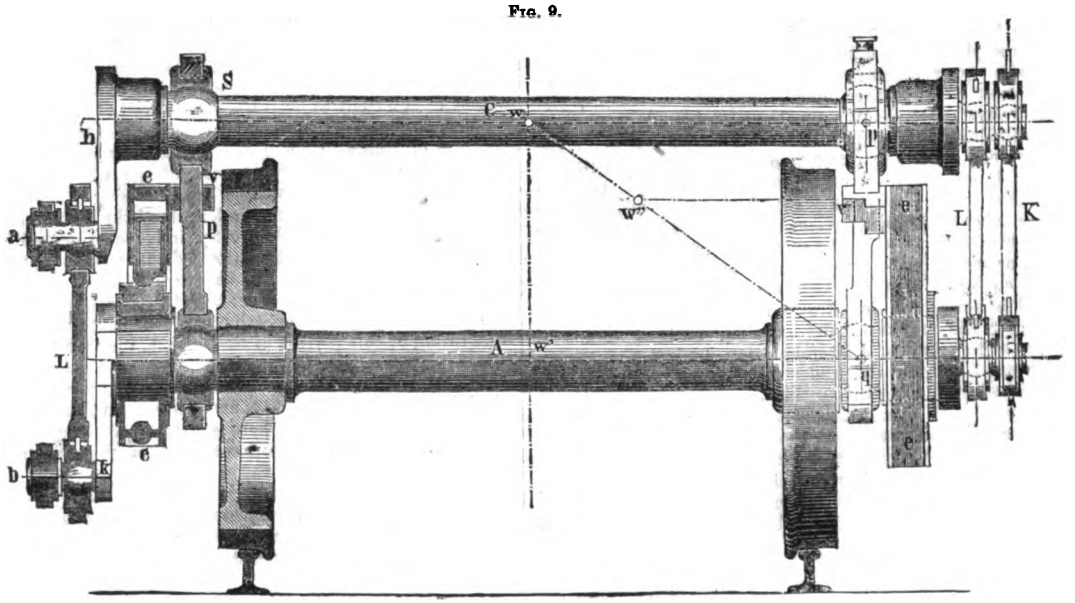



FIG. 10.

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intermediate shaft is replaced by the double crank *a*, while the rods *d d'*, *e e'* connecting *b* and *c* with *a*, are substituted for Kirchweger's coupling rod. The realisation of this arrangement, however, proved quite as impracticable as the first named, although the principle it was based upon is unobjectionable.

In the "Steierdorf" the coupling has been effected upon a plan, the credit of the origination of which is due to Herr Fink, an engineer of the Austrian State Railway Company. This is illustrated by the accompanying wood cuts (Figs. 8 to 12), and also in Plate 240 herewith.

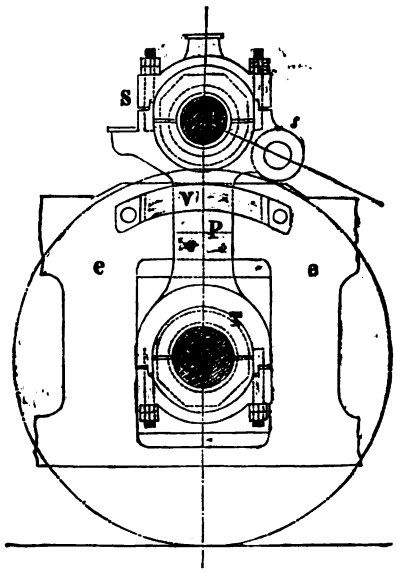
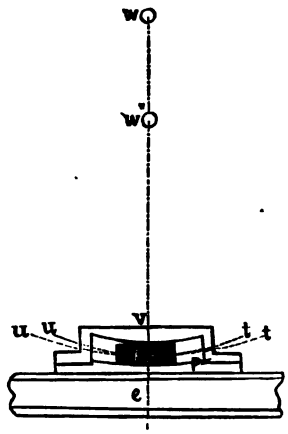



Fig. 11.




.12.

A is the first axle of the tender frame, to be connected with B the last axle of the engine frame. Q pivot bolt joining the two frames. C is the supplementary axle working in the bearings S upon the stays P, supported upon the axle A by means of the bearings T. The journals working in the bearings S and T are spherical, and allow the two axles A and C to alter their position relatively to each other. The bearings S and T are connected together by the rods F F; the extremities of the latter are connected with the bearings through the spherical bolt *r s*, so as to enable their position to be altered with respect to the axle of the engine frame. The supplementary axle is always kept horizontal in traversing curves, by means of the rods F and the stays P, the coupling of both frames being such, that when traversing a curve, one extremity of the axle A is brought nearer the axle B; the other extremity is removed from it to the same distance. The supplementary axle, however, being held at an equal distance from the axle B at both ends, through the intervention of the rods, F, the two extremities of the supplementary axle will have to move in opposite directions to the axle of the tender frame, but in each direction to an equal extent, carrying with them the stays P. When traversing a curve, therefore, the upper bearings of the oscillating stays P will each describe a curve of equal extent, but in opposite directions, and each of them will always descend to an equal extent, the supplementary axle C, thus always remaining horizontal. *v* is a segmental guide for the vertical bearer P, fastened to the tender frame *e* (Figs. 11 and 12). In this guide the bearer P moves in such a manner, that while it revolves round the centre *q* of the lower bearing (Fig 10), the centre *p* of the upper bearing S of the supplementary axle describes a horizontal arc of a circle *t v* round the centre *w* of the axle C. The surface of the paraliel slide *v* is, therefore, conical, or approximately a cylindrical surface, the horizontal section of which has $w_{11}$ for its centre; the latter point is the intersection of the lines *w q* and a horizontal line drawn from *v*. K is an oblique coupling rod connecting the cranks of the axles B and C by means of spherical bearings, so as to admit of a lateral motion against the engine frame; the coupling rod L, joining the tender axle A to the supplementary axle is likewise furnished with spherical bearings.

The chief property of this arrangement is that the motion of the supplementary axle depends exclusively on the shafts which have to be joined; it, therefore, requires no particular mechanism which would involve a connection of the supplementary axle with either engine frame or boiler. This will be more clearly shown by the calculations upon which the arrangement of this coupling is based, and which we purpose giving in our next number.

## A CRITICAL AND HISTORICAL REVIEW OF LOCOMOTIVE ENGINEERING.

By J. J. Birckel.

(*Illustrated by Plate* 241.)

(*Continued from page* 74.)

### The Carriage.

The points to be watched in the construction of the carriage proper, and in the general arrangement of the engine, considered as a carriage, are the following, viz.:—

1 Stability upon the rails.
2 Sufficiency of weight for the purposes of traction.
3 Transmission of the tractional power of the engine in the most direct manner possible from the driving axle to the train.

Now the causes which affect the stability of the engine are of two kinds, first, the position of the wheels underneath the machine, and the distribution of the load upon them; secondly, the disturbing element of the parts of machinery in motion, in connection with which may be mentioned the state of repair of the vehicle.

The earlier engines were supported upon four wheels only, placed between the fire box and the smoke box, and, as the barrel was invariably short, seldom exceeding nine feet, the wheel base was necessarily very short also, and the overhanging load of the firebox behind the driving wheel acted as a balance weight against the load upon the leading wheels, and when the engine was in motion it occasioned an oscillation round the centre of the driving axle known as the pitching motion, the result of which was to lift the engine from the rails in front, and to cause it to leave the track. It is a remarkable fact that Mr. Bury was the first to build an engine carried upon six wheels, as early as 1830, but, as the engine so constructed was too heavy for the rails then in use, it was condemned, and Mr. Bury continued to be, to the end of his career as a locomotive engineer, an unyielding supporter of the *four-wheeled* engine. Soon after this first experiment, however, it was found indispensable to put a third pair of wheels behind the firebox, to ensure the steadiness of the engine upon the rails, the weight of the latter being increased to meet the requirements of higher speeds and of greater weight of engines, which were gradually and of necessity being introduced. Four-wheeled engines are now seldom made for the ordinary purposes of railway traffic, though many of the class known as Bury's engines may still be found doing very useful duty upon our English lines of railway.

The duty of the front wheels being to guide the engine laterally upon the track, the nearer they are placed to the front end of the engine, or the less overhanging weight there is upon the guiding centre, the easier will be the work of leading the engine. It is the duty of the trailing wheels to prevent the pitching motion previously spoken of, a duty which they will perform more effectually the more they are kept backward, and thus we find that one of the means of ensuring the steadiness of the engine is to provide a long wheel base. To this, however, there is undoubtedly a limit imposed by the unavoidable necessity of running round curves, and to define that limit is a question that can be solved by experience alone. Stephenson, in his evidence before the guage commissioners, stated that "the wheel base varies between 10ft. and 13ft. 9in., but the latter is too long." Since then, however, express engines have been built with a wheel base of 18ft., and taken on an average, the wheel base of modern engines for ordinary traffic is about 15ft. With respect to the *distribution* of the weight, it should be such that the load on the leading wheels be sufficient to keep the engine well to the rails, and that in uncoupled engines there be sufficient load upon the driving wheels for the purposes of traction; these are the leading considerations which should influence the general arrrangement of the wheel base; independently of them however, there are various causes arising from certain necessities of constructive detail, such as the length of the connecting rod, the adaptation of springs, &c., which greatly influence the position of the wheels, and consequently the distribution of the weight upon them. To make ourselves acquainted with the best arrangements to be adopted, we think that we cannot do better than to refer to actual practice which at this time must embody the experience of the last thirty years, and for the illustration of this portion of our subject, we have produced a series of diagrams (plate 241), illustrating various types of locomotives, with the distribution of the load upon each pair of wheels as taken from the practice of Messrs. Sinclair, Ramsbottom, Sharp, and others, and from an inspection of these it must be perceived that there is a strong tendency to keep the wheel base down to about 15ft., and to have a load of about 9½ tons upon the leading wheels.

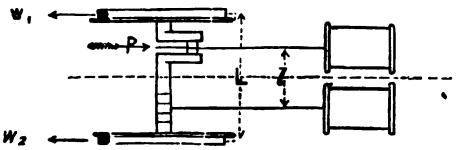
The parts of the machinery in motion, namely, the crank, the connecting rod, the crosshead, the piston and the piston-rod, when unbalanced, give rise to a horizontal fore and aft motion, and inasmuch as their action is not in the longitudinal plane passing through the centre of gravity of

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the engine, they give rise also to a horizontal lateral displacement, which manifests itself in a horizontal sinuous motion of the engine, during its progress upon the rails. The unbalanced portion of the crank, and so much of the weight of the connecting rod as rests upon the crank, have a tendency also, through the centrifugal force generated by their rotary movement, to lift the engine from the rails, and momentarily to reduce its tractive force through reduction of adhesion, but with the heavy engines now invariably built, this tendency is too trifling in its amount to affect the stability of the engine; far more important is the vertical component of the steam pressure, arising from the obliquity of the connecting rod, which cannot be balanced, and the upward action of which is only slightly mitigated by the interposition of the springs. It is stated by Mr. Clark that Messrs. Sharp and Roberts were the first to apply weights to the driving wheels of their engines towards the year 1837, with a view especially to balancing the centrifugal action of the revolving masses; and that Mr. Fernihough was the first, in 1845, to point out the desirability of balancing not only the revolving masses but the whole of the horizontally reciprocating masses, in order to avoid the fore and aft motion and the sinuous motion to which they give rise; it appears, however, that to Mr. Nollau, of the Holstein Railway, and to the late Mr. Polonceau, of the Orleans Railway, is due the exact theory of balancing locomotives, which we are now about to develope to our readers.

In the adjoining sketch, shewing in plan a pair of driving wheels

FIG. 1.




with the crank axle and the cylinders connected with them, let L be the distance of the wheels, or rather the gauge of the rails, $l$ that of the centres of the cylinders which are supposed to be placed inside, and P the total weight of the horizontally reciprocating masses belonging to one cylinder, including the sweep of the crank reduced to its value at the radius of the crank; the intensity of action of that weight upon each wheel is as the inverse ratio of the distance of its centre of motion to those wheels, and if $w_1$ and $w_2$ represent the weights at the radius of the crank, which, at each wheel, would be required to produce equilibrium, the condition of equilibrium is expressed by the following equation,

$$w_1 \frac{L - l}{2} = w_2 \frac{L + l}{2}$$

A second condition of equilibrium is that the sum of the balance weights at the radius of the crank be equal to the disturbing weight, which symbolically reads thus:—

$$w_1 + w_2 = P$$

whence by a very simple algebraic transformation we obtain,

$$w_1 = P \frac{L + l}{2L}$$

and

$$w_2 = P \frac{L - l}{2L}$$

which weights are to be respectively equal for both cylinders, since the disturbing masses are equal; if now, in the adjoining figure 2, the line $o\ c$

FIG. 2.

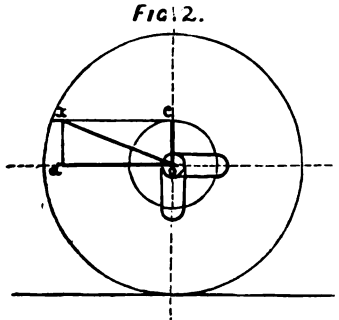
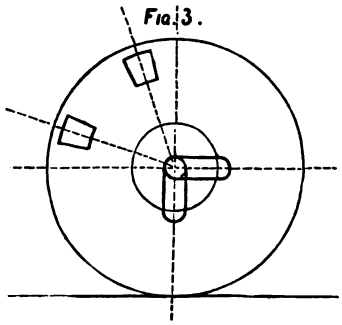



FIG. 3.

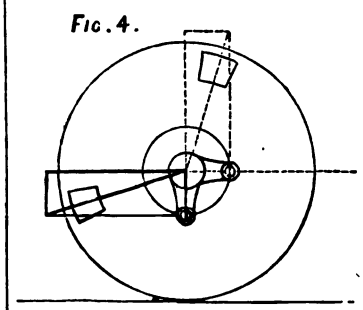


be made to represent the weight $W_2$ required for the crank on the off side of the engine, and $o\ d$ the $W_1$ required for the crank on the near side, the diagonal $o\ x$ of the parallelogram constructed upon these two lines represents in magnitude, and in direction the weight $w$ required at the radius of the crank to produce the effect of the two weights $W_1$ and $W_2$ arithmetically the same may be determined thus:—

$$w = \sqrt{w_1^2 + w_2^2}$$

But as its position must still be determined by actual delineation, the arithmetical method of defining its amount need never be resorted to. When once the weight $w$ at the radius of the crank is found, it is an easy matter to arrive at the weight actually required at the usual distance from the centre near the rim of the wheel, and in general the relative position of both counterweights in one view will be found somewhat similar to that shown in the sketch (fig. 3). When there is a coupling rod placed opposite the inner crank, its weight and that of the unbalanced portion of the wheel boss reduced to its value at the radius of the crank, may at once be subtracted from the weight $W_1$, and the operation afterwards proceeded with as in the manner above indicated. The problem of balancing outside cylinder engines may be solved in a similar manner, and if done so, it will be found that the balance blocks, as seen in one view instead of leaning towards each other from the far crank boss, lean from each other towards the far crank boss as in sketch (Fig. 4), in practice, however, it will not be found necessary to take into account the greater distance of the cylinders than of the wheels, the difference being generally very small, but it will be sufficient to apply exactly opposite the crank boss a counterweight capable of balancing the reciprocating masses at the crank pin.

FIG. 4.



The method of balancing locomotives with a view especially to avoid the horizontal sinuous motion leads to the application of a weight considerably too heavy for the revolving masses proper, and on that account some German authorities recommend to take an arithmetical mean between the weights as calculated for the case above considered, and for the centrifugal action only; this halfway measure, however, does not seem to us to have any claim to preference, especially when it is remembered that the vertically disturbing cause applied as above stated, is of no account. The method which we have given is that also recommended by Dr. Rankine in his work on prime movers.

At this stage of our inquiry, seeing that we have had occasion to speak of inside and outside cylinder engines, it may be proper to inquire into the several causes militating in favour of, and against the adoption of either classs of engines, and these may be briefly stated as follows:—

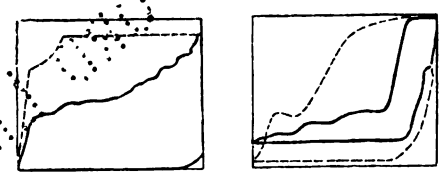
The position of the cylinders between the frames has the disadvantage already mentioned, of leaving but a very limited space for the valve gearing in the case of cylinders of large diameter, and in the case of engines with very large driving wheels, the necessity of providing room for the sweeps of the cranks and for the connecting rods raises the boiler, and, consequently, the centre of gravity of the whole machine to a height very injurious to the stability of the engine; in the earlier days of engineering also, when the tools and appliances for making crank axles were comparatively imperfect, that part of the carriage formed a very expensive item in its construction, and, as breakages were very frequent, the presence of the crank axle was considered to be a capital evil. In our days, however, the making of a crank axle is almost as simple a piece of work as the making of a straight axle, and since, owing to its improved construction, breakages occur less frequently, this no longer forms an objection against the inside cylinder engine. On the other hand, and as a set-off to these objections, the inside cylinder engine, through having the cylinders incased in the hot smoke box has the advantage of being comparatively free from the loss of useful effect caused by condensation of the steam, and since at the same time the reciprocating masses lie nearer the centre of motion of the engine, in a proportionately less degree do they tend to disturb its steadiness.

The outside cylinder engine obviates all the defects, above enumerated, appertaining to inside cylinder engines. It affords ample room for the valve gear, it allows the centre of gravity to be kept as low as possible, and the expense of renewing crank axles is avoided. It is questionable, however, whether these advantages can compensate for the loss of power caused by the condensation of the steam in the cylinders through their partial exposure to the cooling effects of the atmosphere. The diagram (Fig. 5) on next page, reproduced from Mr. Clark's work, where this question is very minutely entered into, and taken from an engine whose cylinders had been allowed to cool down, illustrates in the first place the actual loss of power, through loss of pressure during the working period, the dotted

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lines showing what the diagram would have been had there been no condensation. This, however, is by no means the worst feature of the case, for it has been well shown by Mr. Clark that, during expansion a portion of the condensed steam evaporates again, a circumstance which, at first sight, *seems* to mitigate the evil just pointed out; that evaporation, however, continues also during the period of exhaust, and is productive

Fig. 5. Fig. 6.



of an amount of back pressure which is so much the more injurious as it pervades the whole of the return stroke. The effect of condensation upon back pressure is conspicuously illustrated by the annexed diagram (Fig. 6), where the full lines show a diagram taken from a cylinder which had been allowed to cool down, and the dotted lines are taking from the same cylinder well heated and working at shorter expansion; placed in juxtaposition with each other, the illustrations (Figs. 5 and 6), are calculated to give the reader an adequate idea of the loss of power which may be occasioned by condensation, and of the importance of having the cylinder well protected, and though the cases illustrated are, perhaps, extreme ones, the reader may easily form for himself an idea as to the respective merits of either system on the score of economy of steam.

Formerly also when the theory of balancing engines was not properly understood, the disturbing effect of the reciprocating masses, formed the ground of great objections against the outside cylinder engine which now, however, no longer exists. As to the question of wear and tear it is argued that the outside cylinder engine does not wear so well; that it knocks itself to pieces sooner than the inside cylinder engine, and certain it is that the frame connnections at the smoke box end require to be very strong and stiff to enable the frames to resist the great side strains thrown upon them; on that account also is it really more expensive in its first cost than the inside cylinder engine.

Among locomotive engineers opinions are pretty equally divided as to the predominancy of the merits of either system. Thus we find that Sinclair, Allan, and, we believe, Beattie, adhere to the outside cylinder engine; whereas Stephenson, Sharp and Fairbairn, wherever they have been allowed to carry out their own intentions, have decidedly adhered to the inside cylinder engine. Mr. Ramsbottom puts the cylinders inside in all his luggage engines, and in his ordinary passenger engines; but in the express engines, with 7ft. 6in. wheels, he puts them outside, evidently with a view to keeping the centre of gravity as low as possible. That in the case of express engines considerations of economy should yield to considerations of stability, and, therefore, of safety, seems to us to be sound engineering doctrine, which we should decidedly imitate, and which we cannot but recommend.

*(To be continued).*

## ON A NEW SYSTEM OF CONSTRUCTING SHIPS, PROPOSED TO BE CALLED THE PARABOLIC CONSTRUCTION.

By John W. Nystrom, C.E.

The construction of ships is yet in an empirical state, with no established rules for laying down the principal lines, but is wholly dependent on skill, experience, and taste of the constructor. In the parabolic construction herein proposed, positive rules are established for the principal lines, as the load water-line, rail in plan, cross-sections, displacement, sheer, &c., that when the lines are laid down by those rules, they cannot be improved by taking in or out a little more or less here or there; the rule makes the lines right. This will enable the young constructor to lay down ship-lines as fine as if made by the most experienced shipbuilder; still he will not be confined to any particular shape or proportion of the vessel, but can vary it according to his own taste and judgment.

The advantage of the parabolic construction is not only in laying down fine lines, but the simple calculations connected with it are of great importance, and enable the constructor, with but few figures, to go to work with the greatest certainty of attaining a correct result, without recourse to trial and error, or comparison with other vessels. All the lines in a ship are combinations of the circle, ellipse, parabola, and hyperbola. These lines are derived from the conic sections, where they are curves of the second order, but herein we will employ them to any order whatever. The ordinary formula for a parabola is $y = \sqrt[n]{px}$, in which $y$ = ordinate, $x$ = abscissa, and $p$ = parameter; the letter $n = 2$ in the conic parabola; it is called the *exponent*, and denotes the order of the curve. By assuming different values on the exponent $n$, different forms of parabolas are obtained. When $n = 0$ the parabola will be the two sides forming the right angle in a triangle; when $n = 1$ the parabola will be the hypothenuse in a right-angled triangle; when $n = 2$ it will be the true parabola in the conic sections; and when $n = \infty$ the parabola will again become the two sides forming the right angle in a triangle. The circle, ellipse, and hyperbola follow the same law, which enables us to form theoretically any line in the hull of a ship.

Referring to figs. 1 and 2, page 104, represent parabolas of different orders from 2 to 10, the vertex being at $o$, $x$ = abscissa, and $y$ = ordinate. Figure 1 shows load water-lines of vessels of different sharpness, of which the inner one is considered the sharpest form a vessel can have, being a conic parabola with the exponent $n = 2$. The higher the exponent is, the fuller will the lines be. Figure 2 represents cross-sections of vessels; the inner line is a conic parabola, and the others of higher order, same as in fig. 1. The order of the lines are marked on the drawing. The shading between every other line is to make it more distinct when selecting a desired sharpness. The water-lines and the cross-sections are precisely the same kind of lines; both can be laid down by the same ordinates.

*Letters denote,*

D = displacement of the vessel in cubic feet.
T = displacement in tons of salt water of 35 cubic feet to the ton.
Q = area of the greatest immersed cross-section in square feet.
$q$ = area of any ordinate cross-section between Q and the stem or stern.
L = length of the vessel in the load-line.
$l$ = length from Q to where the parabola meets the centre line.
$l'$ = the whole length from Q to the stem or stern, including the hollow lines.
Z = measure of the hollow lines.
B = breadth of beam in the load-line.
$b$ = half the beam B,
$d$ = load draft of water, omitting the depth of keel.
$\delta$ = any draft of water corresponding with the displacement $t$.
$t$ = displacement in tons at the draft $\delta$
$e$ = depth of centre of gravity of the displacement, under the water-line.
X = abscissa, $y$ = ordinate.
All linear dimensions are in feet.
$n$ = exponent for the parabola in the load water-line.
$n'$ = exponent for the parabolas in the cross-section Q.
$n''$ = exponent for the areas of the ordinate cross-sections $q$.
$r$ = index for displacement at different drafts.
a = area of load water-line in square feet.
$k$ = co-efficient for speed and horse power.
M = nautical miles or knots per hour.
H = horse power required for the speed M.
A = area of the hull of the boat in square feet.
a' = area of the upper deck, or any horizontal section of the hull at $d'$ feet from the keel.
$d'$ = depth from a' to the keel.
Q' = area of the greatest cross-section from the keel to a', or the depth $d'$.
$e'$ = depth of the centre of gravity of the hull from the top of d', supposing the hull to be of uniform thickness.
$a$ and $e$, see fig. 1.
$m$ = height of metacentre above the centre of gravity of the displacement.

Formulæ.

$$y = l \sqrt[n]{\frac{x}{b}} \quad \ldots\ldots (1)$$

$$x = \frac{y^n b}{l^n} \quad \ldots\ldots (2)$$

$$n = \frac{\log. b - \log. x}{\log. l - \log. y} \quad \ldots\ldots (3)$$

$$q = Q \left(1 - \frac{x}{b}\right)^2 \quad \ldots\ldots (4)$$

$$a = \frac{n\,B\,L}{n+1} \quad \ldots\ldots (5)$$

$$n = \frac{a}{B\,L - a} \quad \ldots\ldots (6)$$

$$Q = \frac{n'\,B\,d}{n'+1} \quad \ldots\ldots (7)$$

$$n' = \frac{Q}{B\,d - Q} \quad \ldots\ldots (8)$$

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$$D = \frac{Q\,L\,2\,n^{2''}}{2\,n^{2''} + 3\,n'' + 1} \quad \text{(9)}$$

$$n'' = \frac{\log.\ b\ \sqrt{\frac{q}{Q}}}{\log.\ l - \log.\ y} \quad \text{(10)}$$

$$e = \frac{d}{2}\left(\frac{n' + 1}{n' + 2}\right)\sqrt{\frac{n'' + 1}{n + 2}} \quad \text{(11)}$$

$$r = \frac{(n' + 1)\,(n + 1)}{n'\,n''} \quad \text{(12)}$$

$$\delta = d\ \sqrt[r]{\frac{t}{T}} \quad \text{(13)}$$

$$t = \frac{\delta^r\,T}{d^r} \quad \text{(14)}$$

$$y = \sqrt[n]{b^n - \left(\frac{b\,x}{l}\right)^n} \quad \text{Ellipse} \quad \text{(15)}$$

$$l' = l\left(2\sqrt[n]{\frac{b - z}{b}} - \sqrt[n]{\frac{b - 2\,z}{b}}\right) \quad \text{(16)}$$

$$l = \frac{l'}{2\sqrt[n]{\frac{b - z}{b}} - \sqrt[n]{\frac{b - 2\,z}{b}}} \quad \text{(17)}$$

$$c = L\left(1 - \sqrt[r]{\frac{b - x}{b}}\right) \quad \text{(18)}$$

$$a = l' + c - l \quad \text{(19)}$$

$$A = 2\sqrt{\frac{n''}{n + 1}}\left(Q' + d'\,L\right) + \mathfrak{a}' \quad \text{(20)}$$

$$H = \frac{M^3\,Q}{k\,L} \quad \text{(21)}$$

$$M = \sqrt[3]{\frac{k\,L\,H}{Q}} \quad \text{(22)}$$

$$m = \frac{B^3}{12\,Q}\sqrt[3]{\frac{D}{L\,Q}} \quad \text{(23)}$$

$$m = \frac{B}{12\,Q}\sqrt[3]{\frac{n}{(n + 1)\left(1 + \frac{1}{2\,n''}\right)}} \quad \text{(24)}$$

$$n'' = \frac{\sqrt{8\,D\,(Q\,L - D) + 9\,D^2} - 3\,D}{4\,(Q\,L - D)} \quad \text{(25)}$$

$$e' = \frac{d'\,(d'\,L + \mathfrak{a} + Q)}{2\,d'\,L + \mathfrak{a} + 2\,Q'}\left(\frac{n' + 1}{n' + 2}\sqrt{\frac{n'' + 1}{n + 2}}\right) \quad \text{(26)}$$

TABLE I.

| Exp. $n$ | Ordinates and Cross Sections. 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | Area W L square feet. Disp. cubic feet. | Centre of gravity $e$. Disp. tons. | Exp. $r$. Coefficient $k$. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 2 | ·2345 | ·4375 | ·6094 | ·7500 | ·8593 | ·9375 | ·9844 | $b$ | $a$ = ·6666 B L | $e$ = ·325 $d$ | $r$ = 2·25 |
| | ·0545 | ·1914 | ·3713 | ·5625 | ·7384 | ·8909 | ·9688 | Q | D = ·5333 Q L | T = ·0152 Q L | $k$ = 1·94 |
| 2½ | ·2838 | ·5129 | ·6912 | ·8232 | ·9139 | ·9687 | ·9944 | $b$ | $a$ = ·7142 B L | $e$ = ·343 $d$ | $r$ = 2·00 |
| | ·0805 | ·2512 | ·4778 | ·6777 | ·8352 | ·9383 | ·9889 | Q | D = ·5952 Q L | T = ·0170 Q D | $k$ = 2·00 |
| 3 | ·3301 | ·5781 | ·7558 | ·8750 | ·9472 | ·9844 | ·9980 | $b$ | $a$ = ·7500 B L | $e$ = ·358 $d$ | $r$ = 1·77 |
| | ·1090 | ·3342 | ·5713 | ·7667 | ·8972 | ·9691 | ·9960 | Q | D = ·6429 Q L | T = ·0184 Q L | $k$ = 1·94 |
| 3½ | ·3733 | ·6346 | ·8070 | ·9116 | ·9677 | ·9922 | ·9993 | $b$ | $a$ = ·7777 B L | $e$ = ·370 $d$ | $r$ = 1·71 |
| | ·1394 | ·4027 | ·6512 | ·8310 | ·9365 | ·9845 | ·9986 | Q | D = ·6806 Q L | T = ·0194 Q L | $k$ = 1·88 |
| 4 | ·4138 | ·6836 | ·8474 | ·9375 | ·9802 | ·9961 | ·9997 | $b$ | $a$ = ·8000 B L | $e$ = ·381 $d$ | $r$ = 1·56 |
| | ·1712 | ·4673 | ·7181 | ·8789 | ·9608 | ·9922 | ·9994 | Q | D = ·7111 Q L | T = ·0203 Q L | $k$ = 1·82 |
| 5 | ·4871 | ·7627 | ·9046 | ·9687 | ·9926 | ·9990 | ·9999 | $b$ | $a$ = ·8333 B L | $e$ = ·397 $d$ | $r$ = 1·44 |
| | ·2373 | ·5817 | ·8183 | ·9384 | ·9853 | ·9980 | ·9998 | Q | D = ·7575 Q L | T = ·0216 Q L | $k$ = 1·70 |
| 6 | ·5512 | ·8220 | ·9404 | ·9843 | ·9972 | ·9997 | 1·0000 | $b$ | $a$ = ·8571 B L | $e$ = ·409 $d$ | $r$ = 1·36 |
| | ·3038 | ·6757 | ·8844 | ·9688 | ·9944 | ·9995 | ·9999 | Q | D = ·7924 Q L | T = ·0227 Q L | $k$ = 1·58 |
| 8 | ·6564 | ·8989 | ·9767 | ·9960 | ·9996 | ·9999 | 1·0000 | $b$ | $a$ = ·8888 B L | $e$ = ·426 $d$ | $r$ = 1·26 |
| | ·4309 | ·8080 | ·9540 | ·9920 | ·9992 | ·9998 | 1·0000 | Q | D = ·8366 Q L | T = ·0233 Q L | $k$ = 1·34 |
| 10 | ·7369 | ·9437 | ·9909 | ·9990 | ·9999 | 1·0000 | 1·0000 | $b$ | $a$ = ·9090 B L | $e$ = ·458 $d$ | $r$ = 1·21 |
| | ·5430 | ·8906 | ·9819 | ·9980 | ·9998 | ·9999 | 1·0000 | Q | D = ·8658 Q L | T = ·0248 Q L | $k$ = 1·18 |

### Explanation of Formulæ.

The parabolic formulæ 1 and 2 are for calculating the curvature of the load water-line and cross-section. The abscissa $x$, subtracted from $b$, gives the ordinate from the centre line of the vessel to the water-line or cross-section. Formula 3 is for finding the exponent of the water-line. Formula 4 gives the ordinate immersed cross-sections between Q and the stern or bow. In the accompanying table ordinates and cross-sections are calculated for eight places between Q and the stem or stern, numbered as shown in the table, and figures 1 and 2.

Example 1. Required the fourth ordinate of a water-line with the exponent $n$ = 3 and $b$ = 18 feet. See table, exponent 3, line $b$ in the 4th column. Ordinate 0·8750 × 18 = 15·75 feet, the answer.

Example 2. Required the area of the 3rd, for the exponent $n''$ = 4, Q = 455 square feet. See table, exponent 4, line Q, 3rd column. $q$ = 0·7181 × 455 = 326·7 square feet, the answer.

The exponent $n$ need not be alike, fore and aft, but $n''$ must be the same, so that the area $q$ be equal for the same number of ordinates fore and aft of Q. This rule should be carefully observed.

Example 3. Required the area of the load water-line of a vessel L = 255 feet, B = 28 feet and the exponent $n$ = 3½?

Formula 5. $\mathfrak{a} = \frac{3{\cdot}5 \times 28 \times 255}{3{\cdot}5 + 1}$ = 5553·3 square feet.

Example 4. The greatest immersed cross-section Q = 307 square feet, B = 32 feet, and $d$ = 12 feet. Required the exponent $n'$?

Formula 8. $n' = \frac{307}{32 \times 12 - 307}$ = 4, the answer.

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Example 5. A ship of Q = 307 square feet, L = 250 feet long, and the exponent $n'' = 4$. Required the displacement D in cubic feet?

Formula 9. $D = \frac{307 \times 250 \times 32}{32 + 13} = 54577$ cubic feet.

Formula 25 is for finding the exponent $n''$, when Q, D and L are given.

Formula 10 is for finding the exponent $n''$, when Q, $q$, $l$, $b$, and the distance $y$ between Q and $q$ are given.

The formulæ 3, 6, 8, 10, and 25 will give the exponents for any vessel.

Example 6. A vessel of $d = 12$ feet draft of water (depth of keel omitted), constructed with the exponents $n = 3$, $n' = 6$ and $n'' = 3$. Required the depth of the centre of gravity of displacement under water-line?

Formula 11. $e = \frac{12}{2}\left(\frac{6+1}{6+2}\right)\sqrt{\frac{3+1}{3+2}} = 4{\cdot}695$ feet.

The centre of gravity of the displacement in the length of the vessel will always be halfway between Q and the middle of L.

Example 7. A vessel constructed with the exponents $n = 2\frac{1}{2}$, $n' = 4$ and $n'' = 2\frac{3}{4}$. The load draft of the vessel is $d = 16$ feet, when the displacement T = 4500 tons. Required her displacement $t = ?$ at $\delta = 9$ feet draft.

Formula 12. Index $r = \frac{(4+1)(2{\cdot}5+1)}{4 \times 2{\cdot}75} = 1{\cdot}59$.

Formula 14. $t = \frac{9^{1{\cdot}59} \times 4500}{16^{1{\cdot}59}} = 1432$ tons, the answer.

The launching draft is calculated by the formula 13, when $t$ = weight of the vessel in tons.

The formula 15 is for calculating the elliptic form of the stern-rail or deck; its nature is the same as that of the parabolic formula 1, namely, the higher the exponent is, the fuller will the line be.

Ordinates for ellipses of different orders from 2 to 4, are calculated and contained in the accompanying Table II. Half the greatest rail-beam multiplied by the tabular number, gives the corresponding ordinate in the stern-rail ellipse.

See fig. 8, where the stern-rail is an ellipse of the third order or $n = 3$.

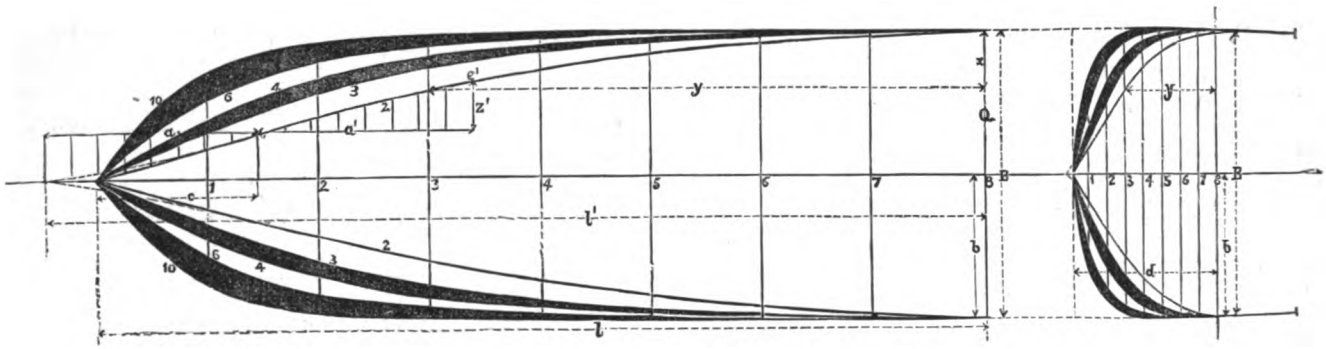


Fig. 1.



Fig. 2.

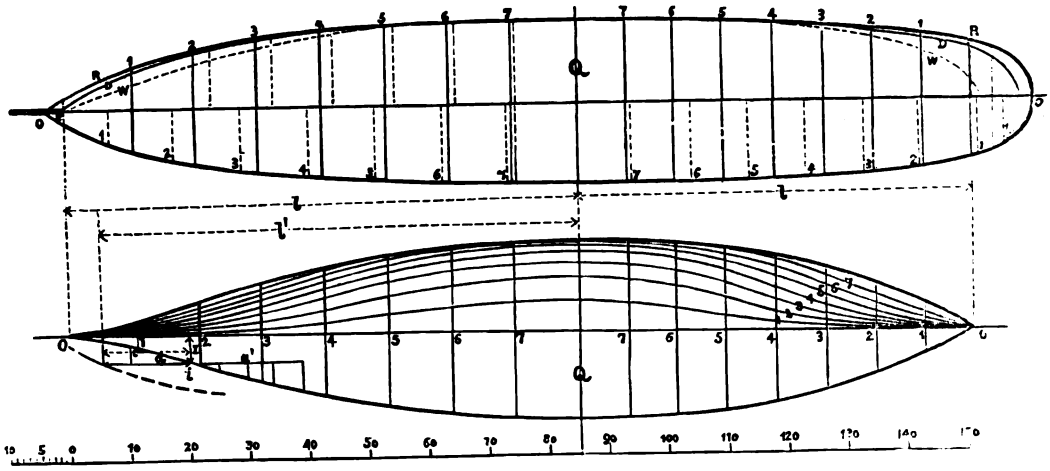


Fig. 8.

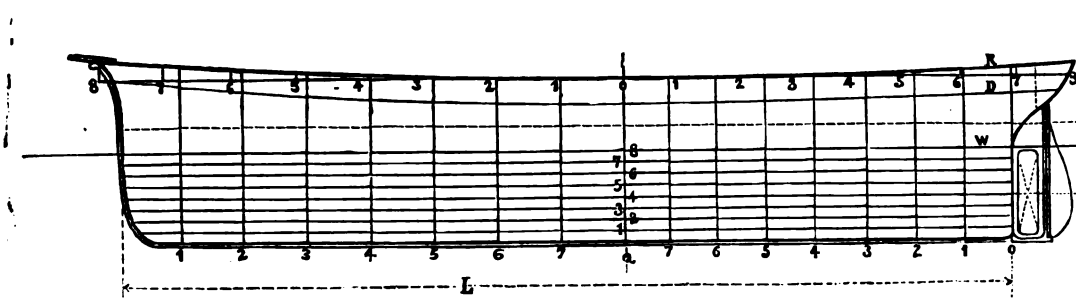


Fig. 6.

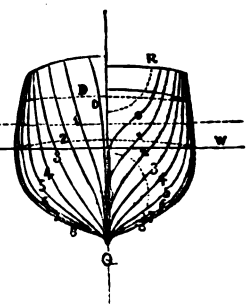


Fig. 7.

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