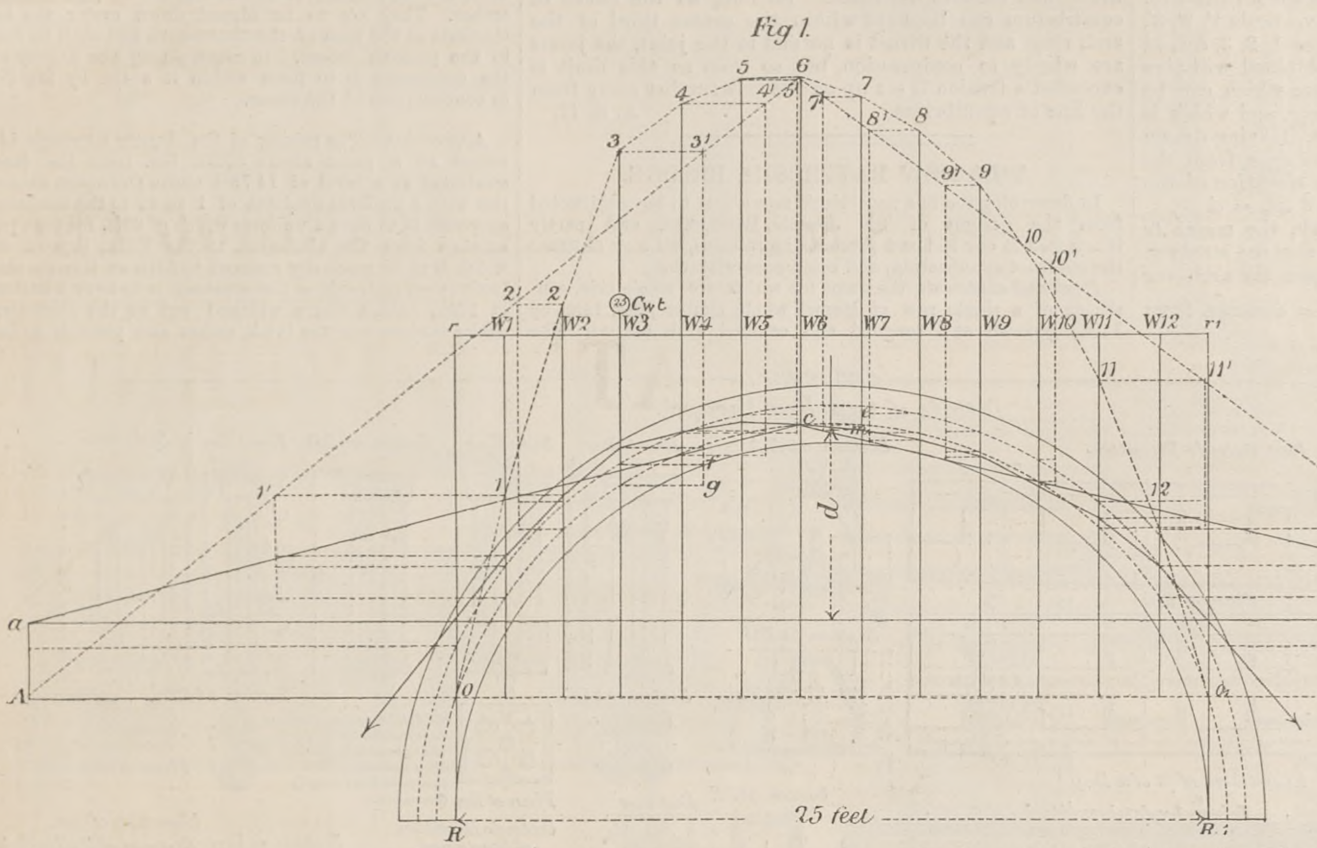
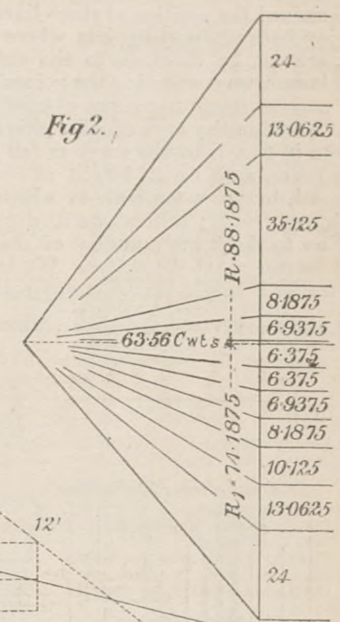
DIRECT GRAPHIC METHOD OF OBTAINING THE CURVE OF EQUILIBRIUM IN MASONRY ARCHES.

ATTENTION has been drawn by various authors to the fact that iron bridges of small span are much more severely strained by the same moving load than are bridges of 60ft. and upwards, but no one up to the present seems to have done the same for that very common and cheap mode of construction, the masonry arch—brick more particularly—wherein it can be clearly shown the same law obtains as in the wrought iron girder construction, as far as relates to unequal loading. Perhaps this may be because there is no concise work on the subject giving the

Fig 1.





necessary data as to obtaining the curve of equilibrium in an easy but at the same time trustworthy method, yet the same information exists, only in disconnected portions.

Professor George Fuller, M.I.C.E., communicated a paper to the Institution of Civil Engineers—vol. xl.—in 1875, showing how the curve of equilibrium could be directly arrived at, acknowledging his indebtedness at the same

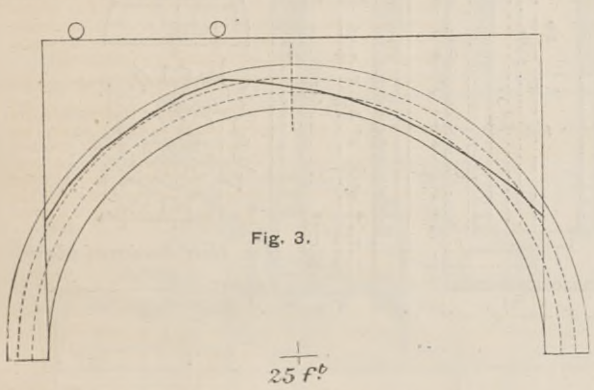


Fig. 3.

time to an anonymous writer in *The Engineer and Architects' Journal* of 1861, who drew attention to the fact "that the ordinates of the curve of equilibrium under vertical forces, vary directly as the bending moments." The above paper being written in regard to the iron arch, and as an amended method of obtaining the curve of equilibrium on Mr. Bell's tentative method—"Proc." Inst. C.E., vol. xxxiii. Rankine, in his "Civil Engineering,"

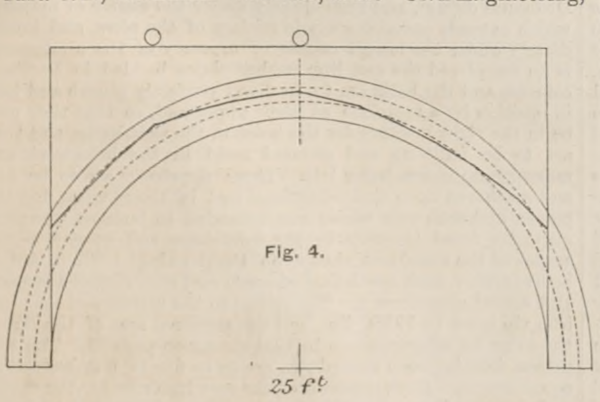


Fig. 4.

addenda page 15, also casually refers to evidently the same writer. Subsequently, the late Professor Fleeming Jenkin, in his article on Bridges in the "Enc Britt.," 1878, refers to Professor Fuller's paper, and adapts it to the masonry arch, but only for symmetrical loading. But it is not in this latter case where the method is of greatest value; but for showing the curve due to the moving loads, for it will be shown hereafter that nothing can be more fallacious than to treat the moving load as an equally distributed load—as some authors do—and add it to that of the structure.

The anonymous writer in *The Engineer and Architects' Journal* gives a couple of examples of unequal loading, but makes two assumptions which are quite untenable, leading him to treat the halves of the arch separately, whereby he gets an erroneous result; and it is patent that the arch cannot be treated in this manner because the curve of equilibrium, when inverted, simply becomes a cord loaded with given weights acting at certain horizontal distances from the points of attachment, and to arrive at the curve assumed by it under these circumstances it must be treated as a whole.

Now having the law "that the ordinates of the curve of equilibrium under vertical forces vary directly as the bending moments"—which is tersely explained in Professor Fuller's paper—the curve of equilibrium for any system of loading can be obtained; at the same time remembering that in the masonry arch we have no bearing on the piers or abutments—the weight above them being carried vertically down—the problem being to wedge that portion of masonry lying above the clear span, and the best way to illustrate this is by an example. Let us take a semicircular arch—Fig. 1—25ft. span in the clear; this will give a 12ft. 6in. radius for the intrados; let the arch ring be the usual five rings of brickwork, or 1ft. 10½in. thick, and the depth at centre of bridge 3ft. 6in., the arch and filling being taken at 100 lb. per cube foot, the units being for 1ft. in width of the arch ring. The unit for the moving load has been arrived at as follows:—Taking a fully-equipped tank engine weighing 45 tons, six wheels coupled, 14ft. wheel base, giving 15 tons on each axle or sleeper; and as the latter usually run about 9ft. in length, and giving 18in. more at each end on the assumption that the filling will distribute the weight that distance, this will give 15 tons ÷ 12ft. = 25 cwt. per foot in width, or working portion of the arch ring.

From the above the units of weight for the structure itself would be: W_1 and W_{12} = 24, W_2 and W_{11} = 13·0625, W_3 and W_{10} = 10·125, W_4 and W_9 = 8·1875,

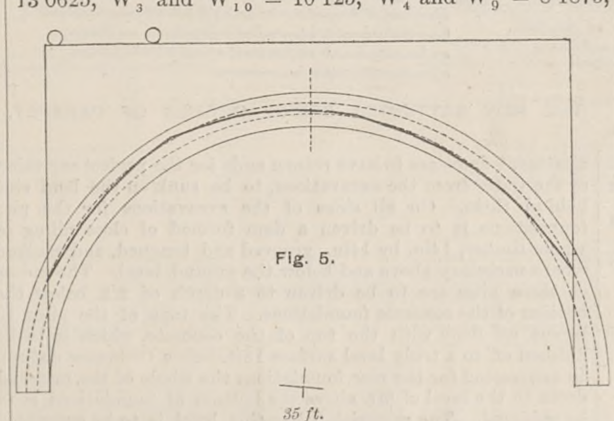


Fig. 5.

W_5 and W_8 = 6·9375, and W_6 and W_7 = 6·375 cwt. The ordinates W_1 and W_{12} are 1ft. 6in. from the face of abutments; the remainder are spaced at 2ft. apart.

We will also suppose the locomotive is entering from the left, and has its front wheels on the bridge 5ft. 6in. from the face of the abutment (W_3). The moments for both dead and live loads would be at each point as follows:—

	W_1	W_2	W_3	W_4	W_5	W_6
Dead load	103·03	192·4	255·34	298·83	325·26	338·02
Live ,,	29·25	68·25	107·25	96·25	85·25	74·25
Totals	132·28	260·65	362·59	395·08	410·51	412·27

	W_7	W_8	W_9	W_{10}	W_{11}	W_{12}
Dead load	338·02	325·26	298·83	255·34	192·40	103·03
Live ,,	63·25	52·25	41·25	30·25	19·25	8·25
Totals	401·27	377·51	340·08	285·59	211·65	111·28

As we are only dealing with the portion R r r_1 R_1 of masonry overlying or superimposed upon the clear span, and also the centre third of the arch ring, produce the face lines of abutments R and R_1 upward to r and r_1, so that they may intersect the middle third of the arch, and at the points where the intrados of the middle third of arch ring cuts these lines, draw the horizontal line A B produced both ways. Upon this line, to any scale of parts, set off vertically the total moments obtained above to their respective ordinates, and this will give a curve of moments for this loading, as shown in dotted lines 0, 1, 2, 3, &c. From 6, the highest point of the curve, draw two straight lines each side to any points on the line A B; on to these lines horizontally project the moments of the curve from the apices of their respective ordinates, whence the points 1′, 2′, 3′, &c., are the projections of the two halves of the linear arch shown in dotted lines. At each of these intersections, 1′, 2′, 3′, &c., draw down vertical lines, as shown by those dotted. It is from this evident that, if the lines 6 A and 6 B are projections of the two halves of the linear arch in dotted lines, two other straight lines starting from somewhere within the apex of the middle third of the arch ring, and cutting the ordinates in dotted lines 1′, 2′, 3′, &c., will be a projection of the linear arch lying within—or thereabouts—the centre third of the arch ring; as the ordinates of the curve within the arch will be submultiples of the ordinates of the arch in dotted lines, which is self-evident if the line A B is moved up vertically along with the curve of moments until it coincides with the line a b; for could we fix in the first instance the position of the line a b, we should have plotted the curve of

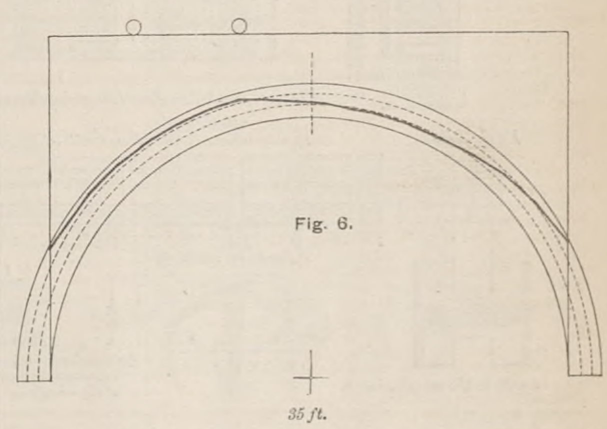


Fig. 6.

moments upon it. Now to see where it is possible to get the most advantageous curve—*i.e.*, of maximum rise, and therefore minimum thrust—within the arch, project horizontally the middle third of the arch ring where cut by the ordinates in full lines, 1, 2, 3, &c., on to their respective ordinates 1′, 2′, 3′, &c., in dotted lines, and if the points so obtained of the extrados were connected by lines, and those for the intrados similarly treated, it would give an enclosed

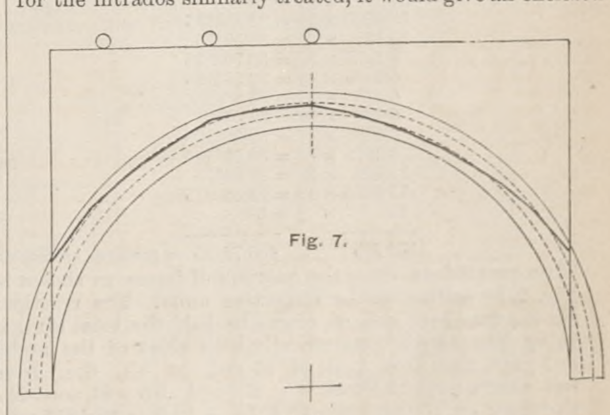


Fig. 7.

area wherein the straight lines lying within it would be the linear arch sought within the centre third of ring—these lines are not shown on the diagram, so as not to confuse—but in fixing the position of these straight lines it must be borne in mind that, as we are seeking the "horizontal thrust," we must adhere to what the term conveys—*i.e.*, that the points a and b shall be at the same level, and perpendicular over the points A and B.

Now, in this example it is impossible to get two straight lines lying within the enclosed area—whence the reason of this example being chosen as illustration—therefore what we have to do is to get two straight lines $a\,c$ and $c\,b$ drawn from the extremities a and b perpendicular over A and B, and meeting at apex of the arch, which shall give a curve which is as much outside the extrados and as much inside the intrados of the centre third of the arch ring. This is satisfied by the lines $a\,c$, $c\,b$ in Fig. 1, for taking the ordinate 3′ in dotted lines, it is seen that at this vertical—the points f and g being the projection of the middle third of arch ring upon it—that the line $a\,c$ is as much above the point f, the projection of the extrados of middle third of the arch ring, as the line $c\,b$ is below the point m, the projection of the intrados of the middle third of arch ring at the vertical 8′—the points $l\,m$ being the projection of the middle third of the ring at this ordinate. Having determined the position of these lines and drawn them in, project back again the points where the verticals 1′, 2′, 3′, &c., are cut by them, on to the ordinates 1, 2, 3, &c., in full lines, then connecting the points so obtained will give the nearest concentric curve of equilibrium which can be drawn within the arch ring for this loading, and which is shown in Fig. 1. by the curve in full lines. Having drawn this curve, measure its height at centre of span from the line $a\,b$, by the same scale to which the elevation of the arch was drawn; in this case its depth is 6·4ft. $= d$.

Now to check the accuracy of the work, the moments may be run out at the centre. We know that the strain at centre for a weight placed at any point upon the arch—or any other structure—is $\frac{x \times w}{2\,d}$, where x = distance from nearest abutment, w = weight, and d = depth or vers. sin. of arch; but as we elect to divide by d at once, the formula can be written $\frac{x}{2} \cdot \frac{w}{d}$, that is, we halve the distance from the abutments instead, which will come to the same thing. Working this out, it will stand thus:—

$$\begin{array}{rcl}
24 \times \frac{3}{4} & = & 18\cdot \\
13\cdot0625 \times 1\frac{3}{4} & = & 22\cdot859375 \\
35\cdot125 \times 2\frac{3}{4} & = & 96\cdot59375 \\
8\cdot1875 \times 3\frac{3}{4} & = & 30\cdot703125 \\
6\cdot9375 \times 4\frac{3}{4} & = & 32\cdot953125 \\
6\cdot375 \times 5\frac{3}{4} & = & 36\cdot65625 \\
6\cdot375 \times 5\frac{3}{4} & = & 36\cdot65625 \\
6\cdot9375 \times 4\frac{3}{4} & = & 32\cdot953125 \\
8\cdot1875 \times 3\frac{3}{4} & = & 30\cdot703125 \\
10\cdot125 \times 2\frac{3}{4} & = & 27\cdot84375 \\
13\cdot0625 \times 1\frac{3}{4} & = & 22\cdot859375 \\
24 \times \frac{3}{4} & = & 18\cdot \\
\hline
162\cdot375 & & 406\cdot78125 = \text{moment at centre.}
\end{array}$$

Then proceed to draw the polygon of forces, as shown in Fig. 2, by setting up the respective units. The reactions for the dead load will of course be half the total load, it being distributed symmetrically both sides of the arch; and for the live load of 25 cwt. at 5ft. 6in. from left abutment, 19·5 cwt. on R, and 5·5 cwt. on R_1, therefore on R there are 68·6875 + 19·5 = 88·1875 cwt., and on R_1 68·6875 + 5·5 = 74·1875 cwt. From the point on the vertical line of loads where these reactions meet draw a horizontal line, its value being $\frac{\text{moment}}{\text{depth}} = \frac{406\cdot78125}{6\cdot4} = 63\cdot56$ cwt. = horizontal thrust. Now complete the polygon. And by drawing lines parallel from the polygon of forces to their respective places in the curve they must coincide in direction, and if this is not so one may be quite sure some error has been made in one or other of the calculations or plotting, which will have to be rectified.

The curve of moments in dotted lines could have been arrived at graphically without calculation by drawing the closed polygon and taking any arbitrary value for the horizontal thrust, but it is not so correct as the method illustrated above, there being always the difficulty of drawing the curve with sufficient nicety when beginning at either side that it shall exactly close in on the opposite point.

In all the other Figs., 3 to 7, the curves of equilibrium for various distributions of the moving load have been got out in the above manner, and it is evident, in comparing the 25ft. and 35ft. spans, that the former with a five ring arch is much more severely strained transversely than the latter with six rings of brickwork, the curve of equilibrium departing more from the centre third of the arch ring in the former than in the latter. So long as the curve of equilibrium can be kept within the centre third of the arch ring, and the thrust is normal to the joint, the joints are wholly in compression, but so soon as this limit is exceeded a tension is set up on the side further away from the line of equilibrium.

A. S. H.

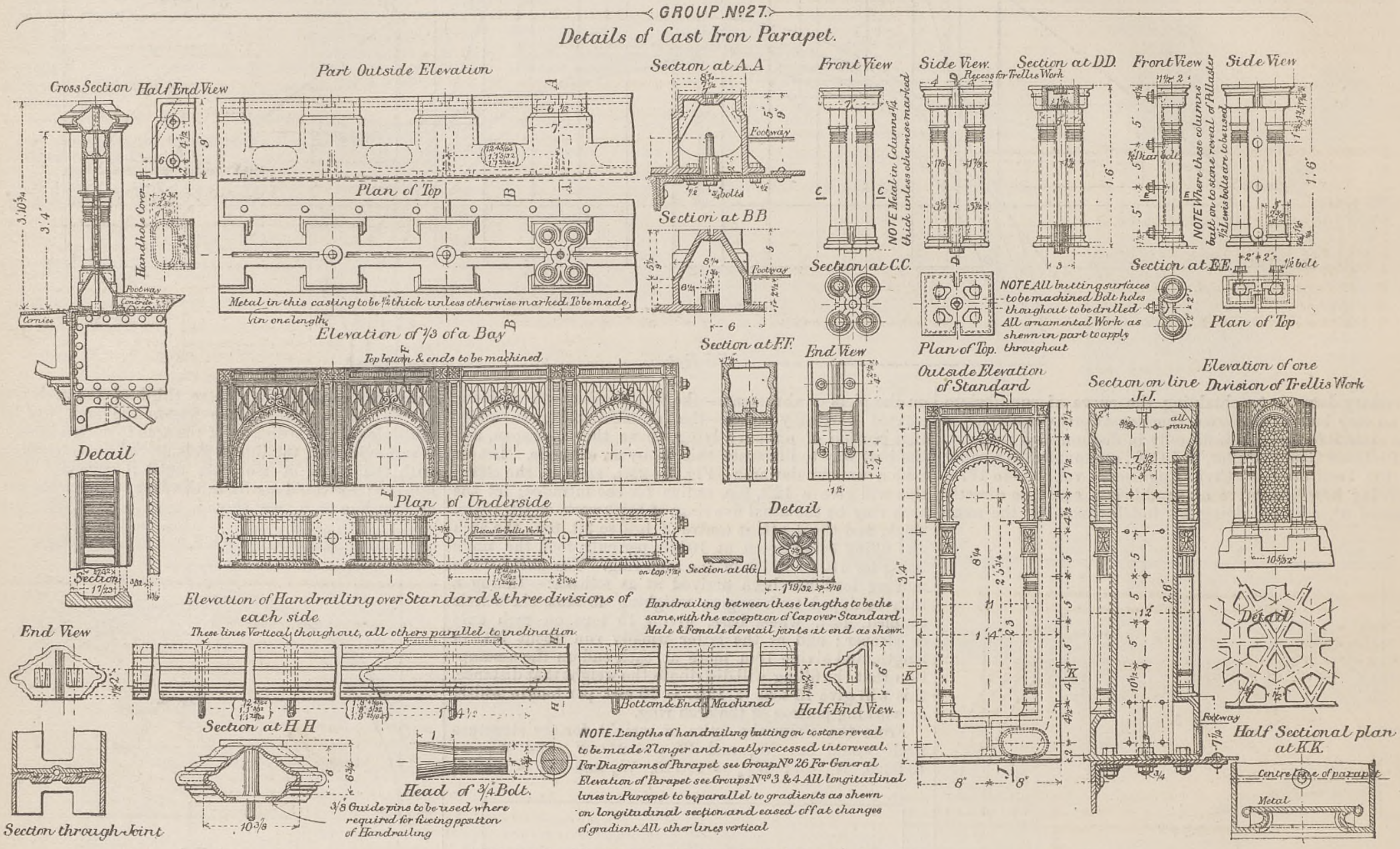
THE NEW BATTERSEA BRIDGE.

IN describing the fine new bridge now about to be constructed from the designs of Sir Joseph Bazalgette, and partly illustrated in our last and present impressions, we may abstract the contract specification, and commence with the

Piers and abutments, the dams for which are whole-tide, consisting of a single row of Memel whole timber piles, 14in. by 14in., grooved and tongued and caulked with oakum. The abutment dams are to have return ends for the perfect exclusion of the water from the excavations, to be sunk on the land side behind them. On all sides of the excavations for the pier foundations is to be driven a dam formed of close piling of whole timber, 14in. by 14in., grooved and tongued, and caulked where necessary above and below the ground level. The points of these piles are to be driven to a depth of 2ft. below the bottom of the concrete foundations. The tops of the piles to be cut off flush with the top of the concrete, which is to be finished off to a truly level surface 18ft. below Ordnance datum. In excavating for the pier foundations the whole of the material down to the level of 6ft. above the bottom of foundations is to be removed. The material below this level is to be excavated in trenches, securely timbered, and the trenches filled with concrete with the least possible delay. The concrete in the piers and abutments is to consist of clean Thames ballast and Portland cement, incorporated in the proportions of 6 to 1—by measure—respectively. The abutments are to be constructed of granite ashlar facing, backed with the best quality of picked stock brickwork set in Portland cement mortar, 2 of sand to 1 of cement, and with Portland cement concrete in the manner shown upon the drawings, page 46. The cast iron skewbacks and the holding down bolts, &c., are to be built in and grouted solid in the brickwork and masonry. The masonry is to be composed of horizontal courses of granite of the vertical depth shown on the drawings, each course to be composed of alternate headers and stretchers. Below Trinity high-water the headers to be not less than 3ft. in depth from the face, and 2ft. in width on the face, and the stretchers not more than 4ft. 6in. in length on the face, nor less than 1ft. 9in. in depth from the face, and above that level the headers to be not less than 2ft. 3in., and the stretchers not less than 1ft. 6in., in depth from the face. The stones in the alternate courses are to break bond with a lap of not less than 12in. The whole of the face of the granite which is below Trinity high-water level is to be smooth and fine axed—except the moulded course—the quality of the work being equal to that of the Victoria Embankment. The horizontal bed joints are to be fine dressed and splayed as shown, but the vertical joints to be plain and perfectly straight and fine picked for at least 15in. inward, the remainder of the granite to preserve its full dimensions and to be fair picked and straight between. Above Trinity high-water level, the whole of the face of the granite is to be smooth and fine axed, except the moulded courses, pedestals, and parapets, which in all cases, whether above or below Trinity high-water level, shall be fine chisel-dressed to the true form shown on the drawings, page 65. The whole of the masonry is to be set flush in beds of mortar, composed of 1 of Portland cement to 1 of sand, and properly grouted. The joints not to exceed ⅛in. in thickness. Grout nicks to be cut in all vertical joints of the ashlar work, according to the directions of the engineer, and the slate dowels or joggles, 2in. square and 4in. in length, to be inserted without extra charge whenever such may be considered necessary by the engineer. Under the footway on each side of the abutments are to be formed boxes or troughs for the purpose of containing any pipes which may be laid across the bridge. These troughs are to be formed in the concrete, as shown, and to be in continuation of the wrought iron pipe boxes over the arches. They are to be dipped down under the kerbs and channels at the back of the abutments, and shall be finished off in the position shown. In constructing the Surrey abutment the contractor is to form within it a 4ft. by 2ft. 8in. sewer in continuation of the sewer.

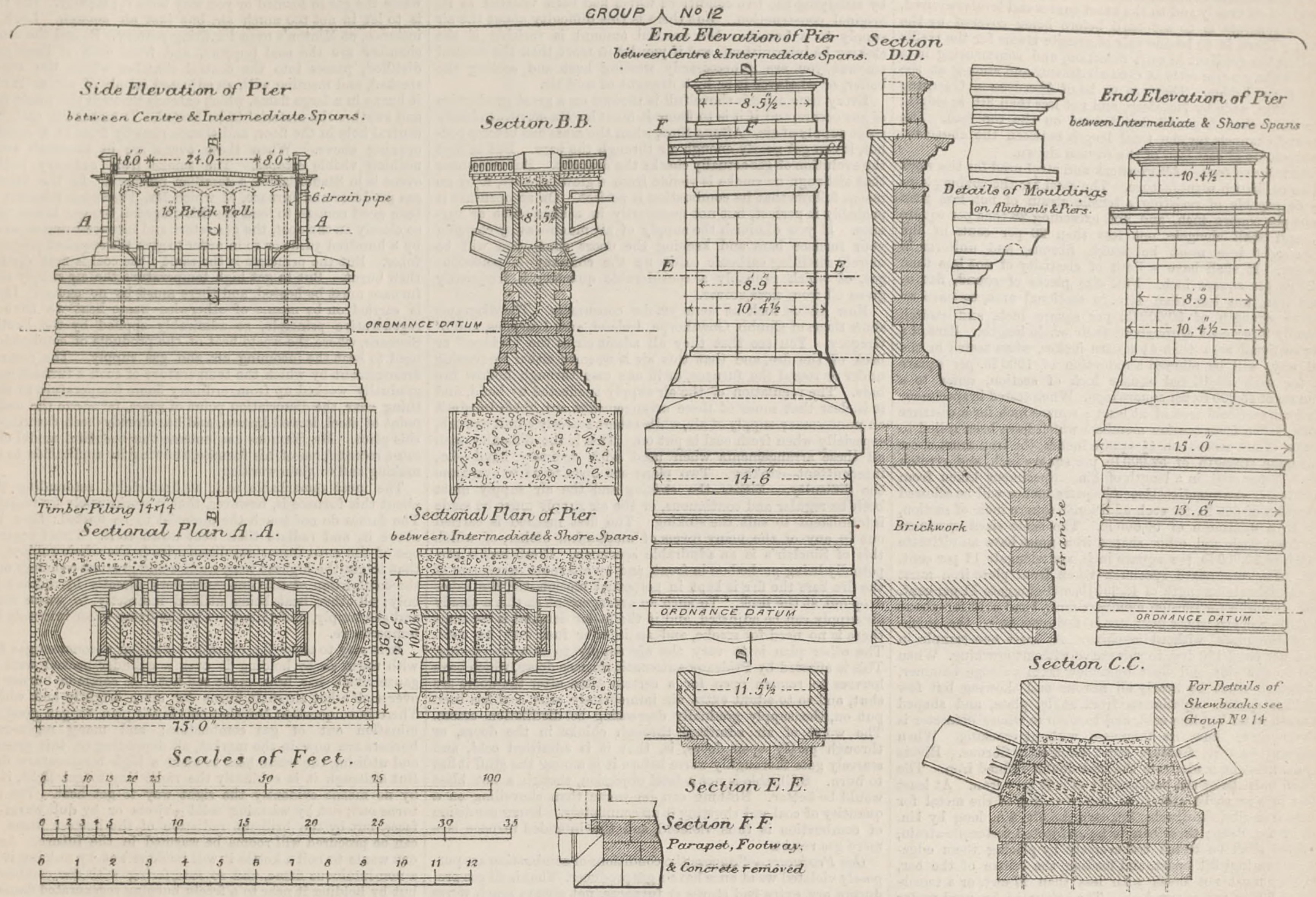
Approaches.—The raising of the Surrey approach is to commence at a point about 352ft. 6in. from the face of the abutment at a level of 14·78ft. above Ordnance datum, and to rise with a uniform gradient of 1 in 30 to the abutment. The approach is to have a uniform width of 60ft. for that part which extends from the abutment to the Folly, beyond which the width is to be gradually reduced to 57ft. at Europa-place. The footway on each side of the approach is to have a uniform width of 12ft., except where widened out at the abutments. The entire surface over the brick arches and piers is to be covered with Claridge's asphalte—quality No. 2—1in. thick, which is to be turned up 6in. at spandrel walls. The approach from the Chelsea Embankment is to commence at a level of 17·5ft. above Ordnance datum, and rise with a uniform gradient of 1 in 30 to the abutment.

Cast iron skewbacks and arched ribs.—At a level 1ft. below Ordnance datum, and immediately under the course of masonry which extends across the whole surface of the piers, and immediately under the lowest course of masonry of the abutments, is to be placed the cast iron washer plates bedded in Portland cement, and the bolts are to be fixed perfectly plumb and held in position by a template at their upper end, so that they may be in the right position for the holes in the skewbacks, and they are to be built up and grouted solid in the brickwork and masonry, no spaces being left. These skewbacks are to be cast and machined upon their skewfaces and in the recesses for the pivots, and each pair which are intended to butt on the piers must be fitted together in the workshops and gauged to the angles of the skewfaces shown on the drawings. There are to be five arches, each consisting of seven cast iron ribs, of the spans and versed sines shown. The radius to the intrados of each cast iron rib must be 193ft. 6in., and the sectional area of the ribs—the same for all arches—to be that shown on page 65. The segments, forming each arched rib, are to be five in number and of equal length. Each segment of the cast iron ribs for the centre and intermediate spans is to have three intermediate radial stiffeners, and each segment for the shore spans two intermediate radial stiffeners, as shown on the drawings. All butting surfaces of the segments are to be planed to radial lines. No bolt holes to be cast, but in all cases drilled, all bosses faced, and all bolts, either for joints or for connecting the wrought iron work, to be turned to an exact fit. On the upper flange, and in the positions required, are to be cast the lugs to which the vertical spandrel pillars are to be bolted. At the ends of the segments intended to form the springing of the arch, the metal of the radial flanges to be made with fillets cast on for holding the pivot. The pivot to be of cast iron and machined to gauge, and surfaced, with its bed, on the arched rib, and with the recess on the face of the skewback, so as to ensure that each arched rib may have a perfect bearing and be free from any initial bending strain at the springing. After the supports of all the arched ribs of a span have been removed so that the ribs take their own

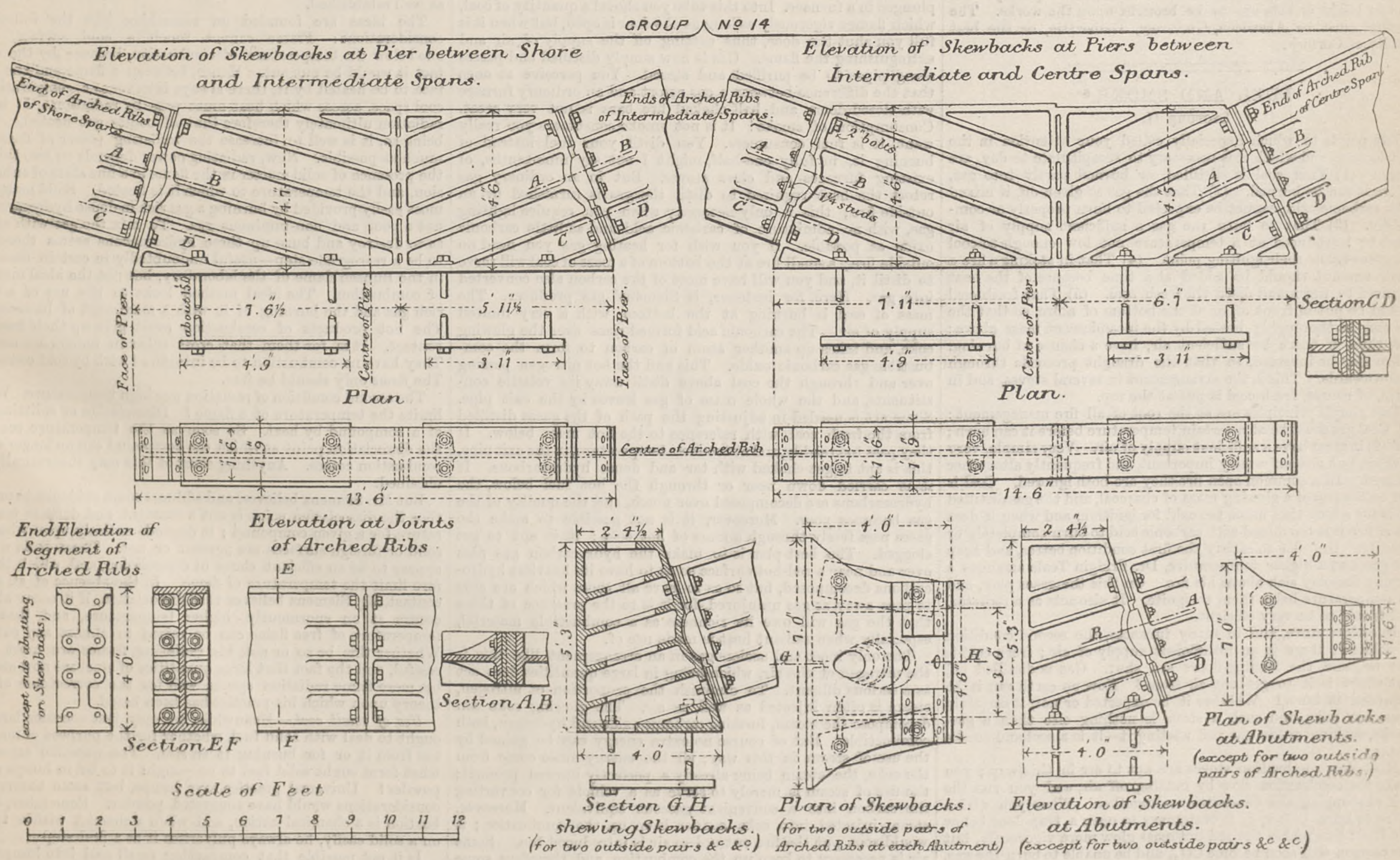


THE NEW BATTERSEA BRIDGE—DETAILS OF PARAPET.

weight, levels are to be taken to ascertain that all ribs occupy their intended position, and any not doing so are to be blocked up again at the supports, and one or more of the segments in such ribs taken out and altered. After all the arched ribs in a span have been ascertained to occupy their correct positions, the steel taper packings shown are to be finally finished off exactly to the required thicknesses and placed in position between the girders. In all angle irons forming the bracing the holes are to be carefully drilled. The lower ends of the T irons forming the pillars are to be neatly joggled to fit the cast iron lugs on the ribs. The bolt holes through the T irons and lugs are to be drilled in place, and the bolts turned to fit. Taper washers to be provided as shown. The construction of the wrought iron box or trough for carrying pipes is to be carried on at the same transverse curvature. At the parts where the above arrangements of curved plates ceases, and the longitudinal girders commence, there will be transverse plates, as shown, connecting angle irons on the lower and upper curved plates, and enclosing the concrete. The longitudinal girders are to be made continuous over the spandrel pillars. The plates for the coving to be of mild steel ½in. thick, and of such a quality that they can



THE NEW BATTERSEA BRIDGE—THE PIERS AND SPRINGINGS.



THE NEW BATTERSEA BRIDGE—DETAILS OF IRON SKEWBACKS.

face of the skewback and the end of the arched rib, the bolt holes drilled through them, and turned bolts inserted as shown. When the springings of all the ribs of a span have been fixed as shown, the radial stiffeners on the ribs are to receive the L iron bracing. Upon the completion of this bracing, the contractor will proceed to erect the vertical T iron pillars, diagonal bracings, and longitudinal and cross girders; and also the framework which is to support the coving and footways, and upon the time as that of the curved plates of the platform. It shall be continued over the piers and widened out at the abutments, and shall be finished off as shown on the drawings. In all cases the space provided inside the box shall be fully equal to that shown on the drawings. The curved plates for supporting the concrete under the carriage-way at the centre of each span are for some length carried directly on the cast iron arched ribs. These plates are to be bent to a radius of 197·5ft. in addition to their be turned out to the required curves and to the exact form shown on drawing. The curves of the top edge of the coving at the centres of the spans are to be tangential to a horizontal line, and the levels of these curves at the centres such that the minimum distance from the underside of the cornice, 21in. deep, to the top edge of the coving, must not be less than 12in. in any of the spans. On the spandrel face, over the edge of the coving is to be bolted the cast iron cornice shown on page 64.

Paving, &c.—Over the whole surface of the curved wrought iron carriage-way and footway plates—which will have been previously tarred—over the whole top surface of the piers, and over the surface of the abutments to the extent shown, is to be a layer of fine Portland cement concrete to form a bed for the paving. The concrete is to be mixed in the proportion of four of very fine ballast to one of Portland cement; the surface shall be finished off evenly and to the exact curves and levels required, and the concrete is to set hard before being covered by the paving. There is to be one pair of granite trams for the traffic ascending the gradient in each direction, and commencing in a line with the granite setts at each abutment, and ending at the centre of the bridge. They are to be of Aberdeen or Guernsey granite, 12in. wide by 7in. deep, and not less than 3ft. in length, all to be worked fair and fine-dressed on the top face. The kerbs and channels for the total length between the abutment faces are to be of cast iron of the section shown.

Materials and tests.—All ironwork and steel used for the work shall be of British manufacture. The steel for the coving plates is to be capable of resisting a tensile strain of not less than 25 tons per square inch, and not exceeding 28 tons per square inch, and shall elongate not less than 20 per cent. in 8in. All wrought iron must be tough, fibrous, and uniform in character. It shall have a limit of elasticity of not less than 26,000 lb. per square inch. Full size pieces of round, flat, or square iron, not less than 4½in. in sectional area, to have an ultimate strength of 50,000 lb. per square inch, and stretch uniformly 9 per cent. throughout their whole length. Bars of a larger sectional area than 4½ square inches, when tested in the usual way, will be allowed a reduction of 1000 lb. per square inch for each additional square inch of section, down to a minimum of 46,000 lb. per square inch. When tested in specimens of uniform sectional area of at least ½ square inch for a distance of 10in., taken from tension members which have been rolled to a section of not more than 4½ square inches, the iron must show an ultimate strength of 52,000 lb. per square inch, and stretch at least 12 per cent. in a length of 8in. Specimens taken from bars of larger cross section than 4½ square inches will be allowed a reduction of 500 lb. for each additional square inch of section, down to a minimum of 50,000 lb. The same sized specimen taken from angle and other shaped iron must have an ultimate strength of 50,000 lb. per square inch, and elongate 11 per cent. in 8in. The same sized specimen taken from plate iron must have an ultimate strength of 48,000 lb. and elongate 11 per cent. in 8in. All iron for tension members must bend cold for about 90 deg., to a curve whose diameter is not over twice the thickness of the piece, without cracking. At least one sample in three must bend 180 deg. to this curve without cracking. When nicked on one side and bent by a blow from a sledge hammer, the fracture must be nearly all fibrous and showing but few crystalline specks. Specimens from angle, plate, and shaped iron must stand bending cold, and to a curve whose diameter is not over three times its thickness, without cracking. When nicked and bent its fracture must be mostly fibrous. Rivets and pins must be made from the best double-refined iron. The cast iron must be of the best quality of soft grey iron. At least six test bars must be cast from each running of the metal for the cast iron ribs, skewbacks, &c., each be 3ft. 6in. long by 1in. broad by 2in. deep; three bars to be subjected to tensile strain, and three shall be tested transversely by placing them edgeways on bearings 3ft. apart, and loading the centre of the bar, when they must not break with less than 27 cwt. or a tensile strain of 9 tons per square inch. The bricks to be used under this contract, except where otherwise specially provided, are to be picked stock bricks, of the best and hardest quality. No broken bricks or bats are to be brought upon the works. The granite must be Aberdeen, Guernsey, Dalbeattie, or the best quality of Cornish.

FUEL AND SMOKE.*

LECTURE II.

THE points to which I specially called your attention in the first lecture, and which it is necessary to recapitulate to-day, are these:—(1) That coal is distilled, or burned partly into gas, before it can be burned. (2) That the gas so given off, if mixed with carbonic acid, cannot be expected to burn properly or completely. (3) That to burn the gas a sufficient supply of air must be introduced at a temperature not low enough to cool the gases below their igniting point. (4) That in stoking a fire a small amount should be added at a time because of the heat required to warm and distil the fresh coal. (5) That fresh coal should be put in front of, or at the bottom of a fire, so that the gas may be thoroughly heated by the incandescent mass above; and thus, if there be sufficient air, have a chance of burning. A fire may be inverted, so that the draught proceeds through it downwards. This is the arrangement in several stoves, and in them, of course, fresh coal is put at the top.

Two simple principles are at the root of all fire management: (1) Coal gas must be at a certain temperature before it can burn; and (2) it must have a sufficient supply of air. Very simple, very obvious, but also extremely important, and frequently altogether ignored. In a common open fire they are both ignored. Coal is put on the top of a glowing mass of charcoal, and the gas distilled off is for a long time much too cold for ignition, and when it does catch fire it is too mixed with carbonic acid to burn completely or steadily. In order to satisfy the first condition better, and keep the gases at a higher temperature, Dr. Pridgin Teale arranges a sloping fire-clay slab above his fire. On this the gases play, and its temperature helps them to ignite. It also acts as a radiator, and is said to be very efficient.

In a close stove, and in many furnaces, the second condition is violated; there is an insufficient supply of air; fresh coal is put on, and the feeding-doors are shut. Gas is distilled off, but where is it to get any air from? How on earth can it be expected to burn? Whether it be expected or not, it certainly does not burn, and such a stove is nothing else than a gas-works, making crude gas and wasting it—it is a soot and smoke factory.

Most slow combustion stoves are apt to err in this way; you make the combustion slow by cutting off air, and you run the risk of stopping the combustion altogether. When you wish a stove to burn better, it is customary to open a trap-door below the fuel; this makes the red-hot mass glow more vigorously, but the oxygen will soon become CO_2, and be unable to burn the gas. The right way to check the ardour of a stove is not to shut off the air supply and make it distil its gases unconsumed, but to admit so much air above the fire that the draught is checked by the chimney ceasing to draw so fiercely. You, at the same time, secure better ventilation; and if the fire becomes visible to the room so much the better and more cheerful. But if you open up the top of a stove like this, it becomes, to all intents and purposes, an open fire. Quite so, and in many respects therefore an open fire is an improvement on a close stove. An open fire has faults, and it certainly wastes heat up the chimney. A close stove may have more faults—it wastes less *heat*, but it is liable to waste *gas* up the chimney—not necessarily visible or smoky gas—it may waste it from coke or anthracite, as CO.

You now easily perceive the principles on which so-called smoke consumers are based. They are all special arrangements or appendages to a furnace for permitting complete combustion by satisfying the two conditions which had been violated in its original construction. But there is this difficulty about the air supply to a furnace: the needful amount is variable if the stoking be intermittent, and if you let in more than the needful amount you are unnecessarily wasting heat and cooling the boiler, or whatever it is, by a draught of cold air.

Every time a fresh shovelfull is thrown on a great production of gas occurs, and if it is to flame it must have a correspondingly great supply of air. After a time, when the mass has become red-hot, it can get nearly enough air through the bars. But at first the evolution of gas actually checks the draught. But remember that although no smoke is visible from a glowing mass, it by no means follows that its combustion is perfect. On an open fire it probably is perfect, but not necessarily in a close stove or furnace. If you diminish the supply of air much—as by clogging your furnace bars and keeping the doors shut—you will be merely distilling carbonic oxide up the chimney—a poisonous gas, of which probably a considerable quantity is frequently given off from close stoves.

Now let us look at some smoke consumers. The diagrams show those of Chubb, Gowthorpe, Ireland, and Lowndes, and of Gregory. You see that they all admit air at the "bridge" or back of the fire, and that this air is warmed either by passing under or round the furnace, or in one case through hollow fire bars. The regulation of the air supply is effected by hand, and it is clear that some of these arrangements are liable to admit an unnecessary supply of air, while others scarcely admit enough, especially when fresh coal is put on. This is the difficulty with all these arrangements when used with ordinary hand—*i.e.*, intermittent—stoking. Two plans are open to us to overcome the difficulty. Either the stoking and the air supply must both be regular and continuous, or the air supply must be made intermittent to suit the stoking. The first method is carried out in any of the many forms of mechanical stoker, of which this of Sinclair's is an admirable specimen. Fresh fuel is perpetually being pushed on in front, and by alternate movement of the fire bars the fire is kept in perpetual motion till the ashes drop out at the back. To such an arrangement as this a steady air supply can be adjusted, and if the boiler demand is constant there is no need for smoke, and an inferior fuel may be used. The other plan is to vary the air supply to suit the stoking. This is effected by Prideaux automatic furnace doors, which have louvres to remain open for a certain time after the doors are shut, and so to admit extra air immediately after coal has been put on, the supply gradually decreasing as distillation ceases. The worst of air admitted through chinks in the doors, or through partly open doors, is, that it is admitted cold, and scarcely gets thoroughly warm before it is among the stuff it has to burn. Still, this is not a fatal objection, though a hot blast would be better. Nothing can be worse than shovelling on a quantity of coal and shutting it up completely. Every condition of combustion is thus violated, and the intended furnace is a mere gas retort.

Gas Producers.—Suppose the conditions of combustion are purposely violated we at once have a gas producer. That is all gas producers are, extra bad stoves or furnaces, not always much worse than things which pretend to serve for combustion. Consider how ordinary gas is made. There is a red-hot retort or cylinder plunged in a furnace. Into this tube you shovel a quantity of coal, which flames vigorously as long as the door is open, but when it is full you shut the door, thus cutting off the supply of air and extinguishing the flame. Gas is now simply distilled and passes along pipes to be purified and stored. You perceive at once that the difference between a gas retort and an ordinary furnace with closed doors and half-choked fire bars is not very great. Consumption of smoke! It is not smoke consumers you really want, it is fuel consumers. You distil your fuel instead of burning it, in fully one-half, might I not say nine-tenths, of existing furnaces and close stoves. But in an ordinary gas retort the heat required to distil the gas is furnished by an outside fire; this is only necessary when you require lighting gas, with no admixture of carbonic acid and as little carbonic oxide as possible. If you wish for heating gas you need no outside fire; a small fire at the bottom of a mass of coal will serve to distil it, and you will have most of the carbon also converted into gas. Here, for instance, is Siemens' gas producer. The mass of coal is burning at the bottom, with a very limited supply of air. The carbonic acid formed rises over the glowing coke, and takes up another atom of carbon to form the combustible gas carbonic oxide. This and the hot nitrogen passing over and through the coal above distil away its volatile constituents, and the whole mass of gas leaves by the exit pipe. Some art is needed in adjusting the path of the gases distilled from the fresh coal with reference to the hot mass below. If they pass too readily, and at too low a temperature, to the exit pipe, this is apt to get choked with tar and dense hydrocarbons. If it is carried down near or through the hot fuel below, the hydrocarbons are decomposed over much, and the quality of the gas becomes poor. Moreover, it is not possible to make the gases pass freely through a mass of hot coke; it is apt to get clogged. The best plan is to make the hydrocarbon gas pass over and near a red-hot surface so as to have its heaviest hydrocarbons decomposed, but so as to leave all those which are able to pass away as gas uninjured, for it is to the presence of these that the gas will owe its richness as a combustible material, especially when radiant heat is made use of.

The only inert and useless gas in an arrangement like this is the nitrogen of the air, which being in large quantities does act as a serious diluent. To diminish the proportion of nitrogen, steam is often injected as well as air. The glowing coke can decompose the steam, forming carbonic oxide and hydrogen, both combustible. But of course no extra energy can be gained by the use of steam in this way; all the energy must come from the coke, the steam being already a perfectly burned product; the use of steam is merely to serve as a vehicle for converting the carbon into a convenient gaseous equivalent. Moreover, steam injected into coke cannot keep up the combustion; it would soon put the fire out unless air is introduced too. Some air is necessary to keep up the combustion, and therefore some nitrogen is unavoidable. But some steam is advisable in every gas producer, unless pure oxygen could be used instead of air; or unless some substance like quicklime, which holds its oxygen with less vigour than carbon does, were mixed with the coke and used to maintain the heat necessary for distillation. A well known gas producer for small scale use is Dowson's. Steam is superheated in a coil of pipe, and blown through glowing anthracite along with air. The gas which comes off consists of 20 per cent. hydrogen, 30 per cent. carbonic oxide, 3 per cent. carbonic acid, and 47 per cent. nitrogen. It is a weak gas, but it serves for gas engines, and is used, I believe, by Thompson, of Leeds, for firing glass and pottery in a gas kiln. It is said to cost 4d. per 1000ft., and to be half as good as coal-gas.

For furnace work, where gas is needed in large quantities, it must be made on the spot. And what I want to insist upon is this, that all well-regulated furnaces are gas retorts and combustion chambers combined. You may talk of burning coal, but you can't do it; you must distil it first, and you may either waste the gas so formed or you may burn it properly. The thing is to let in not too much air, but just air enough. Look, for instance, at Minton's oven for firing pottery. Round the central chamber are the coal hoppers, and from each of these gas is distilled, passes into the central chamber where the ware is stacked, and meeting with an adjusted supply of air as it rises, it burns in a large flame, which extends through the whole space and swathes the material to be heated. It makes its exit by a central hole in the floor, and thence rises by flues to a common opening above. When these ovens are in thorough action, nothing visible escapes. The smoke from ordinary potters' ovens is in Staffordshire a familiar nuisance. In the Siemens gas producer and furnace, of which Mr. Frederick Siemens has been good enough to lend me this diagram, the gas is not made so closely on the spot, the gas retort and furnace being separated by a hundred yards or so in order to give the required propelling force. But the principle is the same; the coal is first distilled, then burnt. But to get high temperature the air supply to the furnace must be heated, and there must be no excess. If this is carried on by means of otherwise waste heat we have the regenerative principle, so admirably applied by the Brothers Siemens, where the waste heat of the products of combustion is used to heat the incoming air and gas supply. The reversing arrangement by which the temperature of such a furnace can be gradually worked up from ordinary flame temperature to something near the dissociation point of gases, far above the melting point of steel, is well known, and has already been described in this place. Mr. Siemens has lent me this beautiful model of the most recent form of his furnace, showing its application to steel making and to glass working.

The most remarkable and, at first sight, astounding thing about this furnace is, however, that it works solely by radiation. The flames do not touch the material to be heated; they burn above it, and radiate their heat down to it. This I regard as one of the most important discoveries in the whole subject, viz., that to get the highest temperature and greatest economy out of the combustion of coal one must work directly by radiant heat only; all other heat being utilised indirectly to warm the air and gas supply, and thus to raise the flame to an intensely high temperature.

It is easy to show the effect of supplying a common gas flame with warm air by holding it over a cylinder packed with wire gauze which has been made red-hot. A common burner held over such a hot air shaft burns far more brightly and whitely. There is no question but that this is the plan to get good illumination out of gas combustion; and many regenerative burners are now in the market, all depending on this principle and utilising the waste heat to make a high temperature flame. But although it is evidently the right way to get light, it was by no means evidently the right way to get heat. Yet so it turns out; not by warming solid objects or by dull warm surfaces, but by the brilliant radiation of the hottest flame that can be procured will rooms be warmed in the future. And if one wants to boil a kettle it will be done not by putting it into a non-luminous flame, and so interfering with the combustion, but by holding it near to a freely burning regenerated flame and using the radiation only. Making toast is the symbol of all the heating of the future, provided we regard Mr. Siemens' view as well established.

The ideas are founded on something like the following considerations:—Flame cannot touch a cold surface, *i.e.*, one below the temperature of combustion, because by the contact it would be put out. Hence, between a flame and the surface to be heated by it, there always intervenes a comparatively cool space, across which heat must pass by radiation. It is by radiation ultimately therefore that all bodies get heated. This being so, it is well to increase the radiating power of flame as much as possible. Now, radiating power depends on two things, the presence of solid matter in the flame in a fine state of subdivision, and the temperature to which it is heated. Solid matter is most easily provided by burning a gas rich in dense hydrocarbons not a poor and non-luminous gas. To mix the gas with air so as to destroy and burn up these hydrocarbons seems therefore to be a retrograde step—useful undoubtedly in certain cases, as in the Bunsen flame of the laboratory, but not the ideal method of combustion. The ideal method looks to the use of a very rich gas and the burning of it with a maximum of luminosity. The hot products of combustion must give up their heat by contact. It is for them that cross tubes in boilers are useful. They have no combustion to be interfered with by cold contacts. The *flame* only should be free.

The second condition of radiation was high temperature. What limits the temperature of a flame? Dissociation or splitting up of a compound by heat. So soon as the temperature reaches the dissociation point at which the compound can no longer exist combustion ceases. Anything short of this may theoretically be obtained.

But Mr. Siemens believes, and adduces some evidence to prove, that the dissociation point is not a constant and definite temperature for a given compound; it depends entirely upon whether solid or foreign surfaces are present or not. These it is which appear to be an efficient cause of dissociation, and which therefore limit the temperature of flame. In the absence of all solid contact, Mr. Siemens believes that dissociation, if it occur at all, occurs at an enormously higher temperature, and that the temperature of free flame can be raised to almost any extent. Whether this be so or not, his radiating flames are most successful, and the fact that large quantities of steel are now melted by mere flame radiation speaks well for the correctness of the theory upon which his practice has been based.

Use of small coal.—Meanwhile, we may just consider how we ought to deal with solid fuel, whether for the purpose of making gas from it or for burning it *in situ*. The question arises, in what form ought solid fuel to be—ought it to be in lumps or in powder? Universal practice says lumps, but some theoretical considerations would have suggested powder. Remember, combustion is a chemical action, and when a chemist wishes to act on a solid easily, he always pulverises it as a first step.

Is it not possible that compacting small coal into lumps is a wrong operation, and that we ought rather to think of breaking big coal down into slack? The idea was suggested to me by Sir W. Thomson in a chance conversation, and it struck me at once as a brilliant one. The amount of coal wasted by being in the form of slack is very great. Thousands of tons are never raised from the pits because the price is too low to pay for the raising—in some places it is only 1s. 6d. a ton. Mr. Mc Millan calculates that 130,000 tons of breeze, or powdered coke, is produced every year by the Gas Light and Coke Company alone, and its price is 3s. a ton at the works, or 5s. delivered.

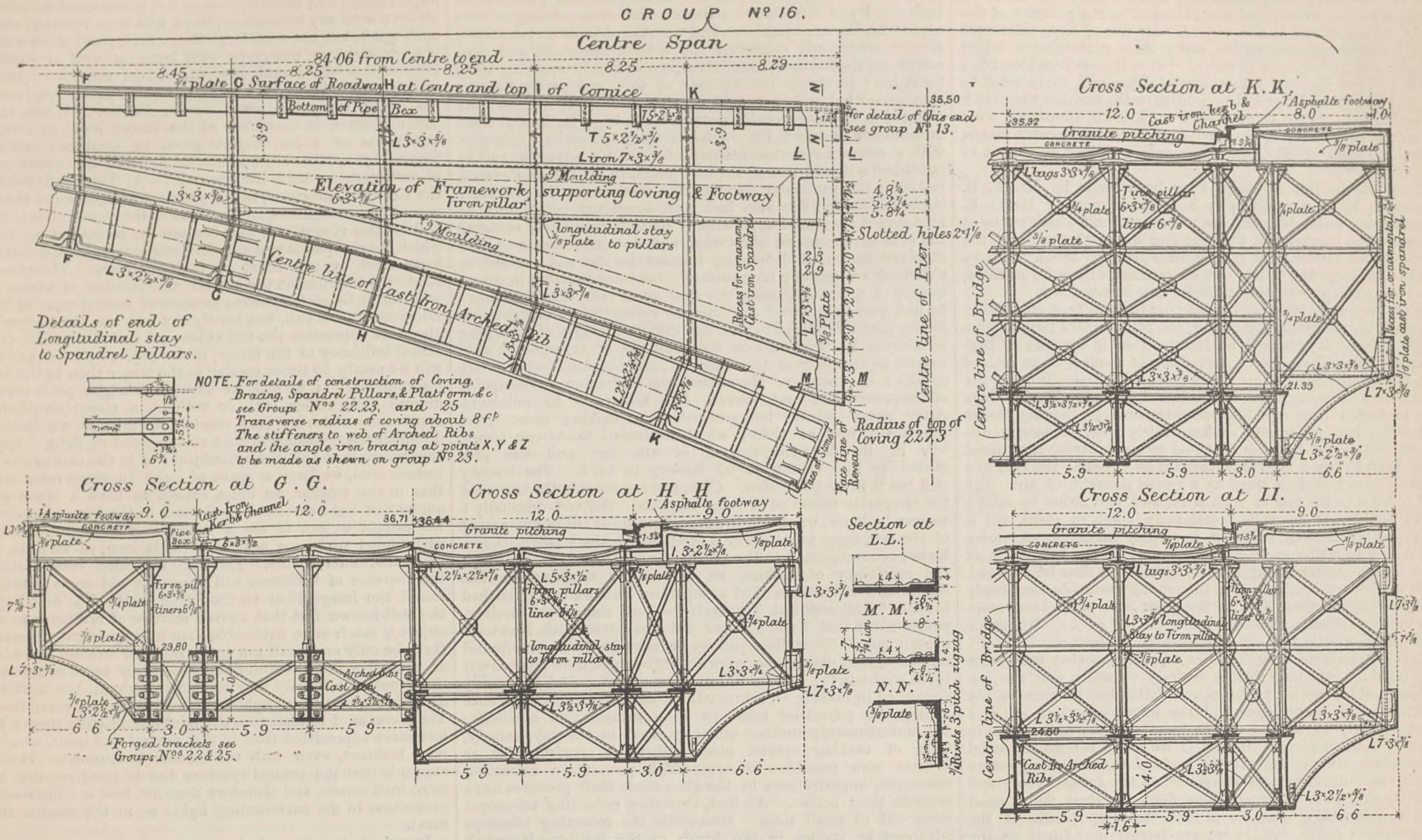
The low price and refuse character of small coal is, of course

* Second of two Lectures delivered by Professor Oliver Lodge, at the Royal Institution, London, on 17th April, 1886.

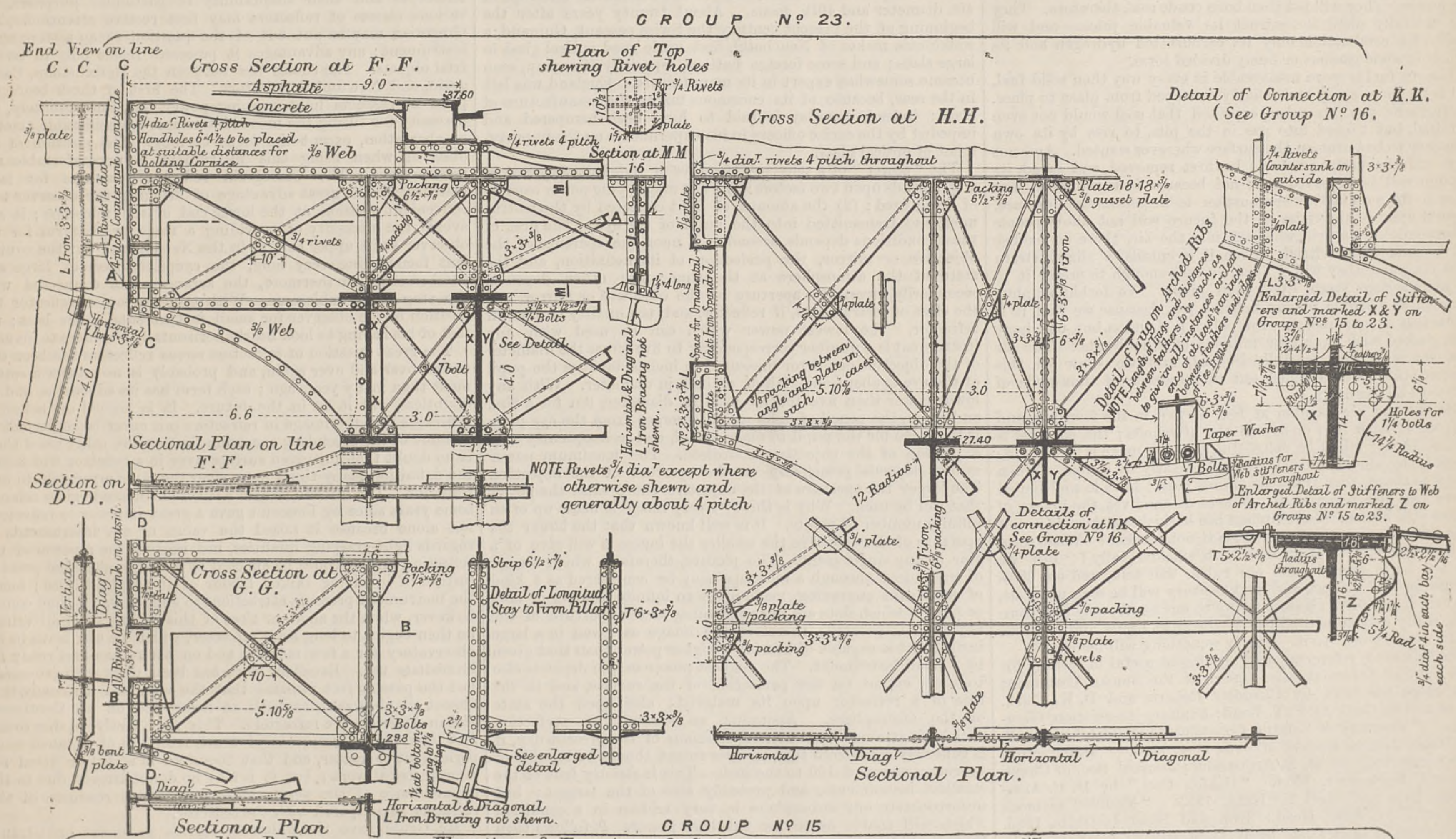
THE NEW BATTERSEA BRIDGE.—DETAILS.

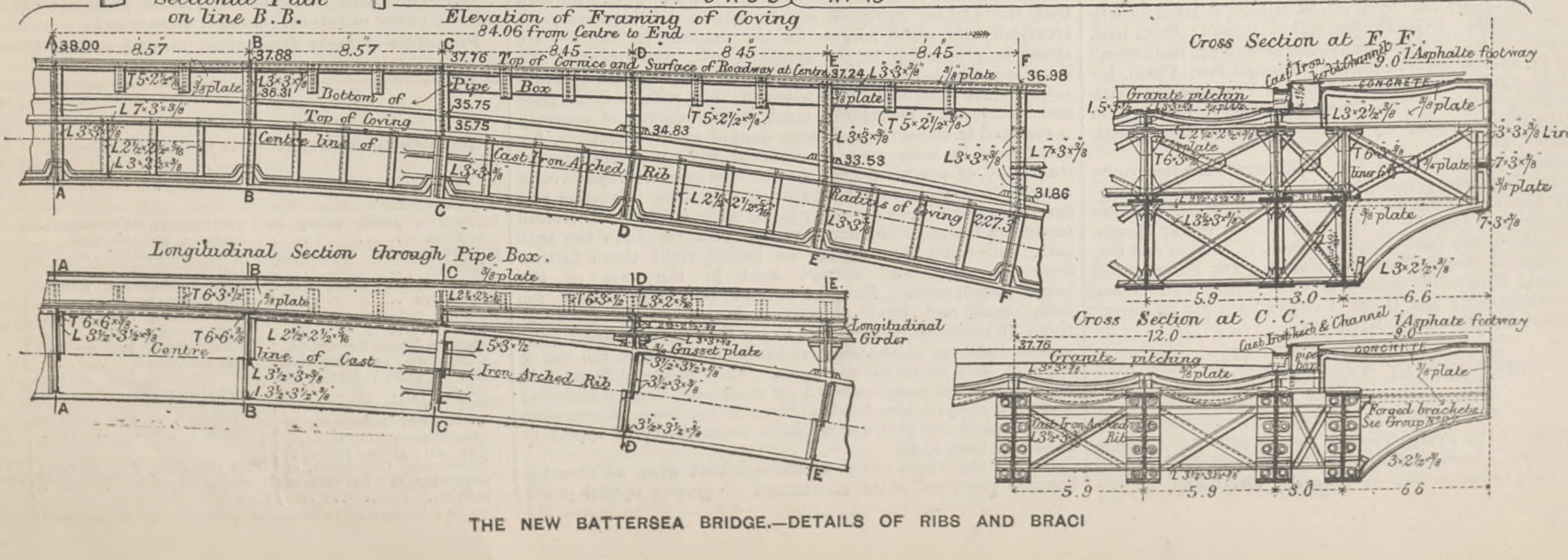
SIR JOSEPH BAZALGETTE, M.I.C.E., ENGINEER.

(For description see page 64.)



THE NEW BATTERSEA BRIDGE.—DETAILS OF CENTRE SPAN IRONWORK





THE NEW BATTERSEA BRIDGE.—DETAILS OF RIBS AND BRACI owing to the fact that no ordinary furnace can burn it. But picture to yourself a blast of hot air into which powdered coal is sifted from above like ground coffee, or like chaff in a threshing mill, and see how rapidly and completely it might burn. Fine dust in a flour mill is so combustible as to be explosive and dangerous, and Mr. Galloway has shown that many colliery explosions are due not to the presence of gas so much as the presence of fine coal dust suspended in the air. If only fine enough, then such dust is eminently combustible, and a blast containing it might become a veritable sheet of flame. [Blow lycopodium through a flame.] Feed the coal into a sort of coffee-mill, there let it be ground and carried forward by a blast to the furnace where it is to be burned. If the thing would work at all, almost any kind of refuse fuel could be burned—sawdust, tan, cinder heaps, organic rubbish of all kinds. The only condition is that it be fine enough.

Attempts in this direction have been made by Mr. T. R. Crampton, by Messrs. Whelpley and Storer, and by Mr. G. K. Stephenson; but a difficulty has presented itself which seems at present to be insuperable, that the slag fluxes the walls of the furnace, and at that high temperature destroys them. If it be feasible to keep the flame out of contact with solid surfaces, however, perhaps even this difficulty can be overcome.

Some success in blast burning of dust fuel has been attained in the more commonplace method of the blacksmith's forge, and a boiler furnace is arranged at Messrs. Donkin's works at Bermondsey on this principle. A pressure of about half an inch of water is produced by a fan and used to drive air through the bars into a chimney draw of another half-inch. The fire bars are protected from the high temperatures by having blades which dip into water, and so keep fairly cool. A totally different method of burning dust fuel by smouldering is attained in M. Perret's low temperature furnace by exposing the fuel in a series of broad, shallow trays to a gentle draught of air. The fuel is fed into the top of such a furnace, and either by raking or by shaking it descends occasionally, stage by stage, till it arrives at the bottom, where it is utterly inorganic and mere refuse. A beautiful earth-worm economy of the last dregs of combustible matter in any kind of refuse can thus be attained. Such methods of combustion as this, though valuable, are plainly of limited application; but for the great bulk of fuel consumption some gas-making process must be looked to. No crude combustion of solid fuel can give ultimate perfection.

Coal tar products, though not so expensive as they were some time back, are still too valuable entirely to waste, and the importance of exceedingly cheap and fertilising manure in the reclamation of waste lands and the improvement of soil is a question likely to become of the most supreme importance in this overcrowded island. Indeed, if we are to believe the social philosophers, the naturally fertile lands of the earth may before long become insufficient for the needs of the human race; and posterity may then be largely dependent for their daily bread upon the fertilising essences of the stored-up plants of the carboniferous epoch, just as we are largely dependent on the stored-up sunlight of that period for our light, our warmth, and our power. They will not then burn crude coal, therefore. They will carefully distil it—extract its valuable juices—and will supply for combustion only its carburetted hydrogen and its carbon in some gaseous or finely divided form.

Gaseous fuel is more manageable in every way than solid fuel, and is far more easily and reliably conveyed from place to place. Dr. Siemens, you remember, expected that coal would not even be raised, but turned into gas in the pits, to rise by its own buoyancy to be burnt on the surface wherever wanted. And not only will the useful products be first removed and saved, its sulphur will be removed too; not because it is valuable, but because its product of combustion is a poisonous nuisance. Depend upon it the cities of the future will not allow people to turn sulphurous acid wholesale into the air, there to oxidise and become oil of vitriol. Even if it entails a slight strain upon the purse they will, I hope, be wise enough to prefer it to the more serious strain upon their lungs. We forbid sulphur as much as possible in our lighting gas, because we find it is deleterious in our rooms. But what is London but one huge room packed with over four millions of inhabitants? The air of a city is limited, fearfully limited, and we allow all this horrible stuff to be belched out of hundreds of thousands of chimneys all day long.

Get up and see London at four or five in the morning, and compare it with four or five in the afternoon; the contrast is painful. A city might be delightful, but you make it loathsome; not only by smoke, indeed, but still greatly by smoke. When no one is about, then is the air almost pure; have it well fouled before you rise to enjoy it. Where no one lives the breeze of heaven still blows; where human life is thickest, there it is not fit to live. Is it not an anomaly, is it not farcical? What term is strong enough to stigmatise such suicidal folly? But we will not be in earnest, and our rulers will talk, and our lives will go on and go out, and next century will be soon upon us, and here is a reform gigantic, ready to our hands, easy to accomplish, really easy to accomplish if the right heads and vigorous means were devoted to it. Surely something will be done?

The following references may be found useful in seeking for more detailed information:—Report of the Smoke Abatement Committee for 1882, by Chandler Roberts and D. K. Clark. "How to Use Gas," by F. T. Bond; Sanitary Association, Gloucester. "Recovery of Volatile Constituents of Coal," by T. B. Lightfoot; Journal Society of Arts, May, 1883. "Manufacture of Gas from Oil," by H. E. Armstrong; Journal Soc. of Chem. Industry, September, 1884. "Coking Coal," by H. E. Armstrong; Iron and Steel Institute, 1885. "Modified Siemens Producer," by John Head; Iron and Steel Institute, 1885. "Utilisation of Dust Fuel," by W. G. McMillan; Journal Society of Arts, April, 1886. "Gas Producers," by Rowan; Proc. Inst. C.E., January, 1886. "Regenerative Furnaces with Radiation," and "On Producers," by F. Siemens; Journal Soc. Chem. Industry, July, 1885, and November, 1885. "Fireplace Construction," by Pridgin Teale; *The Builder*, February, 1886. "On Dissociation Temperatures," by Frederic Siemens; Royal Institution, May 7, 1886.

Diagrams or apparatus were lent to illustrate the lecture by the following firms and gentlemen:—Mr. Fletcher, of Warrington, many appliances; Mr. F. Siemens and Mr. Head, furnaces and gas generator; Captain Galton, the Galton grate; Messrs. Duncan Brothers, Sinclair's stoker; Messrs. B. Donkin and Co., Perret's furnaces; Messrs. Mintons, pottery oven; Messrs. Steel and Garland, Wharncliffe grate; Messrs. Brown and Green, bottom-stoking grate; Mr. B. H. Thwaite, twin gas producer; The Coalbrookdale Company, Kyrle fire.

THE ROYAL INSTITUTION.

ASTRONOMICAL TELESCOPES.

IN addition to the Friday evening lecture on "The Astronomical Telescope," already reported in these pages, Mr. Howard Grubb, F.R.S., delivered two on Saturday afternoons, at the Royal Institution, in which he gave utterance to the following particulars;—

Several countries have claimed the honour of the invention of the telescope, which so far, as decided by accurate historical basis, belongs to Holland; Galileo improved it; the claims for its invention by Roger Bacon and Democritus are purely of an inferential and speculative nature. The first telescopes were made with concave eye-pieces, and were called Galilean telescopes; Kepler afterwards suggested the convex eye-piece, and Gascoigne, an Englishman, took advantage of this in applying wires for sights; partly in consequence of this, and partly because they permitted a larger field of view, convex eye-pieces were adopted in the seventeenth century. The imperfections of these instruments induced Dr. James Gregory to make a telescope with a concave reflector instead of a convex refractor, and he published a description of the instrument in his *Optica Promota*, in 1663; his particular form of the instrument has ever since borne his name; the idea had been suggested before, but he first gave it a practical application. He thus completely removed the evils of chromatic aberration, but does not appear to have obtained improved definition, because he did not succeed in obtaining an optically true surface. Sir Isaac Newton, in consequence of a mistake, made the first good reflecting telescope; he had just discovered the unequal refrangibility of light, and seeing that this accounted for the coloured images of refracting telescopes, he tried various combinations of transparent substances to escape from the difficulty, and obtained but negative results; he therefore abandoned the refractor as incapable of improvement, and turned his attention to reflectors. After great labour he succeeded in making some good reflectors; one of them, which magnified thirty-one times, was in its day the marvel of the age, and was presented by him to the Royal Society in 1671. The Society still has it in its possession. Cassegrain subsequently improved the Gregorian telescope in some respects. Dolland, originally a weaver by trade, was led to the consideration of the improvement of the refracting telescope by a paper which the mathematician, Euler, communicated to the Berlin Academy in 1747, in which the possibility of making an achromatic combination was shadowed forth, and in 1753 a paper by Dolland was published in the "Philosophical Transactions" of the Royal Society, pointing out that Euler's paper did not agree with Newton's experiments. Some discrepancies between Newton's results and certain optical phenomena were about the same time pointed out by Klingenstierna, a Swedish mathematician. Dolland finally succeeded in making an achromatic object glass, thereby at once raising the refracting telescope from comparative obscurity; but unfortunately another difficulty stood in the way, namely, that of making optical glass sufficiently perfect, for as it was now possible to apply high powers to refracting telescopes, imperfections in the glass made their presence more sensible than before. At first, therefore, refracting telescopes were but of small sizes. Meanwhile the reflecting telescope advanced by strides in the hands of Sir William Herschel, culminating in the construction of his celebrated telescope of 4ft. diameter and 40ft. focus. About twenty years after the beginning of the present century the Swiss peasant, Guinand, a watch-case maker of Neuchatel, first made good optical glass in large slabs; and some foreign nations, especially Germany, soon became somewhat expert in its manufacture. England was left in the rear, because of its enormous tax on the manufacture of glass; indeed, Faraday is said to have been hampered and impeded by the excise officers in his experiments on the improvement of optical glass.

The "power" of a telescope is rather an indefinite expression, and depends upon two factors: (1) The magnifying power capable of being used; (2) the amount of light collected by the instrument and transmitted into the pupil of the eye. The first of these conditions depends, secondarily, upon the aperture of the objective or mirror, the perfection of its definition, and the state of the atmosphere at the time; the other depends, secondarily, upon the aperture of the objective or mirror, and the class of instruments, if reflector, and the quality of glass, if refractor. The lowest power which can be used with any instrument is a number corresponding to five times the diameter of the objective or mirror measured in inches, because the pupil of the eye is about one-fifth of an inch in diameter. With any lower power than five for an inch in diameter, ten for a 2in., and so on, the pencil of light which emerges from the eye-piece is too large for the pupil to make use of, and consequently only a portion of the objective is utilised. The maximum power usable depends principally on the aperture of the objective. The larger the aperture of the objective the greater the power that can be used. Why is this? Every image is made up of an infinite number of points. It is well known that the larger the aperture of the objective the smaller the image it will give of a star or any single point. The picture, therefore, which we see of any object through a telescope may be considered as a kind of mezzotint engraving, made up of an infinite number of dots or points, which dots are finer according as the aperture of the objective is greater; therefore the image as given in a large instrument is capable of bearing a higher power than that given by a small instrument. The highest power usable depends also to some extent on the perfection of the surface, and in the case of a refractor upon its material; also upon the state of the atmosphere. Assuming an amount of perfection such as is attained by the finest opticians of the present day, it is generally considered that an instrument should be capable of bearing a power of 100 to the inch. This is strictly true of the smallest instruments, and probably also of the largest; but unfortunately our atmosphere is very seldom in a condition which will enable us to use this high power. It follows then that the highest eye-piece of the largest telescope may be identically the same lens as for the smallest, for the foci are about in proportion to the aperture, and, consequently, the same lens which will give a power of 100 with one inch aperture and one foot focus will give a power of 2800 with a 28in. glass and 28ft. focus. Therefore a much greater degree of accuracy is required in the surface of large than of small objectives, for the image in both cases is observed with the same power magnifier, or eye-piece; but in the one case the rays have to traverse one foot, and in the other 28ft. after refraction and before coming to a focus. Any given error of surface therefore producing the same angular deviation of a ray from the true path, will cause that ray to be twenty-eight times further from its true and correct goal in the case of the larger instruments. But the rule of 100 to the inch for both small and large objectives is subject to qualification. It would be more correct to say that the rule holds good provided the eye of the observer has been trained to the use of large as well as small telescopes. What is the difference in character of the images formed by small and large telescopes? This is a subject about which there is not much information available, and one also about which most observers appear to have very hazy ideas.

He had often been struck by the fact that when an observer becomes possessed of an instrument of greater optical power than he has been accustomed to use, he is never, as far as Mr. Grubb's experience goes, satisfied with the performance of the larger instrument at first. When he was able to give opportunity to a great number of persons to observe with the Vienna 27in. refractor, of the three classes of persons who had that opportunity, viz., those who were not accustomed to habitually observe with any instrument, those who were constant observers with small, but not with large instruments, and those who were old, experienced observers with large as well as with small instruments—he found that the second class were the least satisfied with the appearance of the image in the large refractor. No doubt there was some reason for this. What, then, is the difference in character of the image itself as formed in the focus of a 3in. object glass, as compared with that formed by a 27in. object glass? Suppose an equal amount of perfection in both instruments:—(1) The image formed by the large instrument is, in the ordinary acceptance of the terms, more highly magnified, as the focus of the object glass is larger; and for this reason, and also because the column of air through which the rays pass is larger in diameter, atmospheric disturbances have much greater effect on the definition. Therefore, the larger the instrument the greater the number of nights in the year will it be useless, owing to want of homogeneity of the air. Everyone knows this, but hardly any but the most experienced observers appreciate the full extent of the difference. (2) The actual brilliancy of the image, if the object be a point or a star, will be nearly 80 times greater in the larger than in the smaller instruments. If we look at any small bright point through a minute hole, either with or without a magnifying lens, the appearance will vary very much, according as we increase or diminish the brilliancy of that star in point of light. Applying this principle to the present subject; if, in the case of the larger instruments, we have a space of light 80 times more brilliant than in the smaller, we must expect to have a much greater amount of light surrounding the star in the form of rings; and we cannot expect to see a bright star in a large telescope surrounded with one neat clear little ring, as we often see it in smaller instruments. There are two other reasons also why the increase of brilliancy will appear to add more to the light round the image than to the image itself. The first is due to the well-known fact that a given increase of brilliancy in a faint object is much more noticeable than in very bright objects. If there be only one small gas jet burning in a room, the addition of another makes the illumination sensibly twice as great; but if the room be already very brilliantly lighted, the addition of an equal quantity of lights will not produce a sensible effect. The increase of brilliancy in the faint illumination rings is therefore more appreciated than in the central disc itself, which was very brilliant, even with the smaller instrument. The other reason is that the central spurious disc is itself smaller in the large instrument, and therefore does not look as conspicuous in proportion to the surrounding lights as in the smaller instrument.

In considering the relative merits of the various classes of telescopes and their adaptability to particular purposes, the various classes of reflectors may first receive attention. The Gregorian may be put out of the question as an astronomical instrument; any advantages it possesses relate only to terrestrial objects. The choice lies between the Herschellian, Cassegrain, and Newtonian reflectors. The first of these bears the palm as respects light-grasping power, but, unfortunately, the necessity for tilting the mirror introduces a considerable amount of aberration, except the focus be long. The position of the observer when using this instrument is uncomfortable and inconvenient. The Cassegrain reflector possesses for large instruments the great advantage of bringing the observer to a convenient position at the lower end of the telescope; it also avoids the necessity of providing a stage or platform for the observer at its upper end, as in the Newtonian; but the equivalent focus being very long, the eyepiece becomes large and cumbersome; furthermore, the arrangements connected with the stop are troublesome. With the Newtonian reflector the position of the observer for small instruments is the best; the fact of his having to look nearly horizontally conduces to his ease.

The great question of refractors *versus* reflectors has been discussed over and over again, and probably is no nearer a settlement than many years ago; each form has its advocates, and so, doubtless, will it be in the future. It is argued on behalf of reflectors that the image in refractors can never be so perfect on account of the secondary spectrum, but on the other hand there is no doubt that any given surface error in a reflector will injure the definition many times more than the same error will do in a refractor. The introduction of a silvered surface to glass mirrors some years since by Foucault gave a great impetus to reflectors, not alone because it raised the value of the instruments as regards light-grasping qualities, but because the renewal of the reflecting surface could be effected by a simple chemical process, instead of involving skilled labour of the highest class; hence the instrument presents attractions to amateurs. A time comes, however, when the amateur tires of this process of re-silvering; he then begins to long for a refractor, which he can leave in his observatory for a few months, and on his return find ready for immediate use. Excellent work has been done with reflectors, but the patent fact remains that the standard instruments of almost all observatories, both at home and on the Continent, and in America, are refractors. This may partly be due to the fact that the adjustments of a refractor are of a much more permanent character, and that therefore it is better fitted for micrometrical work; but it is also no doubt largely due to the circumstance of the permanence and general readiness of the refractor as compared with the reflector.

Mr. Grubb gave the following figures as to the light-transmitting power of various classes of telescopes:—

Proportion of Light Transmitted through various Classes of Telescopes.

Description of telescope.	To be taken into account.	Approximate number of rays transmitted out of 100.
Refractors, small sizes, cemented	Two cemented, six uncemented surfaces, and absorption ..	68
Refractors, small sizes, uncemented	Eight uncemented surfaces and absorption	63
Refractors, large sizes, 12 to 20 apertures	Eight uncemented surfaces and absorption	60
Metallic reflector, Herschellian	One reflector, four surfaces, and absorption	52
Metallic reflector, Newtonian, Cassegrain, or Gregorian	Two reflectors, four surfaces, and absorption	27
Silver on glass reflector, Herschellian	One reflector, four surfaces and absorption	70
Silver on glass reflector, Newtonian, Cassegrain, or Gregorian	Two reflectors, four surfaces, and absorption	54
Silver on glass reflector, Newtonian, Cassegrain, or Gregorian, in a fair state of polish	Two reflectors, four surfaces, and absorption	48

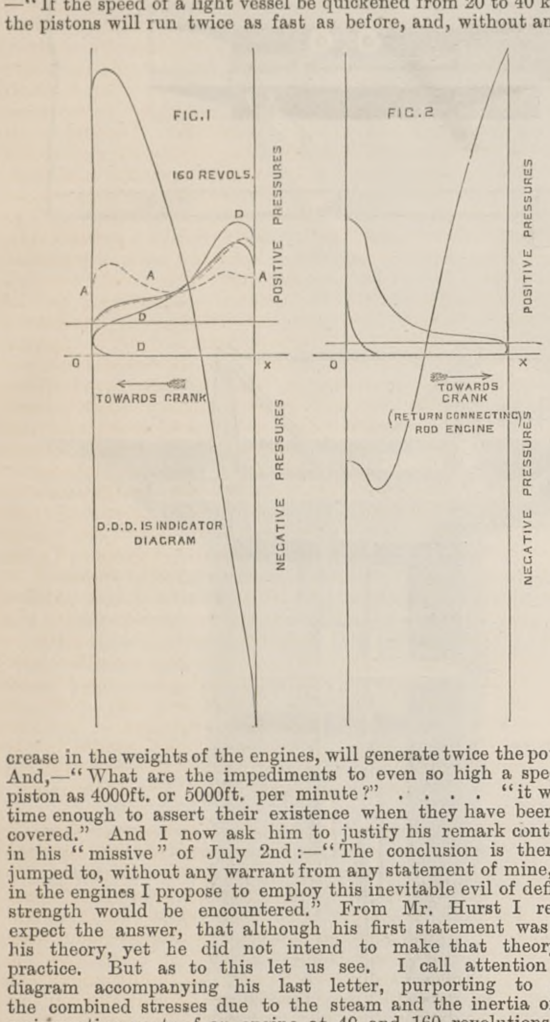
LETTERS TO THE EDITOR.

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

FORTY-KNOT SHIPS.

SIR,—I have no doubt that "in the judgment of the most discriminating portion of your readers" Mr. Hurst's latest contribution will be of itself quite sufficient to show the impracticability of his design for a ship to steam at 40 knots an hour. I may therefore dismiss the subject after having made the following observations.

I call Mr. Hurst's attention to his unqualified statements in his letters of May 28th and June 18th, wherein he states respectively:—"If the speed of a light vessel be quickened from 20 to 40 knots, the pistons will run twice as fast as before, and, without any in-



crease in the weights of the engines, will generate twice the power." And,—"What are the impediments to even so high a speed of piston as 4000ft. or 5000ft. per minute?" . . . . "it will be time enough to assert their existence when they have been discovered." And I now ask him to justify his remark contained in his "missive" of July 2nd:—"The conclusion is therefore jumped to, without any warrant from any statement of mine, that in the engines I propose to employ this inevitable evil of deficient strength would be encountered." From Mr. Hurst I readily expect the answer, that although his first statement was then his theory, yet he did not intend to make that theory his practice. But as to this let us see. I call attention to a diagram accompanying his last letter, purporting to show the combined stresses due to the steam and the inertia of the reciprocating parts of an engine at 40 and 160 revolutions, and remark that not only have the primary inertia curves been wrong in form, but also, assuming that the curve of resultant pressures for 40 revolutions—as represented by the light dotted curve—is correct, the curve denoted by A A A, which is meant to represent these combined stresses at 160 revolutions, should be displaced from the steam curve by sixteen times the displacements of the light dotted curve instead of two times, or a little more, as shown. The inertia stresses seem to have been taken as the square root instead of as the square of the angular velocity. The full lines in the accompanying figure therefore represent correctly the resultant stresses in the two conditions instead of the dotted lines, showing that the actual maximum combined stress exceeds by at least four times that given by Mr. Hurst. But, further, looking at Mr. Hurst's proposed engine, I first remark that a stress of 87 lb. per lb. of reciprocating parts, due to their inertia, assumes a connecting rod of infinite length, and that that quantity would require to be increased to about 105 lb. or 110 lb. to comply with such a length of connecting rod as it would only be rational to adopt. Mr. Hurst's ground for using simple engines, he tells us, is "that the energy of the moving parts finds its equalising counterpoise in the initial pressure of the steam." With a considerably smaller factor of safety than is generally adopted in the fastest running engines, the weight of the reciprocating parts will not be under 6 lb. per square inch of piston area; and the combined steam and inertia stresses will accordingly be of amounts as represented by diagram No. 2, showing that the maximum load on the main bearings will be at least $2\frac{3}{4}$ times that due to the maximum steam-load alone. Mr. Hurst's engines will therefore yet be too heavy; and to increase their weight still more, he proposes to fit on balance weights, whose chief advantage (?) would be to transfer the inertia stresses to that direction in which the shaft bearings are least suitable to withstand them. But again, his simple engines are to use steam at 200 lb. pressure, cut off at $\frac{1}{10}$in., giving an average pressure of 66 lb. per square inch. I pass over the 66 lb. m.p.—Mr. Hurst ought to have known better—to notice that his consumption of fuel will certainly not be under 4 lb. per indicated horse-power per hour. As his ship is to steam 3000 miles, the engines developing 44,480 indicated horse-power for $41\frac{1}{2}$ knots, or 47·8 miles, the weight of his coals will be $\frac{3000 \times 44{,}480}{47{\cdot}8 \times 2240} = 4990$ tons, while her total displacement is only 3360 tons. Thus the coals alone will sink her 12ft. below her load draught; and I venture to predict that in these circumstances the depth of the ocean bottom will be the only correct measure of her draught. I have used Mr. Hurst's estimate of power in the above calculation; but I must again inform him that "Reech's law" is as was stated by Mr. Mansell, and that his power by that law is much under-estimated.

I refrain from noticing Mr. Hurst's argument for the strength of his hull; here he has only shown incapacity to deal with this whole question. There is still much that is open to the gravest objection; notably, his return to simple engines exhausting to the condenser at an absolute pressure of about 15 lb. per square inch. I would have expected that in these days of triple expansion engines Mr. Hurst would have known something of their *raison d'être*. Again, we are informed that he has discovered some engines in which the centrifugal force at the crank-pin is greater than in the engine he proposes, though notably in the case of torpedo-boat engines the centrifugal force is much less. Presumably he has yet to learn that the relative lengths of connecting rod and crank radius alter the inertia stresses of the reciprocating parts so appreciably that his comparisons of centrifugal force are useless, and moreover serve no purpose since he neglects to give the variations of weight per indicated horse-power, with variations of these stresses. Mr. Hurst need never expect that an engine whose maximum stresses per square inch of piston area are three or four times those of another, can be made as light. Lastly, some extremely vague statements about the relative weights of engines running at the same piston speed are made. I suppose that Mr. Hurst intends to state that, in small and large engines running at the same piston speed, the weight per indicated horse-power of the former is a little larger than that of the latter; and if the stroke of the large engine is increased—the piston speed still remaining constant—a further small reduction of weight may be effected. This is quite true, but it is what neither I nor any other of your correspondents have doubted; on the contrary, it is what was pointed out to him. The case which applies to his proposed engines is that in which the revolutions of both small and large engines are constant. Here the number of times which the maximum stresses per square inch of cross-section of the reciprocating parts in the large engine exceeds those in the small engine is at least the square of the ratio in which the large engine is increased from the small one. Consequently, the large engine must be much heavier per indicated horse-power than the small one. Mr. Hurst has therefore evaded the point at issue. I have only again, and in fine, to repeat my former criticism of his designs. He is hopelessly wrong with his estimate of the weight of machinery—his coals alone sufficing to sink the ship—he is too light with his hull, and he yet misunderstands the estimation of power for the speed.

Edinburgh, July 13th. ALEXANDER CLEGHORN.

SIR,—No rejoinder having appeared to Mr. Hurst's letter upon this subject, I presume that the practicability of attaining some such speed as he has indicated with some such power as he has prescribed is now generally recognised and admitted. This being so, it becomes expedient to call attention to the other points of his paper in which the high speed of forty knots was merely one of the incidents claiming public attention. His design was to show how a navy far more efficient than our existing navy might be maintained at far less than the existing cost, and this end was to be accomplished by holding out inducements to steamship owners to provide a class of vessels having a very high speed which in times of peace would be available for carrying the mails and for commercial objects, but which in the event of war should be placed at the disposal of the Admiralty for purposes of defence or aggression on predetermined terms. Lord Charles Beresford has, I observe, quite recently propounded the same idea, which has also the high sanction of Mr. Barnaby's authority, and there appears to be little doubt that the reasons for the adoption of this course are so numerous and forcible that it must before long be adopted.

High-speed vessels must necessarily be light vessels. But in order that their powers of offence may be great, it is necessary that they shall carry very powerful guns, and very powerful guns of the ordinary type are necessarily very heavy. Mr. Hurst, therefore, proposed in his paper that the guns used should be rocket guns, as on this principle of action power and lightness would be reconciled. It is impossible to construct guns of the ordinary character but of very large dimensions in which the metal will not be overstrained. With rocket guns only a small part of the gunpowder is burnt in the gun itself, producing only a very moderate amount of strain; and although this small charge would of itself be insufficient to give a long range, it gives sufficient velocity to the projectile to enable the rocket composition to maintain the flight with little loss from slip.

Another matter dealt with in Mr. Hurst's paper was the production of sound castings in steel and wrought iron by employing a new method in the manufacture of guns. The Rodman system could be introduced, which has heretofore been applicable only to cast iron guns, and consists in cooling the gun from the inside while the outside is kept hot. JAMES C. PAULSON.

Chiswick, W., July 19th.

THE FRAMING OF IRON AND STEEL SHIPS.

SIR,—With reference to your article upon this subject, allow me to state that, in my judgment, the frames of iron and steel ships should be horizontal. Nor is the reason for this conclusion far to seek. The strength of any structure is measurable by the strength of its weakest part. It is in the transverse direction that iron and steel ships have shown most weakness, and it is in that direction they should consequently be strengthened by such reinforcement as only horizontal frames will give. Many iron ships have broken through the middle—some from getting aground on an uneven surface where they were deserted by the tide, while others have cracked down the sides at sea. But I have never heard of any iron vessel breaking horizontally, and vertical frames needlessly recruit the strength in that direction.

When I first began to build iron ships on the Clyde, in 1852, the frames were invariably vertical, and were of heavy scantling, and set very close together. The Persia, which was regarded as the most favourable specimen of Clyde design about this epoch, had the frames set 18in. apart, and the angle irons of which they were formed and the reverse bars together formed a belt of such width that one could hardly see between the frames when looking upon the side of the ship. The first vessel I constructed had also vertical frames, but they were of light scantling, and were set 3ft. apart. The material thus saved was expended in forming the vessel with an iron deck beneath the wooden one, and also with a double bottom. Some few years afterwards I saw both of these vessels in dock at Liverpool. In the Persia thousands of rivets were being cut out, which had worked loose from the great strain to which they had been subjected, and the sides had also cracked down for some distance during a rough Atlantic voyage, so that the vessel had a narrow escape from being lost. In the light vessel formed with a double bottom and iron deck not a rivet was defective, and no repair of any kind was required, though the vessel had been performing very heavy work in the Black Sea during the whole of the Crimean War. In wooden ships many strong ribs are needed, as there is nothing else to keep the edges of the planking together. But in iron vessels the edges of the plates are rivetted to one another, which constitutes a sufficient and far firmer connection. If the frames of the Persia had been horizontal she would not have cracked down the sides at sea, whereas vertical frames do nothing to hinder this. The most important additional element of strength in modern iron vessels, however, is the iron deck upon which the wooden deck is laid. But this innovation was long resisted. I gave several lectures upon the subject more than thirty years ago, at the Mechanics' Institute in Greenock, and had ten models of vessels constructed with and without metal decks, to illustrate the doctrine that in iron ships iron decks were indispensable to obtain the greatest strength with the least materials. The models were first weighed, and then broken, as a beam, by the application of a heavy load, so that the strength of the two could be readily compared. Nevertheless, it was only by slow degrees that the method of constructing vessels with iron decks came into use. Much credit is due to Mr. Brunel for having been amongst the first to discern the advantages of the system, which was very skilfully and effectually applied by him in the case of the Great Eastern—a vessel which, so far as the hull is concerned, must be regarded as the most perfect iron vessel that has yet been built.

Such are some of the reasons which may be recited for constructing iron vessels with horizontal instead of vertical frames. There is still another reason of perhaps still greater cogency, which is not now generally discerned, and which I will not dwell upon now. This reason, however, I may explain in a subsequent letter, should you consider the present one worthy of insertion in your pages.

Sunnyside, Chiswick, July 19th. JOHN BOURNE.

ARRANGEMENT OF STATIONARY ENGINES WITH CONDENSERS.

SIR,—In the arrangement of stationary compound, tandem, or single cylinder horizontal engines, there is sometimes a difficulty as to the best position and mode of working the air-pump. Some engineers prefer placing it below, at the front end of low-pressure cylinder, so as to allow of its being worked from the end of crank-pin and by a connecting-rod to the L lever on the working shaft. Others again place it in this same position, but work it from the piston-rod crosshead, by means of links, and L lever direct. In some engines it is behind the high-pressure cylinder, and worked from piston-rod cap by means of a straight lever, giving motion to a rod passing under cylinders to the said L lever on cross or rocking shaft. Two air pumps, with one condenser between, are used, and worked in the way last described. A better vacuum is claimed in this case, and, through the pumps being balanced, a steadier motion. Double-acting horizontal pumps, placed under and in line with the cylinder, worked by an arm from the piston crosshead, have given good results; but the position of the valves, coupled with the difficulty when repairs are required, prevent their being more generally adopted.

In drawing attention to some of the plans so well known, I hope it may produce an expression of opinion from some of your able correspondents as to the best arrangement, and I trust you will consider the subject worth the space required in your columns.

Rochdale, July 19th. THOMAS S. SAWYER.

HYDRAULIC PROPULSION.

SIR,—Having recently seen some letters in THE ENGINEER relative to hydraulic propulsion of vessels, and having some years ago put an hydraulic propeller in a bluff-bowed canal boat 60ft. long and 13ft. beam as an experiment, must be my excuse for now writing you. I have had this boat loaded with 60 tons on board—the sides of the boat not being more than 5in. above water—and propelled it from three to four miles an hour with about 3-horse power—I was not allowed to drive it any quicker. There was no commotion in the water in the wake of the boat except a few bubbles some yards astern; in fact, it was a success, but circumstances occurred that prevented me from following it up. But I can safely say from experiments I made with this boat and a large model, that I could fit up boats either for speed or towing purposes that would take the shine out of anything afloat. If anything crops up about hydraulic propulsion the Waterwitch is at once instanced as to the failure of the hydraulic principle as applied to the propulsion of vessels, but the wonder to me is that they got the speed out of her that they did. I am an engineer, and have always found an ounce of practice worth a ton of theory. To conclude, and taking into consideration the immense advantages that would accrue from hydraulic propulsion, I cannot but think that it must come to the front yet, as by this plan only can a great speed be got with a small consumption of fuel. The following are some of the advantages to be got by using a perfect hydraulic propeller:—(1) It will propel, no matter how the vessel pitches or rolls. (2) For war ships there is nothing outside the vessel that can be injured. (3) In the event of a leak from any cause the propelling machinery would pump out the water and propel at the same time. (4) For canal boats it would be the very thing, as it would not injure the banks. (5) The machinery would be much simpler than for a screw boat, and would cost less and be more economical. (6) More speed could be got by this method of propulsion than by any other. (7) A vessel can be turned in its own length. (8) A vessel can be steered by this propeller. (9) As an auxiliary on sailing ships for long voyages it would be invaluable. (10) Any vessel, either sailing or steamship, can be altered to this principle. GOAHEAD.

London, July 20th.

FEED-WATER HEATERS AT NORWICH.

SIR,—In your notice of machinery at the Royal Agricultural Society at Norwich, pages 43 and 44, of your issue of July 16th, you illustrate and describe a feed-water heater attached to a traction crane engine, by Messrs. Charles Burrell and Sons, of Thetford. The description states that "The cold water from the pump enters the coils on both sides at the top, and passes out at the bottom to the clack-box at considerably above the boiling temperature. When the engine is running empty the temperature stands at 200, and with the work full on it rises to 250 deg."

As the patentee, and as representing the makers of what we claim to be the most efficient heater, I hope you will allow me to make a few remarks upon such a performance as that mentioned above. The heating pipes are entirely enclosed in a space filled with the exhaust steam, and all the heat transmitted to the water in the heating pipes must be obtained directly from the steam surrounding them. In such a limited space it is impossible to get a very large amount of heating surface; consequently the final temperature of the feed-water must be considerably less than the mean temperature of the exhaust steam—certainly 5 deg. Fah. Exhaust steam from a small engine of this description is certain to be loaded with water in suspension, and consequently at a temperature exactly corresponding to its pressure. In heating the feed-water about one-fifth of its bulk will be condensed on the heating pipes; so it is evident that to obtain a temperature of 250 deg. in the feed-water, the steam supplying the heat, if in presence of condensed water, must be at least 255 deg. mean temperature, corresponding to a mean pressure of about 18 lb. above the atmosphere; *i.e.*, to obtain this temperature the engine must work with a mean back pressure of 18 lb.

It is also stated that the feed-heater is fixed to the base of the chimney "in such a manner as to utilise a portion of the heat from the smoke-box." As near as I can measure it, there is about five square feet of heating surface, which is vertical and only exposed to chimney heat; before this heat could do an atom of good it would have to evaporate the water held in suspension in the exhaust steam, and re-evaporate all the steam condensed on the heating pipes; so it is obvious that this can have no effect whatever on the final temperature of the feed-water, and the result will be identically the same as if the heating pipes were placed elsewhere away from the chimney.

JAMES ATKINSON, Managing Director.

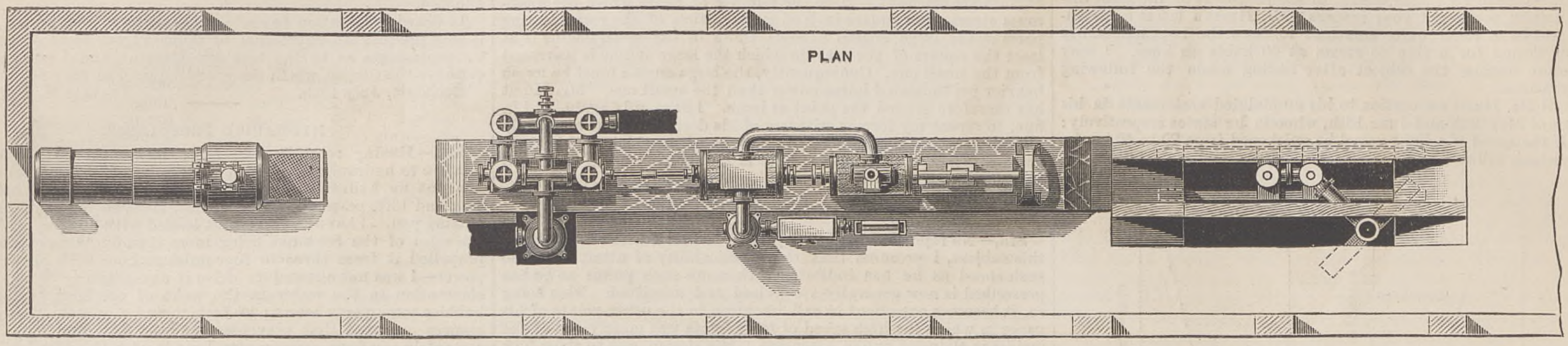
The British Gas Engine and Engineering Company,
Albion Works, Gospel Oak, London, N.W.
July 20th.

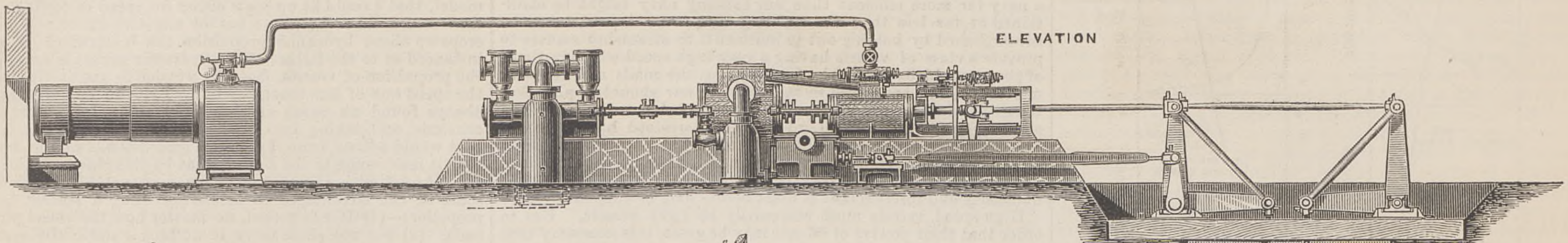
TRADE IN THE NORTH.—On the 14th inst. the members of the North of England Institute of Mining and Mechanical Engineers visited Cleveland in order to inspect the ironstone mines of Messrs. Bell Brothers; the party afterwards adjourned to the Alexandra Hotel, Saltburn, and had luncheon, the chair being occupied by Mr. John Rogerson, one of the directors of the new Manchester Ship Canal. Sir Lothian Bell was also present, and made a few remarks in reply to a vote of thanks unanimously accorded him for the facilities he had afforded during the day. Sir Lothian Bell took a decidedly gloomy view of the prospects of the iron trade. He said that iron was now being sold in large quantities at a price which could only involve loss. If something was not done to bring the trade of the district more into harmony with sound commercial principles disastrous consequences would certainly ensue. At present, he thought that capital was being employed injudiciously, and that the most was not being made of the valuable material produced.

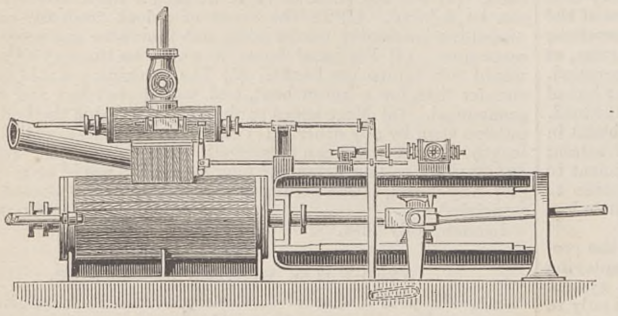
PETROLEUM VESSELS.—Vessels specially arranged for the petroleum trade have already been made by Messrs. R. Craggs and Sons, of Middlesbrough, and Messrs. William Gray and Co., of Hartlepool, and are understood to be answering fully the expectations of their owners. The example appears now to have been followed on the Tyne. A steamer called the Glückauf has been built at the yard of Messrs. Armstrong, Mitchell, and Co., for the same purpose, and is destined to trade between America and Europe. She is 300ft. long, and of a capacity of 3000 tons dead weight, fuel included. The internal arrangements, as regards tanks, are similar to those of her predecessors. The principal difficulties to be met are:—Firstly, the tendency of the crude petroleum to expand with any increase of temperature; and secondly, its liability to give off by volatilisation vapours which might become ignited and explode. These dangers are met by connecting the oil tanks one with another, and by furnishing them with ventilating pipes. The Glückauf left the Tyne on Tuesday week for New York, where she will take in her first cargo of petroleum for transport to Europe.

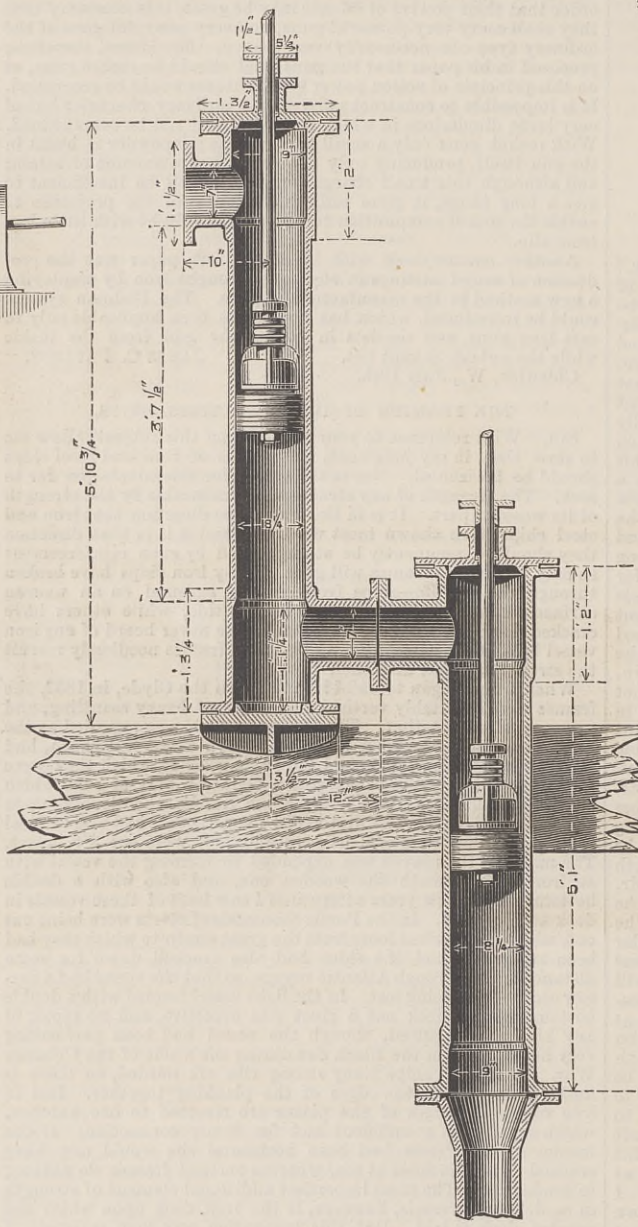
THE MALTA WATERWORKS.—COMPOUND PUMPING ENGINE AND PUMPS.

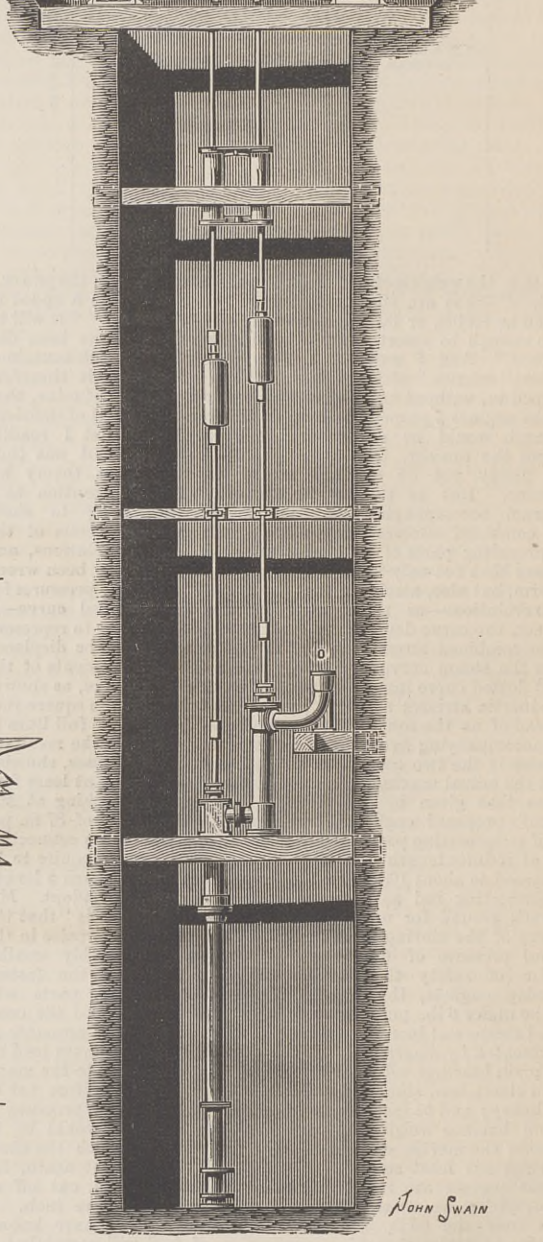
MESSRS. HATHORN, DAVEY, AND CO., LEEDS, ENGINEERS.











COMPOUND PUMPING ENGINE, MALTA WATERWORKS.

THE accompanying engravings illustrate a compound pumping engine and pumps made by Messrs. Hathorn, Davey, and Co., Leeds, for the water supply works of Malta. These engravings may be taken as illustrations of good examples of plant for small waterworks. They include the complete plan and elevation of the engine and pumps, and also a section of the well pumps. The latter show that the water is first pumped from a well to the ground level into a reservoir, and from this it is forced to a higher elevation by means of a double-acting force-pump. The rising main from the well pumps at O is not shown in the engraving, but it will be gathered that the main from O carries the water to the reservoir mentioned, and that the double-acting force pump is that shown at the rear of the engine. A side elevation of the valve gear is given in the enlarged view above. The air pump of the engine condenser is worked off the rocking arm shaft by means of a rod on a separate arm. The pumping engine is fitted with Davey's differential valve gear, as shown in the larger view of that part of the engine. The pumps are of Davey's simple type, and need no description.

THE MEAT SHIP SELEMBRIA.

THE importation of frozen meat to this country continues to increase, and the recent arrival in the East India Docks of a cargo of over 30,000 frozen carcases of mutton—in excellent condition—is the latest, and, as yet, the most extensive contribution that has been made in the form of a single cargo to the meat supply of this country. This has been brought by the steamer Selembria, from the Falkland Islands. It is noteworthy that East Falkland was only colonised by British subjects in 1853, and West Falkland in 1861; and that there are now nearly 600,000 sheep in the islands. Those brought over average from 60 lb. to 70 lb. each, and sales were effected of portions of the cargo at over 5d. per pound. The s.s. Selembria, chartered by the Falkland Islands Meat Company, which has entered into agreements with the owners of sheep for the supply of 60,000 per annum, is a steamer of 3041 tons register, and was fitted out completely by Messrs. J. and E. Hall, of Dartford and London, for this trade, with more powerful refrigerating machinery than any other steamer afloat.

In the after part of the forward 'tween decks are placed four of Messrs. Hall's 70,000ft. refrigerators, made under Ellis's patent. The machines are athwartship, two on either side, and conveniently arranged for access and manipulation. All the machines are connected to the two main boilers of the ship, and also to an auxiliary one of sufficient size and power to drive two of the machines. The necessary valves are fitted so as to permit any machine being driven by any boiler. The three cylinders of the machines are arranged side by side and fixed to a foundation frame, which is provided with a slipper guide in the centre for the compression crosshead, and bored guides on the outside for the other two crossheads. This frame is bolted on to the top of three cast iron boxes, which are fitted as surface condenser, tubular water cooler, and tubular air cooler respectively. The crank shaft has a single throw in the centre with two outside crank pins, one at either end, fixed into the fly-wheel, and on which the steam and air expansion cylinders work, the angular position of these crank pins are similar and at such an angle with the compression crank that is the best to give an equable turning effort, and to enable all the main and cut-off valves to be worked by two excentrics only. All the slide valves are balanced, the pressure being on the inside and exhausting at the outside edges. As a consequence of this arrangement there are no stuffing boxes required for the valves and spindles when they pass through the cast iron casings containing the valves. The pumps, which are horizontal, are fixed at the steam cylinder side of the bed, and worked by a rocking lever, attached by means of a link to the crosshead pin, immediately above it. The pumps are combined in one casing, which is divided into two—one half acting as the air, and the other as the circulating pump; the feed pump being worked by a prolongation of the main-pump rod at the back. The air, after being compressed, passes to the water-cooler, where it is cooled by the circulating water, after which it goes to the air cooler, where its temperature is still further reduced by the circulation of the waste cold air from the chambers; and thence on to the expansion cylinder. The waste or expelled air from the chambers, after passing through the air cooler is drawn into the compression cylinder with fresh air from the engine-room. The approximate capacity of the chamber is such as to hold about 950 to 1000 tons, or 30,000 carcases of mutton. The whole of the two forward main holds, the forward of the after one, and the 'tween decks, both fore and after, are utilised for the chambers. The forward 'tween decks, which are divided into two transversely, immediately above the dividing bulkheads of the main hold, are fitted with hanging arrangements for the purpose of freezing the carcases on board, each chamber acting as a freezing room while the other is being discharged into the hold below, and *vice versâ*. The installation was superintended by Mr. George A. Goodwin, Westminster, as consulting engineer to the company.

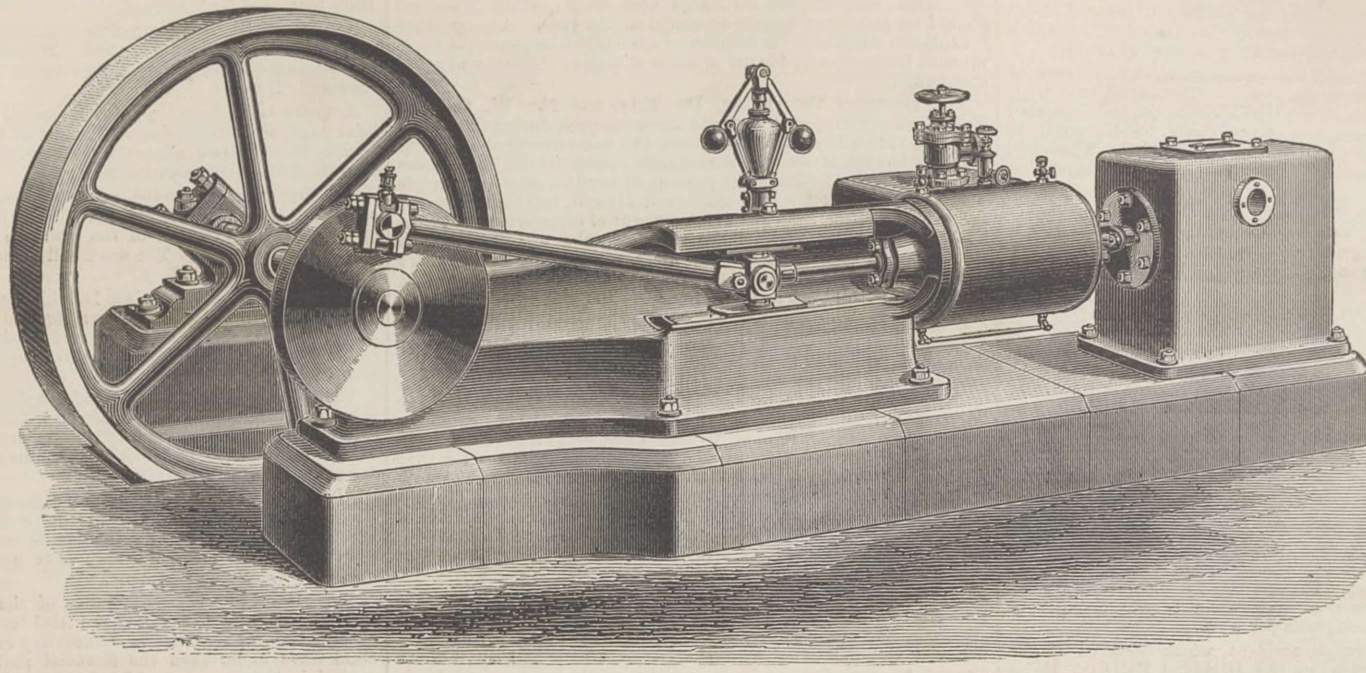
The s.s. Selembria left England in December last, and would, in the ordinary course, have returned in April but for the preparations that it was necessary to make in the first instance before the meat could be shipped, as no labour or materials were to be found on the other side. Thus, it was necessary to take out a staff of butchers to deal with the meat in the first instance, stevedores to stow away the carcases in the lower hold as soon as they were frozen—this latter operation being carried out in the 'tween decks—and mechanics to erect the necessary buildings, tramways, and derricks at the three principal ports where the meat is obtained, all this plant being taken out in the ship. The colonists have hitherto contented themselves with what they could realise with the wool, skins, and tallow to be obtained from their sheep; but now, in consequence of this most recent development in refrigerating machinery by means of cold dry air, they will be able to send their mutton to the English market not only to their own advantage but also to that of the consumers over here, and there appears to be every reason to expect that the enterprise, which has been entered into in so complete and practical a manner, will result successfully.

BEAM PUMPING ENGINES—MIDDLESEX WATERWORKS.

As a supplement, we this week publish a two-page engraving of a very fine beam pumping engine, lately constructed for the Middlesex Waterworks by Messrs. James Simpson and Co., in their engine works, Grosvenor Road, Pimlico. With these engines some of the most economical results ever achieved have been obtained, and we are glad to be able to place before our readers the engravings now published, which will be followed by details and descriptive particulars.

NAVAL ENGINEER APPOINTMENTS.—The following appointments have been made at the Admiralty:—Alfred Waters, fleet engineer, to the Asia, for the Neptune, when paid off; John J. Carey, engineer, to the Asia, for the Neptune, when paid off; John Richardson, assistant engineer, to the Hecla; H. C. M'Lean, assistant engineer, to the Asia, for the Neptune, when paid off.

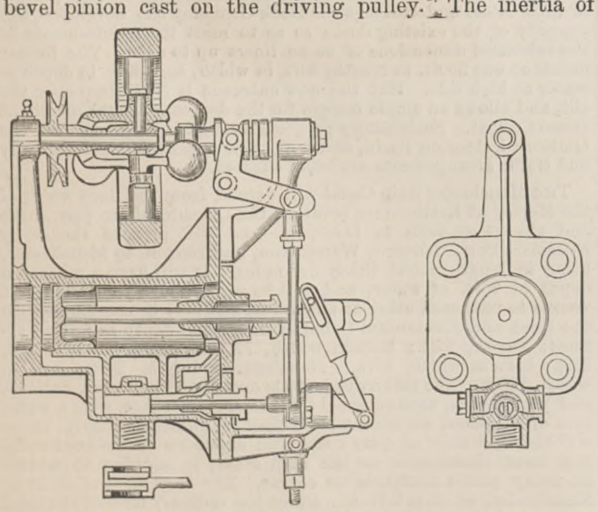
HORIZONTAL CONDENSING ENGINE.—EDINBURGH EXHIBITION.



THE EDINBURGH INTERNATIONAL EXHIBITION.

No. VII.

THE condensing engine illustrated by the accompanying engravings is exhibited in the Edinburgh Exhibition by Mr. John Cochrane, of the Grahamstone Foundry, Barrhead. The engine is of 8-horse power nominal, and has a 9in. cylinder, with 18in. stroke, and makes 100 revolutions per minute. It is fitted with automatic cut-off, as shown by the engravings, Figs. 1-4, Figs. 1 and 2 show the curved face of the valve and valve face respectively, as they would be if developed or flattened out. It will be at once understood that the partial revolution of the valve by the governor causes the V-shaped valve to cover more or less of the V-placed ports of the cylinder or of the exhaust valve. The annexed diagram is from the engine running empty. It tells its own tale. The engine is of good design and workmanship. The accompanying engravings illustrate Murdoch's combination governor for marine engines, as made by Mr. Cochrane. Its purpose specially is the prevention of racing of marine engines, but it can be used for regulating land engines where the power required is great, in an improved manner, by making the governor of a small sensitive type balanced so that the motion of the ship pitching or rolling has no effect on the governing principle. It is driven by a rope or belt from the main engines, and adjusted so that any increase of speed partially or entirely closes the throttle valve. From the section it will be seen that it consists of a very small fly-wheel, combined with four balls running loose on a spindle and driven by a bevel pinion cast on the driving pulley. The inertia of



MURDOCK'S MARINE GOVERNOR.

the fly-wheel allows the bevel pinion to overrun it on any increase of speed, and the acquired centrifugal force in the balls maintains the position. This movement gives a lateral motion to the sleeve, which motion is communicated to the steam cylinder valve spindle, opening to the steam and exhaust passages, whereby the piston in the cylinder is moved out or in, and being connected to the throttle valve of the main engines, it is closed or opened as required. The valve is a small hollow cylinder with a longitudinal partition, which divides it into two compartments, the one open to the top and the other to the bottom of the steam cylinder; there is a helical port cut in each compartment. The angular motion received from the governor opens one end of the cylinder to the steam and the other to the exhaust, causing the piston to move. This motion of the piston gives a lateral motion to the valve cutting of the steam and exhaust in proportion to the amount of angular movement caused by the governor; so that whatever movement is given by the governor to the small valve is followed by a similar proportional movement of the piston in the steam cylinder and communicated to the main throttle valve. The means of adjustment are very simple,

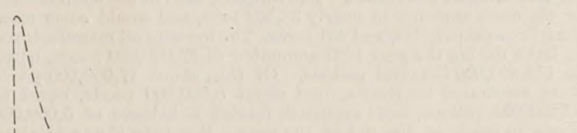


DIAGRAM FROM COCHRANE S ENGINE.

and can be effected while the machine is running. It has been fitted to twelve of her Majesty's ships and to about four hundred merchant ships, giving most satisfactory results.

The name of the inventor of the valve gear described last week was incorrectly given as Swain, instead of Swan.

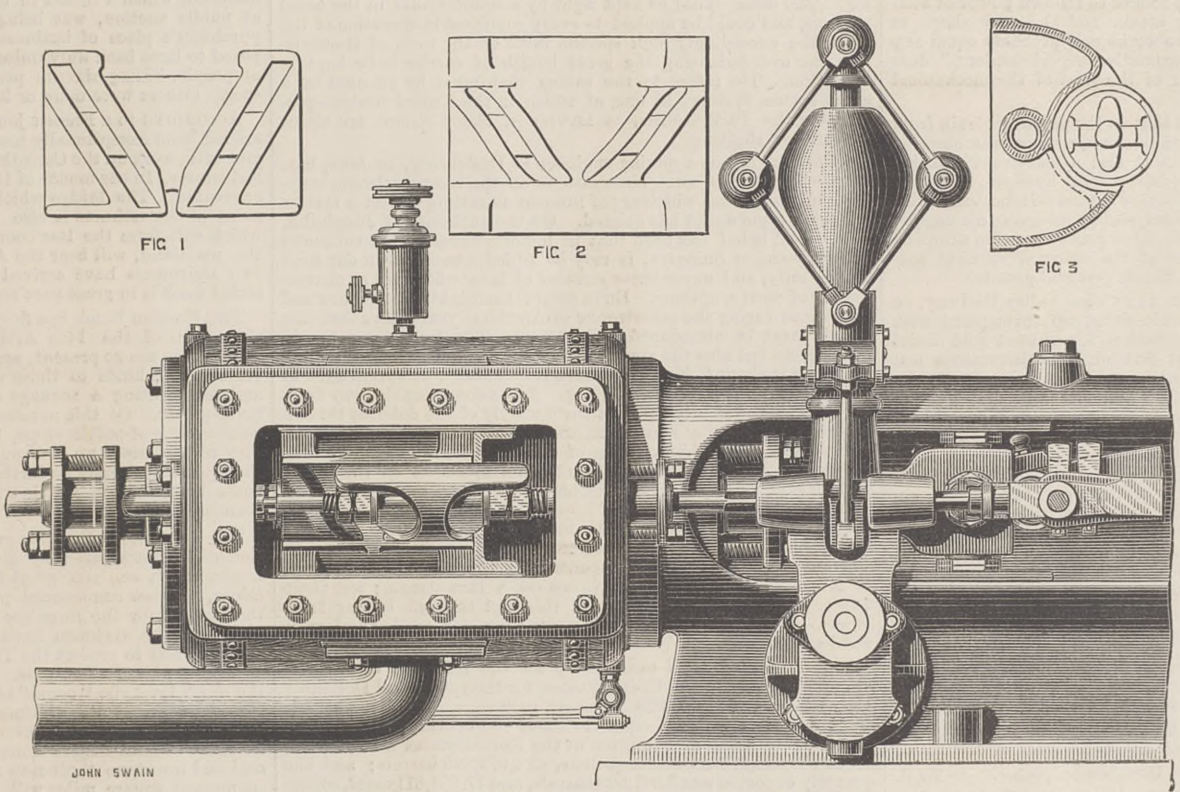
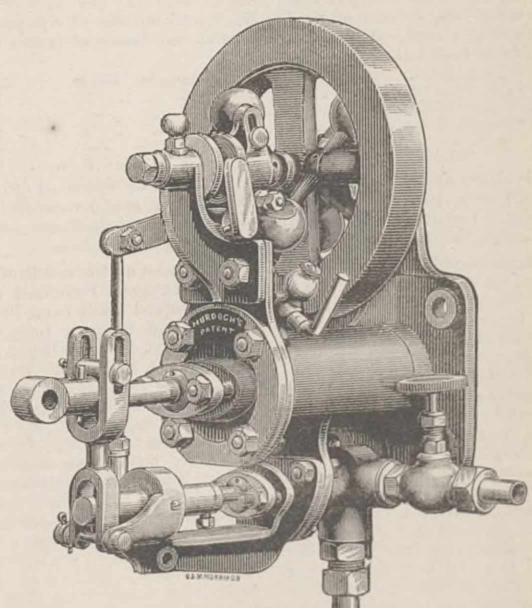


Fig. 4—VALVE AND GOVERNOR OF COCHRANE'S ENGINE.

THE DUSTBIN.

THE head of the engineering department of the Local Government Board, Sir Robert Rawlinson, has the highest possible opinion of the importance of scavenging and of the dangers of neglected dustbins; but he does not seem to have impressed the suburban authorities with the same salutary ideas, for there are districts just outside the four-mile radius from the centre of London where dustbins are not only dangerously neglected by the local vestries, but where even when they are not neglected by the vestries or their contractors, the collection of house refuse is supposed to be sufficiently frequent if it is made once a fortnight. It would be interesting to know whether the Local Government Board consider a fourteen days' collection of rubbish and refuse from a moderate-sized household to be likely to conduce to the sanitary welfare of those in the house. In winter there may be no objection to it, but in the hot weather which we have, fortunately in other respects, had with us lately with but slight intermission, it is calculated to have the worst effects. In summer there is in most houses but one fire, namely, the kitchen fire, to make ashes; whilst, on the other hand, the vegetable and other rapidly decomposing materials are in greater quantities. Hence the necessity for more frequent removal in the summer. To reduce the evil effect of the gases arising from the decomposing rubbish it has been suggested that the ashes should be kept separately from the vegetable and animal refuse; but a correspondent, who calls attention to this subject, says that he has tried the covered galvanised receptacle for the latter, with the result that, at the present time, matters are worse than ever. The ashbin receives but a small daily addition and is perfectly harmless, but the galvanised receptacle is after a week so noisome a producer of foul gases that servants can hardly be induced to raise the cover to add to its contents. This being the case, he is worse off than when only the common brick, wood covered, dust bin was used, and in this dilemma asks what is to be done and to whom he must appeal for a satisfactory solution of a difficulty which, if not removed, will be productive of serious effects on the health of large numbers of people. We can only say that a fortnight is certainly too long a time between each collection, and ought to be reduced to one half this in the summer time. Inhabitants have to pay for the collection at proper times, and local authorities and officers cannot expect that shortcomings on so important and yet so simple a matter can be continually overlooked, and contractors allowed to shirk the work for which they are paid. Scavenging, as Sir Robert Rawlinson insists, is the first and chiefest necessity; but this view needs to be impressed by the Local Government Board upon the local authorities. Concerning the use of the galvanised vegetable and animal refuse receptacle, it may be questioned whether this is



MURDOCK'S MARINE GOVERNOR.

not of necessity productive of more harm than good in summer, for it is usually small in area as compared with the brick dustbin, and decomposition is favoured by the closeness with which the refuse is packed and the greater heat of the foul atmosphere in the metallic box.

RAILWAY MATTERS.

THE Transcaspian Railway to Merv has been completed, and was opened for traffic on the 14th inst.

A BOARD has been appointed by the South Australian Cabinet to inquire into the late railway accident at Islington, by which damage amounting to £1200 was caused by a runaway engine.

THE Sofia Chamber continued the discussion on the 19th inst. of the Ministerial Bill for the purchase of the Rustchuk-Varna Railway, and agreed to the proposals of the Government, and appointed a special committee to examine the arrangement for the purchase of the railway, and to make a report to the Chamber. This vote, it is said, ensures the ratification by the Chamber of the concluded agreement.

THE first through train to Vancouver over the Canadian Pacific Railway was composed of two baggage, mail, and express cars, a second-class car, two immigrant sleepers, two first-class cars, two sleeping cars, and a dining car. There were 140 passengers on the train. The company intend to attach refrigerators to their freight trains, and to deliver frozen salmon in Toronto from Vancouver for 1c. per pound.

THE Russian Government has again under consideration the scheme for constructing a railway across the Caucasus. It provides for a line from Darg-Koch to Gori, 183 versts in length, of which seventeen versts are tunnels. The longest of these will be six versts. The cost of the line is estimated at about forty million roubles, and the construction to take five or six years. The railway will be of great commercial as well as strategic value to Southern Russia.

ON the 15th the directors of the Barry Dock and Railways visited the works, accompanied by the resident engineer, Mr. John Robinson, M.I.C.E. They inspected the Ely Viaduct, the arches of which are now being turned, and many of the bridges, which are fast approaching completion. The masonry for the dock basin has been commenced, and the dock excavation is progressing very rapidly, at about 50,000 cubic yards per week.

IN concluding a report on an accident which occurred on the 1st June, near Brora station, on the Highland Railway, Major Marindin says:—"As to mixed trains, it is becoming almost wearisome to reiterate the statement that the practice is one condemned by the Board of Trade, but I must again record my opinion that no wagon should be allowed, under any circumstances, to be placed in a train in front of passenger carriages, unless it be one specially constructed and fitted for running in passenger trains."

WE understand that Mr. J. A. F. Aspinall, of the Inchicore Works, has been appointed chief mechanical engineer of the Lancashire and Yorkshire Railway. It appears that the company intends to increase its works, so as to add to its own power of self-supply of materials and rolling stock, and the new shops at Holwich are very extensive. These works will probably equal any in the kingdom, and the title "locomotive superintendent" does not cover the comprehensive duties of the chief of the mechanical operations of so large a concern.

THE *Amsterdam Courier* reports that as the passenger train from Essen was approaching Winterswyk station, a train was shunted across the main line just in front of it, and a disastrous collision appeared inevitable. The engine-driver was, however, able, by instantly applying the automatic friction brakes—Heberlein—with which the Prussian train was supplied, and by reversing his engine, to bring his train to a standstill only a few paces from the shunting train, thus affording another proof of the value of efficient continuous brakes at the command of the drivers and guards.

A SERIES of trials was made on the Colne Valley Railway, on the 16th inst., with a passenger train fitted up throughout with the automatic friction—Heberlein—brakes, for which a gold medal was awarded at the International Exhibition of Inventions last year. A number of gentlemen interested in railway appliances witnessed the experiments, including amongst others Colonel le Messurier, R.E., Mr. R. N. Barnett, C.E., Mr. J. Imray, C.E., Mr. Walmisley, C.E., and Messrs. Colam, Ridley, Masters, Mackie, Lennox, Macaulay, and others. The following were amongst the experiments made:—Train to be suddenly stopped by the driver on his remarking, when rounding a curve at high speed, that a bridge has been carried away. A broken axle supposed to be remarked by the guard, who stops the train from the rear van with the steam full on. A coupling supposed to become ruptured on a rising gradient of 1 : 70, the train stopping automatically on the brake cord being broken. Working a team of carriages down an incline without the engine, and moderating and accelerating its speed at pleasure. Stopping suddenly from full speed whilst passing through a station, on the home signal being unexpectedly raised. The simplicity and efficiency of the system gave great satisfaction to all present, as showing its special applicability on railways generally, and particularly for the secondary railways.

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

	Collisions.	Derailments.	Other.	Total.
Defects of road	—	17	—	17
Defects of equipment	10	8	6	24
Negligence in operating	16	5	—	21
Unforeseen obstructions	1	17	2	20
Maliciously caused	—	2	—	2
Unexplained	—	9	—	9
Total	27	58	8	93

Negligence in operating is thus charged with $22\frac{1}{2}$ per cent. of all the accidents, defects of road with 18, and defects of equipment with 26 per cent. A division according to classes of trains and accidents is as follows:—

Accidents.	Collisions.	Derailments.	Other.	Total.
To passenger trains	1	18	3	22
To a pass. and a freight	8	—	—	8
To freight trains	18	40	5	63
Total	27	58	8	93

This shows accidents to a total of 120 trains, of which 31 (26 per cent.) were passenger trains and 89 (74 per cent.) were freight trains. The enormous proportion of derailments does not cease, although the unexplained derailments are somewhat less.

A BOARD of Trade report by Major Marindin on the result of an accident which occurred on June 24th, between Dunphail and Forres, on the Highland Railway, when a mixed train from Perth to Inverness consisting of two engines and tenders, forty-one loaded wagons, one third-class and one first-class carriage, two brake vans—one in the centre and one at the rear of the train—and a closed van immediately in front of the rear brake-van, was running at a speed of about thirty miles an hour down a steep incline about $3\frac{1}{4}$ miles north of Dunphail, one of the wagons left the rails and ran about 340 yards before the rest of the train left. In concluding his report, he says:—"There have been three accidents attributable to this cause on the Highland line within the last year, one near the Mound, on the 26th November, 1885, where three passengers were injured, and some would almost inevitably have been drowned if the accident had taken place at high tide; one near Brora, on June 1st, 1886, where two passengers were injured; and the one now under consideration, where, looking at the position of the third-class carriage, it is astonishing that no passenger was injured. With these warnings before them, it is to be hoped that the company will not run the risk of being called to account for a fatal accident from a similar cause, but will decide to abandon the practice of running goods wagons of ordinary pattern in front of passenger carriages, a practice which has been consistently discountenanced by the Board of Trade, and which is objectionable, not only because of the danger of a wagon breaking down, but because trains so made up cannot well be properly equipped with that amount and description of brake power now considered necessary for passenger trains."

NOTES AND MEMORANDA.

IN the report of the Inspectors of Explosives, the explosion of tablets of chlorate of potash in the pocket of a gentleman in Brookline, Mass., who dropped his watch upon them quickly, is characterised as the most curious explosion of the year. Among other "explosive medicines" is mentioned nitro-glycerine, which is made up with lozenges, &c., for use in cases of angina pectoris and other complaints.

THE report of Dr. Odling, Dr. Tidy, and Mr. W. Crookes, F.R.S., on the supply of water to the metropolis during the month of June, states that it "maintained the same excellent character which it has manifested for some months past. Of the 518 samples of water examined during the past three months, no single sample was found to be otherwise than well filtered, bright, and practically free from colour. The mean amount of organic carbon in the Thames-derived supply for the three months was ·155 part in 100,000 parts of the water, the mean amount in last month's supply being ·152 part, and the maximum amount in any one sample being ·177 part in 100,000 parts of the water."

A REMARKABLE example of the increase of temperature in the earth towards the centre has been presented at Pesth, where the deepest artesian well in the world is that now being bored for the purpose of supplying the public baths and other establishments with hot water. A depth of 951 metres—3120ft.—has already been reached, and it furnishes 800 cubic metres—176,000 gallons—daily, at a temperature of 70 deg. Cent.—158 deg. Fah. The municipality have recently voted a large subvention in order that the boring may be continued to a greater depth, not only to obtain a larger volume of water, but at a temperature of 80 deg. Cent.—176 deg. Fah. It is suggested that it is thus within the bounds of probability that the time may come when a brewer will obtain his water supply from a well of sufficient depth to yield "liquor" at the mashing temperature.

WITH a turbine for power transmission by cable at Ober Ursel, near Frankfort-on-the-Main, over a distance of 3171ft., Prof. Reuleaux estimates that the specific value of transmitted power per pound of material would become with shaft transmission as 1 to 70 of the present transmission, or 70 lb. weight would be required to do what 1 lb. in the present carrier accomplishes. As it is, out of 104-horse power given out at the turbine, 14·56-horse power are lost in transmission, while with shafting the loss would be 52-horse power, and instead of running all the year round, the 40 3-horse power available at low water would not turn the shafting. Prof. Reuleaux proposes to apply rope driving not only to main transmissions, but to run all the machines of a large shop, for which he would use one continuous cable running the counter shafts directly, and in case of most machines even driving the machines directly, with only the intervention of a friction clutch to allow of ungearing. The cable would be kept tight by a counterpoise in the usual manner, and could be applied to every conceivable operation of the shop, the exceedingly high specific value of the form of transmission far over-balancing the great length of carrier to be kept in operation. He refers to the saving that must be effected in a great cotton factory, in one of which in the United States—presumably the Pacific Mills, at Lawrence, Mass.—there are about 4·8 miles of shafting.

HERR FENNEMA, a mining engineer at Buitenzorg, in Java, has, *Nature* says, made some observations on the recent volcanic eruptions in that island which are of interest as setting at rest a matter on which some doubt has existed. On the authority of Junghuhn, the general belief has been that in historic times all the volcanoes of Java—and of Sumatra, it may be added—had thrown out solid matter only, and never those streams of lava which are so characteristic of most eruptions. But a careful examination of Smeru and Lemongau during the catastrophe of April last year shows that this notion must be abandoned as incorrect. The former is not only the highest but also the steepest in Java. From 700 to 1400 metres the slope is about 6 deg., up to 2100 it is 20 deg., and from 2100 to 3671 metres it is more than 30 deg. For a considerable way from the summit the striking cone consists wholly of the detritus thrown out regularly by the almost uninterrupted activity of the crater. Up to April, 1885, the existence of torrents of lava was unknown. On the 12th-13th of that month a stream appeared on the south-eastern side, and forced the residents on the plantations lower down to fly. The stream increased for several days, until it reached a height on the mountain side of about 2100 metres from the level of the sea. The loss of life was due to the avalanche of stones sent down the steep sides of the mountain by the stream. Similarly, at the same time, Lemongau threw out a lava stream; but there was a curious difference between this and the one issuing from Smeru—the latter was andesitic in its character, while the former was basaltic.

THE estimated total outturn by all the refineries of mineral illuminating oils, in the United States, for the year ended December 31st, 1885, was 732,650,628 American gallons, or 14,365,698 barrels of 51 American gallons—equal to about 40 imperial gallons. The approximate home consumption in the United States amounted to about 253,665,075 American gallons, or 4,973,825 barrels; and the quantity exported was 5,381,099 barrels, and 17,254,611 cases, collectively equal to 446,982,159 American gallons. The detailed shipping statistics give the respective quantities for the year 1885 as 6,985,637 barrels, and 16,528,844 cases, a discrepancy which may be due to differences in dates. On the latter basis, the total gross weight of the barrels would be 1,222,486 tons. If piled six high, as they commonly are when stored, the barrels would cover a space of about half a square mile, and if placed end to end would extend for a distance of 3638 miles. The tin-plate used in the manufacture of the cases amounts to nearly 38,502 tons, and would cover more than five square miles, and 431 acres. The burning oil manufactured in Baku during the year 1885 amounted to 27,000,000 poods, equal to 118,800,000 imperial gallons. Of this, about 17,000,000 poods were consumed in Russia, and about 5,000,000 poods, equal to 22,000,000 gallons, were exported, leaving a balance of 5,000,000 poods in stock at the end of the year. We have thus a total of over 700,000,000 gallons of burning oil manufactured per annum in the United States and Russia; to this the similar products manufactured at the refineries on the continent of Europe and in Scotland have to be added.

PROFESSOR REULEAUX gives the following as the result of recent investigations on different means of power transmission, electricity excepted. Circuit transmission means transmission by rope to a number of recipients of the power, the first and last recipient pulley being near the motor, so that there is no return or slack rope. Line transmission means transmission in a line from motor to recipient, as by a belt, the return or slack being equal to the part under useful tension. V in the table = velocity of the rope or carrier in feet per second; T = tension of carrier materials in pounds per square inch; $S\,p\,w$ = the horse-power transmitted per pound of the material in the carrier, supports, wheels, or pipes; and $S\,p\,v$ = the specific value of the different systems, assuming steel rope circuit transmission to be = 100.

Form of transmission.	V	T	$S\,p\,w$	$S\,p\,v$
Steel rope circuit transmission	98·4	21,300	17·48	100·
" " line "	98·4	21,300	8·71	50·
Iron " circuit "	98·4	10,650	8·71	50·
" " line "	98·4	10,650	4·36	25·
Belts " " "	98·4	540	2·72	15·6
Hemp rope line "	98·4	241	1·13	6·5
High-pressure water with steel pipes	13·1	852	·93	5·3
High-pressure water with iron pipes	13·1	426	·47	2·7
Steam pressure, steel pipes	13·1	426	·47	2·7
" cast iron pipes	13·1	142	·15	0·9
Shafts, iron or steel	3·3	426	·12	0·7

It must be noted that under no circumstances could the ideal circuit be practically realised, and it may be said as to shafting that if roller bearings and higher velocities were used it would be at least half way up that table instead of at bottom.

MISCELLANEA.

PROGRAMMES have been issued respecting the London summer meeting of the Institution of Mechanical Engineers, on the 17th, 18th, 19th, and 20th August.

A COMPANY has been formed for purchasing and working Simond's patents for forging iron and steel. It is named the Simond's Steel and Forging Company, and prospectuses now issued offer 30,000 shares of £5 each.

A MEETING has been held of the general passenger agents of the lines west, north-west, and south-west of Chicago, at which it was agreed to withdraw all cut rates throughout their territory, and to restore full tariff rates immediately.

THE first natural gas pipe was put down inside of the city limits of Wheeling, W. Va., on the 4th of June by the Natural Gas Company of West Virginia, in the presence of a large and curious assembly of citizens. The work will henceforth be pushed with the utmost rapidity.

THE new twin-screw dredger Dolphin, constructed by W. Simons and Co., Renfrew, for the Crown Agents for the Colonies, had a successful trial of her steaming and dredging capabilities on the Clyde on Friday last. This vessel is intended for harbour improvements in the West Indies.

THE length of the Swedish telegraph lines at the end of last year was 8578 kilometres, besides 20,967 kilometres of conductors. The number of stations was 180. The greatest number of foreign messages were exchanged with this country, viz., 117,000, Germany following next with 100,000.

A TIDAL wave of considerable dimensions occurred off Cape Flattery, Washington territory, on Saturday night. It was observed that the sea was subsequently covered with dead codfish, halibut, and salmon. We may next hear of some allied carthquake, or volcanic phenomena.

THE contract for the construction of the Manchester Ship Canal has been let to Messrs. Lucas and Aird for the sum of £5,750,000, or £560,000 less than the parliamentary estimate. Messrs. Rothschild have undertaken the financial part of the scheme. The capital is to amount to £8,000,000, and is to be raised in £10 shares.

WATERWORKS are about to be established at the seaside town of Southwold in Suffolk, for which purpose Messrs. Le Grand and Sutcliffe will commence boring the artesian well forthwith. The same firm has also been instructed to make another boring 15in. diameter for the Basingstoke Corporation Waterworks with the view to increasing the town supply.

SHELLS seem to be much more effective as civil than as military weapons. It is reported that as a wagon-load of old artillery material, which a dealer in iron had bought from the Government at public auction, was being discharged on the 14th inst. at the purchaser's place of business in St. Petersburg, a 9in. shell, supposed to have been duly unloaded, burst in the midst of a number of people, killing sixteen persons, including four children, on the spot. Others were more or less seriously injured.

ACCORDING to a French journal, notwithstanding the difficulties arising from exceptionally heavy rains and the hardness of the rock met with, work on the Corinth Canal proceeded successfully during last winter. In the month of December alone 500,000 cubic feet were excavated. The bridge which is to cross the canal at the highest point of the isthmus is also being pushed forward. This bridge which will form the last connecting link between the Morea and the mainland, will bear the Athens Corinth line of railway. The two abutments have arrived at a considerable height and the metal work is in great part ready.

THE Russian Black Sea fleet has been greatly increased since the abrogation of the 14th Article in the Treaty of Paris in 1871. Thus there are at present, according to a Russian journal, 120 war vessels of all kinds in those waters, carrying a total of 166 guns, and representing a tonnage of 70,000 tons, with 12,080 indicated horse-power. Of this number 7 are ironclads, 28 armoured and 1 wooden line-of-battle ships, 59 transports, and 16 torpedo-boats. The rest is made up of armed cruisers and merchantmen, sailers. The fleet will shortly be further strengthened with several torpedo-boats built abroad, which will pass through the Dardanelles by permission of Turkey.

THE magnificent pumping engine of the Mines Drainage Commissioners, manufactured by Messrs. Hathorn, Davey, and Co., of Leeds, which was erected at Bradley for draining the submerged mines, has now commenced pumping through the main bore-hole the water from the immense Bilston underground pound. Since last issue the workmen have succeeded in piercing the rib which had been left to protect the Tipton district, and in that boring has now been placed a 5in. pipe. From it and from a similar pipe in the south level the "come" of water is enough to keep the pumping plant on at its maximum night and day, releasing some 5,000,000 gallons of water every twenty-four hours. So thoroughly have the Commissioners done their work, that whatever seams of coal and ironstone there now are over the whole twelve or fifteen submerged square miles will, it is hoped, certainly a twelvemonth hence, be once again workable.

THE new entrance to the great docks of the St. Katharine's Company, recently described and illustrated in THE ENGINEER, was opened on Wednesday. In April last we recorded the blasting of the concrete wall which excluded the water from the new entrance and extension basin. The 8000 tons of *débris* from that operation have been removed, and the magnificent lock is now open for the finest ships to enter or depart. By the completion of this portion of their latest undertakings the Dock Company has developed the capacity of its existing docks so as to meet the requirements of the increased dimensions of ocean liners up to date. The former entrance was 550ft. in length, 80ft. in width, and 30ft. in depth of water at high tide. But the new entrance is 36ft. deep over the cill, and allows an ample margin for the deepest draught merchant vessels afloat. Satisfactory progress has also been made with the Galleons Extension Basin, and important improvements in railway and traffic arrangements are being effected.

THE Manchester Ship Canal will extend from the deep water of the Mersey at Eastham—a point on the Cheshire shore just above and almost opposite to Liverpool—and will proceed thence by Ellesmere Port, Runcorn, Warrington, and Barton, to Manchester, being in length about thirty-five miles. It will have a minimum depth of 26ft. of water, and will be wide enough for the largest vessels to pass each other at any point, and may be compared with the Suez and Amsterdam Canal in width and depth as follows:—Suez: Depth, 26ft.; bottom width, 72ft. Amsterdam: Depth, 23ft.; bottom width, 89ft. Manchester: Depth. 26ft.; bottom width, 120ft. The estimates include docks in Manchester, Salford, and Warrington, as sanctioned by the company's Act, with a water area of $85\frac{1}{2}$ acres, containing more than four miles of quays. There will also be a mile of quay space and extensive shed accommodation near Manchester on the ship canal, in addition to wharfs at many places alongside its course. The level of the docks at Manchester, which is 60ft. 6in. above the ordinary level of the tidal portion of the canal, will be reached by four sets of locks. The locks will, it is asserted, be of a size sufficient to admit the largest merchant steamers. Each set comprises a large lock, 550ft. by 60ft.; a smaller lock, 300ft. by 40ft., for ordinary vessels; and one lock, 100ft. by 20ft., for small coasters and barges—and all capable of being worked together. Each set of locks will be worked by hydraulic power, enabling, it is contended, vessels to be passed in fifteen minutes. It is hoped that the rivers Irwell and Mersey—which will be diverted into the upper reaches of the canal—will supply more than sufficient water for the locks even in the driest season. Vessels will, it is expected, be able to navigate the canal with safety at a speed of five miles an hour, and it is estimated that the journey from the entrance at Eastham to Manchester will be accomplished in eight hours.

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*** *This week is published a Double Number of* THE ENGINEER *containing the Index to the Sixty-first Volume, and Two Supplements, one being a Table of the Resistance Due to Gravity on Inclines, the other a two-page engraving of the Compound Beam Pumping Engines at the West Middlesex Waterworks, constructed by Messrs. James Simpson and Co. Price of the Double Number, 1s.*

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THE ENGINEER, July 23rd, 1886.

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A LONG SUBSCRIBER.—*The velocity depends much upon the material;* 80*ft. per second is usually taken as a maximum for cast iron. This may be departed from by judicious design and selection of iron, the actual stress being calculated by the formula for centrifugal force.*

AQUA.—*The character of the motor best adapted to your requirements depends upon the head and quantities, which you only give as small. Efficient turbines are made for low falls, but probably an overshot or a high breast water-wheel would suit your purpose best if the quantity varies very much. See Weisbach's "Manual of the Mechanics of Engineering," vol. ii. London: Trübner and Co. See also Unwin's lecture "On Water Motors" to the Institution of Civil Engineers, session* 1884-85; *and Clark's "Rules, Tables, and Data." London: Blackie and Sons.*

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MEETING NEXT WEEK.

INSTITUTE OF NAVAL ARCHITECTS.—Meeting at Liverpool on the 27th, 28th, 29th, and 30th July. Five papers are to be read and numerous excursions have been arranged. The papers are (1) "On the Carriage of Petroleum in Bulk;" (2) "Description of the Mersey and Port of Liverpool;" (3) "Notes upon Losses at Sea;" (4) "Progress and Development of Marine Engineering;" (5) "Atlantic Passenger Steamers."

DEATH.

On the 12th or 13th inst., at Ashfield, N. S. Wales, WILLIAM BURTON WADE, C.E., aged 53. (By telegram.)

THE ENGINEER.

JULY 23, 1886.

THE RIVER LEA.

IN the autumn of last year we had occasion to call attention to the terribly polluted state of the river Lea on the borders of the metropolis. At the date at which we wrote, some palliation of the evils referred to had been effected, the East London and New River Water Companies having flushed the sluggish stream, and swept out a large proportion of the sewage. But there was no immediate prospect of a proper remedy, likely to be permanent in its character. The fear of a repetition in 1886 of what had happened in 1885 was enough to create both indignation and alarm. The population of the district had been excited in no small degree by the sufferings they had undergone, and the political clubs were found taking up the subject with a zeal which threatened extraordinary results. There was a great public meeting on Hackney Downs, a deputation to the Home-office, and a series of angry letters in the newspapers. But while the Government, the Lea Conservancy Board, the Tottenham Local Board, and other authorities, were fiercely denounced for not rescuing the river from its pestilent condition, nobody seemed to know exactly what ought to be done. That the sewage of Tottenham should be taken somewhere else was a demand easily made, but not readily to be complied with. This year a Bill has been passed through Parliament, having for its object the construction of a sewer to divert the effluent of the Tottenham sewage works from the river Lea. There is no doubt that this effluent, owing to its very impure condition, has been the main cause of the pollution of the river. In addition to the legislative action just mentioned, the House of Commons last February appointed a Select Committee to inquire into and report upon the condition of the river Lea, and to make such recommendations as might appear necessary. The labours of this Committee have been cut short by the dissolution of Parliament, and what is intended as an interim report has been presented, in which the Committee recommend that the inquiry shall be resumed when the new Parliament assembles. Concerning the Lea River Purification Act of this year, the Committee observe that the measure "is merely temporary, and will not fully deal with the difficulties of the case." They intimate that some scheme for intercepting the sewage and conveying it to a distance, after the manner of the metropolitan main drainage works, would seem to offer a remedy for the more flagrant evils complained of. In addition, the Committee offer a somewhat singular recommendation, recognising the right of the Lea Conservancy Board to pass more water through their locks than the water companies have lately allowed. The prior right thus ascribed to the Conservators apparently means that the water supply of East London and the City must be subordinated to the cleansing of the Lea.

At this crisis it comes to pass that the river Lea has suddenly exhibited a marked improvement. The scheme for the diversion of the effluent is in embryo, and there has been no restriction enforced upon the water companies. Yet the other day, when the Conservators of the Lea made their annual excursion up and down the stream, they were delighted to find that every trace of the former offensiveness had vanished. The hot weather was admirably adapted to intensify all the worst qualities of the river; but the whole scene was changed, and the stream, which had been so unutterably odious a year ago, was perfectly inoffensive. Neither sewage nor sewage fungus could be discerned, nor could any unpleasant odour be detected, even where the water-wheels of the East London Water Company were churning up the water at Lea Bridge. It might be suggested that things had been made pleasant for the especial entertainment of the Conservators. But this would have been no easy task had it been attempted. The explanation offered is that a particular process has been applied to the sewage, which not only renders the discharge innoxious when entering the stream, but prevents the secondary decomposition which so often accompanies the use of sewage precipitants. The effluent from the sewage works is in such a condition that it benefits rather than injures the river into which it enters, both adding to its volume and purifying it from any polluting ingredients which it may contain. This assuredly is the very perfection of sewage treatment. Major Flower, the Sanitary Engineer to the Lea Conservancy Board, in a letter which he has addressed to Mr. John Hanson, of Wakefield, the inventor of the process, under date of the 15th inst., says: "You will be glad to hear that yesterday, at the annual survey of the river, my Board expressed unqualified delight at the changed condition of the river Lea below the sewage works at Tottenham, which I explained was mainly due to the treatment of the Tottenham sewage by your black ash waste." Such testimony commands respect as being above suspicion, and as proceeding from a gentleman whose experience renders him peculiarly qualified to speak on the subject. The responsible position held by Major Flower is a further guarantee for the accuracy of his statement. There is also the power possessed by thousands to verify or disprove the alleged purification of the Lea by paying a visit to the spot. On the whole, therefore, we are faced by the fact that a river which a year ago created a public sensation by its filthy condition is now, in the presence of hot and sultry weather, in such a state as to afford enjoyment to those who walk upon its banks or boat upon its waters. The river also in its amended condition furnishes the necessary supply of clean water for a number of local industries previously placed in jeopardy by the excessive pollution of the stream. Other questions may be raised, as to the cost of the process and the disposal of the sludge. We are informed that, so far as the purification of the sewage is concerned, the expense is considerably less than by any other method. The quantity of sludge is stated to be small. But these are points on which more information may be expected to follow. The immediate results, as affecting the liquid sewage, have a very satisfactory aspect. The process has been at work at Tottenham for six months, and the appliances at the disposal of Mr. Hanson have been somewhat imperfect, owing to the alterations which are going forward at the Tottenham sewage works. Despite the difficulties and drawbacks thus created, the pollution of the Lea has been stopped, and it may be hoped that some fresh light has been thrown on the sewage problem.

The Blue-book containing the evidence given before the Select Committee on the pollution of the Lea has been published within the last few days, and there we meet with some interesting statements made by Mr. W. C. Young, the consulting chemist to the Lea Conservancy Board. Hanson's process is in operation at Leyton, and was at one time applied to the Aldershot sewage. Mr. Young said to the Committee, "I have examined the effluent from the Leyton sewage works, and from the Aldershot sewage works, which were produced by Hanson's process, and I am bound to say that those effluents have been very satisfactory." Mr. Young stated that at first he could hardly account for the good results obtained by the black ash waste process. On inquiring into it, he found that the material employed is not the waste as produced at the alkali works, but black ash waste that has been exposed to the action of the air for some considerable time, and has become partly oxidised. The sulphides of lime contained in it are oxidised into hypo-sulphites and sulphites. The hypo-sulphites are soluble in water. The sulphites are not soluble in water, but they are soluble in sewage, owing to the circumstance that the latter is acid. Some of the sulphite of lime is accordingly dissolved. Substances having powerful antiseptic and deodorising properties are thus produced, to which the efficacy of the process may be attributed. "The remarkable feature in all the effluents," says Mr. Young, speaking of the Hanson process at Aldershot and Leyton, "is their perfect freedom from microscopic organisms." This result is understood to be due to the presence of sulphurous acid, which kills the animal organisms. The process is one which certainly deserves the attention of sanitarians, and if it permanently cures the pollution of the Lea, it will have established for itself a commanding reputation. Thus far it has done well.

EMERGENCY DRILLS FOR THE NAVY.

ONE profitable result from the growing interest bestowed upon naval matters would be an experiment and estimate of the value of the many complications and refinements which are year by year growing under the present Admiralty practice. Such an experiment as is suggested would not, it is true, be entirely free from risk; but even then the balance of advantage would remain. An order of the nature of an emergency drill, and involving such a train of operations as are likely to occur in actual warfare, would be instructive in more ways than one. Say, for instance, steam starboard engines with all available boiler power; connect all available pumping arrangements in port engine room, and charge the fire service. The manipulation of the various steam and feed pipes, and their host of connections and interconnections, will probably engage the time of the whole engine-room and stokehole staff, even if, on the spur of the moment, sufficiently grasped by the officers in charge. In addition to this, attention must be directed towards keeping steam on the steering, electric light, and various capstan and other engines, as desired. The present system of duplication does not assist matters much, and its value may be questioned; for although a double set of, say, pumping arrangements in each engine-room appears on the surface an advantage, it must be remembered that two articles are a target twice the size of one, and at the same time are more likely to fail from want of attention than one is, so that the advantage is not necessarily doubled. As most large ironclads are twin screw, duplication in such cases means quadruplication. The value of even duplicated pumping arrangements in the Leander did not seem of much service when she went ashore. According to published accounts, she took the ground at or near a bulkhead where the double bottom and single bottom met, and although no holes of any serious size could be seen, it was the luck of having fine weather, more than any elaborate pumping power, that saved her. As regards steam pipes, it is the almost invariable practice in the mercantile marine to supply a separate boiler with range of pipes supplying the various small engines. This range of pipes is capable of being put into immediate communication with the main boilers if desired, and forms an arrangement easily carried in the head. The boiler, too, is usually in the 'tween decks, and away from any immediate danger from flooding. In the Navy the practice seems to be to arrange every separate engine very nearly, so as to be capable of taking steam from any or all of the boilers. This means a problem in combinations both abstract and concrete. The theory is to use all the boilers equally, but the benefit of saving a boiler by endangering the ship is open to question.

With the recent heavily armoured citadels a donkey boiler can be readily and safely stowed high up—in fact, in some of the foreign navies it is usual. Various check valves and safety appliances are introduced in great numbers, but from the nature of things are only very partially automatic taken as a whole. Automatic action must be absolute to be of any value, and probably greater safety in practice would be attained by very much greater simplicity in arrangement, especially as the supervision is frequently changed many times even during the building of the vessel by promotion or draughting away. To understand the lead of the various pipes is a matter of many months' constant study, and by the fortune of war the few men having any knowledge of the subject may be the first disabled or killed. Some of our older and less complicated vessels, if kept in going order, will be found to give a good account of themselves in action, perhaps when more imposing vessels are disabled. For various reasons the Admiralty methods of construction and detail seem to be very much swayed in direction by platform scientists. The fact, too, that the authority of the constructing department ceases directly that a ship is commissioned does not improve matters, as a useful source of experience is thus destroyed. Any acquaintance with official systems will prove that it is to the advantage of no one to make critical observations on large scale, but unofficial conversations with engineer officers will convince anybody of the vast amount of heavy responsibility which they have to bear in the matter of connections alone—certainly greater in amount than most borough engineers have in their charge underground, and with immensely greater risk of failure. With the ponderous weapons of offence now usual, the various requirements in the way of loading, training, &c., depend ultimately on the integrity of the propelling machinery for their proper action. The almost uniform existence of forced draught in the latest ironclads and cruisers does not help matters much, as the various compartments are reached by double doors, and many means of getting about are not available now as readily, and the air machinery is another charge for the engineers. The development, too, of the torpedo system, of which not much is said, very wisely, with its own train of requirements, all tends to increase the duties and cares of office.

Emergency drills of a comprehensive nature are very usual in the German Navy, and are carried out without any previous notice whatever. Their introduction into our service would no doubt render the lives of the engineers for a considerable time almost intolerable, but would let a flood of light into many obscure corners of official practice; and although the result would lead to an enormous expense, would be for the ultimate benefit of our service as a whole. Any defects in administration, construction, and design are very much better found out in peaceful waters than when under the gun fire of a well-matched opponent, which must always be looked upon as a possible, if not a probable, contingency. Naval tactics in the lecture-room and naval tactics afloat are very different affairs. To be forewarned is to be forearmed.

VENTILATION OF PASSENGER SHIPS.

THERE are some annoyances which travellers continually experience with much discomfort, and with involuntary resignation assume are irremediable. Amongst these are stifling, oily, painty, stale kitchen odour, and sickening atmosphere, of almost all the cabins of the steamers by which the shores of France, Holland, Belgium, and other countries are reached. It is always there, and is associated in the mind of every traveller as a gauntlet to be run in the first part of a journey to the Continent, and a purgatory to be gone through as the final destroyer of the pleasures of a continental holiday. Why the enormous numbers of long-suffering English travellers have raised no voice on the subject is inexplicable, especially when the readiness to complain of railway shortcomings is remembered.

There is no reason why steamship berths should not be well ventilated. Those who are robust and happen to have a main deck berth can in moderate and fine weather open the side lights, especially if they do not object to a blast that would do to serve a forge fire. Those in the lower berths cannot enjoy fresh air even by this means, and must leave the door open and ventilate with the thick atmosphere from the interior of the vessel, which is laden with the odours already mentioned. In a rough passage, and when every part of the vessel is crowded with passengers, the combination of smells is enough to kill off all those who are not accustomed to what any physiologist would pronounce a poisonous atmosphere. This need not be; and as there are so many almost equally convenient routes to the Continent, it is surprising that some of the steamboat companies have not bid for the best patronage by effectively ventilating their vessels. A steamship berth is of all places the one which, if the least attention is to be paid to sanitary welfare and comfort, should be most plentifully supplied with fresh air; but it is the least, and natural sickness is aggravated by this unnecessary foulness.

Every berth should be connected with a thoroughly effective ventilating system, or every group of not more than three berths should have a complete and separate ventilation. Mechanically there would be no difficulty about this. One of the simplest methods would be to fix one or two powerful ventilating blowers in suitable places for passing a large quantity of fresh air down into the saloon and passages, the exit for the air being only through outwardly ventilating openings, such as flat grids, with plate valve-like covers. Communicating with these should be ventilating trunks, to carry off bad air by an opening placed in every berth. The arrangement need not involve any element of danger in the worst weather, and the blowers might be worked by the main engines or by a separate engine. A more efficient method would perhaps be possible by means of ventilators at different parts of the vessel, worked by means of water under a small pressure, each ventilator to apply to one or a few berths. This system would lend itself to any arrangement of berths, and with the facility with which water at from sixty to seventy pounds per square inch, and in the small quantity required, could be supplied by a pump worked by the main engines, would make this arrangement comparatively inexpensive. Thick lead or ordinary iron piping for the conveyance of the water costs but little, and is inexpensively laid. Ventilators of this kind were exhibited in the Health Exhibition, and one, which received a gold medal, acted either as a forcing or exhaust ventilator. There is presumably no difficulty in ventilating cabins which could not be easily overcome. The one preventive of proper ventilation on board passenger steamers is probably the cost of ventilating. The addition to the capital cost of a steamer for this purpose would, however, be small, and would soon be looked upon as insignificant once steamship owners were taught to look on fresh air in berths or cabins as a necessity; and it is at least as much a necessity as fresh water, for on short voyages passengers can do without drinking water, where there are always plenty of aerated waters and other substitutes. Even in cold weather passengers will run the risks of passing the night on deck, rather than breathe through the night the stuffy atmosphere of cabins for which they have paid. Surely it is time that some steps were taken in this matter, not merely for the comfort of the passengers, but as a most necessary sanitary reform.

TYNE RIVER WORKS.

THE improvement of the river Tyne affords an example of the enormous sums that may be remuneratively, if judiciously, spent on rivers in industrial districts. It is always interesting to look at the position of the Tyne river works, for they are admittedly amongst the chief of the engineering works of the streams of the kingdom. It is not many years since the river Tyne was such that "small river steamers grounded on some of the shoals for two or three hours at low water and spring tides," between the Northumberland Dock and Newcastle; whilst "above Newcastle the navigation was only used by keels." A plan of river improvement, including the deepening, widening, and straightening the river, was sanctioned by Parliament in 1861, and that and later schemes have been carried on with comparative steadiness since. In 1861 there was dredged from the Tyne 746,932 tons of material; and that quantity yearly rose, until in 1866 the amount of dredging reached the vast quantity of 5,273,585 tons. It has fluctuated considerably since that time, having been as low as 1,552,098 tons in the year 1876; but in the past year it was 2,562,486 tons. It may be added that the average cost last year was under 4½d. per ton, the exact figures being 4·311d. The works which the Commission has begun and completed in large degree are well known; but the present rate of expenditure and the nature of the works in progress are not so well known, and it may be useful to give some of the facts. There is now practical completion of the expenditure, which has been so long continued, on the Albert Edward Dock, and the large work of the Commission is slowly being popularised. In 1884 the Commission expended the large sum of £60,512 on capital account on the dock named, but last year the amount was reduced to £15,665, and now the expenditure will be nearly finished. The piers works still claim a considerable sum—nearly £3000 monthly; the amount and its division last year having been, on the North Pier works, £14,197, and on the South Pier works £19,972. There are in progress also in the river two works of some moment—the Friars Goose Point works, and the Bill Quay Point works; and on the first of these there was expended on capital account last year £3577, and on the latter £1230. There are several minor works on which there has been some expenditure in the past year—works near Blaydon and at South Shields; but these are of comparatively limited cost and duration. In all, the expenditure on capital account last year was £82,228; but a portion of this was taken from the surplus revenue fund. The sum by which the borrowed money was increased—the expenditure on capital after the payment out of revenue of a surplus—was £57,726, or less than half of the amount of the previous year. Still, the debt of the Commission was raised to £3,981,285, or within £20,000 of the authorised borrowing powers of the Board, and it was to this that the recent application was needed to Parliament for powers to enlarge the sums which might be borrowed so as to enable the works in progress to be completed. We have seen what these works chiefly are, and it is thus noticeable that the River Tyne Commission is fast approaching the time when it will be able to close its capital account, unless new needs arise, and when it will be able to devote all its energies to the development of the industries of the river. Its credit has increased, as is evident by the fact that whilst ten years ago the average rate of interest it paid on the money it had borrowed was £4 13s. per cent., the rate of interest is now brought down to £4 0s. 5d., a reduction which saves more than £24,000 yearly. One interesting feature in the results which have attended the great works of river improvement on the Tyne is this, that the size of the vessels frequenting the river has continuously increased. In 1854 the average size of all the vessels frequenting the river was only 149 tons; it rose in nineteen years to 274 tons, in 1875 it was 305 tons, in 1884 it was further increased to 421 tons, and last year the average size was indicated by 428 tons. Finally, it may be said from an official report of Mr. R. Urwin, the secretary to the Tyne Improvement Commission, that in the year 1863 there were only 422 vessels of over 2000 tons register; in 1875 that number had risen to 3500, and last year it was 5100. The trade of the Tyne has its ebbs and flows, and in the dulness of the iron and coal trades there must be an impression on the number and the total tonnage of the vessels which frequent the great port of the north-east; but the facilities which have been given to it, and the added safety and ease in navigating it, as well as the works which have enabled the larger vessels of to-day to use it—these are all omens that the Tyne will share in the larger trade which is expected, and the justice and the need of the works still in progress on the river, but which now near completion—these will be proved. And in the future, it may be hoped that the fuller facilities will enable the conservators of the port to reduce the rates of charge, and to remove some of those imposed to effect the works.

THE FATAL ACCIDENT AT WOOLWICH.

AN inquest took place in the Royal Arsenal, Woolwich, on Monday, July 19th, on the body of a labourer, Daniel Moriarty, killed accidentally in the Royal Gun Factories on Saturday, July 17th. The circumstances were as follows:—A steel casting for an 8in. gun had been run from a 10-ton furnace, the casting not being far short of this weight. A time having elapsed which was thought sufficient for the casting to solidify, it was being lifted in order to set it on pieces of wood termed dummies so as to let the air pass under the base and assist in cooling it. The above-named man descended into the pit to place the dummies, when the casting, which was lifted a short distance from the iron floor of the pit, suddenly yielded at the bottom, and a mass of molten metal rushed out, knocking down, and, as it were, swallowing the poor man so quickly that his fellow workmen could hardly be sure whether they heard a groan or not before he was dead. There was then considerable difficulty in getting his remains out of the metal. Eventually the main part of his trunk, without head or limbs, came out in a mass of steel. This man leaves behind him a wife and five children. It is necessary to mention this very painful event in order to consider its bearing on similar manufacturing operations. Unquestionably workmen themselves are the best judges of the time in which a casting may be expected to set, for this must be learned from experience which only they possess in the fullest extent. Nevertheless we must bear in mind that with the best powers of judging, workmen do not always exhibit the caution which allows margin sufficient to guard against possible mistakes. Who can tell how often a casting has been lifted with the central part still in a liquid condition, and the bottom and walls just sufficiently solid to prevent the breaking out of the molten metal? A Saturday afternoon when men wish to get away, and a very hot day, are conditions which tend to increase the risk slightly, but hardly, we should think, such as would make the difference between a really solid casting and one consisting of a large mass of molten steel in a casing too thin to hold it when lifted off the ground. Probably stringent regulations will be issued for the future, but it is difficult to attach blame very strongly to any one for a mistake where experience could be the only guide, and where experience might have been quite inadequate to say more than that safety had hitherto been secured by conditions which were carried out on this occasion. Unless more information comes out, there is little to be said. Unquestionably the Government will provide handsomely for the widow and children.

TRACTION ENGINES.

THE use of traction engines will probably extend, but it will extend slowly in England, at least, for under the present state of the law respecting them and their use, a law which seems to have the very willing support of most people not users or makers, it is impossible that they can be used except at considerable money risk to their owners, however carefully the engines are worked. There are districts where steam engines, railway, tramway, and steamboats, are so constantly under the eyes of horses that they cannot fail to grow accustomed to them, but these districts are few. The Sheffield County-court Judge gave his decision in a case in point on the 15th inst. The action was one in which Mr. Maurice Booth, coal merchant, sought to recover from Messrs. J. and J. Dyson, brick manufacturers, the sum of £40 as damages for the loss of a horse which was killed by a traction engine belonging to the defendants, and through, it was alleged, their negligence. The Judge held that it was not necessary to find negligence on the part of the defendants' servant when the statute had so carefully preserved the liability of persons who employed a dangerous machine like a traction engine on the public road—an engine which was undoubtedly a very great nuisance and the cause of great danger to persons, especially to equestrians. The Act made it so clear that it seemed to him to be beyond doubt, and the case cited by Mr. Barker showed that even in a case where there was no negligence whatever attributable to the servants of the party using a locomotive on the public road, still they were liable for the injury so caused, and the ground of fixing that liability upon persons who used the locomotive arose upon the 12th section, 28 and 29 Vic., cap. 83, which enacted that "nothing in this Act contained shall authorise any person to use a locomotive which may be so constructed or used as to be a public nuisance at common law." Then followed these words, "and nothing herein contained shall affect the right of any person to recover damages in respect of injury he may have sustained in consequence of the use of a locomotive." Therefore what was put as the ground of liability was not negligence; it was the use of a locomotive. Nothing could be clearer than this. He therefore found a verdict for the plaintiff, and allowed costs. This judgment would probably hold good on appeal, and it only serves to show how great are the obstacles to the extended use of traction engines. It also reminds us that the Royal Agricultural Society is next year to offer a prize for the engines of which the fewest number are required, and on which a few pounds more or less of coal consumption per day is of the least importance.

LITERATURE.

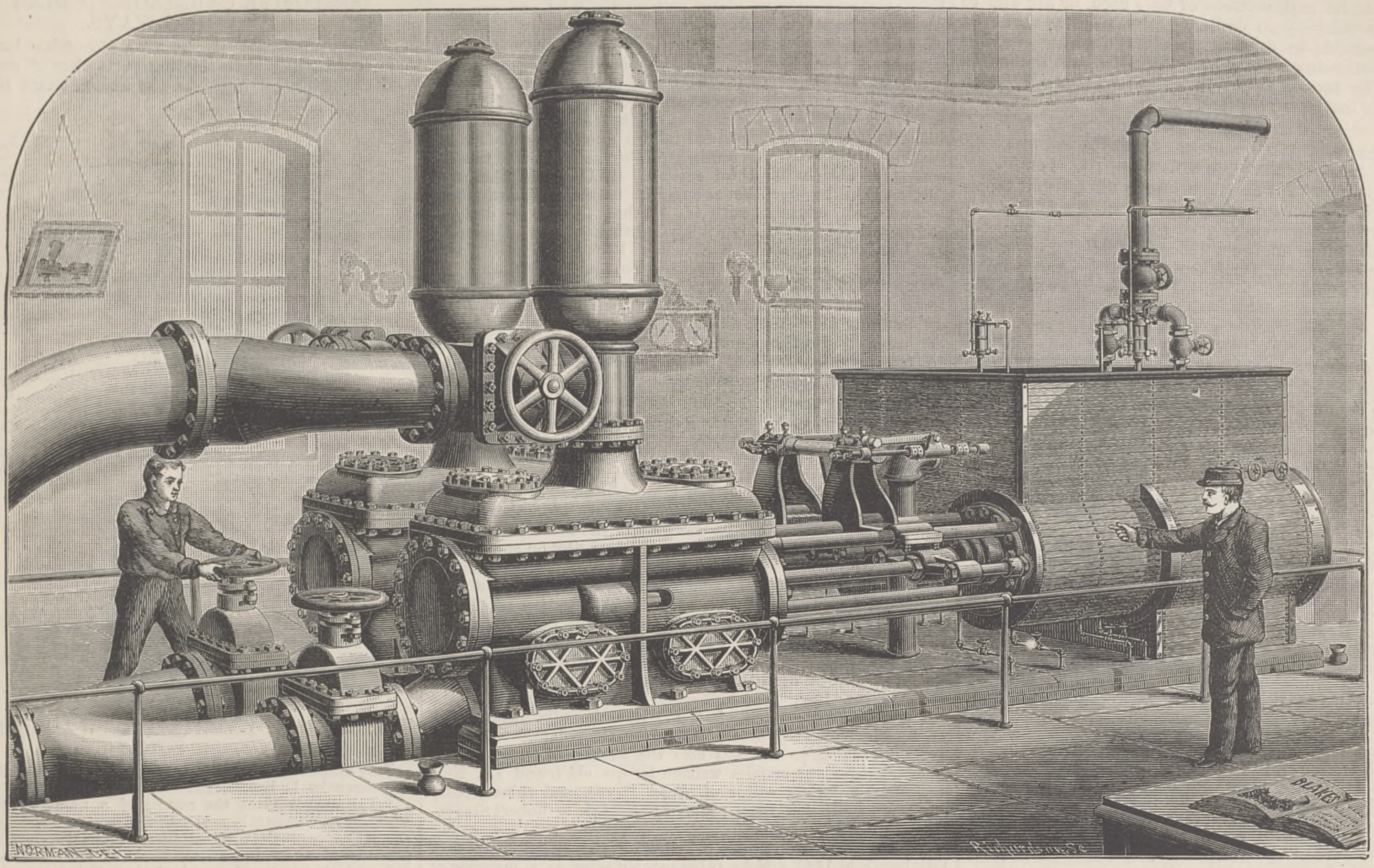
The Boiler-makers' Assistant in Drawing, Templating, and Calculating Boiler and Tank Work. By JOHN COURTNEY; revised and edited by D. K. CLARK, C.E. London: Crosby Lockwood and Co. 1885.

MESSRS. CROSBY LOCKWOOD AND CO. deserve the thanks of all students of practical engineering for the many clear and excellent treatises they have brought out and still continue to publish. The little volume now before us is a useful practical work, bearing all the marks of being, as its author states in his modest preface, the contents of his own note-book, kept by him as a practical boiler-maker, and arranged also by him for publication, subject to the able editing of Mr. D. K. Clark. Mr. Courtney remarks in his preface, "I could not find any one book within the reach of my wages to purchase sufficiently comprehensive and practical to be at once useful to the apprentice as well as to the journeyman, and devoted simply to the craft of the boiler-maker without the use of those mathematical terms which usually perplex and turn away from the study of such works many who would otherwise learn. 'I have therefore arranged for publication what was once a private note-book for my own use.'" The book is one of Messrs. Crosby Lockwood's well known Weales' series, and contains eight chapters, or 106 pages of matter, all of the latter being sound, practical, and easily to be understood. The first three chapters are devoted to useful arithmetical definitions, practical geometry, and the simpler branches of mensuration. The fourth chapter treats of tanks and cisterns of regular and irregular shapes. The fifth refers to rectangular and circular work, cylindrical boilers, angle iron rings, and framing. Chapter six deals with the very important subject of templating, and contains excellent and practical instructions as to how to mark out work, such as plates for elbows, knees, junction of cylinders, &c. All this is very generally taught at the Kensington Schools of Art as well as at other schools, but too frequently is forgotten again by the students after they leave. Mr. Courtney illustrates his rules where necessary with clear diagrams, so that any student of reasonable intelligence can prove their accuracy for himself with a sharp penknife, a pair of scissors, and some cardboard, and this method of study will convey a far clearer insight into matters of boiler and tank-making than the mere development of bodies, as it is called, on paper, as drawings. The seventh chapter deals with the power and proportions of boilers. The author seems to have felt it incumbent upon him to give at least one rule for the proportions of boilers, so he gives the rule of 12 square feet of heating surface to $\frac{2}{3}$ of a square foot of grate, and it is sufficiently safe to be taken in a general sense; but the adage that "circumstances alter cases" is especially true as regards heating, grate, and evaporative rules for steam boilers. The rules for strength, bursting, and working pressure all appear sound; we have checked one or two of them, and they are quite reliable, but we must reluctantly take exception to the mode prescribed for determining the amount of pressure due to the weight of the safety valve and lever. The rule given is as follows:—"(1) To find the distance from the fulcrum at which a given weight is to be placed on the lever in order to balance a given pressure in the boiler, multiply the steam pressure on the whole area of the safety-valve

BLAKE'S COMPOUND DUPLEX DIRECT-ACTING PUMPING ENGINE.

MESSRS. S. OWENS AND CO., LONDON, ENGINEERS.

(*For description see page* 76.)



by the distance of the centre of the valve from the centre of the fulcrum; multiply the dead-weight of the lever and the valve by half the length of the lever; subtract this product from the first product, and divide the remainder by the given weight. The quotient is the required distance of the weight from the fulcrum." The weight of the lever itself, as regards its effect upon the pressure, will not be accurately determined by taking its half length, unless its centre of gravity lie there; and this can only be if the lever is of uniform sectional area from end to end—which is seldom the case. The weight of the valve, and its influence on the steam pressure, has nothing whatever to do with the lever. It is a factor perfectly distinct in itself, and its value will be the dead-weight of the valve divided by the area in square inches of its smallest diameter. By far the simplest and most certain method of determining the pressure that will be due to the weight of the valve and its lever, is to put both in their working position. A small hole, say $\frac{1}{8}$in. in diameter, should be drilled through the lever exactly over the centre of the safety valve; a hook and string can be attached to this, and the other end of the string fastened to one end of an equally divided lever, from the opposite end of which weights can be suspended sufficient to just balance the lever and valve. This weight, divided by the area of the valve, will give exactly the answer required. The proportioning of the weight and length of lever to pressure besides this is easy to determine.

The eighth or last chapter is simply a collection of useful tables of weights and strengths of iron. The book is well indexed, and is clearly printed on good paper. It will be a useful reference book to all boiler-makers, and deserves the attention of apprentices. Its moderate price places it within the purchasing power of even very small purses.

Introduction to the Science of Dynamics. By Professor D. H. MARSHALL. Wm. Bailie, Kingston, Ont. 1886.

THIS is one of a series issued at Queen's University, Kingston, Ontario. This is an active college, working vigorously in the task of raising the standard of education in Canada. The title of the book is modest, but it contains a great deal of excellent teaching. The style of diction is simple, familiar, and easily understood; and yet clear, terse, and logical. It begins by describing the physical natures of the fundamental quantities dealt with—matter, extension, motion, time, velocity, &c. These are taken in the really logical order of the development of our ideas. Thus force comes late in the list, not until after momentum and acceleration of momentum. The definition of force given is, "Force is that aspect of any external influence exerted on a body which is manifested by change of momentum." This would be entirely excellent if it did not, unfortunately, happen that forces are often *not* manifested by any change of momentum of the bodies to which they are applied. If the forces balance, *i.e.*, if the accelerations of momentum sum up to zero, then the momentum effect of the forces is not manifest, but, on the contrary, masked from all possibility of observation. The force effect is then manifested in the *strains* produced in the materials stressed by the forces.

"Energy" is explained as "the power to overcome resistance through space. Work is the expenditure of energy, or is the transference of energy from one body to another. Work is physically manifested either by accelerating the motions of material bodies or by changing the configuration of a material system against resistance." If the author had borne in mind these excellent sentences of his own composition he would have enlarged his definition of force in the direction suggested above. He would also have more clearly recognised that "potential energy" is energy stored up in *strained* substance, and existing in it essentially in consequence of the *strain*. We have for long thought that potential energy would be more fitly named "*latent*" energy. It is in a sense latent because, although the strain or change in configuration may be plainly enough visible or otherwise recognisable, still this strain being a purely geometrical condition, we cannot venture to think that the energy consists essentially and solely in the existence of substance in that geometrical condition. The geometrical condition is, we are forced to believe, merely the invariable and necessary and manifest accompaniment of some physical condition which constitutes the energy lent, of the precise energetic nature of which we are as yet ignorant. In Professor Marshall's book we are told that "when work is done against force on a body which forms a part of a material system, so as to alter the configuration of that system, the *body* in virtue of its new position has energy which it did not previously possess," and which is called its "potential energy." The italics are ours. Now this is inaccurate. The potential energy is not possessed by the *one* body here referred to, but by the whole system whose configuration is changed; that system *including in all probability* the intangible substance or ether which fills up the spaces between the visible separate parts of the system.

A very large number of numerical exercises is given in the book. They are of a lively concrete kind, sure to excite interest. The numerical answers are given in an appendix. Both the C.G.S. and the F.P.S. (foot, pound, second) systems of measurement are used throughout the book. The author has invented several new names. The unit velocity of one centimetre per second is called a "*tach.*" The unit rate of working of one dyne (force) by one tach or one erg per second is called a "*dyntach.*' The unit intensity of stress of one dyne per square centimetre is called a "*prem.*" A very useful table of factors for conversion of quantities from one unit-system to another is given at the end of the book; 1ft. per second = 30·48 tachs, 1 vel. per hour = 44·7 tachs, 1 kilodyne = $15\frac{3}{4}$ grains-weight = about 1 gram-weight. One megadyne = $72\frac{1}{3}$ poundals = about $2\frac{1}{4}$ pounds'-weight. One megaprem, viz., one million prems., is only about one per cent. less than mean atmospheric pressure. One English horse-power = 7456 megadyntachs.

This book is so far above the average text-boox on this subject that we heartily congratulate the students of Queen's College, Kingston, on possessing so good and trustworthy a guide in their dynamical studies.

The Mechanics of Materials. By Professor MANSFIELD MERRIMAN. New York: John Wiley and Sons, 1885.

THIS is an elementary text-book on the strength and stiffness of pieces of material used in engineering structures. It is intended for engineering college students, and for this purpose it has many great merits. It is simple and direct. It does not enter into any mass of detail. The lessons taught are enforced by a great number of numerical exercises which are generally of a useful and thoroughly practical character. In the tables of properties, such as tensile strength, modulus of elasticity, &c., only rough average values are given. This last is a decided advantage to an elementary student whose attention is to be concentrated on the *rationale* of the calculations. For students whose after business is to be real technical engineering, it is somewhat dangerous to allow any idea to grow up that there is any such thing as a fair average strength of, for instance, wrought iron. It is, in fact, rather startling to see stated similar averages for what is called, without any qualification, simply steel.

After dealing with tie-bars, short compression bars, and direct shear, a short section is usefully introduced at an early page on factors of safety. It may be interesting here to quote the table of factors of safety given as representing common American practice:—

Material.	Steady stress (Buildings).	Varying stress (Bridges).	Shocks (Machines).
Timber	8	10	15
Brick and stone ...	15	25	30
Cast iron	6	10	15
Wrought iron ...	4	6	10
Steel	5	7	10

These, of course, are divisions of ultimate strengths. Water and steam pipes, and cylinders, are next dealt with; but here a decided mistake is made in not referring to the influence that the difficulty of casting metal very thin, and yet quite sound, and the stiffness required for true lathe boring, have, upon the practical relation between internal pressure and thickness. The student is taught that the thickness should be simply proportional to $p\,d$, which is wrong. Rivetted joints are explained in the ordinary elementary way. The strength and stiffness of beams is treated fully, the illustrations being thoroughly practical. The shear is taken as uniformly distributed over the section, and this is called the "ordinary" theory of bending. We trust that this does not correctly represent the teaching of engineering Professors either on this or the other side of the Atlantic. In a chapter at the end of the book, however, the true variation of shear over the beam section is satisfactorily explained. We are glad to see prominently noted the fact that the ordinary theory of bending does not really apply beyond the elastic limit, and that it is absurd to apply it to rupture by flexure. But in explaining—page 51—the deviation of the true law beyond the elastic limit from the ordinary elastic theory, the diagram drawn to represent the variation of stress is drawn with its upper boundary concave instead of convex. This is probably due solely to inadvertence. Considerable exception might also be taken to the table on the same page of "moduli of rupture." Continuous beams of uniform section are explained very fully and satisfactorily, but we would suggest the future omission of the statement—page 84—that the only continuous beams used in engineering constructions are those with uniform section and supports on the same level.

With regard to long struts, the formulæ of Euler, Hodgkinson, Tredgold, Gordon, and Rankine are explained, and dissatisfaction is very properly expressed with all of them. A very interesting table is quoted from the "Transactions" of the American Society of Civil Engineers, April, 1884, giving results of an extensive series of experiments on angle and T-iron struts, with ratios of length to radius of gyration of cross section varying from 20 up to 480. The writer has, however, plotted out the figures given in this table as a series of curves on sectional paper. By this means it became at once apparent that, although the figures represent presumably the average results of a large number of experiments, they do not follow any regular law with even a fair degree of accuracy. Whether the deviations are due to large variations in quality in the different lengths and sections of bars used, or are due to errors of calculation in deducing the results, it is, of course, impossible to express an opinion without having had an opportunity of examining the details of the investigation. The torsion of shafts and other matters are also dealt with in the later chapters.

Duncan's Manual of British and Foreign Tramway Companies, 1886. London: Effingham Wilson and Co. 1886.

THIS manual contains abstracts of accounts, traffic tables of the principal tramway companies, tramway tables, and tramway directory generally, giving names and address of the companies and of their officers, receipts, expenses, capital account, reserve fund, engines, cars, horses, miles open, and miles run.

BOOKS RECEIVED.

Canada: its History, Productions, and Natural Resources. Prepared by George Johnson under the direction of Hon. John Carling, Minister of Agriculture, Canada. Canada: The Department of Agriculture. London: The Colonial Exhibition.

Die Bewegung des Wasserstandes des Zuerichsees waehrend 70 Jahren und Mittel zur Senkung seiner Hochwasser. Von K Wetli. Zurich: Hofer and Burger. 1885.

Trusses of Wood and Iron. Practical Applications of Science in Determining the Stresses, Breaking Weights, Safe Loads, Scantlings, and Details of Construction. Vol. 1. By W. Griffiths. Birkenhead: The Author, and Wilmer Bros. and Co. 1886.

Constructive Geometry of Plane Curves, with numerous examples. By T. H. Eagles, M.A. London: Macmillan and Co. 1886.

Modern Steam Engines: an elementary treatise upon the steam engine written in plain language, giving full explanations of the construction of modern steam engines, including diagrams showing their operation. By Joshua Rose, M.E. Philadelphia: Case Baird and Co. London: Sampson Low and Co. 1886.

Track: a complete manual of Maintenance of Way according to the latest and best practice on leading American Railroads. By W. B. Parsons, jun., C.E. New York: *Engineering News* Publishing Company. 1886.

Theory and Practice of the Slide Rule, with Short Explanation of the Properties of Logarithms. By Lieut.-Colonel John R. Campbell, F.G.S. London: E. and F. N. Spon. 1886.

Patents, Designs, and Trade Marks, British and Foreign. An Outline of Laws and Procedure Relative to Patents, Designs, and Trade Marks. By Abel and Imray. London: The Authors. 1886.

The State of the Navy, 1886. *Unarmoured Ships.* By Henry F. Watt. Third edition. London: Philip and Son. Liverpool: W. Potter.

Hydraulics: the Flow of Water through Orifices over Weirs, and through Open Conduits and Pipes. By Hamilton Smith, jun., Member Am. Soc. Civ. Eng. London: Trübner and Co. New York: J. Wiley and Sons. 1886.

Fifth Annual Report U.S. Geological Survey to the Secretary of the Interior, 1883-84. By J. W. Powell, Director Washington Government-office. 1885.

The Miller's, Corn Merchant's, and Farmer's Ready Reckoner. By W. S. Hutton, C.E. Weale's Series. London: Crosby Lockwood and Co. 1886.

Book-keeping Simplified, giving a short System of Double Entry drawn up in a special form to economise time and work in the counting-house, with Appendix, giving forms of books necessary for merchants and traders. By John Adams. London: Unwin Brothers.

COMPOUND PUMPING ENGINE.

THE engraving on page 75 illustrates Blake's compound duplex directing engine, as made by Messrs. S. Owens and Co., of London. In this arrangement one engine so works the valves of the other that the most suitable variation in the velocity of the pistons and dwell at the ends of the strokes are obtained. The engines have 16in. high-pressure, 30in. low-pressure, and 15in. pump cylinders, and 30in. stroke, for pumping 90,000 gallons per hour. They are either made as an ordinary duplex pumping engine, where the steam cylinder of one engine operates the valve gear of its fellow, and preferably is also arranged in such a manner that both engines may run together, or either one independently, an arrangement obviously possessing great advantages over the ordinary type of duplex pump, as should one pump stop from any cause or need repairs the supply can be partially kept up. Condensers are not shown with this engine, but they are usually adopted.

DAVID STEVENSON.

THREE score years and ten have, we regret to record, carried away David Stevenson, one of our most eminent harbour and lighthouse engineers, and the senior member of the firm of D. and T. Stevenson, engineers to the Board of Northern Lighthouses, and the Fishery Board of Scotland for harbours. He died on Saturday last of paralysis at North Berwick; he had retired during the past three years, and his brother Thomas, his two sons, and Mr. Alan Brebner, constitute the present firm.

Mr. Stevenson was the third son of the late Mr. Robert Stevenson, the engineer of the Bell Rock Lighthouse, and was born at Edinburgh in January, 1815. Educated at the High School and University of Edinburgh, he, unlike his brother Alan, who was originally destined for the church, elected from the first to follow his father's profession. Before entering on his apprenticeship, he was for some time in the workshops of one of the best practical millwright engineers of his day, where he acquired manipulative skill and the proper methods of working in different materials—a course he always advocated for those who intended to follow the profession of civil engineering. After serving a regular pupilage as a civil engineer, he was for some time engaged with Mr. Mackenzie, contractor on the Liverpool and Manchester Railway, and he gave a description of this important railway scheme to the Society of Arts more than fifty years ago, and was awarded their medal for his exposition. He then returned to Edinburgh, and, in conjunction with his father and his brother Alan, began practice as an engineer. During the year 1837 he made a three months' tour in Canada and the United States, the result of the inspection of the engineering works of these countries being published in a volume under the title of "Sketch of the Civil Engineering of North America," which was subsequently republished as one of Weale's Series of Engineering Works.

The engineering of rivers and harbours chiefly claimed his attention and interest, and, with his brother, his advice was much sought on this and on dock works, and he was associated with most of the rivers or harbours in Scotland, the rivers Dee, Lune, Ribble, and Wear in England, the Erne and Foyle in Ireland, while the Forth, Tay, and Nith were improved under his advice, and extensive works are now in progress on the estuary of the Clyde from the designs of the firm. He wrote an important paper on the Ribble in the third volume of the "Transactions" of the Institution of Civil Engineers in 1841, and became a member of the Institution in 1844. He also wrote much and originally on the theory of the origin of bars at the mouths of rivers, and on the tidal and non-tidal parts of rivers, on estuaries, and on the proper treatment each should receive for their improvement—Proc. Inst. Civ. Eng., xxi. His book on "Canal and River Engineering," giving the results of his experience in the treatment of rivers, is a standard work on the difficult subject of which it treats. Originally written at the request of his old friend—Mr. Adam Black—about thirty years ago for the "Encyclopædia Britannica," it was shortly afterwards published as a separate treatise, and it is now in its third edition. In 1853, Mr. Stevenson succeeded his brother Alan as engineer to the Northern Lighthouse Board, and along with his brother Thomas he designed and executed no fewer than thirty lighthouses, two of which—on Dhuheartach and the Chicken Rock—are triumphs of engineering. In addition to the Scottish lighthouses, the advice of the deceased's firm was taken by the Governments of India, New Zealand, Japan, and Newfoundland on lighthouse matters, and under their direction schemes for the lighting of the whole coasts of Japan and New Zealand were matured, and are now being carried out. In connection with the lighting of the coasts of Japan, where earthquakes are frequent, Mr. Stevenson devised the aseismic arrangement to mitigate the effects of earthquake shocks on the somewhat delicate optical apparatus used in lighthouses. On this subject he consulted Mallet, but he made an aseismic joint which Mallet considered unsatisfactorily free to move or too loose.

In addition to works of the kind mentioned Stevenson and his firm were engaged on bridge and sewerage and other works. Besides his practical work he was fond of the literary side of his profession, and added to many papers principally on engineering and cognate subjects read before different societies. He found time to write several books which have taken a permanent place in engineering literature, such as "The Application of Marine Surveying and Hydrometry to the Practice of Civil Engineering," "Reclamation and Protection of Agricultural Land," "The Principles and Practice of Canal and River Engineering." He also wrote and experimented on the force and action of waves—Proc. Inst. Civ., xliii.—and several articles for the last and present edition of the "Encyclopædia Britannica," among which may be noted "Canal," "Cofferdam," "Diving," and "Dredging." He was also the author of "Our Lighthouses," being two articles written for his old friend Dr. Norman Macleod, while editor of *Good Words,* and subsequently published by Messrs. Black; and of the "Life of Robert Stevenson," published in 1878.

Mr. Stevenson was elected a Fellow of the Royal Society of Edinburgh in 1844, and he subsequently acted as a member of Council and one of its Vice-Presidents. He was a member of the Council of the Institution of Civil Engineers, and a member of the Society of Civil Engineers of Paris, and of other learned societies. He was consulting engineer to the Highland and Agricultural Society, and to the Convention of Royal Burghs. Mr. Stevenson leaves a family of two sons, as already noticed, and four daughters, one of whom, the *Scotsman* says, is married to Mr. Napier, and another to the Dean of Faculty.

EDWARD BURSTAL.

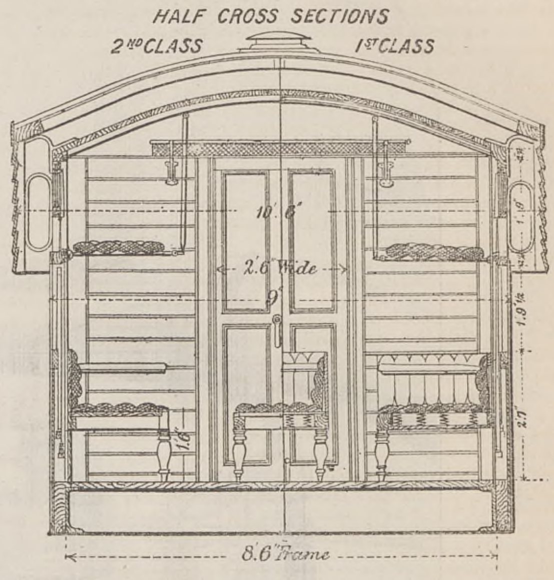
THE death of Edward Burstal, Captain R.N., the Secretary of the Thames Conservancy, at Ramsgate on the 13th instant, removes one who has long been connected with and had great influence on the engineering of the Thames. He was born at Stoke, near Devonport, in 1818, and was the son of Richard Burstal, who had sailing command of H.M.S. Dreadnought at Trafalgar. He entered the Navy in September, 1833, and was at once employed on surveying service on the Thames and Medway, under the late Captain Bullock. In 1838 he received the thanks of the Royal Humane Society for saving three lives. In 1840, as midshipman on board H.M.S. Cambridge, he was engaged in the operations on the Syrian coast and blockade of Alexandria; for his services on this occasion he received English and Turkish medals. In 1846 he was engaged in surveying in the North Sea on board the Fearless, and later he became lieutenant in command during the famine relief on the Irish Coast. After that he was engaged in surveying the South-East Coast of England and West Coast of Scotland. In 1852 he rendered active service in laying the first submarine telegraph cable, *i.e.,* that from Dover to Calais; for this special service he received a handsome present of plate. He subsequently was engaged in laying the telegraph cable from Orfordness to the Hague, and in this latter case, by careful navigation, only 119 miles of cable were used to cover 114 miles of actual distance.

In 1854 Lieutenant Burstal was engaged in the war operations in the Baltic, and in the taking of Bomarsund. On this occasion his surveying experience led to his being specially recommended in despatches for valuable services in taking up combined English and French fleets when the lights and buoys had been removed and misplaced by the Russians, for which he was promoted to the rank of commander. At the close of the Russian war he resumed his work of surveying on the Scotch and English coasts. In the year 1857 the Thames Conservancy was established by Act of Parliament, and Captain Bursal was appointed, on the recommendation of the Admiralty, secretary to that body. This appointment he held until the day of his death. Captain Burstal took a great interest in the prevention of the pollution of the river Thames by the Metropolitan sewage. Although the Conservancy have hitherto been less successful in bringing home to Londoners and their representatives the enormity of their offence than in dealing with the riparian towns above Moulsey, it is to be hoped that the evidence given before Parliamentary committees on the subject will some day bear fruit, and that the metropolis will not be allowed much longer to pollute to any perceptible or material extent the tidal waters of the Thames. At present a large portion of the income of the Thames Conservancy has to be expended in dredging up the materials so abundantly furnished by the Metropolitan outfalls.

Captain Burstal was a member of several Royal Commissions, notably, the Thames Embankment inquiry, which resulted in the plan of the Commissioners being adopted, and the present embankments constructed. His opinion was often in request in connection with marine engineering questions, especially with reference to harbours, docks, bridge foundations, and sea defences. He was apparently in excellent health some three weeks since, and died on July 13th—after a very short illness—in the arms of his only brother, whose life he had, when twelve years of age, saved from drowning. He leaves one son only—the engineer to the Corporation of Oxford—to mourn his loss, but all to whom he was known will feel that one of those fine upright and genial natures which are all too rare in public life has gone from their midst. On Friday, the 16th, his remains were followed to their resting-place in Norwood Cemetery by the leading members of the Thames Conservancy and a large number of sorrowing friends.

COMPOSITE CARRIAGE—INDIAN STATE RAILWAYS.

IN our impression of the 27th November last we gave in "Contracts Open" the leading particulars of some third-class and composite carriages for the Indian State Railways. We



illustrated the third-class carriages, and now illustrate the first-class composite carriages. The illustration will be found on page 78. For the general particulars we must refer to page 413 of vol. lx.

PRESSURE EXERTED BY WATER IN THE SOIL.*

THE following is an abstract of a paper in the *Zeitschrift für Bauwesen* by L. Brennecke:—

"The author gives the results of a number of experiments, which were undertaken principally with a view to determining the influence exerted by capillary attraction in diminishing the pressure of water in various kinds of earth, especially sand of different size and grain, and of clay, it being assumed that the water can only find its way by suffusion through the mass, and that there are no large fissures present. Reference is made to various authors as regards their opinion on this subject, and the amount of deduction which under circumstances may be made from the theoretical pressure of ground-water in designing lock-floors, &c.

"An observation—recorded by Beer—in regard to a filter-basin at Magdeburg 1880 is quoted, bearing upon the amount of frictional resistance to water pressure offered by the ground, even where, as in this instance, of coarse gravel. The basin in question, 178ft.—54·24 metres—in breadth, had been constructed with a concrete floor of 1ft. 7¾in.—0·5 metre—in thickness, and was kept filled with water to counterbalance the pressure of the external ground-water. On the occasion mentioned the water was pumped out to a level of 2in.—0·05 metre—above the floor, when a slight upheaval of portion of the latter being noticeable the basin was quickly refilled. The level of the external ground-water was 7ft. 10½in. above the under side of the concrete floor, and the weight of the floor was equal to a column of water of 3ft. 9in. high; therefore supposing the full pressure due to the height of the ground-water had been active, it would consequently have required a depth of water in the basin of 4ft. 10½in. instead of 2in., to preserve stability.

"Other examples of the varying resistances of different earths to water-pressure are mentioned, viz.: At the coal mine, Wormrevier, some years since, when carrying out some shaft repairs with the aid of pneumatic pressure, on reaching a depth of 48ft. below the surface of the ground-water in a saturated clay-sand, an air-pressure of ¾ atmosphere instead of twice that amount was sufficient to exclude the water; and at the Rheinpreussen mine near Homberg, in 1865, the caisson was sunk with a pressure of only 2½ atmospheres to such a depth as was calculated to require a pressure of 8 atmospheres. In the latter instance, however, a sudden increase of the water-pressure led to a most disastrous accident by bursting the air-lock. It is suggested that the water was held back for some time by the thick beds of clay which it was known had been passed through, but finally found its way through these by channels around the outer skin of the caisson. In the previous case quoted, the author is of opinion that as only half the calculated air-pressure was requisite, that probably half the column of ground-water was supported by the air-pressure, and the remainder by capillary attraction. Details are given of the laboratory experiments upon sands of various size grain, together with a number of formulas and tables, giving the corresponding height of the capillary column."

ROYAL AGRICULTURAL SOCIETY. — Silver medals have been awarded to the following exhibitors:—W. Rainforth and Son, of Lincoln, for self-cleaning rotary corn screen; the Aylesbury Dairy Company, London, for lever and ratchet motion for Johnson's ensilage stack press; Smith and Grace, Thrapstone, for Smith's patent convertible belt pulley, with screwed bush; the Dairy Supply Company, London, for the Delaiteure described above; Ransomes, Sims, and Jefferies, Ipswich, for new patent self-acting feeding apparatus on thrashing machine. In addition, the judges recommended that the following implements, which they deem capable of further development, should be exhibited at the succeeding show of the Society, and classified as exhibits for special inspection:—Mayor's bolting tire, for tying straw from a thrashing machine; the Ofverum Estates Company's new chaff cutter.

MR. WILLIAM LOW.—The death is announced of Mr. William Low, aged seventy-two. He was born at Rothesay, Bute, in 1814, and in early life was engaged as assistant engineer in the construction of a portion of the Great Western Railway main line. Subsequently he became proprietor of collieries in North Wales, and devoted many years to mining enterprise. His energy and perseverance were displayed especially in the prosecution of the Channel Tunnel enterprise. In 1866 he issued a printed circular describing his plans, and in 1867 had an interview with the late Emperor Napoleon on the subject. Subsequently, other engineers were invited to join Mr. Low in this work. Mr. Low went so far as to purchase land on his own account both at Dover and Calais, so anxious was he to push forward the enterprise. The Franco-German war put a stop to the proceedings for a considerable time, but the project was ultimately taken up by Sir E. Watkin, who invited Mr. Low to become one of the engineers. Among other schemes he took up was a proposed England and India railway, 2000 miles of which were personally surveyed in the year 1870.

* "Proceedings" Institution of Civil Engineers.

SHRINKAGE OF EARTHWORK.*

By P. J. FLYNN.

SOME years since experiments were made in Dharwar, in India, by Mr. J. H. E. Hart, C.E., on the shrinkage of earthwork, and the results of these experiments agree with the results arrived at by Mr. Specht—"Transactions" Technical Society, May, 1885—namely, that the embankment at first gave a volume larger than that of the pit from which the material with which it was constructed was excavated. Mr. Hart had three pits excavated, and the material from each pit was formed into a bank. The first pit, in black cotton soil, was 49ft. × 4¼ft. × 2ft. = 416 cubic feet. This was formed into an embankment, which measured 50ft. × 6ft. × 2ft. = 600 cubic feet. After the bank was measured, some of the earth from it was filled back into the pit, up to the level of its edge, and the balance remaining measured, and found to be equal to 191 cubic feet. We have here, first—an increase from pit to bank of 184 cubic feet; and, second, again an increase from bank to pit of 7 cubic feet. During the rainy season—and the rains in Dharwar are heavy—as the material in the pit sank it was filled up to the level of its edge, and at the end of the rainy season the balance was measured, and found to be reduced to 22·5 cubic feet. This showed an increase of the made ground over the pit by 5·3 per cent. The second and third experiments were made in red gravelly soil, or moorum, which is an iron-stone gravel, mixed with about 50 per cent. of earth. In the second experiment a pit 49¾ft. × 4¼ft. × 2ft. = 420 cubic feet formed a bank which measured 49½ft. × 6ft. × 1¾ft. = 520 cubic feet, giving a first increase of 24 per cent. A third pit, 49½ft. × 4½ft. × 2ft. = 445 cubic feet, was excavated, and the material again filled back into the pit, leaving a balance of 111 cubic feet = 25 per cent., as a first increase. During the rains the pit was kept filled to level of edge, and after the rains the balance was 55 cubic feet, giving an increase of 12½ per cent.

Although these experiments are on a small scale, still they are of some use as information on a branch of engineering that has not been experimented on as fully as the subject requires. The experiments, however, would be more useful were full information given as to how the embankments were constructed and the pits filled, that is, as to whether wheelbarrows or baskets were used for the carriage of the material, and the earth deposited in layers and rammed; or as to whether the earth was simply thrown out from the pit and thrown back again after measurement in bank. From the large increase of embankment over the excavation, the inference to be drawn is that the material was not rammed. Embankments in India are often constructed by basket work, the material being carried in saucer-shaped wicker baskets, containing less than a cubic foot. In the construction of embankments to retain water, this basket work is done in thin layers of less than nine inches in depth, the earth being roughly levelled up as it is deposited from the baskets, and then well punned with wooden or cast iron rammers, weighing about 12 lb. In addition, the constant trampling of the men, women, and children employed in carrying the baskets so consolidates the bank as to make it impervious to water. The layers of earth are sometimes watered. Embankments constructed in this manner shrink or settle very little after they are finished. They are, in fact, an approach to puddle work, though not nearly so expensive. The writer has constructed embankments with a grading machine, tipping from wagons from grade, wheelbarrows, hand cars, carts, scrapers, and punned basket-work, and of all these he believes that punned basket-work settles the least, and is the best suited for hydraulic work; and the next best work to it, for a similar purpose, is that done by scrapers. Thousands of embankments, and some of them counted amongst the largest and oldest dams in the world, have been constructed in India by basket-work, without any puddle wall or puddle lining; and some of them that have been looked after and kept in repair are as good, if not better, at the present day than when they were originally constructed, hundreds of years since. This kind of work is done much cheaper there than earthwork in this country. The writer has constructed embankments in the Punjab, the lead being from 100ft. to 200ft., for three rupees per 1000 cubic feet—that is, at the rate of four cents per cubic yard.

More than forty-five years since, Mr. Ellwood Morris, C.E., made some experiments, on a large scale, on the shrinkage of earthwork. The embankments were formed in layers by carts and scrapers, and one winter intervened between the commencement and completion of the work. The results of the measurements are given in Table A.

TABLE A.

Nature of soil.	Excavation, cub. yards.	Embankment, cub. yards.	Compression. In cub. yards.	Compression. Proportional.
Yellow clayey soil ..	6,970	6,262	708	0·1015
" " ..	25,975	23,571	2404	0·0925
Light sandy soil ..	10,701	9,317	1384	0·1293
On the whole ..	43,646	39,150	4496	0·1030

The total average compression in embankment being a little more than ten per cent. of the excavation. Other observations on a smaller scale showed that gravelly earth shrank about one-twelfth. The results of these experiments, along with the experiments on rock, are given in the above Table B. With a few exceptions the results of these experiments have been heretofore used, and are still in use to the present day, in American, English and Indian engineering practice. As a rule, books of reference in the English language give the shrinkage of different materials, without making any allowance on account of different methods of construction and different heights of bank. For instance, the shrinkage of earth, in general, is given at about 10 per cent. Now, if 10 per cent. be sufficient for the shrinkage of a bank of that material, and 30ft. in height, constructed from the end of bank to the full height by "tipping" from wagons, surely a similar bank only 12ft. high, built up in layers, and consolidated by good scraper work, will shrink much less than 10 per cent. In no other branch of civil engineering, since the time when railroads were first commenced, has such an immense quantity of work been carried out, and expenditure incurred, as in earthworks; and in no other branch of engineering, of equal importance, have so few experiments, on a scale adequate to the interests involved, been published.

In other branches of engineering, long, tedious, and expensive experiments are carried out without any other return resulting from them than the information they give; but experiments on earthwork could be carried out on a large scale as actual work, and with little, if any, additional expense more than the contract price of the work.

In the experiments that have been made there is a want of general agreement, and in some cases the results obtained in similar materials differ so much from each other as to point more to errors made by some of the observers than to errors resulting merely from the different methods of construction. This is well illustrated in Table B, which I now give, showing the percentage of increase or diminution from cut to fill. Some of the materials are mentioned more than once, with a slight change in name; but I deem it better to give the author's own words descriptive of the material than to make a selection of the materials under a fewer number of names. The experiments of Henz, Von Kaven, and Graeff, as shown in Table B, are taken from Mr. Specht's paper already referred to. The experiments of Henz, quoted in that table, are stated to give the permanent increase in volume from cut to fill, and to be the result of a large number of observations of actual work. From an inspection of the table it will be seen that Henz gives a permanent increase in volume of from 1 to 6 per cent.—sands and clays—for materials of the same description as those for which Mr. Morris and other engineers allow a shrinkage of from 8·5 to 12·5 per cent. Then, again, for rock Henz allows an increase of from 8 to 12 per cent., and Von Kaven an increase of from 8 to 10 per cent., but for the same material Morris allows 42 to 60 per cent., Searle 60 per cent., Trautwine 66 to 75 per cent., and Molesworth 50 per cent. of increase. The writer is at present engaged on the construction of the south jetty of Oakland harbour for the United States Government. In the carefully-laid dry masonry of this work, where all badly fitting stones are rejected for face work, and the stones are too large to be laid by hand, and require a derrick for that purpose, the voids, before chinking is done, are more than 12 per cent. of the laid face work. There is no method of railroad construction by which an embankment can be made so as to have as few voids as this jetty. On the contrary, however, by the usual methods of construction, the voids will be found to be from six to seven times more than the quantity given by Henz.

TABLE B.

Material.	Authority.	Per cent. of increase + or diminution − of embankment to excavation.	Remarks.
Sand	Hewson	−10	
Very light sand ..	Graeff	−10	
Sandy soil..	Henz	+ 1 to +1·5	
Sandy loam	Specht	+ 9	After fill is finished.
Light sandy earth ..	Morris	−12·5	
Light sandy soil ..	Molesworth	−11	
Gravel and sand ..	Vose	− 9	
Sand and gravel ..	Trautwine—Searle ..	− 8	
Earth..	Miss. Levees, 1882	—	⅕ addition of height of bank.
Earth..	Simms	−10	
Earth (scraper work)	Canadian Pacific R.R.	—	Shrinkage of bank 10 %.
Earth (grading machine)	Canadian Pacific R.R.	—	Shrinkage of bank 15 to 17 %.
Earth (carefully tamped)..	Graeff	− 9 to −20	
Loam & light sandy earth	Vose..	−12	
Loam..	Trautwine—Searle ..	−12	
Clay and loam.. ..	Von Kaven	+ 2	After fill is finished.
Clay and light soil..	Henz	+ 3	
Clay and earth ..	Vose..	−10	
Yellow clayey earth.	Morris	−10	
Gravelly earth.. ..	Morris	− 8·5	
Gravel	Molesworth—Vose ..	− 8	
Clay	Hewson	—	⅙ addition to height of bank.
Clay	Trautwine—Searle ..	−10	
Marl	Henz	+ 4 to +5	
Hard clay..	Von Kaven	+ 5	After fill is finished.
Hard clay..	Henz	+ 6 to +7	
Clay before subsidence	Molesworth	+20	
Clay after subsidence	Molesworth	− 8	
Puddled clay	Trautwine	−25	
Wet soil	Searle	−15	
Loose vegetable surf, soil	Trautwine	−15	
Chalk..	Molesworth	+30	
Soft sandstone ..	Von Kaven	+ 3	After fill is finished.
Rock	Von Kaven	+ 8 to +10	After fill is finished.
Rock	Henz	+ 8 to +12	
Rock	Vose..	+50	
Rock	Graeff	+50 to +60	
Rock	Rhine Nahe Railroad..	+25	
Rock	Trautwine	+66 to +75	
Rock, large fragments	Searle	+60	
Hard sandst'ne rock, large fragments ..	Morris	+42	
Blue slate rock, small fragments	Morris	+60	
Rock, large blocks..	Molesworth	+50	
Rock, medium fragments	Searle	+70	
Rock, medium unselected	Molesworth	+25 to +30	
Rock (metal)	Molesworth	+20	
Rock, small fragments	Searle	+80	
Rock fragments (loose heap)	Trautwine	+90	
Rock fragments (carelessly piled)..	Trautwine	+75	
Rock fragments (carefully piled) ..	Trautwine	+60	
Rock mixed ⅓ to ¼ clay..	Von Kaven	+ 9	
Rock with considerable clay	Graeff	+ 0	

The difference in rock between the German and American and English experiments is very great, but it will not be difficult to prove that there is something wrong with the German rock experiments. Trautwine gives the average weight of granite at 170 lb. to the cubic foot, and he also gives the weight of a cubic foot of roughly-scarbbed, dry rubble granite masonry at 125 lb. There is, therefore, an increase in volume of 36 per cent. from solid rock to dry masonry. In order to reduce the increase to only 8 per cent., given by Henz, the voids in his rock embankment would have to be less than one-fourth of that of the dry granite masonry mentioned. In railroad construction, as generally carried out, this is not possible. Well-dressed granite or limestone uncoursed masonry contains more than 8 per cent. of mortar. General Gilmore, in his work on "Limes, Cements, &c.," states that ordinary masonry in courses of 12in. to 20in. rise contains about 8 per cent. of mortar. If the percentage of increase allowed for rock is to be accepted as a fair sample of the accuracy of the experiments of Henz and Von Kaven as a whole, then the conclusion to be arrived at is that any estimates based on them must be inaccurate, and lead to serious errors.

The disagreement of the German authors from the American and English authors as to shrinkage is certainly remarkable. The Germans give, on the whole, a permanent increase for sands, clays, and similar materials, but, on the contrary, the Americans and English give a diminution. For rock the latter give an increase from cut to fill many times more—in some cases nine times more—than the former. American and English authorities also differ materially on some points, as shown in the small table below, which gives the percentage of increase for rock of different sizes:—

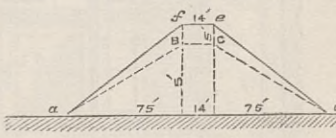
	Molesworth.	Searle.	Trautwine.
Rock, large fragments	+50	+60	+66 to +75
Rock, medium fragments	+25 to +30	+70	—
Rock, small fragments	+20	+80	+60 to +90

In this table it will be seen that Molesworth makes the voids to decrease with the decrease in the size of rock, whereas Searle and Trautwine make the voids to increase with the decrease in size of the rock. Under the heading of "Volume of Interstices in Concrete," Molesworth gives for five descriptions of small stone the percentage of total—that is, the percentage of interstices to total volume. The mean of these five is 44. In a volume of 100, including voids, the voids therefore amount to 44, which is equivalent to an increase in volume of 79 per cent. from the solid rock. This agrees with Searle and Trautwine.

In Gillespie's "Roads and Railroads," he gives a quotation from Gayffier, which says:—"A cubic metre of broken stone, placed in a water-tight box, which they just fill, can receive in the empty spaces between the fragments a volume of water $\frac{48}{100}$, or nearly one-half of the whole, the actual solidity of the stones being therefore only $\frac{52}{100}$. This does not vary for stones from 1in. to 8in. in size." This is equivalent to an increase of 92 per cent., and is practically a close agreement to the result obtained by Trautwine, with a loose heap of rock fragments, which gave an increase of 90 per cent. As an instance of large percentage for shrinkage, I may mention the construction of the Western Division of the Canadian Pacific Railway, where 10 per cent. was allowed for the subsidence of earthen embankments constructed by scraper work, and 15 to 17 per cent. for similar banks constructed with a grading machine. Another instance of still larger percentage is that on the construction of the levees of the Mississippi—1882—where 17 per cent. is allowed for shrinkage of embankment, and this, be it remembered, is for an embankment which is intended to keep out water. The specifications do not state the methods of construction, and no mention is made of a grading machine, but it is stated that "a sufficient number of dumping men be kept on the levee to spread the earth as it is wheeled or carted in." In sandy loam Mr. Specht found the volume of embankment, after completion, to increase more than 9 per cent. over the excavation. Morris and other authorities found that similar materials had an ultimate shrinkage of over 10 per cent. Therefore, to cause an equal shrinkage of 10 per cent. from cut to fill, in Mr. Specht's work, his embankment, after completion, would have to shrink about 18 per cent. In other words, a bank of loam, 10ft. high, built up in layers by scraper work, would have to settle about 2ft. An examination of the Table B will show other serious differences amongst the authorities given in the percentage allowed for shrinkage. In such experiments any near agreement is not to be expected, but at least it is reasonable to expect a general agreement tending one way from the same materials in similar banks. The experiments conducted in this manner should all show, for similar materials, either a diminution or increase, and not a diminution in one case and an increase in the other. In the practice of American and English engineers there is considerable divergence amongst themselves as to the subsidence or settlement of embankments, which subsidence again depends on their shrinkage in volume. Some authors give the percentage of shrinkage without any reference to settlement of bank, and in these cases the inference to be drawn is that the settlement is the same as the shrinkage. Other authors give rules for the settlement which do not agree with the shrinkage.

In order to show the want of accord in the rules given, I give three examples from three well-known authors. Searle, in his "Field Engineering," gives the ratio of shrinkage to cut for different materials, and adds with reference to settlement: "The lineal settlement will be about in the ratios given above." An investigation will show this rule to be correct. Alexander L. Holley, C.E., in his "Railway Practice," states: "The shrinkage of earthwork is stated to be as the cube of the depth; hence the necessity of due provision in lofty banks." For the purpose of illustration the shrinkage and settlement are assumed for a bank 5ft. high, and from this the settlement of a bank 40ft. high is found. The bank shown in Fig. 1—not to scale—is 14ft. wide on top, 5ft. deep, and has side slopes 1½ to 1. After ultimate shrinkage the 5ft. bank is assumed to have settled 3in., therefore the area of shrinkage will be *a*, *b*, *c*, *d*, *e*, *f*, *a*, on Fig. 1, equal to 21·5 × ·25 = 5375 square feet, which is a reasonable shrinkage, being only 5 per cent. of the

Fig. 1.—Not to Scale.



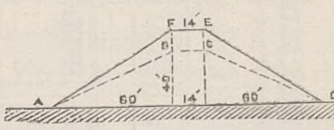


Fig. 2.—Not to Scale.

area of the bank. Now, as $40^3 : 5^3 :: 512 : 1$. Therefore, the shrinkage of the 40ft. bank will be: 5·375 × 512 = 2752 square feet. This is equal to A, B, C, D, E, F, A, Fig. 2; and as the shrinkage is all vertical, the area of shrinkage divided by mean width = settlement.

Therefore the settlement $= \frac{2752}{74} = 37$ft., being almost the full height of bank. If the shrinkage of the 5ft. bank be taken at only 2 per cent., then by the rule of the cube of the depth the settlement of the 40ft. bank will be 14ft. From these examples it will be seen that this rule does not hold good, and that the shrinkage is not as the cube of the depth. Mr. Holley evidently copied this rule without investigation. There is a sort of scientific look about the rule, but an investigation will show that it is nothing more than a most useless and misleading rule-of-thumb. To show how rules are sometimes glanced over and accepted without investigation, it may be mentioned that this rule was given several years since in a work which in other respects is accurate, namely, the "Treatise on Civil Engineering," in use at the Roorkee Civil Engineering College, and in all likelihood it is continued in it to the present day in the last edition. It was not until long after the writer left the college that he tested its accuracy and found out its fallacy. Vose, in his "Manual for Railroad Engineers," quotes the experiments of Morris for shrinkage, after which, and under the heading of "Subsidence," he states:—"It has in some cases been specified that the embankments, when completed by the contractor, should be finished to the full height from 3in. above the intended height, upon a bank 5ft. high to 9in. upon a 40ft. bank, and intermediate heights being in proportion." Vose here gives a rule that, in a certain case, when a 5ft. bank subsides 3in., a 40ft. bank will subside 9in. He also states that banks shrink a certain percentage in proportion to their volume. As already shown, the shrinkage of a 5ft. bank, and corresponding to a subsidence of 3in., is 5·375 square feet, which is 5 per cent. of the area of bank, 107·5 square feet. Now a 40ft. bank—Fig. 2—has an area of 2960 square feet, and 5 per cent. of this = 148 square feet = its shrinkage; and as this shrinkage occurs only in the vertical direction, $\frac{148}{74} = 2$ft. = the depth of settlement, and not 9in. From this it will be seen that the rules for shrinkage and settlement as given by Vose do not agree with each other. I think I have shown that there is a great want of general agreement in the results of experiments on shrinkage, and also in the rules for settlement as given by writers on the subject. Holley says:—"Correct allowance is made for the settling of the material of the bank, and time is given for this settling to occur before the ballast is brought on or the rails and sleepers laid. The shrinkage of earthwork sometimes disturbs the grade at a rate of several feet rise or fall per mile—in normal grades of 60ft., on the New York and Erie road, a distance of 500ft. was found to rise at the rate of 75·4ft. per mile, this distance being approached and succeeded by the regular grade of 60ft. In another place, for the distance of 200ft., the rise was found to be at the rate of 116·7 per mile, with a level of 100ft. length, both above and below—the average grade over the whole mile being 60ft. These cases are similar to what occurs where railway earthwork is not properly settled before being brought into use."

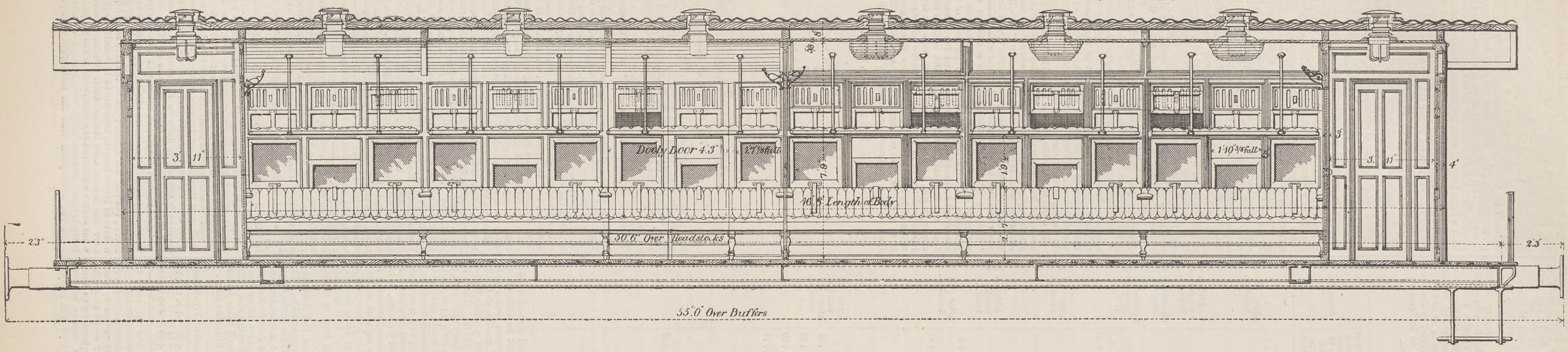
On the assumption that the settlement is in proportion to the

* "Transactions" of the Technical Society of the Pacific Coast.

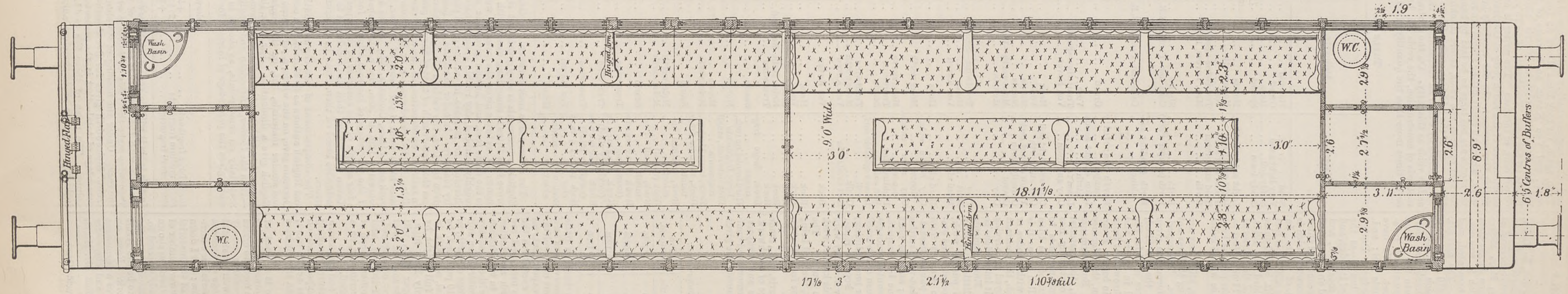
INDIAN STATE RAILWAYS.—DOUBLE BOGIE COMPOSITE CARRIAGES.

(For description see page 77.)

HALF LONGITUDINAL SECTION OF SECOND CLASS — HALF LONGITUDINAL SECTION OF FIRST CLASS



HALF PLAN OF SECOND CLASS — HALF PLAN OF FIRST CLASS



shrinkage in volume, I will now show that, even when due allowance for settlement is given to the bank to make up for the shrinkage in volume "from cut to fill," still cases happen where the bank will settle more than that allowance, and it is possible that the banks mentioned by Mr. Holley had, when they were first built, the full allowance for settlement usually given. It is well to note here that there is a marked difference in some cases between the shrinkage of an embankment and the shrinkage of the material of which it is composed, from cut to fill. Trautwine says:—"Although earth, when first dug and loosely thrown out, swells about $\frac{1}{5}$ part, so that a cubic yard in place averages about $1\frac{1}{5}$, or 1·2 cubic yards, when dug; or one cubic yard when dug is equal to $\frac{5}{6}$, or to ·8333 of a cubic yard in place; yet, when made into an embankment it gradually subsides, settles, or shrinks into a less bulk than it occupied before being dug." Molesworth, in his "Pocket Book," states that clay, before subsidence, increases in volume 20 per cent. from cut to fill, but that after subsidence it shrinks in bank 8 per cent. less than the volume in cut. The embankment therefore shrinks from a volume of 120 to a volume of 92. This amounts to a total shrinkage of embankment of 23 per cent. Mr. Specht's experiments support these statements as to the first or temporary increase from cut to fill. He found that "53,350 cubic yards in cut gave 58,350 in fill," in "sandy loam with small amount of adobe and hard pan," which is an increase of 9·4 per cent. Mr. Specht remarks, with reference to this increase: "This question must not be confounded with that of final settlement, which sometimes even continues for a long time after the embankment is finished."

The temporary increase of volume in embankment, mentioned below, has reference to banks built up with some rapidity, to full height and without layers. In Table B it will be seen that, for materials similar to Mr. Specht's embankment, American and English engineers give a permanent shrinkage from cut to fill of from 8 to 12·5 per cent., being an average of about 10 per cent. This final shrinkage, as well as the first increase, being allowed, it is evident that the total shrinkage of an embankment from its first completion to its permanent settlement must equal the first increase in bank beyond the volume in cut, plus the final shrinkage from cut to fill—that is, in the case just given, 9·4 + 10 = 19·4 in a volume of 110, which is equivalent to 17·6 per cent. In order to have a permanent depth of 40ft. after settlement, an embankment in the material just described would require to be built 48·5ft. in depth at first. If the banks mentioned by Mr. Holley were intended to be, say, as an instance, 46ft. high after final settlement, and that the material of which they were constructed increased at first 5 per cent. more than cut, and had a final shrinkage of 10 per cent. less than the cut, then the total shrinkage of 14 per cent. would require the depth at first to be 53·5ft. If, however, 10 per cent. be allowed only for shrinkage, the bank will at first be 51·1ft. deep, and as the actual settlement of this, at 14 per cent., will be 7·2ft., the bank at final settlement will be only 43·9ft. deep instead of 46ft., which is 2·1ft. lower than intended. This is as much as the greatest settlement of bank already mentioned by Mr. Holley, and is due entirely to the fact that no increase in the depth of bank was allowed in proportion to the first increase in volume from cut to fill. Is it not probable that a great deal of the settlement noticed in earthern banks is to be accounted for as just explained? For balancing cuts and fills, only the permanent difference of volume in cut and settled bank is to be taken into account; but for the settlement of bank an additional allowance has to be made for the temporary increase in volume from cut to fill. Cases occur where it would not be advisable to allow for the full shrinkage of a bank during construction, and it is here that the element of time is of importance. Hewson, in his work on "Levees," says:—"Sand, however loosely it may be shovelled together, fills its space closely, and therefore, whether wet or dry, settles at a very small diminution of the original bulk. In time, too, the process of this settlement is short." "Spon's Dictionary of Engineering" states:—"The ultimate settlement of embankments of gravel or chalk does not require more than two or three years, but clay embankments may, in some cases, continue to shrink for ten years." To give an instance where it would not be advisable to allow for full shrinkage, let an embankment, on a maximum or ruling grade of 1 in 100, be built across a hollow, and let its depth gradually increase until at a distance of 200ft. from beginning of fill, its depth is 40ft. From experience with similar material, it is known that the embankment will shrink about 10 per cent. within two years, of which 5 per cent. takes place within six months, and another 5 per cent. within a further period of eighteen months. The road is to be in full operation within about six months from construction of the embankment. Now if an allowance is made in height of bank for ultimate shrinkage of 10 per cent., then its height at greatest depth will be 44·4ft.; but as within six months it will shrink only 5 per cent., then its height at that time will be 42·2ft.—that is 2·2ft. higher than grade. This 2·2ft. additional height is gained in 200ft., and it increases the grade of road from 1 in 100 to a steeper grade than 1 in 50, but as the ruling grade is to be 1 in 100 the allowance for ultimate settlement during the construction of the bank is not admissible. If, however, shrinkage for only 5 per cent. be allowed at first, and the bank built up to 42·1ft. in height, it will, at the end of six months, have settled down to 40ft. and be even with the ruling grade. After this, as the bank gradually settles, it can in the regular course of track repairs be brought to grade by the trackmen with additional ballast. As to the effect of time in the consolidation of banks, the writer is of opinion that an embankment built of loam with a slight admixture of sand does not after several years so shrink and consolidate as to equal for hydraulic work a comparatively new bank built in layers of less than 1ft. thick and rammed. The effect of time does not consolidate the bank so much as punning during construction. This opinion is based upon considerable experience in cutting through banks of the material mentioned. Very old banks are not here referred to, as the writer has had no experience with them. In the original construction of that part of the Grand Trunk Road from Lahore to Wuzeerabad, in the Punjab, provision was made for drainage—by bridges and culverts—only at the well-defined drainage channels. After the completion of the embankments, the drainage works were found insufficient to carry off the flood waters, as before the construction of the embankment more water was passed away over the surface of the country than by the well-defined drainage channels. In times of very heavy rainfall, the embankment dammed back this water, which rose behind it, flooded the country on the upstream side of the bank, breached the road, carried away bridges, and impeded the traffic. In the construction of bridges and metalled gaps to carry off the flood waters, the writer had to cut through the embankment in more than twenty-four places, making an aggregate length of more than 8000ft. in a distance of fifty-eight miles. In places where the bank was built without punning, it was found that after taking off about 2ft. in depth of the top, the body of the bank appeared like material newly deposited, and it was easily excavated. On the other hand, the banks which were built in layers and punned, were found to be well consolidated and much more difficult to excavate. The difference in the banks, though built of the same material, was very marked, the punned banks, even when comparatively new, being much more difficult to excavate than the others. After each rainy season the tops and slopes of the unpunned banks were much more cut up and fissured, and required more repairs than those that were punned. The banks were 40ft. wide on top, with side slopes of 2ft. to 1ft., and from 4ft. to 12ft. high. In some cases, during floods, the unpunned banks were breached by leakage before the water reached their tops, but not in a single instance was the punned bank reached by the leakage. Where, however, the punned banks were breached, the water first rose above their tops, and in flowing over them and falling to the down stream level cut through them. After a bank was constructed, the heavy and continuous traffic passing over it so consolidated its top that it acted as a roof, and passed off the rain-water to the side slopes. The rain water was thus prevented from entering the body of the bank and contributing to its shrinkage.

From the experience gained in this work, it is the opinion of the writer that time does not so compact and solidify an old unrammed bank as to make it equal, for the purpose of impounding water, to a rammed bank, even when the latter has been built more recently; and it is also his opinion that the top of a bank for impounding water should not be used as a roadway until after the lapse of sufficient time to allow it to take its ultimate shrinkage. A few words here in explanation of metalled gaps. They are simple, inexpensive road works, to pass off surface flood waters, and to save bridging. It was found that the bridging on the Grand Trunk Road required to pass off the flood water amounted to more than 8000ft. in length. The great expense, and the length of time required to complete this work, prohibited bridging. To provide ample outlets for surface drainage, portions of the embankment, varying in length according to the requirements of the flood waters, from 100ft. to 1700ft. at ground level, were excavated, and from ground level at each end, slopes of 1 in 30 were made to top of bank. The slopes and the portion on level of country were metalled to a width of 18ft., and on each side of the metal a brick wall, 2ft. deep and 1ft. wide, was built, the top of the walls being on a level with the metalling. A row of guide-posts 100ft. apart was fixed on each side of the metalling to guide travellers and vehicles to keep on the roadway during floods. During floods, which continue for only a few days in the year, these gaps passed off the surface flood-water at a low depth—less than 2ft.—and at such a low velocity as to permit traffic to be carried on in safety through the water, though at great trouble and inconvenience. During floods the gaps were fords, and at other times they made a good metalled road. After the flood subsided, the ordinary drainage of the country was passed off by the well-defined and deep channels, which had bridges or culverts built over them. This cheap expedient of gaps for passing off surface flood-water permitted the opening of the road during the rainy season several years before it would otherwise have been done had bridges been built at the time instead of gaps for carrying off the surface flood-water.

I will now show that under certain forms of longitudinal section, and one very likely to occur in broken ground, the use of certain formulæ in the computation is sure to cause a serious error in the result. Gillespie says, in his "Roads and Railroads":—"Average end areas is the most useful method in this country" for computing earthwork." Morris, in his "Earthwork," says, in reference to the same formula:—"This rule has been by far the most used of any in our country. With tables of cubic yards it is very expeditious, and has found numerous advocates amongst engineers on account of its simplicity and convenience." Searle states that this formula is approved by statute to be used in the public works of the State of New York. The diagram repre-

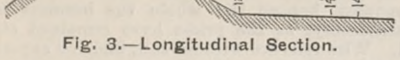


Fig. 3.—Longitudinal Section.

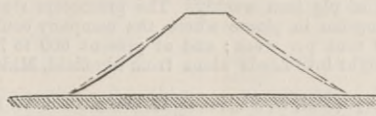
sents the longitudinal section of part of a line of railroad, the ground at all points transversely to the centre line being level, so that all cross-sections will be on level ground. The cut is 18ft. wide at base, with side slopes 1 to 1, and the fill 14ft. on top, with side slopes $1\frac{1}{2}$ to 1. In order to make an experiment on shrinkage, the engineer takes out the cut and builds the bank to the sections required. The end of the bank is assumed to stand vertically at A. The quantity in cut completes the embankment for 197·06ft. in length, as shown in diagram. After final measurement, the engineer computes his quantities by the formula of average end areas. He finds the volume of cut = 3096 cubic yards, and the fill = 2784 cubic yards. The quantity in cut appears therefore to exceed the fill by 312 cubic yards, showing a shrinkage of 10 per cent. In fact, however, there is no shrinkage. If the computations are made by the prismoidal formula, the volume of the cut will be found to be equal to that of the fill, 2708 cubic yards, so that the apparent shrinkage of 10 per cent. was entirely due to the use of an incorrect formula. If, again, the computation be made by the formula of average end heights, in which a section is taken with a height equal to the average of the two end heights, the volume of the cut will be = 2514 cubic yards and the fill 2670 cubic yards, showing an increase of 156 cubic yards = 6 per cent., which increase does not exist, as the cut and fill exactly balance, as before explained. The use of the latter formula of mid-sections gives a deficiency equal in amount to half the excess found by the use of average end areas. Another formula by mean proportionals, which gives less than the correct result, is sometimes used. The prismoidal formula is the only one of the four given which is sure to give correct results. The error will be even more than shown above, when the ground at cut slopes across the centre line of road. The error is greatest when one of the end areas = O, as seen in the column of cut given below. In similar cross-sections, in ground where the end heights do not materially differ, the error is small, as will be seen in the column of fill given below. Error in the results, however, can be avoided only, in so far as the computations are concerned, by the use of the prismoidal formula.

The following table gives the volume of cut and fill by the three formulæ used above:—

	Cut cubic yards.	Fill cubic yards.
Prismoidal formula	2,708	2,708
Average end area	3,096	2,784
Average end heights	2,514	2,670

There is a tendency among workmen to leave the side slopes curved in cross-section. For instance, embankments are sometimes finished with the side slopes concave, as shown in Fig. 4, and cuttings, especially in hard ground, are left with the side slopes convex, as shown in Fig. 5. It is therefore advisable, in cross-sectioning the work for final measurement, to take levels and measurements at frequent intervals, and before doing this work the adjustment of the level and the length of measuring instruments, chains, tape, &c., should be looked to. In descriptions of shrinkage experiments on earthwork, the following information would be useful, and in addition, such other information as might be deemed of use in arriving at a correct result:—(1) The description of material and locality. (2) Method of construction, such as by scrapers, wheel-

Fig. 4



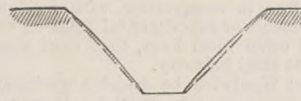


Fig. 5

barrows, tipping from wagons, &c. (3) Longitudinal section, and also cross-sections of cutting and embankment. (4) Average depth of layers, and if rammed. (5) Foundation of bank—that is, description of ground on which the embankment is constructed. (6) Dates of commencement and completion of bank and of measurement. (7) Rainfall, if any, and a general description of weather during period of work. (8) The formula used in computing the quantities. (9) If base of bank has been flooded, the depth of flooding, period during which flood lasted, and state of bank at the time, should be given.

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

(*From our own Correspondent.*)

IRONMASTERS attending 'Change in Wolverhampton yesterday, and in Birmingham to-day—Thursday—maintained before buyers as firm a front as was possible. They urged that the mild improvement which has appeared in the galvanised sheet trade will possibly extend to other branches, and further, that merchants are more ready to place repeat orders at previous prices than some time ago they were. Makers, indeed, declare this week that rather than accept less money they will stop their mills, since, although pig iron, coal, and other raw materials are very cheap, yet to sell finished iron at below current rates would be only adding to previous unsatisfactory business.

The orders placed at this week's meetings were not generally of a conspicuous sort. The sheet makers are best off, some of these firms having contracts upon their books which will provide employment until the middle or close of next month. These people are slightly firmer in their selling rates. Local sheet ironmasters have to compete for the business of the galvanisers and other buyers against the ironmasters of Warrington, and some other localities, who are now rolling sheets at very low rates, and carrying off many of the orders. The 5s. advance declared by the Galvanisers' Association is still quoted. Black sheets, of 20 w.g., are £5 15s.; 24 g., £6 to £6 2s. 6d.; and 27 g., £7. It is, however, as yet very difficult to secure any rise. In the galvanised state, corrugated sheets are abundant at £10 for 24 g. delivered Liverpool, and £11 10s. for 26 g.

Plates are tame at £7 upwards for common sorts, and £8 easy for boiler qualities. Makers of these have to compete against locally made basic steel boiler plates which are offered at £6 10s. to £7. Basic steel is coming to the aid of local machinery engineers, who, in connection with mining machinery and some other work, are enabled, by the product of the Staffordshire dephosphorised steel works, to use plates of greater weight than can conveniently be obtained from the local ironmasters.

In the bar trade here and there a little more business is secured, but as a rule purchasers prefer to buy small lots to meet present requirement. Prices are no stronger, common marked bars being offered at £7, medium sorts at £6, while unbranded iron can be secured at £4 12s. 6d. to £4 15s., which is an exceptionally low figure. Coopers' hoops are £5 5s. upwards, and superior hoops £6 10s.; gas tube strip is £4 15s. to £5.

Round Oak iron, which, more than any other, rules the best bar trade, is selling upon the basis of:—Bars, lowest quality, £7 12s. 6d.; single best, £9; double best, £10 10s.; and treble best, £12 10s. Strips and hoops and angle iron become: Lowest quality, £8 2s. 6d.; single best, £9 10s.; double best, £11; and treble best, £13. His lordship's rivet and tee iron become: Single best, £10; double best, £11 10s.; and treble best, £13 10s. Strips and hoops of $\frac{7}{8}$in. and 20 gauge become £9 2s. 6d., lowest quality; £10 10s., single best; £12, double best; and £14, treble best; while $\frac{3}{8}$in. becomes £10 2s. 6d., £11 10s., £13, and £15 respectively.

Messrs. Brown and Freer quote H.B. Crown bars, ordinary size, £7; hoops, £7 10s.; and sheets—singles—and plates, £8 10s.

Most of the business in pig iron has now been completed by buyers, still some speculative sales of large lots are here and there going on. Deliveries under late contracts are being made with a little more business, but by no means with the freedom which furnace owners would be glad to see. Prices at which current business is being transacted—and it is mostly in the brands imported from other districts—are unsatisfactory. Northampton pigs are 33s. to 34s. at railway stations in this district, and Derbyshires, 34s. to 35s. Local pigs are 50s. to 52s. 6d. for all-mine, and 30s. to 32s. 6d. for common foundry; while common forge remains at 27s. 6d. to 30s. Messrs. Roberts and Co., of Tipton, who have been keeping three out of their four furnaces in blast, have now given their furnacemen a fortnight's notice to terminate existing contracts, since the firm contemplate putting out of blast a second furnace. The reason assigned for this step is that the importations of iron from other districts make it impossible to sell native pigs at a profit.

The trade in minerals is quiet, Barrow purple ore is quoted 12s. 9d. to 13s. delivered into this district. Staffordshire red furnace mine is quoted 12s., and second qualities 10s. 6d., less $2\frac{1}{2}$ per cent. Northampton ironstones are selling at 5s. to 6s. per ton, according mainly to locality of delivery.

Conflicting statements are abroad as to the terms upon which the prolonged strike of the men at two of the Shropshire ironworks has terminated. Masters and men alike claim to have obtained the advantage, but it would seem, on the whole, as though the men have come best out of the business. The masters sought to bring puddlers' wages down to 6s. 3d. per ton, and millmen's wages in proportion, which was 6d. per ton under the scale at which the puddlers in South Staffordshire are now working in accordance with the award of the arbitrator to the Wages' Board. It would now appear that certainly some of the Shropshire puddlers have been allowed to resume at 6s. 9d. pending private arbitration by Mr. B. Hingley, M.P., chairman of the South Staffordshire Masters' Association.

The dulness which has for several months past existed in the Cannock Chase coal trade has now reached a climax which is accompanied by much distress amongst the colliers and their families. The owners keep their pits open as long as possible, but they are closed, on the average, four days a week; and the earnings of a collier are now stated to never average more than 7s. a week, and the surface men are stated to only average 5s. per week. It is even intimated that it is only occasionally that these amounts are realised. Under these circumstances it will be readily imagined that the privations of the colliers' families must be great.

Some colliery owners assert that the want of work is felt quite as acutely in some of the South Staffordshire districts.

At some of the Tipton collieries the men are now being paid at the following rates:—Bandsmen, 4s. 6d. per day; pikemen, in "New Mine" seams, 4s. 10d. per day for two stints; loaders, 3s. 4d.; horse drivers, 3s.; boys, 1s. 9d.; all for eight hours' work. In Belgium the men work twelve and even fourteen hours per day for 2s. 1d.

Certain of the employers are now coming to the aid of the South Staffordshire colliers, in their efforts to increase the ranks of the Union men. At a miners' meeting at Dudley on Monday, Mr. Benjamin Hingley, M.P., chairman of the Ironmasters' Association, urged that a strong and well-conducted Union was of advantage alike to masters and men, for unless the men were united they were sometimes dangerous in the way of violence, having no check upon them. A strong Union, too, kept wages tolerably steady, and a fair trade together. Upon the motion of Mr. Hingley, a resolution was passed, calling upon the men to strengthen the hands of the Union.

In consequence of the employers in the South Staffordshire and East Worcestershire chain trade having during the past twelve months enforced a series of reductions in wages, the majority of operatives are now in a deplorable state of poverty, skilled workmen being unable to earn more than 10s. a week. At a meeting this week it was decided to give notice for an advance, and if the concession is not granted a general strike will be declared.

The directors of the Patent Nut and Bolt Company, Smethwick, have resolved upon the payment of an interim dividend for the past half year at the rate of 5 per cent. per annum on the preference shares, and 10 per cent. per annum on the ordinary shares.

The half-yearly report of the Union Rolling Stock Company, Birmingham, is satisfactory, the improvement in the trade of the United States being regarded as a specially hopeful feature. There is an available total of £3512, out of which 6 per cent. per annum is to be paid on preference, 10 per cent. and a bonus of 2 per cent. on ordinary shares, and £557 to be carried forward.

The balance sheet of the Tamworth District Waterworks, which has just been issued, shows a net profit of £371 during the six months. The capital invested in the undertaking is nearly £30,000.

NOTES FROM LANCASHIRE.

(*From our own Correspondent.*)

Manchester.—A continued absence of improvement is still the sum and substance of any report as to the condition of the iron trade in this district. Users of pig iron are getting no weight of new work to bring them into the market as buyers of the raw material in any quantity, and so many of them have iron still to come in on account of old contracts that actual requirements for consumption are still further very considerably restricted. Where there are any orders to be given out, buyers expect to place them either for deliveries extending over so long a period or at prices so low, that, as a rule, only really necessitous sellers can be induced to accept them, and some makers prefer to stand practically altogether out of the market rather than to enter into competition for business on the unsatisfactory conditions upon which alone it seems to be practicable. In such cases makers assume an attitude of rigid firmness in adhering to their quoted list rates, not because they are able to command them in the market, but because the concessions which would be necessary on their list rates to bring forward business are so far beyond what they would be at all inclined to entertain, that it is practically useless attempting to meet buyers, and it is a wiser policy to offer no concessions whatever. There are, however, very low sellers, and it is chiefly into their hands the few orders that are stirring find their way, but the prices at which they are taken in most cases render it very questionable whether makers can see anything like their own back again out of the transaction. This applies both to common and hematite pig iron, and in manufactured iron business has to be done on much the same unprofitable conditions.

The Manchester iron market on Tuesday again brought forward only very discouraging results so far as business was concerned. There were very few buyers, and the orders offering were of no weight, with sellers in some instances prepared to take extremely low prices where business was to be done. For Lancashire pig iron makers still quote 37s. to 37s. 6d., less $2\frac{1}{2}$, delivered equal to Manchester, as their list prices. At these figures they are out of the market, and are doing little or nothing; but if offers leading to actual orders were made, there is no doubt they would be prepared to meet buyers with some concession. As regards district brands, there is a very wide margin between the prices which some makers quote and those which others are taking. For some Lincolnshire brands makers are not quoting under 35s. 6d. to 36s. 6d., less $2\frac{1}{2}$, delivered equal to Manchester; whilst others are being offered as low as 33s. 6d. and 34s. 6d., less $2\frac{1}{2}$, delivered here, and on about the basis of the minimum figures orders have been placed for delivery over the remainder of the year. For outside brands coming into this market the current quoted rates remain without material change, but there are cheap sellers, and in Scotch brands there is much more than the ordinary margin in the favour of the buyer between the price of makers' iron and warrants, whilst in Middlesbrough iron there is underselling to secure orders.

For hematites there is still only a very poor demand, and prices are extremely low, No. 3 foundry Cumberland hematites being obtainable at about 50s. 6d. to 51s., less $2\frac{1}{2}$ per cent., delivered equal to Manchester, and local brands at 2s. or even 3s. per ton under these figures.

In the manufactured iron trade, shipping orders have brought a little more work into the hands of some of the makers, and here and there forges are fairly well employed; but there is no real improvement in trade generally, and no better prices are being got. Makers do not openly quote on any lower basis than £4 17s. 6d. for bars, £5 7s. 6d. for hoops, and £6 10s. for sheets, delivered into the Manchester district; but there are merchants who are prepared to undersell at these figures.

In some branches of the engineering trades a rather more cheerful tone seems to prevail, and there are more hopeful reports from the Continent. There is, however, still nothing definite in the shape of actual improvement, and amongst general engineers and locomotive builders trade continues very slack, with no increasing weight of orders coming forward.

In connection with fire brigade appliances, I may mention that Mr. Superintendent Tozer has designed a very simple telescopic fire escape as an addition to the ordinary hand hose-cart. This is constructed of three sliding ladders, which are elevated by means of ropes and pulleys, and the escape is carried on the top of the hose-cart, which can be utilised to form a part of the escape, or the ladders can be taken off and used independently. The ropes and ladders are self-locking at any point, and can be used at any height up to 40ft. or 50ft., and the whole apparatus, which can be added to the hose cart at a cost of about £10, weighs less than 3 cwt. This escape is now in general use in the Manchester Brigade, and has been found extremely useful. In addition to its handiness it is very useful in narrow passages, and can be conveyed without difficulty under railway arches and telegraph wires, or taken through an ordinary garden gate, which would be an impossibility with the usual type of fire-escape.

The Manchester Ship Canal scheme has this week been fairly launched as a financial operation, and although general surprise has been expressed at the very short period which has been fixed—from Tuesday to Friday in the present week—for receiving subscriptions for the required capital of $7\frac{1}{4}$ millions, from what I can hear the promoters have every reason to be satisfied with the manner in which the shares have been taken up. The successful raising of the required capital being now generally accepted as an accomplished fact, the question is being repeatedly asked, When will the actual work of building the canal commence? It is rather premature to offer any opinion upon this point, but as the land which will be required has not yet all been surveyed, and has still to be bought, there is a good deal of preliminary work to be got through before the contractors can formally enter upon their work, and if they commence operations early next spring it is perhaps as soon as can reasonably be expected.

In the condition of the coal trade there is no material change to report. For all descriptions of fuel the demand continues extremely dull, and pits are not kept working more than about four days a week. With this restricted output, stocks of all description of round coal are accumulating. Prices are without quotable alteration, and except where sales have to be forced to clear away stocks, they are about as low as they are at all likely to go during the summer.

Shipping shows a little more activity, but no better prices are being got, 6s. 6d. to 7s. per ton remaining the average figures for steam coal delivered at the Mersey ports.

The efforts to establish a sliding scale to regulate miners' wages in the West Lancashire district have got so far that the coalowners have now made a definite and final proposal, which it remains for the men to accept or reject.

Barrow.—There is a steady tone in the hematite pig iron trade of this district. Makers are fairly employed, and the demand is well sustained from home, continental, and American sources. There is every prospect of a continuance of the present condition of the market, as makers are not only fairly sold forward, but they are in receipt of enquiries which are likely to lead to contracts before the close of the season. There is of course a large number of furnaces out of blast, but it is also noticeable that those which are making iron are yielding a heavy tonnage. The furnaces are now producing something like 27,000 tons of pig iron per week, and all this is going into immediate consumption. Prices are still very steady, and mixed Bessemer numbers are selling at 42s. per ton net at works, prompt delivery. There is a poor trade in forge and foundry samples; indeed, forge and foundry work generally throughout the district is at a very low point. The steel trade remains busy in the two chief departments. Steel rails have been well ordered for Canada, the Continent, and for home consumers, and there is still a good enquiry, especially now that prices have gone down to about £3 10s. per ton for heavy sections net at makers' works. The mills engaged in the tin-plate bar trade are also very busy, and there is a good demand for this class of goods which is likely to lead to continued activity in this branch of industry. There is a very weak trade doing in steel plates for either ships or boilers, and the minor branches of the steel trade are also very inactively employed. The shipbuilding industry is getting more and more short of orders. Very few are offering, and these are keenly competed for. Engineers are short of employment, except in the case of marine engineers, who are busily employed on pressing orders. Iron ore is in poor demand at from 8s. 6d. to 11s. per ton net, at mines, but only the better qualities of ore command any sale. Coal and coke are in steady request, but the trade generally is slow. Shipping has found better employment of late.

THE NORTH OF ENGLAND.

(*From our own Correspondent.*)

THERE are still no signs of improvement in the Cleveland pig iron trade. Indeed prices are somewhat weaker than at the beginning of last week; and as buyers believe still lower rates will be taken, they purchase only in small quantities, and for prompt delivery. Towards the close of last week some transactions took place in No. 3, g.m.b., at 29s. per ton. At the market held at Middlesbrough on Tuesday last, prices were a little firmer, the usual quotation by merchants being 29s. 3d. per ton. Only two or three could be found who would accept 29s. 1½d. Consumers were unwilling, however, to give more than 29s., that price having been recently taken; consequently no sales were made, and business was almost at a dead-lock.

No business can be reported in warrants; the price remains nominally at 29s. 6d. per ton.

For the week ending Monday, the 19th inst., the increase in Messrs. Connal and Co.'s Middlesbrough stock was 2979 tons. The total quantity in store on the same day was 265,333 tons. The shipments of pig iron from Middlesbrough continue very disappointing. During the first nineteen days of the month only 33,515 tons had been exported, against 44,709 tons during the corresponding portion of June.

In the finished iron trade the outlook is no better. But few specifications are being given out, and it is only with the greatest difficulty that the works which still remain open can be kept employed. Prices are as follows:—Ship plates, £4 10s. per ton; angles, £4 5s. per ton; and common bars, £4 10s., all free on trucks at makers' works, less 2½ per cent. discount. Steel manufacturers are well employed, but the prices they obtain are miserably low. Rails are offered at £3 12s. 6d. to £3 15s. per ton, plates at £5 17s. 6d. to £6, and angles at £5 15s. at works.

It is reported that Messrs. Wm. Gray and Co., of West Hartlepool, have secured orders for three large steamers of about 3500 tons capacity each. They are for the American trade. Two are for a Bristol firm, and one for an American company. The engines will be made by themselves at their Central Marine Engine Works.

Shipments of Cleveland steel rails and sleepers have improved considerably during the last three months. For the quarter ending June 30th, 1886, the quantity exported was 55,176 tons, as against 33,906 tons for the previous quarter, and 22,794 tons for the last quarter of 1885.

Many hopes are beginning to arise as to the effect of the new convention between Great Britain and Spain. The measure has passed the Spanish Cortes by a large majority, notwithstanding the strenuous opposition of the Catalan manufacturers, who fear competition from Lancashire. The value of the convention to English producers may, however, be easily over-estimated. All that it will effect will be to place England in the same position as other countries. The import duties on manufactured articles will still be very heavy. Notwithstanding that a considerable portion of our national debt was run up in years past, in order to assist the Spaniards to turn out the French army under Marshall Soult—an act of friendliness which ought to have made them regard us with feelings of special gratitude for ever—they alone of all nations have hitherto refused us, the "most favoured nation" trade conditions. There never was a more glaring instance of national ingratitude. However, "by-gones must now be bygones," and we shall have once again a chance of competing on equal terms with France, Germany, and Belgium in supplying our manufactures to the Peninsular. The new import duties will be reduced as follows:—Pig iron, from 1s. 0¾d. per cwt. to 9¼d. per cwt.; rough bars, from 5s. 3d. to 1s. 5d.; rails, from 3s. 3d. to 1s. 10d.; bars, hoops, and plates, from 5s. 3d. to 3s. 6d.; nails and screws, from 8s. 2d. to 6s. 0½d.; engines and machinery, from 1s. 0½d. to 9¾d. There are also considerable reductions on the import duties on salt and soap.

The Northumberland coal trade seems to be in a very uncertain and despondent condition. At several of the collieries work is exceedingly slack. At this time of the year all which can produce steam coal ought to be working full time. It is not so, however; scarcely any of the miners having obtained their full number of shifts since the winter, when they suffered great privations. All this is occasioning anxiety, inasmuch as it is feared that another winter will arrive before either employers or workmen have been able to accumulate much in order to enable them to withstand it.

THE SHEFFIELD DISTRICT.

(*From our own Correspondent.*)

IN the Yorkshire and Derbyshire coal districts the depression seems to deepen. About two hundred colliers employed at the Coppice-side Colliery, belonging to Mr. E. M. Mundy, of Shipley Hall, have had notices served upon them, the reason assigned being the serious depression in the coal trade. Twelve stalls at the New Sinking Pit, Coppice-side, and others at different pits belonging to the company, are to be closed. For some time the miners have only worked about quarter time. The Butterley Company is widening the main shaft at its Bayley Brook Colliery, Heanor. The work will last over three months, during which time the men have been required to find employment elsewhere.

Fresh competition is springing up in the Bessemer and open-hearth steel, a company having been formed at Hunslet, Leeds, for the production of those grades of steel suitable to the requirements of the West Yorkshire and Lancashire districts. At first the output is expected to be 1000 to 1200 tons per week of steel suitable for rolling off into finished materials in bars, sheets, plates, tires, and steel castings. The blast furnaces are estimated to produce up to 2000 tons of pig iron weekly. The promoters state that the actual consumption in places where the company could compete exceeds 5000 tons per week; and at present 600 to 700 tons per week are brought into Leeds alone from Sheffield, Middlesbrough, and Glasgow.

Rails are very quiet, at £3 10s. to £3 15s. per ton for an ordinary heavy section. I heard of a small order being taken a few days ago by a local firm in competition with foreign makers. It is expected, as the result of experimental trials on various sections of the Midland and other local lines, that steel sleepers will form a new branch of the steel industry.

The accident at Woolwich, by which a workman was killed, has excited much interest in this district. It was distinctly stated that the Woolwich authorities had abandoned all idea of producing large steel ingots for the manufacture of heavy ordnance, and on their decision the local firms expended large sums of money in laying down new plant and adopting the finest appliances for the work. One firm alone must have spent about £100,000, and other three companies have been adding largely to their capital on this account.

Only the other day I heard the chairman of Messrs. John Brown and Co., Atlas Steel and Ironworks, announce to his shareholders the satisfaction he felt that their industry was not going to be disturbed by a Government monopoly. Mr. Mundella, in the course of his campaign in Brightside, where the great Sheffield works are situated, made a feature of his energetic efforts to prevent Woolwich becoming a competitor with Sheffield. Mr. Wortley, another of our local members, had also the promise given to him by the Surveyor-General of Ordnance in Mr. Gladstone's late Administration, and it was repeated to others, that the Woolwich gun factory should not be permitted to embark in the manufacture of large steel ingots; yet, according to the *Times*, the accident occurred while the authorites were trying their hands at an ingot for a 68-ton gun. There will no doubt be a searching inquiry into the matter, for it is of paramount importance that the local firms who have so readily met all the Government requirements and expended enormous sums of money to make Sheffield equal to producing anything that may be needed, should know exactly where they are.

NOTES FROM SCOTLAND.

(*From our own Correspondent.*)

THE past week has been an exceptionally quiet one in the Scotch iron trade, in consequence of the Glasgow Fair holidays. The pig iron market, which was closed for several days, has been dull since its reopening, but the quotations of warrants have been fairly steady. The week's shipments of pigs were 6916 tons, which is below the average, but compares with 5311 tons in the preceding week. The home and foreign inquiry are both quiet, and the prospects of the trade the reverse of cheering. Considerable additions to stock have been made in the course of the week. There are 85 furnaces in blast, as compared with 90 at this date last year.

Business was done in the warrant market on Thursday before closing for the holidays, at 38s. 10½d. cash. On Tuesday, when the market again opened. transactions took place at 38s. 10½d. to 38s. 10d. cash. Business on Wednesday was done from 38s. 9½d. to 38s. 10d. cash, closing with sellers at 38s. 10½d. cash. To-day —Thursday—the market opened firm, and considerable business was done from 38s. 10½d. to 38s. 11d. cash, closing in the afternoon with sellers at latter prices.

The values of makers' pig iron are as follow:—G.m.b., f.o.b. at Glasgow, per ton, No. 1, 39s. 6d.; No. 3, 36s.; Coltness, 46s. 6d. and 43s.; Langloan, 43s. and 41s.; Calder, 45s. 6d. and 41s.; Summerlee, 45s. 6d. and 41s.; Gartsherrie, 42s. 9d. and 41s.; Clyde, 42s. and 39s.; Carnbroe, 41s. 6d. and 39s.; M. and C., 39s. and 37s.; Glengarnock, at Ardrossan, 42s. and 39s. 6d.; Eglinton, 39s. 3d. and 36s.; Dalmellington, 40s. 6d. and 37s. 6d.; Shotts, at Leith, 44s. and 43s. 6d.; Kinneil, at Bo'ness, 43s. and 42s.; Carron, at Grangemouth, 46s. and 45s.

Hematite warrants are quoted at Glasgow Exchange at 41s. cash.

The past week's arrivals of Cleveland pigs at Grangemouth were 4705 tons, as compared with 4990 in the corresponding week of last year.

In the course of the past week there were despatched from the Clyde five locomotive engines and tenders, valued at £11,650, for Kurrachee; £14,493 worth of various kinds of machinery, exclusive of sewing machines, of which £4850 worth were despatched; steel goods, £4800; and general iron manufactures, £32,900.

The coal trade has been quieter than usual on the West coast in the past week, and the next week's shipping business may also be expected to be of small proportions. At Grangemouth the supplies from the West are reported to be coming to hand slowly, but there is plenty of coals at the harbour available to make up present cargoes, and a large quantity is being despatched. During the week four steamers and ten sailing vessels got away from Bo'ness with coals, but the exports from Leith were rather below the average.

The action taken by the iron and coalmasters in the West of Scotland in reducing the wages of the miners is now being followed in the eastern mining districts. A few days ago the masters of Mid and East Lothian gave notice of a reduction of 10 per cent., which was to affect the pay of all other workmen in their employment, as well as miners. Several meetings of miners have been held at Dackeith to consider the situation. At one of these upwards of 1000 men were present. It was stated by the chairman—Mr. James Low, of Newbattle—that this was the third time the miners of the Lothians had been called upon to suffer a reduction of wages. Delegates from fifteen collieries attended a subsequent meeting, and it was resolved to revive the miners' association of the district, which has been out of existence for several years.

Messrs. Robert Duncan and Co., shipbuilders, Port Glasgow, have obtained an order to build two steamers of 1600 tons each, and of a high rate of speed, for a firm at New York. Messrs. J. and W. Goffey, of Liverpool, have arranged with Messrs. Russell and Co., of Greenock, to build a four-masted ship of 2400 tons net register. This will be the largest sailing vessel ever built at Greenock.

WALES AND ADJOINING COUNTIES.

(*From our own Correspondent.*)

IT is currently stated that several important collieries are on the eve of being closed. One of the managers in explanation said that present prices meant giving the coal away, and that it would be better to endeavour to put up with a little loss in keeping colliery in working order than go on at present rate. A shipowner at Cardiff told me on Saturday that Monmouthshire coal was then being sold f.o.b. in Cardiff for 6s. 9d. This means about 4s. 9d. at the pit's mouth. Blaenavon and Ebbw Vale coal are conspicuous Monmouthshire coals in present competition, and it is questionable if it is worth while opposing on the part of Glamorganshire owners. I question if the four-feet, six-feet, and nine-feet of Glamorgan can be matched by Monmouthshire, but lower prices tempt, especially if the article is fairly good.

Cardiff showed a larger export last week, but demand is far behind capacity of even moderate output. Shippers and coalowners regard the times as the worst they have endured for the last quarter of a century, and the outlook is bad. "European complications," as coalowners call possible war between the Great Powers, are regarded as the only means of lifting prices, though such a curative is not desired. Some are hoping that general industries may improve after the formation of a strong Conservative Government. Anyhow, conditions are critical throughout Wales, and dry docks and various industries are suffering as badly as coal. In iron ore vessels trading are doing so at a constant loss, for there is not an assured return cargo, and freights are only 3s. 6d. Foreign ore can now be bought in Cardiff, ex-ship, for 9s. 6d., and in some cases a few pence less. These are the lowest quotations yet.

Dowlais, Ebbw Vale, and Blaenavon have received large consignments this week. Iron and steel exports have been small again, and little is doing. Middlesbrough is competing successfully with our works in supplying tin-plate works with pig, but a fair trade is being done at Dowlais and other works in steel bar for tin-plate, and Bessemer is taking the lead. It is fortunate for Wales that tin-plate continues firm. This is the only industry that exhibits any amount of vitality. Prices are firm, sales large, since the quarterly meeting, and stocks are gradually decreasing. Good brands cannot be had under 13s. 9d., though some ordinary cokes are on the market at 13s. 6d. For good Bessemer as much as 14s. 3d. is obtainable, and workers are not pushing trade.

Last week 3200 tons of tin-plates were shipped from Swansea to Baltimore and Philadelphia, and a cargo also went to Portugal. The total shipments of tin-plates from that port amounted to 40,125, and as only 35,000 boxes came from the works, it is evident that stocks are being eaten into; Siemens meet with a moderate sale at 14s.

Swansea coal trade with France has suffered of late seriously. It is evident that industries everywhere are at a low ebb. Demand for patent fuel shows some improvement. Last week Swansea shipped 7000 tons and Cardiff 4000 tons.

I see that "Nettlefolds" at Newport are progressing well. There were some good clearances of coal from that port on Saturday. I may note a few cargoes, viz., 3091 tons for Bombay, 2800 tons for Spezia, 1450 tons Leghorn, 1740 tons Savona, 1600 tons Genoa.

Railway shares continue to depreciate. Taff Vale are at 217, the lowest yet known. These shares have touched £301. Barry Dock are at 3 to 3½; Rhondda and Swansea, 6¼; Severn and Wye, 4. Other industries show the stagnation in coal. Bute Dry Dock are at 29, issued not long ago at 50; Gloucester Wagon Company at 5½.

The sale is announced of valuable engines and a quantity of plant at Cadexton Collieries, Neath.

Important changes are suggested with regard to the Swansea and Cardiff Smokeless Steam Company, as, while Penbre in the Rhondda yields a steady profit, Resolven, in the Neath Valley, entails a loss.

I am glad to find that I was in error last week with regard to the Yspitty Works. I find that they have been re-started, and have been working continuously for some little time.

NOTES FROM GERMANY.

(*From our own Correspondent.*)

IT was expected in some quarters that the restriction of output in pig iron would have the effect of causing buyers to come to the sellers instead of, as hitherto, the sellers being obliged to seek the buyers; but up to the present, at all events, such has not been the case, and the best that can be said is that prices have become stationary, and that there are not so many sellers *à tout prix* in the market as formerly. In fact, prices have fallen to that level that it can now only be a question of ceasing production altogether or losing more money, so that lower prices are scarcely to be looked for. The reports from France, on the other hand, exhibit quite a rosy hue, and as the various members composing the different industrial conventions are acting with loyalty towards each other in keeping to their agreements, not only are prices declared satisfactory, but work is abundant, especially for consumption in Paris.

In Belgium fewer orders are coming forward, but in prices there is no alteration. To return to Rheinland-Westphalia; iron ores, both native and foreign, are in poor request, at prices if anything a shade weaker than last quoted. The prices of spiegeleisen are unchanged, and the export demand has not increased. Forge pig is freely offered, but at losing prices. Foundry pig, as is to be expected when the machine-shops are slack of work, is obliged to suffer a sacrifice. There is little demand for Bessemer and basic pig, and the prices are maintained with difficulty. The malleable iron market is as unfavourably situated as ever; works obliged to carry on without profit, and no sign of speedy improvement. Boiler-plates have maintained the prices the last fortnight, as there has been a better call for them; but they are unremunerative at the prices quoted. As a rule, no works are able to work full time. Thin sheets have in some cases been in request, but on the whole the business in them has been unsatisfactory, as the prices have remained stationary, as last noted. Wire rods are without call, and the export trade next to nothing. In rails the outlook is not encouraging, as since the rail combination with England has ceased, English rails may be put upon the German market; so the makers here, who are as it is badly off for orders, are beginning to fear the competition, and if the German-Belgian combination ceases too, they will have that of the latter country to contend with as well. The wagon building works have little to do, and the few orders which have been lately given out, when divided amongst so many, is scarcely felt by any of them. With the exception of a few factories, engaged on special machines, all have little work on hand. The prices of coal and coke are beginning to weaken, on account of the breaking up of the convention as last reported. It appears that for the first quarter of this year twenty-three applications for indemnification had been handed in to the board of management of the convention to cover the loss sustained on 22,972 tons of coke and 33,937 of coals, which were not required to be raised according to the amount agreed upon. The indemnification amounted to M. 27,976, but as only M. 9000 was in hand the M. 19,000 had to be raised by a rate of M. 20 per 1000 tons on the output of the quarter.

Krupp, of Essen, has secured an order for 1500 tons of rails for China, and, as is said, for renewals on an existing railway of 15 to 18 kilometres in length. This is an insignificant quantity, it is true; but, nevertheless, it is the insertion of the thin end of the German wedge in those parts. This proves that the observations on this subject in a former letter were not made without a good reason, and when it is considered what astute diplomacy, what personal energy and perseverance is displayed in the East by our would-be rivals, it becomes quite clear that if we are to hold our own the parties concerned must be up and doing, keeping continual watch on what is there going on, putting forth their well-known accustomed enterprising energy, courage, and perseverance, and above all, keeping themselves always and at all times *en évidence* on the spot, which cannot be better accomplished than by establishing—by means of and in conjunction with the united Chambers of Commerce, which are principally interested, perhaps—a personality permanently in the country who has touch with our diplomacy in Pekin, knows the country, chief officials, its language, manners and customs well, and who is besides a business man of tact and high standing. Such a well-known man, for instance, as one of the present Commissioners in Upper Burmah, who, as it happens, is also an engineer, which, under the circumstances, would be an advantage.

The Russian Government is about to send a circular to all the railway administrations in the country to forbid them ordering any more machinery or parts thereof from abroad.

The first of the vessels which started on its voyage at the beginning of the month from Bremen to the East took in 850 tons of cargo at Antwerp, and received the same quantity at Bremen.

AMERICAN NOTES.

(From our own Correspondent.)

NEW YORK, July 10th.

WE are now in the dull season, and but little business is being done by iron or steel manufacturers or by coal or lumber interests, and even there is very little inquiry for autumn supplies, because of the doubt entertained in some quarters that a reaction must set in. Labour agitations have about subsided on railroads and among manufacturing establishments. The labour leaders are seeking legislation at Washington, but will not secure it. The fell trade will open about August 1st, two weeks sooner than usual, because of the light stocks in buyers' hands, and the restricted stocks among manufacturing and jobbing interests. The abundance of money is stimulating enterprise in several quarters—as, for instance, in railroad building, house building, and in the manufacturing of electrical appliances. Several companies, with capital ranging from 250,000 dols. to 1,000,000 dols., have been organised within thirty days to supply electric light and power. Pneumatic companies are also being talked of, and Philadelphia is soon to be furnished with a well-organised and equipped company. The tendency of prices is neither up nor down in iron, steel, coal, lumber, or textile goods. The iron trade is depressed at this time, and a great many bar iron, plate, and sheet mills are idle, while the rail mills are running full time, and orders are seeking acceptance for early and mid-winter delivery. It is more evident now than it has been for some time that railroad construction during the past two years has been in excess of demand. It is estimated that as much as 15,000 miles of road are now in danger of bankruptcy, but the impression prevails that with a continuance of the better conditions the danger can be tided over.

The evils of over capitalisation, stock watering, and the partial failure of the pooling system are discussed among railroad builders and managers with more freedom than heretofore. The discredit which attaches to railway management is recognised, and the better class of managers are anxious that legislation be interposed to prevent the repetition of much of the discreditable management of past years. It is proposed to prevent incorporators of companies from being the constructor of their roads, directly or indirectly, and it is also proposed that all contracts for construction, equipment, extension, or improvement shall be made upon open competitive bids with substantial guarantees. No doubt legislation of a rather rigid character will be enacted in order to as far as possible prevent the construction of new and competitive roads. The older and well established companies will endeavour to check further competitive mileage for their own interests, and in this way work out a better management.

The rolling mills throughout the country will resume within ten days or two weeks, and the plate and structural mills will start up next week with more orders than they have had since the 1st of April. A large amount of bridge work running into several thousand tons is wanted. The crude ironmakers and brokers report things quiet. The better makes of iron are firm, but concessions of 25 to 50 cents have been made upon lower grades of forge.

NEW COMPANIES.

THE following companies have just been registered:—

A. H. Bateman and Co. Limited.

This is a reconstruction of a company of the same name—now in course of voluntary liquidation—carrying on business at East Greenwich as emery-wheel makers, engineers, and artificial stone makers. It was registered on the 8th inst. with a capital of £15,000, in £1 shares. The subscribers are:—

	Shares.
*A. H. Bateman, 93, Pelton-road, East Greenwich	1
*Captain H. S. Pasley, East Sheen	1
E. D. Barker, 58, Belsize-road, engineer	1
C. J. A. Brunhold, 88, Sussex-square, Brighton	1
F. D. Thompson, 3, Cornwall-residences, Regent's Park, solicitor	1
M. J. Letcher, 10, Mincing-lane, solicitor	1
M. G. Rooper, 6, Kensington-gardens-square, solicitor	1

The number of directors is not to be less than two nor more than four; the first are the subscribers denoted by an asterisk, and Mr. W. H. Beck. The company in general meeting will determine the remuneration of the ordinary directors.

Barton Positive Water Meter Company, Limited.

This company proposes to acquire and work the letters patent No. 1561, dated 27th March, 1883, and No. 2876, dated 4th March, 1885, for improvements in fluid meters. It was registered on the 12th inst. with a capital of £10,000, in £1 shares. The subscribers are:—

	Shares.
*James Jackson, 110, Cannon-street, director Kimberley Waterworks	1000
*Colonel G. Carden, Horne Lodge, Surbiton	100
Adolf von Andre, 1, Whittington-avenue	400
Carl Kiehn, 1, Whittington-avenue	100
J. W. H. James, C.E., 9, Victoria-chambers	250
S. Spencer, C.E., 3, Queen-street-place	100
R. H. Twigg, C.E., 4, Victoria-street, S.W.	500

The number of directors is not to be less than three nor more than seven; qualification, 100 shares; the first are Sir John R. Heron Maxwell, Bart., Hamilton House, Tooting; William Mendel, of Andre, Remers, and Co., 1, Whittington-avenue, and the first two subscribers. The remuneration of the board is to be at the rate of £100 per annum for each director, with an additional £50 for the chairman, and in addition the directors will be entitled to 10 per cent. on the dividends paid in excess of 20 per cent. per annum.

Benares Tramway Company, Limited.

This company was registered on the 8th inst. with a capital of £100,000, in £10 shares, to acquire the benefit of a concession from the Municipal Board of Benares, and approved by the Indian Government, for the construction and working of tramways in Benares. The company will adopt an agreement of the 7th inst. between S. H. Robinson and D. M. Morrison of the one part, and F. W. Haddon (for the company) of the other part, and will also enter into agreements with George Pearson and Weetman Dickinson Pearson and with Walter Wood. Particulars of these agreements are not given in the memorandum and articles of association. The subscribers are:—

	Shares.
Walter Wood, 13, Delahay-street, S.W., engineer	1
S. Wright, 2, Manor-road, Bradford, solicitor	1
W. D. Pearson, 4, Durham-place, Kensington, contractor	1
S. B. Lawrence, 155, Grove-lane, S.E., secretary	1
G. E. Arnold, C.E., 12, Harley-road, S.E.	1
W. H. Churchward, C.E., 10, Kingswood Villas, New Brompton	1
D. T. Fender, 2, Trafalgar-road, Twickenham	1

The number of directors is not to be less than three nor more than twelve; qualification, shares or stock in the company, but any director may act before acquiring such qualification. The first directors are Lieut.-General G. G. Anderson, J. Brunton, C.E., J. Walrond Clarke, Lieut.-General T. N. Harward, and Lieut.-General J. L. Vaughan, C.B.; the company in general meeting will determine remuneration. The directors may appoint one of their number to the position of managing director, and may determine his remuneration.

Cinnamon Mountain Gold and Silver Mining Company, Limited.

This company proposes to acquire and work four gold and silver full mining claims known as Golden Lode, the Pacific Lode, the Rock Creek Lode, and the Allen Lode (each 1500ft. long by 300ft. wide), situate upon the east side of Cinnamon Mountain, at the junction of the West Rock Creek and Paradise Gulch, in the Elk Mining District, Gunniston County, Colorado, U.S.A. It was registered on the 8th inst. with a capital of £150,000, in £1 shares, power being taken to acquire other property in the United States of North America. The subscribers are:—

	Shares.
F. Burchall Carter, Abchurch-chambers, merchant	1
S. E. Probert, 24, Lloyd-square, W.C., accountant	1
P. Stoner, 20, King William-street, engineer	1
E. P. Littlewood, Finchley-lane, Hendon	1
H. E. West, Stracey-road, Willesden	1
W. H. Foy, 58, Union-road, Clapham	1
E. W. Stevens, 31, Beckenham-road, Penge	1

The number of directors is not to be less than three nor more than seven; qualification 250 shares; the first are Messrs. Thomas Stevens Lindsay, J. J. Mackenzie, and Andreas Holtz. The remuneration of the board for the first year will be 750 fully-paid shares, which are to be transferred to the directors by Mr. Levi Lincoln Atwood out of the share to be allotted to him in pursuance of an unregistered agreement of the 16th ult. After the first year the remuneration of the directors will be £1000 per annum.

London Engraved and Etched Glass Company, Limited.

This company proposes to carry on the business of glass engravers, benders, cutters, perforators, embossers, enamellers, stainers, &c., and for such purpose will purchase certain inventions referred to in an unregistered agreement of the 1st inst. It was incorporated on the 9th inst. with a capital of £20,000, in £1 shares, 750 of which are to be issued as fully-paid, and 14,004 are to be issued as paid up to the extent of 17s. 6d. each. The subscribers are:—

	Shares.
W. B. Brand, Wanstead Park, Wanstead	1
C. G. Terry, Selhurst-road, South Norwood	1
W. Duncan, 2, Copthall-buildings, stockbroker	1
A. Wilkinson, 20, Ferne Park-road, North Hornsey, clerk	1
W. W. Feast, 5, Eastcheap, chartered accountant	1
E. Howard, Longton-avenue, Sydenham, merchant	1
W. L. Lynde, 40, Mildmay-chambers, Union-court, Old Broad-street, contractor	1

The number of directors is not to be less than three nor more than seven; the subscribers are to appoint the first and act *ad interim*; the company in general meeting will determine remuneration.

Gweek Consols Mining Company, Limited.

This company was registered on the 14th inst. with a capital of £20,000, in £1 shares, to carry on mining operations in Cornwall. The subscribers are:—

	Shares.
E. Miller, 9, Vine-street, Lambeth, clerk	1
E. Carter, 52, Finsbury-pavement, share dealer	1
R. Libby, 10, Union-court, Old Broad-street, agent	1
J. Gregory, 16, Union-court, Old Broad-street, agent	1
W. J. Libby, 101, Winston-road, Green-lane, stationer	1
A. R. McKay, 12, New Church-street, Bermondsey, accountant	1
D. Durrant, 32, Cornwallis-road, Holloway, commercial traveller	1

The number of directors is not to be less than two nor more than five; the subscribers are to appoint the first.

Primitiva Nitrate Company, Limited.

This company proposes to purchase and work the nitrate grounds known as Primitiva, situate in the canton of Negrieros, in the province of Tarapaca, South America. It was registered on the 8th inst. with a capital of £200,000, in £5 shares. The subscribers are:—

	Shares.
*R. R. Lockett, 12, King-street, Liverpool, merchant	1
J. S. H. Bonner, 24, North John-street, Liverpool, chartered accountant	1
H. Shield, 17, York-street, Liverpool, engineer	1
R. Brocklebank, jun., 3, Rumford-street, Liverpool, merchant	1
*J. Waite, 12, King-street, Liverpool, merchant	1
F. Bond, 16, South Castle-street, Liverpool, merchant	1
*W. J. Lockett, 12, King-street, Liverpool, merchant	1

The number of directors is not to be less than three nor more than seven; the first are the subscribers denoted by an asterisk, and Messrs. J. T. North, of Eltham, and G. Bush, C.E., of Lee Park, Kent, late of Iquique; the company in general meeting will determine remuneration.

Imperial and Colonial Marine Insurance Company, Limited.

This company was registered on the 10th inst. with a capital of £1,000,000, in £20 shares—one-half of which is to be treated as reserve liability—to transact marine insurance business in all branches. Two agreements dated 10th ult., the first between John Breyen Little and Clement Davidson Leggatt (for the company), and the second between Clement Davidson Leggatt (for the company) and Henry Charles Saunders, will be adopted. The subscribers are:—

	Shares.
*Ellis Elias, 15, Great Winchester-street, merchant	1
*J. H. Hamilton, 21, Mincing-lane, merchant	1
*W. Hemmant, 45, Whitecross street, merchant	1
*J. E. O. Daly, 2, Little Love-lane, Wood-street, merchant	1
*J. Graham, 39, Ennismore-gardens, merchant	1
*A. Hüttenbach, 4, Fenchurch-avenue, merchant	1
*Donald Graham, 5, Cathedral-street, Glasgow, merchant	1
*A. Lyle, Greenock, merchant	1
*J. Birkmyre, Port Glasgow, merchant	1

The number of directors is not to exceed twelve; the subscribers are the first; qualification, fifty shares; remuneration, such sum not being less than £2000 nor more than £3000 as will give to each director not less than £250 per annum.

Rock Oils Syndicate, Limited.

This company was registered on the 9th inst. with a capital of £5000, in £1 shares, to search for, extract, and dispose of mineral oils and mineral substances. The subscribers are:—

	Shares.
Peter Tait, 58, St. Mary-axe, merchant	1
P. Tait, jun., 58, St. Mary-axe, merchant	1
L. Nicoll, 27, Richmond-road, Dalston, clerk	1
B. Logie, jun., 11, Park-terrace, Twickenham	1
J. T. Whatmough, 8, Holly-place, Hampstead, clerk	1
W. Henderson, 88, De Beauvoir-road, Kingsland, clerk	1
R. Banks Lavery, 6, Portland-place, W., merchant	1

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

DISTANT SIGNAL OPERATED BY A WIRE RUN THROUGH A PIPE FILLED WITH OIL.*

IN the "Proceedings" of the Engineers' Club of Philadelphia, vol. v., 1886, p. 341, Mr. William H. Dechant has described this:

"In September 1885, a distant signal was required to protect a new crossing over the little Schuylkill branch of the Philadelphia and Reading Railroad, between last Mahanoy Junction and Tamanend. The distance from the operating office to the semaphore signal post is 1103ft., and is partway along a 4 deg. and a 6 deg. curve. Instead of leading the wire through a long wooden box supported on small pulleys above the surface of the ground, as is usually done, it was decided to try the experiment of running the wire through a pipe filled with oil buried below the surface of the ground. A trench averaging 15in. in depth was dug along a carefully laid out line; stakes 8ft. apart were driven along the bottom of this trench, so that their tops should come to a uniform grade line, which in this case was about 66ft. per mile; upon the tops of these stakes the ¾in. galvanised iron pipe was fastened so as to hold it in as true a position as possible. A No. 15 iron wire was strung through each piece of pipe before screwing up, so that it might be used to draw the signal wire through the pipe-line after all was laid. The pipes were all carefully examined and cleaned; a number had to be rejected on account of lumps of iron or galvanising material obstructing the bore of the pipe. After the pipe was all laid the $\frac{3}{16}$in. iron signal wire was stretched out with block and tackle to straighten it, and take out all the short kinks, and it was then pulled through into its proper position in the pipe by the smaller wire that had been strung through during the laying of the pipe. A small brass stuffing box was screwed to each end of the pipe, through which the ends of the leading wire were passed, to prevent the escape of the oil. The ends of the pipe being thus closed up, it was filled with common car lubricating oil, mixed with about ¼ part of refined coal-oil to keep it from thickening in cold weather. The filling was done through a short upright branch attached to the highest end of the pipe.

"The lever by which the distant signal is operated turns by the same movement four signal boards on the tower; and during summer the usual counterbalance on the semaphore signal post adjusted to exert its least weight would operate the arm on the signal post, and revolve the signal boards on the tower; during colder weather the lubrication is possibly slightly stiffened, so that this same counterbalance barely turns the signal boards in the tower and must have slight assistance. The experiment has proved very successful thus far in the severe weather of this winter, and the apparatus has required no attention since being placed in position.

"The apparent advantages of the plan are: (1) A very permanent and lasting arrangement. (2) Freedom from disturbance or accident to the signal wire. (3) Entire freedom from the difficulties caused by the expansion if the pipe is laid below the frost line; and subjected to but slight changes from changes of temperature, if laid only 1ft. underground. (4) Suppression of the necessity to provide angle-fixtures to change the direction of the wire around curves. The difference in cost of materials per 100ft. is but a trifle; being 5·38 for the pipe plan, and 5·42—22s. 5d. and 22s. 7d. respectively—for the wooden-box plan. The difference in labour would depend on the character of the ground; but in most cases it would be nearly the same."

ASSOCIATION OF MUNICIPAL AND SANITARY ENGINEERS.—In our report of the proceedings of this Society, published on p. 57 of our last impression, reference was made to a paper by Mr. William Dent, describing the refuse destructor at Nelson. This should have been the refuse destroyer.

* "Proceedings" Inst. C.E.

THE PATENT JOURNAL.

Condensed from the Journal of the Commissioners of Patents.

Applications for Letters Patent.

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

13th July, 1886.

9099. Springs for Carriages by Insulated Bearings at the Ends, R. Grindle, Birmingham.
9100. Forks, R. F. Mackay, Dundee.
9101. Forks R. F. Mackay, Dundee.
9102. Electric Clocks, J. Cassey and J. F. Dixon, Birmingham.
9103. Flat Type Printing Presses, W. Tregaskis, Liverpool.
9104. Shovels, A. E. Stayner, Mill Houses.
9105. Chamber Pail, J. Jones, Wolverhampton
9106. Belt Stretching Machinery, F. Reddaway, Manchester.
9107. Bellows for Forcing Gaseous Fluids, G. Munro, Manchester.
9108. Construction of Railway Trucks, W. E. Fowler, London.
9109. Charging Carburetters Attached to Gas Burners, T. George, London.
9110. Bicycle Tires, P. M. Justice.—(*L. E. Whiton, United States.*)
9111. Valve Apparatus for Water Closets, H. W. Buchan, Glasgow.
9112. Cartesian Barometer, D. Winstanley, Great Marton.
9113. Safety Lamp for Mines, C. R. Whittaker, Manchester.
9114. Pencil Sharpener, G. Grainger, Lozells.
9115. Stereotype Matrices, A. J. Boult.—(*O. Mergenthaler, United States.*)
9116. Heating Gas, J. Roberts, London.
9117. Producing Motive-power, P. Brennicke and T. Schiller, Liverpool.
9118. Paper Box Machines, I. T. Brown, Liverpool.
9119. Washing Apparatus, J. M. Smales, London.
9120. Gas Regulators, W. Cox, London.
9121. Machinery for the Manufacture of Staples, E. O. Ely.—(*J. H. Vinton, United States.*)
9122. Portable Apparatus for Gathering Hay, W. Mytton, London.
9123. Breaking Minerals, E. Mould, London.
9124. Cleansing Tram Lines, T. P. Millett, London.
9125. Fire-escapes, G. A. Cook, London.
9126. Electric Meter, S. C. C. Currie, London.
9127. Single-rail Elevated Railways, F. B. Behr, London.
9128. Machinery for Finishing Woollen Fabrics, G. H. Nussey and W. B. Leachman, London.
9129. Corsets, R. A. Young and R. Neilson, London.
9130. Prong for the Standards of Metallic Fencing, S. M. Wilmot, London.
9131. Draining Steam Jackets, H. E. Newton.—(*C. C. Worthington, United States.*)
9132. Fountain Pens, F. C. Brown, London.
9133. Coupling Up of Railway Carriages, P. Jensen.—(*Count E. Siccardi, Italy.*)
9134. Propellers for Ships, R. Wilcox, London.
9135. Protective Device for the Use of Riders, W. Kennedy, London.
9136. Ascertaining the Weight of Load, G. Capper, London.
9137. Ornamental Glass Letters, A. and W. E. Moore, London.
9138. Marking Railway and other Tickets, W. Smith, London.
9139. Propelling Ships, G. F. Redfern.—(*G. A. Poole, France.*)
9140. Umbrellas, G. F. Redfern.—(*G. A. Poole, France.*)
9141. Jacket or Dolman, E. Edwards.—(*P. Parmier, France.*)
9142. Velocipedes, E. Edwards.—(*E. Cohn, Germany.*)
9143. Cleaning Chimneys, J. T. Gough, London.
9144. Filling Bottles, J. Thompson, London.
9145. Ticket Printing, &c., Mechanism, H. H. Lake.—(*J. P. Dunn, U.S.*)
9146. Bicycles, W. La F. Fish, London.
9147. Wire Nails, C. Lovell, London.
9148. Adhesive Suture Appliance, F. A. Reichardt, London.
9149. Fastening Window Sashes, &c., H. H. Lake.—(*J. Brady, U.S.*)
9150. Latch Operating Devices, O. H. Gilbert, London.
9151. Sewing Machines, H. H. Lake.—(*A. Morehouse, U.S.*)

14th July, 1886.

9152. Walking Sticks, &c., A. C. Farrington, Norfolk.
9153. Making Ice in Moulds, F. N. Mackay, Liverpool.
9154. Corks, Bungs, &c., R. Irvine, Glasgow.
9155. Vignette Papers for Photography, G. J. Sershall, Birmingham.
9156. Steam Boilers, J. C. Jopling, Sunderland.
9157. Bottles for Containing Aerated Waters, &c., H. E. C. Way, London.
9158. Spelter from Zinc Ores, P. Higgs, London.
9159. Oil Lamps, G. Asher and J. Buttress, Birmingham.
9160. Spinning and Doubling Frames, E. Hird, London.
9161. Silent Exit of Air, &c., under Pressure, J. Hughes, Liverpool.
9162. Railway Chair, C. H. Thomas, Newport.
9163. Fastening for Studs, &c., C. E. A. de Jong.—(*O. F. C. Baunier, Germany.*)
9164. Safety Cot, A. E. Pile, Truro.
9165. Handle Bars for Bicycles, J. K. Starley, London.
9166. Explosives, C. Roth, London.
9167. Potion for Improving the Skin and Complexion, S. A. Perry, London.
9168. Umbrellas and Sun-shades, L. H. Pearce, London.
9169. Handle Fan-holder, A. S. L. Newington, London.
9170. Holder for Newspapers, &c., L. Hallett and J. Hayward, London.
9171. Boilers for Domestic Purposes, J. Benn, London.
9172. Beating Out and Sharpening Scythes, E. Vaklly, London.
9173. Nozzles for Injecting Air in Ventilating, H. F. Green and A. W. P. Steckman, London.
9174. Cold Drawing Rods and Tubes, C. M. Pielsticker, London.
9175. Meteorological Stick for Umbrellas, &c., F. J. Biggs, London.
9176. Ultramarine, L. J. B. A. J. Bouillett, London.
9177. Tinder Boxes, A. J. Boult.—(*J. J. Him and — Jacqui, Belgium.*)
9178. Paper Pulp from Moss Peat, A. J. Boult.—(*A. Ubbelohde, Hanover.*)
9179. Paper Bags, H. E. Newton.—(*F. E. de Germain, France.*)
9180. Preventing Fouling of Bottoms of Ships, &c., R. Atkin, London.
9181. Preventing, &c., Incrustation, J. G. Galley, London.
9182. Cutting Tobacco, E. A. de Pass.—(*A. Hen, U.S.*)
9183. Bobbin, Bouvet frères, London.
9184. Locking Nuts upon Screw Bolts, H. H. Lake.—(*C. Legrand, Belgium.*)

15th July, 1886.

9185. Stop Cocks, J. A. and J. Hopkinson, London.
9186. Step Ladders, J. O. Nicholson, Tynemouth.
9187. Joining Pipes or Tubes, R. H. Taunton—(*J. B. Root, U.S.*)
9188. Ball Mills for Grinding Purposes, J. Konegen, London.
9189. Watch Protectors, A. Shallaway, Manchester.
9190. Ball Stoppers for Bottles, J. Bedford, Halifax,

9191. Recuperative Lamps, B. H. Thwaite, Liverpool.
9192. Securing Box Lids, J. W. Southern, Manchester.
9193. Watch Protector, W. Beverley, Glasgow.
9194. Tilting Beer Barrels, E. Fulton, J. McCue, and M. McDonald, Middlesbrough.
9195. Match-boxes, F. R. Baker and J. Walker, Birmingham.
9196. Gas Governors, A. E. Layton, Redditch.
9197. Boxes or Cases for Bottles, F. C. Tomkinson, Tunstall.
9198. Drawing Heating and other Furnaces, A. Harrison, Barrow-in-Furness.
9199. Non-conducting Covering for Boilers, A. Haacke, London.
9200. Shuttle-boxes for Looms, J. Hollingworth, Huddersfield.
9201. Splicing Leather, S. Haley, Bramley.
9202. Guards for Circular Saws, R. Woodhouse and S. Mitchell, Bradford.
9203. Friction Pulleys, J. Dean, J. Smith, and J. Grace, Bradford.
9204. Roller Seats for Skiffs, &c., G. Monk, Chester.
9205. Dowel Pins, S. J. Newman, London.
9206. Bearer for Hats, T. Rawson, London.
9207. Bins for Ashes, &c., J. W. Wood, Liverpool.
9208. Producing Ammonia from Sulphate of Ammonia, H. W. Deacon and F. Hurter, London.
9209. Gas Regulators, G. B. Fearnley, London.
9210. Silos, E. E. Allen, London.
9211. Bottles, T. E. Harper, South Weald.
9212. Oil Lamps, J. Roots, London.
9213. Waterproof Coats, G. H. Ellis, London.
9214. Coating Metal Wares, F. Elmore, London.
9215. Application of Electricity to Vehicles, F. Wynne, Westminster.
9216. Fastenings for Gloves, &c., W. A. Critchlow, London.
9217. Moulding the Edges of Plates of Glass, O. C. Hawkes, London.
9218. Women's Wearing Apparel, R. Haddan.—(R. Hicks, United States.)—4th May, 1886.
9219. Pocket Note-book, E. W. Schmitz and C. F. Voit, London.
9220. Volatile Liquid, E. Edwards.—(J. Quiri, Germany.)
9221. Mechanical Educational Toy, W. F. Hopkins, London.
9222. Spark Arrester, H. Livesey.—(F. Hudson, Uruguay.)
9223. Separating Dust from Air, C. E. Kreiss, London.
9224. Cinder Sieve, &c., J. O. Spong and W. J. Sage, London.
9225. Workmen's Daily Food Carrier, J. T. Parlour, London.
9226. Sheets of Glass, &c., H. H. Lake.—(M. P. H. Bécoulet and L. J. O. Bellet, France.)
9227. Purifying Water, J. S. Sawrey, London.
9228. Generating Electricity by means of Heat, W. Brakefield, London.
9229. Incandescent Electric Lamps, &c., P. Ward, London.
9230. Chair for Medical and other Purposes, F. Sharpe, London.

16th July, 1886.

9231. Common Hand Sweeping Brushes, J. Ripley, Bolton-le-Moors.
9232. Fasteners for Machine Belts, H. Jewson, Norwich.
9233. Non-vibrating Adjustable Handle Bar for Bicycles, &c., W. R. Kettle, Smethwick.
9234. Velocipedes, W. Golding, Manchester.
9235. Pocket, &c., Protector, H. A. Macfarlane, Rothesay.
9236. Obtaining Motive Power by means of Air, &c., C. J. Eyre, London.
9237. Shearing Punch, J. Y. Hawdon, Newcastle-upon-Tyne, and J. English, Wallsend.
9238. Safer Administration of Nitrous Oxide Gas, W. G. Jones, London.
9239. Invertible, &c., Section-case, W. W. Welch, Southampton.
9240. Pencil Protectors and Sharpening Pencils, F. J. Beaumont, London.
9241. Steam Engines, R. Woodhouse and G. G. Rhodes, Bedford.
9242. Weaving Shuttles, J. Campbell, Glasgow.
9243. Silos, R. H. Fraser, Glasgow.
9244. Surveyor's Levels, S. M. Yeates, Dublin.
9245. Valves for Pumps, T. Norman and H. S. Motteram, Attercliffe.
9246. Lump Sugar, C. and J. Lyle, London.
9247. Lump Sugar, C. and J. Lyle, London.
9248. Regulation of Vitriol, W. Cooper, Salford.
9249. Steam Boilers, A. Metcalf, Preston.
9250. Card Foundations, J. Heginbottom, Manchester.
9251. Rotatory Steam Engines, J. Murrie, Glasgow.
9252. Cramp for Flooring, &c., F. J. Dove, London.
9253. Checking the Receipt of Money, J. M. Black, London.
9254. Preserving the Brilliancy of High Coloured Fish for Exhibiting Purposes, A. Haly, Colombo, Ceylon.
9255. Standards for Securing the Netting used in Lawn-tennis, P. King, Glasgow.
9256. Breaking of Tea, W. French and R. H. B. Thomson, Glasgow.
9257. Slicing or Cutting Soap, J. Baird, Glasgow.
9258. Igniting of Charges of Gunpowder, S. Baynes Glasgow.
9259. Rapidly Heating or Cooling Liquids, J. Brown, London.
9260. Gas, H. C. Bull, Liverpool.
9261. Foot Grips for Pedals of Cycles, J. R. Evans, London.
9262. Supplying Liquid Fuel to Furnace Fires, J. Hammond, London.
9263. Pea-shelling, &c., Machine, G. E. and J. B. Hardisty, London.
9264. Preparation of Food for Animals, &c., J. W. Hill, London.
9265. Sash Stop and Lock, H. F. Coombs.—(G. F. Thompson, Canada.)
9266. Power Fire-engines, G. W. Melvin, London.
9267. Electric Railways, J. C. Henry, London.
9268. Liquid and Fluid Meters, H. T. Clarke, London.
9269. Marbled Oil Cloth, H. L. and I. H. Storey, Manchester.
9270. Watches, A. Goy-Golay, London.
9271. Shaving Brush and Soap Holders, W. J. Lemon, London.
9272. Holophotal Projectors, J. G. Statter and S. L. Brunton, London.
9273. Preserving Life at Sea, E. Abate, London.
9274. Heating Feed-water for Boilers, C. J. Galloway and J. H. Beckwith, London.
9275. Distilling Solid Materials, J. C. Grant, London.
9276. Separating Waste Lye, E. Bohlig and G. O. Heyne, London.
9277. Transmitting Instructions on Board Ships, H. P. Sherlock, London.
9278. Convertible Velocipedes, F. E. Duckham, London.
9279. Brick Cutting Tables, R. C. Robinson, London.
9280. Steering Gear, P. J. Neate, Rochester.
9281. Attaching Ornaments to Fabrics, J. H. Johnson.—(Messrs Jarrosson and Monnier, France.)
9282. Turning Paper and other Fabrics, E. König, London.
9283. Bicycles, &c., J. H. Carter, London.
9284. Steam Engines, W. Thompson.—(F. A. T. de Beauregard, France.)

17th July, 1886.

9285. Ventilation of Bulkhead Spaces, C. J. W. Kerin and E. L. Sheldon, London.
9286. Dyeing Wool, &c., F. A. Gatty, Manchester.
9287. Raising Water by means of Rise and Fall of Tide, D. McLachlan, Glasgow.
9288. Gas Governors, J. T. King.—(J. S. Connelly and T. E. Connelly, United States.)
9289. Chain Mattresses, I. Chorlton and G. L. Scott, Manchester.
9290. Adjustable Mattress Frames, I. Chorlton and G. L. Scott, Manchester.
9291. Recording Variations in the Speed of Machinery, N. Macbeth, Manchester.
9292. Fancy Yarns, J. F. Rouse, Bradford.
9293. Table Forks, R. F. Mackay, Dundee.
9294. Self-extinguishing Candles, R. Ashton, Heaton.
9295. Operating the Shedding Motion, &c., of Looms for Weaving, F. Leeming, Halifax.
9296. Pillows or Columns for Building, J. Maxwell and W. C. Tuke, Manchester.
9297. Operating Shafts or Gears in Looms for Weaving, W. Irving and F. Howarth, Liversedge.
9298. Chimney Pot for Ventilating, B. Pitt, Bristol.
9299. Bottom-grates for Kitchen-stoves, &c., T. Redmayne, Sheffield.
9300. Making Infusions of Tea, T. L. Reeve, Birmingham.
9301. Bag Frame Fasteners, W. T. Holt, Birmingham.
9302. Seating for Garden Seats, H. Tylor, London.
9303. Ruling Parallel Lines, &c., R. de Metz, F. Fesquet, Count S. Ostrorog, London.
9304. Dress Improvers, T. Jack, Manchester.
9305. Napkin Rings, E. Hall, jun., Sheffield.
9306. Illuminating Steam, &c., Gauges, F. Skevington, Birmingham.
9307. Distillation of Solid Materials, B. P. Walker, Birmingham.
9308. Ploughs, J. Murray and J. Hay, Glasgow.
9309. Furnace Fire-bars, D. Mellor, London.
9310. Electric Shocks, N. W. Russ, London.
9311. Hoof Protectors, G. R. Bruce, London.
9312. Distilling, &c., Raw Fatty Acids, F. Sahlfeld, London.
9313. Electro-motors to Vehicles, W. L. Holt and M. Immisch, London.
9314. Fastening for Knobs, H. G. Hesketh, Burslem.
9315. Needles, E. W. Harding, London.
9316. Horseshoes, S. S. Harper, London.
9317. Rims or Felloes of Tricycles, &c., J. T. Spencer, Halifax.
9318. Gas Regulator, A. W. Kitsell and G. George, Birmingham.
9319. Self-acting Float for Regulating the Flow of Liquids, C. Hardacre, Liverpool.
9320. Water Supply for Baths, W. Bartholomew, London.
9321. Money Tills, P. M. and J. Grieve, London.
9322. Food for Animals, F. P. Warren, London.
9323. Securing Percussion Caps in Cartridges, C. D. Abel.—(W. Lorenz, Germany.)
9324. Firing Cartridges, C. D. Abel.—(W. Lorenz, Germany.)
9325. Supporting Guides for Rods, J. Saxby, J. S. Farmer, and C. Hodgson, London.
9326. Morse Inker Apparatus, C. D. Abel.—(Messrs. Siemens and Halske, Germany.)
9327. Tinned Plates, &c., R. Kirkman and H. J. Kirkman, London.
9328. Turning on or off the Supply of Gas, G. Joslin, Westminster.
9329. Mechanical Musical Instruments, F. E. P. Ehrlich, London.
9330. Heating Rolls, F. Hilton, London.
9331. Oil-can, J. R. C. Taunton, London.
9332. Varnishes, J. Carvell and W. Holland, London.
9333. Mooring Boats, G. W. Whitaker, London.
9334. Launching Tow Lines, G. Whitaker, London.
9335. Buttons, E. Bouron, London.
9336. Paper, D. Lindo, London.

19th July, 1886.

9337. India-rubber Fabrics, P. M. Matthew, jun., Edinburgh.
9338. Weaving Fabrics, J. Schofield and S. Hill, Manchester.
9339. Nozzle, J. Knott, Manchester.
9340. Preparing Letters for the Post, D. Gilmore, Belfast.
9341. Punching Machines, J. Z. Thornton, Shrewsbury.
9342. Refuse Furnaces, B. D. Healey, Liverpool.
9343. Pedomotive Machine, A. E. Haslam, Manchester.
9344. Oil-cans, J. McHardy, Dollar, N.B.
9345. Boring Coal, &c., J. Swift, Sheffield.
9346. Self-feeding Pens and Holders, J. J. Ridge, Enfield.
9347. Pipe Wrenches, J. Roscoe, Hyde.
9348. Affixing Mirrors to Walls, J. Scott, Bristol.
9349. Gloves, W. A. Firkins and T. Ratcliffe, Birmingham.
9350. Doubling Yarns, G. H. Wade, Halifax.
9351. Chemical Compound for Inhalation, &c., J. McGeary, London.
9352. Collapsible Bucket and Refrigerating, &c., Device, T. Bowley.—(—— Southcott and —— Payne, South Australia.)
9353. Supporting, &c., Lawn Tennis Nets, J. F. Gilmore, London.
9354. Secondary Batteries, W. H. Akester, London.
9355. Solutions of Soluble Materials, W. H. Akester, London.
9356. Spiral Spring Non-pressure Folder, S. Pearce, F. Lione, and J. Lester, London.
9357. Fibre-cleaning Machines, T. Watson and J. Davidson, London.
9358. Paper for Bills of Exchange, &c., E. Musil, London.
9359. Fore-sights of Revolvers, &c., H. A. Silver and W. Fletcher, London.
9360. Frames of Tricycles, &c., A. E. Briant, London.
9361. Safety Slip for Saddles, W. S. Simpson, London.
9362. Opening, &c., Top Sashes of Windows, W. S. Simpson, London.
9363. Reeling Silk, L. Camel, London.
9364. Governor and Expansion Valve, H. Davey, London.
9365. Escapements for Clocks, H. Davey, London.
9366. Ammonia-soda Apparatus, O. Imray.—(La Société Anonyme pour l'Etude et la Création de Soudières, France.)
9367. Safety Bicycles, E. Greenfield, Hastings.
9368. Cigarettes, W. H. Beck.—(A. E. Decouflé, France.)
9369. Writing and Drawing Slates, E. Greenfield, London.
9370. Gun Carriages, H. H. Lake.—(H. Gruson, Germany.)
9371. Breech-loading Guns, H. H. Lake.—(C. Roestel, Germany.)
9372. Mariners' Compasses, H. H. Lake.—(Professor E. Baroni, Italy.)
9373. Magnetic Steel Springs for Scarves, &c., G. R. McDonald, London.

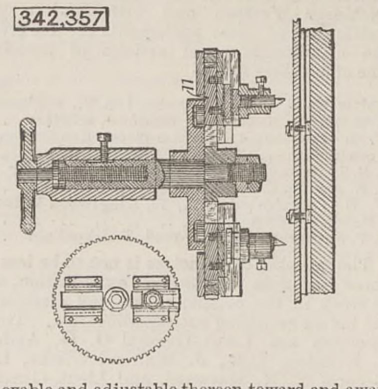
SELECTED AMERICAN PATENTS.

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

342,357. Machine for Cutting Elliptical Shapes, *Michael Helbling, Allegheny City, Pa.—Filed March 13th, 1886.*

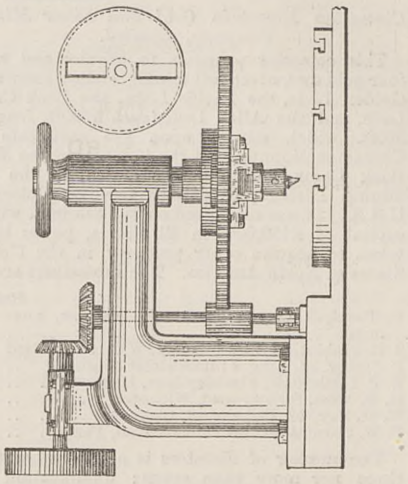
Claim.—(1) In a machine for cutting elliptical shapes, the combination of a travelling cutter and an elliptical guide which guides the cutter and causes it to describe an ellipse, substantially as and for the purposes described. (2) In a machine for cutting elliptical shapes, the combination of a rotary disc or plate, a cutter secured thereto and movable radially thereon, and an elliptical guide bearing on and guiding said cutter, substantially as and for the purposes described. (3) In a machine for cutting elliptical shapes, the combination of a rotary disc or plate, a cutter secured thereto and movable radially thereon, an elliptical guide bearing on and guiding said cutter, and mechanism, substantially as described, for elevating and depressing said plate or disc and the cutter, as and for the purposes specified. (4) In a machine for cutting elliptical shapes, the combination of a rotary disc or plate, an elliptical guide, a block 11, mounted on said disc or plate, movable radially thereon and bearing on said guide, and a cutter-head secured to said block

342,357



and movable and adjustable thereon toward and away from the centre of rotation of said disc or plate, substantially as and for the purposes described. (5) In a machine for cutting elliptical shapes, the combination of a cutter mounted in slideways and an elliptical

342,357

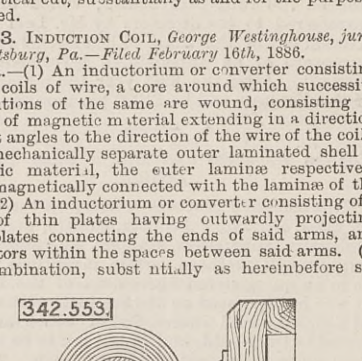


guide which bears on and guides the cutter, causing it to move back and forth in its slideways correspondingly to the shape of the guide, whereby it produces an elliptical cut, substantially as and for the purposes described.

342,553. Induction Coil, *George Westinghouse, jun., Pittsburg, Pa.—Filed February 16th, 1886.*

Claim.—(1) An inductorium or converter consisting of two coils of wire, a core around which successive convolutions of the same are wound, consisting of laminæ of magnetic material extending in a direction at right angles to the direction of the wire of the coils, and a mechanically separate outer laminated shell of magnetic material, the outer laminæ respectively being magnetically connected with the laminæ of the core. (2) An inductorium or converter consisting of a series of thin plates having outwardly projecting arms, plates connecting the ends of said arms, and conductors within the spaces between said arms. (3) The combination, substantially as hereinbefore set

342,553

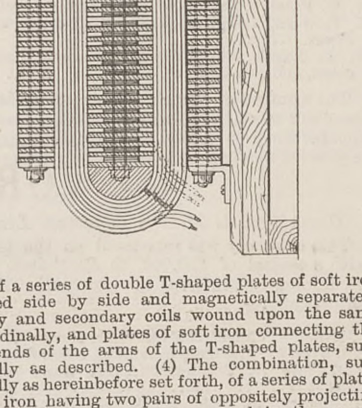


forth, of a series of double T-shaped plates of soft iron arranged side by side and magnetically separated, primary and secondary coils wound upon the same longitudinally, and plates of soft iron connecting the outer ends of the arms of the T-shaped plates, substantially as described. (4) The combination, substantially as hereinbefore set forth, of a series of plates of soft iron having two pairs of oppositely projecting arms, coils of insulated wire wound in the spaces between the arms, and plates connecting the outer ends of the arms, substantially as described.

342,586. Device for Converting Motion, *Peter Deissler, Philadelphia, Pa.—Filed October 14th, 1885.*

Claim.—(1) A wheel and shaft with a friction device, substantially as described, the hub of said wheel having a groove opening at the surface of the shaft and receiving said friction device and communicating

342,586

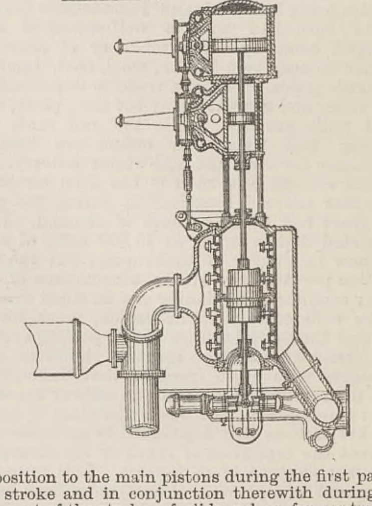


with a passage or bore leading to the exterior surface of the hub, as stated. (2) A wheel having in its hub a groove and a passage or bore, in combination with a friction device, substantially as described, and a plug closing said bore, the groove and bore being in communication, as stated. (3) A wheel having in its hub a groove and a passage or bore, in combination with a friction device, substantially as described, a spring and a plug closing the bore, said spring bearing against said device and plug, as stated.

342,669. Direct-acting Engine, *Charles C. Worthington, Irvington, N.Y.—Filed November 19th, 1885. Patented in England December 22nd, 1885, No. 15,770.*

Claim.—(1) The combination, with the main cylinder or cylinders and piston or pistons of a direct-acting engine, and a compensating cylinder or cylinders and piston or pistons arranged to act in opposition to the main piston or pistons during the first part of the stroke and in conjunction therewith during the last part of the stroke, of a slide valve or valves for controlling the admission and exhaust of the steam to and from the main cylinder or cylinders, the cut-off valves 12, arranged in the induction ports and having the arms 11, and the lever or levers 61, connected to the arms 11 by the links 10 and operated from some moving part of the engine, said lever or levers, arms, and links being arranged to operate substantially as described. (2) The combination, with the main cylinders and pistons forming the two sides of a direct-acting duplex engine, and a compensating cylinder or cylinders and piston or pistons for each side of the engine, which are arranged to act in

342,669

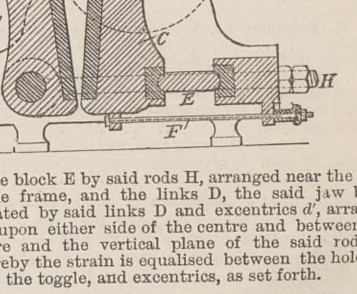


opposition to the main pistons during the first part of the stroke and in conjunction therewith during the last part of the stroke, of slide valves for controlling the admission and exhaust of the steam to and from the main cylinders, connections by which the slide valve or valves of each side of the engine is or are operated by the other side of the engine, the cut-off valves 12, located in the induction ports and having the arms 11, and the levers 61, connected to the arms 11 by the links 10, and operated by the same side of the engine, said levers, arms, and links being arranged to operate substantially as described. (3) In a direct-acting engine provided with a compensating cylinder or cylinders, the combination, with cut-off valves arranged at opposite ends of the steam cylinder, of an arrangement of levers and arms connected with said valves and with the rod 67, secured to the steam piston and passing through the end of the steam cylinder, whereby said valves are positively operated both in opening and in closing, substantially as described. (4) The combination, with the cylinders A B and their cut-off valves, as 12, of the rod 67, secured to the piston of the cylinder B, and the levers 61, having arms 62, connected to said rod and to the cut-off valves, substantially as described.

342,870. Ore Crusher, *Mahlon Hoagland, jun., Rockaway, N.J.—Filed May 26th, 1885.*

Claim.—The combination of the rod F, shaft B, provided with central excentric *d* and excentrics *d'*, arranged one upon either side of said central excentric, toggle block E, the jaw C, held centrally by said rod F and operated by the central excentric upon said shaft, the rods H, the shaft G^2, and the jaw G, mounted thereon and held in the direction of the

342,870

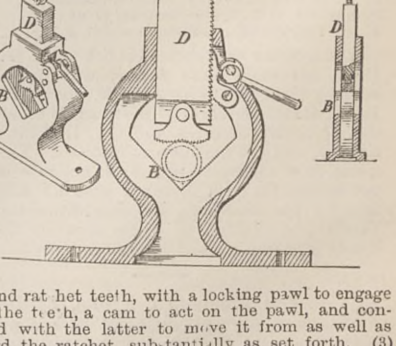


toggle block E by said rods H, arranged near the sides of the frame, and the links D, the said jaw being operated by said links D and excentrics *d'*, arranged one upon either side of the centre and between the centre and the vertical plane of the said rods H, whereby the strain is equalised between the holding-rods, the toggle, and excentrics, as set forth.

342,992. Pipe and Rod Vice, *Joseph G. Baker, Fernwood, Pa.—Filed March 29th, 1886.*

Claim.—(1) The combination of the frame or yoke having jaws B, with a movable block D, carrying a gripping jaw and having ratchet teeth, with a locking pawl pivoted to the yoke or frame, to engage with said ratchet teeth, and a cam to act on the pawl, all substantially as specified. (2) The combination of the yoke or frame, the sliding block D, having a gripping

342,992



jaw and ratchet teeth, with a locking pawl to engage with the teeth, a cam to act on the pawl, and connected with the latter to move it from as well as toward the ratchet, substantially as set forth. (3) The combination of the yoke or frame, having jaws B, with a block having a pivotted gripping jaw provided with two curved and toothed gripping faces substantially as described.

BEAM PUMPING ENGINES, MIDDLESEX WATERWORKS.

MESSRS. JAMES SIMPSON AND CO., PIMLICO, ENGINEERS

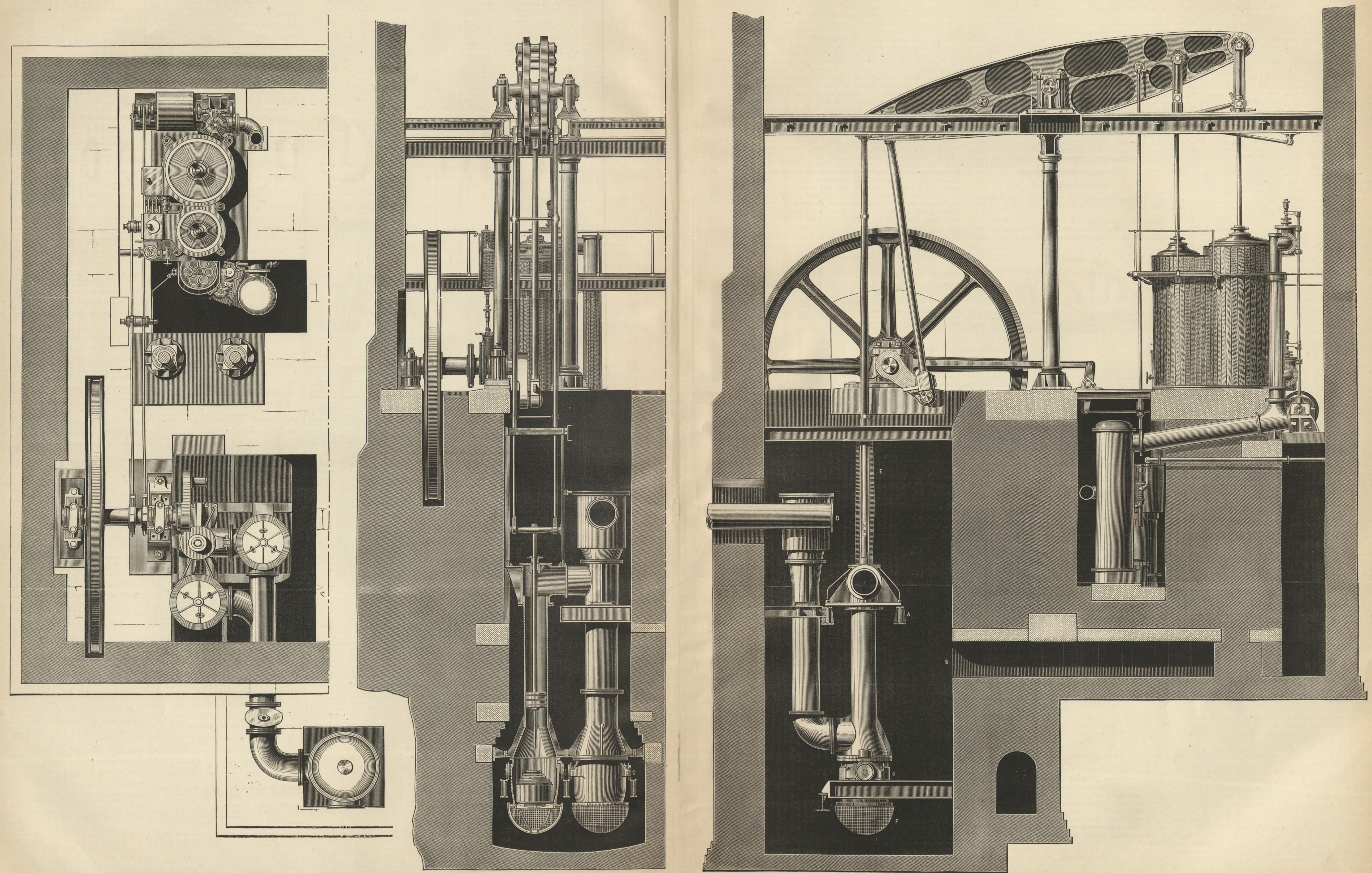


TABLE OF THE RESISTANCE DUE TO GRAVITY ON INCLINES.

COMPILED BY MR. J. FORREST BRUNTON, ASSOC. M.I.C.E., WESTMINSTER.

Inclination.	Angle of incline.			Sine of angle of incline.	Resistance due to gravity.	Total resistance on tramways.	Total resistance on railways.
	deg.	min.	sec.		lbs. per ton.	lbs. per ton.	lbs. per ton.
Level	0	0	0	0·00000	0·000	30·000	20·000
1 in 10,000	0	0	20	0·00010	0·224	30·224	20·224
1 in 9,000	0	0	22	0·00011	0·246	30·246	20·246
1 in 8,000	0	0	24	0·00012	0·269	30·269	20·269
1 in 7,000	0	0	28	0·00014	0·312	30·312	20·312
1 in 6,000	0	0	34	0·00017	0·381	30·381	20·381
1 in 5,000	0	0	41	0·00020	0·448	30·448	20·448
1 in 4,800	0	0	43	0·00021	0·470	30·470	20·470
1 in 4,600	0	0	45	0·00022	0·493	30·493	20·493
1 in 4,400	0	0	47	0·00023	0·515	30·515	20·515
1 in 4,200	0	0	49	0·00024	0·538	30·538	20·538
1 in 4,000	0	0	51	0·00025	0·560	30·560	20·560
1 in 3,800	0	0	53	0·00026	0·582	30·582	20·582
1 in 3,600	0	0	56	0·00027	0·605	30·605	20·605
1 in 3,400	0	1	00	0·00029	0·649	30·649	20·649
1 in 3,200	0	1	4	0·00031	0·694	30·694	20·694
1 in 3,000	0	1	8	0·00033	0·739	30·739	20·739
1 in 2,900	0	1	10	0·00034	0·761	30·761	20·761
1 in 2,800	0	1	13	0·00035	0·784	30·784	20·784
1 in 2,700	0	1	16	0·00037	0·838	30·838	20·838
1 in 2,600	0	1	19	0·00038	0·851	30·851	20·851
1 in 2,500	0	1	23	0·00040	0·896	30·896	20·896
1 in 2,400	0	1	27	0·00042	0·941	30·941	20·941
1 in 2,300	0	1	30	0·00044	0·985	30·985	20·985
1 in 2,200	0	1	33	0·00045	1·008	31·008	21·008
1 in 2,100	0	1	38	0·00047	1·053	31·053	21·053
1 in 2,000	0	1	43	0·00050	1·120	31·120	21·120
1 in 1,900	0	1	49	0·00053	1·187	31·187	21·187
1 in 1,800	0	1	54	0·00055	1·232	31·232	21·232
1 in 1,700	0	2	2	0·00059	1·322	31·322	21·322
1 in 1,600	0	2	7	0·00062	1·389	31·389	21·389
1 in 1,500	0	2	17	0·00066	1·478	31·478	21·478
1 in 1,400	0	2	26	0·00071	1·590	31·590	21·590
1 in 1,300	0	2	39	0·00077	1·615	31·615	21·615
1 in 1,200	0	2	51	0·00083	1·859	31·859	21·859
1 in 1,100	0	3	9	0·00091	2·038	32·038	22·038
1 in 1,000	0	3	27	0·00100	2·240	32·240	22·240
1 in 975	0	3	31	0·00102	2·285	32·285	22·285
1 in 950	0	3	35	0·00104	2·330	32·330	22·330
1 in 925	0	3	41	0·00107	2·397	32·397	22·397
1 in 900	0	3	49	0·00111	2·486	32·486	22·486
1 in 875	0	3	56	0·00114	2·554	32·554	22·554
1 in 850	0	4	4	0·00118	2·643	32·643	22·643
1 in 825	0	4	10	0·00121	2·710	32·710	22·710
1 in 800	0	4	18	0·00125	2·800	32·800	22·800
1 in 775	0	4	27	0·00129	2·890	32·890	22·890
1 in 750	0	4	35	0·00133	2·979	32·979	22·979
1 in 725	0	4	45	0·00138	3·091	33·091	23·091
1 in 700	0	4	56	0·00143	3·103	33·103	23·103
1 in 675	0	5	6	0·00148	3·215	33·215	23·215
1 in 650	0	5	17	0·00153	3·427	33·427	23·427
1 in 625	0	5	31	0·00160	3·584	33·584	23·584
1 in 600	0	5	45	0·00167	3·741	33·741	23·741
1 in 575	0	6	00	0·00174	3·898	33·898	23·898
1 in 550	0	6	15	0·00181	4·054	34·054	24·054
1 in 525	0	6	33	0·00190	4·256	34·256	24·256
1 in 500	0	6	50	0·00200	4·480	34·480	24·480
1 in 475	0	7	15	0·00210	4·704	34·704	24·704
1 in 450	0	7	39	0·00222	4·973	34·973	24·973
1 in 425	0	8	4	0·00235	5·264	35·264	25·264
1 in 400	0	8	35	0·00250	5·600	35·600	25·600
1 in 390	0	8	47	0·00256	5·730	35·730	25·730
1 in 380	0	9	2	0·00263	5·891	35·891	25·891
1 in 370	0	9	17	0·00270	6·048	36·048	26·048
1 in 360	0	9	35	0·00279	6·250	36·250	26·250
1 in 350	0	9	49	0·00286	6·406	36·406	26·406
1 in 340	0	10	6	0·00294	6·586	36·586	26·586
1 in 330	0	10	25	0·00303	6·787	36·787	26·787
1 in 320	0	10	43	0·00312	6·989	36·989	26·989
1 in 310	0	11	3	0·00323	7·235	37·235	27·235
1 in 300	0	11	27	0·00333	7·459	37·459	27·459
1 in 290	0	11	47	0·00343	7·683	37·683	27·683
1 in 280	0	12	17	0·00357	7·997	37·997	27·997
1 in 270	0	12	43	0·00370	8·288	38·288	28·288
1 in 260	0	13	12	0·00384	8·502	38·502	28·502
1 in 250	0	13	45	0·00400	8·960	38·960	28·960
1 in 240	0	14	19	0·00416	9·318	39·318	29·318
1 in 230	0	15	0	0·00436	9·766	39·766	29·766
1 in 220	0	15	37	0·00454	10·129	40·129	30·129
1 in 210	0	16	23	0·00476	10·662	40·662	30·662
1 in 200	0	17	12	0·00500	11·200	41·200	31·200
1 in 195	0	17	37	0·00512	11·469	41·469	31·469
1 in 190	0	18	4	0·00526	11·782	41·782	31·782
1 in 185	0	18	33	0·00540	12·096	42·096	32·096
1 in 180	0	19	5	0·00555	12·432	42·432	32·432
1 in 175	0	20	37	0·00571	12·790	42·790	32·790
1 in 170	0	20	12	0·00588	13·171	43·171	33·171
1 in 165	0	20	49	0·00606	13·574	43·574	33·574
1 in 160	0	21	29	0·00625	14·000	44·000	34·000
1 in 155	0	22	10	0·00645	14·448	44·448	34·448
1 in 150	0	22	55	0·00667	14·941	44·941	34·941
1 in 145	0	23	41	0·00689	15·434	45·434	35·434
1 in 140	0	24	33	0·00714	15·994	45·994	35·994
1 in 135	0	25	27	0·00740	16·576	46·576	36·576
1 in 130	0	26	27	0·00769	17·226	47·226	37·226
1 in 125	0	27	31	0·00800	17·920	47·920	37·920
1 in 120	0	28	39	0·00833	18·659	48·659	38·659
1 in 115	0	29	52	0·00869	19·466	49·466	39·466
1 in 110	0	31	14	0·00909	20·362	50·362	40·362
1 in 105	0	32	43	0·00952	21·325	51·325	41·325
1 in 100	0	34	22	0·01000	22·400	52·400	42·400
1 in 99	0	34	43	0·01010	22·624	52·624	42·624
1 in 98	0	35	4	0·01020	22·848	52·848	42·848
1 in 97	0	35	27	0·01031	23·094	53·094	43·094
1 in 96	0	35	49	0·01042	23·341	53·341	43·341
1 in 95	0	36	10	0·01052	23·565	53·565	43·565
1 in 94	0	36	33	0·01063	23·811	53·811	43·811
1 in 93	0	36	57	0·01075	24·080	54·080	44·080
1 in 92	0	37	21	0·01086	24·326	54·326	44·326
1 in 91	0	37	47	0·01099	24·617	54·617	44·617
1 in 90	0	38	6	0·01111	24·886	54·886	44·886
1 in 89	0	38	37	0·01123	25·175	55·175	45·175

Inclination.	Angle of incline.			Sine of angle of incline.	Resistance due to gravity.	Total resistance on tramways.	Total resistance on railways.
	deg.	min.	sec.		lbs. per ton.	lbs per ton.	lbs. per ton.
1 in 88	0	39	4	0·01136	25·446	55·446	45·446
1 in 87	0	39	33	0·01150	25·760	55·760	45·760
1 in 86	0	39	57	0·01162	26·029	56·029	46·029
1 in 85	0	40	27	0·01176	26·342	56·342	46·342
1 in 84	0	40	55	0·01190	26·656	56·656	46·656
1 in 83	0	41	24	0·01205	26·992	56·992	46·992
1 in 82	0	41	53	0·01219	27·305	57·305	47·305
1 in 81	0	42	25	0·01234	27·642	57·642	47·642
1 in 80	0	42	57	0·01250	28·000	58·000	48·000
1 in 79	0	43	29	0·01265	28·336	58·336	48·336
1 in 78	0	44	6	0·01282	28·617	58·617	48·617
1 in 77	0	44	39	0·01298	29·075	59·075	49·075
1 in 76	0	45	12	0·01315	29·456	59·456	49·456
1 in 75	0	45	49	0·01326	29·702	59·702	49·702
1 in 74	0	46	27	0·01351	30·262	60·262	50·262
1 in 73	0	47	4	0·01369	30·666	60·666	50·666
1 in 72	0	47	45	0·01389	31·114	61·114	51·114
1 in 71	0	48	25	0·01408	31·539	61·539	51·539
1 in 70	0	49	6	0·01429	31·987	61·987	51·987
1 in 69	0	49	51	0·01450	32·480	62·480	52·480
1 in 68	0	50	32	0·01470	32·928	62·928	52·928
1 in 67	0	51	16	0·01492	33·421	63·421	53·421
1 in 66	0	52	4	0·01515	33·936	66·936	53·936
1 in 65	0	52	51	0·01538	34·451	64·451	54·451
1 in 64	0	53	41	0·01562	34·879	64·879	54·879
1 in 63	0	54	32	0·01587	35·549	65·549	55·549
1 in 62	0	55	27	0·01613	36·131	66·131	56·131
1 in 61	0	56	23	0·01640	36·736	66·736	56·736
1 in 60	0	57	8	0·01666	37·328	67·328	57·328
1 in 59	0	58	16	0·01695	37·968	67·968	57·968
1 in 58	0	59	8	0·01724	38·618	68·618	58·618
1 in 57	1	0	18	0·01754	39·290	69·290	59·290
1 in 56	1	1	20	0·01784	39·962	69·962	59·962
1 in 55	1	2	29	0·01817	40·701	70·701	60·701
1 in 54	1	3	39	0·01852	41·485	71·485	61·485
1 in 53	1	4	49	0·01885	42·224	72·224	62·224
1 in 52	1	6	6	0·01939	43·434	73·434	63·434
1 in 51	1	7	23	0·01960	43·904	73·904	63·904
1 in 50	1	8	45	0·01999	44·777	74·777	64·777
1 in 49	1	10	10	0·02041	45·718	75·718	65·718
1 in 48	1	11	35	0·02082	46·517	76·517	66·517
1 in 47	1	13	4	0·02125	47·600	77·600	67·600
1 in 46	1	14	43	0·02173	48·675	78·675	68·675
1 in 45	1	16	23	0·02222	49·773	79·773	69·773
1 in 44	1	18	6	0·02272	50·893	80·893	70·893
1 in 43	1	19	55	0·02324	52·058	82·058	72·058
1 in 42	1	21	49	0·02380	53·312	83·312	73·312
1 in 41	1	23	47	0·02437	54·589	84·589	74·589
1 in 40	1	25	55	0·02499	55·977	85·977	75·977
1 in 39	1	28	8	0·02565	57·456	87·456	77·456
1 in 38	1	30	29	0·02632	58·957	88·957	78·957
1 in 37	1	32	51	0·02700	60·480	90·480	80·480
1 in 36	1	35	27	0·02776	62·182	92·182	82·182
1 in 35	1	38	10	0·02855	63·952	93·952	83·952
1 in 34	1	41	4	0·02957	66·237	96·237	86·237
1 in 33	1	44	8	0·03026	67·782	97·782	87·782
1 in 32	1	47	25	0·03124	69·978	99·978	89·978
1 in 31	1	50	51	0·03224	72·118	102·118	92·118
1 in 30	1	54	33	0·03332	74·637	104·637	94·637
1 in 29	1	58	31	0·03447	76·213	106·213	96·213
1 in 28	2	2	42	0·03568	79·923	109·923	99·923
1 in 27	2	7	14	0·03700	82·880	112·880	102·880
1 in 26	2	12	8	0·03842	85·061	115·061	105·061
1 in 25	2	17	26	0·03997	89·533	119·533	109·533
1 in 24	2	23	8	0·04162	93·229	123·229	113·229
1 in 23	2	29	21	0·04343	96·283	126·283	116·283
1 in 22	2	36	8	0·04540	101·696	131·696	121·696
1 in 21	2	43	35	0·04756	106·534	136·534	126·534
1 in 20	2	51	45	0·04994	111·866	141·866	131·866
1 in 19½	2	56	8	0·05121	114·710	144·710	134·710
1 in 19	3	1	4	0·05264	117·914	147·914	137·914
1 in 18½	3	5	37	0·05394	120·826	152·826	140·826
1 in 18	3	10	46	0·05546	124·230	154·230	144·230
1 in 17½	3	16	14	0·05705	127·792	157·792	147·792
1 in 17	3	22	00	0·05873	131·555	161·555	151·555
1 in 16½	3	28	6	0·06050	135·520	165·520	155·520
1 in 16	3	34	55	0·06248	139·955	169·955	159·955
1 in 15½	3	41	29	0·06438	144·311	174·311	164·311
1 in 15	3	48	51	0·06652	149·005	179·005	169·005
1 in 14½	3	56	41	0·06879	154·089	184·089	174·089
1 in 14	4	5	8	0·07125	159·600	189·600	179·600
1 in 13½	4	11	39	0·07314	163·834	193·834	183·834
1 in 13	4	23	55	0·07669	171·786	201·786	191·786
1 in 12½	4	34	27	0·07975	177·630	207·630	197·630
1 in 12	4	45	49	0·08303	185·987	215·987	205·987
1 in 11½	4	58	10	0·08662	194·029	224·029	214·029
1 in 11	5	11	41	0·09054	202·810	232·810	222·810
1 in 10½	5	26	26	0·09481	212·374	242·374	232·374
1 in 10	5	42	39	0·09949	222·858	252·858	242·858
1 in 9½	5	59	49	0·10447	234·013	264·013	254·013
1 in 9	6	20	4	0·11033	247·139	277·139	267·139
1 in 8½	6	43	37	0·11754	263·290	293·290	283·290
1 in 8	7	7	31	0·12404	277·850	307·850	297·850
1 in 7½	7	35	41	0·13216	296·038	326·038	316·038
1 in 7	8	7	49	0·14142	316·781	346·781	336·781
1 in 6½	8	44	45	0·15205	340·592	370·592	360·592
1 in 6	9	27	45	0·16438	368·211	398·211	388·211
1 in 5½	10	18	18	0·17889	400·814	430·814	420·814
1 in 5	11	18	37	0·19612	439·309	469·309	459·309
1 in 4½	12	31	47	0·21695	485·968	515·968	505·968
1 in 4	14	2	10	0·24253	543·267	573·267	563·267
1 in 3½	15	56	47	0·27474	615·318	645·318	635·318
1 in 3	18	26	4	0·31622	708·333	738·333	728·333
1 in 2½	21	48	6	0·37139	831·914	861·914	851·914
1 in 2	26	33	55	0·44722	1001·777	1031·777	1021·777
1 in 1½	33	42	23	0·55494	1242·066	1272·066	1262·066
1 in 1	45	0	0	0·70711	1583·926	1613·926	1603·926
1 in ¾	53	7	47	0·79999	1791·776	1821·776	1811·776
1 in ½	63	26	5	0·89442	2002·456	2032·456	2022·456
1 in ¼	75	57	49	0·97014	2173·114	2203·114	2193·114
Vertical	90	0	0	1·00000	2240·000	2270·000	2260·000

NOTE.—Columns 5 and 6 are based on the assumption that the *average* resistance on tramways and railways, where the line is both straight and level, is 30 lb. and 20 lb. per ton respectively.