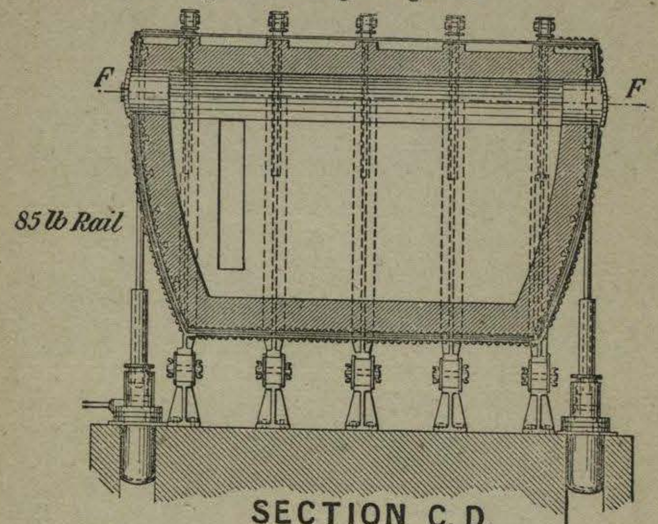
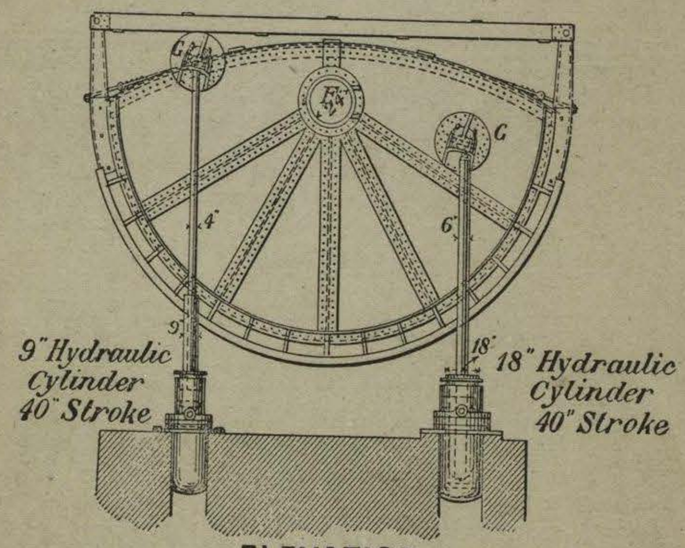
of Sulphur—and another blast furnace is making grey silicious iron, then, by mixing the two irons, a product will be obtained suitable for steel-making. It will be hot enough for blowing, and the Sulphur, after an interval, will not, as might be expected, be the mean of the Sulphur percentages of the two metals, but will be reduced, especially if the grey iron is from a blast furnace working a charge containing Manganese.



SECTION C. D.



ELEVATION.

Figs. 25 and 26.

The larger the mixer the better are the results obtained, both with respect to the purification and also in retaining the available heat of the metal. Mixers capable of holding 600 tons of metal are now in use.

Figs. 23, 24, 25, and 26 show the general arrangement of a 300-ton metal mixer in use at the Cambria Iron Company's Works.

The shell is made up of 1-inch steel plates rivetted together, and stiffened by flat bottomed rails. The mixer is lined with fire-brick 18 inches thick. The shell is bound on the outside by 5 cast-steel binders, which rest on roller-bearings, and are continued up at each end, and joined across the top by channels and strap-bolts. The roller-bearings consist of a number of flanged cast-steel rollers, 14 inches in diameter, which are free to move between two cast-steel channels, joined together by distance bolts. The roller-frames are free to move on the heavy cast-iron sole plates, which are circled to form a race for the rollers.

The metal is poured in at the filler, E, and emptied at the spout, H. The mixer is emptied by means of two rams, 18 inches in diameter by 40-inch stroke, and is brought back to the horizontal position by two rams, 9 inches by 40-inch stroke. The rams are attached to the side of the mixer by means of spherical bearings, G. Cleaning and paddling doors are provided at F.

Metals within a reasonable range of composition can be used, but neither very grey (silicious) nor very white (sulphurous) irons can be added in excess without risk of obtaining unsuitable metal for the converter. One important advantage in the use of the mixer is that a reserve of metal is always available, and no time is lost in waiting for the iron to melt down in the cupola. The receiver also admits of the hot metal ladle standing on a weighing machine during pouring, so that the exact quantity of metal wanted may be readily poured into it from the mixer—a condition not so easily fulfilled when the metal is taken from the blast furnace. Charging the receiver is commenced on Sunday night, so that it may be full of metal on Monday morning, aud it is found as a matter of experience that it is never advisable to allow the charge of metal to be reduced below one-half the capacity of the mixer until Saturday morning, when it must be gradually reduced prior to emptying. After emptying at each week end the mixer is repaired with ganister, the mouth bricked up, and the charging hole covered and luted with clay, by which means it is kept sufficiently hot to restart on Sunday night.

Mr. Edgar J. Windsor Richards * has given some very complete analyses showing the quantities of iron of varying composition both with regard to Sulphur and Silicon, which can be dealt with in a mixer of fair capacity, and the following results are taken from a table showing removal of Silicon during one month's consecutive working:—

Furnace Metal Charged into Mixer.		Metal taken from the Mixer.	
Composition.	Quantity.	Composition.	Quantity.
Silicon.		Silicon.	
1·25 to 2·00	24·26% of total charge -	1·50 to 2·00	3·64% of total charge.
2·25 to 3·00	51·9 ,, ,, -	2·25 to 2·75	96·03 ,, ,,
3·25 to 4·00	20·8 ,, ,, -	3·00	0·33 ,, ,,
4·25 to 5·00	3·04 ,, ,, -	...	No metal above 3% Silicon.

It will thus be seen that although 24 per cent. of the metal charges varied in Silicon from 1·25 to 2·00 per cent., 51 per cent. from 2·25 to 3·0 per cent., 21 per cent. from 3·25 to 4·0, and 3 per cent. from 4 to 5 per cent., yet 96·0 of metal, after passing through the mixer, varied only between 2·25 and 2·75, and only 3·6 per cent. contained less, and practically none exceeded 2·7 per cent. of Silicon.

* *West of Scotland I. and S. Inst. Journal*, 1899.

The removal of Sulphur in the mixer depends largely upon the composition of the metal, the most important constituent apparently being Manganese. Given about 2 per cent. of Manganese in the furnace metal, Sulphur is rapidly eliminated, and a very considerable reduction takes place, provided the Manganese in the bath of the mixer metal does not fall below 1 per cent.

TABLE I.—Analyses showing variations in the Metal before being charged-into, and after being drawn from, the Mixer at Hœrde.

Blow No.	Before Mixing.			After Mixing.		
	Per Cent. of Manganese.	Per Cent. of Silicon.	Per Cent. of Sulphur.	Per Cent. of Manganese.	Per Cent. of Silicon.	Per Cent. of Sulphur.
3932	2·68	·25	·033	2·29	·22	·033
3933	2·86	·34	·055	2·19	·23	·033
3934	2·28	·31	·104	2·54	·27	·041
3935	2·25	·20	·131	2·48	·20	·027
3936	2·23	·35	·050	2·57	·17	·027
3937	1·70	·34	·134	2·34	·20	·033
3938	2·63	·26	·085	2·31	·19	·055
3939	1·93	·20	·074	1·73	·22	·033
3940	2·02	·30	·118	2·43	·18	·038
3941	2·37	·30	·044	2·22	·19	·036
3942	2·37	·17	·074	2·25	·19	·038
3943	2·07	·16	·120	2·22	·19	·036
3944	3·14	·78	·055	2·05	·24	·030
3945	1·93	·17	·071	2·34	·23	·038
3946	2·40	·29	·044	2·25	·51	·044
3965	1·87	·29	·007	2·34	·25	·044
9966	2·34	·29	·107	2·22	·25	·029
3967	2·45	·44	·052	2·10	·31	·038
3968	1·18	·18	·134	2·07	·34	·032
3969	2·68	·37	·137	2·13	·29	·027
3970	2·36	·34	·088	2·07	·28	·022
3971	·89	·21	·160	2·16	·27	·022
3972	2·04	·18	·090	2·10	·31	·027
3973	1·86	·29	·093	1·61	·23	·033
3974	1·37	·40	·047	1·73	·22	·033
3975	1·44	·12	·158	1·76	·22	·030
3976	2·33	·45	·120	1·70	·24	·038

It seems practically certain, from Massenez's * results, that the Sulphur passes into the slag as a Sulphide of Manganese; but whatever the exact reaction may be, the decrease on mixing an iron high in Sulphur with one high in Manganese is undoubted. In Table i. are given analyses of metal from the mixer at Hœrde showing the result of passing manganiferous metal of irregular composition (as regards Sulphur) through the mixer, and further results dealing with irons containing much larger percentages of Sulphur will be found in Massenez's paper referred to above. It will be noticed that the metal from the mixer is very regular in composition, and although frequently the furnace metal contained over 0·100 per cent., and sometimes as much as 0·160 per cent. of Sulphur, in no case did the mixer metal contain more than 0·044 per cent., and it rarely exceeded 0·035 per cent. No doubt the very low Silicon in the metal was favourable to the removal of the Sulphur, and had the former been 1·00 to 2·50 per cent., with the same content of Sulphur, probably the latter would not have been quite so completely removed.

* *Iron and Steel Inst. Journ.*, 1891, vol. ii, p. 76.

The modern type of metal mixer is similar in general construction to that shown in figs. 23, 24, 25, and 26, but is gas-fired, with or without regeneration; in some cases the air and gas are regenerated, and in other cases the air alone, exactly in the same way as in an open hearth furnace. For basic bessemer or basic open hearth plants, the mixer is usually basic-lined, and the gas firing enables small additions of oxide of iron and lime to be added to form a slag which considerably assists in the removal of Silicon and Sulphur. Under these conditions, in a large mixer Silicon can be reduced from 1·5 to ·5 per cent. or less.

The introduction of the metal mixer marked a very important departure in steel works' practice, and effected considerable saving directly by rendering remelting in the cupola unnecessary, and indirectly by insuring a metal of uniform composition and at a fairly constant temperature. The introduction of the gas-fired basic-lined mixer for basic steel works is another step in advance, effecting still further preliminary purification, and thus saving time and decreasing the cost of refractories and repairs in the steel furnace or converter.

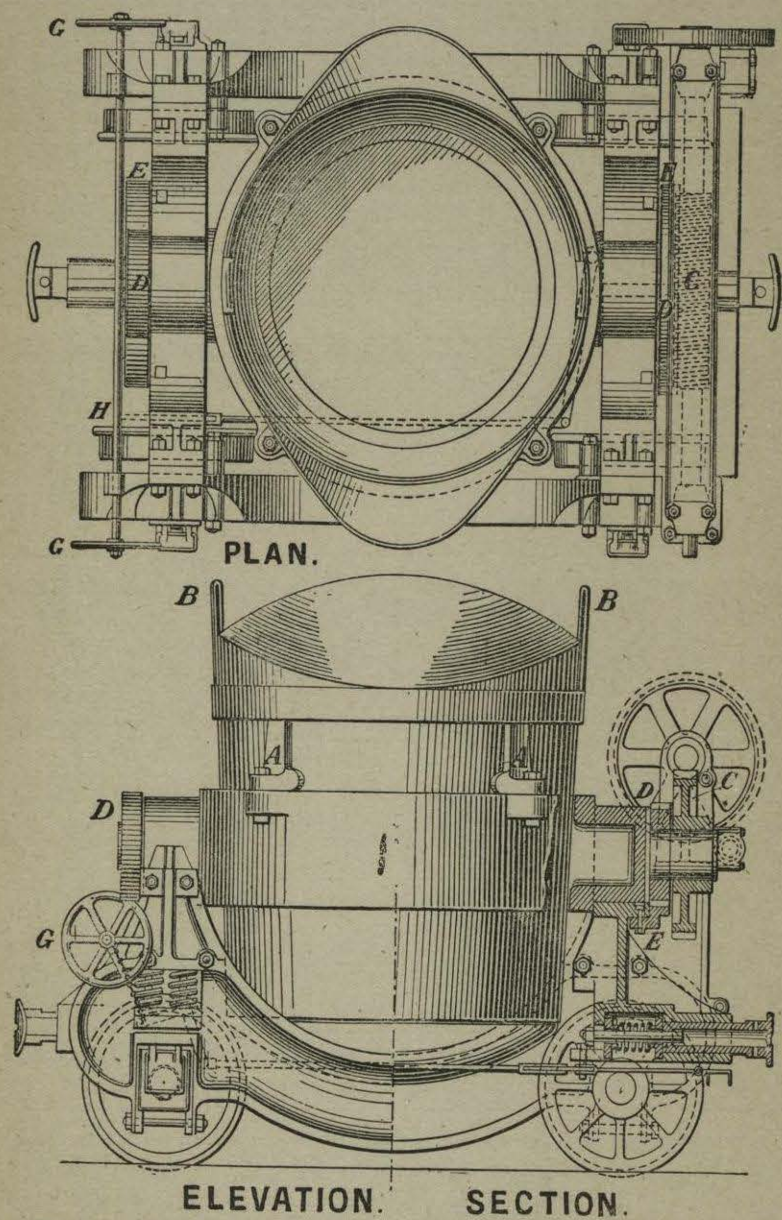
Supply of Metal to Converter.—The molten cast iron may be conveyed to the converter in two principal ways—*i.e.*, either directly from the cupolas by runners, which are simply troughs lined with loam, or other refractory material, and the ends of which enter the mouth of the converters, and are movable; or by first casting from the cupolas, blast furnaces, or mixer into ladles. The former method is now practically obsolete as regards modern practice, and it is therefore necessary to discuss the latter only. The charges of metal are often brought considerable distances in ladles from the blast furnace to the converter or mixer, and may be a considerable time on the road without the occurrence of any inconvenient loss of heat. These ladles are invariably tipping ladles—*i.e.*, the metal is poured from them as from a jug.

Tipping Ladles.—Such ladles are known as direct, or hot-metal ladles—their general features are shown in figs. 27, 28, and 29—and they are specially designed to facilitate pouring the metal and charging the ladle.

It will be seen that the tipping action is effected by a worm and screw motion actuating a trunnion, and one workman can by this gear pour a 10- to 20-ton charge into a converter or mixer without difficulty.

The ladle is held in a cast-iron trunnion belt by means of bolts through brackets, A, on the ladle, and snugs cast on to the trunnion belt. When the ladle requires repairs, the bolts are removed, and it is lifted by lugs, B, and another ladle is dropped into the belt and bolted on. On referring to the drawing, it will be seen that the ladle can be teemed from either side. It is moved forward while it is being turned by the worm and worm-wheel, C., and its forward motion is obtained by means of spur-wheels, "D," which are keyed into the trunnions and geared into the racks E, which are bolted to the end frames of the carriage. To empty the ladle it is moved into position, F, shown in dotted lines in fig. 29. The ladle is provided with a lid lined with fire-brick. The back wheels of the carriage are provided with a brake. By turning the hand-wheels, G, on the front of the carriage a chain coils on to the axle at H, and the brake is brought into action. It will be observed that the carriage is supported on, and the buffers provided with, strong helical springs. The ladle is generally lined with fire-bricks fitting into one another with taper sides, and when these are built in, the whole is covered with a fireclay daubing. This form of ladle can be used either for taking metal direct from the furnace to the mixer or the converter, or from the mixer to the converter.

There are various methods of conveying the ladle to the converter, depending somewhat upon the arrangement of the plant. The plan usually adopted in England is to have an elevated railway track on the platform in front of or behind the converters at about the same level as the trunnions of the converters, and the ladle, with tipping gear attached, as shown in figs. 27, 28, and 29, is run along this until in front of the vessel, when the metal is poured into the converter. At one end, generally near the cupolas,



Figs. 27 and 28.—Hot-metal Ladle - A, Brackets on ladle for securing latter to trunnion belt; B, lifting lugs; C, worm-wheel gearing for turning the ladle; D and E, spur-wheel and rack gearing to give forward motion to ladle during pouring; G, hand-wheel for actuating brake on axle, H.

is a lift which raises the metal ladle to the level of the platform. Instead of being raised by a lift, the hot-metal ladle may be drawn up an inclined plane. Another method is to raise the ladle from its carriage by means of a crane to the mouth of the converter, and while it is suspended by its trunnions, tip the ladle by a chain attached to the bottom.

Another arrangement for tilting the ladle to effect the pouring is that shown in fig. 68, which is in use at the Barrow Works. Here the ladle is tilted by a chain fixed to the bottom and attached to a hydraulic cylinder, while the ladle is supported in the bearing of the carriage. The special point about the ladle is that the trunnions are not fixed centrally on the ladle, but somewhat in front, so that the whole of the metal can be poured into the converter by tilting without moving the ladle forward.

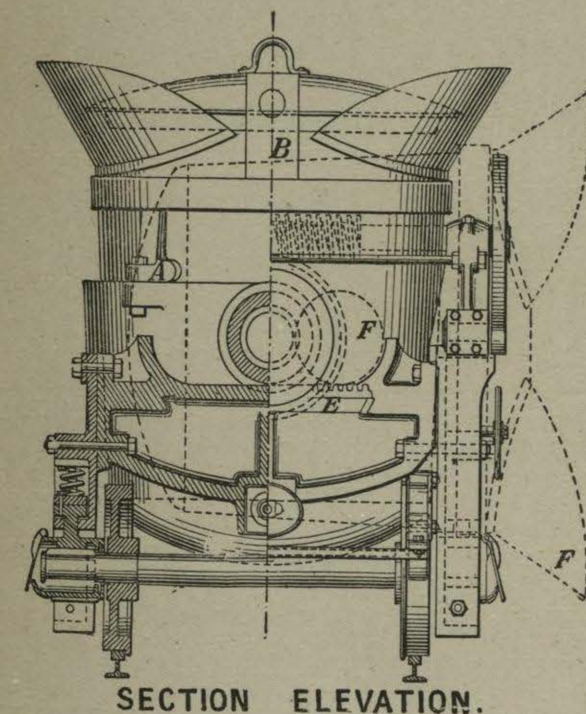
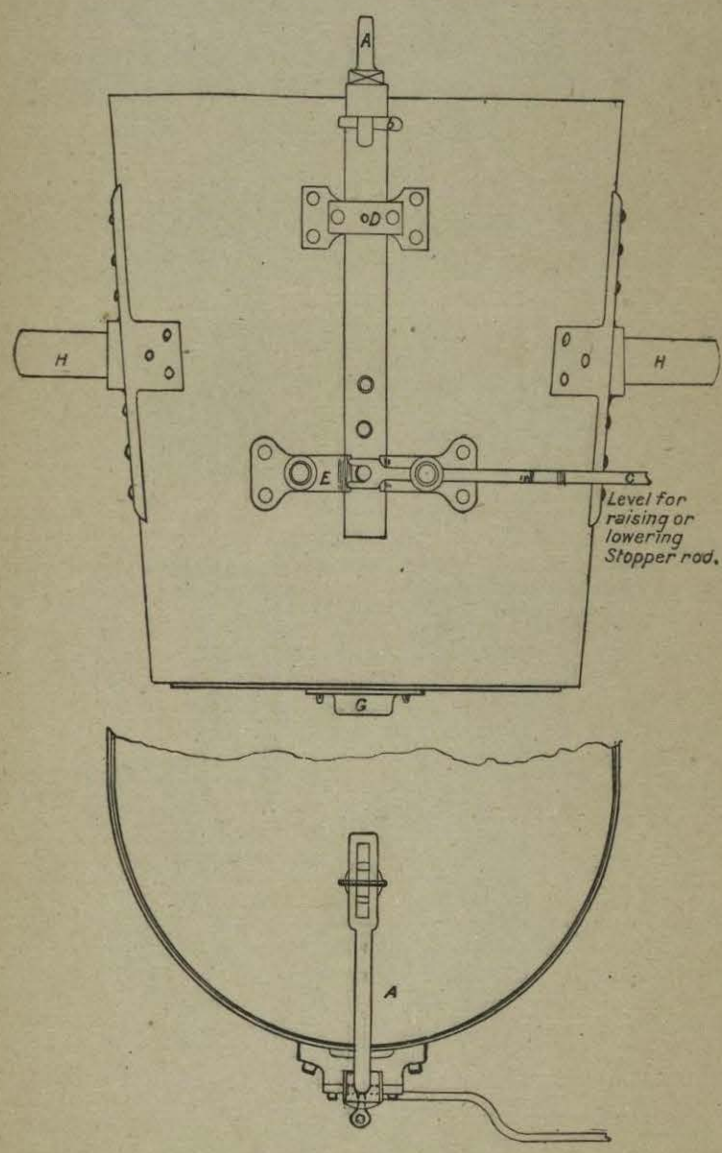


Fig. 29.—The dotted lines show the position of ladle when being emptied.

Blast for the Converter.—The air blast for the converter is supplied by a high-pressure double-cylinder blowing engine, usually of the horizontal type, and the pressure of blast will depend upon the size of converter and the head of metal to be overcome. Usually the pressure is about 20 to 25 lbs. to the square inch, and generally a large wrought-iron reservoir is interposed somewhere between the blast engine and the converter to ensure a steady pressure of blast at the twyers of the converters. In a modern engine the blast cylinders will be 58 to 60 inches, or even more, in diameter, but the total twyer area in 20-ton vessels will not exceed 112 square inches, and is generally less, although for rapid blowing the more air forced through in a given time the better. In the new Barrow plant, when first started, they had thirty-three twyers, each containing nineteen holes five-sixteenths of an inch in diameter, and a shallow bath; but although blows were finished extremely quickly, the metal was so hot as to be unmanageable, and the amount of metal blown out of the converter and wear and tear on linings were so great that the depth of bath had to be increased, and the twyers reduced to twenty-four in number.

The Casting Ladle.—The casting ladle, or the ladle which receives the finished steel for casting into moulds, is shown in figs. 30, 31, and 32, and differs very materially from the "direct metal" ladle. The introduction into the converter of a small amount of slag floating on the metal in the



Front Elevation and Plan.

Fig. 30.—Casting Ladle showing details of arrangement of lever for raising and lowering stopper.—H, Trunnion; D, guide for movable bar carrying goose-neck; A, goose-neck; G, nozzle through which steel is teemed.

direct metal ladle does little harm, but if slag is allowed to pass into the ingot moulds with the steel, the latter is liable to be spoiled, and in consequence the steel cannot be poured from a lip into the moulds, but has to be tapped or teemed from a hole in the bottom of the ladle. For this pur-

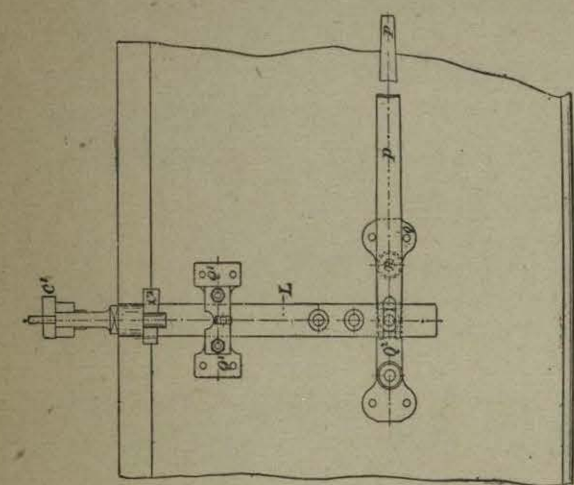
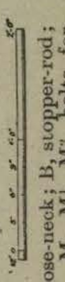


Fig. 32.—As the sliding bar, L, and stopper-rod, B, move together as one piece, previous to teeming the stopper-rod is held rigidly in position by screw, K, and when L is released by unscrewing this, the stopper-rod can be moved freely up and down by means of lever, P.



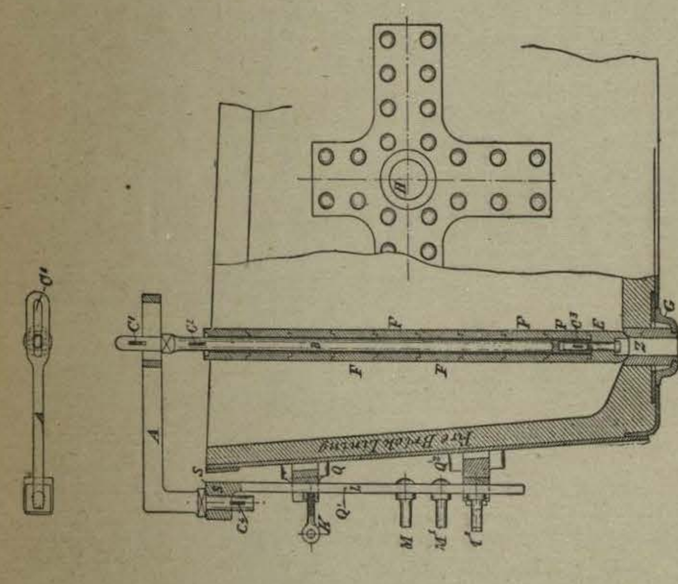


Fig. 31.—Details of Casting Ladle—A, Goose-neck; B, stopper-rod; L, sliding bar carrying gooseneck; M, M^1, M^2, bolts for attaching lever, P; P, lever bar; Q^1, Q^2, brackets on ladle to guide sliding bar, L; K, screw bolt for holding sliding bar rigidly in position previous to teeming; F, fireclay sleeves threaded on steel stopper-rod, B; Z, teeming nozzle; E, fireclay stopper head; G, nozzle box; H, trunnion; C^1, C^2, C^3, C^4, cotter pins; S, forged head on sliding bar through which end of goose-neck is passed, and is fixed by cotter pin C^4.

pose a very simple form of fire-brick valve is used, the general arrangement of which is shown (fig. 31) in position in the ladle. It consists essentially of an iron rod, B, protected from the action of the liquid steel by a series of fire-brick sleeves (fig. 33), which are threaded on the rod, and each sleeve recesses or dovetails into its neighbour. The bottom sleeve, known as the stopper-head (fig. 34), has practically a spherical end, which fits into a hollow cup-shaped brick built into the bottom of the ladle as shown at Z (fig. 31). This forms the valve seat, and is known as the nozzle. The stopper-head and nozzle (fig. 34) being practically similar surfaces, when the stopper is fixed down firmly into the latter, and a little sand sprinkled round, a metal-tight joint is formed, and no metal can pass from the ladle; but on raising the stopper rod, B, by means of the lever shown, the molten

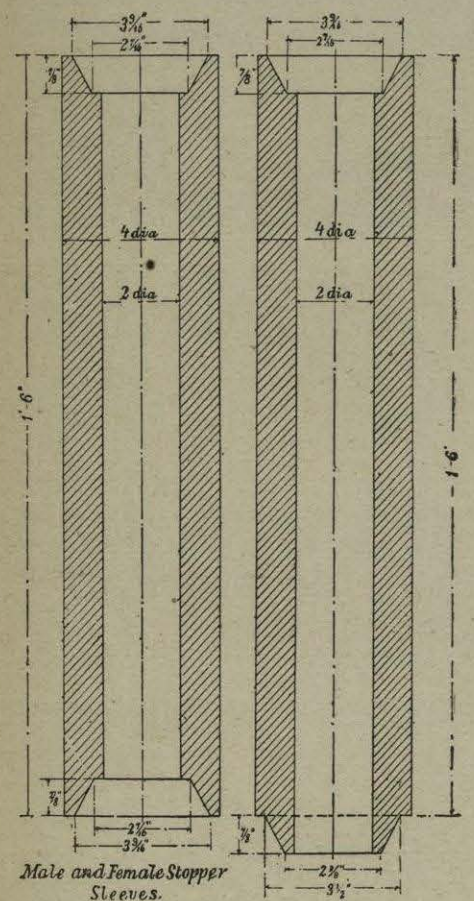


Fig. 33.

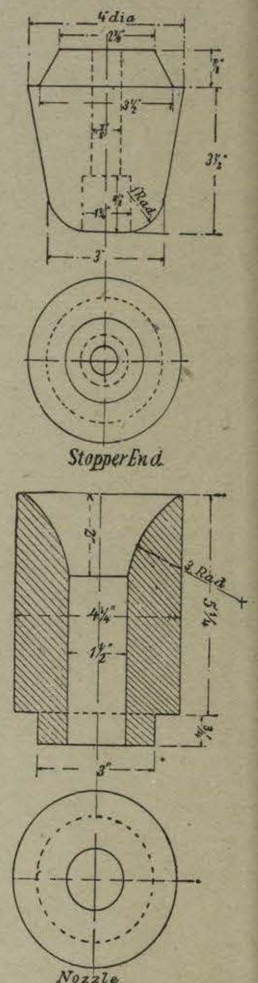


Fig. 34.

steel flows freely through Z, and can be received in an ingot mould placed underneath. The stopper-head is fixed on to the rod, B, by an iron or steel bolt with a forged head at one end to fit in the recess at the bottom of the brick, and the other end of this bolt fits into the end of the iron rod, B, (fig. 31), which is bored out to receive it, and a cotter pin, C^3, hammered in and bent over rigidly connects the two. The bottom recess in the stopper-head, which is not completely filled with the bolt head, is rammed up with stiff fireclay, and the whole dipped in clay wash, previous to fixing on the

rod, B. The sleeves shown in fig. 33 are also dipped in clay-wash, and threaded on B from the top end of the rod until the rod is covered, when they are held rigidly together by means of an iron collar and cotter pin, C^2.

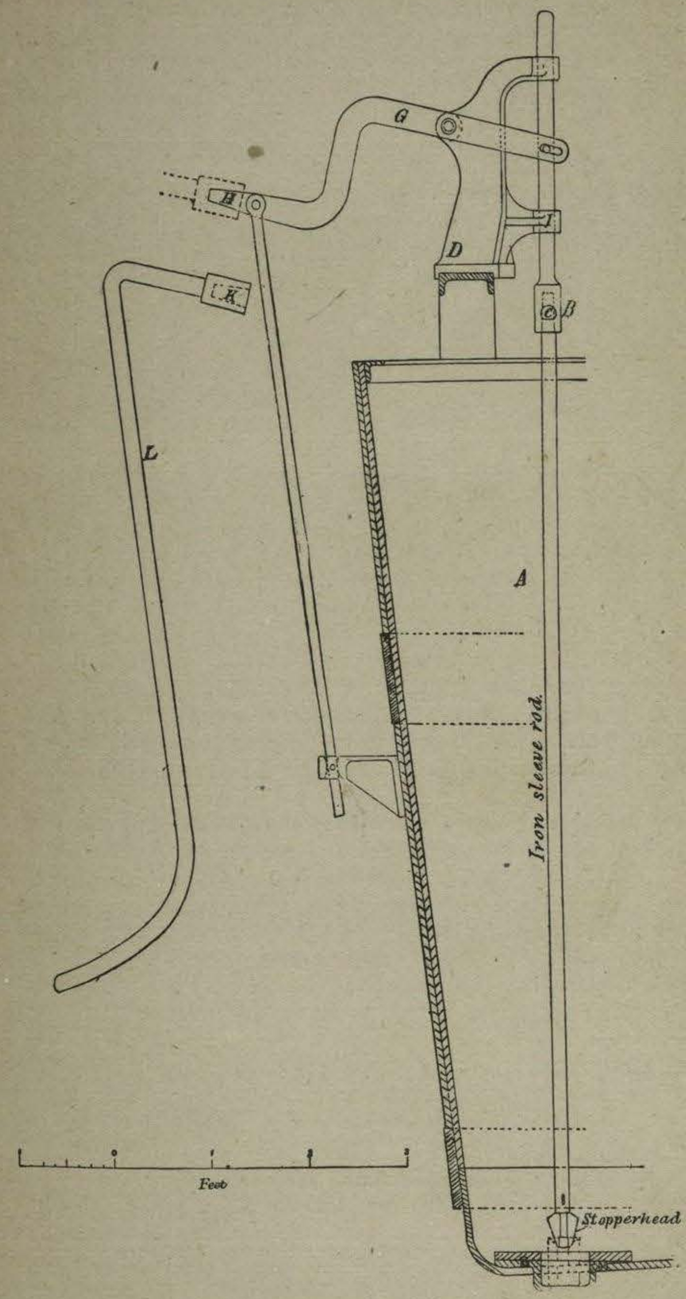


Fig. 35.—Details of 40-ton Casting Ladle—A, Stopper-rod ; B, socket for receiving end of stopper rod ; D, bracket for holding and guiding stopper-rods; G, lever for raising or lowering stopper-rod ; L, movable lever bar which fits on lever G at H.

The whole rod is then well daubed with and dipped in clay-wash, to make all the joints between the sleeves perfectly close so that no metal can get between them. Great care is necessary when threading the sleeves on the rod to see that each joint is well dovetailed into its neighbour. When finished, the stopper-rod is carefully dried, and is then ready for fixing into the goose-neck, A, by passing the top end through the slot in this bar, and firmly cottering it by means of cotter pin, C^1.

The nozzle is usually fixed in the bottom of the ladle, a few inches from the front side, and the slot in the goose-neck, A, allows of reasonable adjustments either nearer or further away from the front side of the ladle. The careful adjustment of the stopper-rod, so that it will work easily and yet truly into the nozzle, is one of the most important practical details in a steel-melting shop. If this is not most carefully attended to, a leaky joint at the valve seat is the result, and the metal slowly trickles through, and rapidly cuts away the nozzle; or if the metal is at all cold, it may solidify round the stopper-end. In the latter case, it may be impossible to teem the metal at all, and in the former what is known as a running stopper will result, and half the metal may be lost in the casting pit before it can be got into the ingot moulds.

Fig. 30 shows an excellent design for a 10-ton ladle, used by Mr. Joseph Colley at Messrs. Hickman's works, which combines rigidity with simplicity; with care there should be little risk of trouble with such an arrangement, as the stopper can be raised and lowered easily by the lever so that the stream of metal passing through Z is well under control. Fig. 35 shows another arrangement of lever for operating the stopper-rod, which has given excellent results with a large 40-ton ladle. The ladle itself is generally lined with special fire-bricks 1½ to 2 inches thick, and afterwards daubed with ganister, Stourbridge bricks being those usually employed in this country. Care must be taken to dry the ladle thoroughly before use.

In some English works the ladles are lined with a mixture of loam, sand, and ganister, the bottom being rammed ganister, but in America at many works, according to Mr. Howe,* loam or moulding sand is used alone.

After the teeming of each heat, the goose-neck, A, and the stopper-rod, B (fig. 31), are removed, the ladle turned over, the slag poured and afterwards chipped out if necessary, and the nozzle carefully cleaned and reformed by ramming a little loam sand round it, and coating it with fireclay-wash. Great care must be taken not to leave any loose sand on the sides where the stopper-head has to bear, otherwise a running stopper will result. The goose-neck is then replaced in S (fig. 31), a new stopper-rod is fixed into the goose-neck by a cotter, C^1, as before, and the ladle is ready to receive another heat.

The Casting Crane.—The casting ladle is usually carried upon a centre crane known as the casting crane, and this is one of the most important mechanical appliances in a Bessemer plant, especially in these days of large charges and rapid work. In fig. 36 is shown a 15-ton hydraulic casting crane, designed by Messrs. Tannett, Walker & Co., Ltd. It consists of a large hydraulic ram, to which is attached a radial arm or jib which carries the casting ladle. The crane must have at least three motions—(1) a vertical motion up and down to enable the ladle to be brought close under the nose of the converter, and to be able to clear ingot moulds of different heights; (2) a horizontal motion for a few feet along the jib of the crane, so that it can accommodate itself to the converter as it tilts over more or less; and (3) it must move round horizontally with as large a radius as possible, so that

* Howe, *Metallurgy of Steel*, p. 359.

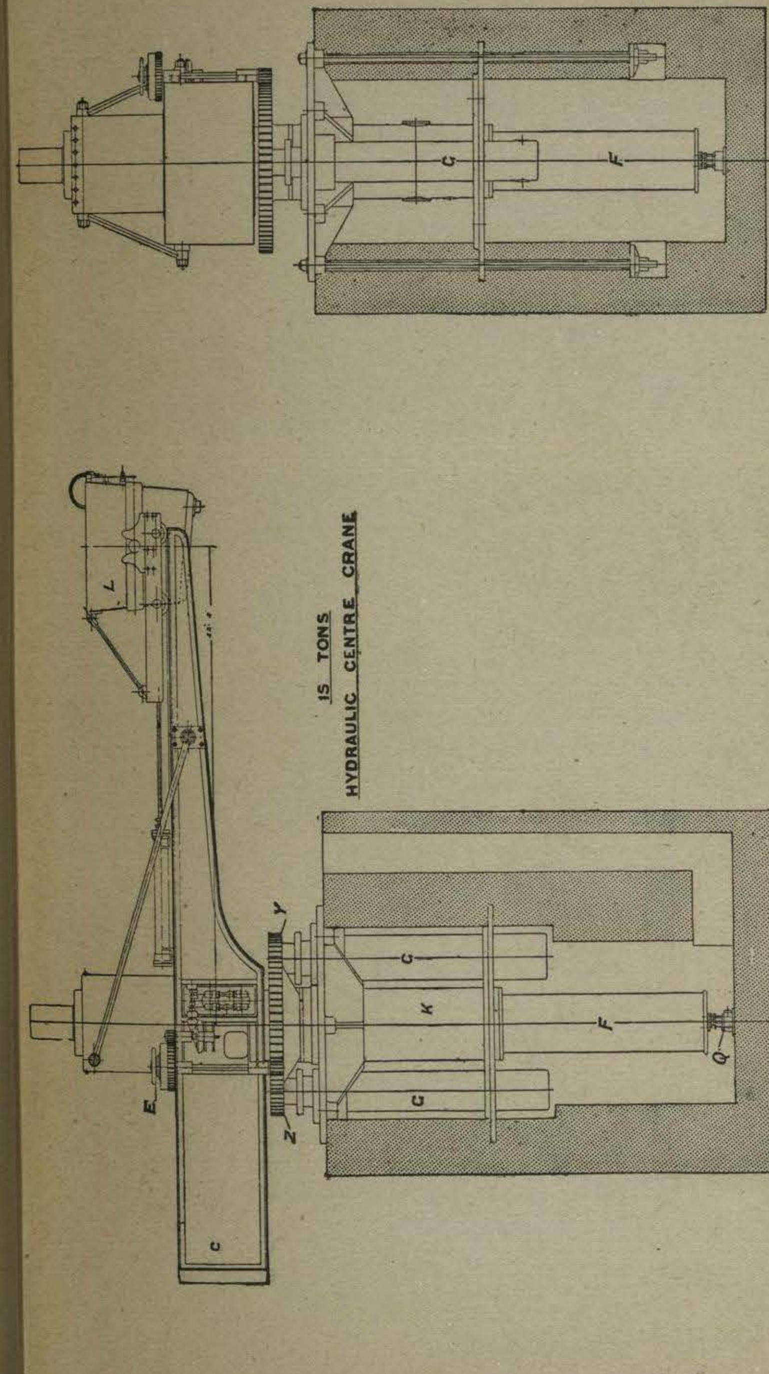


Fig 36.—15-Ton Centre Casting Crane.

The actual lifting is done by two lifting cylinders, G G, the ram, F, acting as a guide and post for withstanding the stress of the load, sliding up and down in a strong foundation casting, K, capable of carrying the whole weight of crane. At the top of F is a crosshead, Y, firmly attached to it with teeth cast on its circumference into which gears the turning pinion, Z. The rotation is done by the small hydraulic reversing engine through gearing to Z, the wheel, E, being a friction clutch to couple up the gearing. The water goes in and out at the telescope tubes shown at Q. At C there is a balance weight to balance partially weight of ladle, L, when full of metal. The water is admitted into the lifting cylinders, G G, at the top of each cylinder, so that when the crane lowers, each cylinder is left full of water in the clearance space.

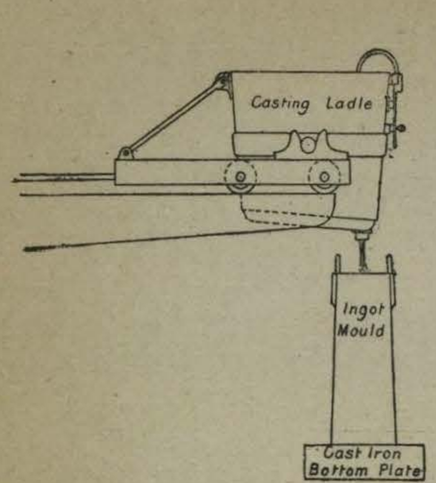


Fig. 37.—Ingot Mould standing on Cast-Iron Plate, with steel being teemed into it from Casting Ladle.

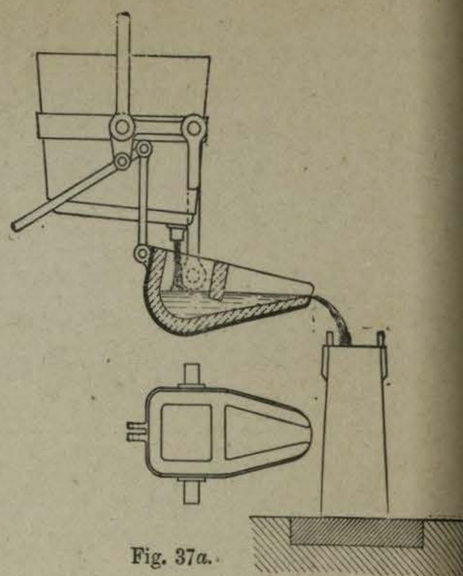


Fig. 37a.

it may cover a large number of ingot moulds standing at the circumference of the pit. The crane shown fulfils all these conditions, besides being admirably designed for strength, and for the ease with which it can be manipulated. The details will be readily understood from the sketch and description. Many modern centre cranes are top-supported, but the one shown is not, and the advantages and disadvantages of the two types are engineering questions which we have not space to discuss here.

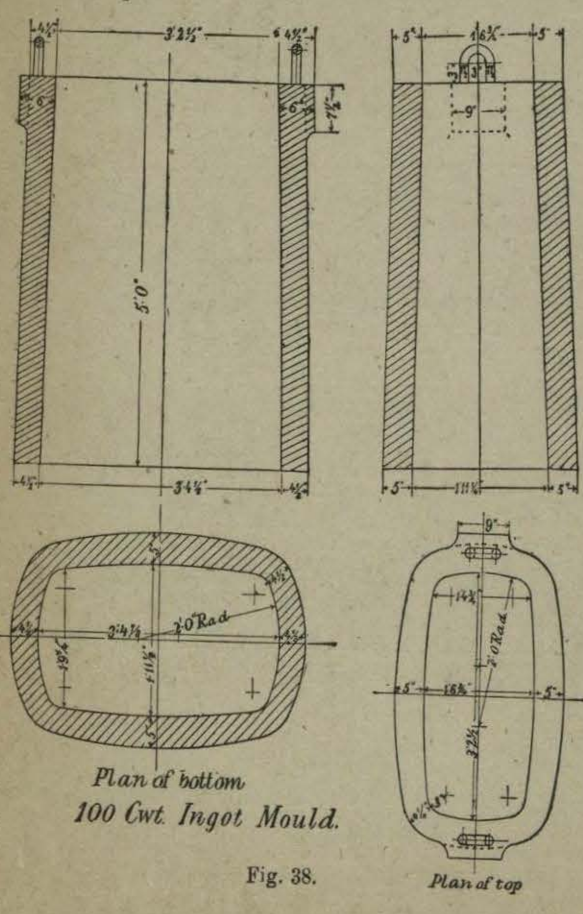


Fig. 38.

Ingot Moulds.—The fluid metal from the casting ladle is teemed into cast-iron moulds or shapes, which may be of almost any convenient form and size, these being determined by the purpose for which the steel is required. Thus, we may have ingot moulds square, circular, oval, flat, octagonal, &c., in horizontal section, but

generally the section is rectangular, with rounded corners and just sufficient taper to allow the mould to be easily drawn off when the ingots are set. The moulds should always be made of grey hematite pig, and when ready to receive the steel should stand on thick cast-iron plates known as bottom plates (see fig. 37). The intensely hot steel has a tendency to cut these bottom plates away rapidly; but their life may be somewhat prolonged by putting a small piece of thin scrap steel plate on the centre of each bottom before casting.

When the metal is teemed direct in this way it falls into the ingot mould with considerable force, especially when the ladle is a large one, and contains a considerable weight of metal; splashing up the sides of the ingot mould is then liable to occur, and cause surface defects on the ingot, which may or may not roll or forge out during subsequent treatment. A device to mitigate this trouble is shown in fig. 37a, by which the metal is first teemed into a vessel attached to the ladle and allowed to overflow into the moulds from a spout.

In figs. 38, 39, 40, and 41 are given sketches of ingot moulds of different shapes. The dimensions of ingot moulds for different weights of ingots are given (Tables ii., iii., and iv.) for reference. The letters on the sketches correspond to those in the different tables; thus, A and B, Table ii., give the width and breadth of the bottom of the mould, C and D the same at the top, while O gives the depth of the mould, and E F G H I the thickness of the metal walls in the positions indicated.

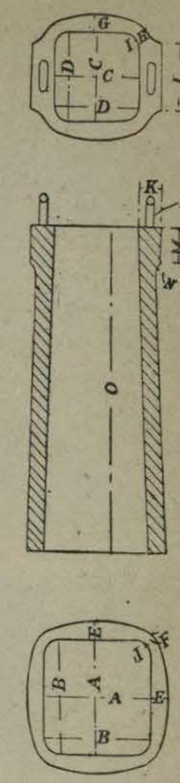


Fig. 39.—Square Ingot Moulds, with dimensions.

TABLE II.—Sizes in Inches (Fig. 39).

Weight of Ingot.	A	B	C	D	E	F	G	H	I	K	L	M	N	O	P
7 cwts.	8¾	8½	7¼	7	2¾	2½	2¼	1¾	1¼	3¼	7	5¼	5	55	1
15 ,,	10	9¾	8½	8¼	3	2½	2½	2	1¾	4	8½	6	...	72	1½
19 ,,	13¾	13½	11¾	11½	3	2½	2¼	2	1¼	3½	8	6	5	56	1¼
20 ,,	14	13¾	12½	12¼	4	3¾	3¾	3½	2	5¼	10	5	...	54½	1½
20 ,,	14½	14¼	12¾	12½	3¾	3¼	3	2½	2	4¼	9	6	...	54	1½
22½ ,,	14¾	14	12¾	12½	3	2½	2¼	2	1¼	3½	7½	6	5	57	1¼
26 ,,	11½	11¼	9½	9¼	3½	3	3	2½	1¾	4	9	6	...	72	1½
26 ,,	15½	15¼	13¾	13½	4⅛	3¾	3⅜	3¼	2	4¼	9	6	...	57	1½
26 ,,	15½	...	13½	...	3½	...	3½	3	2	4	...	6	...	66	1½
32 ,,	14½	14¼	12¾	12½	3¾	3¼	3¼	2¾	2	4¼	9	6	...	66	1½
42 ,,	20	19¾	18½	18¼	4½	4	3½	3	1½	5½	11	6	...	54	1⅝
23 ,,	13¾	...	11½	...	3	...	2½	...	1½	3	6	5	...	65	1¼
36 ,,	15½	...	13½	...	2¾	...	2½	...	2	3¼	8	4	...	72	1⅜

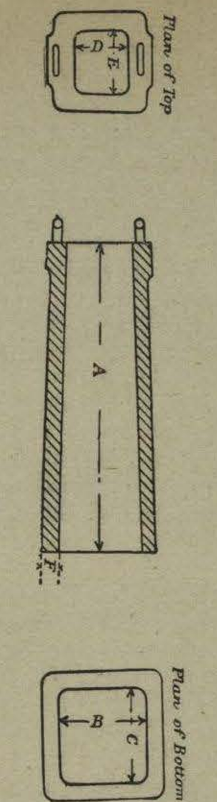


Fig. 40.—Square Ingot Moulds, with dimensions.

TABLE III.—Sizes in Inches (Fig. 40).

Shape.	A	B	C	D	E	F	Weight of Ingot Moulds.		
	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Cwts.	Qrs.	Lbs.
Square, - - -	63	13¼	...	10¾	...	3		...	
,, - - -	64	13¼	...	10¾	...	3	21	2	20
,, - - -	65	13¾	...	11½	...	3	21	2	0
,, - - -	60	12	...	11	...	4	28	0	14
,, - - -	54	10	...	7¾	...	2¾		...	
,, - - -	45	9	...	7⅛	...	2¾		...	
Oblong, - - -	44	27	16	25	14	4½	35	0	0
,, - - -	43	25½	15	23½	12	4½	33	0	0
Quadruple group mould	32	6	...	5¼	...	1¾	15	0	0
,, ,,	32	7	...	6¼	...	2	17	3	0
,, ,,	40	8	...	7¼	...	2½	29	2	0
Square, - - -	64	13	...	10½	...	3	19	3	0
,, - - -	48	14¼	...	12¼	...	4	24	1	14
,, - - -	48	14¼	...	12¼	...	3		...	
Solid end, - - -	66	10¼	...	8⅝	...	2¾	19	2	0
Oblong, - - -	73	31	21	27½	18	4½	70	0	0
,, - - -	65	32½	19	29½	16	4	55	1	0
Square, - - -	56	11¼	...	9½	...	3	16	2	0
Oblong, - - -	51½	29½	20	27	18¼	4½	47	1	0
Square, - - -	54	15¼	...	14	...	3¼	24	2	14
,, - - -	66	14	...	12	...	3		...	

TABLE III.—*Continued.*

Shape.	A	B	C	D	E	F	Weight of Ingot Moulds.		
	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Cwts.	Qrs.	Lbs.
Square, - - -	66	15	...	13	...	3¼		...	
,, - - -	60	16	...	14	...	3½		...	
Oblong, - - -	84	36	22½	32½	18½	3¾	75	0	0
,, - - -	72	24	20	22	18	4½	60	0	0
,, - - -	66	30½	17¾	29½	16¾	3½	52	0	0
Square, - - -	66	15½	...	13$\frac{11}{16}$	...	2¾		...	
,, - - -	66	16½	...	14½	...	3¾		...	
,, - - -	82	18½	...	16½	...	4		...	
,, - - -	78	18½	...	16½	...	4		...	
,, - - -	46	11¼	...	10	...	3	14	1	0
Oblong, - - -	66	30½	18½	29½	16¾	3½	52	1	0
,, - - -	66	20	17	18	15	3½		...	
Square, - - -	66	18	...	16	...	3½	52	1	0
Oblong, - - -	67½	32½	25	29½	22¾	5		...	
Square, - - -	69	13¾	...	11¼	...	3	23	0	0
Oblong. - - -	84	28¼	18½	26¼	16¼	4⅛	61	2	0
Square, - - -	60	17	...	15	...	3½		...	
Oblong, - - -	75	28	18¼	26¼	16¼	4		...	
Square, - - -	48	12	...	10½	...	3		...	
,, - - -	66	12½	...	10	...	2¼		...	
Oblong, - - -	54	19	12¼	18	10¾	3	22	2	0
Square, - - -	67½	14	...	11¾	...	3	22	0	0
,, - - -	66	10¼	...	8⅝	...	2¾	18	1	0
,, - - -	66	17	...	15	...	3½		...	
,, - - -	66	18	...	16	...	3⅜		...	
Oblong, - - -	72	18	15	20	17	3½		...	
Square, - - -	72	14½	...	12	...	2⅞		...	
,, - - -	72	17	...	14¾	...	3 × 3½		...	
,, - - -	72	17	...	15	...	3¾		...	
,, - - -	66	18¼	...	16½	...	3¾		...	
,, - - -	66	16	...	14	...	3½		...	
,, - - -	72	14	...	12	...	3		...	
,, - - -	72	12½	...	10	...	2¼		...	
Octagon, - - -	48	17	...	17	...	4⅜	1	10	1
,, - - -	72	18¼	...	18¼	...	5⅜	2	19	0
Square, - - -	64	10½	...	9½	...	3	0	19	1
Oblong, - - -	54	15½	12½	14½	11½	3		...	
,, - - -	45	15½	12½	14½	11½	3		...	
Square, - - -	60	14	...	12	...	3		Closed top.	
Group, - - -	32	6	...	5¼	...	1¾		,,	
Oblong, - - -	60	40⅞	23¼	38½	18¾	4½ × 5		,,	
Square, - - -	72	13	...	10½	...	3		,,	
Oblong, - - -	72	36	22½	32½	18½	...		Semi-closed.	
Square, - - -	72	17	...	14¾	...	3 × 3½		...	
,, - - -	72	16	...	14	...	3½		...	
,, - - -	66	17	...	14¾	...	3 × 3½		...	
,, - - -	76½	14⅛	...	11⅝	...	3		...	
,, - - -	72	18	...	16	...	3⅜		..	
,, - - -	65½	13	...	10½	...	3		...	
,, - - -	63	17	...	14¾	...	...		...	
Oblong, - - -	60	40⅞	23¼	38½	18¾	4½ × 5		...	
Square, - - -	60	11¾	11¾	9½	9½	3		...	
Oblong, - - -	33	6 × 5	11½	5¼ × 4¼	10¾	2⅜		...	
,, - - -	33	4½	10½	3¾	9¾	2½		...	
,, - - -	72	36	22½	32½	18½	...		Open top.	
Square, - - -	72	15½	...	13½	...	2¾		...	
,, - - -	72	15	...	13	...	3¼		...	
Oblong, - - -	60	52⅜	22¾	50	18¼	6 × 5½		Open top.	
,, - - -	78	34½	21½	31½	18½	3¾		Contracted top.	

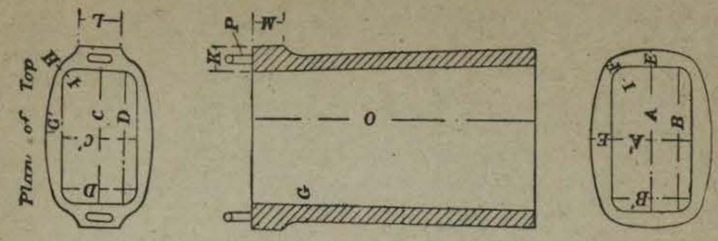


Fig. 41.—Slab Ingot Mould.

TABLE IV.—SIZES IN INCHES (Fig. 41).

Weight of Ingot.	A	A¹	B	B¹	C	C¹	D	D¹	E	E¹	F	G	G¹	H	I	K	L	M	O	P
26½ cwts. - -	18½	12	18⅜	11⅞	16	10½	15⅞	10⅜	2½	3	2	2½	2¼	2	1½	3½	8	5	57	1½
29 ,, - - -	18½	15	18¼	14¾	16½	13	16¼	12¾	5¼	5¼	4¾	5	5	...	2	6½	11	6	54	2
30 ,, - - -	21	18	...	...	19½	16½	...	...	4¼	4¼	4	4¼	4¼	4	...	5	10	6	44	1½
30 ,, - - -	14	13	13¾	12¾	12	11	11¾	10¾	3¾	3¾	3¼	3	3	2¾	1¾	4¼	8½	6	66	1½
33 ,, - - -	19¼	15¼	19	15	16¾	12¾	16½	12½	3	3¾	2¾	3	2¾	2⅜	2¼	4¼	10	6	57	1½
35 ,, - - -	19	15	...	...	17	13	...	...	3¾	3¾	3¼	3¾	3¾	3¼	2	4	...	6	66	1½
40 ,, - - -	18	14½	17¾	14¼	16	13	15¾	12¾	4	4	3½	3½	3½	3	2	4½	8½	6	72	1½
45 ,, - - -	24½	17	22½	15	22	14	19½	12	4⅜	4½	...	4⅝	4½	...	...	...	...	...	56	1⅝
45 ,, - - -	23½	18½	23¼	18¼	22	17	21¾	16¾	5	5	4¼	4	4	3½	1½	5½	11	6	54	1⅝
52 ,, - - -	24	17	23¾	16¾	22	16	21¾	15¾	4	4	3½	3½	3½	3	2	4½	8½	6	72	1½
65 ,, - - -	26	19	25¾	18¾	23½	17¼	23¼	17	4¼	4½	4¼	4	4¼	4	3	6½	11	6	73	1¾
70 ,, - - -	30½	19	29	18	27½	16	...	...	4	4¼	3½	4	4¼	3½	2½	5	...	8½	65	1⅝
72 ,, - - -	32¾	18	...	17½	30	16¼	...	...	4½	5	4¼	4	4½	...	3	6¼	11	6	67	2
75 ,, - - -	32½	19	30	18	29½	16	27	15	4	4¼	3½	4	4	3½	2½	5	...	8½	65	1⅝
80 ,, - - -	30	17	29¾	16¾	28	16	27¾	15¾	4½	4¾	4¼	4¼	4¼	3¼	2½	5½	8½	6	72	1½
80 ,, - - -	32½	21	32¼	20½	30½	19½	30	18	4½	4¾	3¾	4½	4	3½	3	5½	...	...	60	...
95 ,, - - -	36	22	33½	20	33	19	30½	17	4½	5	4	4	4½	3½	1½	5	...	8½	65	1⅝
35 ,, - - -	22½	15½	22⅜	15⅜	20	13	19⅞	12⅞	3	3½	2¾	3	3	2½	2½	4¼	10	6	54	1½

As the cost of ingot moulds amounts, in the aggregate, to a considerable sum in a large works, it is of the greatest importance that they should have as long a life as possible. To ensure this, they must be made from high quality grey hematite pig-iron, the presence of comparatively small amounts of Phosphorus causing them to crack, &c.

Apart from the extra cost directly involved, the loss of time due to a bad set of moulds causing ingots to stick, &c., is an important matter, and may seriously interfere with the output of the plant. For ordinary Bessemer or Siemens steel an ingot mould should stand from 60 to 70 casts, but frequently they do not average more than 50 and sometimes less, while, on the other hand, 100 casts are sometimes obtained.

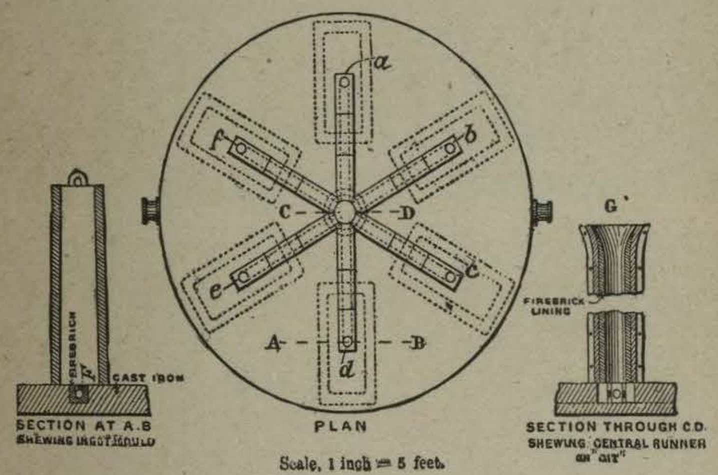


Fig. 42.—Cast-Iron Plate for Bottom Casting, showing "git" and moulds in position. The metal is teemed from the ladle down the "git," G, and flows along the six fire-clay pipes, built up of runner-bricks, when it enters the centre of the ingot mould through the holes in top of the runner-bricks, marked *a*, *b*, *c*, *d*, *e*, *f*, and rises until the moulds are full.

Moderate sized ingots from, say, 10 inches square and upwards are generally cast from the top as above described, but sometimes bottom casting is employed, more especially when a large number of small ingots are required. In bottom or group casting the moulds are closed at the top, but have small ventholes for the air to escape, and, instead of each ingot mould standing upon a separate bottom plate, one large bottom plate is used on which from 4 to 12 ingots may be cast according to size. In these bottom plates are cast grooves in which runner-bricks can be placed, these bricks being really fireclay pipes for the metal to run through. The runner-brick which comes under each ingot has a central hole about 1½ inches diameter for metal to pass up into the mould. In fig. 42 is shown this method of bottom casting. The metal is teemed down a central pipe or "git," shown in section, C D, lined with fire-brick or a ramming of ganister daubed with fire-clay, and then flows through the runner-pipes to the ingot moulds, arranged on each side or radially (fig. 42); teeming is continued until the group of moulds is full. Sometimes an ingot mould is used as a "git" for casting, but if a number of ingots are being cast in a group, the large quantity of metal passing down this central mould shortens its life very considerably.

In some cases for special work large ingots are cast from the bottom in groups of 3 or 4 according to their sizes. Fig. 43 is a sketch of an ingot mould used for bottom casting, showing details of cover for closing the top and method of wedging the cover down.

Various methods of casting small ingots in groups have been suggested from time to time, and Mr. Pink, of Hœrde, was the first to suggest that of casting ingots superimposed upon each other, and carried it out with more or less success. The tendency of late years has been to cast larger and

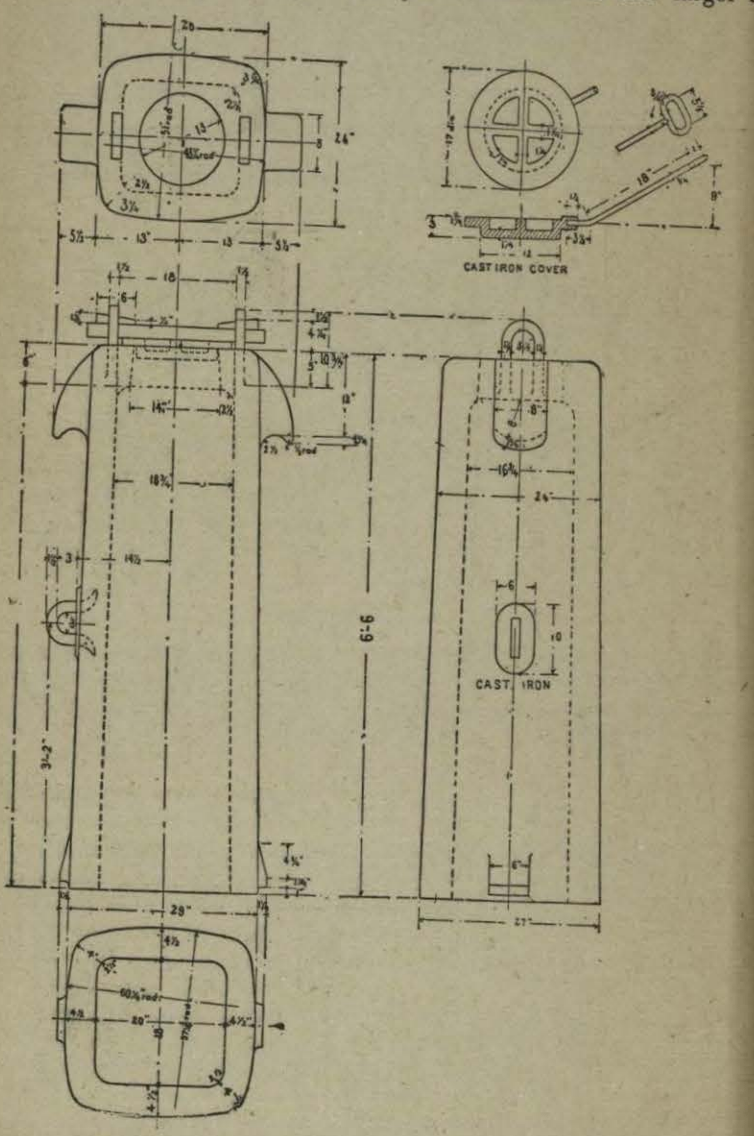
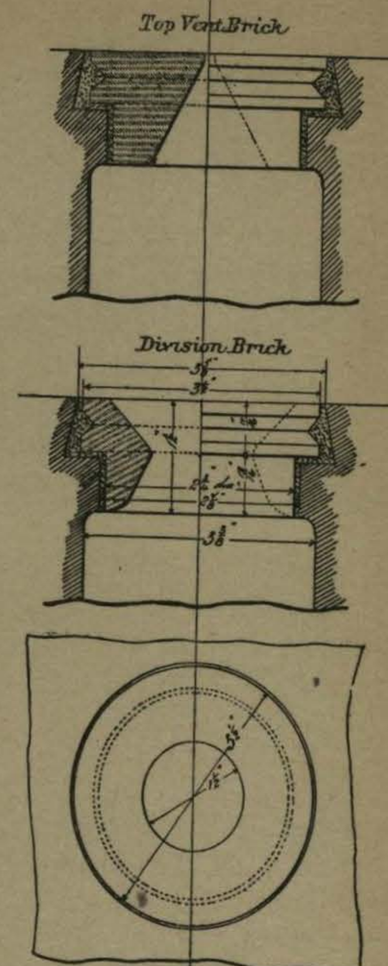


Fig. 43.—Closed Top Ingot Mould for Bottom Casting.

larger ingots, and cog down to blooms in the mill, finally rolling these to the required sections. To meet special conditions, however, small ingots are still cast, and one of the systems which has met with most practical success is that patented some years ago by Mr. Thos. Turner, of Kilmarnock. Its chief features are the grouping of a number of ingots on one bottom-

stem of Casting Small Ingots. [To face p. 36.

Fig. 48.



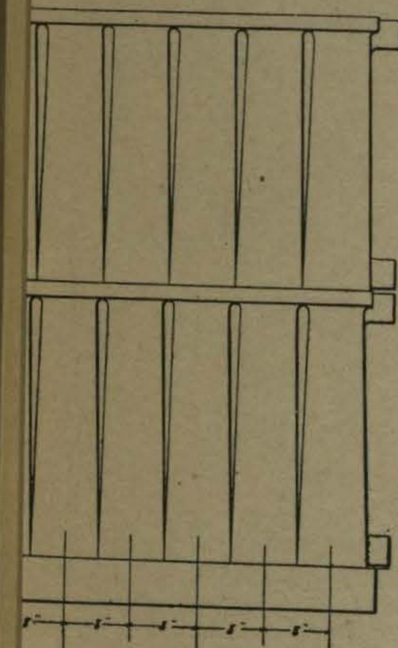


Fig. 47.

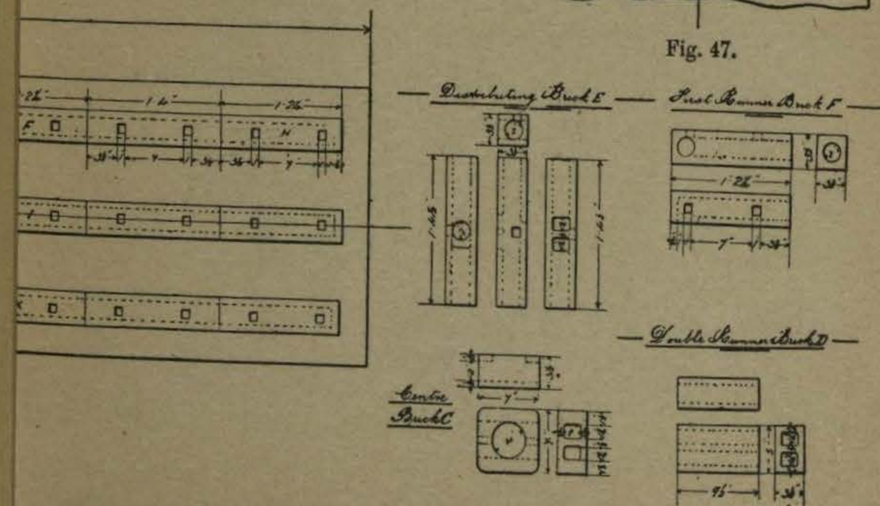


PLATE II.—The Thomas Turner Patent System of Casting Small Ingots.

[To face p. 36.

Fig. 46.

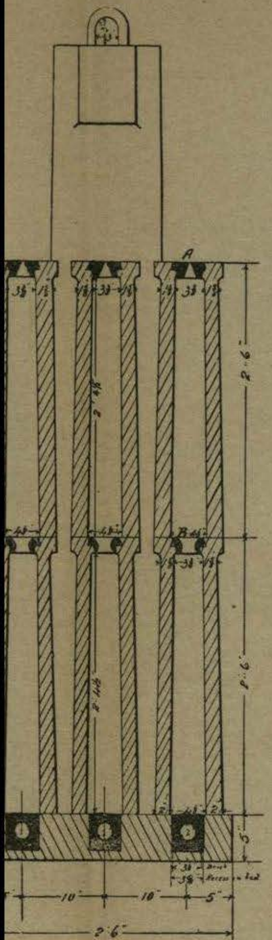
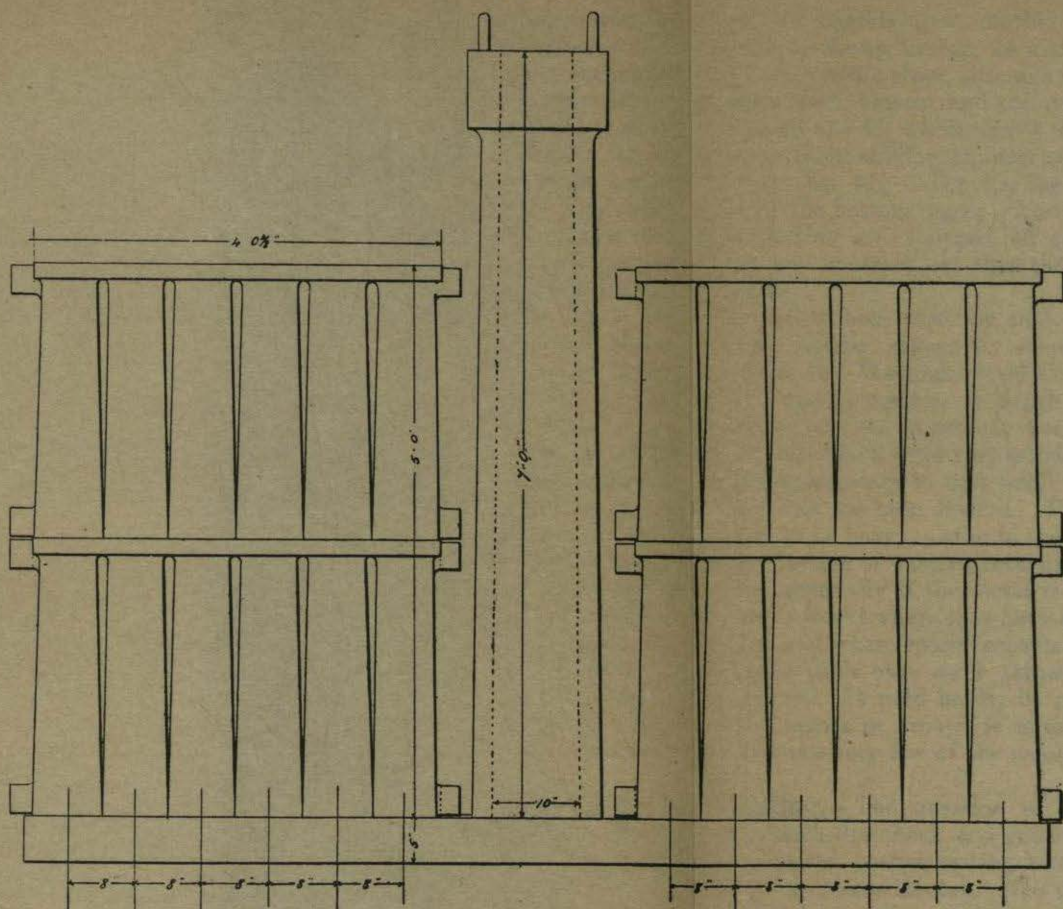


Fig. 44.



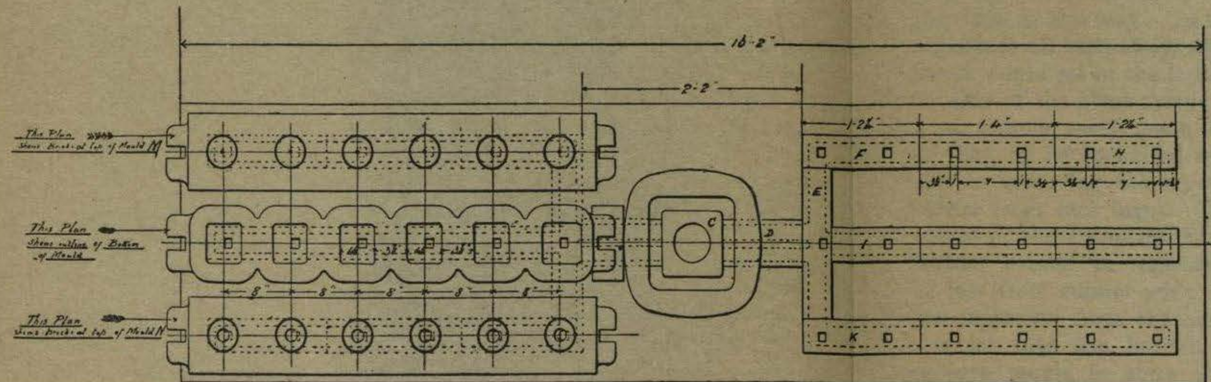


Fig. 48.

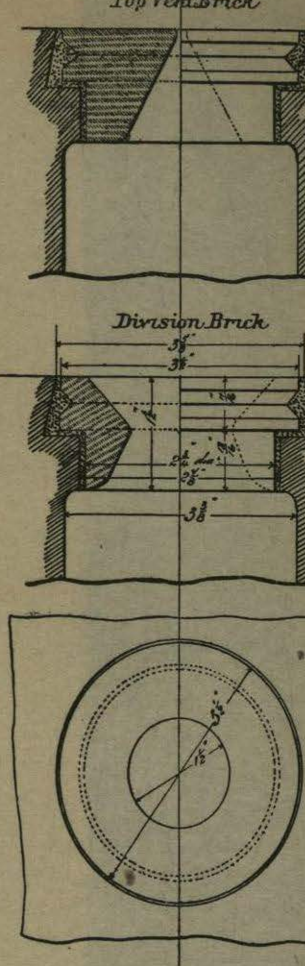


Fig. 47.