Sheet 1, 3 Sheets.

H. Bessemer.

Making Bessemer Steel.

No. 49,055. Patented Jul. 25, 1865.

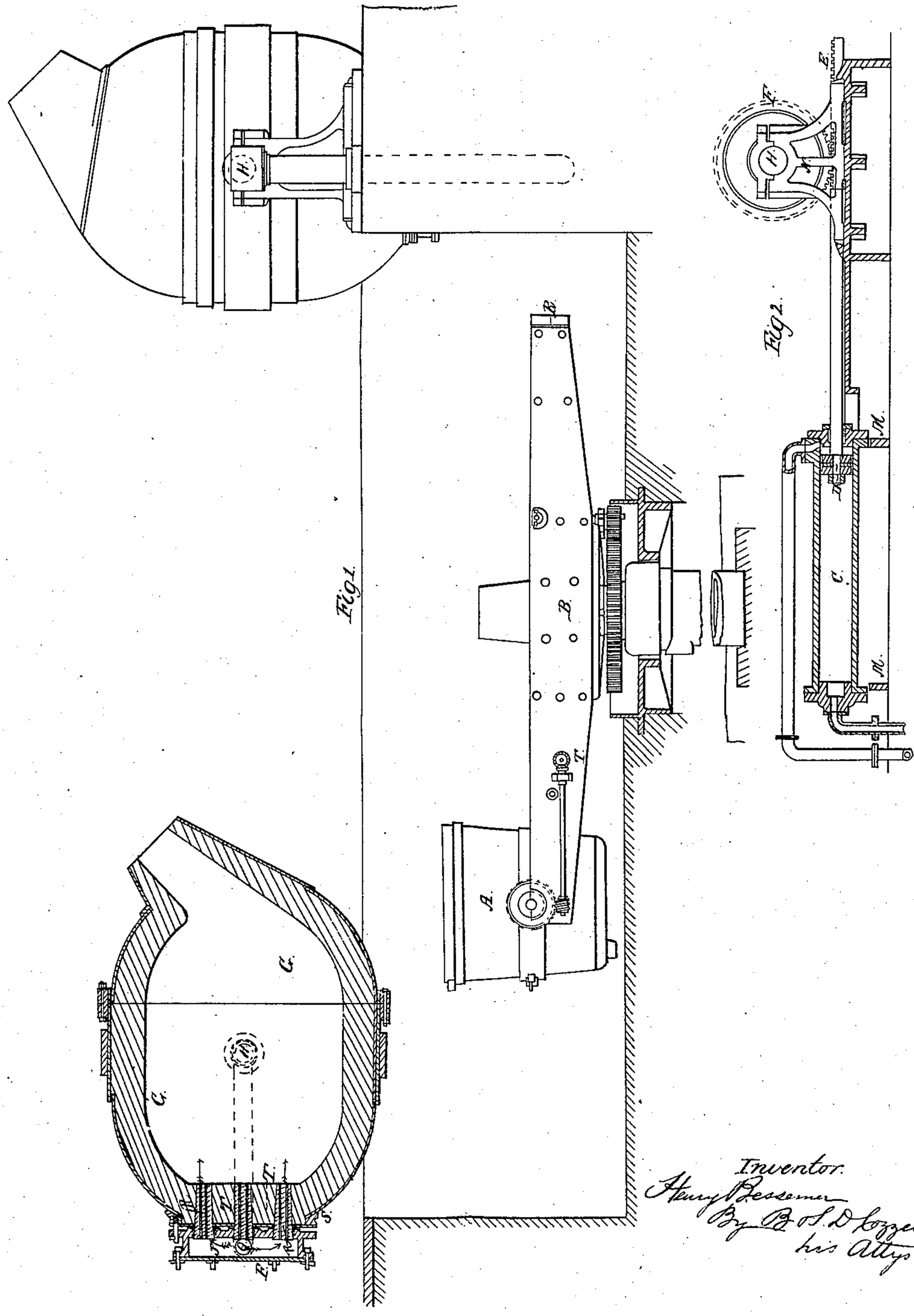

Fig. 1.

Fig. 2.

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Sheet 2, 3 Sheets.

H. Bessemer.

Making Bessemer Steel.

No. 49,055. Patented Jul. 25, 1865.

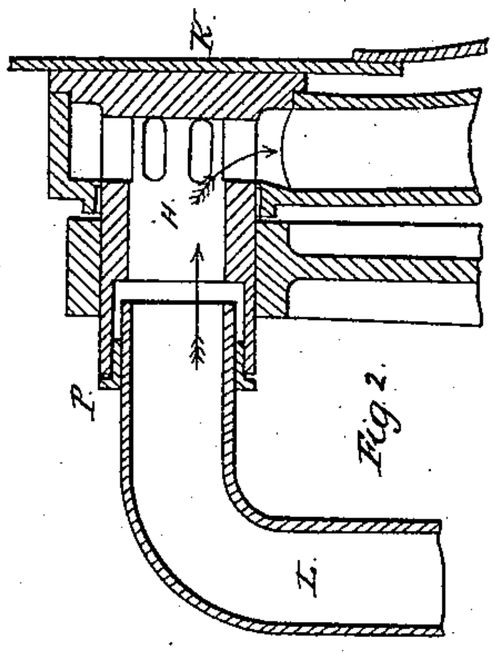

Fig. 2.

Fig. 1.

Fig. 5.

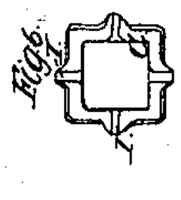

Fig. 6.

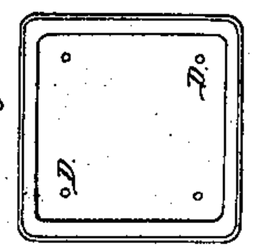

Fig. 4.

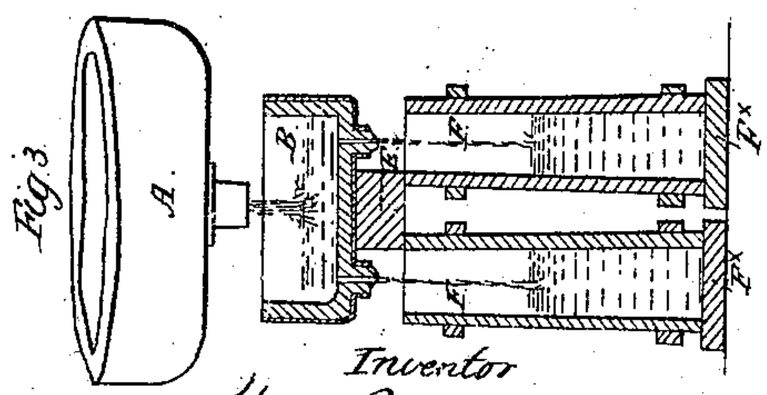

Fig. 3.

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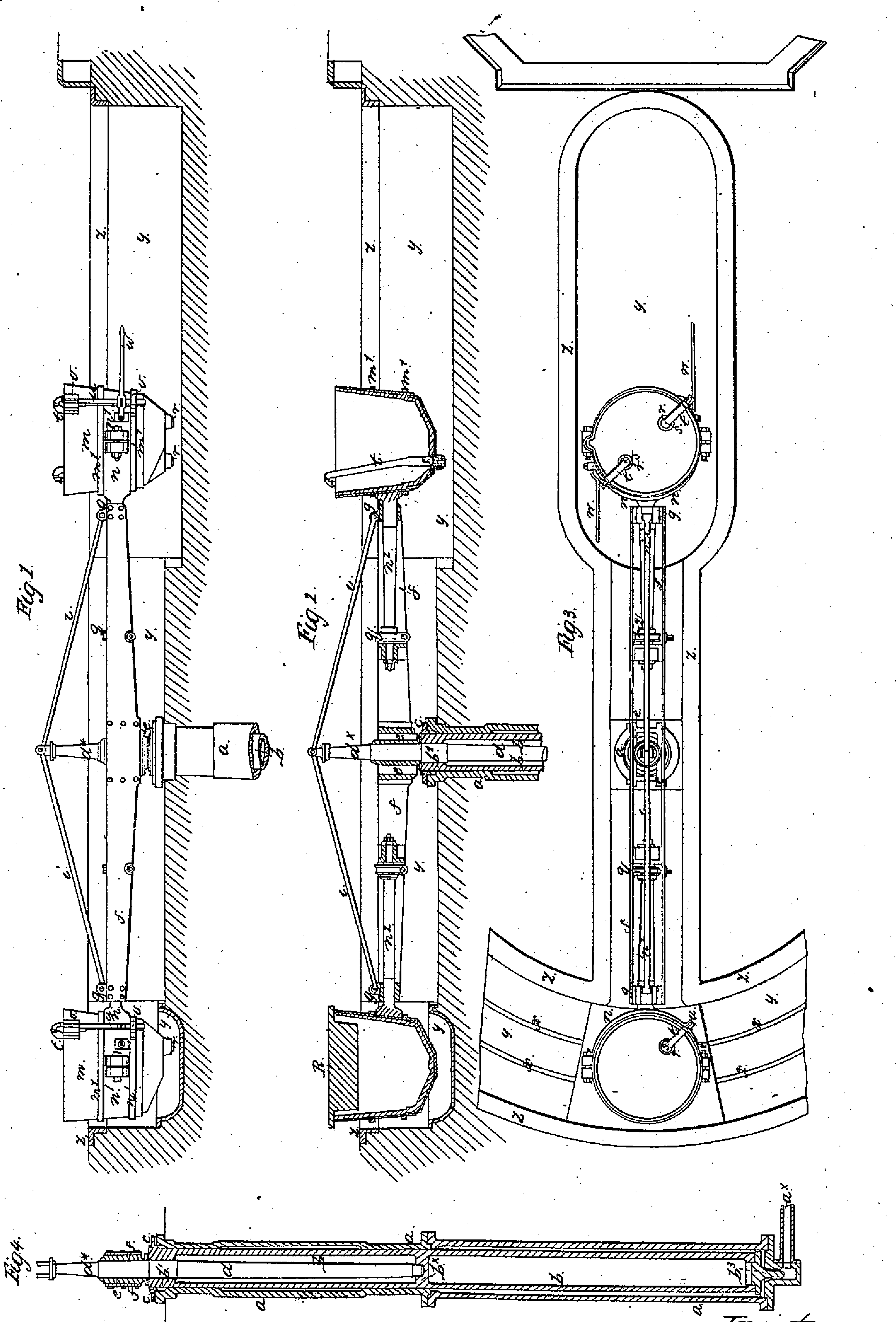
Sheet 3, 3 Sheets.

H. Bessemer.

Making Bessemer Steel.

N° 49,055. Patented Jul. 25, 1865.



Inventor.
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UNITED STATES PATENT OFFICE.

HENRY BESSEMER, OF LONDON, GREAT BRITAIN.

IMPROVEMENT IN MACHINERY FOR THE MANUFACTURE OF IRON AND STEEL.

Specification forming part of Letters Patent No. **49,055**, dated July 25, 1865.

To all whom it may concern:

Be it known that I, HENRY BESSEMER, of Queen Street Place, New Cannon Street, in the city of London, in the Kingdom of Great Britain, have invented certain new and useful Improvements in Machinery or Apparatus Employed in the Manufacture of Iron and Steel; and I do hereby declare the following to be a full and exact description of the same, reference being had to the accompanying drawings.

My improvements relate to the manufacture of iron and steel by blowing currents of air or steam into fluid crude iron, as patented by me in the United States November 11, 1856, and consist in the means of moving a converting-vessel on its axis; also, in attaching to the vessel a tuyere-box and arranging other parts, by means of which air or steam is introduced into the converting-vessel in order to facilitate the use and repairs of the apparatus; also, in the arrangement, counterbalancing, and movement of the ladle and crane employed in transferring the fluid iron or steel from the converting-vessel to the molds; also, in employing two or more valves in the ladle to provide greater security against the setting of the metal in the vessel; also, in using an intermediate vessel or basin having several lips or holes, so that one large stream directed from the ladle into the basin may be conveyed by said lips or holes with less force and in smaller quantities into several ingot-molds beneath, for the purpose of making sounder ingots, and at the same time emptying the ladle rapidly; also, in forming tuyeres for the above-mentioned converting-vessels by pressure from dry or nearly dry materials.

To enable others skilled in the art to more fully understand and construct and use my invention, I will proceed to describe the construction and operation more fully.

To enable the specification to be better understood, I have included therein and in the accompanying drawings various matters which pertain to the inventions heretofore made by me, upon which these improvements are additions.

Of the accompanying drawings, Figure 1, Sheet A, is a longitudinal section of the tuyere-box J and converting-vessel G partially turned down, and an elevation of the ladle A and ladle-crane B for receiving the fluid metal from the converting-vessel and conveying it to the molds. Fig. 2, Sheet A, is a longitudinal section of the hydraulic cylinder C and piston D, and an elevation of the rack E and pinion F for rotating the converting-vessel on its axis H. Fig. 1, Sheet B, is a plan of the apparatus shown on Sheet A. The converting-vessel G is turned bottom upward and the cover of the tuyere-box J is removed. Fig. 2, Sheet B, is a section, on a larger scale, of a part of the side K of the converting-vessel, and of the hollow trunnions H, and of a part of the air-pipe L which conducts air from the blowing-engine to the converting-vessel. Fig. 1, Sheet C, is an elevation, Fig. 2 is a section, and Fig. 3 is a plan, of another form of ladle and crane. Fig. 4 is a section of the hydraulic lift for raising and lowering the ladle and crane, and Figs. 3 to 6 are sections and plans of ingot-molds and intermediate basins to be used between the ladle and the ingot-molds.

The converting-vessel I at present prefer is made of stout plate-iron lined with a silicious stone called "ganister," or with any suitable refractory material. The form of the vessel is cylindrical, with rounded ends and an inclined mouth-piece. The converting-vessel is mounted on trunnions, through one of which the air for decarbonizing the fluid crude iron is conveyed to tuyeres situated in the lower part of the vessel, and thence into the vessel.

When converting-vessels are of a size sufficient to convert several tons of molten iron at a single operation, the power required to move them on their axes sufficiently quick renders the direct application of manual labor unsuitable for this purpose. I therefore prefer to effect such movement of the vessel by hydraulic power, because the varying speed of the vessel's motion and the stopping or starting of it at irregular intervals are most conveniently effected by such means.

The apparatus by which I carry into effect this part of my improvements consists of a bed-plate or frame, on which a hydraulic cylinder is fixed in a horizontal position. The piston-rod moving in this cylinder is formed into a rack at one end, which gears into a spur-wheel keyed onto a short intermediate shaft supported on two strong standards affixed to the said bed-plate. A third standard on the same bed-plate supports one axis of the converting-vessel, the end of the axis being formed into a clutch. A similar clutch-piece is also formed on one end of the before-named intermediate shaft, and is so

arranged as to transmit the semi-rotary motion of the spur-wheel to the vessel whenever the piston is acted upon with sufficient hydrostatic pressure on one side, while the other side of it is relieved of its pressure by a suitable valve or cock. This hydraulic apparatus is shown with the cylinder broken off on Sheet B of the drawings hereunto annexed, and in connection with the converting-vessel, and is also shown separately in vertical section at Fig. 2, Sheet A, where M is the frame or bed-plate on which the cylinder C is bolted, and which also serves to support the standards N, in which the shaft H works. Within the cylinder C is a piston, D, having double-cupped leathers to render it water-tight. There is also a pipe attached to each end of the cylinder, which pipes lead under ground to a convenient distance, where they are united to a suitably-arranged four-way cock, and by means of which the workman can cause water under pressure to be delivered by the pipes to either end of the cylinder, while the pipe at the opposite end of the cylinder will allow the water to be discharged. Thus the workman may from a distance control the motion of the piston, the rod of which is formed into a rack at E, which is in gear with the spur-wheel F, keyed on the axis of the vessel, and through the agency of which mechanism the workman who operates upon the four-way cock before referred to may cause the vessel to move partly round in either direction at a speed dependent on the extent to which he opens the cock, or by entirely closing the said cock he may retain the vessel in any desired position.

I will now show the manner in which I prefer to convey the air into the converting-vessel.

The pipe L, Sheet B, conducts air from the blast-engine to the hollow trunnion H of the converting-vessel, which is shown on an enlarged scale at Fig. 2, Sheet B. The joint of the pipe L, with the trunnion, is made tight by means of the stuffing-box P. From the hollow trunnions the air is conducted through the pipe Q into a tuyere-box attached to the converting-vessel. This tuyere-box forms an air-reservoir, from which all the tuyeres R lead into the interior of the converting-vessel. It will thus be seen that a constant stream of air may be kept blowing into the converting-vessel, whatever the position of said vessel may be, and also while said vessel is turning on its axis. The tuyeres are made of fire-clay or other suitable material, and are cylindrical in form for the greater part of their length, the lower part swelling out into a cone for the purpose of fitting it more securely into the top of the tuyere-box. In a vessel for converting fifty hundredweight of crude-iron, each tuyere may have five circular passages passing through its entire length, thus dividing the air into as many separate jets. There may be seven such tuyeres fitted into each box, one in the center and the other six surrounding it at equal distances, thus dividing the air into thirty-five separate jets, which pass vertically upward through the fluid metal.

The tuyere-box is entirely constructed of iron or steel, and is held onto the large angle-flange S of the converting-vessel by means of slotted studs and cotters, so as to enable it to be readily removed for the purpose of facilitating the repairs of the apparatus. The openings in the upper part of the tuyere-box are conical in form, having deep grooves formed in them. Through these openings the tuyeres are inserted, a little wet clay being first smeared round the conical part to cause a close joint to be made. The spaces T between the tuyeres are filled up with any suitable material. I prefer a ground stone known as "ganister" mixed into the consistency of batter with water. After the tuyere-box is secured to the bottom of the converting-vessel this semi-fluid matter is poured in until it reaches the top of the tuyeres, and thus fills up the vacant spaces between them and the lining of the vessel, which lining may also consist entirely of ganister rammed in a moist state, as in making a sand mold for casting; or the vessel may first have a lining of fire-brick, and be then lined with ganister or road-drift to protect the bricks from the action of the molten metal and slags. The bottom I of the tuyere-box J is fastened on by any suitable means. I prefer slotted studs and cotters, so as to be easily removed, when necessary, to ascertain if the tuyeres are open and in working order, or to stop up or repair or renew any of the tuyeres.

The kind of furnace which I prefer for melting crude metal is the ordinary air or reverberatory furnace; but as such furnaces form no part of my invention I have not shown them in the drawings.

Before using the apparatus for the conversion of crude molten iron into malleable iron or steel a fire should be made in the vessel, and by means of the blast the lining of the vessel should be well heated, after which the remaining fuel may be emptied out by turning the vessel on its own axis one-half of a revolution, which will entirely empty the vessel. The vessel should then be turned into such a position by means of the hydraulic apparatus before described that the liquid metal, when poured into it, will lie in the intermediate part of the vessel without running into the tuyeres or out of the mouth of the vessel. By means of a suitable trough or gutter the liquid iron in the melting-furnace may then be run into the mouth of the vessel. As soon as this is done the blast may be turned on and the handle of the hydraulic apparatus is moved so as to cause the vessel to assume the vertical position. The process is thus brought into full activity, the sparks and flame being received into a suitable chimney. So soon as the metal has been converted the hydraulic handle is reversed and the mouth of the vessel steadily and slowly lowered, whereby the whole of the converted metal will be poured out and be received in a suitable casting-ladle. The vessel may then be turned a little farther round until the mouth of it is as low as possible. A sudden turning on

of the blast for a few seconds will blow out the scoria, and the vessel may then be turned into a position suitable for receiving another charge of metal.

For the purpose of raising the fluid converted metal and conveying it to the molds, I use a hydraulic lift or crane having a cross-head or arms made of malleable iron or steel, which may be strengthened by tension-rods at one end of it. I mount the casting-ladle on an axis, to which I affix a worm-wheel or other gearing, so as to cause the ladle to move round when required, and thus pour out its contents over a spout or lip formed in the upper part thereof. I also form in the bottom of the said ladle two or more openings provided with suitable plugs or stoppers, which are guided externally, and are provided with handles, so as to let into the molds a regulated supply of metal when desired. On the opposite end of the cross-head I place a counter-weight, R, which I prefer to be equal to the weight of the casting-ladle, and also equal to one-half of the metal to be lifted in such ladle; or, in lieu of or in addition to such counter-weight, I sometimes employ a second ladle at this end of the cross-head, for the purpose of receiving converted or partially converted metal from any one of the converting-vessels, or from any other source, and of elevating or transferring it to any one or other of the converting-vessels, when found necessary or desirable. The object of the counter-weight is to partially neutralize the weight of the ladle and its contents, thus relieving the strain on the hydraulic apparatus which carries the crane.

The mode in which the hydraulic crane is constructed will be understood by reference to Sheet C of the annexed drawings, where Fig. 1 is a side elevation, showing part of the ram and cylinder broken off. Fig. 2 is a vertical section of the same, and Fig. 3 a plan, and Fig. 4 a vertical section, of the ram and cylinder, taken at right angles to Figs. 1 and 2.

a is the outer cylinder, the upper part of which is bored out and fitted truly to the hollow ram *b*, which is kept water-tight by the stuffing-box *c*. Into the upper part of the ram is fitted an axis, *d*, which forms the crane-post. The lower part of it rests in a foot-step, *b**, and is further supported at *b'*, where a collar is formed, in which it is free to revolve. On the axis *d* is keyed an iron casting, *e*, to which the flat wrought-iron or steel bars *f f* are bolted. At each end of and between these bars pieces of iron, *g*, are securely fastened, serving not only to hold the bars *f* in position, but, having a hole bored through them, serve also to support the axes n^2 of the casting-ladles. To the upper part of the pieces *g* are also fastened one end of the tension-rods *i*, while the other ends of them are supported by the elongated axis *d**, and thus enables the apparatus to support a great weight of metal in the casting-ladles *m*, which are constructed of sheet plate-iron strengthened by hoops *m'*, between which a space is formed to receive the two halves of a stout iron-hoop, *n* and *n'*, the part *n'* being readily detached, while the other half has a projecting part, n^2, which forms the axis on which the ladle is turned round. A piece of iron, *p*, is riveted in between the bars *f*, and serves to support one end of the axis of the ladle, which has keyed onto it a worm-wheel, *q*, into which a worm is geared, the worm-shaft passing through the bars *f f*, and having a ladle at one end, by which the movement of the casting-ladle on its axis is effected when necessary, the casting in general being effected by running out the metal from the lower part of the ladle, for which purpose there are two projecting pieces beneath the ladle, into which a tubular piece, *r*, of burned fire-clay, is fitted, the upper part being formed into a hollow cone, into which a conical plug or valve-piece, *s*, also of burned fire-clay, is fitted. This plug is fastened onto an iron rod, *t*, which is coated with loam to defend it from the metal.

On the outside of the ladle a sliding bar, *u*, works up and down in guides *v* by means of the handle *w*, and to the upper end of the bar *u* the rod *t* is fixed, so that the lifting up of the handle *w* will cause a corresponding motion of the valve-plug *s* and allow the fluid metal to run out in a clear stream, free from the melted scoria which floats on its surface. Two or more valves may be made in each ladle; but when two are employed I prefer to place them diagonally, as represented at Fig. 3, as it affords a better opportunity of working the handles. After filling a mold from each valve the ladle may be moved round on the axis *d* until the valves are brought over other molds, when the lifting of the handles will again allow the metal to flow. The molds should be placed in a semicircular pit previous to the casting operation. A portion of this pit is shown at *y*, having an iron curb, *z*, around it. The ladle and portion of the crane are lowered down into the cavity *y* formed in the floor of the converting-house. The lines *x* show the position which the molds should occupy in order to come under the valves when the crane is turned round. The ladles should be lined with loam and well dried and heated before running the metal from the converting-vessel into them. The drying is easily effected by inverting the ladles by means of the worm and handle, and then lowering them over a small fire made in a basket for that purpose, and placed within the sweep of the crane.

In order to receive the metal from the converting-vessel it will be necessary first to elevate the ladle so as to catch the first portions of the metal that runs out. The further lowering of the mouth of the converting-vessel will render necessary the lowering down of the casting-ladle, so as to catch the whole of the metal. When this is done the ladle, with its charge of metal, is to be raised so as to bring the bottom of the ladle above the level of the molds. This rise and fall of the ladle are ef-

fected with ease and steadiness by means of hydrostatic pressure acting on the ram *b*. Water for this purpose may be had from a vessel containing water under a pressure of two hundred to three hundred pounds per square inch, for the purpose of working the hydraulic cylinders that move the converting-vessels. The water from this vessel is to be admitted by a stop-cock placed in any convenient position, and communicating with the pipe *a** at the foot of the ram. When the ram is lowered down by the discharge of the water from the cylinder the conical projecting piece b^3 enters the orifice through which the water escapes and partially closes the passage, whereby any concussion that might otherwise be caused by such a heavy mass striking the bottom of the cylinder is prevented by the last part of its descent being very slow in consequence of the diminished area of the outlet. One of the ladles will only be generally required for casting; but the second one is most valuable in case of any accident rendering the former one unserviceable, or for transferring the metal from one converting-vessel to another, when necessary. The second ladle serves also as a counter-balance to the other one, and may be loaded to half the weight of the charge of fluid metal, and thus equalize more nearly the strain upon the apparatus.

Another method of arranging the ladle and the crane is shown by Sheets A and B of the accompanying drawings. The cheeks or bars U forming the crane-arm are in this case far enough apart to take in the ladle A between them. The ladle is supported on trunnions formed thereon and rests in bearings formed near the ends of the crane-arm, the axis of the ladle being at right angles to the cheeks of the crane. The motion of the ladle on its trunnions is effected by a worm and wheel, T, to which motion is communicated by a shaft and handles. This shaft works in bearings formed in the crane-arm, and a pair of beveled wheels serves to communicate its motion to the worm which moves the ladle. Various other means of either tipping the ladle on its axis and of preventing the ladle from tipping will suggest themselves to mechanics. The motion of the ladle on its axes affords facility for the discharge therefrom of fuel put there to dry it, also the slags or other matters left after it has been used. It also allows the ladle to be inverted over a fire, when that mode of heating is preferred. A ladle merely suspended—as by a chain, for instance—so as to be capable of lateral or swinging motion, or of spinning motion, would be liable to be moved away from under the mouth of the converting-vessel by the force of the fluid wrought-iron or steel pouring into the ladle, and to be moved away from over the ingot-molds by various causes, thus spilling a part of the fluid iron or steel. It is also important that the stream of iron or steel should enter near the vertical axis of the molds to prevent its striking the sides of the molds.

Now, it will be seen that with my improved apparatus, as above described, the ladle can be tipped or held from tipping on its axis when required, while at the same time it is always held by the crane at a certain fixed distance from the vertical axis of the crane, and will therefore move round in a fixed orbit, instead of swinging or spinning.

These improvements also consist in the use of a basin or vessel of malleable iron lined with sand or loam, or made of fire-clay and baked clay, and preferably used red-hot, such basin having several lips or spouts formed around its upper edge, or having several openings made in the bottom thereof, so that when such basin is placed above several small ingot or other molds one large stream from the casting-ladle directed into such basin will, by means of the said lips or holes, be conveyed with less force and in smaller quantities into the several molds beneath, by which means sounder ingots will be produced, owing to the diminished velocity with which the metal enters the mold from these basins, while the slow filling of each mold by a small stream of metal also tends to improve the ingots, but at the same time does not prevent the rapid emptying of the casting-ladle, and thus a large number of small ingots may be made from one large ladle of metal without retaining the metal therein until it has cooled too far for casting. In order that this mode of supplying the metal to the several ingot-molds may be fully understood, I have given on Sheet B of the drawings a vertical section of the basin and molds at Fig. 3, and a plan of the same at Fig. 4.

Another modification of the basin is shown in section at Fig. 5, and a plan at Fig. 6. A represents the lower portion of the casting-ladle, from which a large stream of metal flows into the basin B, which may have four holes, D, in the bottom of it, each of the required diameter. It rests upon a block of fire-clay, E, which is placed on the molds F. These molds are simply square tubes, slightly conical, and resting on flat plates F*.

In Fig. 5 the basin G is shown as resting on the top of the molds H. It has a lip or spout formed on each side, as shown at I, Fig. 6. When the molten steel is poured into this basin it will overflow at the several spouts and supply the molds beneath with a gentle stream of metal. The metal formed in this form of basin may, when the casting-ladle is emptied, be turned up with a pair of tongs, so as to empty its contents into one of the molds.

The tuyeres used in the converting-vessel are sometimes rapidly acted upon by the impurities of the metal; and I have found it preferable to form such tuyeres as dense and as free as possible from those cracks which are frequently found in tuyeres made of plastic clay. For this purpose I employ ganister, silicate of alumina, fire-clay, silicate of magnesia, lime, plumbago, or oxide of iron. These substances may be used alone, or any two or more of them

may be combined in any desirable proportions. They are to be reduced to a fine powder and to be used in a dry or nearly dry state. I compress these matters, or either of them, in a suitable mold by means of hydraulic pressure or by percussion, after which the tuyeres so made may be used in the state in which they come from the mold; but I prefer first to bake them in a pottery-kiln and to glaze the interior of the holes so as to render them smooth and even.

I do not confine myself to the precise arrangement of parts herein shown, and details not herein laid down may be carried out in any manner known to the art, and which may be found suitable to my invention.

Having thus described my invention, the following is what I claim as new therein and desire to secure by Letters Patent:

1. A converting-vessel capable of rotary motion upon its own axis, in combination with a rack and pinion, or any equivatent mechanism operated by hydrostatic pressure in a cylinder, for the purpose of giving to such vessel a rotary or semi-rotary movement.

2. A converting-vessel, combined with a tuyere-box so constructed as to constitute a chamber for receiving air for decarbonizing crude liquid metals and distributing such air to the tuyeres.

3. A tuyere-box so constructed as to constitute a chamber for receiving air for decarbonizing crude liquid metal and distributing such air to the tuyeres, when the bottom of said tuyere-box is made of a piece or pieces suitable to be easily removed, as and for the purposes set forth.

4. The combination of the ladle with the crane-arm or its equivalent, so that the ladle shall be held in a fixed position relatively to the crane-arm, but shall be capable of being tipped when desired, substantially as and for the purposes specified.

5. The combination of a ladle capable of being held in a fixed position relatively to the crane-arm or its equivalent, substantially as described, with any suitable means of lowering the ladle, as and for the purposes specified.

6. The employment, in the manufacture of malleable iron or steel, of casting-ladles having two or more valvular openings in their bottoms.

7. The method of filling several molds at one time from a basin or vessel having several outlets, such basin or vessel being supplied with fluid malleable iron or steel during such casting process, substantially as described.

8. The method herein described of forming tuyeres by pressure from dry or nearly dry materials.

HENRY BESSEMER.

Witnesses:
THOS. BROWN,
DAVD. LONGSDON.