5 Sheets—Sheet 1.

H. BESSEMER.

MANUFACTURE OF IRON AND STEEL.

No. 51,398. Patented Dec. 5, 1865.

Fig. 1

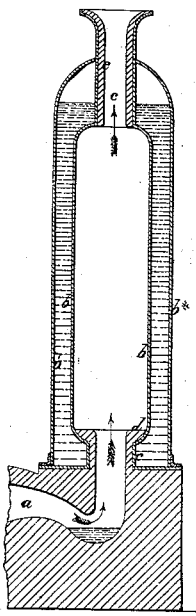


Fig. 2 Case H.

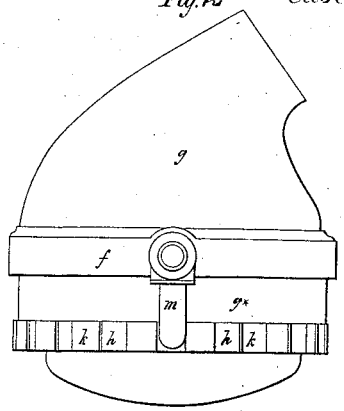


Fig. 3

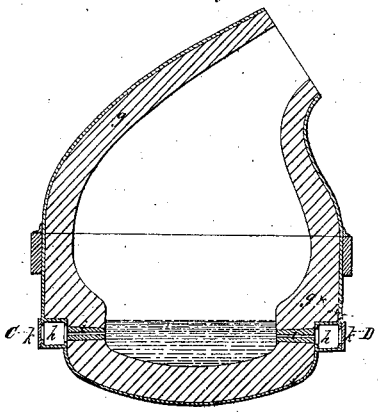


Fig. 4

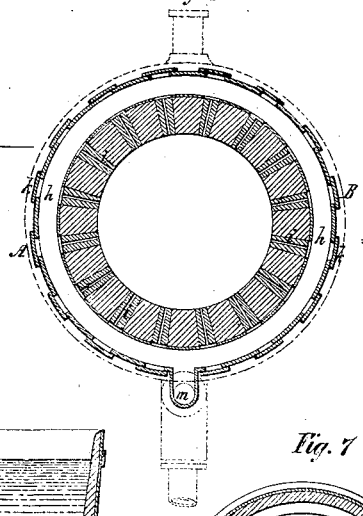


Fig. 5

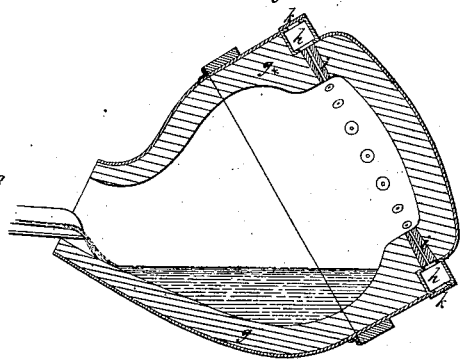


Fig. 6

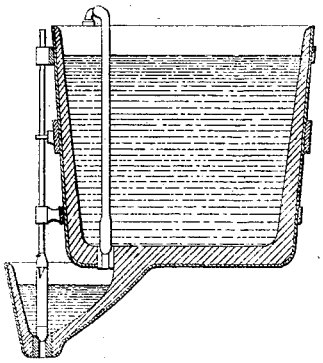


Fig. 7

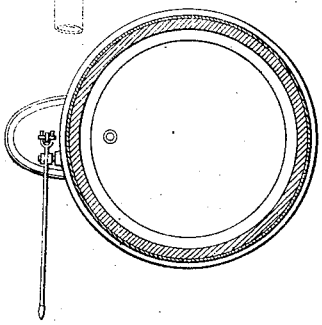
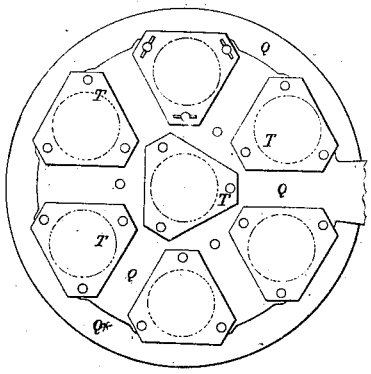


Fig. 11



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5 Sheets—Sheet 2.

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MANUFACTURE OF IRON AND STEEL.

No. 51,398. Patented Dec. 5, 1865.

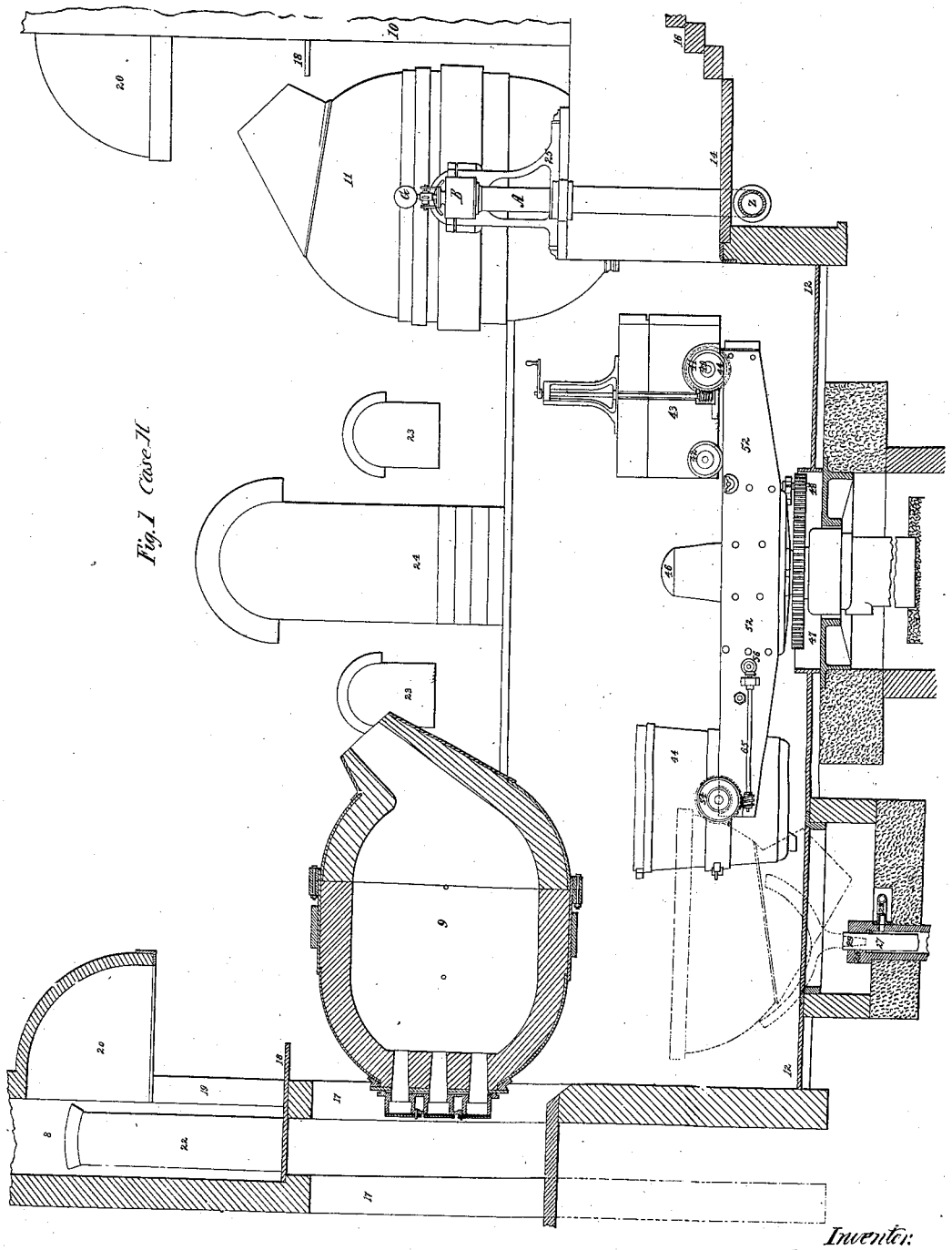

Fig. 1 Case II.

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5 Sheets—Sheet 3.

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MANUFACTURE OF IRON AND STEEL.

No. 51,398. Patented Dec. 5, 1865.

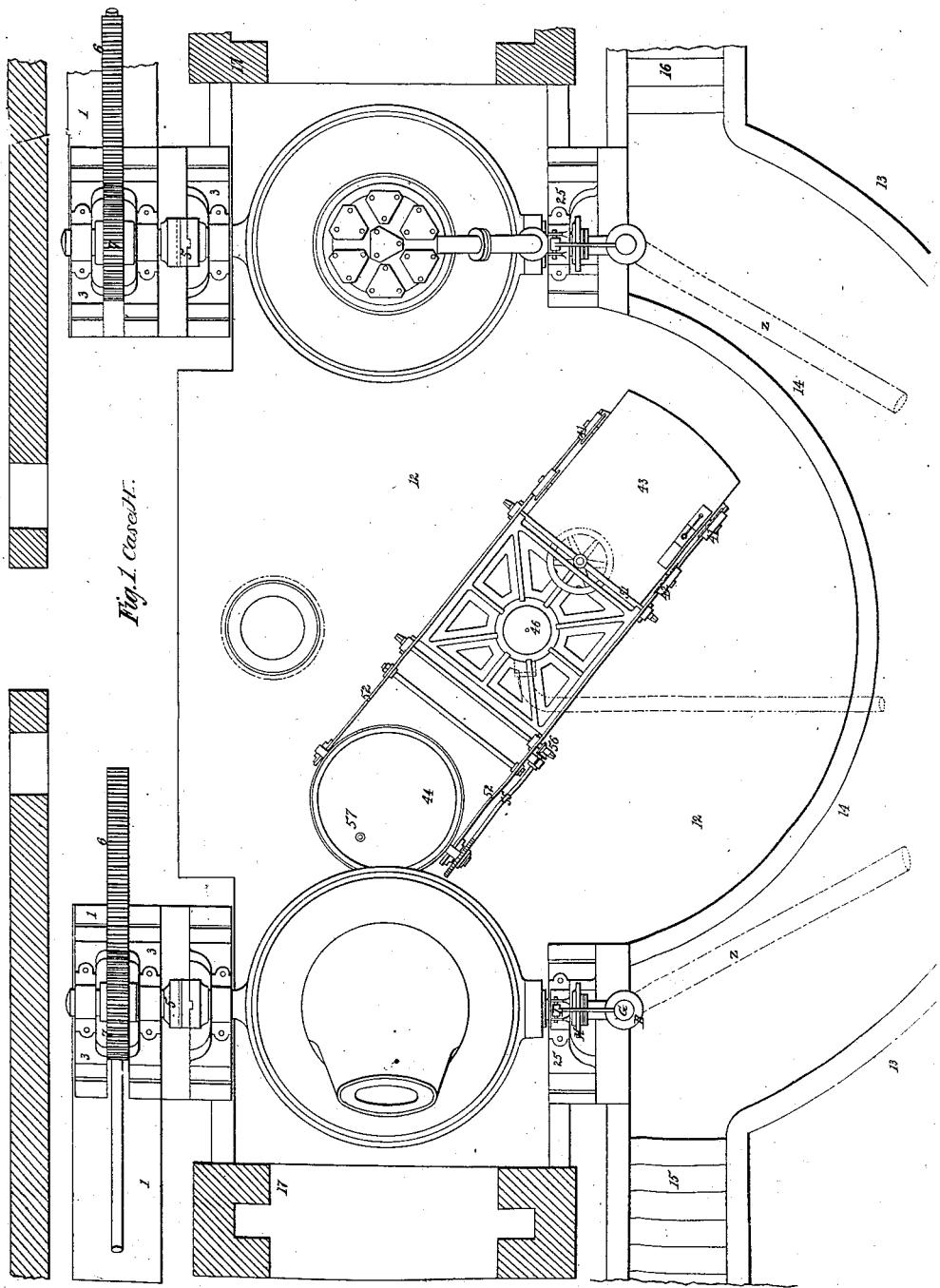

Fig. 1. Case H.

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MANUFACTURE OF IRON AND STEEL.

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Fig. 4 Case H

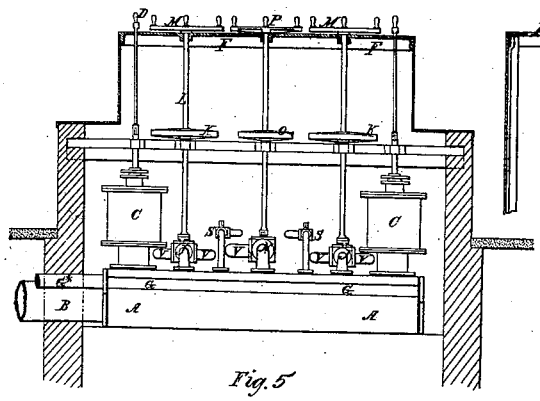


Fig. 8

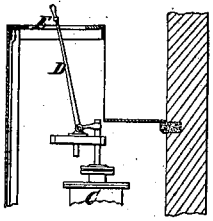


Fig. 6

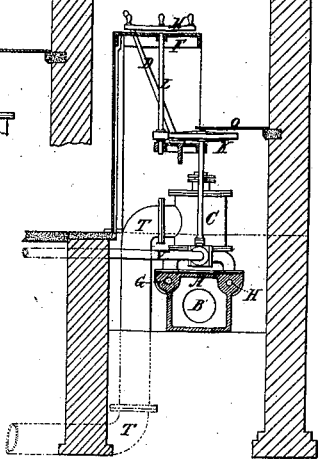


Fig. 5

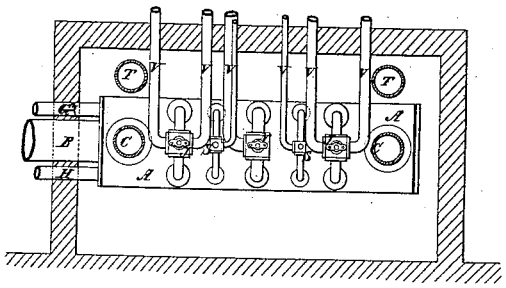


Fig. 7

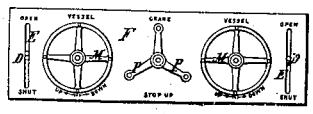


Fig. 3

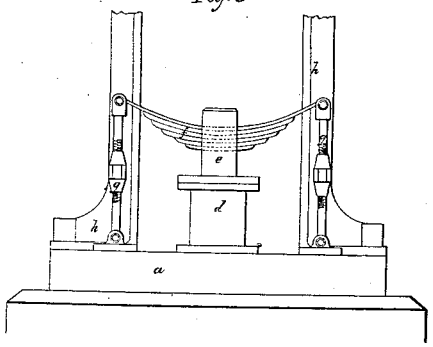


Fig. 9

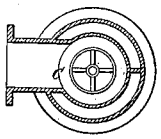
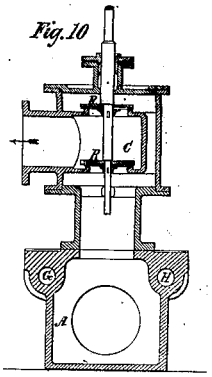


Fig. 10



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MANUFACTURE OF IRON AND STEEL.

No. 51,398. Patented Dec. 5, 1865.

Case H.

Fig. 1

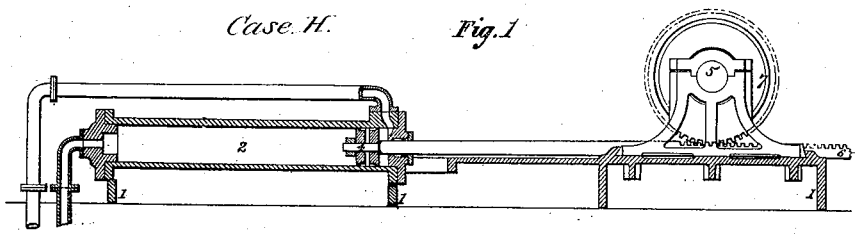


Fig. 2

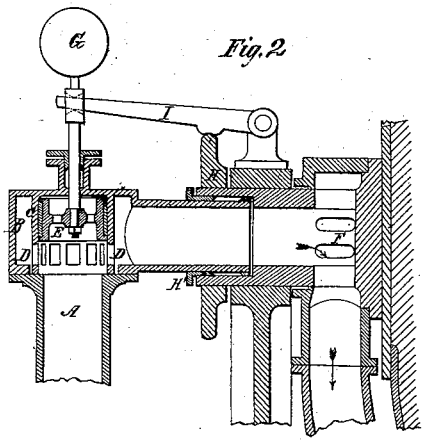


Fig. 8

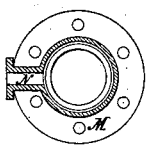


Fig. 9

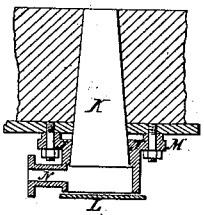


Fig. 10

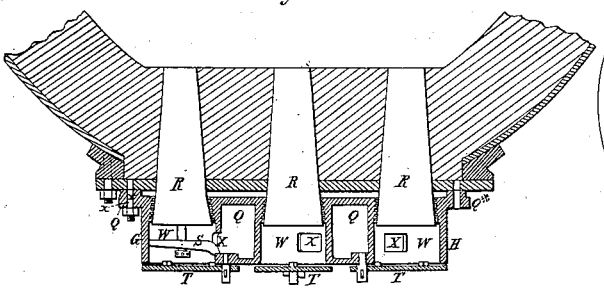
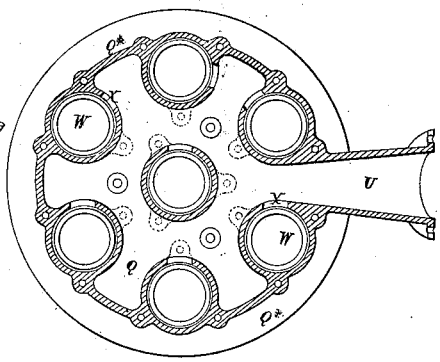


Fig. 12



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By B. & H. Bozzano,
his Attys.

UNITED STATES PATENT OFFICE.

HENRY BESSEMER, OF LONDON, ENGLAND.

IMPROVEMENT IN THE MANUFACTURE OF IRON AND STEEL.

Specification forming part of Letters Patent No. **51,398**, dated December 5, 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 the Machinery and Apparatus Employed in the Manufacture of Malleable 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 refer to the process of making malleable iron and steel by forcing currents of air through molten crude metal, as patented by me November 11, 1856; and consist in generating steam by the waste heat of the melting-furnaces, in the means and methods of admitting air to the converting-vessels, in the situation and moving of the converting-vessels, in the use and construction of apparatus for controlling the movement and operation of construction of converting-vessels and ladles, in the construction of ladles, and in certain arrangements and combinations of apparatus.

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

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

When it is desired to operate upon crude metal that has been formed into pigs of iron in the usual manner or which has previously been refined, I employ for the remelting of such metal a reverberatory furnace similar to those employed in melting iron for founding, but sometimes differing from them in having a second bed or hearth placed beyond the ordinary hearth or bank of the furnace and below the chimney, by which means two charges of metal differing from each other in quantity and quality may be melted in the same furnace without becoming mixed with each other. The chimney of the said furnace I prefer to consist of two vertical concentric cylinders made of boiler-plates, with a water-space between them, the inner cylinder being of a diameter much beyond that required to carry off the products of combustion, the inlet at the bottom and the outlet at the top of the said inner cylinder being contracted in size and lined with fire-bricks, so that the highly-heated vapors of the furnace are prevented from impinging forcibly on the metal surface of the boiler, whereby its durability is increased, while the utilization of the heat escaping from the melting-furnace will lessen the cost of manufacture by furnishing steam for driving the blast-engine or other machinery employed.

And in order that this arrangement of a steam-boiler in connection with the melting-furnace may be fully understood, I have shown a vertical section of the same on Sheet A, Figure 1, of the drawings hereunto annexed, where—

a represents the end part of the reverberatory furnace, on which is placed the vertical cylindrical boiler *b*, its lower end being made flat and stayed by vertical radial plates (not seen in the drawings) for the purpose of enabling the lower part to sustain the great internal pressure to which it is subjected. The contracted part *c* of the flue-tube is lined with fire-bricks, *d*, as shown, so as to conduct the highly-heated products of combustion into the enlarged part of the flue-tube *b** without allowing the flame to impinge forcibly upon the metallic surface of the boiler. The upper part of the flue-tube *b** is also contracted and lined with fire-bricks *e*, so that no part of the metal of the boiler-flue which is surrounded by steam shall be in contact with the flame or heated vapors of the furnace.

The boiler should be provided with the usual steam-pipes, water-supply pipe, and safety-valve, (not shown in the drawings,) and the outer and inner shell may be connected at intervals with stay-bolts in a manner similar to that employed in the construction of the fire-boxes of locomotive-engines.

Access to the interior of the boiler may be had through a man-hole in the usual manner. The space between the flue-tube and the outer shell of the boiler I prefer to be such as will admit a workman, to clean the whole interior of the boiler when required.

The converting-vessels, in which the melted iron is converted into malleable iron or steel, are provided with axes on which they are moved by hydraulic apparatus, as shown in the drawings, or by any other convenient means, when required. Through one of these axes the air is conducted from a fixed pipe.

It is of great importance to the successful

working of the apparatus that the admission of the air to the vessel and its exclusion therefrom should never fail to take place whenever the vessel assumes certain positions both in its upward or downward movements. Otherwise the tuyeres may become stopped up with fluid metal or the metal may be blown out at the mouth of the vessel. To render the operation certain I employ a valve in the air-pipe near the axis of the vessel, and I fix onto the axis a cam which acts on a lever so placed as to open or shut off the air by the vessel's own motion, instead of moving the valve by the hand of the workman, as hitherto practiced.

In order that the construction and mode of working this valve may be fully understood, I have shown the same in elevation in its proper place on Sheets B and C of the drawings hereunto annexed, and in vertical section in the detached Fig. 2 on Sheet E. In each figure, A represents the stand-pipe which conducts the air upward from the main pipes Z. Below the floor B is the valve-box, which consists of a cylindrical chamber with an inner cylinder, C, forming a continuation of the vertical pipe A. The cylinder C is bored truly, and has fitted to it a piston-valve, E, having an elastic metallic packing. Slots are formed in the cylinder C, which allow the air to pass from the pipe A into the annular space D formed between the two cylinders, and from thence into the axis F of the converting-vessel. The piston E, when lowered down, covers the slots and shuts off the communication with the main blast-pipe. It will be observed that the piston-valve has openings, through which the air may pass to its upper side, in order that the pressure of the air may be equalized on both sides of it, and thereby allow the weight G to retain it in place when lowered down. A cam, H, is keyed onto the axis of the vessel, and above it there is a lever, I, jointed at one end, and at the other it passes through a slot in the rod of piston-valve E. A projecting piece from this lever rests on the cam so that the cam may, by means of the inclines formed on its periphery, cause the lever I to rise and fall, and with it the piston-valve, and thus, by the motion of the converting-vessel, the air may be let on or shut off at any point required, and which will depend on the configuration of the cam, as is well understood.

The tuyere box or chamber forming the lower part of the converting-vessel has hitherto been made so as to gain access to each of the tuyeres through one opening, each tuyere communicating with one air-chamber common to all. It has therefore sometimes happened that the failure of one tuyere has allowed the fluid metal to descend into the tuyere-box, and thus for the time prevent all further use with either of the other tuyeres, and thus rendering the completion of the process impossible, as well as rendering each tuyere unfit for further use.

Now, my present improvement in this part of the apparatus consists in forming several small tuyere-boxes, each containing a single tuyere, with any suitable number of openings in it. A single tuyere-box so formed is shown in section at Figs. 8 and 9, Sheet E. It is of a cylindrical form, and has a beveled opening, J, at one end, into which the conical end of the tuyere K is fitted. The box is closed by a lid, L, and the tuyere-box is provided with an outer flange, M, by which it is bolted to the lower side of the converting-vessel. Any convenient number of such separate tuyere-boxes may be grouped together and be connected to the blast-pipe by separate branch-pipes communicating with an opening made in the side of the box, as shown at N.

My improvements also consist in forming one tuyere-box with several separate compartments, so that a failure of one of the tuyeres may not prevent the continuation of the process with the other tuyeres, the faulty tuyere being stopped by a plate of iron coated with loam, or it may be removed and the full efficiency of the apparatus insured by the insertion of a fresh tuyere in its place. The tuyeres being made conical and occupying separate compartments will give great facility for their removal and replacement with new ones, either before the completion of a charge of metal under operation or after it has been converted and run out of the vessel and previous to a repetition of the process. This mode of combining several separate compartments each containing a tuyere admits of the several tuyeres being placed nearer to each other than can conveniently be done when separate tuyere-boxes are used.

The mode of construction which I prefer is represented on Sheets A and E of the drawings hereunto annexed, where Fig. 10 is a vertical section through the lower part of the vessel and tuyere-box; Fig. 11, a plan of the under side, and Fig. 12 a section taken through the box on the line G H of Fig. 10.

The tuyere-box Q, as here represented, consists of an iron casting having seven circular chambers, W, formed therein, into each of which the tuyeres R are fitted and made air-tight by a luting of clay smeared upon the lower conical part of the tuyere at the time of fitting it into the box, the conical opening into which it fits having rings or grooves formed around it the better to hold the luting in place. A bar of iron, S, with a screw passing through its center, is fitted across the circular chambers, for the purpose of forcing the tuyere tightly into its seat and retaining it there.

T T are covering-plates, for the purpose of closing the several compartments of the tuyere-box by means of slotted studs having cotters passing through them, as shown. The joints of the covering-plates are rendered tight by a gasket of hemp covered with very soft clay or lime and water in a semi-fluid state. The air is forced into the tuyere-box by the pipe U, and, passing into the closed space between the circular chambers, enters them through lateral openings X, and from thence through the orifices of the tuyeres into the fluid metal. The

tuyere-box is attached to the converting-vessel by bolts, which pass through the flange Q* of the tuyere-box.

It is sometimes found desirable to form ingots or castings of a greater weight than can be produced in a converting-vessel of a convenient size. To effect this object without the necessity of erecting larger vessels I place two or more converting-vessels in such a position with reference to each other and to the crane which supports the casting-ladle that two separate charges of metal may simultaneously be converted, and be afterward poured one quickly after the other into the same casting-ladle, and thereby be made to produce an ingot or casting in one piece equal in weight to the produce of the two vessels, the position of the said vessels with reference to each other being also such as to render it convenient to repair either of them while the other one is in active operation. For this purpose I place the vessels several feet apart and opposite each other, each one having a separate chimney to take off the flame and products of combustion, the chimneys being in a line with the two vessels which are placed between them and at a small distance from the wall of the melting-house, the axes of the vessels being parallel to each other and at right angles to the plane of the said wall. The chimneys are built on open arches, from under which the workman may have ready access to the tuyere-boxes when the vessels are turned into a horizontal position. The space above the arches may be lined with iron plates, and thus form receptacles for the splashes or slags thrown out during the converting process.

The relative position of the converting-vessels and the construction of the chimneys will be seen by reference to Sheets B and C of the annexed drawings.

At Fig. 1 on Sheet B I have shown the chimney 8 and vessel 9 in vertical section, and on the opposite side of the drawings I have shown the chimney 10 and the converting-vessel 11 in elevation. The general arrangement of the several parts may also be seen in plan on Sheet C, Fig. 1. A portion of the floor of the converting-house is sunk below the general level. The sunk part, which forms the casting-pit, is represented at 12, and the upper or general floor-level at 13. A further portion, 14, is also sunk to an intermediate depth, free access to which is given by the steps 15 and 16. This curved space 14 extends partly around the casting-pit, and is for the purpose of allowing the workmen free access to the molds at the time of casting the ingots, the molds being arranged in a semicircle in the casting-pit and near to the curved wall which bounds the casting-pit on the side where the sunk space 14 is formed. The chimneys are built on open arches 17, the piers of which are shown in plan at 17 on Sheet C. Above the arch an iron plate, 18, forms a sort of shelf, on which the splashes of slag thrown from the vessel are received, there being an arched opening into the chimney at 19 with a projecting hood, 20, the better to collect the flame and heated gases from the vessel and cause them to ascend the chimney, which contracts in width by a series of "sets off" in the brick-work, above which it is square, and passes up through the roof of the building to any convenient height. An iron door, 22, will enable the workman to enter and clean out the chimney, and will also afford access for the purpose of putting fuel into the vessel when it is required to heat the vessel prior to commencing work.

On reference to Sheet B, it will be seen that when either of the vessels are being used the splashes thrown out of one will be in an opposite direction to the other vessel, so that the repairs of one vessel or setting or renewal of tuyeres may be going on in one vessel while the other vessel is in operation, or both vessels may be worked at one time and their respective charges of metal be poured into one ladle, and thence transferred to a single mold when large masses are required. In my Patent No. 49,055 I have described certain advantages due to this arrangement of ladle and ladle-crane. The ladle being held in a fixed position relatively to the crane-arm will not have a swinging or spinning motion, but is at the same time capable of tipping. It will be obvious that these advantages may be realized in an equal or greater degree when a ladle and crane thus arranged are combined with two or more converting-vessels.

The vessel 9 is shown in the position necessary to afford free access to the tuyere-box, the workman standing for that purpose beneath the open arches 17 of the chimney. Metal is supplied to these vessels through openings 23, a gutter being temporarily placed to convey the fluid iron from the melting-furnaces, which I prefer to place on the opposite side of the wall of the converting-house, and at such a height above the general floor-level as will admit of the metal flowing from the furnaces direct into the mouth of the vessel. The doorway and steps shown at 24 serve to communicate between the converting-house and the furnace-room adjoining.

It will be seen that the converting-vessels are mounted on axes resting at one end on a standard supported by the bed-plates 1 of hydraulic apparatus, and at the opposite ends are supported on standards 25, bolted firmly down to the foundations. The casting-crane occupies a position midway between the two converting-vessels, the center of it being farther from the melting-house wall than the converting-vessels. When the converting-vessel requires to be relined the upper part of the vessel should be removed, and after the old lining of stony matter is broken out of the iron shell the new material is to be rammed in and the two parts again carefully put together, and so as to avoid the displacement of any portion of the new lining, which posseses very little coherence until it has been fired. To effect this separation of the vessel and its after union

the vessel should be inverted or turned mouth downward. Below its center and beneath the floor of the casting-pit I fix a small vertical hydraulic cylinder and ram, the upper part of the ram being provided with a forked piece so made as to embrace the movable part of the vessel and retain it in its proper position. By this means one part of the vessel may be lowered down vertically beneath the other portion, which is still retained in position by resting on its axes. After the vessel is relined it may be steadily raised into its former position, and be there united by bolts to the other part. On sheet B the upper part of this small hydraulic ram is shown in vertical section.

26 is the cylinder, which fits accurately to the ram or plunger 27 for a sufficient distance to cause the ram to rise and fall steadily. A hydraulic leather keeps a water-tight joint in the usual manner, and the pipe 28 is connected to a reservoir of water under pressure or to force-pumps, so that by means of a cock the ram may be raised and lowered when required. A forked piece for the upper part of the vessel to rest on, and shown by dots, is made to fit into a socket (shown at 29) in the head of the ram, the forked piece being removed when not required for lowering the top of the vessel.

In the conversion of crude iron into steel or malleable iron by forcing air therein it has been found that some kinds or qualities of iron are converted much more rapidly than others. This is especially the case with some of the purer kinds of charcoal pig-iron. It has also been found that some irons thus rapidly converted acquire a higher temperature if blown into by horizontal tuyeres, because by this means there can, if desired, be employed a larger orifice and less pressure of air than has been generally employed when blowing vertically upward into the metal. This arrangement also enables the air to be blown in at various points, which is advantageous. Now, in order to obtain the high temperature producible under such circumstances and to retain the advantages derivable from the axial motion of the vessel, I prefer to construct a vessel mounted on trunnions and provided with a line of tuyeres either extending horizontally around, or nearly around, the lower part of the vessel, the part where the tuyeres are situated being of a somewhat less diameter than the cylindrical body of the vessel. I also make the vessel of less height in proportion to its diameter than the movable vessels hitherto constructed, while the back part of it is curved outward, so as to contain the metal when it is turned up and prevent too great a pressure over the orifices of those tuyeres which are situated at or near the back part of the vessel.

The form and construction of this modification of the converting-vessel is represented on Sheet A of the drawings hereunto annexed, where Fig. 2 is an elevation; Fig. 3 a vertical section on the line A B of Fig. 4, and Fig. 4 a horizontal cross-section on the line C D of Fig. 3. The position into which the vessel is turned when receiving its charge of melted iron is also shown at Fig. 5 on the same sheet. This form of converting-vessel is, by preference, constructed of plate-iron having a trunnion-band, *f*, passing around its largest circumference and secured by rivets or bolts to the vessel. It has also one solid trunnion and one hollow trunnion for the passage of the blast, as in other converting-vessels now in use.

The upper portion of the vessel *g* is bolted to the trunnion-band, and may be removed when the vessel requires relining; but the lower part, *g**, of the vessel is riveted or otherwise firmly secured to the trunnion-band, and has a channel, *h*, extending around it. This channel is provided with a number of openings both on its internal and external circumference. It is through these openings that the tuyeres *i* are inserted. The outer openings are secured by plates *k*, screwed on over them, the lining of the vessel and the setting of the tuyeres being effected in a similar manner to those now in use. A pipe, *m*, from the hollow trunnion will allow the air to pass down on the outside of the vessel and enter the hollow annular channel *h* and supply the tuyeres, which may have one or any other number of holes in them, as at present practiced. I have before shown how two charges of metal simultaneously converted may be poured into one casting-ladle.

It will be obvious that the converting-vessel may, if desired, be fixed instead of being movable, as I have described it, and still be provided with the line of tuyeres mentioned.

The extra weight of metal to be dealt with in such cases renders some modification of the casting crane and ladle desirable; and, in order that the general construction and mode of operating with this improved form of crane may be fully understood, I have shown the same in elevation on Sheet B and in plan on Sheet C of the drawings hereunto annexed. Most of this apparatus works in the manner set forth in my Letters Patent No. ; but for convenience I will here repeat a part of the description of it therein contained.

The great weight of the double charge of metal is also thrown on one arm of the hydraulic crane. I prefer to neutralize by placing on the other arm of the crane a counterbalance-weight, movable on four flanged wheels, which run on the side cheeks of the crane-arm, the wheels receiving motion by means of a handle and worm-wheel, the latter being fixed on the axle 40 of one of the pairs of wheels 41 and 42, whereby the weight 43 may be moved so as to balance the varying quantity of metal contained in the ladle. The head of the crane, which carries the ladle 44 and counter-weight 43, is suspended on a ball-joint formed on the top of the ram 46, to which ram a spur-wheel, 47, is keyed. A pinion, 48, gearing in this wheel also carries on its axis a beveled wheel, 50, through which motion is communicated from a horizontal shaft, 51, which passes through bearings in the side cheeks, 52, of the crane-

arm, and is provided with handles on each end, by turning which a slow and steady motion of the head of the crane takes place. The casting-ladle 44 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 52 of the crane. The motion of the ladle on its trunnions is effected by a worm and wheel, 54, to which motion is communicated by a shaft and handles. This shaft 55 works in bearings formed in the crane-arm, and a pair of beveled wheels, 56, serve to communicate its motion to the worm which moves the ladle. The valve or stopper used for running out the fluid metal is placed on the side of the ladle farthest from the center of the crane, as seen at 57. The desired motion upward and downward of the crane is effected by the admission or discharge of water under pressure to the cylinder 58, by which means the ram or plunger which supports the head of the crane is put in motion and the height of the ladle adjusted to suit the height of the molds. The motion of the ladle on its axis 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. The cylinder in which the ram of the crane works I prefer to make in two parts, the lower one being cast with a closed bottom and the upper one open at both ends, and having ribs projecting inward which fit close to the ram, the spaces between these ribs giving ingress and egress to the water by which the ram is put in motion, and thus enabling the water-pipe to be connected to its upper end.

In some cases I form on the exterior of the casting-ladle, and near to or below the bottom of it, a small chamber, bowl, or receptacle lined with loam, and also provided with a valve or stopper with a suitable handle for working the same. This valve is fitted to an orifice or nozzle formed in the lowest part of the receptacle, and is for the purpose of regulating the supply of metal to the molds, the molten metal in the ladle being supplied to this receptacle by a valve or stopper similar to those now in use, so that the receptacle may be kept full up to a certain level during the casting operation, the use of this receptacle being to lessen the pressure of the fluid over the escape-orifice into the mold, and by that means cause the column of fluid to enter the mold with a velocity lessened in proportion, as the head of the metal in the receptacle is less in perpendicular height than the head of metal in the casting-ladle. A vertical section of this form of casting-ladle is shown at Fig. 6 and in plan at Fig. 7, Sheet A, of the drawings annexed.

The whole of the vessel may be constructed of plate-iron, and be lined with loam or other suitable slow conductor of heat, the orifices through which the metal flows being by preference formed in small pieces of well-burned fire-clay, retained in their places by the loam or other lining.

The valve-rod V may be made of iron, and defended with a coating of loam, as practiced with the valve rods generally employed in such casting-ladles.

The different hydraulic apparatus employed in the process of manufacturing malleable iron and steel may be efficiently worked in any well-known manner.

In order that the movement of the converting-vessels and crane may be under perfect control and that the workman who directs the process may readily effect all such movements of the apparatus without loss of time, it is preferable that the several valves by which these movement are effected, as well as the air-valves, should be arranged near to each other and in such a position that the workman may observe from that place the operations that are going on; and in order that the arrangement of these valves may be fully understood I have shown the same in elevation at Fig. 4, in plan at Fig. 5, and in end elevation at Fig. 6 on Sheet D of the drawings annexed, where Fig. 7 is also a plan of the index-plate of the valves and Figs. 8, 9, and 10 details on a larger scale. It is desirable to place these valves near to each other, and for this purpose I form a long, rectangular trunk or box, A, into the central compartment of which the air from the blast-engine is conducted by a pipe, B. On the upper side of the box I fix a pair of double-beat balance-valves, C, with suitable lever-handles D passing through slots E in the table F, before which the workman places himself. These valves admit air in such quantities as are found desirable to each of the vessels. A pressure-gage may be fitted on the table, showing the pressure of the air and indicating to the workman the effect he is producing by each movement of the air-valves on each side of the trunk or box A. The passages G and H are formed, one to receive water under pressure from the force-pumps by the pipe G* and the second one to receive the waste or back water and return it by the pipe H* to the cistern that supplies the pumps. Mounted over these passages and communicating with them are a pair of four-way cocks, I and J, which are turned by spur-gearing K. Two vertical shafts, L, rising above the table F, are provided with small fly-wheels M M and handles, so as to allow the workman to operate readily on the cocks whenever any movement of the vessel on its axis is to be made. A three-way cock, N, is similarly mounted with spur-gearing O and handles, P, for the purpose of controlling the motions of the hydraulic crane and enabling the workman to raise the large ladle with facility above the level of the molds, into which the fluid malleable iron, or steel is to be passed. In operating with these valves the workman stands on the plate Q, which is raised a few feet above the general floor-level of the building, the table F being at a convenient height,

so as to enable him to have full control over the several handles before him.

The lever-handles D are made with an angular projection at their lower ends, which enter slots formed in the spindles of the balance-valves C. This lever-handle is shown more clearly at Fig. 8. The vertical section, Fig. 10, and cross-section, Fig. 9, show the internal form of the valve-box C and the manner in which the valves R balance each other, and thus admit of their easy movements by the lever-handle. Two small cocks, S S, are also mounted on the trunk A, and are made to communicate with the pressure and escape passages G and H. These cocks have a square formed on their keys, in order to move them when required. They are made to communicate with the small hydraulic cylinders employed to raise and lower the upper part of the converting-vessel when a new lining is required.

The blast-pipe T and water-pipes V communicating with the several cocks are carried underground to the different apparatus for which they are required, and thus allow one workman to have the movements of the vessels and crane as well as the supply of air under his control.

Having described the manner in which the several parts of my invention may be carried into practical operation, I desire it to be understood that I do not confine myself to the precise details hereinbefore described; but

What I claim, and desire to secure by Letters Patent, is—

1. In the manufacture of malleable iron and steel when forcing currents of atmospheric air through the fluid metal, the combined arrangement, substantially as herein described, whereby the steam employed for forcing such air is generated by means of the heat escaping from the reverberatory furnaces that are employed in melting the iron to be so converted.

2. The opening and closing of the passage conducting air into a converting-vessel by means of the rotary motion of such vessel acting through suitable mechanism on a valve situated in said air-passages.

3. In combination with a converting-vessel, several separate tuyere-boxes constructed and operating substantially as described.

4. The combination, with a converting-vessel, of tuyere-boxes with separate compartments, constructed and operating substantially as described.

5. Employing a pair of converting-vessels placed in such a position with reference to each other that the flame and splashes emitted therefrom shall be projected in opposite directions, substantially as and for the purposes described.

6. Employing a pair of converting-vessels, so movable upon their own axes as to be capable of being placed in such relation to each other that the flame and splashes emitted therefrom shall be projected in opposite directions, and as to be also capable of being placed, when desired, in such positions as to discharge their contents into the same ladle.

7. Combining with two or more converting-vessels a ladle so arranged and operated, either by means of a crane or in any other convenient manner, that the contents of said vessel may be discharged into it and at the same time so that the ladle shall be capable of swinging or turning on its point or points of suspension while being moved, substantially as described.

8. Combining a converting-vessel with a chimney constructed with an open space beneath it, substantially as described, for the purpose of giving access to such converting-vessel.

9. A converting-vessel provided with a line of tuyeres placed through the sides of the vessel, substantially as and for the purposes set forth.

10. The employment of ladles formed with a second chamber or receptacle attached thereto for regulating the supply of metal to the molds, substantially as described.

11. Combining the valves and cocks by which the apparatus is set in operation, so that the workman may conveniently move them from a given place, substantially in the manner described.

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