Sheet 1, 5 Sheets.

H. Bessemer.

Making Bessemer Steel.

No. 51,399. Patented Dec. 5, 1865.

Fig. 3.

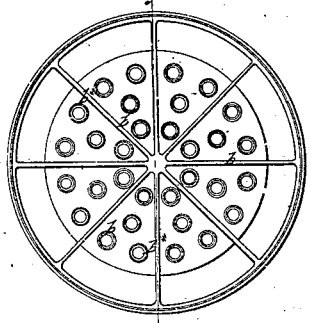


Fig. 1.

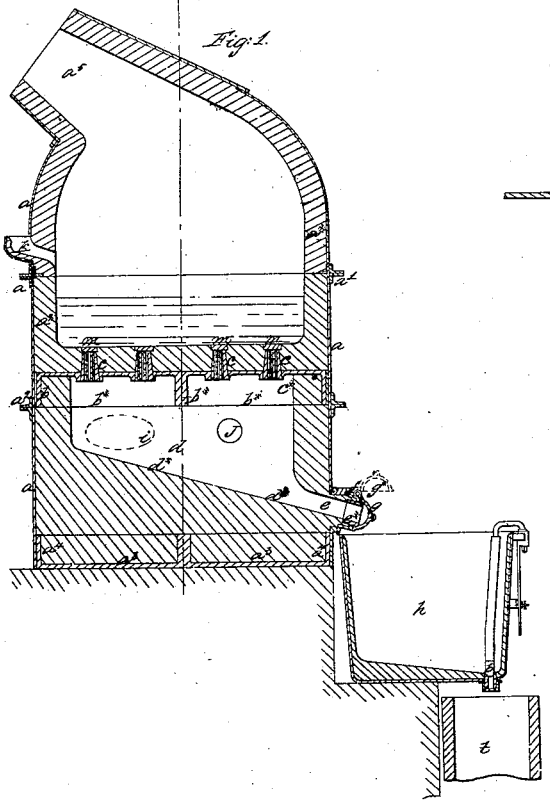
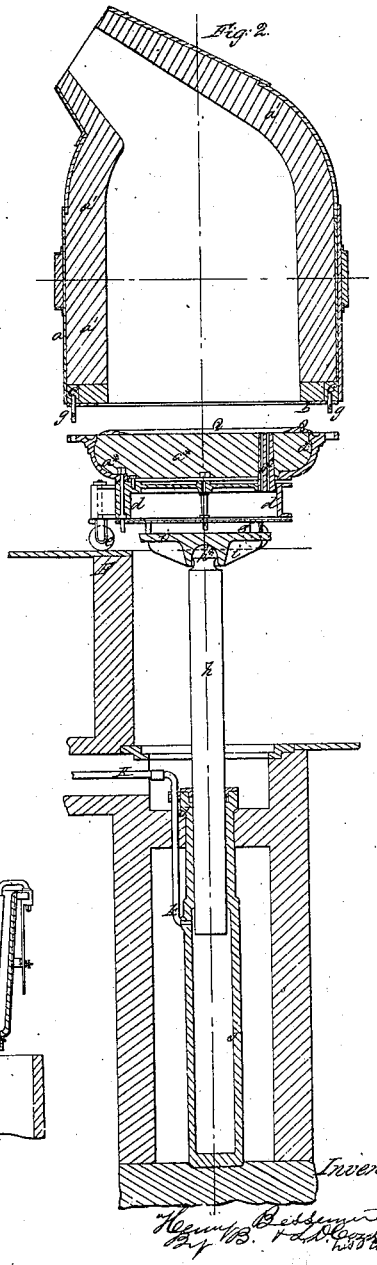


Fig. 2.



Inventor.

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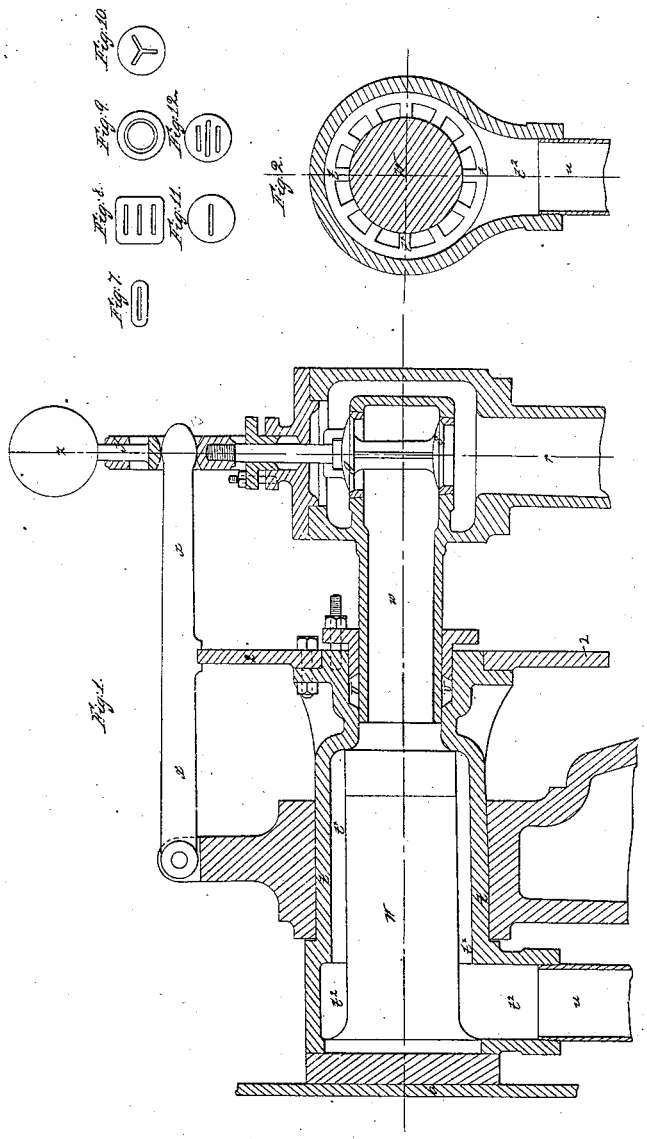
By his Attys.
[illegible]

H. Bessemer.

Making Bessemer Steel.

No. 51,399. Patented Dec. 5, 1865.



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Sheet 3, 5 Sheets.

H. Bessemer.

Making Bessemer Steel.

No. 51,399. Patented Dec. 5, 1865.

Fig: 2.

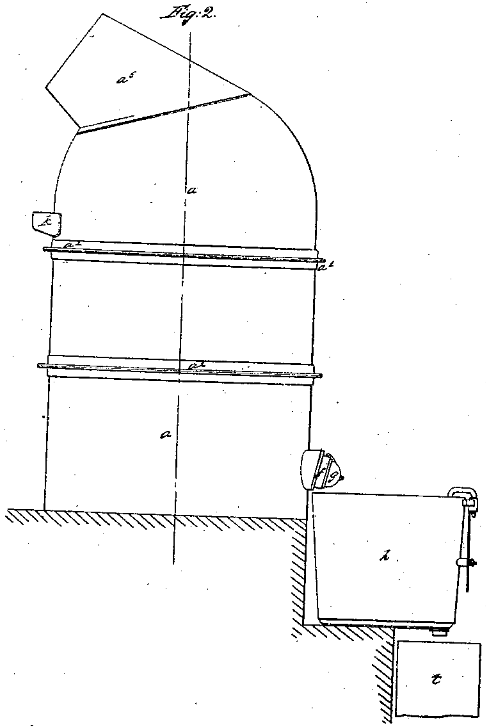


Fig: 6.

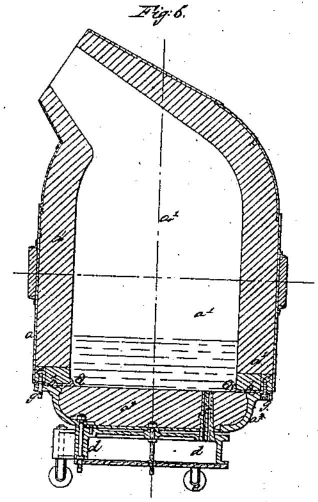
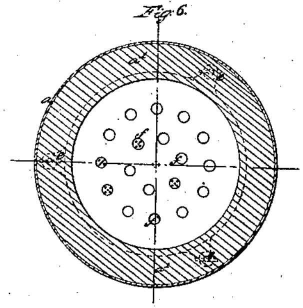


Fig: 6.



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Sheet 4. 5 Sheets.

H. Bessemer.

Making Bessemer Steel.

No. 51,394 Patented Dec. 5, 1865.

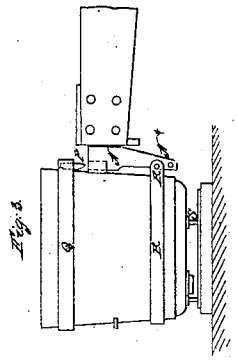

Fig. 2.

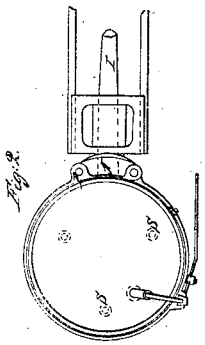

Fig. 3.

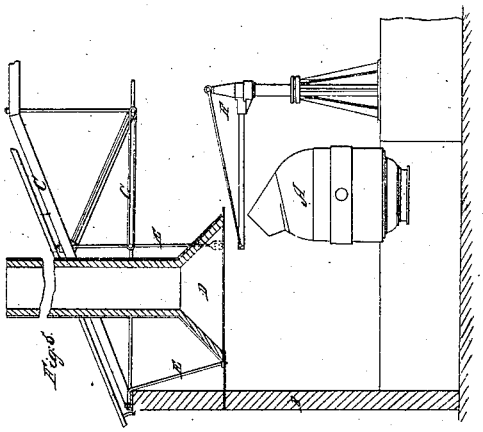

Fig. 5.

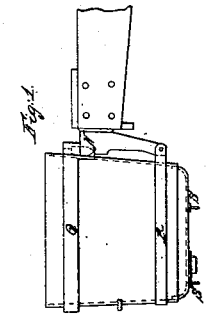

Fig. 1.

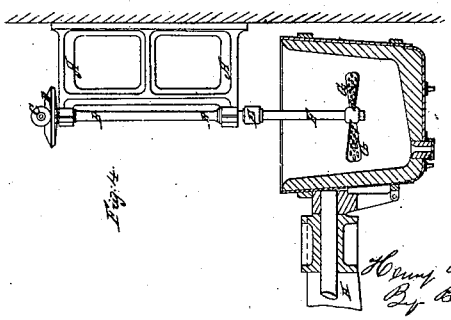

Fig. 4.

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Sheet 5, 5 Sheets.

H. Bessemer.

Making Bessemer Steel.

No. 51,399. Patented Dec. 5, 1865.

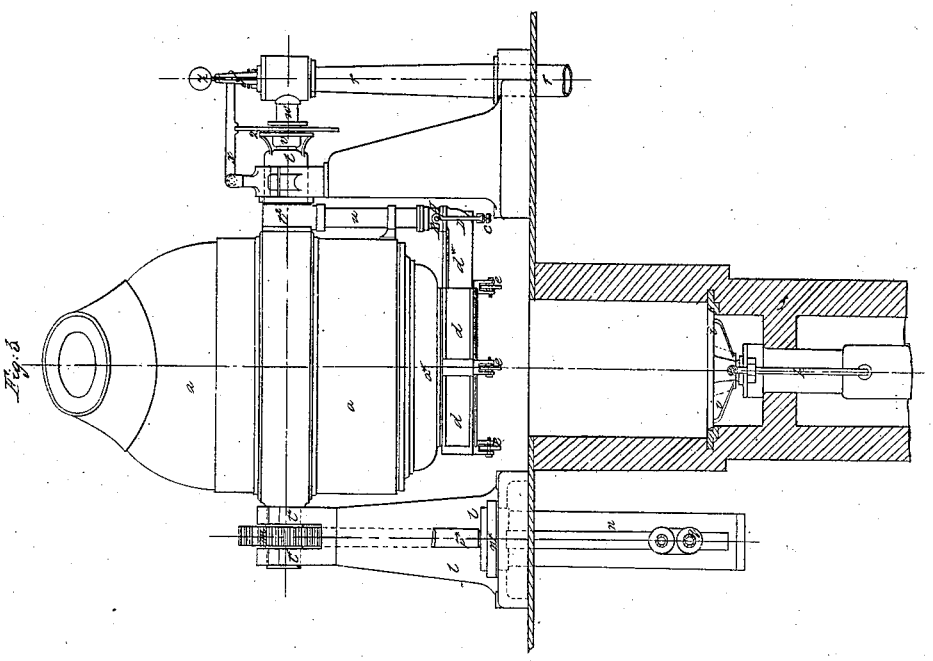

Fig. 3.

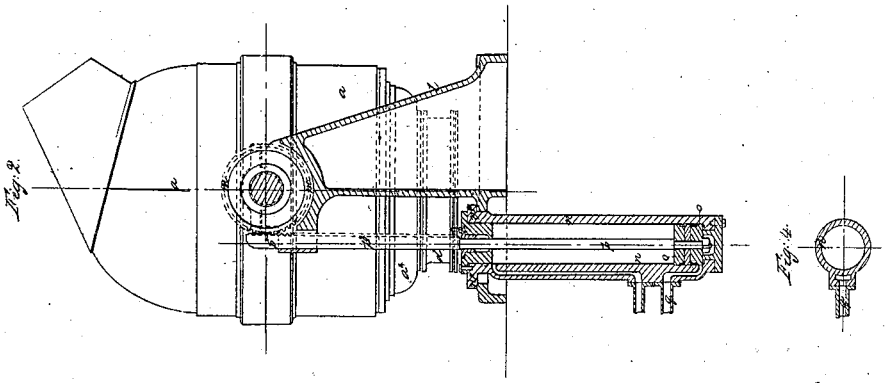

Fig. 2.

Fig. 4.

Witnesses:

Henry Bessemer,
By Baldwin Coggeshall
his Attys

UNITED STATES PATENT OFFICE.

HENRY BESSEMER, OF LONDON, ENGLAND.

IMPROVEMENT IN THE MANUFACTURE OF MALLEABLE IRON AND STEEL.

Specification forming part of Letters Patent No. **51,399**, 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 a certain new and useful Improvement in the Manufacture of Malleable Iron and Steel, and in Machinery and Apparatus Employed in such Manufacture; 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 invention refers to the manufacture of malleable iron and steel by forcing currents of air into molten crude iron, as patented by me November 11, 1856; and it consists in improvements in the structure, movement, arrangement, and situation and repairs of converting-vessels, and in the method and means of supplying air thereto; also, in the ladles and other apparatus, and in the methods employed for weighing and retaining the heat of and mixing converted and unconverted metals.

To enable this 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, to 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 nature and operation of the same.

In the manufacture of malleable iron and steel direct from fluid crude iron, or from remelted pig or refined iron, great facilities are obtained by giving axial motion to the converting-vessel, whereby the tuyeres may be made to assume such a position that the whole of the metal may be run into the vessel before the blast of air is turned on. The process can also be arrested at the desired moment by a like change of position of the vessel and tuyeres, so that the blowing need not continue during the discharge of the converted metal; but when single masses of cast malleable iron or steel are required of a weight varying from twenty to forty tons, more or less, the movable converting-vessel, with its necessary appliances, becomes a very costly apparatus, and from its great weight is somewhat difficult to manage. I therefore prefer to use for very large charges of metal a fixed vessel constructed in the manner represented in vertical section at Figure 1, Sheet A, and in elevation at Fig. 2 on Sheet B, of the drawings hereunto annexed, Fig. 3, Sheet A, being a plan of the underside of the partition *b*, shown in Fig. 1.

The converting-vessel *a* consists of an upright cylindrical vessel, made of strong plate-iron and lined with "ganister," or fire-brick, or other refractory material, as shown at a^*. It is divided into three parts, attached together by flanges and bolts, as shown at a' and a^2. The converting-chamber *a* has a flat cast-iron partition, *b*, having strong ribs b^* formed on its under side, and is provided with numerous conical openings, as shown at c^*, Fig. 3, into which the fire-clay tuyeres *c* are fitted, the converting-chamber consisting of a vertical cylinder, lined in the usual manner, and having a flat bottom or partition and a domed top, terminating in an inclined opening, a^5, similar to the tops of the movable converting-vessels now in use.

Below the converting-chamber I form a shallow chamber or receiver, *d*, with an inclined bottom, d^*, terminating in a spout, *e*. This receiver, being also lined with brick, loam, or ganister, is covered over by the flat partition *b* of the converting-vessel shown at Fig. 3, and which consists of an iron frame having numerous conical holes, into which the tuyeres are fitted. The bottom a^3 of the receiver is provided with a flange, a^4, by means of which it is secured to the iron plates of which the cylindrical part of the vessel *a* is formed.

The space within and above the flange a^4 is filled with ganister, with its surface inclined at an angle downward toward the spout *e*. The mouth of this spout is formed with a molded and baked piece of fire-clay, e^*, through which the molten metal flows, and is thereby prevented from coming in contact with the iron tubular projection *f*, formed on the side of the vessel. A cap of metal, *g*, is hinged to the upper part of the tubular piece *f*, and has its face accurately fitted to the surface of the piece *f*, so as to form, when pressed down by a suitable lever, a nearly air-tight joint, the cap *g* being arranged on a joint, so as to be suddenly lifted up into the position shown by dots at g^*, and thus allow the metal to flow from the receiver *d* into the ladle *h* whenever the blowing operation ceases. The receiver *d* is lined with bricks or loam, and is provided with a manhole at *i*, by means of which access may be had for the purpose of putting in new tuyeres when necessary.

On the top of each tuyere a flat circular cap or disk of fire-clay, *m*, is placed, and the spaces left between the tuyeres are then filled up with ground ganister level with the top of the tuyere-caps *m*, so that the interior of the converting-vessel presents no appearance of tuyere-holes. The orifice of the main blast-pipe communicates with the receiver or chamber *d*, as shown at *j*, the spout *e*, before described, being closed during the blowing operation.

Before the air is turned on the whole of the charge of fluid iron may be run in through a suitable opening made in the side of the vessel for that purpose, as shown at *k*. The hole is then stopped with loam, and the valve on the blast-pipe being opened, the air will fill the receiver *d*, and, pressing on the under side of the tuyere-caps *m*, will immediately displace them and pass upward through the metal, and thus clearly define the time of commencing the process, which may be as suddenly arrested by the simultaneous shutting of a suitable valve on the air-pipe *j* and the opening of the orifice or spout *e* of the receiver. The metal, being no longer supported by the pressure of air, will rapidly descend through the numerous tuyere-holes into the receiver *d*, and, passing through the inclined spout, may be received in a large fixed or movable ladle, *h*, provided with a valve or plug in the usual way, as shown at *p*.

Before running the converted metal into the mold *t* it may be recarbonized by the addition of a carburet of iron, or it may be alloyed or stirred or otherwise treated, as may be desired.

The tuyeres may, if preferred, be inserted through the sides of the vessel, instead of through the bottom of it, and thus blow in horizontally, or nearly so, in which case the tyuere should have a bent passage formed in it, so that on ceasing to blow the metal may find its level by running up the tuyeres without doing further injury to the apparatus, the metal in such case being tapped out through a suitable opening at the lowest level of the vessel, the orifices of the horizontal or inclined tuyeres before named being protected from the metal running into them by a disk or cap, as before described.

The recarbonization or alloying of the converted metal may take place in the converting-vessel or in the ladle.

It will be obvious that converting-vessels constructed as hereinbefore described may be employed in the conversion of small charges of crude molten iron into steel or into malleable iron, although such vessels are specially adapted for the conversion of very large charges of metal. Although I have described such vessels as fixed vessels, in order to distinguish them from vessels having axial motion, I nevertheless desire it to be understood that such vessels may be made movable on wheels, so as to be readily removed to or from the casting-pit; or the upper part of such vessels may be removed by a crane, the vessel being divided at a level somewhat above the level of the charge of metal, or divided on a level with the upper ends of the tuyeres. The upper portion of the vessel may thus be removed to facilitate the repair of the tuyeres; or it may, after the conversion of a charge of metal, be at once placed over another set of tuyeres and the process of conversion be repeated. It is obvious that this method of covering the orifices of the tuyeres may be employed, when desired, in vessels having axial motion.

The second part of my invention relates to improvements in the mode of changing and repairing the tuyeres employed in converting-vessels. In the drawings I have shown this mode of changing and repairing tuyeres in vessels having axial motion; but it is obvious that it is applicable to converting-vessels which do not have axial motion.

In order that this portion of my said invention may be fully understood, I have hereunto annexed a sheet of drawings (marked B) whereon the said apparatus is in part represented.

Fig. 2, Sheet A, is a vertical section of the converting-vessel and of the hydraulic apparatus employed for lowering the bottom of the converting-vessel when the tuyeres require to be changed. This figure shows the tuyere-box and bottom of the vessel removed. Fig. 2, Sheet C, is a vertical section taken through the hydraulic apparatus employed to give axial motion to the vessel, the latter being shown in elevation. This figure also shows in section the standard or support on which the axis of the vessel rests. Fig. 3, Sheet C, is a front elevation of the converting-vessel and both of the standards or supports on which it rests; and Fig. 4, Sheet C, is a horizontal cross-section through the hydraulic cylinder shown in Figs. 2, Sheet A, and 2, Sheet C. This converting-vessel is also shown in vertical section at Fig. 5, Sheet B, with the bottom of the vessel and tuyere-box fastened thereto. A sectional plan of the converting-vessel is also shown at Fig. 6, Sheet B, and at Fig. 1 on Sheet D I have also shown, on a larger scale, a vertical section through the axis and air-valves, and at Fig. 2 on the same sheet a cross-section through the axis of the vessel.

The same letters are employed on Sheets A, B, C, and D to denote a repetition of the parts in the several figures in which this apparatus is shown.

In carrying this part of my invention into practical operation, I make the converting-vessel *a* with a movable bottom, *a**, the lining of the vessel *a'* being supported during the removal of the bottom by a ring of iron or steel, *b*, bolted to a stout hoop, *c*, riveted around the lower part of the vessel *a*. The tuyere-box *d* is bolted to the movable bottom *a**, and is provided with three wheels, *e*, by which it is wheeled away in conjunction with the bottom of the vessel, and is replaced by another bottom of precisely similar construction whenever the tuyeres require to be repaired. Several tuyeres are employed, one of which is shown in vertical section at *f* in Fig. 2, Sheet A.

When making vessels according to my present invention several movable bottoms are pro-

vided, and tuyeres are set in them while they are away from the vessel; and I employ a proper stove or oven for drying the mass of ganister in which the tuyeres are embedded, and which forms the bottom lining of the vessel, and also for imparting to the movable bottom and tuyeres the requisite amount of heat preparatory to commencing the converting process. The movable bottom and tuyeres thus prepared may be employed for the conversion of a charge of metal as soon as they are fastened to the under side of the vessel by means of the cotters and bolts *g* provided for that purpose, and thus a succession of charges of metal may rapidly follow after each other without the delay heretofore occasioned by setting a fresh set of tuyeres with wet ganister in the vessel, and consequently without the employment of the fuel in the vessel now used to dry them and heat them before they are used.

A hydraulic ram, *h*, placed below the center of the vessel, is employed to lower and raise the bottom of the vessel and tuyere-box whenever it requires to be changed. The ram or plunger *h* is formed into a hemisphere at its upper end at *h**, which fits into a socket formed on the under side of the strong ribbed plate *i*. The lower end of the ram is fitted into a hydraulic cylinder, *j*, the joint being formed by a leather ring or cup in the usual way. A pipe, *k*, conveys water into the cylinder, by which means the movement of the ram is controlled.

The large opening formed by the removal of the bottom of the vessel will allow the lining (when too much worn) to be removed through it without the necessity of taking off the upper part of the vessel, as heretofore practiced. No upper joint in the vessel is therefore made.

A sound joint is made at the junction of the movable bottom with the vessel by a little lute, as shown at Q, Fig. 2, Sheet A. It may be formed of fire-clay and ganister or other suitable fire-resisting plastic material. This lute is laid in a circle around the group of tuyeres, and at such a distance beyond them that it will be pressed between the under side of the lining of the vessel and the upper surface of the movable bottom. This lute is firmly compressed by the hydraulic ram before referred to, after which the cotters are driven home. The lute employed is so small in quantity as to be rapidly dried on its surface when exposed to the heated interior of the vessel.

It will be observed that in this form of converting-vessel the tuyeres may be spread over the entire area of the bottom of the vessel, at small distances apart from each other, as shown at *f*, Fig. 6, Sheet B, and thus distribute the blast more perfectly throughout the metal.

In order that free access may be had to the vessel, I prefer to suspend from the roof or walls by suitable framing a large open-mouthed iron pipe lined with fire-brick or loam, in lieu of the brick chimney heretofore used to convey the heated vapors and flame issuing from the vessel. One method of suspending a chimney is shown on Fig. 5, Sheet E, of the accompanying drawings, where A is the converting-vessel, B a wall of the building, C the roof, and D the chimney, suspended by the rods E E; or the chimney may rest on one or more girders running from wall to wall, in which case the chimney may be wholly of brick. Another advantage due to omitting the bottom part of the ordinary chimney is that a crane, F, Fig. 5, Sheet E, can swing entirely around over the converting-vessel and under the chimney.

The motion of the vessel on its axis I prefer to effect by means of a hydraulic cylinder and piston acting vertically direct upon a spur-wheel on the axis of the vessel, (in lieu of the horizontal hydraulic apparatus heretofore employed,) such piston being actuated by water under pressure in a manner well understood.

In carrying into practice this part of my said invention, I construct a support for the vessel of a hollow pyramidal form, as shown at *l*. The upper part projects forward, and is formed into a double plumber-block, *l* l**, which supports the axis of the vessel, on which a spur-wheel, *m*, is keyed. The support *l* also projects forward at foot and supports the upper flange, *n**, of the hydraulic cylinder *n*. In this cylinder is fitted a piston, *o*, having a double set of leathers, so as to form a water-tight joint in both directions. The piston-rod *p* is formed into a rack at *p**, gearing into the wheel *m*, so that when water under sufficient pressure is admitted by the pipe *q* beneath the piston the movement of it upward will lower the mouth of the converting-vessel, while a reversal of the valves will allow the water to escape from beneath the piston and admit the water under pressure above the piston, and produce a motion of the vessel in an opposite direction. The other axis of the vessel is also supported on a hollow pyramidal casting, the upper part being formed into a plumber-block, and the foot of the casting forming a support for the pipe *r* and equilibrium-valve *s*, (shown on a larger scale in section at Fig. 1, Sheet D.)

Instead of forming the axis W of the vessel hollow, for the air to pass through in the ordinary manner, I prefer to fit upon the axis a tube, *t*, having ribs *t** formed along the inside thereof, which fit tightly against the axis of the vessel, while the spaces between these ribs form channels, along which the air passes to a chamber, t^2, into which the pipe *u* is fitted. The exterior of the tube *t* is fitted to the plumber-block, and is provided with a stuffing-box at *v*, so as to keep an air-tight joint with the pipe *w*, which communicates direct with the equilibrium-valve. On the flange of the stuffing-box *v* a disk or cam, 2, is fitted, which moves round with the axis of the vessel, and by the inclines formed on its periphery it moves up and down the lever *x*, and thus raises or lowers the valve *s* at the proper time. One end of the lever *x* is jointed to the top of the plumber-block cap and the other end passes through a slot in the valve-rod, which is guided by the

arched casting *y*. The valve is retained in its seat by the ball *z*, which is secured to the top valve-rod.

In order to facilitate the removal of the tuyere-box when required, the pipe *u*, Fig. 3, Sheet C, is provided with a sliding piece, A, having a stuffing-box formed at its upper edge and a stud, B, formed at each side. The tuyere-box *d* has a projecting pipe, *d**, formed on it on one side, its end terminating in an elbow, the upper surface of which is truly faced and made to fit against the lower edge of the sliding piece A, so that whenever the tuyere-box has to be removed it is only necessary to loosen the screw C and remove the bridle-piece D from the studs B, and the joint is undone. The joint is better kept if a ring of india-rubber be placed between the surfaces.

It will be observed that in the arrangement of apparatus here shown the converting-vessel is placed high enough to admit of the removal of the bottom of the vessel on the floor-level of the building. When lowering the bottom of the vessel the wheels *e* will rest on the floor, as shown at F, Fig. 2, Sheet A.

When a charge of metal has been converted into malleable iron or steel by the forcing of atmospheric air below its surface, an addition thereto of molten pig-iron in small quantities is generally made when treating iron that has been melted with mineral fuel, a carburet of iron containing silica and manganese in a state of alloy being preferred for that purpose. Now, it is very necessary that this mixture of metals, if made, should be as complete as possible. It is also desirable that the metal, after such addition of carburet of iron has been made, should be exposed as little as possible to the action of atmospheric air until after the mass has become solidified in the molds. In order to effect a thorough mechanical mixture of the converted and unconverted metal, I fix up a vertical-revolving shaft, by means of brackets projecting from the wall of the converting-house, in such a position that the casting-ladle may be brought directly under it. On this shaft I fix cross-arms, paddles, or screw-blades of iron, coated with loam, fire-clay, or other suitable slow conductor of heat, and by engine-power I put the shaft and paddles in motion. This arrangement is shown on Sheet E of the annexed drawings, where Fig. 4 is an elevation of the mixing apparatus, with the casting-ladle beneath it in vertical section.

A frame, A, is bolted to the wall of the building, and serves to support the vertical shaft B, which receives rotatory motion from the beveled wheels C and D.

At E is a socket, into which the axis F of the paddle or agitator G is keyed. This axis and the paddles are roughened or perforated in order the better to retain a coating of loam or fire-clay employed as a means of protecting the apparatus from direct contact with the molten metal.

The ladle is supported at the end of the crane-arm H, and is capable of being raised or lowered when required.

The alloying metal may be put into the casting-ladle before or after or during the pouring in of the converted metal, or the metals may be put together into the converting-vessel before the converted metal is poured out of it. As soon as the whole of the metal is in the ladle the crane is to be moved round until the ladle is beneath the paddle-shaft. The paddles are then put in motion and the ladle raised by the crane-ram. The ladle may be moved gradually up and down, or the paddle-shaft may, if desired, be made to move upward and downward in addition to its rotatory motion, or it may turn first one way round and then the reverse, or a simple reciprocating motion may be given to the paddle or agitator, the object in either case being to agitate and mechanically mix the fluid particles as completely as possible, and thus produce therefrom a homogeneous mass of metal. Other modes of actuating the paddle will readily suggest themselves to mechanics. The surface of the metal under treatment may be covered with charcoal, sand, clay powder, lime, or any other slow conductor of heat that will exclude the atmosphere and assist in retaining the heat of the metal without injuring its quality.

It will be understood that this mode of mechanically agitating and mixing the metal may also be employed in all cases where alloys of any metal are intended to be mixed with malleable iron or steel produced from crude or cast iron by the forcing of atmospheric air into and among the particles of molten iron, whether such alloying metal be added thereto in a molten, granular, or solid state.

When the degree of carburation of converted metal is to be regulated by the addition thereto of a carburet of iron after the converting process has ceased, and also when any definite alloy is to be made with such converted metal and some other metal, it is of great importance that the actual weight of metal to be carbureted or alloyed should be first ascertained, in order that the weight of metal to be added thereto may be determined on. To effect this object with accuracy, and to insure the desired temper or quality of each charge of metal, I support the casting-ladle on a series of levers attached to the casting-crane, such levers being made and worked in a similar manner to those employed in ordinary weighing-machines, and which are well understood. The empty ladle having its counterbalance-weight adjusted, the metal may be run into it from the converting-vessel and the weight taken. The carburet of iron or other alloy may be slowly added until the desired proportion is indicated by the action of the apparatus, when the whole may be agitated and mixed in the manner hereinbefore described; or, in lieu of constructing the crane in such manner as to weigh the fluid metal, I prefer that a suitable weighing-machine may be fixed in the casting-pit in such

a position that the casting-crane may pass over it, the arrangement for holding the ladle onto the crane being such that the ladle of metal may be lowered onto the platform of the said weighing-machine and again lifted up with as little delay as possible.

And in order that the arrangement which I prefer of detaching the casting-ladle from the crane and placing it on the weighing-machine may be fully understood, I have shown the casting-ladle in elevation at Fig. 1 and in plan at Fig. 2, and also in elevation, detached from the crane and resting on the weighing-machine, in Fig. 3, Sheet E of the annexed drawings. The axis I of the ladle has keyed upon it a T-piece, N, the upper part of which receives two conical-ended pins, P P. These pins are fixed firmly into the hoop Q, which embraces the upper part of the ladle. A similar hoop, R, passes round the lower part of the ladle, and is provided with lugs R*, between which the lower limb, N*, of the T-piece is fitted. A hole is made through these lugs, in order to secure the ladle in place while turning the ladle round on its axis. When the crane-arm is turned round so as to bring the ladle over the weighing-machine the crane is to be lowered until the ladle is made to rest its three feet S S S onto the table Z of the weighing-machine. The further movement downward of the crane-arm will withdraw the pins P P from the T-piece, and thus allow the ladle to rest its entire weight freely on the weighing-machine. The upward movement of the crane-arm will reattach the ladle as before.

And, further, I desire it to be understood that although the tuyeres hereinbefore mentioned may be made of the ordinary form—that is, a truncated cone with a group of circular holes passing longitudinally through them—such tuyeres may have a long narrow slit or a series of narrow longitudinal openings made therein, in lieu of round holes, for the purpose of more perfectly distributing the air throughout the metal; or the orifice of the tuyeres may consist of a narrow annular opening formed by the insertion of a plug or central piece into a cylindrical opening of somewhat larger diameter made in the tuyere or passage conducting air into the metal. The shape of the tuyere-orifices and the position they bear with reference to each other will be fully understood by reference to Figs. 7, 8, 9, 10, 11, and 12 on Sheet D, each figure representing that end of the tuyere from which the air passes into the metal.

Having described the several parts of my invention and the manner in which the same may be carried into practical operation, I desire it to be understood that I do not confine myself to the precise details herein given, provided the essential parts of my said improvements be retained; but

What I claim in the manufacture of malleable iron and steel is—

1. The employment of a converting-vessel having a receiver formed beneath it, into which the air is forced before entering the tuyeres, and into which the converted metal is received when the forcing in of the air ceases.

2. Covering orifices of tuyeres in converting-vessels so as to prevent the access of metal or other matters thereto until the blast of air is applied beneath such covering.

3. Making the joint between the upper and lower divisions of a converting-vessel above the level of the charge of fluid metal, substantially as shown.

4. Constructing the converting-vessel in such a manner that the contained fluid metal, when not supported by the pressure of the air, may descend through the tuyere-holes, when such vessel is provided with any suitable means for conducting the metal into a ladle or mold.

5. Mounting converting-vessels on wheels, so that they may be movable to or from the casting-pit, substantially as described.

6. Employing the upper part of one converting-vessel over the lower part of another converting-vessel, so as to hasten or facilitate a repetition of the converting process, substantially as set forth.

7. The employment in converting-vessels of a movable bottom, to which the tuyere-box is attached.

8. Providing several movable bottoms containing tuyeres and capable of being attached to a converting-vessel, substantially as and for the purposes described.

9. Setting tuyeres in a detached portion of a converting-vessel, substantially as and for the purposes described.

10. Drying or baking the detached portion of a converting-vessel, together with the tuyeres therein contained, prior to connecting said portion to the vessel.

11. Heating the movable bottom and the tuyeres therein contained preparatory to commencing the converting process, substantially as and for the purposes set forth.

12. Substituting a funnel or chimney of suitable material suspended from the roof, or secured in such a manner as to afford a free open space around the converting-vessel, in lieu of the chimneys heretofore used opposite to the mouth of each converting-vessel, substantially as and for the purposes described.

13. The combination of a converting-vessel mounted on an axis with a piston and rack placed in a vertical position for giving motion to such converting-vessel, substantially as described.

14. Conveying the blast through a tube surrounding the axis of converting-vessels, in lieu of passing it through the axis, as heretofore practiced, substantially as described.

15. Constructing tuyeres the orifices of which are formed or arranged substantially in the manner represented in Figs. 7, 8, 9, 10, 11, and 12 on Sheet D of the drawings annexed.

16. The employment of a rotary, semi-rotary, or reciprocating paddle or agitator, for the purpose of facilitating the mixing, carbonizing,

or alloying of converted with unconverted metal.

17. Covering the surface of the metal while in the ladle, substantially in the manner described, in order to lessen the escape of heat therefrom.

18. Coating the paddle or agitator with loam or other slow conductor of heat, substantially as and for the purposes described.

19. Connecting the ladle with the crane-arm or other mechanism by which such ladle is supported by any suitable means that will enable the contents of the ladle to be weighed, substantially as and for the purposes described.

20. The mode of attaching the casting-ladle to and detaching it from the crane-arm or lifting apparatus, substantially as described.

HENRY BESSEMER.

Witnesses:
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DAVID LONGSDON.