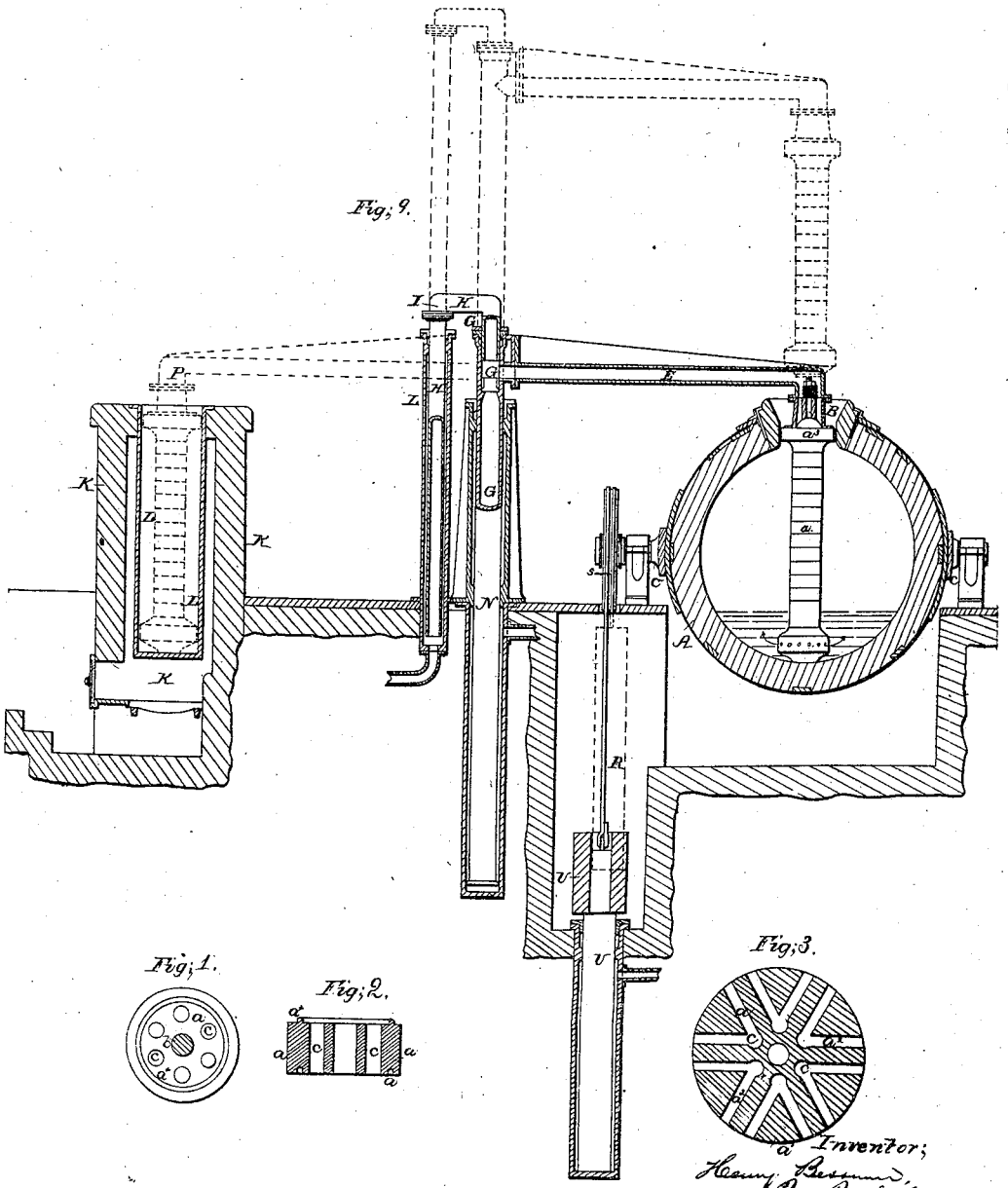
Sheet 1, 2 Sheets.

H. Bessemer.

Making Bessemer Steel.

No. 51,397. Patented Dec. 5, 1865.

Fig; 9.



Fig; 1.

Fig; 2.

Fig; 3.

Inventor;
Henry Bessemer
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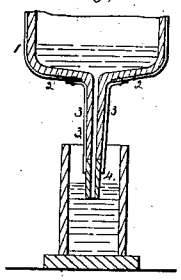
Sheet 2, 2 Sheets.

H. Bessemer.

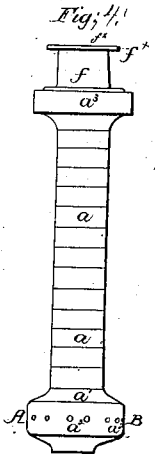
Making Bessemer Steel.

No. 51,397. Patented Dec. 5, 1865.

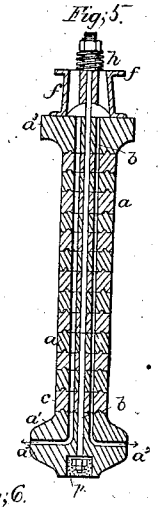
Fig; 11.



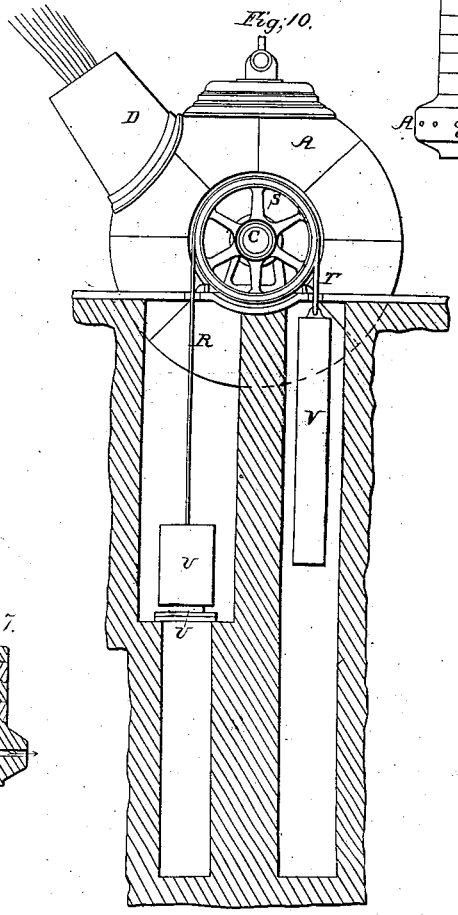
Fig; 4.



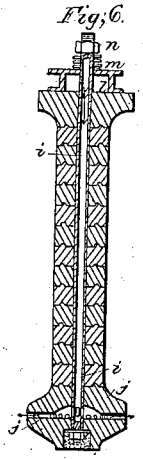
Fig; 5.



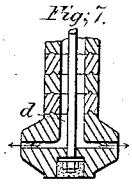
Fig; 10.



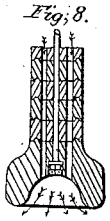
Fig; 6.



Fig; 7.



Fig; 8.



Inventor;
Henry Bessemer,
By B. Hall & Eggs
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. **51,397**, 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 Manufacture of Malleable Iron and Steel, and in the Machinery or 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.

In the manufacture of malleable iron and steel by forcing atmospheric air beneath the surface of molten crude or pig iron it has been found that the powerful heat generated at or near to the orifices of the tuyeres, together with the chemical action of the slags or oxides of iron and silicum, has the effect of enlarging these orifices, and in a short time rendering the tuyeres unfit for further use. The tuyeres when thus worn have to be replaced by new ones. The fitting in of these new tuyeres by the plan at present practiced renders it necessary first to knock out the old ones, and then to cool down the converting-vessel, after which the new tuyeres may be inserted in their places, and the spaces around them filled up with a plastic matter or "grout," which is generally composed of powdered "ganister" mixed with water. After this is done a fire is lighted in the converting-vessel, and the wet parts thereby properly dried, and the interior of the vessel again highly heated before the process of conversion can be repeated, the change of tuyeres thus rendering the apparatus incapable of being used for several hours.

Now, my invention consists, first, in constructing tuyeres independent of the vessel; second, in putting in and removing such tuyeres from the converting-vessel by hydraulic apparatus; third, in the employment and arrangement of retorts or chambers for heating and retaining the heat of said tuyeres.

My improvement further consists in giving a rotary or semi-rotary motion to a converting-vessel by a hydraulic plunger and its counterweight; also, in constructing and using a casting-ladle with an elongated tubular spout made to descend into the ingot-mold.

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

On the sheet of drawings hereto annexed, Figure 1 is a plan, on an enlarged scale, of one of the circular bricks forming the tuyere; Fig. 2, a section through the center of the same; Fig. 3, a cross-section on the line A B of Fig. 4, Fig. 4 being an elevation of the tuyere when built up, and Fig. 5 a vertical section of the same. Fig. 6 is also a vertical section of another modification of the improved tuyere, in which the air-passage is formed by a wrought-iron pipe passing down the center of the tuyere. Figs. 7 and 8 also show the lower portion of two other modifications of my improved tuyere, which consists of a number of rings or disks of fire-clay, Cornish clay, plumbago and fire-clay, "silica clay," silicate of magnesia, or other suitable refractory substance. These rings *a* have a central hole in them, through which a stout steel or iron rod, *b*, passes. There are also several other holes, *c*, made through them at a small distance from the central one, which holes are for the purpose of allowing air to pass through. Each ring or circular brick is put onto the iron rod *b*, and some fire-clay or other "lute" or plastic matter is put between them, so as to make a tight joint.

The surfaces of each disk may be ground flat, or they may be molded with concentric grooves and with corresponding raised rings or ridges alternating, as shown at a^*, Figs. 1 and 2, so as to fit closely and assist in holding each other together. A long column or tuyere is thus to be built up upon the rod, the air-passages in each piece being so placed as to form continuous tubes throughout the whole length of the column or tuyere. At the lower end a larger ring, a', is put on, having other holes, a^2, around its periphery communicating with those before mentioned, the upper part of the column or tuyere being surmounted with a disk, a^3, larger in diameter than the rest of the circular pieces, for the purpose of filling up the orifice in the vessel through which the tuyere is inserted.

The upper end of the iron rod *b*, on which the tuyere is built, passes into a metal cap, *f*, so made as to be readily fixed to and form a close joint with the blast-pipe.

The different pieces constituting the tuyere are pressed together by a powerful spiral spring, *h*, which allows the necessary expansion of the rod and its rings, while they are firmly held together under a regulated pressure.

The lower enlarged ring a', in which the tuyere-

orifices are formed, may be perforated with numerous small holes, or with a less number of holes of a larger size, or, in lieu thereof, the air may be made to escape between flat or grooved disks, as shown in Fig. 7, or from a hollow or bell-shaped cavity formed beneath the center of the tuyere, as shown in Fig. 8; but I prefer to employ circular orifices of one-half inch to three-fourths of an inch in diameter, more or less, as shown at a^2, Figs. 3, 4, and 5.

As a general rule I prefer, in this form of tuyere, to direct the jets of air horizontally or at a slight angle downward; but the openings may be so made as to direct the jets in any other direction, either upward or downward, or at a tangent to the axis of the tuyere, so as to cause a rotation of the metal in the vessel.

In lieu of the several air-passages formed around the iron rod, one large central hole, *d*, may be employed with the rod passing also down it, as shown in Fig. 7, or several rods may pass through separate holes in the rings, instead of one in the center.

In one form or modification of the improved tuyere I employ an iron pipe, *i*, as shown in Fig. 6, in lieu of the solid iron rod. The pipe not only serves to hold the various parts of the tuyere together, but to convey the air to the lower part of it, and thereby render unnecessary the several air-passages before described. The pipe *i* has a plug, *k*, screwed into its lower end. A washer under the head of the plug secures the lower perforated circular brick, J, in its place, and thus holds the several parts of the tuyere together. The air which passes down the pipe *i* passes through slots formed near the bottom of it, and escapes into the metal through radial perforations J′ formed in the lower part, J, of the tuyere. The top end of the pipe *i*, passing through a metal cap, *l*, and spring *m*, is secured by a screwed nut, *n*, and thus the whole may be held together under a pressure equal to the force of the spring *m*.

On reference to Fig. 5, it will also be seen that the central rod, *b*, has its lower end also screwed by a nut and washer, *p*, which are contained in a recess formed in the center of the lower circular brick, *a′*. After screwing on this nut the recess is filled with clay or loam, to prevent the metal from having access to it, this precaution being taken in every modification of these improved tuyeres.

In order to defend the tuyere from the sudden action of the heat thereon, I prefer to "loam up" the outside of it with any suitable plastic matter, such as fire-clay and sand, or what is known as "silica clay," the outside of the tuyere-bricks being scored or roughened to facilitate the adhesion of this coating.

The several rings before mentioned may be made of plastic clay or other material; but I prefer to make them of dry materials by means of powerful pressure in suitable molds, in a manner well understood and practiced in making bricks, tiles, and other articles in dry powdered clay or china-earth, after which they are to be baked or burned.

Having described the nature of my improved tuyeres, I will now proceed to show in what manner they are to be employed in the manufacture of malleable iron and steel. For this purpose I have on the sheet of drawings hereunto annexed shown, at Fig. 9, a vertical section of the converting apparatus and its appliances, and at Fig. 10 an elevation of the converting-vessel and the hydraulic apparatus employed to give motion to it.

I prefer to employ a spherical vessel, A, mounted on axes C, for the conversion of crude iron with my improved tuyeres, and to make, in addition to the usual chimney or outlet D of the vessel, a circular opening, B, on the top of it, through which the tuyere *a* may be lowered down into the fluid metal and be again raised up vertically from it, whenever it may be deemed necessary to do so, the metal cap *f* on the top of the tuyere being attached to the hollow arm or jib E of a hydraulic crane, the ram G of which moves vertically and parallel with the blast-pipe H leading from the blowing-engine, the pipe sliding up and down through a suitable stuffing-box, I, formed on the vertical pipe L*, so that the connection of the blast with the tuyere will not be interrupted by any motion of the tuyere and crane-arm upward or downward, nor by the movement of the crane on its vertical axis. Thus great facility is afforded for the rapid removal and change of the tuyere. It also admits of the raising or lowering into or out of the metal, more or less, at different stages of the process.

On the upper side of the blast-pipe, and in a position vertically over the air-passages of the tuyere, I sometimes fix a small globular vessel provided with two cocks, one communicating with the blast-pipe and the other with the external air. This vessel is for the purpose of holding any fluid, granular, or powdery matter—such as nitrate of soda, fluor-spar, metallic oxides, or any other flux or matter intended to be forced by the blast into the molten metal, either for the purpose of improving or purifying the metal, or for rendering the slags more fusible and easily run off.

Within the range or sweep of the hydraulic crane-arm E, I construct a furnace, K, having several compartments or chambers, each of a size suitable for holding a tuyere, and thus affording a convenient mode of heating up the tuyeres gradually, and retaining their heat until they may be required.

One of these chambers, L, is shown in section in Fig. 9. They may be constructed of fire-bricks, or of simple cylinders of fire-clay, or in lieu thereof cast-iron vessels or retorts may be inserted in a vertical position in the furnace K to receive and heat the tuyeres.

Whenever the apparatus lastly described is to be put in operation a tuyere is attached by the flange *f** of the metal cap *f* to a corresponding flange, which forms the extreme end of the tubular crane-arm E. As soon as it is so fixed water under pressure is allowed to enter the hydraulic cylinder N by a suitable valve, and by

its pressure raise the ram G and the crane-arm E, with the tuyere attached thereto. The arm E is then turned round until the tuyere comes vertically over one of the retorts or chambers L. The ram is then lowered by allowing the water to flow out and the tuyere deposited in the retort, as shown by dots at P. This process may be repeated until the retorts are each filled. A gentle fire is then to be made in the furnace K, and as soon as the tuyeres acquire a red heat they will be fit for use, but may remain there in readiness for any convenient period of time. The interior of the converting-vessel A having been heated by burning fuel in the interior thereof, will also be in readiness for use as soon as the whole of the unconsumed fuel is discharged therefrom by turning the vessel upside down. A charge of molten crude iron having been run into the vessel A, and one of the heated tuyeres having been attached to the crane-arm, the latter is to be raised so as to lift the tuyere from the chamber L. The arm is then to be turned into the position shown by dots at Q and the tuyere lowered vertically through the opening B into vessel A. The air from the blast-engine is conveyed into the lower part of the pipe L*, and passes through the pipe H into the upper part of the ram G, the stuffing-box G* allowing the ram to move freely round the pipe H, so that the tubular arm E may at all times be in connection with the blast L*. Before lowering the tuyere into the molten metal the blast-cock must be opened and the air allowed to pass out of the orifices of the tuyeres, which may then be allowed to descend below the surface of the metal, and thus effect its conversion into steel or malleable iron in a manner now well understood. As soon as the conversion is effected the crane-arm and tuyere are to be again raised into the portion shown by dots at Q. The malleable metal may then be discharged from the vessel by turning it round on its axis by means of a hydraulic apparatus hereinafter described. While the vessel is still in a highly-heated state another charge of crude iron may be run in and the tuyere again caused to descend into the fluid metal, as before. When by this means the tuyere becomes too much worn away to act properly it may be withdrawn and placed down on the floor and another one inserted in its place, and so on continuously so long as the lining of the converting-vessel lasts, thus avoiding the loss of time and the cooling of the vessel caused by the insertion of tuyeres into the body of the lining of the vessel by the running in of wet ganister, in the manner hereinbefore described.

My invention also consists in giving motion to the converting-vessel by means of a hydraulic ram or plunger moving vertically in a cylinder, and placed below the axis of the vessel, the ram or plunger being raised by the pressure of water from any elevated tank or vessel under pressure, and again lowered by allowing the water to escape from beneath it. This motion of the ram is communicated to the axis of the converting-vessel by means of a wire rope, R, attached to the ram U, and passing round and attached to a grooved pulley, S, keyed on the axis of the vessel. A second wire rope, T, suspends a counterbalance-weight, V, on the opposite side of the pulley. This weight may be about equal to one-half of the weight of the ram or plunger, so that whenever the ram is raised the lowering of the counter-weight will cause the vessel to turn round, while the lowering of the ram will raise the counter-weight and turn the vessel in the opposite direction. These movements will be under the control of the workman, who admits or discharges the water from the apparatus by a suitable valve and handle. The converting-vessel may thus at any time be made to discharge its contents or be put into a position suitable for running in a charge of crude metal.

In pouring out the fluid iron or steel from the converting-vessel the spout or opening from which the metal flows is moved (as the pouring proceeds) away from the spot where the pouring first commenced. I therefore find it advantageous to provide the hydraulic casting-crane with a suitable sliding motion, whereby the casting-ladle may be moved horizontally in a straight line farther from the ram or axis of the crane as the pouring proceeds, and thus insure the ladle being at all times beneath the opening from which the metal flows.

When large armor-plates or other large flat masses of malleable iron or steel are required I prefer to cast such masses in shallow ingot-molds, so proportioned that the top surface of the ingot shall form one of the large planes or surfaces of the plate or slab after it is hammered or rolled, and, when desirable, I make such ingots of distinct layers of steel of different qualities, or of steel and malleable iron, by pouring into the mold molten steel or molten malleable iron, one after the other, so that a union of the different qualities of metal may be effected at or near their point of junction, but, nevertheless, so that the different qualities of metal shall for the most part be distinct from each other, forming layers or strata of hard and soft metal.

The action of the air upon the upper exposed surface of the ingot may be lessened or entirely prevented by strewing thereon powdered glass of borax or other readily-fusible flux, silicate, or saline matter.

In making ingots or castings in large shallow molds I find it advantageous to elongate the tubular fire-clay orifice through which the molten metal flows from the casting-ladle, so that the clay tube may dip into the fluid metal in the mold, and thus prevent the flowing stream of metal from taking down air with it into the fluid mass below. This improvement in the casting-ladle, and in the mode of casting ingots, is shown at Fig. 11 on the annexed sheet of drawings. Fig. 11 is a vertical section of the lower part of the casting-ladle, and the mold into which the fluid malleable iron is being run. The iron ladle 1 is lined with

loam, as shown at 2. A conical metal tube, 3, is secured by a flange to the under side of the ladle, a piece of well-baked tube of fire-clay, or of fire-clay and plumbago, 4, is inserted in the lower end of the iron tube 3, so as to project therefrom, as shown. The rest of the tube 3 may be lined with loam, and the upper part of the tube may be formed into a valve-seating, as already practiced in ladles employed for casting steel, so that the fluid metal is admitted to the vertical tube only at such times and in such quantities as may be desired.

When casting with this improved ladle the nozzle 4 should be made red-hot over the fire, and then be lowered nearly to the bottom of the mold 5. The valve may then be raised and the fluid metal be allowed to flow out. It will soon rise above the orifice of the nozzle 4, and thus prevent the air from being taken down into the metal. Air so introduced acts both chemically and mechanically in producing the cellular condition so common in cast-steel. As the metal rises in the mold the ladle should also be steadily raised, so as to keep the nozzle only a small distance below the surface of the fluid metal independently of the bubbles produced in pouring.

Having described my invention, and the manner in which the same may be carried into effect, I desire it to be understood that I do not confine myself to the precise details herein described, so long as the peculiar features of the several parts of my said invention are retained; but

What I do claim is—

1. The arrangement and construction of converting apparatus, substantially as and for the purposes shown.

2. Tuyeres which pass into the fluid metal in a converting-vessel through the upper surface of said metal, in combination with a converting-vessel mounted on axes.

3. The employment, in the conversion of molten crude or refined pig-iron into steel or into malleable iron, of tuyeres built up or constructed as herein described.

4. Introducing one or more tuyeres into the converting-vessel, and removing the same therefrom through suitable openings made in said vessel, in the manner herein described.

5. Heating the tuyeres in a retort or chamber previous to introducing them into a converting-vessel.

6. A tuyere used in a converting-vessel, in combination with any suitable apparatus capable of conveniently varying the speed of the tuyere, or of instantly stopping it when desired.

7. A casting ladle or receptacle for casting malleable iron or steel or other suitable material, provided with a tubular spout adapted to descend into the ingot-mold, substantially as herein described.

8. In the casting of ingots of malleable iron or steel, the immersion below the surface of the fluid metal of the orifice from which the metal flows into the mold.

9. Moving said orifice gradually upward as the level of the metal rises in the mold.

10. A converting-vessel capable of rotary motion upon its own axis, in combination with a rope, or any equivalent means, operated by hydraulic pressure in a cylinder, for the purpose of giving to such vessel a rotary or semi-rotary movement.

HENRY BESSEMER.

Witnesses:

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DAVID LONGSDON.