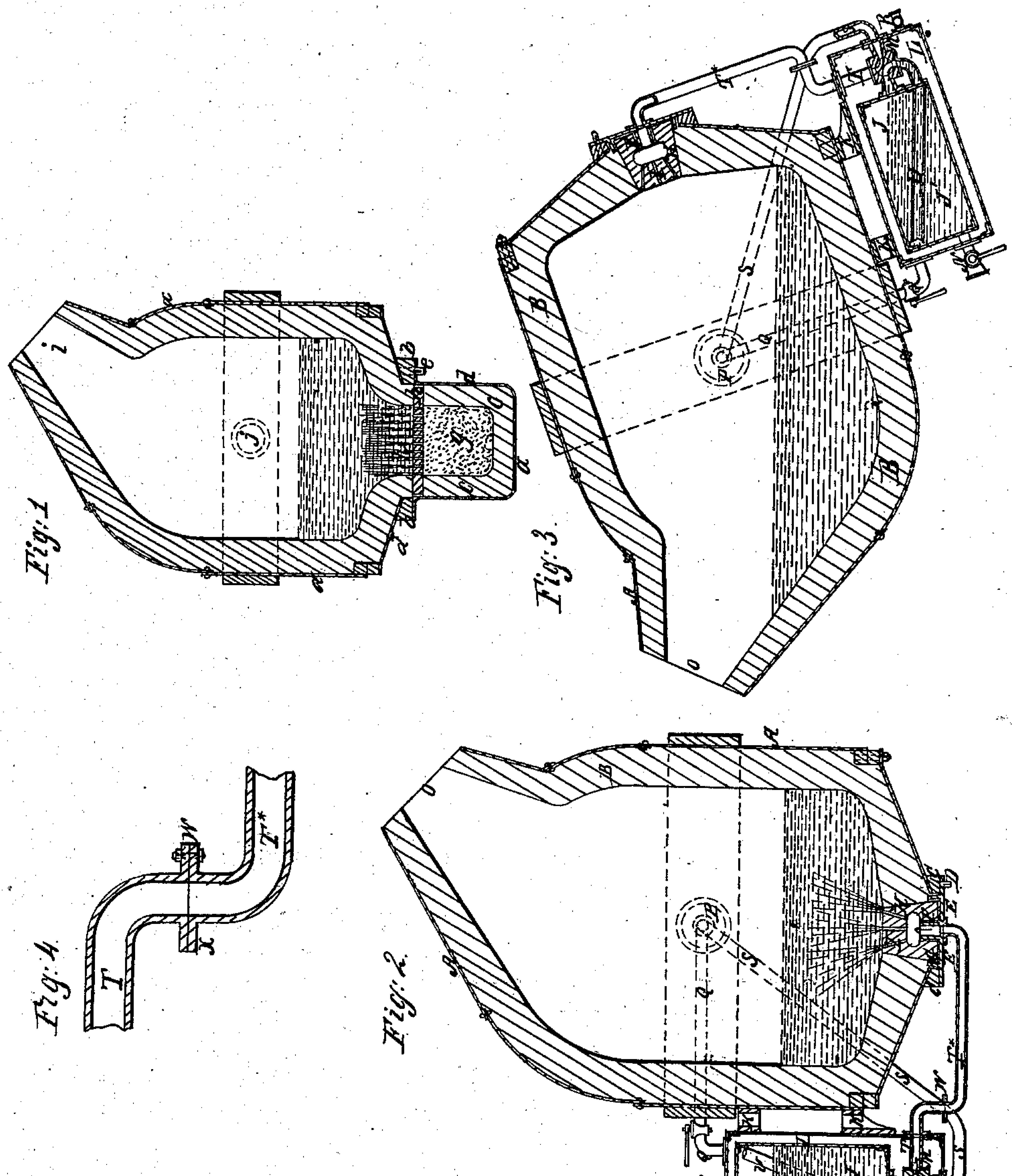
H. Bessemer.

Making Iron & Steel.

No. 94,994. Patented Sept. 21, 1869.



Witnesses.

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HENRY BESSEMER, OF LONDON, ENGLAND.

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IMPROVEMENT IN THE MANUFACTURE OF IRON AND STEEL.

The Schedule referred to in these Letters Patent and making part of the same.

To all to whom it may concern:

Be it known that I, HENRY BESSEMER, of Queen Street Place, Cannon street, in the city of London, a subject of the Queen of Great Britain, have invented or discovered new and useful "Improvements in the Treatment of Crude or Cast-Iron, and in the Manufacture of Malleable Iron and Steel;" and I, the said HENRY BESSEMER, do hereby declare the nature of the said invention, and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement thereof; that is to say—

In the specification of a patent granted to me in England, and dated the 12th day of February, 1856, No. 356, there is described the conversion of molten crude iron, or of remelted pig or finery iron into steel or into malleable iron, without the use of fuel for reheating, or continuing to heat the molten iron, such conversion being effected by forcing into and among the particles of a mass of molten iron, currents of air or gaseous matter, containing, or capable of evolving sufficient oxygen to keep up the combustion of the carbon contained in the iron, till the conversion is accomplished. This process is now well known as the Bessemer process.

One method of conducting it is to place beneath the molten iron a perforated case, capable of bearing a high heat, and containing a solid matter, such as nitrate of soda, which gives off oxygen on being heated.

The heat of the molten iron causes the nitrate or other matter to liberate oxygen, which forces its way through the perforations in the case, and it issues into and amongst the particles of the molten iron, as when air is forced through the tuyere-pipes in the ordinary way of conducting the Bessemer process.

When solid matters are used to generate the oxygen, as above stated, it is advantageous to use a converting-vessel like that which is usually employed in conducting the Bessemer process, that is to say, a vessel mounted on trunnions, and with a mouth or opening to receive and discharge the metal and give exit to the gases passing away during the conversion, and also with an aperture at the bottom.

This aperture usually receives the tuyere-box, which closes it when the vessel is at work, and air is blown through the tuyeres, but when solid substances are to be used, I replace the tuyere-box by a case or chamber lined with refractory material. This case or chamber is filled with the nitrate of soda, or other material capable of evolving oxygen, and is closed at the top with a perforated fire-tile, or it may be with a slab of refractory stone.

I make the case of such dimensions that the area of the surface of the nitrate or material is but small, as compared with the area of the principal horizontal section of the metal in the converting-vessel.

In this way I both modify the intensity of the action and also prevent the rapid scoring-action which would result from the passage of the gas between the metal and the sides of the vessel.

Also, in order to render the action more regular than it otherwise would be I fuse the nitrate of soda or other material, and cast it into the case or chamber in which it is to be used, and there allow it to solidify.

The melted metal is then effectually prevented from acting on more than the upper surface of the cast block of nitrate or material, or the fused nitrate or material may be cast into separate moulds, and afterward placed in the cases or chambers, or in some cases I mould the nitrate or material into blocks, under heavy pressure, before inserting it into the case or chamber; and the viol of the action of the nitrate or material on the iron may be reduced to any desired extent, by mixing dry clay or other inert matter with the nitrate or material; but I lay no claim to the moulding of such blocks by pressure, nor to the mixture of inert matters with the nitrates or other material; nor do I lay any general claim to the use of nitrates or materials yielding oxygen-gas, except when used according to my present invention.

In order that the way in which the case or chamber containing the nitrates or other material capable of yielding oxygen-gas is applied to converting-vessels, such as are generally employed in the Bessemer process, may be fully understood, I have shown a vertical section of an apparatus, so arranged, at Figure 1, on the sheet of drawings hereunto annexed.

At the lower part of the vessel *a*, which is similar to the vessels usually employed in conducting the Bessemer process, a ring or hoop, of iron, *b*, is fixed to the plates $a^{\times}$, which form the lower part of the vessel.

The case or chamber *d*, for holding the nitrates or other material, is provided with a flange at its upper edge, which is secured to the vessel by a series of slotted studs and cotters, one of which studs is shown at *e*.

The case or chamber is lined with fire-brick, fire-clay, gannister, or other suitable refractory material, as shown at *c*.

When the nitrate or other material, shown at *g*, is put into the case, the perforated cover or tuyere-plate *h*, composed of fire-brick or Ransom's concrete stone, is put on, and the case will then be in a condition ready for use.

When, however, the nitrate or other material is fused, and cast into the case or chamber *d*, and has become solidified therein, the use of the tuyere-plate may be dispensed with, as the metal will act on the upper surface of the nitrate or other material, and fuse it gradually, and not float it upward in the way that loose crystals of the nitrates would be carried up if tuyere-plates were omitted.

Before operating on the crude iron, I prefer to heat the vessel, which may be effected by securing an iron grating to the bottom of the converting-vessel, by means of the slotted studs *e*. On this grating a fire can be made, the products of combustion escaping by the mouth *i* of the vessel.

When the vessel has been heated sufficiently, the grating may be removed, and the case or chamber *d* may be secured in place, as shown in fig. 1.

A little "slip" or mixture of clay and fine sand, in a creamy state, is put around the edges of the tuyere-plate *h*, so as to secure a good joint, after which the vessel may be turned on its axes, (one of which is shown by dots at *j*,) into a position to receive the molten crude iron to be operated upon, so that the whole of the metal from the melting-furnace may be run or poured into the vessel before any action of the nitrates takes place.

The movement upward of the vessel thus brings the whole of the metal simultaneously into a position to be operated on.

The fluid iron enters the tuyere-holes, and coming in contact with the nitrate or other material, rapidly generates oxygen-gas, which passes upward from the tuyere-plate in numerous streams, through the fluid metal, in the same manner as air passes upward from the tuyere-holes in the ordinary Bessemer process.

The oxygen will decarbonize the crude iron, and convert it into malleable iron or steel, after which the products may be discharged from the mouth *i* of the vessel, by turning the vessel on its axes, as usually practised.

Also, according to my invention, when I employ either nitrate of soda or nitrate of potash, or other easily-fusible matter, which yields oxygen on coming in contact with fluid iron, and purifies or decarbonizes the same, I bring the nitrates or other matters into a fluid state, in a suitable vessel, before such matters are brought in contact with the molten iron, and I introduce such fused nitrates or other matters in jets or currents, which are forced through small openings or tuyeres, into the fluid metal, the force with which they are injected being such as will prevent the fluid iron from entering the tuyeres or the chamber containing the aforesaid fluid nitrates or other matters.

I prefer to fuse these matters in an iron vessel, provided with a jacket for the circulation of superheated steam or hot air.

I insert one or more fire-clay tuyeres in the lower part of the converting-vessel, which tuyere or tuyeres I connect by a short pipe with the vessel containing the fluid matters before named.

The passages leading into and through the tuyeres may be heated by passing superheated steam or hot air through them previous to admitting thereto the fluid nitrates or other matters.

The emission of the superheated steam or hot air will serve to exclude the fluid metal from the tuyere-openings until it is desired to introduce the fluid matters into the vessel, and also after the whole of the fluid nitrate or other matters have been injected, the steam or air will again pass, and thus prevent the iron from entering the tuyeres or passages.

In order to force these jets of fluid into the molten iron, I also employ superheated steam or hot air, under sufficient pressure to act on the surface of the said fluids, the mouth of the vessel containing them being closed by a valve for that purpose.

I would observe that when I so employ fluid matters to refine, purify, or decarbonize any molten iron, I prefer that the vessel containing the iron should be of such form as will admit of a much greater depth of fluid metal in proportion to its diameter than vessels usually employed in the Bessemer process; but this increased depth of metal is not essential to the success of the process, but it is to be preferred in constructing new apparatus.

Such vessels may either be movable on trunnions, or they may be fixed cylindrical or other-shaped vessels, but I prefer to employ vessels mounted on trunnions, usually called tipping-vessels, such as are generally employed in the Bessemer process.

Vessels that are now in use for that purpose may be readily adapted to the use of fluid nitrates in lieu of atmospheric air, as will be readily understood on reference to the sheet of drawings hereunto annexed, where

Figures 2 and 3 represent vertical sections of a Bessemer converting-vessel, in different positions, with the apparatus necessary for using fluid nitrates, attached thereto.

The converting-vessel A is constructed of plate-iron, and has a lining of gannister, B, at the lower part of the vessel.

There is a hoop of iron, C, from which slotted studs D project, and by means of which the tuyere-plate E is secured to the vessel.

This plate has a tubular part, F, and an inclined ring, G, projecting from its upper surface.

A block or tuyere, of burned fire-clay, H, is fitted into the inclined ring G, and rendered air-tight, by running in some Portland cement or plaster.

The centre part of the tuyere H is made hollow, and several small openings, I, diverge from it, as shown, for the purpose of distributing the fluid nitrates or other materials in small streams through the fluid metal.

At the back of the converting-vessel, the chamber J is fixed; it is surrounded by a jacket, L, which also encloses the four-way cock M, the handle of which is external to the jacket, and therefore not seen in the drawing.

K K are brackets, by which the jacket L is connected with the casing of the converting-vessel.

Before the apparatus is employed to convert the crude metal, a fire may be made in the vessel, a blast of hot air being propelled through the tuyere-block G for the purpose of keeping up the combustion of the fuel.

Meanwhile the nitrate of soda, or other material, yielding oxygen-gas, is put into the chamber J, through the funnel and cock N, which is then closed.

Highly heated air is passed by or through the axis of the vessel, shown by dots at P, and the air is conveyed by the pipe Q into the jacket, and allowed to blow off through the cock R.

The air is heated to a temperature sufficiently high to melt or fuse the nitrates or other materials contained in the chamber J, or their fusion may be effected in other vessels before they are supplied to the chamber J, where they are then retained in a fluid state by the hot air passing through the jacket.

Figure 3 shows the position the apparatus is put into for the purpose of receiving the crude molten iron to be operated on, which is run in through the open mouth *o* of the vessel.

Whilst the metal is running in, a current of hot air is employed to heat the pipes and tuyere-blocks, through which the fluid nitrates are to pass, the air also serving to prevent any of the molten iron from entering the tuyeres.

The air for this purpose is conveyed from the axis of the vessel, by the pipe S, passes through the four-way cock M, and pipes T and T×, into the tuyere-block, from which it escapes by several small passages.

As the mouth O of the vessel is turned upward, the tuyere-block H descends, and just as it is about to be immersed beneath the surface of the molten iron, the four-way cock M is reversed. The vessel is then turned up into the position shown in fig. 2.

By the reversal of the four-way cock, the air under pressure no longer passes through the pipes T and T×, into the tuyere-block, but finds its way through the pipe U, into the upper part of the chamber J, and there pressing on the surface of the molten nitrate or other material, forces it through the four-way cock and pipes T and T×, and through the several tuyere-openings, into the fluid metal.

When the whole of the fluid has been discharged, the air under pressure will follow through the same passages, and exclude the metal from the tuyere-block until the vessel is turned down, and its contents discharged.

If the nitrate or other material, yielding oxygen-gas, be used in such quantity as only to partially decarbonize the crude iron, the passage of air through the metal, after all the fluid nitrate has been discharged, will not only complete the decarbonization to the desired extent, but it will increase the temperature of the metal.

This increase of temperature will be still more readily effected if some fluid, *spiegel eisen*, or other carburet of iron, be added at the time, that is to say, after all the nitrate or material has been injected.

In order that the removal of an old tuyere-block and the supply of a new one may be effected readily, a joint is made on the pipe T×, at W. This is shown on a larger scale at Figure 4.

The elbow-pipe T has a dovetailed ring, X, bolted to it, and the pipe T× has a corresponding dovetailed flange fitted into the ring X, and capable of moving within the dovetailed ring, so that whenever the flange of the pipe T× is unbolted from the tuyere-plate E, it may be moved on the joint W, out of the way, and thus admit of the removal of the tuyere-plate from the vessel.

Such vessels may either be movable, on trunnions, or they may be fixed cylindrical or other-shaped vessels.

Usually I employ such a proportion of nitrate or material in relation to the quantity of crude or cast-iron operated on as to convert the metal at once into malleable iron or steel.

In some cases, however, it may be convenient to employ a smaller proportion of nitrate or material, and to leave the metal in the form of a readily-fusible cast-iron, but of improved quality, and this cast-iron may be afterward converted by the ordinary Bessemer process, or otherwise employed.

It is well known that there are many gradations of quality or degrees of decarbonization between what is usually called mild steel and that quality of metal which is usually termed cast-steel, and it will be obvious that the decarbonization of the metal may have any range between these limits, depending on the quantity of oxygen-producing material employed, and the quantity of carbon originally contained in the crude iron, and therefore, that the metal may be discharged from the vessel after treatment with the nitrates or other material, in such a state of decarbonization as may best adapt it to the uses or after-processes for which it may be required.

Nitrate of soda or nitrate of potash, or chlorate of soda or chlorate of potash, may be carried into and amongst the molten iron by means of a current or currents of air introduced below the surface of the metal, as is suggested in general terms in the specification of my said former patent, as also in that of another patent granted to me in England, and dated the 31st of May, 1856, No. 1,292.

In some cases, however, it is desired, in place of converting the metal in part by the air introduced, and in part by the nitrate and chlorate which it carries with it, to effect the conversion entirely by the nitrate or chlorate.

I then employ a current or currents of an inert gas, such as carbonic-acid gas, or steam, or vapor, to carry the powdered nitrate or chlorate into the converting-vessel, amongst the molten metal.

For this purpose I prefer to reduce the nitrates or other materials, capable of yielding oxygen-gas, to a fine powder, having first baked them, so as to deprive them as far as possible of water.

The powder may be admitted to the pipes which convey the gas into the metal by a feeding-screw, or other known contrivance for regulating the supply of powdered or granulated materials.

The gaseous matters employed for conveying these powered materials into the molten metal may be obtained by passing air or steam, under sufficient pressure, through a close vessel, lined with fire-brick, and containing coke or other fuel in an incandescent state, as is well understood, or the gases may be generated by any other known and efficient means.

I do not claim under my present invention the use of atmospheric air or steam in their natural state, for the purpose of carrying nitrates or other matters into molten iron.

Having thus described the nature of my said invention, and the manner of performing the same, I would have it understood that I do not confine myself to the exact details described; but

What I claim, is—

The treating molten crude or cast-iron with nitrate of soda or other solid oxygen-yielding substance in a vessel mounted on trunnions, such vessel being provided at one end with a chamber or case, to contain the nitrate or other substance, and at the other end with a mouth, serving to receive and deliver the iron, and also as an exit for the gases passing away during the conversion, the arrangement being also such that the vessel may have the metal poured into it at the mouth without coming in contact with the nitrate or other substance, and may then be tipped so as to carry the nitrate or substance below the molten metal, and finally, when the conversion is complete, may be again tipped to pour out the metal at the mouth.

Also, in treating molten crude or cast-iron, the pouring the nitrate of soda or other fusible oxygen-yielding substance, in a melted state, into the case or chamber in which it is used, allowing it to become solid in the said case or chamber, and form a mass, the surface only of which can be attacked by the molten iron.

Also, in treating molten crude or cast-iron, the closing the top of the case or chamber in which the nitrate or other substance is contained beneath the molten iron, with a perforated fire-tile, or a slab of refractory stone.

Also, the treating molten crude or cast-iron with nitrate of soda or other fusible oxygen-yielding substance, by forcing the liquid nitrate or substance in jets into and amongst the molten metal.

Also, the forcing heated air or steam through the same tuyeres or orifices by which the liquid nitrate or other substance is forced into the metal, so as, before the nitrate is supplied, to heat the said tuyeres or orifices, and to exclude the metal from them both before and after the application of the liquid nitrate or substance.

Also, in the treatment of molten crude or cast-iron, and in the manufacture of malleable iron and steel, the use of apparatus, arranged as is represented in figs. 2 and 3 of the drawings.

Also, the treating molten crude or cast-iron by carrying nitrate of soda or other oxygen-yielding substance, in a powdered state, into and amongst the said metal, by means of a jet or jets of carbonic-acid gas, or other gas incapable of yielding oxygen to the molten metal.

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Witnesses:

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