No. 742,315. PATENTED OCT. 27, 1903.

H. HARMET.

ELECTRIC FURNACE.

APPLICATION FILED NOV. 29, 1901.

NO MODEL.

Fig. 1.

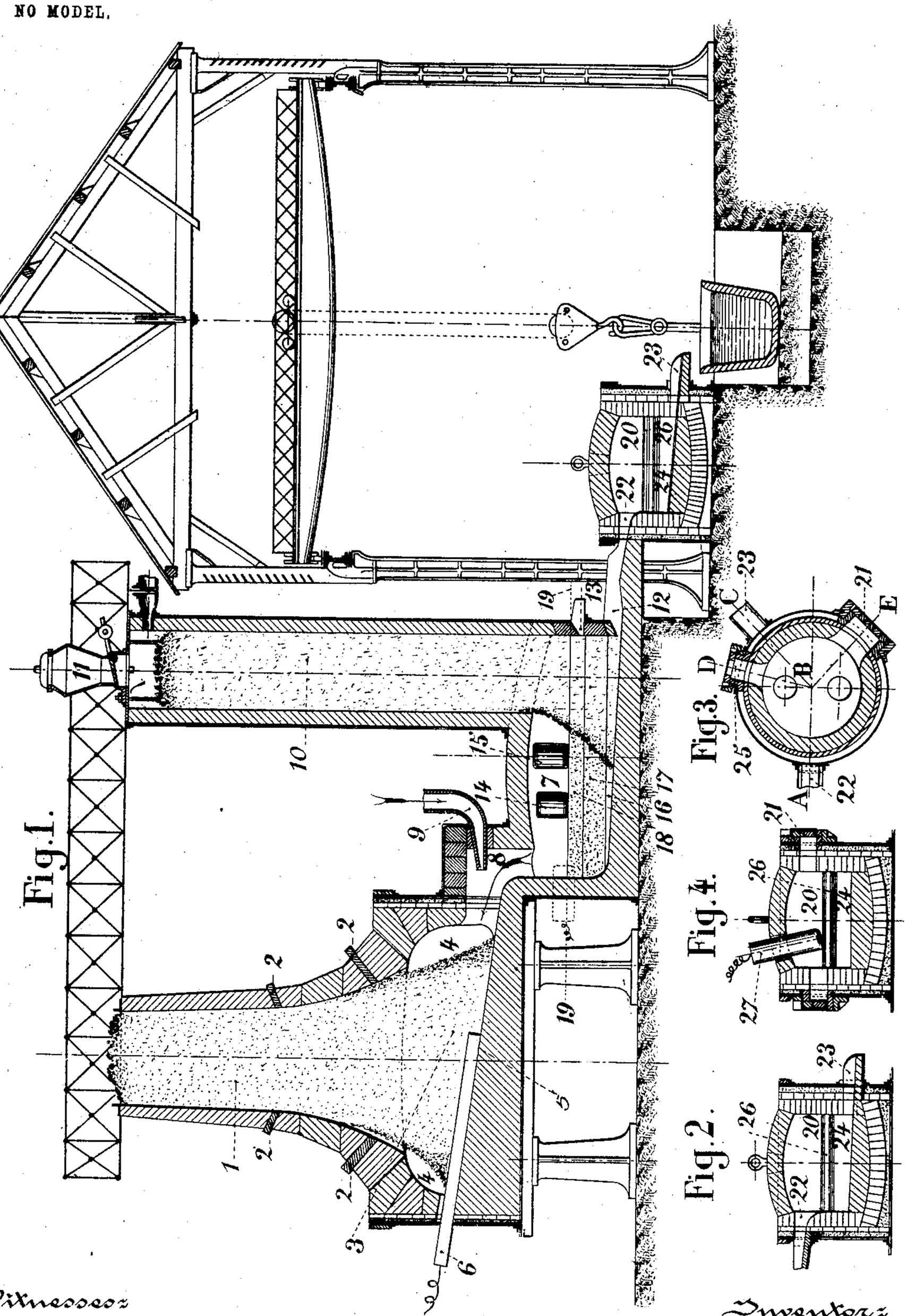

Fig. 3.

Fig. 4.

Fig. 2.

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UNITED STATES PATENT OFFICE.

HENRI HARMET, OF ST. ETIENNE, FRANCE.

ELECTRIC FURNACE.

SPECIFICATION forming part of Letters Patent No. 742,315, dated October 27, 1903.

Application filed November 29, 1901. Serial No. 84,026. (No model.)

To all whom it may concern:

Be it known that I, HENRI HARMET, a citizen of the Republic of France, residing at St. Etienne, Loire, France, have invented certain new and useful Improvements in the Electrometallurgy of Iron and Steel, of which the following is a specification.

My invention has relation to an apparatus for the continuous and complete conversion of iron ores into iron and steel by a series of electrometallurgical operations in which the ore is first fused, then reduced, and finally refined, and in such connection it relates to the construction and arrangement of such an apparatus.

In a former application for patent filed by me on September 30, 1901, under the Serial No. 77,012 an apparatus is shown in the nature of an electric blast-furnace wherein iron ore may be first reduced and then fused by electrometallurgy. The present apparatus differs from that of my former application in that it is designed to first fuse and thereafter reduce the oxids prior to their treatment in the refining-oven.

The nature and scope of my invention will be more fully understood from the following description, taken in connection with the accompanying drawings, forming part hereof, in which—

Figure 1 is a longitudinal sectional view of a complete apparatus for carrying out the process of my present invention; and Figs. 2, 3, and 4 are detail views in section, illustrating the construction and arrangement of the refining-oven wherein the crude metal is refined.

Referring to the drawings, it will be found that the complete apparatus for carrying out the process of my present invention comprises three connected parts—namely, a fusion-chamber, a reduction-chamber, and a refining-oven. It will also be observed that the fused materials leave the hearth or crucible of the fusion-chamber to enter directly the hearth or crucible of the reduction-chamber, pouring or running over an inclined sole in its passage between the two crucibles. Again, the reduced materials leave the hearth or crucible of the reduction-chamber by pouring or running over an inclined sole and gutter into the refining oven or crucible, traversing in its passage a column of highly-heated reducing-carbon, as will be hereinafter more fully described.

The fusion-chamber 1 is conical and expands at its base into a flaring bell-mouth, forming the crucible 3 of the fusion-chamber. The top of the chamber 1 is preferably open for the ready charging of the ores and fluxes, as well as for the exit of gases which are useless in the process. The walls of the chamber 1 are pierced at intervals, as at 2, to permit the entrance of stoking-tools when required; otherwise the holes are bricked up or closed by removable bricks 2. The crucible 3 or fusion-hearth of the chamber 1 is preferably circular in horizontal section and has a sloping sole, upon which are supported the inclined electrodes 6, which give to the crucible 3 the additional heat required for fusion. The column of the charge in the chamber 1 rests upon the sole 5 (see Fig. 1) in pyramidal form and does not completely fill the crucible 3, there being an annular space 4 around the charge in which combustion and circulation of the gases may take place and from which the gases may pass into and through the mass of oxids to heat the same. After traversing the charge in the chamber 1 the gases pass out of the open mouth of the chamber 1 and are dispersed, since after their passage through the fusion-chamber they are burned out and of no value. The fusion of the oxids is caused by gases passing out of the reducing-crucible 7 through the opening 8. These gases are mainly composed of carbonic oxid, and the heat rendered up either by their combustion or by their cooling is ordinarily sufficient to fuse the oxids on the sole or hearth of the crucible 3. When the gases pass out through the opening or passage-way 8, they are mixed with air under pressure forced through the twyers or blowpipe 9. When so mixed, they play upon the base of the column of oxids, which has already been highly heated, and fuse the oxids upon the base or sole of the crucible 3. The gases then spread around the column in the annular space 4 and complete their combustion. From the space 4 the burned gases filter into and through the porous column of oxids, heating it progressively, and then pass out of the mouth. The hot

gases from the reducing-crucible 7 are usually sufficient to fuse the oxids in the crucible 3; but it is preferable to have an auxiliary source of heat in the crucible 3 in the form of an electric current. This electric heat supplies any heat necessary in addition to the gaseous heat and also regulates the fusion upon the sole of the crucible 3, since said sole being very large and the blowpipe or blowpipes 9 acting mainly upon the base of the column of oxids there may not be sufficient heat to fuse with regularity all portions of the oxids resting upon the sole, and especially the portions farthest away from the blowpipes 9. A current of electricity capable of giving the additional heat required is passed through two electrodes 6 parallel with the sole of the furnace and passed through openings in the upper surface of the inclined plane forming the sole. The current, however, may be led in through vertical carbons or electrodes, if desired, or in any other manner. It is, however, preferable to so arrange the electrodes that they shall heat those points of the sole remote from the blowpipes 9.

The reducing-furnace is composed of a vertical charging-chamber 10, preferably circular in cross-section and adapted to receive the coke, charcoal, or other reducing agent at the top, and a crucible 7, through one end of which the chamber 10, with its charge, extends. The top of the chamber 10 is closed by a charging apparatus 11 of the usual construction arranged in such a manner as to prevent the passage of gases out through the mouth or top of the chamber 10 during the charging operation unless it is desired to permit the exit of a portion or all of the gases from said mouth. The crucible or reducer 7 is a horizontally-arranged furnace, preferably circular in cross-section, with its lateral walls practically vertical. The base or sole of the reducing-crucible 7 is inclined in the direction in which the materials are to flow—that is to say, from the point of arrival of the fused oxids, as at 8, to the point of the outlets 12 and 13 for the fused and reduced metal and dross into the regulator or refining-oven 20. The dome of the crucible 7 has the general shape of a portion of a sphere and is provided with a large circular opening above the discharge or outlet 12 of the crucible and permits the charge of carbon in the chamber 10 to descend in the form of a column upon the base or sole of the crucible 7. The dome also has an opening 8, which is the passage-way for the gases from the reducing-crucible 7 into the fusion-crucible 3. When preferred, the electrodes 14 and 15 also pass through the dome of the crucible 7. The lateral walls of the crucible 7 may, if desired, be provided with doors for examination and inside repairing, and if the carbons or electrodes 14 and 15 are horizontally arranged the walls of the crucible 7 may be perforated to admit these electrodes. The outlet end of the crucible 7 should also be provided with at least two openings or outlets 12 and 13. The outlet 12, as before explained, is for the passage of the fused and reduced metal from the crucible 7, while the outlet 13, situated above the outlet 12, is for the tapping of the slag or dross floating above the fused and reduced metal. The two openings 12 and 13 are situated in the rear of the column of reducing-carbon, so that the metal and the slag must both traverse this column before being tapped or withdrawn from the crucible 7. Inasmuch as in the crucible 7 the reduction of the oxids absorbs more heat than is produced by the transformation of the carbon or coke reducing agent into carbonic oxid, the crucible is heated by an electric current. This current is led in through the electrodes 14 and 15, which enter the crucible 7 to a depth so as to reach but not penetrate the dross or slag 18 in the crucible. The reduction in the crucible 7 takes place as follows: After working for some time a first layer of metal 16 collects upon the sole of the crucible and is surmounted by a layer 17 of incompletely-reduced oxids more or less mixed with a top or third layer 18 of dross or slag. The main column of coke in chamber 10 remains resting at its base upon the sole of the crucible; but fragments of the coke are lifted by the metal and dross and float upon the liquid mass, spreading everywhere until it fills the entire lower portion of the crucible 7, rising to the height 19 19. (Indicated on Fig. 1 of the drawings.) The liquid mass now circulates in the spaces left between the fragments of coke, as in ordinary blast-furnaces. The melted oxids discharged from the fusion-crucible 3 fall upon a mixture of coke and dross and are then reduced under the influence of the high temperature produced by the electric current. The freed gases, also highly heated, then pass out through the passage-way 8 into the fusion-crucible to fuse the oxids therein. The reduced metal falls to the sole of the crucible 7 and there collects, and upon this reduced metal floats the dross or slag, deprived of nearly all of the oxids. Before the reduced metal or the dross can be tapped from the crucible 7 they must both pass through the column of reducing-carbon, which at the point the metal and dross pass through it is in an incandescent state, and this perfects the reduction. After the reduced metal leaves the crucible 7 it flows into the refining-oven or regulator 20. This regulator 20 is a crucible of preferably circular cross-section having a charging-door 21, a channel or passage-way 22, through which the crude metal enters, a tap-hole 23 for the metal 24, and a tap-hole 25 for the dross or slag 26. The crucible 20 is heated by the electric current through two electrodes 27, which pass either vertically or inclined through the dome or through the lateral wall of the crucible. These electrodes 27 penetrate the liquid in the crucible 20. The refining operation in the regulator-cruci-

ble 20 is conducted in a manner analogous to the operation conducted in the Martin refining-oven. When but one regulator 20 is used to receive the metal, the reduced metal is allowed to accumulate in the reducer 7 and then discharged *en bloc* into the regulator without disturbing, however, the continuous working of the reducer. In many cases, however, it will be found advantageous to have for each reducer two regulators or refining-ovens, into which the crude metal flows regularly as soon as produced. In this instance one of the regulators receives and becomes charged with the metal while the other is bringing the refined metal to the point of hardness and the composition required.

Having thus described the nature and objects of my invention, what I claim as new, and desire to secure by Letters Patent, is—

1. In an apparatus for the complete and continuous conversion of iron ores into iron and steel by electrometallurgy, a fusion-crucible having a sole and passage-way, a reducing-crucible located adjacent to the sole of said fusion-crucible and communicating with said crucible through said passage-way, means wherein the reducing-carbon is charged and traversing said reducing-crucible, and a refining oven or crucible into which the reducing-crucible directly discharges, means for heating the fusion-crucible by a blast of hot gases forced from the reducing-crucible into the fusion-crucible and means for heating each crucible separately by the electric current.

2. In an apparatus of the character described, a fusion-chamber of frusto-conical shape, a horizontally-arranged crucible forming a bell-mouthed base of the chamber, an inclined sole for the crucible, an opening formed in the crucible at the lowermost portion of the inclined sole, a horizontally-arranged reducing-crucible located below the sole of the fusion-crucible and communicating directly therewith through the opening, means for blowing gases arising in the reducing-crucible into the fusion-crucible, means for electrically heating the reducing-crucible, and a refining-crucible located below the sole of the reducing-crucible and in direct communication with said reducing-crucible.

3. In an apparatus of the character described, a fusion-crucible having an inclined sole and a passage-way at the lowermost portion of said sole, a reducing-crucible located below the sole of the fusion-crucible and communicating directly with the fusion-crucible through said passage-way, a chamber wherein the reducing-carbon is charged and traversing the reducing-crucible at its outlet or tapping end, a refining-crucible located below the sole of the fusion-crucible and communicating therewith through a passage-way normally obstructed by the charge of reducing-carbon, all combined with means for heating the reducing-crucible and refining-crucible separately by means of the electric current.

In testimony whereof I have signed this specification in the presence of two subscribing witnesses.

HENRI HARMET.

Witnesses:
DAVID GUILLA,
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