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A. A. MacPHAIL

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ROTATING HEARTH ELECTRIC FURNACE

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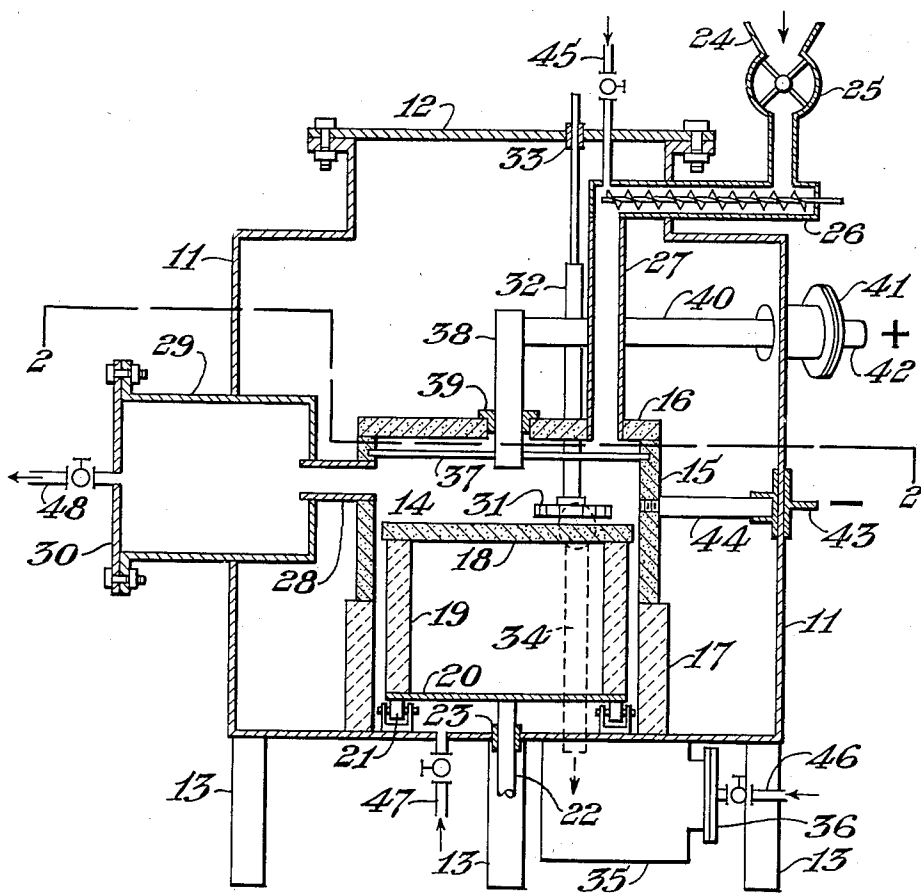


Fig. 1

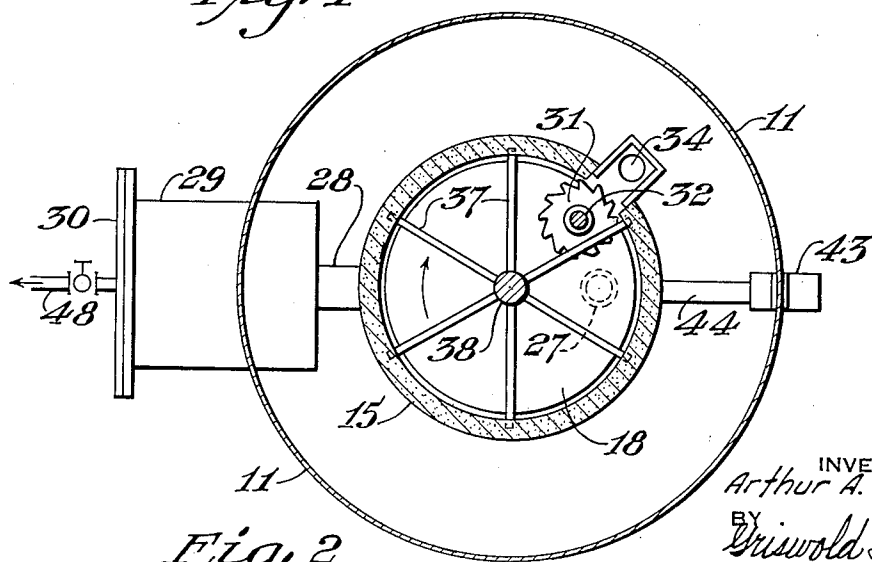


Fig. 2

INVENTOR
Arthur A. MacPhail
BY
Griswold & Burdick
ATTORNEYS

UNITED STATES PATENT OFFICE

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ROTATING HEARTH ELECTRIC FURNACE

Arthur A. MacPhail, Midland, Mich., assignor to
The Dow Chemical Company, Midland, Mich., a
corporation of Michigan

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7 Claims. (Cl. 13—8)

This invention relates to a rotating hearth electric furnace for use in metallurgical processes, particularly those operated under vacuum.

In various metallurgical processes, such as the production of calcium and magnesium, an oxide-containing ore and a reducing agent are heated together at an elevated temperature, usually above 1000° C., at which temperature they interact, liberating a metal vapor, which may be withdrawn and condensed, and leaving a solid residue. A number of furnaces have been suggested for use in such thermal reduction processes, but have been far from ideally suited to the purpose. In particular, the furnaces have not provided for an even heating of the reduction charge under controlled conditions of temperature and reaction time.

In view of these difficulties, an object of the invention is to provide an improved electric furnace for use in thermal reduction processes of the character mentioned. Another object is to describe a furnace in which reduction charges may be heated evenly at reaction temperatures for carefully controllable periods of time. Other objects will be apparent from the following description.

The construction of the improved furnace may best be explained with reference to the accompanying drawing in which

Fig. 1 is a vertical sectional view of a furnace according to the invention, and

Fig. 2 is a horizontal sectional view along the line 2—2 in Fig. 1.

In the preferred embodiment illustrated, the furnace consists of a cylindrical gas-tight steel shell 11 provided with a removable cover 12 and supported above the floor on legs 13. The furnace chamber or reaction zone 14 is formed of a vertical cylinder 15 of graphite or other refractory material, and a circular cover 16 of the same material, and is mounted on a cylindrical base 17 of refractory brick resting on the bottom of the shell 11. Within the furnace chamber 14 is a rotating hearth structure consisting of a thick circular horizontal plate or hearth 18 of diameter only slightly smaller than that of the cylinder 15 and preferably made of the same material as the latter, this plate being supported by a refractory brick base 19 mounted on a circular steel plate 20. The entire hearth structure is supported on bearings or rollers 21 and may be rotated by a shaft 22 which extends outside the shell 11 through a gas-tight bushing 23 to a driving mechanism not shown.

The metallurgical ore charge to be heated is

introduced into the furnace chamber from a hopper 24 through a vacuum lock 25, a screw conveyor 26, and a feed pipe 27, and drops onto the hearth 18. At the temperature of the furnace, the charge reacts, forming metal vapors which escape through an outlet 28 into a condenser 29 projecting through the shell 11 and provided with a removable cover 30. Residue remaining after reaction of the ore charge is removed from the hearth 18 by a rotatable toothed wheel or scraper 31 which is mounted just above the hearth 18 at the periphery thereof at a position which is angularly remote, in the direction of hearth rotation, from the feed pipe 27. The scraper may be rotated by a shaft 32 which extends upwardly out of the furnace 14 through a gas-tight bearing 33 in the cover 12 to driving means not illustrated. When rotated, the scraper 31 forces reaction residue off the edge of the hearth into a graphite chute 34 from which it spills into a pit 35 having a gas-tight removable cover 36.

The furnace chamber 14 is heated by electric resistor bars 37 which are disposed radially a short distance above the hearth 18. One end of each resistor bar is secured to a central graphite terminal 38 which is insulated from the cover 16 by an alundum bushing 39 and is connected to a graphite bus-bar 40 extending outside the shell 11 through a gas-tight joint 41 to a terminal 42. The other end of each resistor bar 37 is connected firmly to the graphite wall 15 of the chamber 14, this wall being electrically grounded on the shell 11 at a terminal 43 by means of a graphite rod 44.

Gas may be admitted to the furnace chamber through valved inlets 45, 46, and 47 which lead, respectively, into the feed pipe 27, the residue pit 35, and the bottom of the chamber 14 below the hearth structure, as hereinafter explained. The furnace is evacuated through a valved gas outlet 48 located in the cover 30 of the condenser 29. In practice, the space between the furnace chamber and the steel shell is filled with heat insulating material.

In operating the furnace, the hearth 18 and its supporting structure is rotated at a slow rate about the shaft 22, and the screw conveyor 26 and the scraper 31 are set in motion. Electric current of the desired voltage is applied to the terminals 42 and 43, thereby heating the resistor bars 37 and raising the furnace to an operating temperature. A charge of oxide ore and reducing agent is placed into the hopper 24, from which it is fed slowly into the feed pipe 27 and falls onto the rotating hearth 18 as a uniform

thin layer. The rotation of the hearth carries the charge directly under the resistor bars 37, which heat it quickly to a reaction temperature. Metal vapors are evolved rapidly and escape to the condenser 28 where they are chilled by contact with the condenser walls, forming solid metal. Reaction residue left on the hearth is carried around to the rotating scraper 31 and is there removed into the pit 35. After the furnace has been in operation for some time, the condensed metal and the residual slag are removed by temporarily shutting the furnace down, discontinuing the feed, releasing the vacuum, and removing the covers from the condenser 29 and slag pit 35 so as to permit scraping out the condenser and pit. Operation is then resumed.

The furnace chamber 14 is exhausted continuously through the gas outlet 45 in the condenser 28 by means of a suitable vacuum pump not shown. In order to insure that the metal vapors liberated in the furnace escape only into the condenser, small quantities of an inert gas are bled continuously into the reaction chamber through the inlets 43, 46, and 47. In this way there is at all times a small positive vapor flow from all parts of the furnace toward the condenser, and metal vapors do not diffuse into the feed pipe 27 or pit 35 or around the bearings 21 where they might otherwise condense, causing opening difficulties and loss of metal.

It will be appreciated that in the furnace illustrated, the period of exposure of the reduction charge to the elevated temperature of the furnace may be regulated, simply by adjusting the rotational speed of the hearth. Careful time-temperature control of the reduction process is thus easily attained. In addition, the charge is heated by radiation while in the form of a thin layer; heat transfer conditions are ideal and uniform and complete reaction throughout the entire charge is achieved. Continuous automatic trouble-free operation is entirely possible.

It is to be understood that the invention is not limited to the specific embodiment shown. Thus, the hearth may be in the form of an annular ring instead of being a solid plate, in which case the reaction residue may be scraped off at the center of the hearth rather than at the edge. The valved inlets 43, 46, and 47 may be replaced with other vapor-directing means, and, for some operations, entirely eliminated. Other changes in detail within the scope of the appended claims will doubtless occur to those skilled in the art.

I claim:

1. In a high-temperature vacuum electric furnace for use in processes wherein an oxide ore charge is heated, liberating a metal vapor and leaving a solid residue, the combination of: a gas-tight shell; a furnace chamber formed of high-temperature refractory material mounted within the shell; a rotatable hearth structure within the chamber; means for evacuating the furnace; electric resistance heating elements disposed within the furnace chamber directly above the hearth and radially about a point above the center thereof; a condenser in communication with the chamber and having a gas outlet for applying vacuum to the chamber; a residue pit in communication with the chamber; mechanical feeding means for introducing an ore charge into the furnace chamber onto the rotating hearth; a vacuum lock in said feeding means; and scraping means adapted to scrape residue from the hearth into the residue pit.

2. In a high-temperature vacuum electric fur-

nace for use in processes wherein an oxide ore charge is heated, liberating a metal vapor and leaving a solid residue, the combination of: a gas-tight shell; a graphite furnace chamber mounted within the shell; a rotatable hearth structure within the chamber; means for evacuating the furnace; electric resistance heating elements disposed within the furnace chamber directly above the hearth; a condenser in communication with the chamber and having a gas outlet for applying vacuum to the chamber; a residue pit in communication with the chamber through a chute disposed near the rotating hearth; mechanically actuated feeding means for introducing an ore charge into the furnace chamber onto the rotating hearth; a vacuum lock in said feeding means; and a rotatable toothed wheel mounted directly above the hearth and adapted to scrape residue into the aforesaid chute.

3. In a high-temperature vacuum electric furnace, the combination: a gas-tight shell; a furnace chamber formed of a graphite cylinder surmounted by a circular graphite plate, the said cylinder being mounted on refractory brick resting on the bottom of the shell; a hearth structure within the furnace chamber comprising a circular graphite hearth having a diameter only slightly smaller than that of the graphite cylinder; means for rotating the hearth structure; and means for evacuating the furnace.

4. In a high-temperature vacuum electric furnace, the combination of: a gas-tight shell; a furnace chamber formed of a graphite cylinder surmounted by a circular graphite plate, the said cylinder being mounted on refractory brick resting on the bottom of the shell; a rotatable hearth structure within the furnace chamber comprising a circular graphite plate having a diameter only slightly smaller than that of the graphite cylinder and mounted on refractory brick resting upon a circular steel plate, said plate resting on bearings mounted on the bottom of the gas-tight shell; and means for evacuating the furnace.

5. In a high-temperature vacuum electric furnace for use in processes wherein an oxide ore charge is heated, liberating metal vapor and leaving a residue, the combination of: a gas tight shell; a furnace chamber formed of a high-temperature refractory material mounted within the shell; a rotatable hearth structure within the chamber; means for evacuating the furnace; electric resistance heating elements disposed within the furnace chamber directly above the hearth and radially about a point above the center thereof; a condenser in communication with the chamber; means for introducing an ore charge into the furnace chamber onto the hearth; and means for removing residue from the hearth.

6. In a high-temperature vacuum electric furnace, the combination of: a gas-tight shell; a furnace chamber mounted within the shell and formed of a cylinder of high-temperature refractory material surmounted by a circular refractory plate; electric heating means within the furnace chamber; a hearth structure within the furnace chamber comprising a circular refractory hearth having a diameter only slightly smaller than that of the refractory cylinder; means for rotating the hearth structure; and means for evacuating the furnace.

7. In a high temperature vacuum electric furnace for use in processes wherein an oxide ore charge is heated, liberating a metal vapor and leaving a solid residue, the combination of: a gas-tight shell; a graphite furnace chamber mounted

within the shell; a rotatable hearth structure within the chamber; means for evacuating the furnace; electric resistance heating elements disposed within the furnace chamber directly above the hearth; a condenser in communication with the chamber and having a gas outlet for applying vacuum to the chamber; a residue pit in communication with the chamber through a chute dis-

posed near the rotating hearth; feeding means for introducing an ore charge into the furnace chamber onto the rotating hearth; a vacuum lock in said feeding means; and a scraper mounted directly above the hearth and adapted to scrape residue into the aforesaid chute.

ARTHUR A. MacPHAIL.