

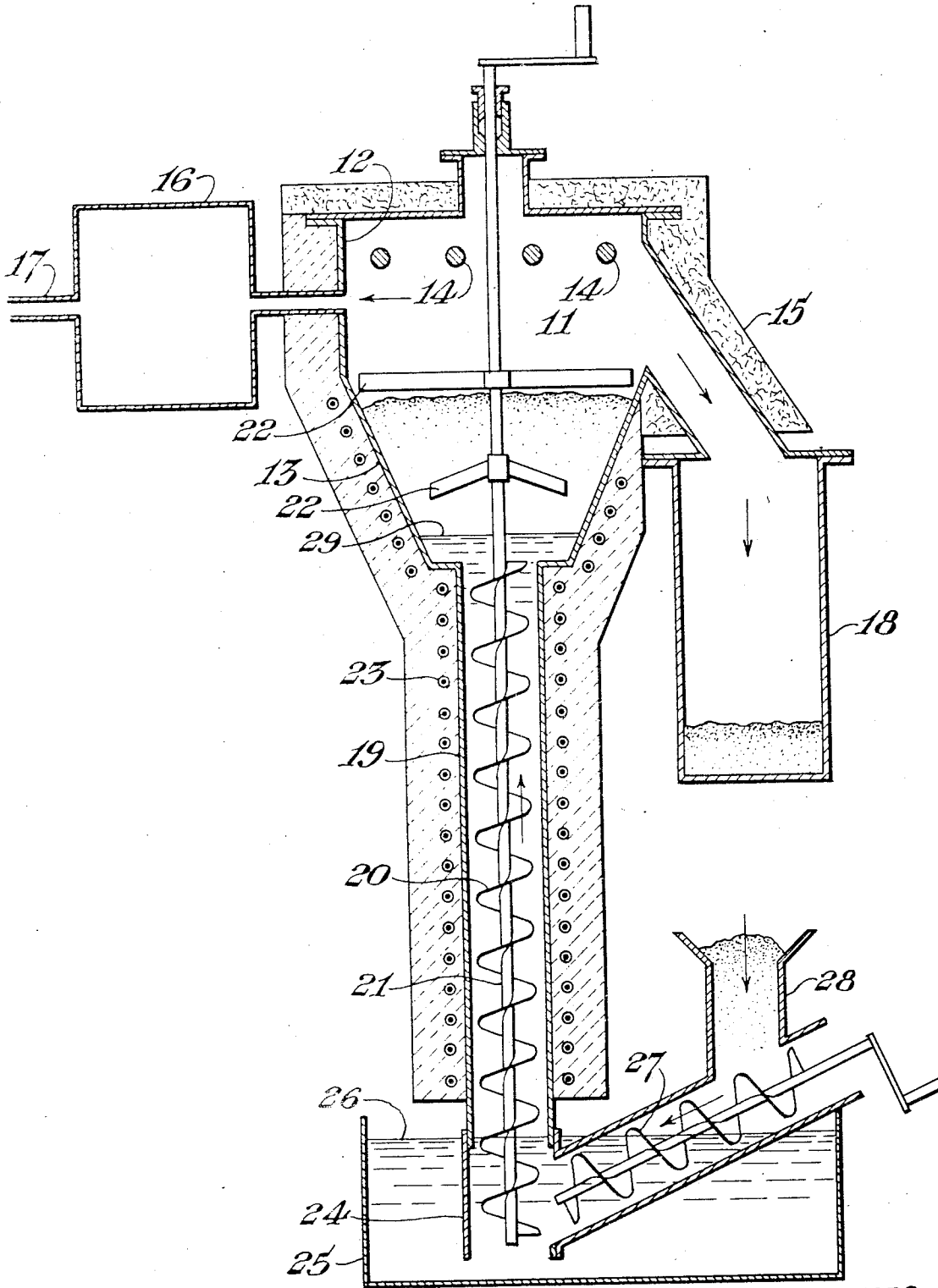
April 15, 1941.

J. D. HANAWALT ET AL

2,238,792

CHARGING A HIGH-TEMPERATURE VACUUM FURNACE

Filed July 28, 1939



INVENTORS
Joseph D. Hanawalt
By Charles E. Nelson
Griswold & Burdick
ATTORNEYS

UNITED STATES PATENT OFFICE

2,238,792

CHARGING A HIGH-TEMPERATURE
VACUUM FURNACE

Joseph D. Hanawalt and Charles E. Nelson, Midland, Mich., assignors to The Dow Chemical Company, Midland, Mich., a corporation of Michigan

Application July 28, 1939, Serial No. 286,986

9 Claims. (Cl. 13—8)

This invention relates to an apparatus and method for transferring solid materials into and out of high-temperature vacuum furnaces.

In certain metallurgical processes, especially those in which an ore is reduced at elevated temperature to form a metal which vaporizes from the charge and is subsequently condensed, it is often advantageous to operate under vacuum, e. g. at an absolute pressure below 25 millimeters of mercury. If the process is to be continuous, it becomes necessary to provide means for continually introducing the ore charge into the furnace zone and removing residual slag therefrom without breaking the prevailing vacuum at each such transfer of material. In prior vacuum furnaces, charging has been accomplished principally through mechanically complicated vacuum lock systems which require constant attention and which, because of the high temperatures to which they are exposed, are often subject to gasket troubles, vacuum leaks, and the like.

An object of the present invention, then, is to provide a simple convenient means for charging solid materials into high-temperature vacuum furnaces which requires little supervision and is not subject to the difficulties of prior art structures.

According to the invention, solid materials may be fed into a high-temperature vacuum furnace or removed therefrom through a barometric seal of a heavy liquid which is substantially non-volatile and is chemically inert to the solid materials under the existing conditions of temperature and pressure.

The invention may best be understood with reference to the accompanying drawing which illustrates diagrammatically one form of apparatus according to the invention. This apparatus is particularly adapted to use in metallurgical processes wherein an oxide ore is reduced, liberating metal vapor and leaving a residual slag.

The furnace proper comprises a furnace chamber 11 formed by a cylindrical shell 12 terminated at its lower end by a conical shell 13. The chamber 11 is heated internally by electric resistor bars 14, and is insulated against heat loss by a refractory covering 15. In communication with the chamber 11 are a condenser 16 provided with a vacuum line 17, and a slag pit 18. Ore charge is forced into the bottom of the furnace cone 13 through a feed pipe 19 in which a feed screw 20 is mounted on a rotatable shaft 21. This shaft extends upwardly through the furnace chamber 11 and is provided with rabble arms 22 for agitating ore charge in cone 13. The

feed pipe 19 is surrounded by thermal insulation in which are embedded electrical heating elements 23. The feed pipe 19 and screw 20 terminate at their lower end in a sleeve 24 located near the bottom of a liquid reservoir 25 which is filled with liquid to some level 26 above the sleeve 24. Fresh charge may be charged into the sleeve 24 and thence into the feed pipe 19 by means of a short downwardly-directed feed screw 27 which takes ore charge from a hopper 28. As the result of the reduced pressure in the chamber 11, a part of the liquid in the reservoir 25 rises in the pipe 19 to some level 29, thus providing a simple and effective liquid vacuum seal through which ore charge can be introduced.

In operation the furnace chamber 11 and feed pipe 19 are brought up to their operating temperatures by their respective electric heating units and vacuum is applied through the line 17 on the condenser 16, thus evacuating the system and causing the liquid in the pipe 19 to rise, forming the barometric column or seal. Ore charge in powder form is placed into the hopper 28 and the feed screws 20 and 27 are set in motion. The ore charge is gradually conveyed down the screw 27 under the surface of the liquid seal and thence into the feed pipe 19 where it is conveyed upwardly into the furnace chamber 11 by means of the screw 20. At the temperature prevailing in the furnace the ingredients of the charge react with one another, liberating metal vapors which pass into the condenser 16, and also forming a residual slag. This slag is gradually worked upwardly in the cone 13 by the rotating rabble arms 22 and eventually drops into the slag pit 18. The slag near the top of the cone 13 serves as a thermal blanket, preventing too rapid a reaction of the ore charge entering the bottom of the cone and also shielding the liquid in the pipe 19 against the direct heat of the furnace. After operation for a considerable period of time, the apparatus may be shut down to remove the metal from the condenser 16 and to clean out the pit 18. Alternatively, the process may be made entirely continuous by providing for removal of the condensed metal and residual slag through barometric seals similar to that in the feed pipe 19.

The principle of the invention may also be employed in forms other than the one illustrated. Thus the feed screw 19 may be replaced by any other suitable conveying means. Again, when the reduction charge is in briquette form, the feed screws 20 and 27 may be eliminated altogether, the briquettes being introduced below the sur-

face of the liquid seal directly into the sleeve 24 and allowed to float up into chamber 11. In the apparatus, the barometric seal need not lead directly into the bottom of the furnace chamber as shown, but instead may terminate at any point from which the ore charge may fall or be conveyed into the furnace chamber.

As stated, the apparatus is particularly adapted to the reduction of oxide ores in which a pre-formed charge is heated, liberating a metal vapor and leaving a residual slag. Examples of such processes are the production of magnesium from calcined dolomite or calcined magnesite using carbon or ferro-silicon as the reducing agent, the liberation of metallic calcium from lime, etc. Such processes are carried out at temperatures in excess of 1000° C. and at an absolute pressure below 25 mm. of mercury. In these cases it is essential in the apparatus of the invention that the heavy fluid in the barometric seal be chemically inert to the reduction charge and also be substantially nonvolatile at the existing temperature and pressure. For the metallurgical processes mentioned, the heavy fluid is usually a molten heavy metal, preferably lead, tin, or a lead-tin alloy. In using a molten metal as a seal, it is essential that the barometric leg be heated so as to maintain the metal in the liquid state, and preferably at a temperature sufficiently high to prevent condensation in the barometric seal of the metal vapor liberated in the furnace. This heat may be supplied directly from the furnace chamber or better by auxiliary heating means as illustrated in the drawing.

It is to be understood that the foregoing description is illustrative rather than strictly limitative and that the invention is co-extensive in scope with the following claims.

We claim:

1. In a metallurgical furnace for use in processes wherein an ore charge is reduced, the combination of: a furnace chamber; heating means within the chamber; means for evacuating the chamber; a feed pipe for introducing an ore charge into the furnace chamber; and a barometric seal closing the feed pipe and formed of a heavy liquid which is substantially nonvolatile and is inert to the ore charge at the existing temperature and pressure.

2. In a metallurgical furnace for use in processes wherein an ore charge is reduced, the combination of: a furnace chamber; heating means within the chamber; means for evacuating the chamber; an inlet into the chamber; a barometric seal closing the inlet formed of a heavy liquid which is substantially non-volatile and is inert to the ore charge at the existing temperature and pressure; and conveying means within the said inlet and adapted to transfer solid material through the barometric seal into the furnace chamber.

3. In a metallurgical furnace for use in processes wherein an ore charge is reduced forming a metal vapor and leaving a residual slag, the combination of: a furnace chamber; electric heating means within the chamber; means for evacuating the chamber; a feed pipe for introducing an ore charge into the furnace chamber; a barometric seal closing the feed pipe and formed of a molten heavy metal selected from the class consisting of lead, tin, and lead-tin alloys; and means for maintaining said heavy metal at a temperature above its melting point.

4. In a metallurgical furnace for use in processes wherein an ore charge is reduced, forming

a metal vapor, the combination of: a furnace chamber; heating means within the chamber; means for evacuating the chamber; a closed condenser for metal vapor in communication with the chamber; a feed pipe for introducing an ore charge into the furnace chamber; and a barometric seal closing the feed pipe and formed of a heavy liquid which is substantially nonvolatile and is inert to the ore charge at the existing temperature and pressure.

5. In a metallurgical furnace for use in processes wherein an ore charge is reduced forming a metal vapor and leaving a residual slag, the combination of: a furnace chamber; heating means within the chamber; means for evacuating the chamber; a closed condenser for metal vapor in communication with the chamber; a closed residue pit adapted to receive residual slag from the furnace chamber; a feed pipe for introducing an ore charge into the furnace chamber; and a barometric seal closing the feed pipe and formed of a heavy liquid which is substantially nonvolatile and is inert to the ore charge at the existing temperature and pressure.

6. In a metallurgical furnace for use in processes wherein an ore charge is reduced forming a metal vapor and leaving a residual slag, the combination of: a furnace chamber; electric resistance heating means within the chamber; means for evacuating the chamber; a closed condenser for metal vapor in communication with the chamber; a closed residue pit adapted to receive residual slag from the furnace chamber; a feed pipe for introducing an ore charge into the furnace chamber; a barometric seal closing the feed pipe and formed of a molten heavy metal selected from the class consisting of lead, tin, and lead-tin alloys; means for maintaining said heavy metal at a temperature above its melting point; and conveying means for introducing the ore charge through said barometric seal into the furnace chamber.

7. In a metallurgical process wherein a reduction charge comprising an oxide ore is transferred into a furnace maintained at a high temperature and at reduced pressure without breaking the vacuum, the step which comprises transferring the said charge into the furnace chamber through a barometric seal formed by a heavy liquid which is substantially nonvolatile and is chemically inert to the ore charge at the existing temperature and pressure.

8. In a metallurgical process wherein a reduction charge comprising an oxide ore is transferred into a furnace maintained at a temperature above 1000° C. and at reduced pressure without breaking the vacuum, the step which comprises transferring the said charge into the furnace chamber through a barometric seal formed by a molten heavy metal which is substantially nonvolatile and is chemically inert to the ore charge at the existing temperature and pressure.

9. In a metallurgical process wherein a reduction charge comprising an oxide ore is transferred into a furnace maintained at a temperature above 1000° C. and at an absolute pressure below 25 mm. of mercury without breaking the vacuum, the step which comprises transferring the said charge into the furnace chamber through a barometric seal formed by a molten heavy metal selected from the class consisting of lead, tin, and lead-tin alloys.

JOSEPH D. HANAWALT.
CHARLES E. NELSON.