Sept. 4, 1956 R. A. WILKINS 2,761,672

FURNACES FOR GENERATING ZINC VAPORS

Filed April 13, 1953 3 Sheets-Sheet 1

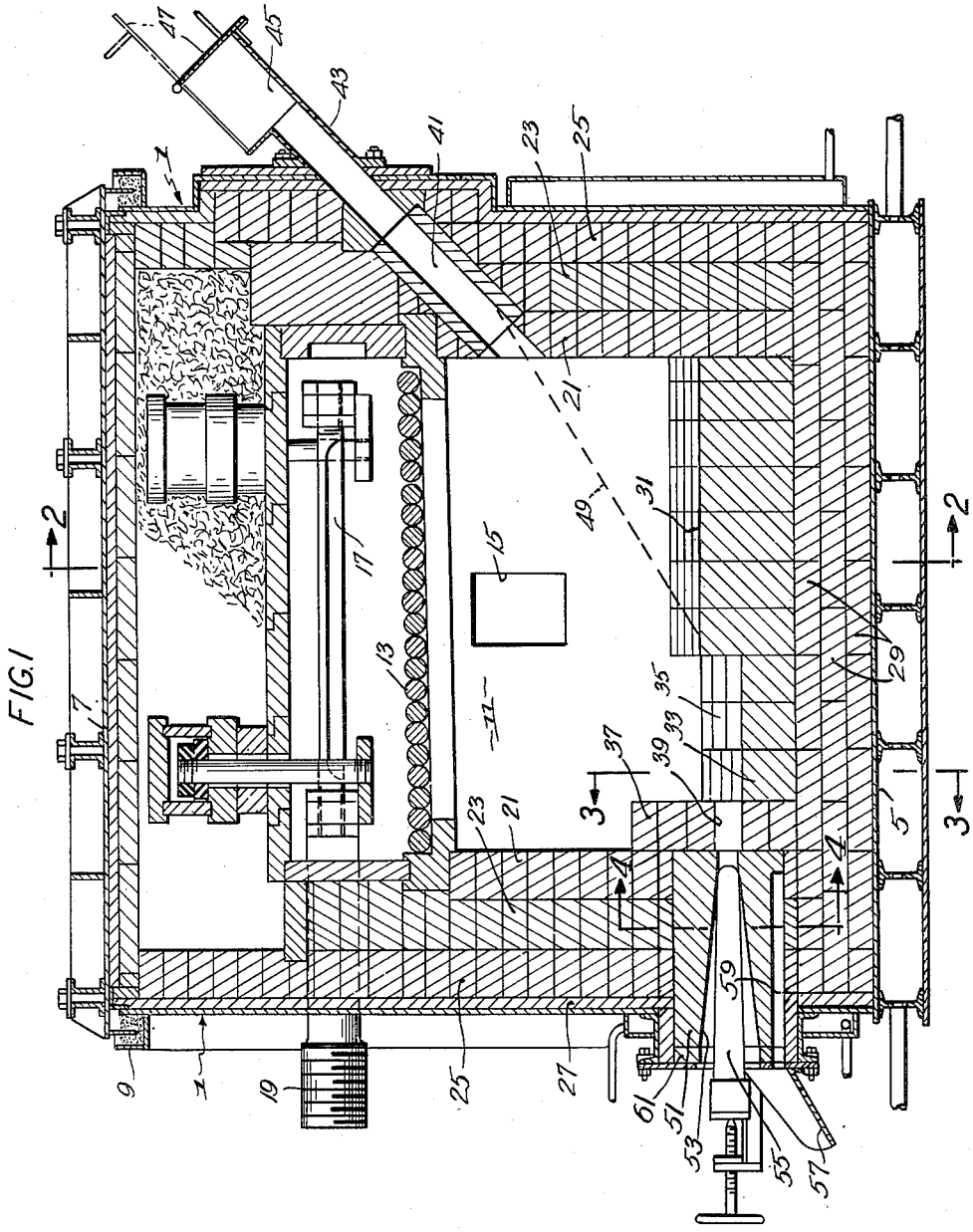



FIG. 1

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FIG. 2

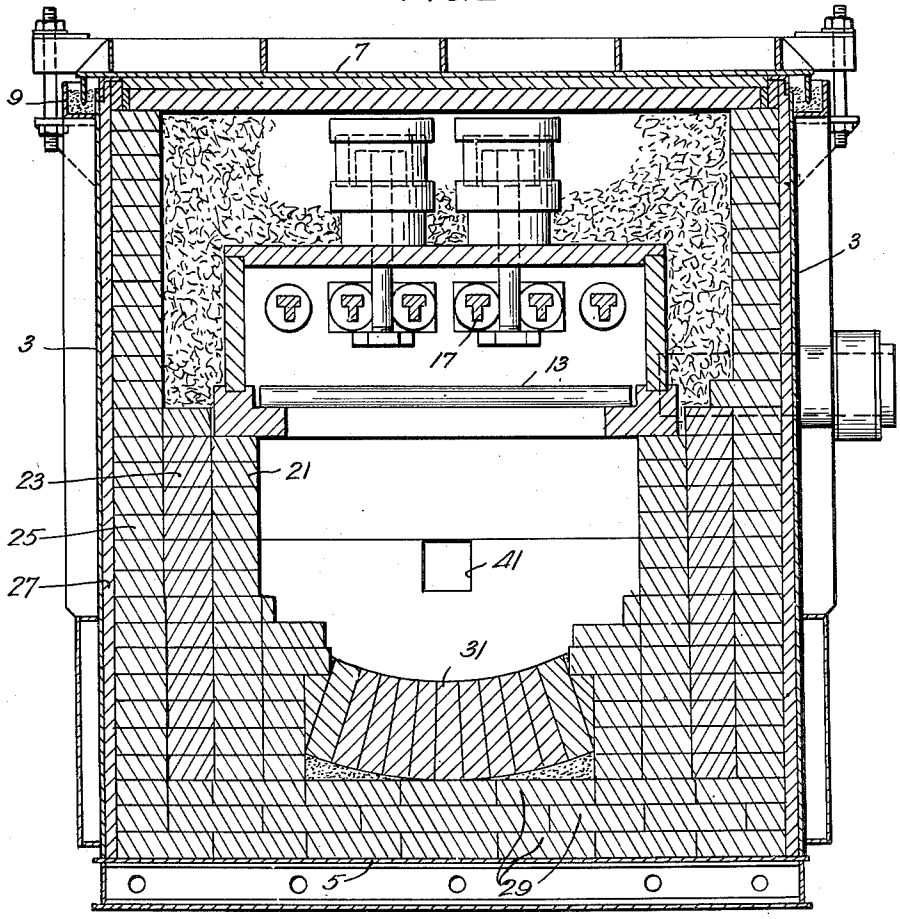



FIG. 3

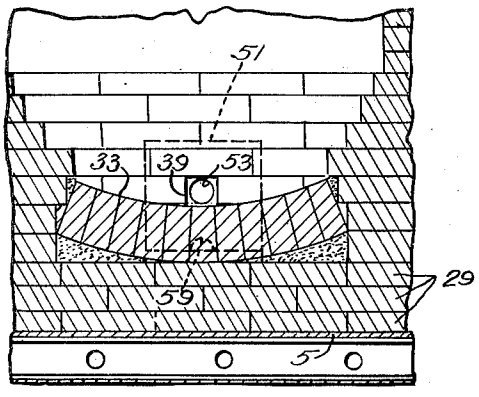
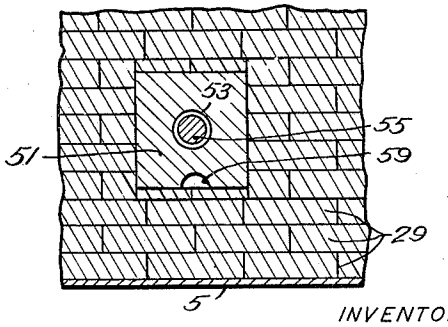



FIG. 4




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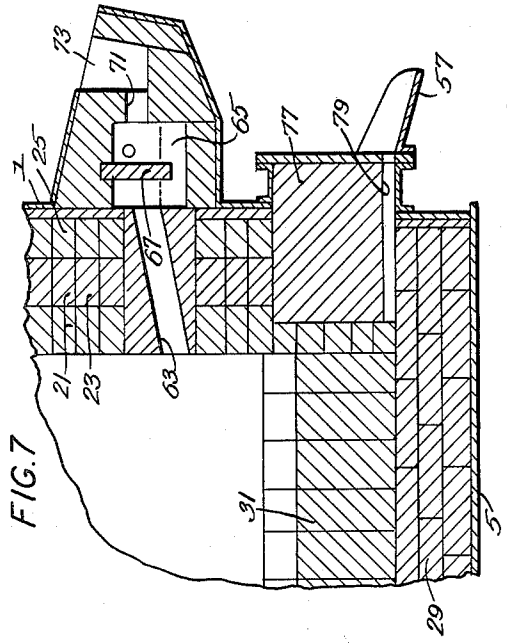



FIG. 7

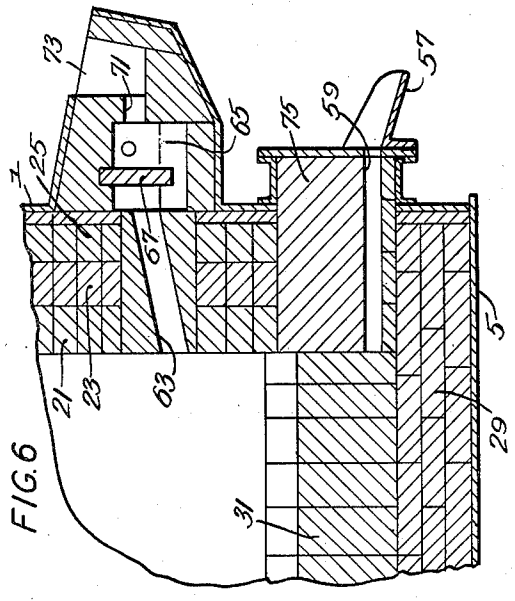



FIG. 6

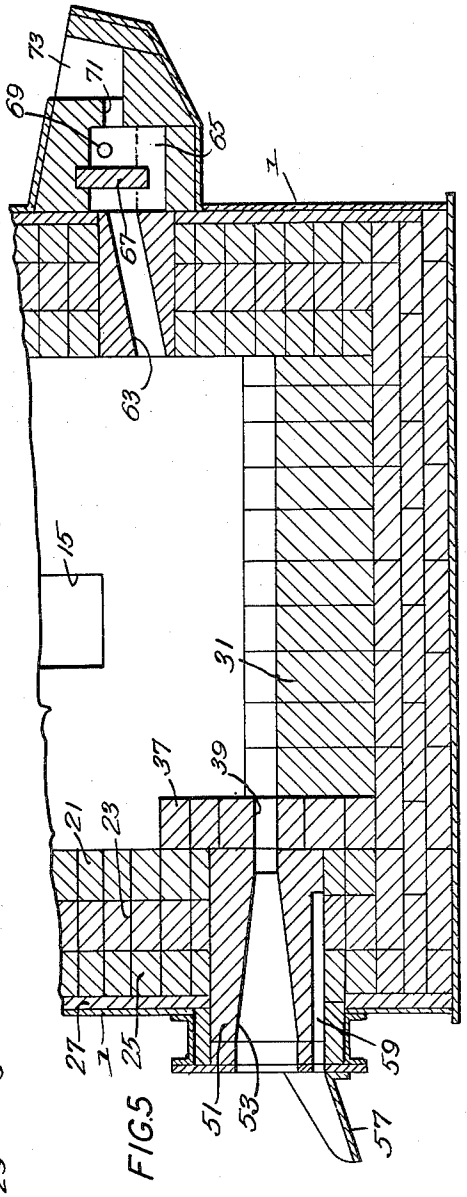



FIG. 5

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2,761,672

# FURNACES FOR GENERATING ZINC VAPORS

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Application April 13, 1953, Serial No. 348,433

8 Claims. (Cl. 266—24)

My invention relates to furnaces, particularly to electric furnaces for generating zinc vapors from zinciferous material and melting the residue of the zinciferous material and discharging it therefrom.

Furnaces according to the invention are particularly applicable for performing the operations disclosed by pending joint application of applicant and Kenneth A. Phillips, Serial Number 220,574, filed April 12, 1951, and by United States patent to Frank F. Poland 2,463,468, granted March 1, 1949, and from this aspect may be considered as constituting improvements in the furnaces disclosed by said application and patent.

In the drawings:

Fig. 1 is a longitudinal section of a furnace constructed according to the invention;

Figs. 2, 3 and 4 are sections on the lines 2—2, 3—3 and 4—4, respectively, of Fig. 1;

Fig. 5 is a fragment of a longitudinal section of a modified form of furnace;

Fig. 6 is a fragment of a longitudinal section of a further modified form of furnace; and

Fig. 7 is a fragment of a longitudinal section of a still further modified form of furnace.

The furnace according to Figs. 1 to 4 is a zinc smelting furnace generally like that disclosed by the above mentioned pending application. It comprises an exterior air-tight box-like casing, preferably of steel, having the opposite side walls 1 and 3, bottom wall 5, and removable top wall or cover 7, the joint between the top wall and side walls being rendered air-tight by the seal 9 extending entirely around the furnace.

Interiorly the furnace is formed to provide a furnace chamber 11 divided into upper and lower portions by a partition formed of graphite bars 13. The portion of the chamber below the partition constitutes the laboratory and zinc vapor space of the chamber, from which latter the zinc vapors discharge through a conduit 15 to a condenser (not shown) where the vapors are condensed to liquid zinc.

Above the partition formed by the bars 13 is suspended in insulated relation to the rest of the furnace a heating grid comprising graphite electric heating resistors 17, the terminals 19 of the grid being located at the exterior of the casing.

The side walls of the portion of the furnace casing surrounding the vapor space of the furnace chamber are operatively lined with brickwork or the like comprising the inner courses of bricks or blocks 21 of highly refractory material such as alumina, intermediate courses of insulating firebrick 23, and outer courses of ordinary firebrick 25, there being interposed between the latter and the casing a layer 27 of refractory resilient lagging to take up the expansion of the brickwork when it is heated.

The bottom wall of the casing is operatively lined by brickwork or the like, the lower portion of which comprises the superimposed courses of firebrick 29, on which courses the brickwork forming the side walls of the furnace chamber rests. Supported on the courses of firebrick 29 between the side walls of the furnace chamber and forming the upper portion of the bottom wall of the furnace is a layer of wedge-shaped bricks or blocks 31 and 33 preferably of alumina or hard carbon, the bricks or blocks 33 being of less thickness vertically than the blocks 31 so as to form a pit 35 at the left hand side of the furnace chamber as viewed in Fig. 1. As shown, the course of blocks 33 does not extend entirely to the adjacent side wall of the furnace, the space between the two being formed by courses of readily replaceable wear resistant blocks 37, formed of heat refractory material such as hard carbon or alumina, one of these blocks as shown being laid to form a taphole 39 communicating with the pit adjacent its bottom.



As shown, one of the side walls of the furnace is provided with a downwardly inclined charging port 41 having a metallic extension 43 at the exterior of the furnace carried by the adjacent side walls of the furnace casing. At its outer end this extension is formed to provide a box-like enlargement 45 having a normally closed hinged air-tight lid 47, which latter may be opened to permit the furnace to be charged with granular oxidized zinciferous material mixed with granulated reaction carbon as, for example, roasted zinc ore concentrate mixed with broken up coke of relatively small particle size. This mixture forms on the bottom of the chamber at one side of the pit 35 a mass of mixture having a downwardly sloping upper surface 49, the mixture being charged from time to time to maintain such mass.

The heat radiated by the resistors 17 heats the partition formed of the bars 13, which heat is radiated downward on the upper surface of the mass of mixture and into the pit. This heat causes reaction between the oxidized zinciferous material and the reaction carbon at the upper sloping surface of the charge, to produce zinc vapors and gaseous reaction products. It also melts at the upper sloping surface of the charge the slag from the mixture, which slag gravitates down said surface to the space between the lower edge of said surface and the pit, and flows into and collects in the pit. In practice the temperature in the vapor space of the furnace chamber may be about 2800° F., while the temperature of the upper sloping surface of the mass of mixture, due to the endothermic nature of the reaction, will not exceed about 2300° F. The slag in the pit, under these conditions, will be heated to about 2400° F.

Extending through the side wall of the furnace is shown a block 51 provided with a taphole 53 aligned and communicating with the taphole 39, the taphole 53 being normally closed by a removable plug 55 of known construction. Upon removal of the plug the molten slag will discharge through the aligned tapholes 39 and 53 to the exterior of the furnace and be caught by a spout 57 for discharging it into a convenient receptacle.

The brickwork and the like forming the side and bottom walls of the furnace chamber is of such thickness with relation to its heat conductivity as to maintain the metallic furnace casing at a temperature below that at which it will soften, preferably a temperature not greater than about 350 to 400° F. It will be observed that the brickwork forming the side walls is exposed to the vapor space of the furnace chamber. Consequently such vapor unavoidably enters the interstices of the side walls, which walls and the bottom wall are laid dry. At an intermediate portion of the thickness of said walls the vapors condense to liquid zinc, and adjacent the metal casing such liquid zinc solidifies, resulting in there being three zones of zinc in the interstices of the side walls, namely, an inner zone in which the zinc is in vapor form, an intermediate zone in which it is in liquid form, and an outer zone in which it is in solid form. This liquid zinc, it

has been found, percolates downward through the interstices of the side walls to the interstices of the bottom wall, tending, if means are not provided to prevent it, to fill the interstices of the bottom wall intermediate its thickness with liquid zinc, such also seeping into the pit.

Liquid zinc being a good conductor of heat will, if it is permitted to fill the interstices of the bottom wall and seep into the pit as above described, prevent proper heating of the bottom wall and the slag in the pit. It has been found, for example, that after about twenty-four hours of continued operation of the furnace, if means are not provided for draining the liquid zinc from such interstices and from the pit to a sufficiently low level below the bottom of the pit, the taphole from the pit becomes plugged with solidified slag, and a layer of solidified slag is formed intermediate the height of the pit on the liquid zinc therein, with a layer of liquid slag above the solidified layer thereof. The conductivity of the liquid zinc is such that the slag cannot be effectively melted to clear the taphole or remove the solidified layer of slag in the pit by raising the temperature of the furnace any practical amount. Inserting the usual hand operated bar through the taphole to free it and break the solidified layer of slag in the pit it has been found causes the molten slag above the solidified layer thereof to descend and contact the liquid zinc in the pit and the adjacent interstices of the bottom wall and violently explode the liquid zinc, because the melting point of the liquid slag, which is about 2200° F., is far in excess of the boiling point of zinc. Such explosions are exceedingly dangerous to the operator and result in severe damage to the furnace.

To avoid the above deleterious effects the block **51** is preferably made of highly heat conductive material, such as graphite, so that it will be heated by conduction from the inner hot portions of the furnace walls throughout its extent to a temperature above the melting point of zinc. By providing such block on its under side with a groove **59** opening at its outer end at the exterior of the furnace communication is established between the exterior of the furnace and the portion of the interstices of the bottom wall containing liquid zinc. This groove will therefore serve to drain liquid zinc from such interstices through the zone of solidified zinc adjacent the metal furnace casing to maintain the level of such liquid zinc in said interstices at a sufficiently low level to keep liquid zinc out of the pit and to permit all the slag in the pit and portion of the taphole inwardly of the plug **55** to be heated by radiation from above to such temperatures as will maintain it in molten state during normal operation of the furnace. In practice, after the furnace is in operation for about twenty-four hours, a small stream of liquid zinc will more or less continuously trickle from the outer end of the groove **59**.

The graphite block **51** tends to be heated to incandescence, and to prevent it from burning its outer end is preferably faced with a slab **61** of non-combustible refractory material such as alumina, while the space between the taphole **53** of said block and the plug **55** at the outer end of such space is normally filled with a readily broken away mass of fireclay (not shown).

The operations described by the above mentioned Poland Patent 2,463,468, briefly stated, comprise charging molten zinciferous material containing iron, such as galvanizing dross, at a temperature of about 1300° F., into a furnace chamber wherein it is heated to about 1700 to 2000° F. by radiation from above to evaporate zinc therefrom, the iron precipitating in solid form and collecting at the bottom of the furnace chamber, and, upon this precipitated iron accumulating, the charging and evaporating operations are temporarily discontinued and the furnace temperature raised to heat such iron to a temperature of about 2600° F. for melting it for permitting it to be discharged from the furnace chamber through a suitable normally plugged taphole.

The furnace for performing the operations described by the Poland Patent 2,463,468 may take the form of that illustrated by Fig. 5 which may be identical with that heretofore described except that no pit in the bottom wall of the furnace is provided and means are provided for entering molten charge instead of solid charge into the furnace chamber.

As shown in Fig. 5, one of the side walls of the furnace chamber is provided with a charging port **63** which communicates with a chamber **65** intermediate the height of the latter, this chamber being provided with a partition **67** extending downwardly to a point below the level of the point of communication of the port **63** with said chamber so as to form a trap for preventing escape of zinc vapors from the furnace chamber and entrance of air thereto, the metal in the chamber **65** being maintained in liquid state by a gaseous or liquid fuel torch discharging a combustible mixture or fluid into said chamber through the opening **69**. The molten dross is charged to the chamber **65**, and hence to the port **63**, through a passage **71** which communicates with an open top chamber **73** into which the molten dross from an exterior source is adapted to be ladled. This construction, for charging molten dross to the furnace chamber, is substantially identical with that described by said patent and need not be further described.

It has been found that collection of liquid zinc in the interstices of the bottom wall of the furnace according to Fig. 5 for performing the operations described in the Poland Patent 2,463,468 acts to prevent the residual iron from being effectively melted when the temperature of the furnace is raised in an attempt to melt such iron. This collection of molten zinc in said interstices may, however, be prevented in exactly the same way as described in connection with the furnace according to Figs. 1 to 4.

It will be understood that the means for preventing an excess of accumulation of molten zinc in the interstices of the bottom wall of the furnace need not be associated with the taphole **53**. For example, the opposite end of the furnace from the block **51** of Fig. 5 may be provided, as shown by Fig. 6, with the graphite block **75** identical with the block **51** except that the taphole is omitted, the groove **59** of the block **75** communicating with the interstices of the bottom wall of the furnace and acting in the same way to drain liquid zinc from said interstices as the like groove in the block **51**.

It will also be understood that the block **75** of Fig. 6 need not extend entirely through the wall of the furnace chamber, but may terminate short of such wall as indicated by the block **77** of Fig. 7, the block **77** being heated by conduction from the inner hotter portions of the furnace wall to maintain it at a sufficiently high temperature throughout its length to cause the liquid zinc which collects in the groove **79** of said block to be maintained liquid so that it may discharge from said groove to the exterior of the furnace.

The term "brickwork" is used for convenience of terminology in the appended claims as including bricks, blocks, slabs and other shapes adapted to be laid to form a wall.

It will be understood that within the scope of the appended claims wide deviations may be made from the forms of the invention herein described without departing from the spirit of the invention.

I claim:

1. Apparatus for generating zinc vapors from zinciferous material comprising means forming a furnace chamber comprising bottom and lateral walls, heating means above said bottom wall for heating zinciferous material charged to said chamber for generating zinc vapors from such material, discharge means from said chamber for the zinc vapors, the said means forming said chamber having an exterior metal casing which is operatively lined by said bottom and lateral walls, which walls are of such thickness with relation to their heat conductivities as to maintain said casing and the adjacent por-

tions of said walls at a reduced temperature below the melting point of zinc and comprise brickwork at a side of said chamber and its bottom, the brickwork at the side of said chamber being exposed to the zinc vapor space of said chamber whereby zinc vapors unavoidably enter the interstices of such brickwork and condense to liquid zinc intermediate its thickness and percolate downward through such interstices to those of the brickwork of the bottom wall of said chamber, and means for draining to the exterior of said casing liquid zinc which collects in the interstices of said bottom wall comprising material of high heat conductivity extending through such wall from adjacent said chamber to adjacent said casing forming a drainage conduit in communication with such interstices.

2. Apparatus according to claim 1 in which the means forming the conduit for draining liquid zinc from the interstices of the bottom wall comprises a block of graphite grooved on its lower side to form such conduit, the open side of such groove communicating with the interstices of said bottom wall.

3. Apparatus for generating zinc vapors from zinciferous material comprising means forming a furnace chamber comprising bottom and lateral walls, heating means above said bottom wall for heating zinciferous material charged to said chamber for generating zinc vapors from such material, discharge means from said chamber for the zinc vapors, the said means forming said chamber having an exterior metal casing which is operatively lined by said bottom and lateral walls, which walls are of such thickness with relation to their heat conductivities as to maintain said casing and the adjacent portions of said walls at a reduced temperature below the melting point of zinc and comprise brickwork at a side of said chamber and its bottom, the brickwork at the side of said chamber being exposed to the zinc vapor space of said chamber whereby zinc vapors unavoidably enter the interstices of such brickwork and condense to liquid zinc intermediate its thickness and percolate downward through such interstices to those of the brickwork of the bottom wall of said chamber, means forming a taphole communicating with said chamber adjacent the bottom thereof for discharging residue of such zinciferous material therefrom, said last mentioned means comprising material of high heat conductivity extending through said walls from adjacent said chamber to adjacent the exterior of said casing and formed to provide a conduit communicating with the interstices of said bottom wall for draining liquid zinc therefrom.

4. Apparatus for generating zinc vapors from zinciferous material comprising means forming a furnace chamber comprising bottom and lateral walls, heating means above said bottom wall for heating zinciferous material charged to said chamber for generating zinc vapors from such material, discharge means from said chamber for the zinc vapors, the said means forming said chamber having an exterior metal casing which is operatively lined by said bottom and lateral walls, which walls are of such thickness with relation to their heat conductivities as to maintain said casing and the adjacent portions of said walls at a reduced temperature below the melting point of zinc and comprise brickwork at a side of said chamber and its bottom, the brickwork at the side of said chamber being exposed to the zinc vapor space of said chamber whereby zinc vapors unavoidably enter the interstices of such brickwork and condense to liquid zinc intermediate its thickness and percolate downward through such interstices to those of the brickwork of the bottom wall of said chamber, means forming a taphole communicating with said chamber adjacent the bottom thereof for discharging residue of such zinciferous material therefrom, said last mentioned means comprising material of high heat conductivity extending through said walls from adjacent said chamber to adjacent the exterior of said casing and formed to provide on its under side a



longitudinally extending groove the open side of which communicates with the interstices of said bottom wall for draining liquid zinc therefrom.

5. Apparatus for generating zinc vapors from zinciferous material comprising means forming a furnace chamber comprising bottom and lateral walls, heating means above said bottom wall for heating zinciferous material charged to said chamber for generating zinc vapors from such material, discharge means from said chamber for the zinc vapors, the said means forming said chamber having an exterior metal casing which is operatively lined by said bottom and lateral walls, which walls are of such thickness with relation to their heat conductivities as to maintain said casing and the adjacent portions of said walls at a reduced temperature below the melting point of zinc and comprise brickwork at a side of said chamber and its bottom, the brickwork at the side of said chamber being exposed to the zinc vapor space of said chamber whereby zinc vapors unavoidably enter the interstices of such brickwork and condense to liquid zinc intermediate its thickness and percolate downward through such interstices to those of the brickwork of the bottom wall of said chamber, means forming a taphole communicating with said chamber adjacent the bottom thereof for discharging residue of such zinciferous material therefrom, said last mentioned means comprising material of graphite extending through said walls from adjacent said chamber to adjacent the exterior of said casing and formed to provide a conduit communicating with the interstices of said bottom wall for draining liquid zinc therefrom.

6. Apparatus for generating zinc vapors from zinciferous material comprising means forming a furnace chamber comprising bottom and lateral walls, heating means above said bottom wall for heating zinciferous material charged to said chamber for generating zinc vapors from such material, discharge means from said chamber for the zinc vapors, the said means forming said chamber having an exterior metal casing which is operatively lined by said bottom and lateral walls, which walls are of such thickness with relation to their heat conductivities as to maintain said casing and the adjacent portions of said walls at a reduced temperature below the melting point of zinc and comprise brickwork at a side of said chamber and its bottom, the brickwork at the side of said chamber being exposed to the zinc vapor space of said chamber whereby zinc vapors unavoidably enter the interstices of such brickwork and condense to liquid zinc intermediate its thickness and percolate downward through such interstices to those of the brickwork of the bottom wall of said chamber, means forming a taphole communicating with said chamber adjacent the bottom thereof for discharging residue of such zinciferous material therefrom, said last mentioned means comprising material of graphite extending through said walls from adjacent said chamber to adjacent the exterior of said casing and formed to provide on its under side a longitudinally extending groove the open side of which communicates with the interstices of said bottom wall for draining liquid zinc therefrom.

7. Zinc smelting apparatus comprising means forming a furnace chamber having bottom and lateral walls, means for charging oxidized zinciferous material mixed with reaction carbon to said chamber to form and maintain on the upper surface of said bottom wall a mass of such charge having an upper surface which slopes downwardly heating means above said bottom wall for radiating heat downward on such charge for generating zinc vapors therefrom and causing molten slag from said charge to gravitate down said sloping surface, said bottom wall being formed to provide a pit for receiving such slag, the said means forming said chamber having an exterior metal casing which is operatively lined by said walls, which walls are of such thickness with relation to their heat conductivities as to maintain said casing and the adjacent portions of

said walls at a reduced temperature below the melting point of zinc and comprise brickwork at the side of said chamber and its bottom, the brickwork at the side of said chamber being exposed to the zinc vapor space of said chamber whereby zinc vapors unavoidably enter the interstices of such brickwork and condense to liquid zinc intermediate its thickness and percolate downward through such interstices to those of the brickwork of the bottom wall of said chamber, means forming a taphole for discharging molten slag from said pit to the exterior of said casing, and separate means for draining to the exterior of said casing liquid zinc which collects in the interstices of said bottom wall comprising material of high heat conductivity extending through such wall from adjacent said chamber to adjacent said casing forming a drainage conduit in communication with such interstices.

8. Zinc smelting apparatus comprising means forming a furnace chamber having bottom and lateral walls, means for charging oxidized zinciferous material mixed with reaction carbon to said chamber to form and maintain on the upper surface of said bottom wall a mass of such charge having an upper surface which slopes downwardly, heating means above said bottom wall for radiating heat downward on such charge for generating zinc vapors therefrom and causing molten slag from said charge to gravitate down said sloping surface, said bottom wall being formed to provide a pit for receiving such slag, the said means



forming said chamber having an exterior metal casing which is operatively lined by said walls, which walls are of such thickness with relation to their heat conductivities as to maintain said casing and the adjacent portions of said walls at a reduced temperature below the melting point of zinc and comprise brickwork at the side of said chamber and its bottom, the brickwork at the side of said chamber being exposed to the zinc vapor space of said chamber whereby zinc vapors unavoidably enter the interstices of such brickwork and condense to liquid zinc intermediate its thickness and percolate downward through such insterstices to those of the brickwork of the bottom wall of said chamber, and means forming a taphole for discharging molten slag from said pit to the exterior of said casing comprising material of high heat conductivity extending from adjacent a side wall of said pit to adjacent said casing and formed to provide a groove the open side of which communicates with the interstices of said bottom wall for draining liquid zinc therefrom for discharge at the exterior of said casing.

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