Dec. 28, 1948. E. C. HANDWERK ET AL 2,457,549

APPARATUS FOR CONDENSING ZINC VAPOR

Filed July 1, 1947

2 Sheets-Sheet 1

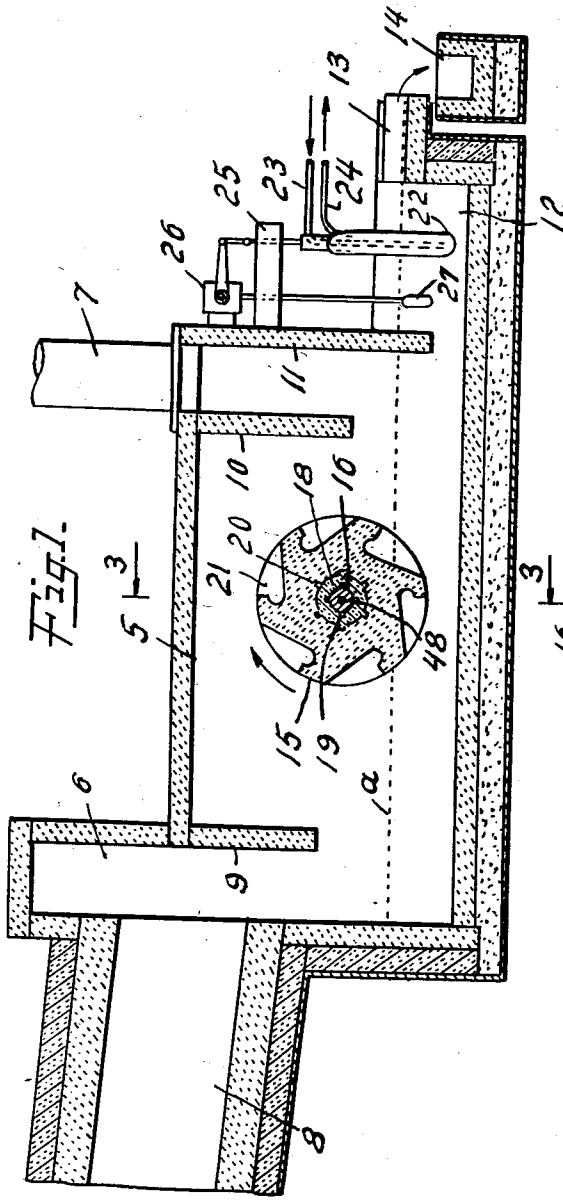


Fig. 1.

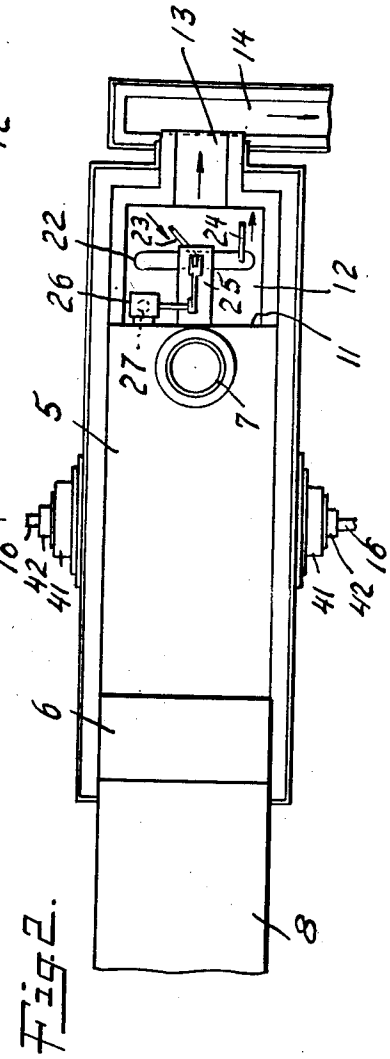


Fig. 2.

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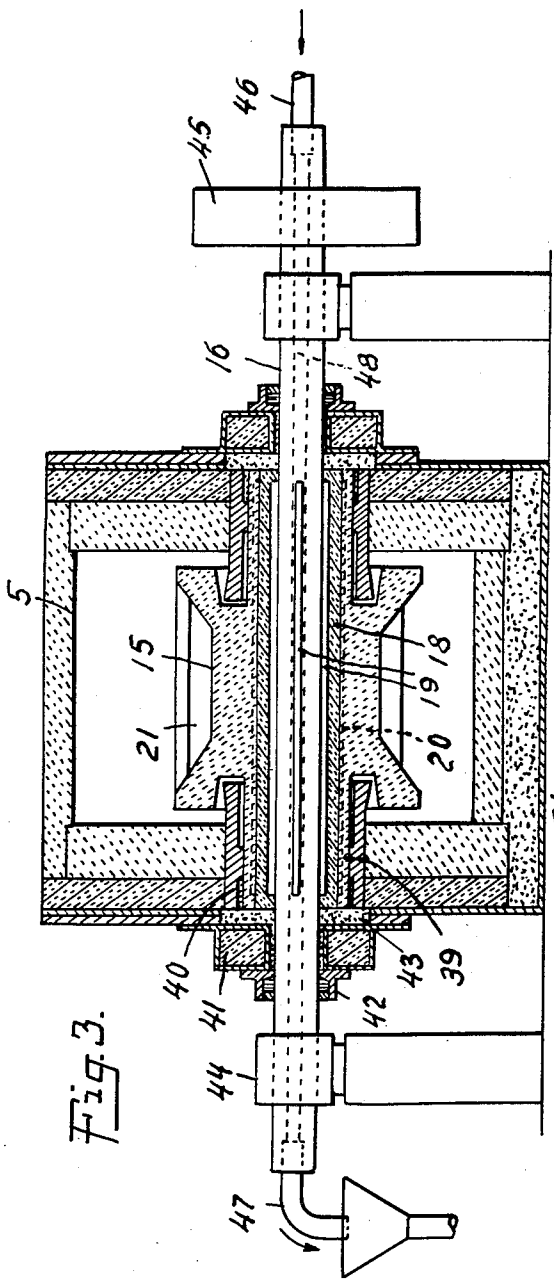


Fig. 3.

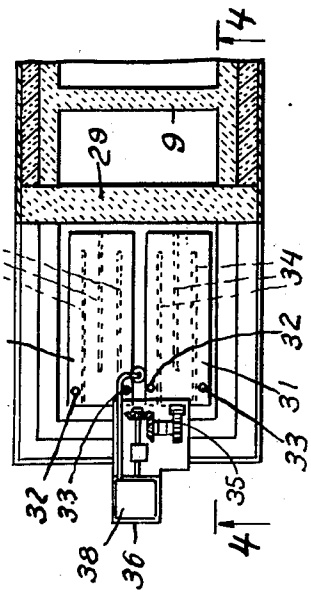


Fig. 5.

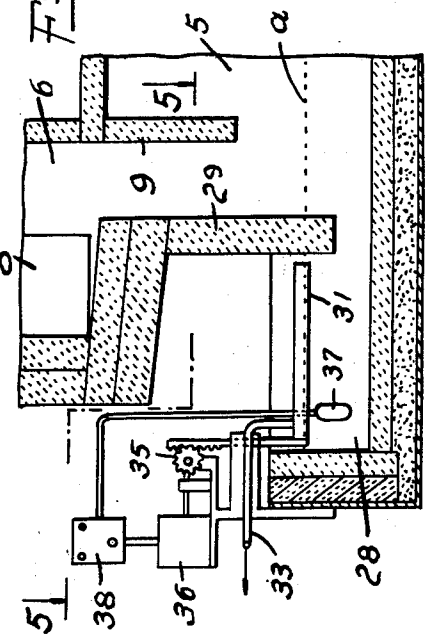


Fig. 4.

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UNITED STATES PATENT OFFICE

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APPARATUS FOR CONDENSING ZINC VAPOR

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Application July 1, 1947, Serial No. 758,288

3 Claims. (Cl. 266—15)

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This invention relates to condensing zinc vapor, and has for its object an improved condenser for zinc vapor. This application is a continuation in part of our application Ser. No. 678,540, filed June 22, 1946.

In the customary pyrometallurgical practices of smelting zinc ores, the zinc is recovered as molten metal by condensing the zinc vapor contained in the gaseous products of the smelting operation. In continuously operated smelting equipment, such as modern externally heated retorts or electro-thermally heated retorts, the zinc vapor diluted with ordinary smelting gases, such as carbon monoxide and the like, is passed through a condenser in which an operating temperature is maintained for effective condensation of the zinc vapor to molten zinc. This temperature may advantageously be of the order of from 500 to 550° C. Since the gas frequently enters the condenser at a temperature at least 300° C. higher than the proper operating temperature, it is customary in such cases to thermally associate with the condenser suitable heat-dissipating means for maintaining the proper temperature, and especially is this so with zinc smelting equipment of relatively large capacity. In the copending patent application of ourselves and Harry C. Haupt, Serial No. 626,508, filed November 3, 1945, there is disclosed a splash zinc condenser in which the heat-dissipating means for the condensing chamber are cooling jackets thermally associated with the outside walls of the chamber, and in a companion application Ser. No. 633,004, filed December 5, 1945, we describe the positioning of positive artificial cooling means within the condensing chamber itself.

A characteristic feature of the splash condenser described in the aforementioned applications is the provision of a substantial volume of molten zinc in the bottom of the condensing chamber, which is kept under continuous agitation and which communicates with another body of molten zinc in a discharge well exterior of the condensing chamber. While investigating the performance of this splash condenser under commercial operating conditions, we have discovered that it is possible to maintain a proper operating temperature within the condensing chamber by appropriate dissipation of heat from the body of molten metal in the discharge well. Thus, by direct artificial cooling of the molten metal in the discharge well, we have found that sufficient heat can be withdrawn from the communicating body of molten zinc in the condensing

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chamber to maintain the proper operating temperature of the chamber.

Accordingly, the zinc condenser of the present invention comprises a condensing chamber having a zinc vapor inlet and a gas outlet and adapted to hold a body of molten zinc and having a well communicating directly with said chamber adapted to hold a body of molten zinc in communication with molten zinc in the chamber. A rotor is provided with peripherally disposed pockets capable upon rotation of the rotor of agitating molten zinc in the condensing chamber to facilitate circulation of molten zinc between said bodies thereof and capable of hurling molten zinc from said body thereof within the condensing chamber into the upper portion of the chamber in the path of zinc vapor passing therethrough. Means are provided for rotating the rotor, and a cooling shell is positioned in the molten zinc in the well. Means are advantageously provided for varying the submerged area of the cooling shell in response to temperature changes in one of the bodies of molten zinc. As more fully described hereinafter, two cooling shells may be provided, one of which is relatively fixed and the other movable to vary its submerged area.

The foregoing and other novel features of the invention will be best understood from the following description taken in conjunction with the accompanying drawings, in which

Fig. 1 is a longitudinal sectional elevation of a condenser embodying the invention,

Fig. 2 is a top plan view of the condenser,

Fig. 3 is a transverse sectional elevation on the section line 3—3 of Fig. 1, and

Figs. 4 and 5 are fragmentary longitudinal sectional elevation (section line 4—4 of Fig. 5) and top plan partly in section 5—5 of Fig. 4), respectively, of the condenser with a second cooling well at its other end.

The condenser illustrated in the drawing is of the splash type described in the aforementioned applications, to which reference is made for a fuller description of such features of construction as are not directly concerned with the present invention and hence not herein illustrated and described. As shown in the drawings, the condenser comprises a generally rectangular condensing chamber 5 having a zinc vapor inlet 6 aproximate one end and an exhaust or waste gas outlet 7 approximate its other end, and is lined with suitable refractory material. The zinc vapor inlet 6 is connected by a pipe 8 to a source of zinc vapor, such as a vertical zinc smelting retort.

The zinc vapor inlet 6 and the gas outlet 7 are shielded by depending refractory baffles 9 and 10, respectively, to prevent splashing or spraying of molten zinc into the inlet or outlet.

The condensing chamber communicates, beneath the lower edge of its end wall 11, with a discharge well 12 having an overflow spout 13 determining the level (a) of the body of molten zinc in the collecting chamber. A collecting trough 14 receives the molten metal overflowing the spout 13 and conveys it to casting equipment or the like. The lower portion of the end wall 11 dips into the molten metal between the condensing chamber and the communicating discharge well and seals the condensing chamber from the atmosphere at this point. The overflow spout 13 and trough 14 may be dispensed with, and molten metal manually dipped or otherwise suitably removed from the well 12 for casting, storage or other purpose. As zinc vapor condenses in the chamber 5, the resulting molten zinc collects in the body of molten zinc in the chamber, and molten zinc is removed from the well 12 by continuous overflow, by dipping at periodic intervals, or in any other suitable manner to maintain, for all practical purposes, a substantially constant volume of molten zinc in the chamber.

A generally cylindrical rotor 15 is mounted within the condensing chamber 5. The rotor is carried by a hollow or axially bored metal shaft 16 mounted in bearings outside the condenser. The shaft 16 is horizontally disposed and extends through the side walls of the condensing chamber between the zinc inlet and the gas outlet in a direction generally transverse to the direction of gas flow through the chamber. The rotor may be constructed of graphite, silicon carbide or other suitable refractory, and is separated from direct contact with the shaft 16 by a sleeve 18 of insulating cement. The shaft 16 has a plurality of circumferentially spaced peripheral ribs 19 embedded in the cement sleeve, and the bore of the rotor has a plurality of spaced recesses 20 filled with the cement of the sleeve, so that the shaft, sleeve and rotor are effectively keyed together. The shaft 16 is cooled by the flow of a cooling medium, such as water, through its axial bore.

The peripheral surface of the rotor 15 has a plurality of circumferentially spaced pockets or cups 21. The pockets have a generally scoop-like section with a relatively long advancing flat section and a shallow semi-circular depression at the inner end or bottom of the pocket. The shaft 16 is positioned at a level substantially above that of the molten zinc adapted to be held in the chamber 5, and the rotor 15 is of such outside diameter that its lowermost pocket is beneath the molten zinc level (a). The shaft 16 (and hence the rotor 15) is driven by an electric motor or other suitable source of power (not shown).

Artificial cooling means are operatively associated with the discharge well 12 to cool the body of molten zinc therein. While the artificial cooling means may be of any suitable type, satisfactory results are secured with a bayonet water-cooler depending from a suitable support or resting on the refractory floor or bottom of the well. As illustrated in the drawing, a metallic (e. g. iron) cooling shell 22 of substantial width and having water inlet and outlet pipes 23 and 24, respectively, is operatively supported by a frame 25 and depends into and substantially to the bottom of the well 12. Any other suitable cooling liquid may be circulated through the shell 22 instead of water.

In the practice of the invention in the condenser illustrated in the drawing, a continuous stream of gas containing zinc vapor enters the condensing chamber beneath the baffle 9 of the inlet 6, and flows in a generally horizontal direction through the chamber and beneath the baffle 10 to the exhaust gas outlet 7. Where the entering gas is derived from a vertical retort smelting operation, it will have a temperature of around 820–900° C., and will generally contain around 30 to 50% zinc vapor diluted for the most part with carbon monoxide gas. The rotor 15 is rotated at a relatively high speed, say around 150–200 R. P. M., clockwise as viewed in Fig. 1, so that the pockets 21 in rapid succession pick up and throw sheets or showers of molten zinc into the gas stream. The upwardly-directed and rapidly succeeding sheets or showers of molten metal splash into the shower or rain of molten metal particles falling through the chamber, and also splash against the baffle 9 and the roof of the condensing chamber, with the result that the condensing chamber is substantially filled with sheet-like showers and moving particles of molten zinc which form ideal nuclei for the condensation and subsequent coalescence of the zinc vapor.

The rotor 15 agitates the body of molten zinc in the bottom of the condensing chamber and the molten metal is hence in constant motion. The temperature of this body of molten zinc may be, for all practical purposes, taken as the operating temperature of the condensing chamber and hence of the condenser itself. In accordance with the invention, this body of molten zinc is maintained at the contemplated operating temperature by the dissipation or withdrawal of heat therefrom into the artificially cooled body of molten zinc in the discharge well. Thus, circulation of the cooling medium in the cooling shell 22 abstracts heat from the molten zinc in the well and as a consequence heat is withdrawn from the communicating molten zinc in the condensing chamber. Due to its agitated condition and its inherent good heat conductivity, the molten zinc in the condensing chamber readily gives up its heat to the artificially cooled communicating molten zinc in the discharge well. By properly controlling the artificial cooling applied to the molten zinc in the well, heat is withdrawn or dissipated from the molten zinc in the condensing chamber in such amounts and at such a rate as to maintain the proper operating temperature of the condenser, e. g. 500 to 550° C. At this operating temperature, substantially all of the zinc vapor is condensed, the condensed molten zinc is collected in the body of molten zinc in the condensing chamber, and molten zinc is withdrawn from the chamber into the discharge well.

The artificial cooling to which the molten zinc in the well 12 is subjected is advantageously regulated by varying the submerged area of the cooling shell 22. This may be done manually by lifting or lowering the shell, or by varying its inclination. Since the operating temperature of the condenser is indicated by the temperature of the molten zinc in the condensing chamber, the artificial cooling may advantageously be regulated by that temperature as obtained from a suitably positioned pyrometer or other temperature measuring instrument. Due to the agitation of the molten zinc in the condensing chamber, the molten zinc in the communicating well is in constant circulation and when the slight operating temperature differential between the two bodies of molten zinc for a particular condenser

has been ascertained, the artificial cooling may be regulated by the temperature of the molten zinc in the well. The artificial cooling may be automatically adjusted in response to temperature changes of the molten zinc in either the condensing chamber or well. Thus, as shown in Figs. 1 and 2, the submerged area of the cooling shell 22 is automatically regulated by a temperature-responsive actuating means 26 operatively connected to a pyrometer 27 positioned in the molten zinc in the well 12. If the temperature of the molten zinc in the well rises, the actuating means 26, responding to that temperature rise, lowers the shell 22, thereby increasing its submerged area and hence its cooling effect. If, on the other hand, the temperature of the molten zinc decreases, the actuating means 26 raises the shell 22 and thereby decreases its cooling effect. In this manner, the temperature of the molten zinc in the well is maintained within predetermined limits by regulating the cooling effect of the shell 22, and thereby the operating temperature of the condensing chamber is controlled. As previously stated, the pyrometer 27 may be positioned in the molten zinc in the condensing chamber, although it is generally more convenient and equally satisfactory to position it in the molten zinc in the well.

Molten zinc may be manually or otherwise dipped from the discharge well 12, instead of overflowing the spout 13 into the trough 14. Dipping is generally carried out at periodic but frequent intervals, and only such an amount of molten zinc is removed from the well at each dipping as to maintain, for practical purposes, a substantially constant volume of molten zinc in the condensing chamber. A certain minimum volume of molten zinc should be maintained in the well in order to provide an adequate heat reservoir for withdrawing heat from the condensing chamber and dissipating such heat through the artificial cooling means as well as to prevent freezing during such interruptions in condenser operation as occasionally occur in practice, and the depth of molten zinc in the well should be sufficient to permit adequate immersion of the cooling means. In practice, heat is dissipated from the molten zinc in the well at about the same rate that heat is withdrawn from the condensing chamber, and the molten zinc in the well is hence not unduly cooled. While the relative volumes of molten zinc in the condensing chamber and discharge well will depend upon the size and capacity of the condenser, and perhaps to a lesser degree upon the effectiveness of the agitation of the molten zinc in the chamber, the following example is indicative of these factors:

The condenser was of the splash type illustrated in the drawing and had a condensing capacity of about 6 tons of zinc per day of 24 hours. About 2000–2500 pounds of molten zinc was maintained in the condensing chamber and about 500 pounds in the discharge well, and the area of communication between the two bodies of molten zinc was of the order of one-half square foot. The rotor 15 lifted about 5000 pounds of molten zinc per minute. In other words, molten zinc in amount approximately equivalent to the body thereof in the condensing chamber was lifted from that body and thrown into the chamber by the rotor every 30 seconds. This resulted in a vigorous agitation of the molten zinc in the chamber which was transmitted to the communicating body of molten zinc in the well. The

operating temperature of the condensing chamber was maintained slightly above 500° C. by immersion of a water-cooled shell (22) in the molten metal in the well 12, the immersion area of the shell (of the order of about one-half square foot) being manually regulated in accordance with the temperature of the molten zinc in the well. With continuous overflow of molten zinc from the discharge well 12 into the trough 14, the temperature of the molten zinc in the well is 10–15° C. lower than that of the molten zinc in the condensing chamber. With manual dipping from the discharge well about 400 pounds of molten zinc is removed from the well, and the depth of molten zinc in the condensing chamber drops from about 7 inches to about 6 inches.

The external and communicating body of molten zinc need not be held in the discharge well of the condenser, but may be an equivalent externally positioned auxiliary cooling well in similar communication with the condensing chamber, as for example at the opposite end or at the side of the condenser. Aside from the fact that molten zinc is not ordinarily removed from such an auxiliary cooling well, the molten zinc therein is artificially cooled and functions in the same manner as herein described with respect to the molten zinc in the discharge well 12. An adequate depth of molten zinc should be maintained in the well 12 or equivalent cooling well to permit such immersion of the artificial cooling means as is required for the practice of the invention. With a water-cooled iron shell (12), a thin coating or crust of solidified zinc forms on the submerged area of the shell, but this does not adversely affect the cooling efficiency, and moreover protects the iron shell from corrosion by the molten zinc. While it is now our preferred practice to use a cooling shell for the dissipation of heat from the molten zinc in the cooling well, any other appropriate cooling means may be employed. Wherever situated, the area of communication between the condensing chamber and cooling well should be substantial, and preferably as large as practical, while effectively sealing the condensing chamber against the entrance of atmospheric air, in order to provide an adequate area of heat exchange between the communicating bodies of molten zinc and to provide some agitation or circulation of the molten metal in the cooling well in consequence of the agitation of the communicating body of molten zinc in the condensing chamber.

In Figs. 4 and 5 of the drawings, the other or rearward end of the condenser is provided with a molten zinc cooling well 28 communicating with the molten zinc in the condensing chamber 5. The pipe 8', connected to the source of zinc vapor, enters the zinc vapor inlet 6 at one side thereof. The lower portion of the rearward end wall 29 of the condensing chamber dips into the molten zinc between the chamber and the communicating well 28 and seals the condensing chamber from the atmosphere at this point. Two artificial cooling elements 30 and 31 are associated with the molten zinc in the well 28. These elements are flat metal shells with water inlet and outlet pipes 32 and 33, respectively, and have internal baffles 34 to provide a tortuous path for the cooling medium. They are immersed about ¼ to ½ inch in the molten zinc and together cover a substantial part of the surface area of the molten metal. One element 30 is fixed in position, and the other element 31 is movable into and out of the molten zinc in response to a predetermined decline or

rise, respectively, of the temperature of the molten zinc in the well 28. Thus, the element 31, suitably suspended, is operatively connected by a rack and pinion 35 to a temperature-responsive actuating means 36 operatively connected to a pyrometer 37 positioned in the molten zinc in the well 28. Changes in temperature of the molten zinc in the well 28 are transmitted from the pyrometer 37 to a "high" and "low" temperature control device 38. When the control device 38 moves to its "high" position it sets the actuating means 36 in operation to raise the cooling element 31 out of the molten zinc, and when the device 38 moves to its "low" position, it again sets the actuating means 36 in operation to lower the cooling element 31 until it is immersed to a predetermined depth in the molten zinc. In this manner the temperature of the molten zinc in the well 28 is automatically held within a predetermined range.

Where the condenser is provided with the cooling well 28, all of the artificial cooling and the automatic or manual control thereof may be effected in this well. Artificial cooling may also be effected, if desired, in the discharge well 12, and the cooling means in the well 12 may be fixed or movable, and if movable may be manually or automatically controlled.

As disclosed in the aforementioned applications Ser. Nos. 626,508 and 633,004, the rotor 15 has a laterally extending sleeve 39 at each end thereof surrounding the cement sleeve 18 where the latter extends through the wall of the condenser. The rotating sleeves 39 extend through stationary sleeves 40. The outer ends of the concentric sleeves 18, 39 and 40 are enclosed by a seal comprising a cap 41 of moulded asbestos and a gland bushing 42 through which the shaft 16 extends. The cap 41 presses tightly against the side wall of the condenser, and the space between the cap and the ends of the sleeves is filled with a suitable packing material 43 such as flake graphite. This type of seal for preventing the leakage of zinc vapor through the apertures in the side walls through which the shaft 17 extends has been found as effective as and in some case preferable to the gas seal described in the aforementioned applications.

The shaft 16, mounted in bearings 44 outside the condenser, has a drive pulley 45 secured thereto. Water inlet and outlet pipes 46 and 47, respectively, provide a flow of cooling medium through the axial bore 48 of the shaft 16.

We claim:

1. A condenser for zinc vapor comprising a condensing chamber having a zinc inlet and a gas outlet and adapted to hold a body of molten zinc, a well communicating directly with said chamber and adapted to hold a body of molten zinc in communication with molten zinc in the chamber, a rotor provided with peripherally disposed pockets capable upon rotation of the rotor of agitating molten zinc in the condensing chamber

to facilitate circulation of molten zinc between said bodies thereof and capable of hurling molten zinc from said body thereof within the condensing chamber into the upper portion of the chamber in the path of zinc vapor passing therethrough, means for rotating said rotor, and a cooling shell positioned in the molten zinc in said well.

2. A condenser for zinc vapor comprising a condensing chamber having a zinc vapor inlet and a gas outlet and adapted to hold a body of molten zinc, a well communicating directly with said chamber and adapted to hold a body of molten zinc in communication with molten zinc in the chamber, a rotor provided with peripherally disposed pockets capable upon rotation of the rotor of agitating molten zinc in the condensing chamber to facilitate circulation of molten zinc between said bodies thereof and capable of hurling molten zinc from said body thereof within the condensing chamber into the upper portion of the chamber in the path of zinc vapor passing therethrough, means for rotating said rotor, a cooling shell positioned in the molten zinc in said well, and means for varying the submerged area of the cooling shell in response to temperature changes of one of said bodies of molten zinc.

3. A condenser for zinc vapor comprising a condensing chamber having a zinc vapor inlet and a gas outlet and adapted to hold a body of molten zinc, a well communicating directly with said chamber and adapted to hold a body of molten zinc in communication with molten zinc in the chamber, a rotor provided with peripherally disposed pockets capable upon rotation of the rotor of agitating molten zinc in the condensing chamber to facilitate circulation of molten zinc between said bodies thereof and capable of hurling molten zinc from said body thereof within the condensing chamber into the upper portion of the chamber in the path of zinc vapor passing therethrough, means for rotating said rotor, two cooling shells operatively associated with said well and adapted to be immersed in molten zinc therein, one of said shells being relatively fixed and the other movable to vary the area thereof immersed in the molten zinc, and means for circulating water through said shells.

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The following references are of record in the file of this patent:

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Certificate of Correction

Patent No. 2,457,549. December 28, 1948.

ERWIN C. HANDWERK ET AL.

It is hereby certified that errors appear in the printed specification of the above numbered patent requiring correction as follows:

Column 2, line 39, before "5—5" insert an opening parenthesis; column 7, line 56, claim 1, after the word "zinc" insert *vapor*;

and that the said Letters Patent should be read with these corrections therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 3rd day of May, A. D. 1949.

[SEAL]

THOMAS F. MURPHY,
Assistant Commissioner of Patents.