Dec. 28, 1948. E. C. HANDWERK ET AL 2,457,546

PROCESS FOR CONDENSING ZINC VAPOR

Original Filed Dec. 5, 1945 2 Sheets-Sheet 1

Fig. 1.

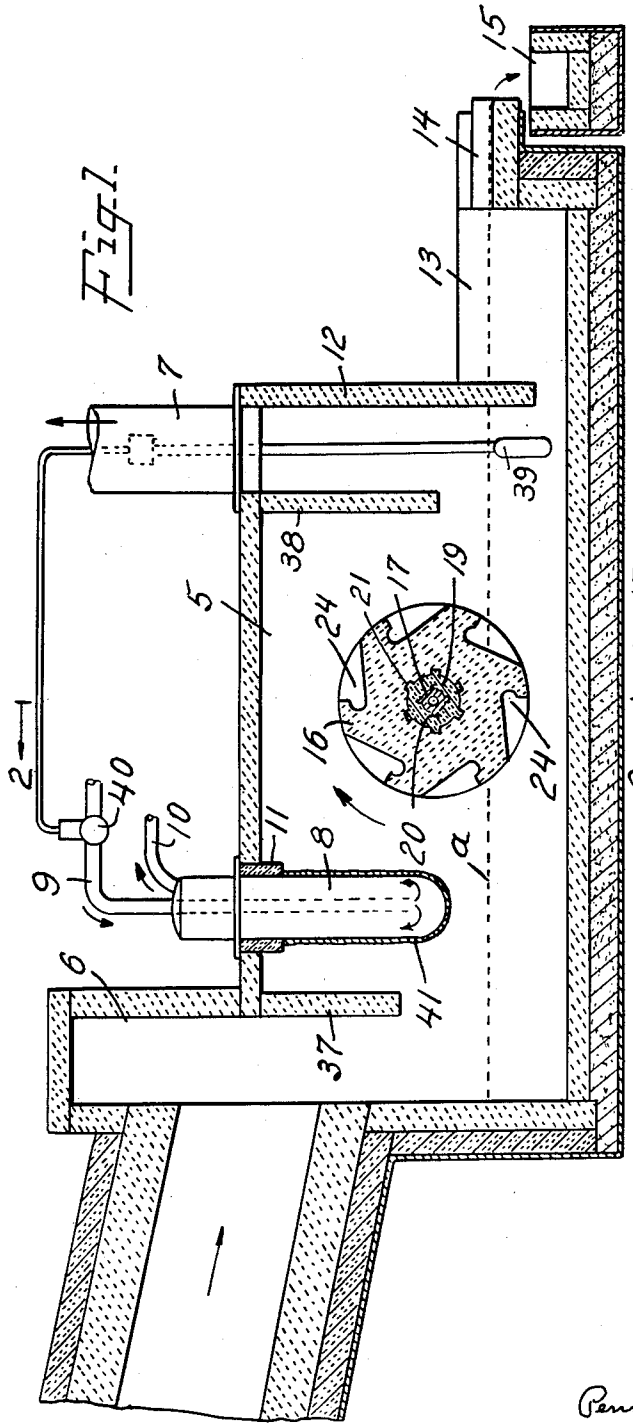
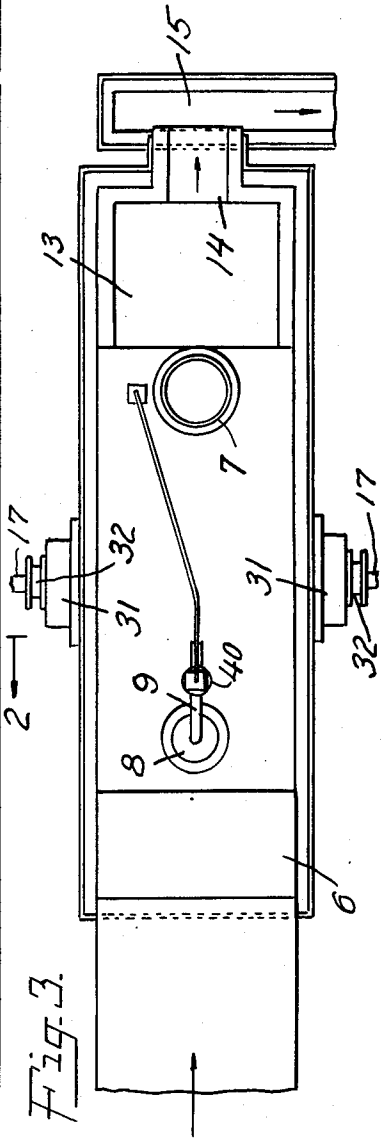



Fig. 3.




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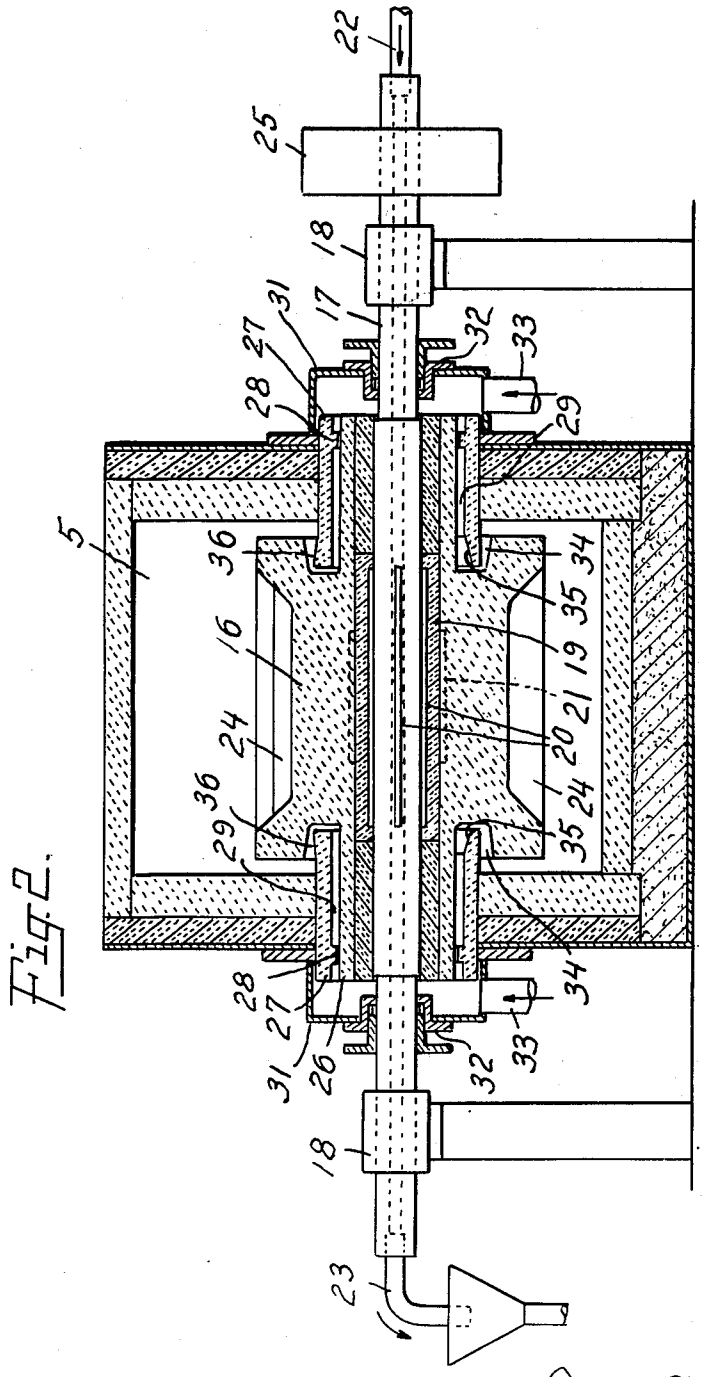



Fig. 2.

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# UNITED STATES PATENT OFFICE

2,457,546

## PROCESS FOR CONDENSING ZINC VAPOR

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Original application December 5, 1945, Serial No. 633,004. Divided and this application January 14, 1947, Serial No. 722,066

2 Claims. (Cl. 75—88)

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This invention relates to condensing zinc vapor, and has for its object the provision of an improved method of Process for condensing zinc vapor.

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. The condensers ordinarily used for condensing the zinc vapor produce a considerable amount of zinc dust or blue powder which usually is returned to the smelting operation. For example, the condensers heretofore used with modern externally-heated vertical zinc retorts commonly produce blue powder or zinc dust amounting to 7 to 15% of the output of zinc. It is ordinarily necessary to recirculate this blue powder through the vertical retorts, since it is usually not in the form of salable zinc dust and is difficult to melt down to liquid zinc with the use of the heretofore available equipment. A particular object of the invention is the provision of an improved method of condensing zinc vapor diluted with ordinary smelting gases, such as carbon monoxide and the like, with the formation of only a minimum amount of blue powder. The invention is particularly adapted for use with smelting equipment of relatively large capacity such as modern externally-heated vertical zinc retorts or electro-thermally heated retorts.

In accordance with the method of the invention, a gaseous stream containing the zinc vapor to be condensed is subjected to direct and positive artificial cooling within a condensing chamber having a body of molten zinc in the bottom thereof from whence rapidly succeeding upwardly-directed sheets or showers of molten zinc are thrown into the gaseous stream in the region of the artificial cooling. The upwardly-directed and rapidly succeeding sheets or showers of molten zinc splash against the walls and roof of the condensing chamber and against the artificial cooling means and thereby produce a shower or rain of molten zinc particles through which the gaseous stream passes. The artificial cooling means generally comprises a stream of extraneous cooling medium flowing through a confined path within the condensing chamber and out of direct contact with the zinc therein. Thus, the sheets of molten zinc hurled upwardly against the confining path of the cooling medium effect heat exchange between the zinc vapors and the cooling medium in said confined path through the medium of the molten zinc splashed on said confined path. Any zinc dust formed as a consequence of the direct artificial cooling is caught in the rain or shower of molten zinc particles and carried to the body of molten zinc in the bottom of the chamber and thereby effectively melted. The upwardly-directed showers or sheets of molten zinc are preferably produced by a generally cylindrical rotor having circumferentially-spaced peripheral pockets that successively dip into the molten zinc as the rotor is rotated, such as described in our copending application Ser. No. 626,508, filed November 3, 1945. The body of molten zinc in the condensing chamber is maintained within a predetermined temperature range by controlling the heat dissipated from the chamber as a consequence of the artificial cooling, and thereby the operating temperature of the condensing chamber is maintained.

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The foregoing and other novel features of the invention will be best understood from the following description taken in conjunction with the accompanying drawings, which illustrate, by way of example, a condenser in which the invention may advantageously be practiced, and in which

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

Fig. 2 is a transverse sectional elevation on the section line 2—2 of Fig. 1, and

Fig. 3 is a top plan view of the condenser.

The condenser illustrated in the drawings comprises a generally rectangular condensing chamber 5 having a zinc vapor inlet 6 approximate one end and an exhaust or waste gas outlet 7 approximate its other end. The condensing chamber is lined with suitable refractory material and is interiorly provided with artificial cooling means. While the artificial cooling means may be of any suitable type, satisfactory results are secured with a bayonet water-cooler depending from the roof of the chamber. As illustrated in the drawings, a metallic (e. g. iron) cooling shell 8 having water inlet and outlet pipes 9 and 10, respectively, is operatively supported in the roof of the condensing chamber, and depends into the chamber to a short distance above the normal molten zinc level (a) therein. The shell 8 should preferably not dip into the bath of molten zinc in the chamber, in order to avoid freezing the zinc bath if the supply of zinc vapor should be cut off, or, alternatively, any portion of the shell (or cooler) that traverses the zinc bath should be heat insulated. The portion of the shell adjacent the roof of the chamber is surrounded with heat insulation 11 so that frozen zinc will not bind the shell to the roof and thereby prevent its removal.

The condensing chamber 5 communicates, beneath the lower edge of its end wall 12, with a discharge well 13 having an overflow spout 14 determining the level (a) of the body of molten zinc in the condensing chamber. A collecting trough 15 receives the molten metal overflowing the spout 14 and conveys it to casting equipment or the like. The lower portion of the end wall 12 dips into the molten metal between the condensing chamber and the discharge well and seals the condensing chamber from the atmosphere at this point. The volume of molten zinc in the condensing chamber is thus maintained substantially constant by continuously withdrawing molten zinc from the chamber as zinc vapor is condensed therein.

A generally cylindrical rotor 16 is mounted within the condensing chamber 5. The rotor is carried by a hollow or axially-bored metal shaft 17 mounted in bearings 18 outside the condenser. The shaft 17 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 17 by a sleeve 19 of insulating cement. The shaft 17 has a plurality of circumferentially spaced peripheral ribs 20 embedded in the cement sleeve, and the bore of the rotor has a plurality of spaced recesses 21 filled with the cement of the sleeve, so that the shaft, sleeve and rotor are effectively keyed together. The shaft 17 is cooled by the flow of a cooling medium, such as water, through its axial bore, the cooling medium being supplied to the bore at one end of the shaft by a pipe 22 and discharged from the other end through a pipe 23.

The peripheral surface of the rotor 16 has a plurality of circumferentially spaced pockets or cups 24. The shaft 17 is positioned at a level substantially above that of the molten zinc adapted to be held in the chamber 5, and the rotor 16 is of such outside diameter that its lowermost pocket is beneath the molten zinc level (a). The rotor is rotated by means of a pulley 25 secured to the shaft 17 and operatively connected to a suitable source of power, such as an electric motor (not shown).

The condenser is provided with effective seals for preventing the leakage of zinc vapor through and the freezing of molten zinc in the apertures in the side walls through which the shaft 17 extends. Thus, the rotor 16 has a laterally extending sleeve 26 at each end thereof surrounding the cement sleeve 19 where the latter extends through the wall of the condenser. The rotating sleeves 26 extend through stationary sleeves 27. Each stationary sleeve 27 has a constricted portion 28, near its outer end, to provide a close clearance with the rotating sleeve 26, and is elsewhere spaced from the rotating sleeve to provide an elongated inner annular space 29. The outer ends of the concentric sleeves 19, 26 and 27 are enclosed in a gas seal comprising a tight fitting cap or housing 31 having a gland bushing 32 through which the shaft 17 extends. A suitable non-oxidizing gas, such for example as a portion of the exhaust gas exciting from the condenser through the outlet 7, is pumped into the caps 31 through the inlet pipes 33 to maintain a sufficiently high gas pressure within the caps to prevent zinc vapor and diluting gas from flowing outwardly between the stationary sleeves 27 and the rotating sleeves 26.



The sleeves 26 and 27 are so shaped that molten metal does not accumulate in the elongated annular space 29 between the sleeves, but on the contrary runs out by gravity into the molten zinc at the bottom of the condensing chamber. Thus, the ends of the stationary sleeves 27 extend into annular grooves 34 in the ends of the rotor 16, and the lower portions of these ends are internally beveled or thinned to form spouts 35 for discharging by gravity any molten metal entering the space 29 between the sleeves. The annular grooves 34 are outwardly flared to facilitate the flow of molten metal therefrom. The upper portion of the end of each sleeve 27 is beveled or thickened to form a backwardly sloping spout 36 for guiding any molten metal falling on or wetting the upper surface of the sleeve towards the condenser wall and thence downwardly over the sleeve to the body of molten metal.

In the practice of the invention in the condenser illustrated in the drawings, a continuous stream of gas containing zinc vapor enters the condensing chamber beneath a depending baffle 37 of the inlet 6, and flows in a generally horizontal direction through the chamber and beneath a depending baffle 38 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 to 900° C. and will generally contain around 30 to 50% zinc vapor diluted for the most part with carbon monoxide gas. Dissipation of heat from the condenser is controlled by regulating the water, or other cooling medium, flowing through the interior cooler 8, the operating temperature within the condensing chamber being thereby maintained at about 500 to 550° C. Since the operating temperature of the condensing chamber is indicated by the temperature of the molten zinc in the chamber, the artificial cooling may advantageously be regulated and controlled by that temperature as obtained from a suitably positioned pyrometer or other temperature measuring instrument. The contemplated condenser temperature is preferably maintained automatically by means of a pyrometer 39 positioned in the bath of molten condensed zinc (preferably near the discharge end of the condenser) and operatively associated with a valve 40 of the inlet pipe 9. The rate of flow of the cooling medium through the cooler 8, and hence its cooling effect, is automatically controlled by the pyrometer so that the temperature of the body of molten zinc in the condensing chamber is held within a desired predetermined range, thus controlling the operating temperature of the condensing chamber.

The rotor 16 is rotated at a relatively high speed, say around 100 to 150 R. P. M., clockwise as viewed in Fig. 1, so that the pockets 24 in rapid succession pick up small amounts of molten zinc and hurl or throw sheets or showers of molten zinc into the entering gas stream. The pockets 24 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 pockets terminate short of the circumferential peripheral ends of the rotor, so that little or no molten zinc is thrown laterally against the side walls of the condensing chamber. The upwardly-directed and rapidly succeeding sheets or showers of molten zinc splash into the shower or rain of molten zinc

particles falling through the chamber, and also splash against the cooler 8, the baffles 37 and 38, and the roof of the 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 zinc vapor, as well as an ideal atmosphere for dissolving or entrapping particles of zinc dust and carrying them to the molten zinc bath, where they promptly melt.

In the operation of the condenser, the cooler 8 becomes covered with a layer of solid zinc 41, since the zinc splashed on the cooler by the rotor freezes until thermal equilibrium is established. Any zinc dust produced by the cooling of the zinc vapor by the cooler is at once dissolved by the splashing molten zinc or promptly carried into the molten zinc bath and there dissolved. Since one square foot of cooler surface can remove about 5,000 B.t.u.'s per minute from the condenser, a relatively small cooler is adequate for condensing large amounts of zinc. Instead of the automatic control hereinbefore described, the flow of cooling medium through the cooler may be manually controlled from pyrometer readings.

Cooling of the shaft 17 permits the use of a metal shaft, and the sleeve 19 of insulating cement inhibits appreciable cooling of the condensing chamber by the cooling medium flowing through the shaft, and eliminates any thermal stresses in the rotor 16. The special configuration of the stationary sleeve 27 prevents the collection and freezing of zinc metal in the close clearance between the sleeves 26 and 27, and consequent stoppage of the drive shaft. The gas seals prevent the infiltration of air and the escape of zinc vapor through the rotating contact between the sleeves 26 and 27, and thus insure free relative movement of these sleeves.

While the invention is particularly applicable to the condensation of zinc vapor from the gaseous products of zinc smelting operations carried out in externally or electrically heated retorts, where the zinc vapor content is relatively high, it is also applicable to the condensation of zinc vapor from larger relative amounts of diluting gases. For example, the invention may be advantageously applied to condensing zinc vapor from the gases produced in zinc smelting operations carried out in blast or cupola furnaces, where the zinc vapor content of the gas may be as low as 2 to 5%, provided the carbon dioxide content of such gases is low enough and if the temperature is sufficiently below the zinc dew point. In all cases, the condensing efficiency is high, and the exhaust gas contains only a relatively small percentage of uncondensed zinc. While the artificial cooling means is preferably positioned to contact the gaseous stream in the initial stage of its passage through the chamber, it may be otherwise positioned at any suitable place in the chamber, since the rotor throws the splashing sheets or showers of molten zinc throughout the entire gas stream and thus splashes molten zinc on the cooling means wherever located between the baffles 37 and 38 above the metal bath.



The condenser illustrated in the accompanying drawings is the subject matter of our copending application Ser. No. 633,004, filed December 5, 1945, of which this application is a division.

We claim:

1. The method of condensing zinc vapor which comprises passing a gaseous stream containing zinc vapor through a condensing chamber having a body of molten zinc in the bottom thereof, subjecting the gaseous stream during its passage through the chamber to the cooling effect of a stream of extraneous cooling medium flowing through a confined path within the chamber and out of direct contact with the zinc therein, and hurling sheets of molten zinc from said body thereof upwardly against the confined path of said cooling medium in such manner that heat exchange between the zinc vapors in said gaseous stream and the cooling medium in said confined path is effected through the medium of the molten zinc splashed on said confined path.

2. The method of condensing zinc vapor which comprises passing a gaseous stream containing zinc vapor through a condensing chamber having a body of molten zinc in the bottom thereof, subjecting the gaseous stream during its passage through the chamber to the cooling effect of a stream of extraneous cooling medium flowing through a confined path within the chamber and out of direct contact with the zinc therein, and picking up in rapid succession from said body of molten zinc small amounts thereof and hurling the picked-up molten metal against the confined path of said cooling medium in such manner that heat exchange between the zinc vapors in said gaseous stream and the cooling medium in said confined path is effected through the medium of the molten zinc splashed on said confined path.

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HARRY C. HAUPT.


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## Certificate of Correction

Patent No. 2,457,546. 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 1, line 3, strike out the words "Process for"; line 4, for "pyrometallurgical" read *pyrometallurgical*; column 3, line 71, for "exciting" read *exiting*; 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.*