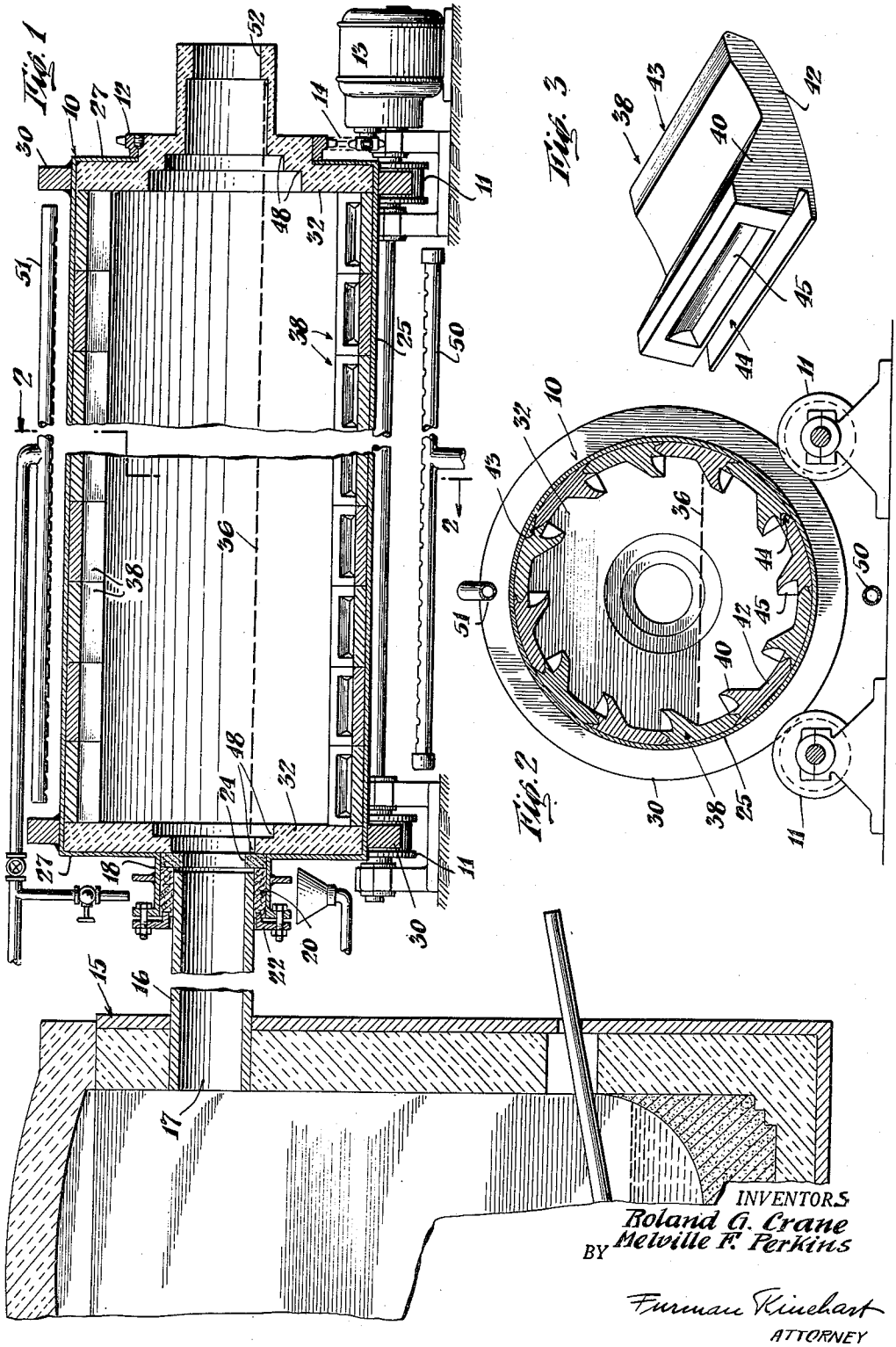
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METAL VAPOR CONDENSATION

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METAL VAPOR CONDENSATION

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This invention relates to the metallurgy of zinc and more particularly to an improved condenser and method of condensing zinc vapors formed by smelting zinc containing substances. The invention is adapted for use with any of the conventional furnaces but is especially useful in condensing metal vapors from electric arc smelting furnaces.

In the recovery of metallic zinc by thermal reduction of zincy substances with carbonaceous reducing agents, zinc is vaporized and conducted to a condenser where it is condensed to liquid metal. Many different types of condensers and smelting arrangements have been proposed heretofore, including rotary devices, but such devices have been primarily designed and used to recover metallic zinc from blue powder. Further, prior to our invention, in spite of all precautions, it has been practically impossible to condense metal vapors, such as zinc, from an arc furnace without forming excessive amounts of blue powder which requires resmelting or special treatment for the recovery of its metallic zinc content.

It is the principal object of this invention to overcome these difficulties and provide a condenser and method of treating zinc vapors whereby they can be condensed directly to metallic zinc while avoiding the formation of a high proportion of blue powder.

Another object is to provide an improved rotary condenser which is operable to effect substantially instantaneous condensation of the metal vapors upon entering the condenser.

Another object is to devise a method of cooling zinc metal vapors as emitted from an arc smelting furnace with such rapidity that oxidation of the zinc to form blue powder in appreciable amounts is avoided.

Other objects and advantages of the invention will become apparent from the following detailed description taken in conjunction with the accompanying drawing, in which

Figure 1 is a view in vertical longitudinal section of a condenser constructed in accordance with the present invention, the condenser being shown connected to an arc smelting furnace which is illustrated diagrammatically and shown partly broken away;

Figure 2 is a vertical cross-sectional view taken substantially on the line 2—2 of Figure 1;

Figure 3 is an enlarged perspective view of one of the baffles which are shaped to be fitted together to form a lining for the condenser.

Referring to the drawing in detail, the condenser, as illustrated in Figure 1, consists of a hollow cylindrical member, generally designated 10, which is supported horizontally on roller means 11. During the processing treatment, the condenser is rotated. Mechanism, suitable for effecting this, is shown in Figure 1 and comprises a ring gear 12 which is attached to the condenser and arranged to be driven by a motor 13 through the interconnecting chain means 14. Hot metal vapors are conducted from a smelting furnace generally designated at 15 into the condenser by way of the conduit 16. This conduit is preferably made of refractory material and forms an extension of the furnace flue 17.

To form a gas tight connection between the outer end of the conduit 16 and the condenser, the member 16 is telescopically fit into the cylindrical extension 18 of the condenser, as shown in Figure 1. Asbestos packing 20 is compressed into the space between the outer wall of the conduit 16 and the circumjacent extension 18 of the condenser and is held in place by a retaining ring member 22. Suitable means is also provided for flowing cooling water over the outer surface of the member 18, as illustrated in Figure 1, to improve the seal between the parts. A graphite disc 24 of suitable thickness is interposed between the outer end of the conduit 16 and the condenser to assist in forming a gas tight joint.

The condenser comprises a metal shell 25 having the end closing plates 27. The shell is equipped with tires 30 for engaging the supporting roller means 11 during rotation of the condenser. To protect the metal shell, it is lined with refractory tile 32, such as silicon carbide or the like material which is substantially impermeable to the metal vapors being condensed. Where further protection is desired, a layer of mica or asbestors, not shown, may be placed in between the outer metal shell 25 and the refractory lining 32. A bath or pool of liquid metal 36 is maintained in the lower portion of the condenser. During rotation of the condenser, liquid metal is continually splashed, lifted and hurled from the bath into the space thereabove, producing an atmosphere filled with moving droplets of liquid metal. To provide means for accomplishing this, the circular side wall of the condenser is made up of spaced rows of baffle blocks 38 which are shaped to splash and dip up liquid metal from the bottom part of the condenser as it is rotated.

The baffles are constructed from refractory

material, shaped and fitted together, as illustrated in Figures 2 and 3, to form a substantially continuous inner wall. This baffle wall construction preferably extends throughout the entire length of the condenser inasmuch as we have found by tests that where the condenser is made up of plain unbaffled sections the resultant efficiency of the condenser is lowered. Each baffle member comprises a shoulder or abutment 40 which protrudes inwardly and is inclined to the curved backing wall portion 42. Tongue and groove sections 43 and 44 respectively are provided at the opposite ends of the curbed backing portions to form tight joints between the baffle blocks. An elongated cup or trough 45 is formed on the outer sloping side of the abutment part 40 of each baffle which, during rotation of the condenser, is filled with liquid metal from the pool 36. In this manner, as the condenser rotates, liquid metal is picked up from the bath and carried into the upper part of the condenser where the metal is discharged producing a series of liquid metal cascades to which the incoming hot metal vapor is subjected.

To eliminate end-to-end surging of the metal bath resulting in excessive discharge of liquid metal therefrom which would lower the efficiency of the process, the inner end wall sections of the condenser are corbelled, as shown at 48 in Figure 1. This improved construction effectively inhibits surging of the liquid metal bath permitting the condenser to be rotated at high speed while the amount of the liquid metal in the bath remains substantially constant.

Heat is dissipated rapidly by our rotary condenser arrangement, so that, in most installations, it is necessary to supply heat to the exterior of the condenser to maintain the liquid metal bath at the proper temperature. Suitable means may be provided for supplying heat, such as by the use of a burner, as shown at 50. Where the temperature of the metal vapors entering the condenser is such as to require cooling of the condenser, conventional means such as shown at 51, may be utilized in place of the burner for applying a spray of water or the like cooling medium to the outer walls of the condenser.

In smelting zinc materials in an arc furnace, there is a tendency for many compounds of moderately low vapor pressure, such as PbO, PbS, SnO, ZnO and the like, to volatilize in the intense heat of the arc. The more reducible of these are immediately acted upon by the hot metal vapors and by carbon monoxide with the resultant formation, either directly or indirectly, of CO_2. The carbon dioxide gas which does not come in contact with hot carbon, passes to the condenser with the metal vapor stream. Other compounds, for example volatile sulphides, which are not easily reduced, are also conducted to the condenser and condensed as solids. The presence of appreciable amounts of CO_2 and solids in the condenser gases contributes largely to the difficulties encountered heretofore in condensing the metal vapors from this type furnace. These difficulties, however, have been overcome by our improved rotary condenser and method of operation.

A typical example showing the results attained using the improved condenser for the production of zinc is given:

Example

A condenser, constructed as illustrated and described, having an inside diameter of twenty inches and a length of seven feet was directly connected to a top-arc smelting furnace. The condenser which was partially filled with liquid metal zinc was rotated at a speed of 45 R. P. M. Approximately 1600 pounds of zinc metal was recovered per day using a charge assaying about 60% zinc. This charge consisted of a mixture by weight of 100 parts brass furnace dust calcined and screened to $-\frac{1}{4}''$, 16 parts coke of $-\frac{1}{4}''$, and 5 parts calcareous slag material. Sufficient heat was supplied to maintain the liquid metal bath at about 500° C. Metal vapor at a temperature of around 1000° C. was condensed with about 6 to 12% of the zinc entering the condenser emerging in the form of blue powder. This represents a decided improvement over results attained heretofore using the conventional condensing mechanism wherein from 30 to 75% of the zinc is recovered as blue powder.

To initiate the process, the condenser is heated to around 500° C. and the lower part of the condenser is filled with molten zinc 36. As metal vapor passes into the condenser and is recovered as liquid metal increasing the size of the metal bath 36, a like amount is drawn off through the opening 52 or is intermittently tapped from the condenser. During the process the condenser is continuously rotated at a substantially constant R. P. M. Preferably, the condenser is rotated at between $\frac{3}{5}$ and $\frac{4}{5}$ of the critical rotational speed or that at which the liquid metal would centrifuge. This critical rotational speed for any given size rotary drum-like member has been authoritatively represented by the following formula:

$$\text{R. P. M.} = \frac{54.19}{\sqrt{\text{Internal radius of the drum in feet}}}$$

Rotation of the condenser at this relatively high speed during the process has been found to be a salient factor in obtaining the improved results. The metal vapors which leave the arc furnace at a temperature of about 1100° C. enter the condenser at considerable velocity and are forced to take a twisting, spirally extended path therethrough. Intimate intermixing of the vapors with liquid metal zinc at a temperature below the dew point of the metal vapor is effected by subjecting the vapor to a torrential shower of liquid zinc falling in cascades from the top portion of the condenser. This enveloping and uniform intermixing of the metal vapor phase with the liquid zinc combined with the vigorous splashing and sloshing created by the baffles travelling into and out of the pool of metal in the lower part of the condenser, produces an intense scrubbing action on the metal vapors and mechanically disrupts the metal condensate films on the droplets of zinc causing the same to coalesce to liquid zinc and decreasing to a minimum the metallic zinc content of the small amount of blue powder formed. In order to secure the best results, it is necessary that sufficient amount of liquid metal zinc is kept in the condenser so that the maximum effect of the moving baffles can be obtained at all times.

Although the improved condenser and method is particularly useful in connection with the production of zinc metal, it will be obvious that the invention may be advantageously employed to condense other metal vapors, such as magnesium and the like, to liquid metal form as well as vapors comprising a mixture of different metals for example, lead, zinc, tin, etc.

While the preferred form of apparatus and

method of practicing the invention has been described in detail, it is to be understood that the procedure and form of condenser may be modified by those skilled in the art without departing from the spirit and scope of the invention as defined by the appended claims.

What is claimed is:

1. An improved condenser for condensing zinc metal vapors formed in an electric arc smelting furnace comprising a rotatable chamber into which the hot metal vapors from the furnace are conducted, means for rotating said chamber, a bath of liquid zinc metal filling the lower portion of said chamber, means comprising spaced interlocked baffle blocks forming the inner wall of said rotating member for splashing and hurling liquid metal from said bath into the space thereabove to maintain the same filled with falling droplets of liquid zinc metal and to produce an intense scrubbing and substantially instantaneous quenching action on the metal vapors upon their entry into said chamber, said chamber having corbelled end-wall sections to inhibit end-to-end surging and premature discharge of liquid metal from said bath as said chamber is rotated.

2. In the art of producing zinc by reducing zinc bearing substances in an electric arc furnace and condensing the metal vapors emitted therefrom, that improvement which consists in directly subjecting the zinc vapor from the reduction operation without intermediate conditioning treatment to substantially instantaneous quenching by intimately intermixing said zinc vapor with a torrential shower of moving droplets of liquid zinc while intimately contacting it with a vigorously agitated bath of liquid zinc.

3. The process of producing zinc which consists in heating a charge comprising zinc containing material and carbonaceous reducing agent in an electric arc furnace, conducting the zinc vapors formed in the arc furnace directly without intermediate treatment into a rotary condenser comprising a cooling shower of liquid zinc which is maintained over a bath of liquid zinc metal to thereby quench the zinc vapor and condense the same to liquid zinc metal without appreciable lapse of time avoiding the formation of a deleterious amount of blue powder.

4. The process of cooling and condensing zinc metal vapor at a temperature of approximately 1100° C., which comprises subjecting said zinc vapor without intermediate treatment to a torrential shower of molten zinc by conducting said zinc vapor into a chamber filled with moving droplets of molten liquid zinc maintained over a bath of liquid zinc metal contained in said chamber, and subjecting said droplets to attrition by intimately contacting the same with said bath of liquid zinc while it is vigorously agitated to thereby mechanically disrupt the films formed on the droplets to recover zinc as liquid metal and controlling the temperature of said molten zinc so as to quickly absorb the heat of condensation whereby the zinc vapor is condensed to the liquid phase in such a short period of time that oxidation of the zinc to form substantial amounts of blue powder is inhibited.

5. An improved condenser for condensing zinc vapors formed in an electric arc smelting furnace to liquid zinc metal comprising a rotary chamber into which hot zinc metal vapors are introduced directly from said arc furnace, said chamber being adapted to contain a bath of liquid zinc in the lower portion thereof, spaced inner baffle wall means protruding inwardly and extending substantially throughout the length of said chamber, said baffle means having an integral backing wall which is curved to fit the circular wall of the chamber, said backing walls being interlocked in such a manner to form a continuous lining wall for said chamber, mean for rotating said chamber at a relatively high uniform rotational speed to cause portions of the liquid zinc to be picked up from the bath and carried to the uppermost part of the rotating chamber by said baffle wall means and cascaded through said zinc metal vapors in the form of droplets as said vapors are conducted into said chamber, said zinc vapors being cooled to the dew point with such rapidity that oxidation of the zinc to form blue powder in appreciable amounts is avoided, said chamber having corbelled end-wall sections to inhibit end-to-end surging and premature discharge of liquid metal from said bath as said chamber is rotated.

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