

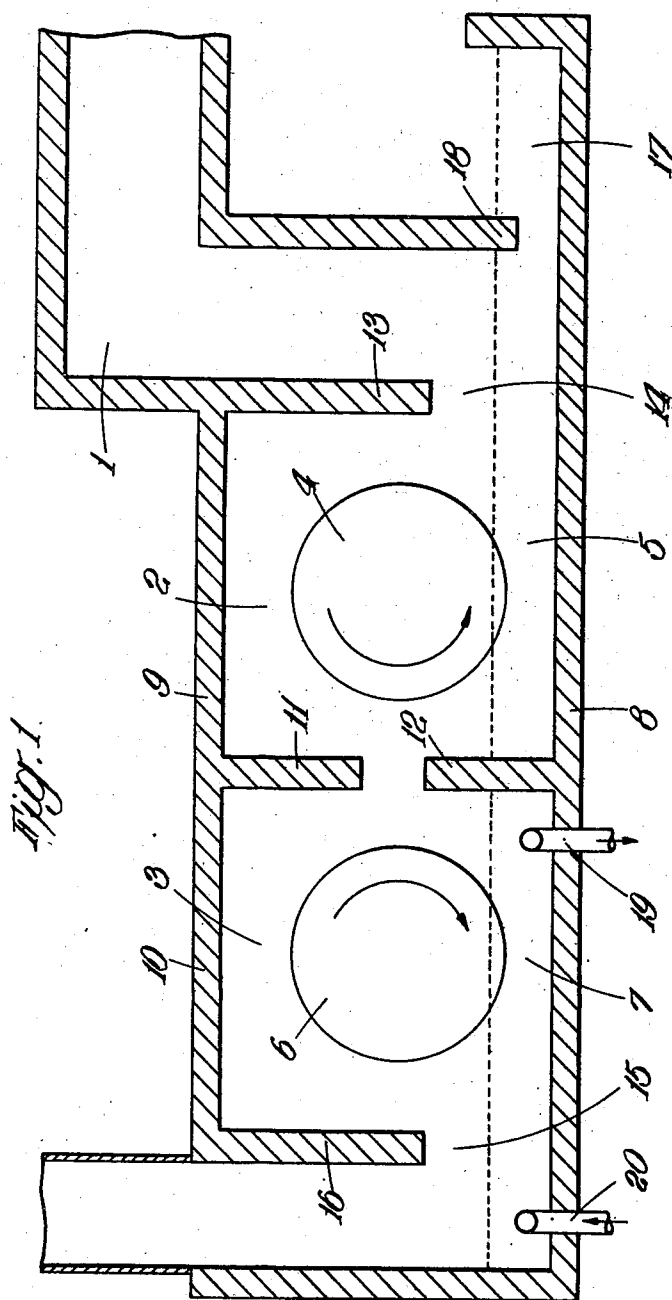
June 14, 1949.

S. ROBSON
CONDENSATION OF ZINC FROM ITS
VAPOR IN GASEOUS MIXTURES

2,473,304

Filed June 18, 1947

4 Sheets-Sheet 1



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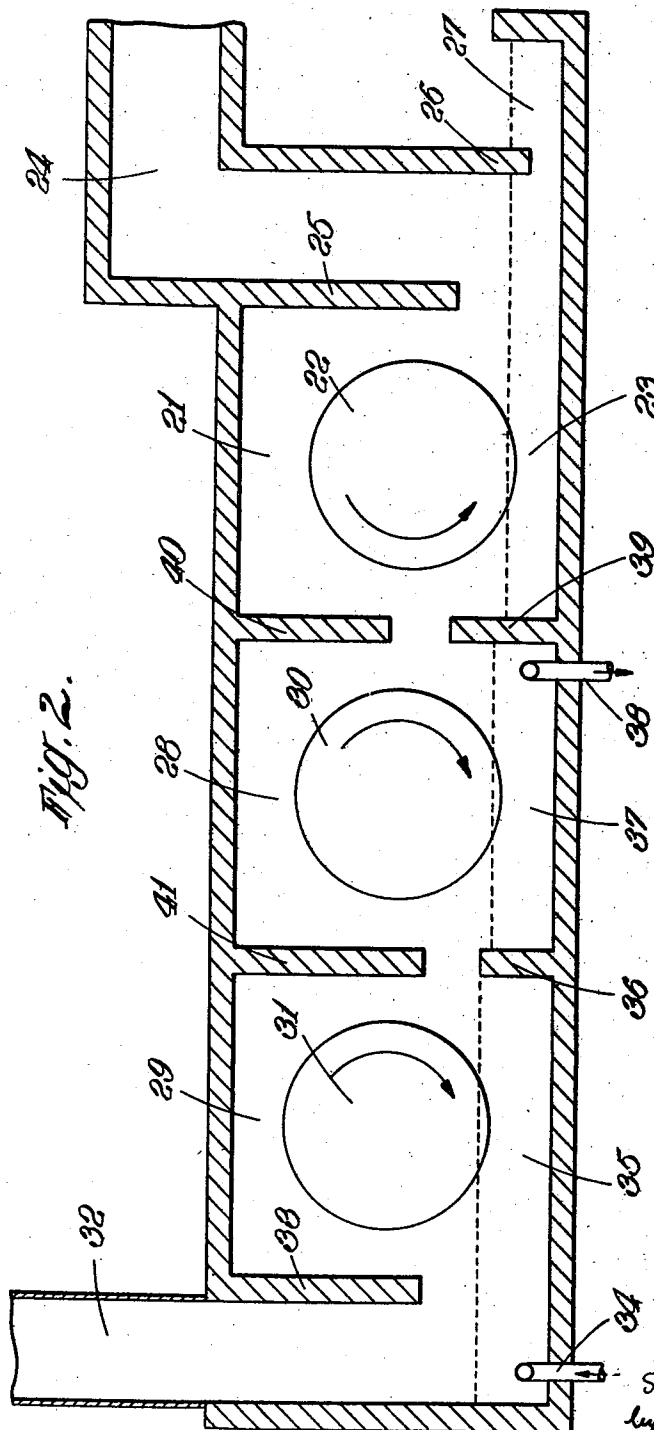
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4 Sheets-Sheet 3

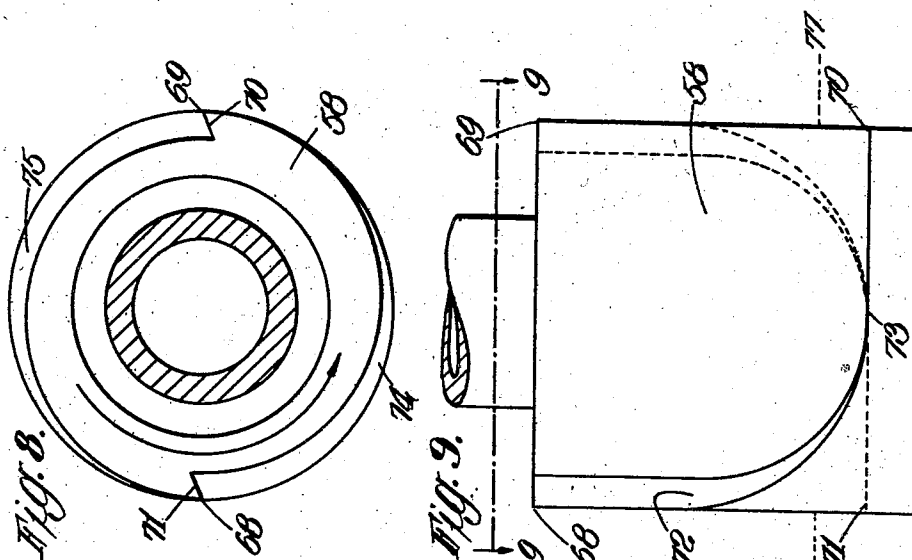
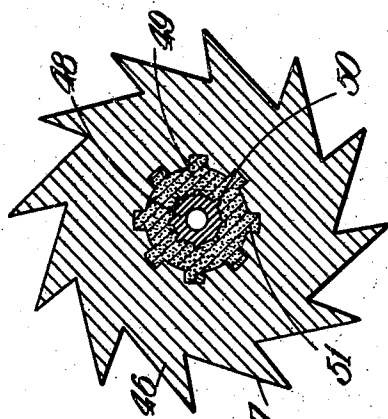


Fig. 4.

Fig. 6.

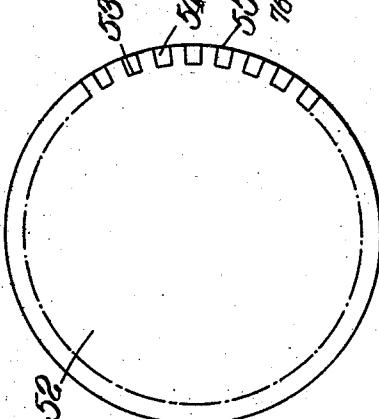
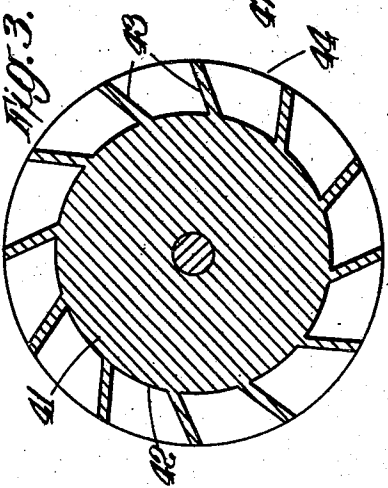
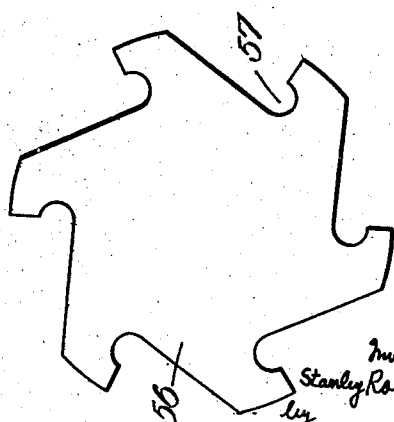


Fig. 3.



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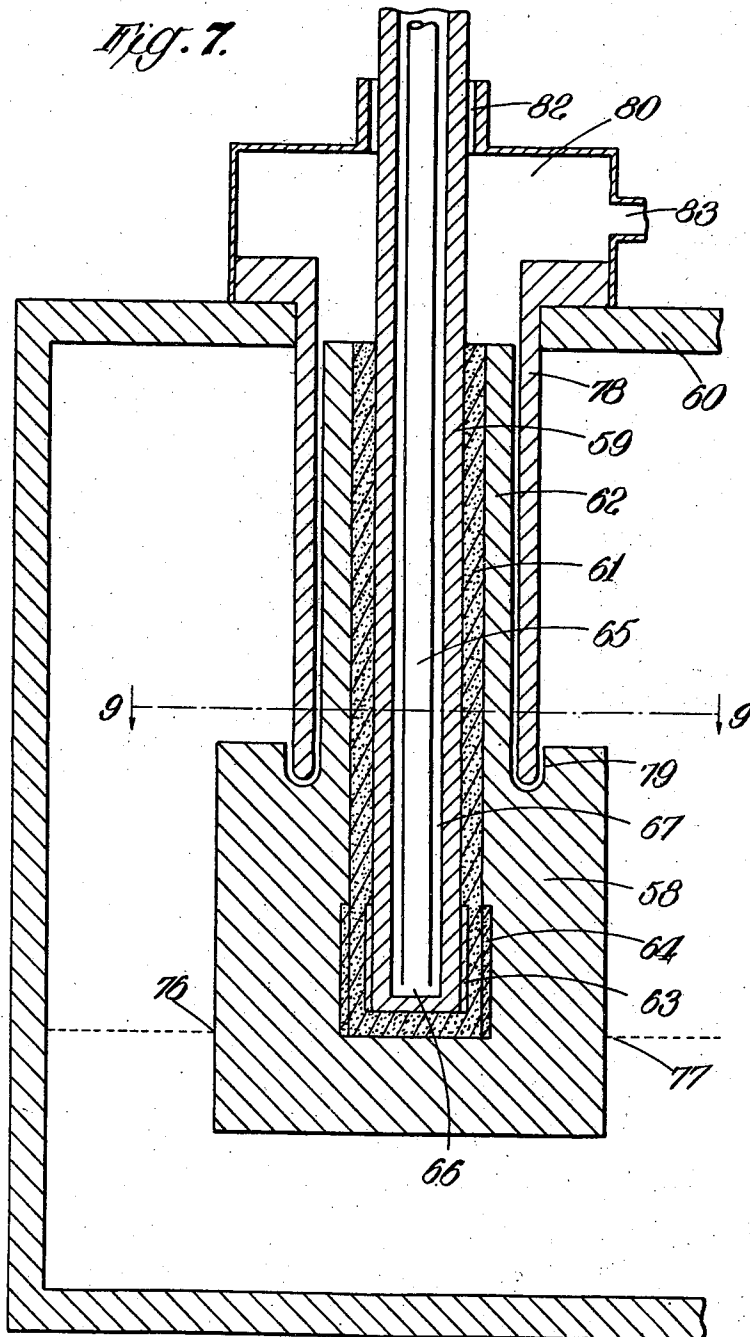
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4 Sheets-Sheet 4



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UNITED STATES PATENT OFFICE

2,473,304

CONDENSATION OF ZINC FROM ITS VAPOR
IN GASEOUS MIXTURESStanley Robson, Redland, Bristol, England, as-
signor to The National Smelting Company Lim-
ited, London, England, a British companyApplication June 18, 1947, Serial No. 755,443
In Great Britain March 12, 1946Section 1, Public Law 690, August 8, 1946
Patent expires March 12, 1966

4 Claims. (Cl. 75—88)

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This invention relates to an improved method of condensing liquid zinc from a mixture of zinc vapour with permanent gases. It is adapted to deal with, for instance, the gaseous products evolved when oxidised zinciferous materials are reduced by carbonaceous reducing agents in externally heated retorts, electrothermic furnaces or shaft furnaces. It is an object of this invention to provide a condenser in which most of the zinc contained in the incoming gases can be condensed to liquid metal; in particular, besides ensuring that no large amount of zinc vapour escapes condensation, the practice of this invention prevents the formation of any large quantity of zinc dust and dross, consisting of metallic zinc with more or less zinc oxide, commonly known as blue powder.

In retort processes of zinc smelting the main overall reaction occurring is reduction of zinc oxide by carbon to give equal volumes of zinc vapour and carbon monoxide, according to the equation,



As a typical instance of retort smelting may be mentioned the process in which a briquetted charge of oxidised zinc ores and carbonaceous material is heated in a vertical retort. In this vertical retort process it is customary to admit a certain volume of air or other gas or vapour, e. g. steam, at the bottom of the retort, so that the gases finally evolved contain only 30% to 40% zinc vapour by volume, the balance being chiefly carbon monoxide but including some nitrogen, hydrogen, and a small amount of carbon dioxide. From such gases, in the types of condensers usually employed, it is possible to condense the greater part of the zinc as liquid metal, but quite a considerable fraction, of the order of 10-15%, is obtained as blue powder.

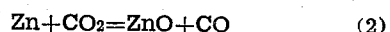
When zinc oxide compounds are reduced by smelting in electric arc furnaces, the main reaction taking place is the same as in retort smelting, namely, reduction of zinc oxide by carbon, according to the reaction (1) above. The difficulty of condensing to liquid zinc is found to be greater. The difference may be due to the fact that more dust and fume, and somewhat more carbon dioxide, is present in the gases from an arc furnace than from a vertical retort. With the conventional condensers, refractory chambers fitted with baffles, upwards of 30% of the zinc is generally obtained in the form of blue powder.

When zinc ores are smelted in a blast furnace,

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the heat required is provided by burning carbon in a furnace that also contains the zinciferous material. Consequently the zinc vapour evolved is mixed with the products of combustion of the fuel. The gaseous products may contain only about 5% of zinc by volume; the carbon dioxide content may also be about 5%, the balance consisting chiefly of carbon monoxide and nitrogen. From such gases it is a matter of difficulty to condense any substantial fraction of the zinc as liquid metal in the conventional types of condensers.

Blue powder consists mainly of small particles of metallic zinc. It is especially liable to be formed when the gas mixture contains only a small concentration of zinc vapor. It generally contains some zinc oxide, produced by reaction between zinc vapour and carbon dioxide, according to the equation



Sudden chilling in the conventional types of zinc condenser promotes blue powder formation. In the presence of considerable carbon dioxide, slow cooling promotes the formation of oxidized blue powder by reaction (2). Conflicting requirements are thus encountered in dealing with a gas mixture whose zinc concentration is relatively small and which contains gases, such as carbon dioxide, that can oxidize zinc.

It is an object of the present invention to reconcile these conflicting requirements more especially when the gas to be treated has a relatively small concentration of zinc vapour and there are present gases, such as carbon dioxide, that can oxidize the zinc. With such gases, slow cooling promotes chemical blue powder formation, by giving opportunity for reaction of zinc vapour with carbon dioxide or other oxidising gases present, while rapid cooling, at least in a conventional "surface" condenser, tends to promote physical blue powder formation by causing formation of droplets of zinc within the gas phase rather than on the condenser walls. This dilemma is encountered in dealing with the gaseous products resulting from treating zinc ores in a blast furnace.

The condensation process according to this invention comprises at least two stages in both of which the gas mixture, fed directly to the first condensation stage from the producing unit, is brought into intimate contact with a shower or spray of molten metal; and in the second stage the temperature of the metallic shower or spray is less than the minimum practicable tempera-

ture for tapping molten zinc for casting into ingots.

The metal on or in which the zinc from the gas mixture is condensed in the first stage of condensation is zinc itself. The metallic shower or spray in the second (and optional third) stage of condensation is lead (in practice having a very small amount of zinc in solution), the first stage having a shower or spray of liquid zinc.

For carrying out this process, a preferred form of apparatus comprises a stationary condensing unit, partitioned to provide two or three internal chambers, each of which contains mechanical means for producing a continuous shower or spray of the liquid metal. The unit also comprises an inlet for the gases into the first of the chambers and a stack outlet from the last chamber, and the chambers communicate with one another above the levels of the molten metal in them.

The spray or shower of molten metal through which the gases are caused to pass may be produced by a number of devices. One method is to cause a rotary paddle-wheel to dip into a pool of the molten metal. Within compartments of the condenser in which liquid zinc is present all portions of the paddle-wheel and its shaft are constructed of, or encased in, a material, such as graphite or silicon carbide, that is not attacked by zinc at the temperature at which the condenser works. The paddle wheels are enclosed in a box having at one end an opening for the admission of the zinc vapour and gases and at the other end an outlet for the gases out of which zinc has been condensed. The box is made of a steel casing, the lid of which is removable, and is lined throughout with bricks or a cement that is not attacked by liquid zinc or lead. One or two similarly lined partitions separate the chambers in which successive condensation stages are effected and each partition has an opening to allow the gases to pass from one chamber to the next.

The gas inlet and outlet openings of each chamber should be so located with reference to the paddle-wheels that the gases are compelled to traverse the shower or spray of molten metal, the final exhaust stack being at the top of the last chamber at the end remote from that at which the gases enter. The paddle-wheel should have only a small axial clearance at each end from the sides of the chamber, to ensure that the shower or spray of molten metal extends across the full width of the chamber. The outlet for liquid metal from each chamber should be situated at a level ensuring adequate immersion of the paddle-wheel for showering the molten metal at all times. The liquid metal outlet above referred to is either a top hole or a weir separating two adjacent condensing chambers both containing the same liquid metal as condensing agent, as in a three-stage process with the first stage using a shower of molten zinc and the second and third stages using showers of molten lead, as hereinafter described. Control of heat loss from the chambers may be obtained by placing heat insulating bricks round them as required, or by cooling the base of the chambers by means of water jackets or pipes.

The mechanical condensing apparatus should be situated as close as possible to the outlet by which the gases leave the furnace, to ensure that the zinc-bearing gases are brought into contact with the shower or spray of molten zinc as soon as possible after leaving the furnace and

without appreciable loss of temperature. Rapid chilling is thereby effected, heat being abstracted from the gases at a high rate by the rain of molten zinc; appreciable oxidation of zinc by carbon dioxide is substantially avoided, and blue powder is not formed to any great extent.

The compartment in which the first stage of condensation is effected by a shower of molten zinc is isolated from the second stage compartment except for the gas transfer opening, so as to avoid mixing of the zinc and lead baths of the first and second stages. The heat insulation of the first stage condenser compartment is preferably so adjusted that all the molten zinc is maintained at about the minimum satisfactory tapping temperature, say from 500° to 550° C.; whereas the temperature of the molten lead in the second condensation stage may be kept as low as 420° C.

The method of condensing zinc from a mixture of its vapour with permanent gases by bringing the gases directly from the producing unit into a stationary chamber in which a shower or spray of molten lead is maintained by mechanical means such as a rotary paddle-wheel is described in application Ser. No. 535,290 of Robson and Derham, filed May 12, 1944, now Patent No. 2,464,262. In this process the temperature of the lead is normally between 500° and 550° C. and a very large quantity of lead is employed on account of the low solubility of zinc in lead, which decreases as the temperature is lowered; with cyclic operation, in which the lead is re-circulated after cooling to enable dissolved zinc to be separated, the rate of circulation of lead must usually be from 100 to 200 times the rate of extraction of zinc by weight. In the two-stage process of the present invention, in which the major part of the total zinc extraction is performed in the first stage by molten zinc, the quantity of lead required for circulation in the second stage is much less than is required in the single-stage lead process of application Ser. No. 535,290, and the lead can be kept at a lower temperature. Full advantage can in fact be taken of the fact that lead has a lower melting point than zinc, so that the gases when finally discharged can have been scrubbed at a temperature below the melting point of zinc.

Scrubbing the gas with lead at a low temperature ensures that zinc vapour is almost completely removed from the gas. If, however, the lead leaves the condenser at a temperature below the melting point of zinc, cooling this lead further brings the condensed zinc out of solution as crystals, which have to be remelted to produce liquid zinc. It is preferable that, on the one hand, the gas should be scrubbed by lead at a temperature below the melting point of zinc, while, on the other hand, the lead should leave the condenser at a temperature above the melting-point of zinc.

To obtain the greatest benefit in this respect, the lead condensation may be performed in two stages, making, with the first stage of condensation by molten zinc, three stages in all. The two-stage lead condensation is performed in two chambers in series each provided with mechanical shower producing means and counter-current flow of molten metal and gas, the latter passing from the first to the second of the two lead condensation chambers and the molten lead flowing from the second to the first chamber.

Such a three-stage plant, using molten zinc and lead in series, is suitable for the treatment of

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gas from a blast furnace in which sintered zinc ore is reduced. In a typical plant of this kind the first condensing apparatus, containing a device for producing a shower or spray of molten zinc, is situated as close as possible to the outlet by which the gases leave the furnace; rapid chilling is thereby effected, and any considerable amount of oxidation of zinc by carbon dioxide or other gases present is avoided. This first condenser has a tap hole or other means through which liquid zinc can be run off; the heat insulation round this chamber is so adjusted that the molten zinc tapped has a temperature of, say, 550° C. from the zinc-showering or -spraying condenser the gases then pass in turn through two condensers, each fitted with apparatus for producing a shower or spray of molten lead, the last of these condensers having an opening in the roof for the stack by which the gases finally leave. Through these two latter condensers molten lead is circulated, in countercurrent with the gas stream; lead is introduced continuously, at a temperature of, say 350° C., into the chamber through which the gases finally pass before leaving by the stack, and flows over a weir into the next compartment, whence it is allowed to flow out continuously, its temperature then possibly being 500° C. The lead, containing some zinc in solution, is cooled under controlled conditions to separate some of its dissolved zinc, and is then re-circulated. A wall between the zinc spraying chamber and the adjacent lead spraying is of sufficient height to prevent flow of liquid metal from one compartment to the other, but there is sufficient free space above the top of the wall to permit free travel of gases.

The paddle-wheel referred to can have a variety of forms. It may consist of a drum with projecting paddles, which may be shrouded by end flanges. Alternatively it may have a saw-tooth profile. Furthermore, the depth of the projections, and the number of them disposed round the circumference, may be varied. In one case, which may be of importance, a notched, fluted or grooved roller is used; in this case there will be very numerous indentations or, alternatively regarded, very numerous teeth, all of small size. Whatever type of rotating apparatus is employed, it is advisable to cool the glands through which the shaft is introduced into the condenser by means of water. There is serious risk of zinc vapour diffusing to the glands and solidifying there. Arrangements should be made to force a slow stream of gas from the outside through the glands to ensure that no zinc vapour can reach them. A suitable gas for this purpose is one consisting chiefly of carbon monoxide, such as the condenser gas after it has been scrubbed and cooled.

The spray-producing device need not necessarily revolve round a horizontal axis. For instance, one type of device that may be used comprises a propeller, or series of cones or cups, or a centrifugal impeller, rotated by a vertical central shaft introduced through the roof of the chamber.

Another method, particularly convenient for the stage or stages of condensation for which lead is used, is to allow a stream of the molten metal to fall on to a table which is kept in rapid rotation by a vertical shaft.

The process of this invention may also include the step of condensing residual zinc from the gases exhausted through the stack in the form of blue powder and allowing this blue powder to

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fall into the scrubbing zone of the condenser for recovery as liquid metal.

The accompanying drawings illustrate schematically some typical examples of zinc condenser assemblies according to the invention, and since the manner of carrying out our improved process, and various modifications thereof, have already been fully described and the apparatus explained in general terms, a brief description of each condenser assembly illustrated will suffice for its understanding.

The drawings also include figures illustrating typical examples of paddle-wheels and other showering devices for molten metal for use in condenser assemblies according to the invention.

In the drawings:

Figs. 1 and 2 respectively are schematical central vertical sections of a first and second example of a condenser-assembly;

Figs. 3 and 4 are respectively transverse sections of two alternative examples of paddle-wheel or rotor structure;

Figs. 5 and 6 show two further examples of paddle-wheel or rotor structure in transverse section (outline only);

Fig. 7 is a central vertical section of a centrifugal impeller mechanism for showering molten metal, with vertical axis;

Fig. 8 is a transverse section on the line 8—8 of Figs. 7 and 9;

Fig. 9 is a view in elevation of the impeller itself.

In Fig. 1, showing a two-stage condenser, 1 represents a flue by which the zinc-bearing gases are conducted from the source, which may, for example, be a zinc blast furnace, to the condenser, which is divided into two compartments, 2 and 3. In compartment 2 is a paddle-wheel 4 dipping into a pool of molten zinc 5. In compartment 3 is a similar paddle-wheel 6 dipping into a pool of molten lead 7. The floor 8 of the condenser is constructed of, or lined with, suitable refractory material that is not attacked by liquid zinc or lead. The lids 9 and 10 of the compartments are removable and are similarly constructed. Between the two compartments there is a baffle 11 depending from the roof; beneath it is a baffle 12 supported from the floor and of sufficient height to prevent liquid zinc or lead flowing from one compartment to the other. Through the opening between these baffles the gas passes from compartment 2 to compartment 3. At the inlet end of compartment 2 is a depending baffle 13 which compels the incoming gas to pass through an opening 14 just above the level of the molten zinc. The paddle-wheel 4 is rotated in a direction shown by an arrow such that the lower half is moving towards the opening 14; this ensures that the entering gases are immediately brought into contact with a spray of molten zinc. In compartment 3 the paddle-wheel 6 is moving in the opposite direction (as shown by an arrow), so that its lower half is moving towards the gas outlet 15, which is limited at the top by a depending baffle 16. This arrangement ensures that the gases traverse, firstly a spray of molten zinc in compartment 2, and then a spray of molten lead in compartment 3.

The pool of liquid zinc 5 is connected with an outer well 17 by an underflow weir 18. From this well 17 the zinc is run off continuously or removed at frequent intervals, to maintain the desired level of zinc in compartment 2 and thus a suitable depth of immersion of the paddle-wheel

4. Should the temperature of the zinc in compartment 2 rise above the desired figure, which is generally about 500° C. to 550° C., this can be corrected by effecting auxiliary cooling in the well 17, or by circulating cooling water in a jacket round the sump. Should the temperature of the zinc become too low, this can be corrected by placing insulation bricks round compartment 2.

Lead is continuously circulated through compartment 3, entering by pipe 29 and leaving by pipe 19; it takes some zinc into solution and rises in temperature during its passage. It is then cooled under controlled conditions to separate some of its dissolved zinc and is returned through the pipe 29.

In Fig. 2, the first condensing chamber 21 contains a paddle-wheel 22 which rotates and dips into a pool 23 of molten zinc, producing a shower of molten zinc. This effects rapid chilling of the zinc bearing gases entering from a flue 24 beneath a baffle 25 to be brought into contact with the shower of molten zinc. The zinc condensed can be run off under a baffle 26 to an outside well 27, whence it can be removed by any convenient means; alternatively, the zinc can be run off directly from a tap-hole (not shown) arranged in chamber 21. The temperature of the molten zinc is maintained at about 550° C. If it becomes too cold, insulating bricks may be placed round chamber 21. If the zinc becomes too hot, cooling may conveniently be effected by an immersion water-cooler in well 27. Alternatively cooling may be effected by a water-jacket round the sides and bottom of the sump.

From the zinc spraying condenser 21 the gases then pass through two condensers 28 and 29, each fitted with a paddle-wheel 30 and 31 respectively, for producing a shower or spray of molten lead. From chamber 29 the gases leave by a flue 32. While the opening to flue 32 may be situated directly in the roof of chamber 29, it is found convenient to have a baffle 33 interposed to force the gas to enter the flue near the bottom of chamber 29. Molten lead, at a temperature of, say, 350° C., is introduced into chamber 29 by pipe 34 and forms a pool 35 into which the paddle-wheel 31 dips. The lead then flows over a weir 36 into chamber 28, where it forms a pool 37, into which paddle-wheel 30 dips. Thence the lead flows out continuously through pipe 38, its temperature then being about 500° C. The lead, containing some zinc in solution, is cooled under controlled conditions to separate some of its dissolved zinc and is then recirculated back by pipe 34. Arrows indicate the directions of rotation of the paddle-wheels.

Between the zinc spraying chamber 21 and the adjacent lead spraying chamber 28 is a wall 39 of sufficient height to prevent flow of liquid metal between chambers 21 and 22. The space above this wall 39 up to the roof may be left open, but it is found preferable to hang a baffle 40 from the roof to prevent spray being thrown from one compartment to another. There is sufficient space between baffles 39 and 40 to permit free flow of gas from compartment 21 to compartment 29. A depending baffle 41 is also interposed between chambers 28 and 29.

Some typical examples of paddle-wheels and other rotary devices for showering molten metal for use in condensers according to this invention will now be briefly described.

In Fig. 3, 41 is a paddle-wheel comprising a metal drum 42, with projecting paddles 43, which

may be shrouded by end flanges 44. This is suitable only for use in lead.

In Fig. 4 is shown a rotor 46 with a saw-tooth profile 47. This may be constructed of graphite and carried by a water-cooled metal shaft 48 which extends through the side walls of the condenser. Separating the hollow shaft 48 from direct contact with the graphite is a sleeve 49 of insulating cement, embedded in which are several ribs 50 projecting from the shaft 48. Similarly, the cement is keyed to the graphite by providing recesses 51 in the graphite which are filled with cement.

Fig. 5 shows the profile of a rotor 56 constructed of graphite, so shaped as to provide cups 57 which serve to pick up the molten metal into which it dips.

Fig. 6 shows the profile of a graphite rotor 52, notched with numerous indentations 53, or, alternatively regarded, provided with numerous teeth 54. This is shrouded by end flanges 55, also consisting of graphite.

Fig. 7 shows a centrifugal impeller device which consists of a generally cylindrical rotor 58 which is carried by a hollow metal shaft 59, vertically mounted and extended through the roof 60 of the condensing chamber. The rotor 58 may be constructed of graphite or other suitable refractory material and is separated from direct contact with the shaft 59 by a sleeve 61 of insulating cement. Of one piece with the rotor is an upwardly extending hollow cylinder 62 of graphite which surrounds the shaft 59, with a layer of insulating cement in between, up to the roof 60 of the condensing chamber. At its lower end the shaft 59 is furnished with splines 63 so as to key it to the insulating cement. In the same region there are recesses 64 in the rotor and these are filled with cement, so that the shaft, sleeve and rotor are effectively keyed together. The shaft 59 is cooled by water or other cooling medium introduced through a pipe 65 which terminates just above the bottom of the hollow shaft 59. Leaving the open end 66 of this pipe, the water flows upwards through the annulus 67 between the pipe 64 and the shaft 59.

On the outside surface of the rotor are two similar and diametrically opposite ledges cut out of the cylindrical surface, each, as shown by Figs. 7 and 8, extending from a point 68 or 69 at the top of the rotor to a diametrically opposite point 70 or 71 respectively at the bottom of the rotor. The path followed on the cylindrical surface of the rotor may be described by considering this surface as unrolled onto a plane; the ledge from 68 to 70 would then be vertical from 68 to 72, approximately circular, forming a quadrant of a circle, from 72 to 73, and horizontal from 73 to 70. The ledges are recessed into the surface, being cut at a somewhat acute angle.

In horizontal projection the ledges taper from a maximum depth at 68 (69) through a mean depth at 74 (75) to zero depth at 70 (71). The direction of rotation is shown by an arrow in Fig. 8.

The bottom of the rotor is situated at a level below that of the molten zinc to be held in the condensing chamber and the upper end of the body of the rotor is above the molten zinc level. A convenient level for the molten zinc is shown by the line 76—77.

The rotating sleeve 62, fits, with only a narrow clearance, inside a stationary sleeve 78 extending downwards from the roof 60 of the condenser and into a circular trough 79 cut into the

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top of the rotor. In this trough is maintained liquid zinc, which forms an effective seal. The upper end of the stationary sleeve 78 is enclosed in a gas seal, comprising a tight fitting box 80 with an opening in the top through which the shaft 59 extends, this being fitted with a bush 82. In the side of the box 80 there is an opening 83 through which a slow stream of gas is pumped; a suitable gas for this purpose is one consisting chiefly of carbon monoxide, such as the condenser gas after zinc has been removed from it. This gas passes down the annulus between the stationary sleeve 78 and the rotating sleeve 62, becoming heated as it does so, and then bubbles through the metal contained in the circular trough 79.

I claim:

1. A process for condensing zinc as liquid from a mixture of zinc vapour with permanent gases, comprising at least two stages of condensation in which the gas-zinc vapour mixture is fed with the minimum possible heat loss from the producing unit to a first condensing stage where the mixture is brought into intimate contact with a shower of molten zinc metal at a temperature high enough to permit tapping of molten zinc for casting into ingots, and the gas mixture is thence fed to a second condensing stage in which the mixture is brought into intimate contact with a shower of molten lead which may contain a residual amount of zinc in solution and whose temperature is below the minimum practical

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temperature for tapping molten zinc for casting into ingots.

2. A process for condensing zinc as claimed in claim 1, including a third condensing stage in which the zinc vapour-bearing gas mixture is brought into intimate contact with a shower of molten lead which may contain a residual amount of zinc in solution and whose temperature is lower than in the second condensing stage.

3. A process for condensing zinc as claimed in claim 2 in which molten lead for the second condensing stage is provided by the flow of molten lead from the third condensing stage.

4. A process for condensing zinc as claimed in claim 3 in which molten lead is introduced into the third condensing stage at a temperature of about 350° C. and leaves the second condensing stage at a temperature of about 500° C.

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