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Racunas et al.

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[54] **STRUCTURE AND METHOD FOR SEPARATING INSOLUBLE PARTICLES FROM A MOLTEN BATH**

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[52] **U.S. Cl.** **233/3**, 233/27

[51] **Int. Cl.** **B04b 1/00**

[58] **Field of Search** ..... 233/1 E, 27.46, 28, 3, 233/10, 21, 22, 16, 7, 26; 266/37; 210/369, 78; 415/88

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[57] **ABSTRACT**

A device and method particularly suitable for separating particulate matter in a molten salt or molten metal bath from the bath. The device comprises a unitary bowl and pump structure adapted to be immersed into and rotated in a pool of the bath, and to draw into the bowl the bath and particulate matter when the bowl is rotated. With rotation of the bowl, the particulate matter, in large measure, is collected in a concentrated form in the bowl while the bath, which is now largely depleted of particulate matter, is discharged from the bowl. To remove the particulate matter, and any bath entrapped therewith, from the bowl, the bowl is removed from the bath and a blade means is inserted into the bowl to scrape the particulate matter from the bowl. The particulate matter falls from the bowl through an opening provided in the lower end thereof. After the particulate matter is removed from the bowl, the bowl is returned to the bath for another cycle of collection and particle removal.

10 Claims, 3 Drawing Figures

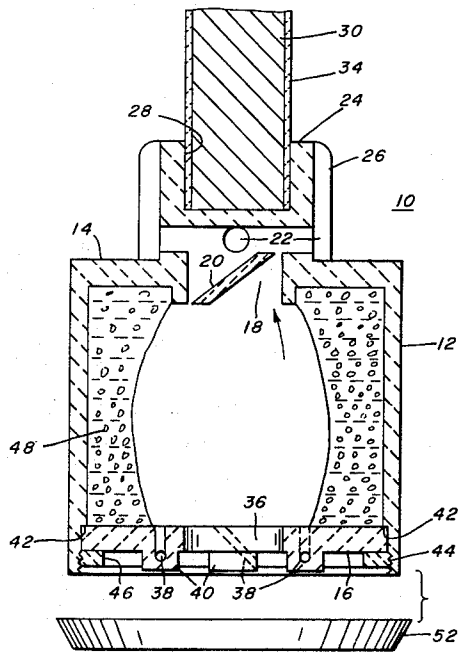


FIG. 1.

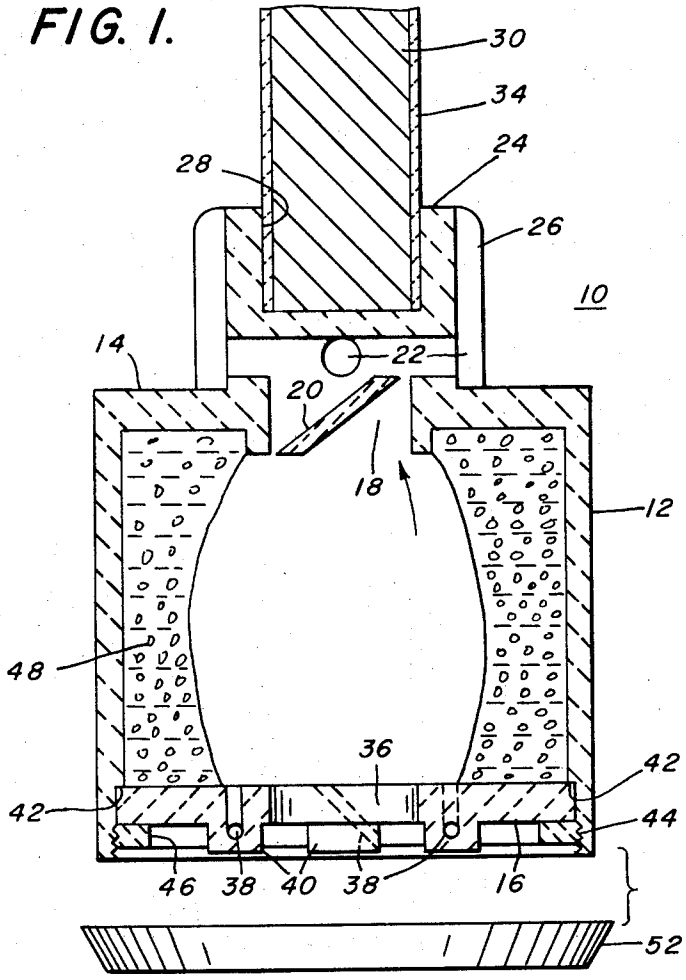


FIG. 2.

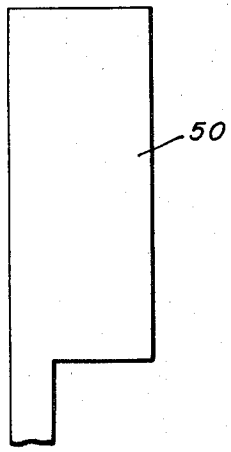
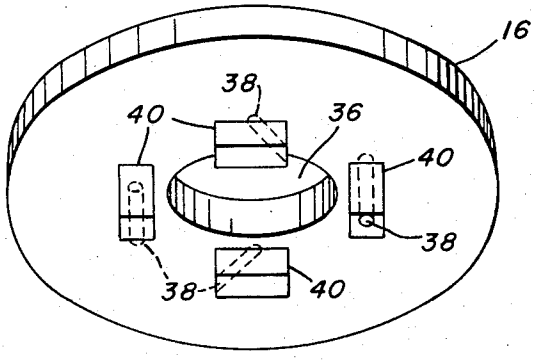


FIG. 3.



STRUCTURE AND METHOD FOR SEPARATING INSOLUBLE PARTICLES FROM A MOLTEN BATH

BACKGROUND OF THE INVENTION

The present invention relates generally to liquid-solids separation, and particularly to a structure and method capable of rapidly and economically separating non-metallic solids and particles, substantially insoluble in a molten salt and/or metal bath, from the bath.

There has been considerable interest over the years in the subject of separating particulate solids contained in molten baths of metal and salt from the baths, which interest has generated a substantial amount of literature describing different structures and procedures attempting to accomplish such separation in an economical manner.

It has long been known that molten salt fluxes are effective in separating aluminum from non-metallic impurities, such as oxide, carbide and nitride solids of the aluminum, in such scrap forms as skim, dross, powder, turnings and other forms of scrap. The utilization of the separating concept, however, has been hampered by the lack of means that are efficient and rapid in removing the solids, which accumulate as a result of the separating process, from the molten salt once separation of the non-metallic impurities and metal has occurred.

Rotary salt furnaces, for example, are effective in separating oxides and other non-metallic solids and impurities from aluminum but at the end of the separating process, a considerable amount of salt is dumped from the furnace with the accumulated non-metallic impurities. The salt and impurities must then be further processed to separate the salt from the impurities so that the salt can be reused in the rotary furnace. This further processing of the salt and impurities adds costs to the metal-solids separating process, which costs could be elminated or at least substantially reduced if means were available for rapidly and economically removing the solids from the salt bath.

Another area of interest involving liquid-solids separation, in which it is advantageous to effect such separation in a rapid and economical manner, is the making of magnesium from magnesium chloride. Here it would be advantageous if insoluble impurities were separated from the magnesium chloride before it is used in an electrolytic reduction cell.

Thus, in the area of metal reclamation, as well as in other areas involving molten baths containing solid materials of low solubility in the bath, it is desirable that a liquid-solids separation device and process be found that provides salt economy and high metal recovery, and that lends itself to being automated for further economy and efficiency.

BRIEF SUMMARY OF THE INVENTION

The present invention provides such a device in the form of a simple, unitary bowl and pump means adapted to be immersed into and rotated in a pool of a molten liquid bath of metal or salt containing solid impurities. With rotation of the bowl in the pool, the bath and solids are directed to the side of the bowl by centrifugal force while the pumping means directs the liquid salt or metal, now substantially depleted of the solids, from the bowl and into pool in which the bowl is immersed. The solids are trapped inside the bowl adjacent the side wall thereof, and are removed from the bowl by a scraping means inserted therein when the bowl is removed from the bath and pool. After the solids are removed from the bowl, the scraping means is withdrawn and the bowl returned to the bath for a repetition of the above process.

The bowl and pump means, as briefly described thus far, provides a metal and salt economy, heretofore unavailable, by concentrating solids in the bowl to such a high degree that minimum metal and salt liquid are entrapped with the solids, and thus minimum metal and salt is removed with the solids when they are scraped from the bowl. With presently available liquid-solids separation processes, such entrapped metal and salt is of a substantially greater quantity, and it is lost when and if the solids are discarded.

The device and operation of the present invention readily lends itself to being automated so that the liquid-solids separating and removal functions of the invention are both rapid and essentially continuous. Further, since the liquid salt is returned to the pool, in molten salt applications, and only the solid particles are removed from the bath, with a minimum amount of salt collected with the particles, the salt economy of the present invention is considerably improved over prior processes which dispose of the salt and insolubles together.

THE DRAWING

The invention, along with its objectives and advantages, will be more apparent after consideration of the following detailed description in connection with the accompanying drawing in which:

FIG. 1 shows a vertical section of the unitary bowl and pump of the present invention;

FIG. 2 is a side elevation view of a blade for scraping insoluble material from the bowl of FIG. 1; and

FIG. 3 is a perspective view of a plate structure forming the lower end of the bowl of FIG. 1.

PREFERRED EMBODIMENTS OF THE INVENTION

Referring now to the drawing, FIG. 1 shows, in vertical section, a unitary bowl and pump structure and device generally designated **10.** The bowl is shown comprised of a generally cylindrical side wall **12,** though the invention is not limited thereto, and opposed, top and bottom end walls **14** and **16.** The end wall **14,** as shown in FIG. **1,** may be provided with an opening **18** to accommodate a pump impeller **20.** The impeller is attached to or integrally formed with the bowl to rotate therewith as explained in greater detail hereinafter. Peripheral openings **22** are provided in a wall of a hub portion **24** above the impeller, the external surface of the hub portion, in turn, being provided with vertically extending, peripheral vanes **26.** A center recess **28** extends into the hub portion from the top thereof, and is dimensioned to receive a shaft **30** for rotating the bowl and pump device **10.**

As shown in FIG. **1,** the shaft **30** preferably comprises an inner, solid shaft structure **32** made of high strength metal surrounded by a corrosive resistant sleeve **34** made of material such as graphite. The recess **28** receiving the shaft **30,** and the portion of the shaft extending into the recess may be provided with mating planar surfaces to effect rotation of the bowl and pump when the shaft is rotated by a drive motor (not shown) mechanically coupled thereto.

The end wall **16** at the bottom of bowl **10** preferably comprises a plate structure (FIG. 3) provided with a center opening **36** and a plurality of slanted openings **38** (FIG. 1) located about the center opening. On the surface of the plate facing downwardly and outwardly from the bowl are located pumping blocks **40**, the slanted openings **38** extending through the plate and preferably through the blocks in the manner shown in FIG. **1**, which blocks may be formed integrally with the plate.

With the use of a plate such as **16**, the inner diameter of the bowl at its lower end is widened somewhat to provide a downwardly facing annular ledge **42**, below which is a threaded portion **44**. The plate **16** is secured in the bottom end of the bowl and in abutting engagement with the ledge **42** by a ring **46** having its outer edge provided with threads, the ring being threaded into the threaded portion **44** of the bowl as shown in FIG. **1**. The plate may be suitably keyed to the side wall of the bowl to prevent its rotation relative to the bowl.

In a similar manner, the impeller **20**, if used and if it is a separate structure, must be suitably fastened to the bowl so that it rotates with the bowl when the bowl is rotated. In the operation of bowl **10**, the bowl is rotated about its axis, and the impeller **20**, with the pumping blocks **40** and the vanes **26**, function as pumping means to direct a molten bath into and out of the bowl in a manner presently to be explained. Since the impeller, vanes and blocks are effective as pumping means, it is not necessary, for the purposes of the invention, to employ all three means,

Since the bowl and pumping device operates immersed in a pool of molten bath (not shown) and in corrosive environments, the material of the bowl and pumping means must be heat and corrosion resistant. To this end, graphite has been found to be a suitable material for the device **10**. In addition, a graphite bowl with an end plate **16** made of silicon carbide (for abrasion resistance) has operated successfully in molten salt and combinations of molten salt and molten aluminum baths. The structure of the invention, however, is not limited to graphite and silicon carbide materials, nor is it limited to a separate bowl and plate construction.

The bowl and pump structures may be cast as a single unit, though the preferred embodiment of the invention is to provide a separately made end plate **16**, as discussed above and as shown in the figures, and a separate impeller **20**, if used. The end plate may be cast to provide the pumping blocks **40** integral therewith, and the slanting holes **38** can be provided in the casting process, or drilled through the blocks and plate.

In the operation of the bowl and pump device **10**, the device is immersed in a pool of a molten salt or metal contained within a furnace, for example, the salt or metal containing solid or particulate impurities that have a specific gravity generally greater than that of the salt or metal, and that need to be removed therefrom for anyone of a number of reasons and purposes, such as those outlined earlier in discussing the background of the invention. The bowl, with its associated pumping impeller **20**, blocks **40** and/or vanes **26** is rotated in the bath at a suitable speed by the shaft **30**, which may, in turn, be rotated by a suitable motor (not shown) mechanically connected thereto. With rotation of the device, the vanes and the impeller or blocks (or all three) are effective to direct into the bowl the molten salt, molten metal and solid particles through the opening **36** and through openings **38** provided in plate **16**.

As the particles enter the rotating bowl, they are directed to the side wall thereof by centrifugal force acting upon their heavier mass and by the impetus given to them by the slanting holes in the bottom plate. As the particles reach the walls of the bowl they tend to concentrate and collect thereon while the molten salt or metal is directed from the bowl through the openings **18** and **22** in the upper wall **14** of the bowl. In this manner, the salt or metal pumped into the bowl is returned to the pool in a state substantially depleted of particulate material.

The rotation of the bowl is continued until a sufficient amount of particles or concentrate is collected in the bowl along its side wall, as indicated by numeral **48** in FIG. **1**. The bowl is then raised above the level of the pool for the insertion of a means to scrape the particles from the bowl in a manner presently to be explained.

The particles and solids concentrated and collected in the bowl, can be removed therefrom by a simple blade structure **50**, as shown in FIG. **2**, mounted in an upright position. The width and height of the blade are such that the blade can be inserted into the bowl through the opening **36** in the bottom wall thereof, and be moved laterally within the bowl and into the concentrate **48** collected therein. With the blade so positioned, the bowl is rotated about its axis, the concentrate moving past the blade to be scraped from the bowl. As the concentrate is scaped from the bowl, it falls through the opening **36**, and may be collected in a suitable container or pan **52** positioned beneath the bowl.

The operation of the structure, as thus far described, is preferably automated, which operation may function in the manner presently to be described, keeping in mind that the invention is not limited thereto.

While the bowl and pump **10** is in the molten pool of a salt or metal, from which it is desired to separate solid impurities therefrom, and when the bowl and pump is removed from the pool and furnace, with the concentrate **48** collected in the bowl, the blade **50** is located above the bath or furnace in an out-of-the-way position, i.e., in a position external to the path traversed by the bowl as it is removed from the furnace. The bowl is lifted to a height above the furnace sufficient for the blade to be moved under the bowl. The raising of the bowl can be initiated and automated by the use of a timing device, and the moving of the blade to a position under the bowl can be automated by limit switches or other types of proximity devices. For example, when the bowl reaches a height above the furnace to accommodate the blade thereunder, a limit switch can be actuated to cause energization of an actuating means capable of bringing the blade into position under the bowl. In a similar manner, when the blade is positioned and centered beneath the opening **36** in the bowl end wall **16**, the bowl is lowered over the blade to a position where the end wall **16** of the bowl is clear of the lower edge of the blade. Similarly, the motor for rotating the bowl shaft **30** is then energized, and the blade is actuated to move laterally into the concentrate **48** within the bowl. With the blade engaging the concentrate, and with the bowl rotating, the concentrate is scraped from the bowl as lateral movement of the blade into the concentrate continues.

To collect the concentrate scraped from the bowl in the pan **52**, the pan can be positioned under the bowl automatically in a manner similar to that described above in connection with the automated movement of the bowl and blade.

After a time period sufficient to scrape essentially all of the solids **48** from the bowl, the rotation of the bowl is stopped, preferably automatically, and the reverse of the above sequence takes place. The bowl is thus raised above the blade, and the blade is moved to one side of the bowl. The bowl is then vertically lowered into the molten bath to collect solids therein (again) in the manner described above.

Whether the structure and process of the invention is automated or operated under manual control of personnel, the structure and process provides a rapid and essentially continuous process for collecting and separating particulate impurities from a molten salt or metal bath. In addition, the process of disposing and rotating the bowl in a pool of the molten bath, as well as the process of removing the bowl from the bath and pool, and inserting and removing the scraping device **50** from the bowl, involve rather straight forward mechanical movements. This allows the structure of the invention to be mounted and moved without substantial difficulty, equipment and cost so that the present invention provides the essentially continuous and rapid process for removing impurities in an economical manner.

While the invention has been described in terms of preferred embodiments, the claims appended hereto are intended to encompass all embodiments which fall within the spirit of the invention.

Having thus described our invention and certain embodiments thereof, we claim:

1. A device for removing particles from a bath of molten salt or metal, or from a bath comprised of molten salt and metal, said device comprising

a unitary bowl and pump means made of a heat and corrosive resistant material and adapted to be rotated about a common axis, and to be immersed in and removed from a pool of the molten bath,

said bowl having opposed end walls, with entrance and exit openings provided in said walls for respectively admitting and discharging the bath to and from the bowl,

said pump means including pumping blocks located on the outside surface of the end wall having the entrance openings, and

shaft means for rotating said bowl and pump means, said pump means being effective, when rotated in said bath, to direct the bath through the bowl while said bowl is effective to concentrate and collect the particles in the bowl adjacent the sides thereof.

2. The structure of claim **1** in which the entrance openings comprise a center opening and a plurality of openings spaced about the center opening.

3. The structure of claim **2** in which the plurality of entrance openings extend diagonally through the end wall and through the pumping blocks.

4. The structure of claim **1** in which the pump means includes an impeller located adjacent the exit openings.

5. The structure of claim **1** in which the bowl is provided with external vanes located adjacent the discharge openings.

6. The structure of claim **1** in which a separate, abrasive resistant plate structure forms an end wall of the bowl.

7. The structure of claim **6** in which the separate plate structure is secured in one end of the bowl by a ring means threaded into said end.

8. A method of removing suspended particles from a pool of a molten liquid salt or metal bath, or a bath comprising both molten salt and metal, the method comprising the steps of

immersing a bowl having a side wall and unitary pump means in said pool,

rotating said bowl and pump means about a common axis within said pool to draw the bath and particles into the bowl through an entrance opening therein, the centrifugal forces produced by the rotating bowl being effective to direct the particles toward the side wall of the bowl for collection thereon while the bath is directed therefrom through an exit opening,

periodically removing said bowl, with the particles collected therein, from said pool, and

removing the particles from said bowl.

9. The method of claim **8** wherein the collected particles are removed from the bowl by inserting a scraping device into the bowl through the entrance opening therein,

moving said device into engagement with the particles, and

moving the bowl or scraping device relative to the other about the axis of the bowl to scrape the particles from the side of the bowl.

10. The method of claim **8** wherein the bowl is disposed vertically in the pool of the molten bath, and the rotation of the bowl is about its vertical axis.

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