

Dec. 9, 1958

K. J. BRONDYKE ET AL

2,863,558

FILTERING MOLTEN ALUMINOUS METAL

Filed April 29, 1957

2 Sheets-Sheet 1

Fig. 1.

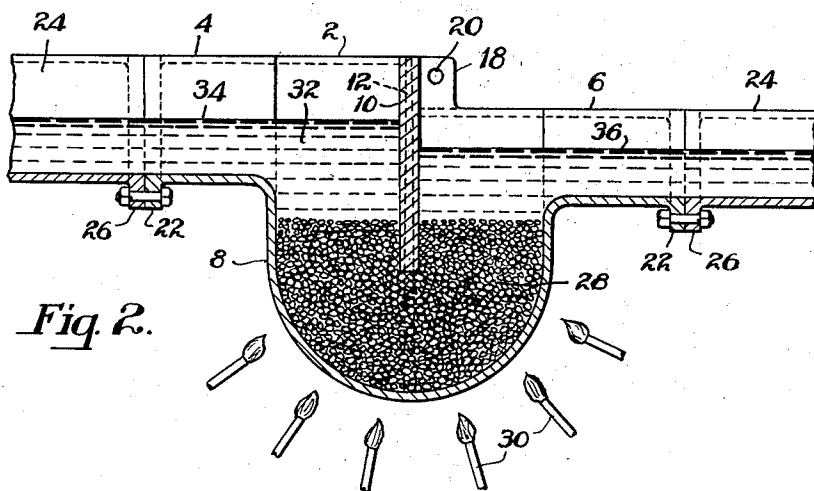
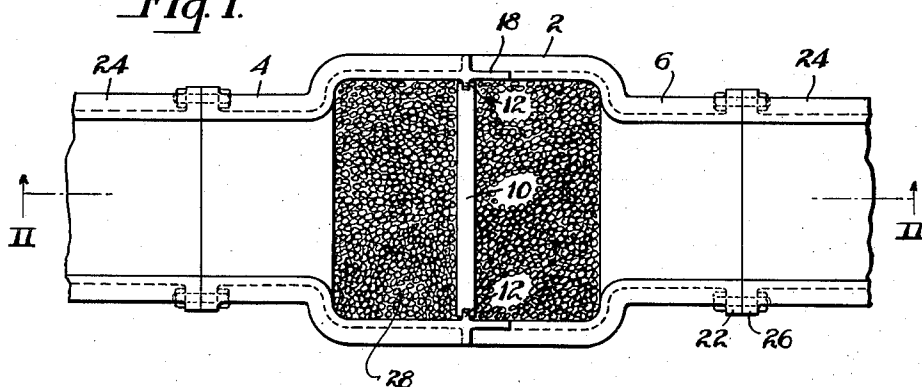
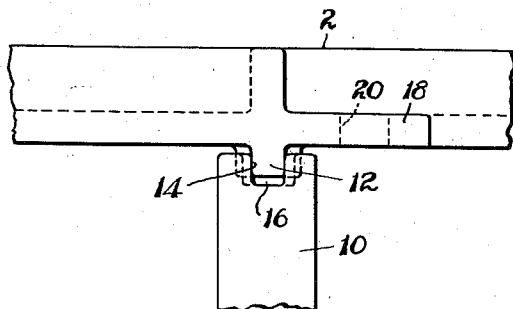


Fig. 2.

Fig. 3.



INVENTORS
Kenneth J. Brondyke
Philip T. Stroup
BY
George B. Todd
ATTORNEY

Dec. 9, 1958

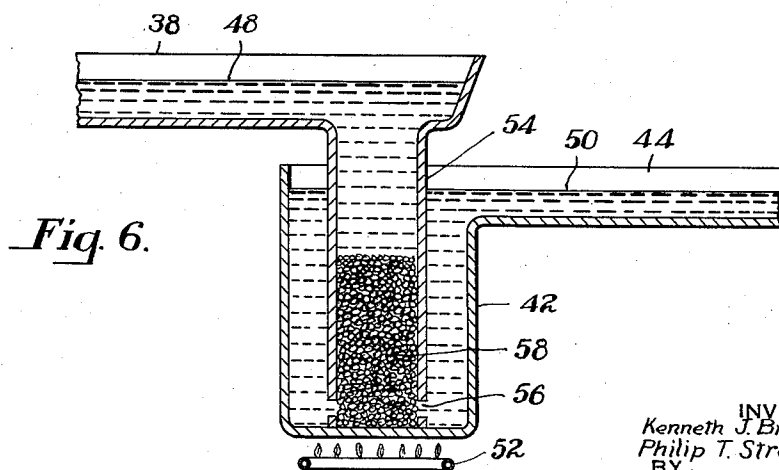
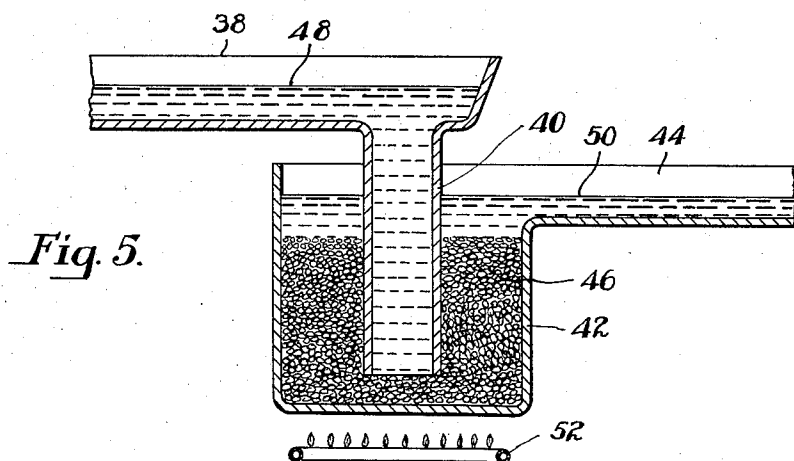
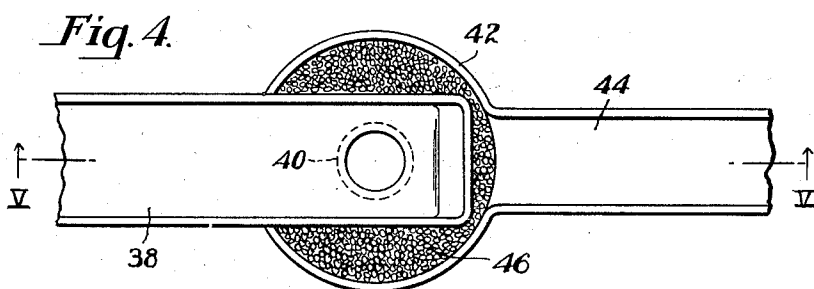
K. J. BRONDYKE ET AL

2,863.558

FILTERING MOLTEN ALUMINOUS METAL

Filed April 29, 1957

2 Sheets-Sheet 2



INVENTORS
Kenneth J. Brondyke
Philip T. Stroup
BY
George B. Todd
ATTORNEY

1

2,863,558

FILTERING MOLTEN ALUMINOUS METAL

Kenneth J. Brondyke, Oakmont, and Philip T. Stroup, New Kensington, Pa., assignors to Aluminum Company of America, Pittsburgh, Pa., a corporation of Pennsylvania

Application April 29, 1957, Serial No. 655,746

5 Claims. (Cl. 210—69)

This invention relates to filtering molten aluminous metal to remove therefrom finely divided non-metallic particles which may be entrapped in the metal. In referring to aluminous metal, it is to be understood that this means those alloys which contain at least 50% by weight of aluminum.

In the melting of aluminous metal and the subsequent transfer to a mold or other receptacle, a film generally forms on the surface of the melt which is largely composed of metal oxides, the principal oxide being that of aluminum. This film is, of course, broken up as the metal is stirred or otherwise agitated in the course of adding alloy components, fluxing and transfer to a ladle or a mold. The particles of oxide film become entrapped in the metal by reason of their small size and a density which closely approaches that of the molten metal, so that they neither settle to the bottom of the melt nor rise to the surface. While such non-metallic impurities are harmless in some castings and wrought products, they are objectionable in others, especially if they are associated with voids and interfere with obtaining a fine finish on the final product. In some instances, the inclusions may be of such a size and character as to interfere with machining of the metal by dulling the cutting tools or gouging the surface when caught on the edge of a cutting tool.

The filtering of liquid metal as practiced heretofore has involved passing the metal through a solid body having fine pores therein or in employing a compacted mass of filter material. A common method of removing the coarser solid particles has been to insert screens in the path of the molten metal stream. Such a means of straining the molten metal is not efficient in trapping the very small finely divided particles of oxide carried along by a stream of molten aluminous metal.

The problem of obtaining a greater flow of metal through a filter has brought forth the suggestion that the metal should be forced through the filter under super atmospheric pressure. As an alternative, it has been proposed that a vacuum be established on the discharge side of the filter and rely upon atmospheric pressure to drive the metal through the filter element. Such expedients are obviously expensive and awkward to manipulate under commercial melting room conditions.

It is an object of our invention to overcome the foregoing difficulties in treating molten aluminous metal. It is a particular object to provide a rapid method of filtering molten aluminous metal which effectively removes finely divided suspended oxide particles. Another object is to provide a method for filtering a stream of molten metal delivered from a furnace or other source of a metal. A further object is to provide a method of filtering molten aluminous metal which permits quick starting and stopping of the filtering operation. Yet another object is to provide a method of filtering molten aluminous metal which allows a rapid change of filtering media without draining the filter unit. A special object is to provide a method of filtering molten aluminous metal

2

that increases the density of metal when frozen under reduced pressure conditions.

These and other objects and advantages will be apparent from the following description and examples taken in conjunction with the accompanying drawings wherein:

Fig. 1 is a top plan view of one form of filter apparatus adapted to carry out our process;

Fig. 2 is a vertical section on the line II—II of Fig. 1 and shows the flow of metal through the unit;

Fig. 3 is an enlarged top view of the joint between the partition plate and filter chamber wall as seen in Fig. 1;

Fig. 4 is a top plan view of another form of apparatus wherein the molten metal descends from an upper to a lower transfer trough;

Fig. 5 is a vertical section on the line V—V of Fig. 4; and

Fig. 6 is a modification of the unit seen in Figs. 4 and 5 wherein the filter bed is disposed within the downspout.

We have discovered that molten aluminous metal can be rapidly and effectively filtered by passing it through a heated bed of predetermined thickness of relatively coarse granules of an anhydrous refractory material gravitationally held below the surface of the metal, the refractory being composed of at least one substance selected from the group consisting of chromite, corundum, forsterite, magnesite spinel, periclase, silicon carbide and zircon. Of these, tabular alumina (synthetic corundum) is preferred. These refractories are particularly adapted to use in our process because they are inert towards molten aluminum, they have a high melting point, above 3400° F., they possess a high hardness greater than 5 on the Mohs' scale, they are resistant to attrition, and they have a specific gravity of not less than 3 so that the granules will sink to the bottom of the molten aluminous metal. All of these materials, with the exception of forsterite and zircon, are free from silica; but in the case of the last two, the silica is chemically combined with another oxide in such a manner that it is not attacked by the molten aluminum. For this reason, all of the materials are regarded as being inert toward the molten aluminous metal.

A filter bed composed of one or more of the foregoing materials has a relatively long life and when spent it can be easily and quickly replaced by suitably prepared fresh material. The removal and replacement is facilitated by the loose condition of the submerged refractory since it is only held in place by gravity in the molten aluminous metal.

Molten aluminous metal which has been filtered in accordance with our process is not only substantially free from non-metallic inclusions, but when frozen under a pressure of 5 mm. it has a greater density than the unfiltered metal. We have found, for example, that under such a reduced pressure the density may be increased from a value of 2.3 to over 2.6, and even the true density of the metal by passing the molten metal through a filter bed of the kind described above. The increase in density is believed to be attributable to the removal of gas associated with the solid non-metallic particles. The density determinations just referred to may be made on 150–300 g. samples in apparatus of the kind described in Light Metals (London), vol. 15, pages 306, 307 (September 1952). In such tests the molten metal sample tends to puff up if any gas is present and form a porous casting. The density measurements are made on the castings.

In our filtering process the filtering medium must have a granule size of 3 to 14 mesh except for a layer of coarser material on the order of ¼ to ¾ inch that may be used in certain forms of apparatus to prevent displacement of the finer material by the stream of molten metal. The layer of coarse granules is considered to have little, if any effect, upon the removal of solid impurities. If granules smaller than 14 mesh are employed,

the flow of metal is unduly impeded; whereas if larger granules than 3 mesh are used, the filtering is less effective. In our preferred practice the granules are between 3 and 8 in mesh size. The term mesh size as used herein will be understood to refer to the size of the openings in standard screens used for analysis of granular material.

To obtain the desired removal of non-metallic impurities, it is necessary to pass the molten metal through the filter medium for a distance of at least 6 inches and preferably 8 inches. If a shorter distance than 6 inches is used, the filtering action is incomplete. A greater length of travel may be used, providing the molten metal can be passed through the bed with sufficient rapidity to fill the mold or other receptacle at a reasonably rapid rate. Ordinarily, the length of travel through the filter medium should not exceed about 36 inches. Although the filter bed can be formed by simply allowing the refractory granules to sink in the initial body of molten metal, it is often helpful to lightly tamp the filter bed.

The filter bed is prepared by first washing out all of the fine particles from the granular refractory mass, and thus preclude any entrapment of these in the metal discharged from the filter unit. Following the wash operation the mass of refractory granules are heated to a temperature between 1200 and 1500° F. This heating serves to eliminate any water and bring the granules up to a temperature close to that of the molten metal to which they are added.

To place a filter unit in operation, the chamber which is to hold the refractory granules is partially filled with molten aluminous metal and maintained at a temperature between about 1200 and 1400° F. Enough metal must be provided to completely cover the bed of refractory material which is subsequently introduced. Generally speaking, it is advisable to provide enough molten metal to bring the level close to or at the level of the discharge port of the container when the refractory is added. The preheated refractory granules are poured into the molten aluminous metal body and sink to the bottom thereof. The molten metal should not freeze on the granules, so that they are free to settle in the molten metal body. Furthermore, by initially surrounding the granules with molten metal the filter is ready for immediate use, and the flow of metal is substantially uniform throughout the bed with a resultant improvement in filtering effectiveness. Also, by reason of their greater density than the molten metal, the granules are not easily washed out of place and into the stream of metal leaving the filter bed. The gravitational placement of the filter medium has the further advantage of preventing any channeling such as might occur if molten metal were introduced into a dry mass of the refractory granules.

Under some conditions it may be desirable to lightly tamp the granular mass to insure firm placement. However, the compacting must not be great enough to interfere with subsequent removal.

To prevent any undue chilling of either the molten metal or the filtering medium, it is desirable to heat the filter chamber and maintain it during operation at a temperature between about 1200 and 1400° F.

Once the refractory granules are in place, the flow of metal through the bed may be started. Although the flow may be slow, if desired, it is often necessary to filter a given volume of metal as rapidly as possible, and our process is adapted to such rapid operation. In our process, it is possible to filter metal passing from a furnace or supply ladle to an ingot mold at a rate comparable to that which has been used in transferring unfiltered metal. We have found that with a bed of refractory granules of the size referred to above and 8 inches in length it is possible to pass 200 pounds of metal per hour through the filter bed per square inch of cross section normal to the direction of metal flow. If a larger volume of metal is to be treated, the area of the bed must be correspondingly increased. If the bed is

much longer, on the order of 15 to 25 inches, then it may be necessary to increase the cross sectional area to obtain the desired rate of flow of metal.

To replace the filter bed, it is only necessary to stop the flow of metal, ladle out the loose refractory granules and replace them with fresh material. In this manner there is a minimum interruption of the filtering operation.

Although our filtering method is applicable to all aluminum base alloys, it has been found to be especially effective in the case of those which contain one or more of the elements magnesium, silicon, zinc, manganese and copper.

Our process may be carried out in different types of filter units, the differences residing in the arrangement of the filter bed. One of the preferred types is that shown in Figs. 1 and 2. Here, a U-shaped cast iron filter chamber 2 has an upper or intake leg 4 and a lower discharge leg 6. The filtering medium 28, such as tabular alumina of 3 to 14 mesh in size, is held in the semi-circular bowl 8. A vertically movable metal partition 10 divides the chamber into two portions so that the incoming molten metal 32 is forced to travel down one side of the U and up the other side, the total distance traveled through the filter bed being at least 6 inches. The metal partition 10 is held in place through engagement between vertical tapered channels 14 in the edge thereof and the vertical tapered guide ribs 12 projecting inwardly from the wall of the filter chamber. The width of the tapered channel is so adjusted that the partition plate 10 can only descend to a predetermined level and thus compel the molten metal to flow under it from one leg of the U to the other. The construction of the channel and rib are more clearly seen in Fig. 3 which is an enlarged view of this detail. In addition to the diverging downward taper, a clearance 16 is provided between the edge of the rib and the bottom of the channel to permit some degree of lateral expansion and contraction of the plate and chamber walls without warpage. The taper construction of the rib and channel permits the establishment of a tight seal against any leakage of molten metal and yet allows easy vertical removal of the partition when desired, such as when the filter bed is to be removed and replaced by a fresh charge.

In the form of apparatus shown in Figs. 1 and 2 the filter unit is adapted to fit into a metal transfer trough line 24, the unit 2 being provided with flanges 22 for attachment by bolts to corresponding flanges 26 on the trough. A lug 18 is also provided at the top of the unit with hole 20 therein for reception of a hook or other means for raising and lowering the unit.

To heat the unit and maintain it at the desired temperature, any conventional heating means may be employed, as gas burners 30 disposed around the bowl portion 8 of the unit.

In the modification shown in Figs. 4 and 5 the metal descends from one transfer trough to another, and in the course of transfer the metal passes upwardly through a filter bed. In this arrangement an upper transfer trough 38 has a circular downspout 40 rigidly attached to the bottom thereof and which extends almost to the bottom of the filter bed 46 held in bowl 42 at one end of the lower transfer trough 44. The bowl is heated by any suitable means such as a gas burner 52 to maintain the filter bed at the desired temperature level. The lower end of the downspout is spaced from the bottom of the mold by a sufficient distance to permit free flow of molten metal into the filter bed. It is necessary, however, to surround the downspout with a filter medium of proper mesh size to a depth of at least 6 inches to insure adequate filtration. In operation of the filter unit, the molten metal is maintained at a level 48 in the upper transfer trough and at 50 in the lower trough.

The filter unit shown in Fig. 6 resembles that in Figs. 4 and 5, but the filter material is positioned within the downspout and the molten metal is discharged through

lateral openings 56 adjacent the bottom of the downspout. The downspout 54 must be of a sufficient cross section to accommodate the flow of metal, and it must be filled with a filtering medium 58, such as tabular alumina, of appropriate size to a depth of at least 6 inches above the lateral openings 56. The bottom edge of the downspout should rest on the bottom of bowl 42 and thus insure the filter medium is retained in place and that all of the molten metal is discharged through the lateral ports. To prevent washing out of the filter medium, it is advisable to fill the downspout with a coarse grade of refractory of $\frac{1}{4}$ to $\frac{3}{4}$ inch in size to a level above the discharge ports. In establishing the filter bed, it is, of course, necessary to introduce the coarse material first, and add the finer granules on top of the first layer.

It is to be understood that the surface of the filter elements and metal transfer means exposed to the molten metal may be coated with a conventional protective wash, or a layer of heat insulating material may be applied to such surfaces in place of the wash.

To begin the operation of the filter units, they are heated to a temperature above the melting point of the metal to be filtered, usually at 1200 to 1300° F. Molten metal is then introduced and the bowl is partially filled. The desired filtering medium should also be heated to approximately the same temperature and poured into the pool of molten metal. The refractory granules should be allowed to settle in the body of molten metal and the entire bed be completely submerged. The addition of the granules raises the metal level, and preferably it should be brought to or close to the point of discharge from the filter container. The filter unit is then ready for reception of unfiltered metal, and operation can start immediately and can be continued until the supply of metal is cut off. The temperature of the unit must be maintained at a high enough level to keep the metal molten and free flowing.

To replace the spent filtering medium, it is only necessary to halt the introduction of molten metal and disassemble the unit to such an extent that the refractory can be ladled out of the pool of molten metal remaining in the bowl portion. In the case of the unit illustrated in Figs. 1 and 2 the partition plate 10 is raised thus facilitating use of a ladle or dipper or other means of scooping up the granular material. In filter units of the type shown in Figs. 4, 5 and 6, the bowl portion must be first separated from the downspout and then the filtering material removed as mentioned above. It is essential, of course, that the unit be maintained at a high enough temperature during the exchange to prevent the molten metal from freezing.

The following examples will serve to illustrate the filtering process of our invention and the results obtained thereby.

In one case, apparatus of the kind shown in Figs. 1 and 2 was used. In this instance a molten aluminum base alloy having a nominal composition of aluminum, 4.4% copper, 0.8% silicon, 0.8% manganese and 0.4% magnesium was passed through a tabular alumina bed maintained at a temperature of about 1325° F. The U-shaped filter chamber has a cross sectional area of 16 sq. in. in each leg of the U and the chamber was filled with 30 lbs. of tabular alumina granules ranging from 3 to 6 mesh in size. The filter bed provided a path of travel for the molten metal 8 inches in length. The molten metal passed through the filter bed at the rate of 50 lbs. per minute. Density measurements made on metal frozen under a reduced pressure of 5 mm. indicated that the unfiltered metal had a density of 2.2 whereas the filtered metal had a density of 2.75. The increase in density is regarded as demonstrating the effectiveness of the filtering operation.

In another instance, a molten aluminum alloy of the same composition was filtered in apparatus of the type

shown in Fig. 6. The circular downspout which had a cross sectional area of 50 sq. in. was filled with coarse tabular alumina granules $\frac{1}{4}$ " to $\frac{1}{2}$ " in size to a point just above the lateral discharge ports adjacent the bottom of the downspout. A bed of 60 lbs. of tabular alumina granules of 3 to 6 mesh in size was placed on top of the bottom layer which provided a bed length of 8 inches. With the bed maintained at a temperature of about 1330° F., 155 lbs. per minute of molten metal were passed through the filter. Density determinations made samples frozen under 5 mm. pressure showed that the density had increased from 2.1 to 2.77.

In another test on a larger unit of the same type where the downspout had a cross sectional area of 113 sq. in. and 120 lbs. of tabular alumina of the same range in mesh size filled the downspout for a distance of 8 inches above the discharge ports, a molten alloy of the composition given above was passed through the filter at the rate of 350 lbs. per minute. The filter bed and metal were maintained at a temperature of about 1325° F. during the operation. The density test showed that the density had increased from 2.2 to 2.76 as a result of filtering.

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

1. The method of removing solid non-metallic particles of impurities from molten aluminous metal comprising the steps of providing an initial body of molten metal in a container having an outlet adjacent the top thereof, said body of molten metal only partially filling said container, preheating a mass of refractory granules of 3 to 14 mesh in size to a temperature of 1200 to 1500° F., said refractory being inert toward molten aluminum and consisting of at least one substance selected from the group composed of chromite, corundum, forsterite, magnesia spinel, periclase, silicon carbide and zircon, adding said hot refractory to said body of molten metal and allowing it to settle therein, the amount added being sufficient to provide a bed at least 6 inches in length that is completely submerged in said molten metal, and thereafter passing molten metal through said bed while maintaining the bed at a temperature of 1200 to 1400° F.

2. The method of removing solid non-metallic particles of impurities from molten aluminous metal comprising the steps of providing an initial body of molten metal at a temperature between 1200 and 1400° F. in a container having an outlet adjacent the top thereof, said body of molten metal only partially filling said container, preheating a mass of refractory granules of 3 to 8 mesh in size to a temperature of 1200 to 1500° F., said refractory being inert toward molten aluminum and consisting of at least one substance selected from the group composed of chromite, corundum, forsterite, magnesia spinel, periclase, silicon carbide and zircon, adding said hot refractory to said body of molten metal and allowing it to settle therein in such amount as to provide a bed between 8 and 36 inches in length completely submerged in said molten metal, and thereafter passing molten metal through said bed while maintaining it at 1200 to 1400° F.

3. The method according to claim 2 wherein the refractory granules consist of tabular alumina.

4. The method of removing solid non-metallic particles of impurities from molten aluminous metal comprising the steps of providing an initial body of molten metal at 1200 to 1400° F. in a container having an outlet adjacent the top thereof and a centrally disposed shell with lateral openings adjacent the bottom thereof within said container and extending above the container through which the molten metal is admitted to the chamber, said body of molten metal partially filling said container and said shell positioned therein, preheating a first mass of refractory granules from $\frac{1}{4}$ to $\frac{3}{4}$ inch in size to 1200 to 1500° F., adding them to said body of metal within said shell in an amount sufficient to reach a height above the lateral

7

openings adjacent the base of the shell, preheating a second mass of refractory granules from 3 to 14 mesh in size and adding them to said molten metal within said shell and on top of said first mass of granules, the amount of said second mass being sufficient to create a bed at least 6 inches in height and completely submerged in said molten metal, said first and second masses of refractory granules consisting of a material inert toward molten aluminum and selected from at least one substance of the group consisting of chromite, corundum, forsterite, magnesia spinel, periclase, silicon carbide and zircon, allowing said refractory granules to settle in the molten metal when added thereto, and thereafter passing molten aluminum metal through said bed while maintaining the temperature thereof between 1200 and 1400° F.

5. The method of removing solid non-metallic impurities from a stream of molten aluminous metal passing from a source of supply to a mold comprising passing said stream through a bed of refractory granules, the length of travel of said metal through said bed being at least 6

8

inches, said bed being prepared by providing a body of molten metal in a container having an outlet adjacent the top thereof, preheating a mass of refractory granules of 3 to 14 mesh size to a temperature of 1200 to 1500° F., said refractory being inert toward molten aluminum and consisting of at least one substance selected from the group composed of chromite, corundum, forsterite, magnesia spinel, periclase, silicon carbide and zircon, adding said hot refractory to said body of molten metal, allowing it to settle therein, in an amount which causes the metal to rise to the level of the outlet of said container, said amount also being sufficient to provide a bed at least 6 inches in length through which the metal must travel, and maintaining said bed and molten metal passing there-
15 through at a temperature of 1200 to 1400° F.

References Cited in the file of this patent

FOREIGN PATENTS

20 1,040,447 France ----- May 20, 1953