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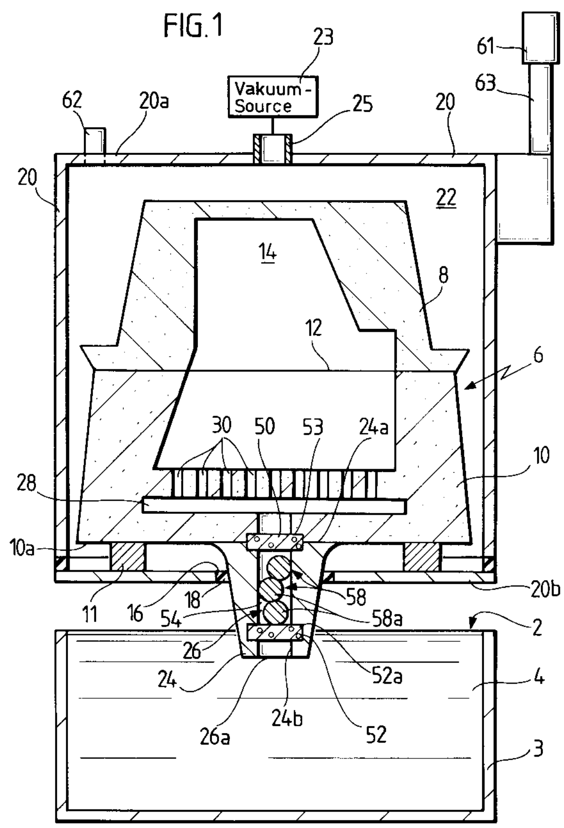
(54) Differential pressure, countergravity casting with alloyant introduction.

(57) A casting mold includes an inlet flow passage having first and second filtering members disposed therein in spaced apart relation to define an alloyant-receiving chamber therebetween in the flow passage. Alloyant, such as an inoculating and/or nodularizing agent, is disposed in the chamber such that molten metal is drawn through the chamber during countergravity casting to have the alloyant introduced therein immediately prior to the entry of the molten metal into a mold cavity thereabove.

FIG.1



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Field Of The Invention

This invention relates to an improved apparatus and method for the differential pressure, countergravity casting of a melt in such a manner as to selectively introduce alloyant into the melt as it is drawn upwardly into the mold cavity.

Background Of The Invention

A vacuum countergravity casting process using a gas permeable mold sealingly received in a vacuum housing is described in such patents as the Chandley et al U.S. Patents 3,900,064; 4,340,108 and 4,606,396. That countergravity process involves providing a mold having a porous, gas permeable upper mold member (cope) and a lower mold member (drag) sealingly engaged at a parting plane, sealing the mouth of a vacuum housing to a surface of the mold such that a vacuum chamber formed in the housing confronts the gas permeable upper mold member, submerging the underside of the lower mold member in an underlying melt and evacuating the vacuum chamber to draw the melt upwardly through one or more narrow ingates (pin gates) in the lower mold member and into one or more mold cavities formed between the upper and lower mold members.

In practicing the vacuum countergravity process to produce nodular iron castings, the melt is typically prepared in a melting vessel (e.g., a cupola) using a charge of pig iron to which additions of alloyants are made to provide the desired base melt chemistry. For example, in casting nodular iron, ferromanganese (Fe-Mn), ferrosilicon (Fe-Si) and other additions are made to the base pig iron charge to provide a desired base melt chemistry.

Once the desired base melt composition is achieved, the melt is transferred from the melting vessel to a ladle where an inoculating/nodularizing agent (e.g., a Fe-Si-Mg alloy) is periodically added to spherodize (nodularize) the carbon and inhibit formation of iron carbides in the casting. A gradual build-up of Si can occur in the melt over time as a result of the periodic ladle inoculations with the Fe-Si-Mg agent. Moreover, whenever the melt in the ladle is topped up with fresh melt from the melting vessel, the overall Si concentration of the melt will drop. A cyclic variation (increase/decrease) in the Si concentration of the melt thus occurs over time.

Prior art workers have also experienced difficulty in maintaining an effective concentration (i.e., at least 0.02 percent by weight) of magnesium in the melt over time, especially during the extended time required to cast a plurality of molds in succession from the melt after the melt is transferred from the ladle to a casting vessel. This difficulty is attributable to the rapid evaporation of magnesium from the melt after the treatment(s) with the inoculating/nodularizing agent. Erratic, uncontrolled loss (also known as fade) of the fugitive magnesium from the melt over time has been experienced and resulted in off-chemistry melts in so far as magnesium content is concerned and correspondingly inconsistent nodularization.

As a result of this inability to reliably control and maintain the melt chemistry over time, use of the countergravity casting processes described in the aforesaid patents in high volume production of nodular iron parts has been rendered impractical and/or uneconomical to date.

Moreover, in order to produce iron castings having different compositions/microstructures (e.g., corresponding to the known ferritic nodular grade 4010 or pearlitic nodular grade 5203), the practice has been to prepare separate base melts of the desired different compositions using pig iron charges to which appropriate alloy additives are made in the melting vessel and then ladling and countergravity casting the separate base melts from the casting vessel as described above. This practice amounts to producing castings of one composition/microstructure in one batch and castings of another different composition/microstructure in a separate batch with preparation as well as subsequent handling, treatment and casting of different base melts for each batch.

It is an object of the present invention to provide an improved apparatus and method for the differential pressure, countergravity casting of a melt wherein the melt is drawn through an alloyant-receiving chamber formed in a mold molten flow passage between spaced apart molten metal filtering members so as to introduce the alloyant into the melt in a controlled, effective concentration.

It is another object of the invention to provide an improved apparatus and method for the differential pressure, countergravity casting of a melt wherein a treating agent, such as an inoculating and/or nodularizing alloyant used to treat iron, is introduced into the melt in a chamber formed in a mold molten metal flow passage between spaced apart molten metal filtering members so as to maintain a predetermined effective concentration of the alloyant in the melt, thereby avoiding variations/losses in the alloyant concentration of the melt over time.

It is another object of the invention to provide an improved apparatus and method for the differential pressure, countergravity casting of a melt wherein contamination of the melt as cast in the mold and as present in an underlying casting vessel is reduced by use of spaced apart molten metal filtering members in a mold molten metal flow passage.

The aforementioned objects and advantages of the present invention set forth hereinabove will become more readily apparent from the detailed description and drawing which follow.

Summary Of The Invention

The present invention contemplates an improved apparatus and method for the differential pressure, countergravity casting of molten metal wherein first and second molten metal filtering members are disposed in a molten metal flow passage of a casting mold in spaced apart relation so as to define an alloyant-receiving chamber therebetween in the flow passage. The molten metal is drawn upwardly in the flow passage by differential pressure and flows through the filtering means and the chamber where the molten metal so contacts alloyant in the chamber as to introduce the alloyant in the melt in a controlled manner. The molten metal flows from the chamber to the mold cavity to fill it with filtered molten metal containing the alloyant therein.

In one embodiment of the invention, the mold includes a fill tube depending from an underside thereof for immersion in an underlying pool of molten metal. The molten metal flow passage comprises an upstanding molten metal inlet passage in the fill tube for receiving the molten metal from the pool. First and second porous, ceramic filtering members are disposed in the inlet passage at spaced apart axial locations to define an alloyant-receiving chamber therebetween. A plurality of alloyant bodies (e.g., spheres) are confined in the chamber between the filtering members and are so sized as to treat a given amount of the molten metal to be cast into the mold cavity.

In another embodiment specifically adapted for countergravity casting of iron, an iron-treating agent (e.g., an alloyant comprising a inoculating and/or nodularizing agent, such as an Fe-Si or Fe-Si-Mg alloy) is disposed and confined in the chamber formed between the filtering members to so contact the molten iron drawn upwardly through the filtering members and the chamber as to introduce the treating agent into the molten metal immediately prior to its entering the mold cavity. The concentration of the treating agent in the molten metal entering the mold cavity is maintained above a predetermined effective concentration for inhibiting formation of iron carbides in the casting in the case of an inoculating agent and for nodularizing carbon in the casting in the case of a nodularizing agent. Introduction of the treating agent in this manner alleviates variations in the concentration thereof in the melt over time (i.e., fade) experienced heretofore in the countergravity casting of iron and reduces the amount of inoculating and/or nodularizing agent needed.

Brief Description of the Drawing

Figure 1 is a sectioned, side view of a vacuum countergravity casting apparatus in accordance with one embodiment of the invention.

Figure 2 is a sectioned, side view of a vacuum countergravity casting apparatus in accordance with another embodiment of the invention.

Detailed Description Of Specific Embodiments

Figure 1 depicts a pool 2 of molten metal 4 which is to be drawn upwardly into a casting mold 6 comprising a gas-permeable, upper mold cope 8 disposed on a lower mold drag 10 at a parting line 12. The mold cope 8 and mold drag 10 define one or more mold cavities 14 therebetween (only one shown). The melt 4 is contained in an underlying casting furnace or vessel 3 heated by one or more induction coils (not shown) to maintain the melt 4 at a desired casting temperature.

The mold 6 is disposed in a vacuum box 20 on a mold support 11. The vacuum box 20 defines a vacuum chamber 22 about the mold 6. The vacuum chamber 22 encloses the mold cope and drag 8,10 and communicates with a vacuum source 23 (e.g., a vacuum pump) via conduit 25 in the upper wall 20a of the vacuum box 20.

The mold drag 10 includes an elongated, refractory molten metal fill tube 24 extending outside the vacuum chamber 22 toward the underlying molten metal pool 2 for immersion therein in a manner to be described. The fill tube 24 extends through an opening 16 in a bottom wall 20b of the vacuum box 20 and is sealed therein by a refractory sealing gasket 18. The fill tube 24 is attached (e.g., glued) to the underside of the mold drag 10. The fill tube 24 is made of a refractory material resistant to degradation in the molten metal 4 to enable reuse in the casting of other disposable molds 6. A fill tube 24 of resin-bonded sand may be used.

The fill tube 24 includes an upstanding molten metal inlet flow passage 26 adapted to receive the molten metal 4 from the pool 2. The inlet flow passage 26 communicates with a lateral runner 28 thereabove to supply the molten metal 4 thereto. The runner 28, in turn, is communicated to a plurality of narrow ingate passages 30 that are adapted to supply the molten metal 4 to the mold cavity 14. The molten metal inlet flow passage 26 includes a lower open end 26a for engaging the pool 2 and supplying the melt 4 to the mold cavity 14 via the runner 28 and ingate passages 30 when the lower end 26a is immersed in the pool 2 with the mold cavity 14 evacuated as will be explained hereinbelow.

The mold cope 8 comprises a gas-permeable material (e.g., resin-bonded sand) which permits gases to be withdrawn therethrough from the mold cavity 14 when a vacuum is drawn in the vacuum chamber 22. The mold drag 10 may conveniently comprise the same material as the mold cope 8 or other materials, permeable or impermeable, which are compatible with the material of the upper mold cope 8. The mold cope and drag 8,10 are each made in accordance with known mold practice where a compliant (shapeable) mixture of sand or equivalent particles and a settable binder material (e.g., an inorganic or organic thermal or chemical setting plastic resin) is formed to shape and then cured or hardened against respective contoured pattern plates (not shown).

The mold cope and the drag 8,10 are typically adhered (glued) together at parting plane 12. Alternately they can be pressed into sealing engagement (i.e., at the parting line 12) by means of a plurality of plungers, springs and the like (not shown) disposed between the upper wall 20a of the vacuum box 20 and the top of the mold 6 so as to eliminate, if desired, the need to glue the mold cope and drag 8,10 together at the parting line 12. Arrangements for pressing the mold cope and drag 8,10 sealingly together sans glue are shown in U.S. Patents 4,862,945; 4,828,011; 4,825,933 and 4,809,767.

In accordance with the present invention, upper (first) and lower (second) molten metal filtering members 50,52 are disposed in the inlet flow passage 26 at axially spaced locations to define an alloyant-receiving chamber 54 therebetween in the flow passage 26. The filtering members 50,52 each preferably comprises a porous, ceramic material (e.g., zirconia, alumina, etc.) resistant to degradation by the melt 4 and configured to span or extend laterally across the inlet flow passage 26. The upper filtering member 50 is positioned in a recess 53 formed between the underside 10a of the mold drag 10 and the top side 24a of the fill tube 24. The lower filtering member 52 includes a peripheral side 52a embedded in the adjoining fill tube wall 24b during or after fabrication thereof. For example, the fill tube 24 may be molded in-situ about the filtering member 52. Alternately, the fill tube 24 may be molded to shape and then machined to form an annular recess in the open end 26a for receiving the filtering member 52. The filtering member 52 is placed in the recess and suitable refractory material is packed into the recess against the filtering member 52 to reconstruct the lower end 26a to the configuration shown in Figure 1. The filtering members 50,52 are thereby positioned and supported across the flow passage 26 at the spaced apart axial locations.

The filtering members 50,52 serve to confine alloyant 58, such as one or more alloyant bodies 58a (e.g., spheres), therebetween in the chamber 54 for contact with, and dissolution by, the molten metal 4 as it is drawn upwardly through the inlet flow passage 26. The alloyant bodies 58a are prevented by the filtering members 50,52 from falling downwardly out of the inlet flow passage 26 and also from being drawn upwardly into the runner 28 when the molten metal 4 is drawn upwardly therethrough during casting as will be explained.

Moreover, as will become apparent hereinbelow, the filtering members 50,52 prevent nonmetallic impurities (such as oxide particles, slag particles, sand or ceramic particles and the like), any undissolved alloyant 58, and any reaction slag by-products (resulting from the melt/alloyant reaction) from being drawn upwardly with the molten metal 4 into the mold cavity 14 during casting. Similarly, the filtering members 50,52 prevent these same contaminants from being discharged back into the pool 2 after casting when molten metal is drained from the inlet flow passage 26. The dimensions and pore size of the ceramic filtering material are selected to these ends.

The porous, ceramic filtering members 50,52 may be selected from commercially available ceramic "cellular" filters and ceramic "sponge" filters having desired pore size. A ceramic "cellular" material useful in practicing the invention is sold under the trademark CELTEX® and comprises, by weight, 60% dordierite and 40% mullite. This filter typically includes 100 cells/pores per square inch. A ceramic "sponge" filter useful in practicing the invention is sold under the trademark SEDEX® and comprises greater than 90% by weight alumina. This filter typically exhibits an open cell porosity of about 90% and an average pore size of about 0.080 inch. Those skilled in the art will appreciate that various types of molten metal filter materials may be used in practicing the invention.

The alloyant bodies 58a are positioned in the chamber 54 before the fill tube 24 is assembled (e.g., glued) to the underside 10a of the mold drag 10. In particular, the alloyant bodies 58a (three shown) are first placed in the inlet flow passage 26 atop the lower filtering member 52, which is already embedded in the fill tube 24. The upper filtering member 50 is then glued or otherwise fastened to the top side 24a of the fill tube 24. The fill tube 24 is then glued to the underside 10a of the mold drag 10 as shown so that the upper filtering member 50 is disposed in the recess 53.

Referring to Figure 1, countergravity casting of the melt 4 into the casting mold 6 is effected by relatively moving the vacuum box 20 and the pool 2 to immerse the lower open end 26a of the inlet flow passage 26 in the melt 4. Typically, the vacuum box 20 is lowered toward the pool 2 using a hydraulic power cylinder 61 (shown schematically) actuating a support arm 63 (shown schematically) that is connected to the vacuum box 20. The vacuum chamber 22 is then evacuated to draw the melt 4 upwardly in the inlet flow passage 26 so as to flow through the filtering members 50,52 and the chamber 54 where the melt 4 so contacts the alloyant bodies 58a as to have the alloyant introduced (e.g., dissolved) therein above a predetermined effective concentration. The alloyant bodies 58a have a weight/size as to insure that all the molten metal 4 drawn upwardly into the mold cavity 14 is contacted and treated to introduce the alloyant therein in desired concentration.

As the melt 4 is drawn upwardly, the filtering members 50,52 trap and remove any non-metallic impurities, undissolved alloyant and slag by-products (resulting from the melt/alloyant reaction) having a size greater than the selected filter pore size to prevent their being drawn into the metal cavity 14. The filtered, treated melt 4 (i.e., the melt containing the alloyant) is drawn from the chamber 54 through the runner 28 and the ingate passages 30 into the mold cavity 14 to fill it with the melt 4.

Those skilled in the art will appreciate that the size and shape of the inlet flow passage 26, the runner 28 and the ingate passages 30 of the mold 6 as well as the pore size of the filtering members 50,52 are selected to provide a desired melt flow rate and melt residence time in the chamber 54 and melt flow rate into the mold cavity 14.

After filling of each mold cavity 14 with the filtered, treated melt 4 and initial solidification of the melt in the ingate passages 30, the vacuum box 20 is raised by hydraulic power cylinder 61 to withdraw the lower open end 26a of the inlet flow passage 26 out of the pool 2. The number and size of the ingate passages 30 to achieve melt solidification initially thereat can be selected in accordance with the teachings of U.S. Patent 4,340,108. Alternatively, the filtered, treated melt 4 can be allowed to solidify in both the ingate passages 30 and the mold cavity 14 before raising the vacuum box 20 to withdraw the fill tube 24 out of the pool 2. In still another alternative, the pore size of the upper filtering member 50 can be selected such that surface tension effects will hold the melt in the filter sufficiently to plug the flow passage 26 and prevent backflow of melt from the mold into the pool 2.

After the vacuum box 20 is raised to remove the fill tube 24 from the pool 2, the vacuum in the vacuum chamber 22 is released by actuation of a suitable valve means 62 (e.g., to connect vacuum chamber 22 to ambient pressure) to allow the melt 4 in the inlet flow passage 26 to drain back to the pool 2. The filtering members 50,52 trap and remove any non-metallic impurities, undissolved alloyant 58 and reaction slag by-products (resulting from the melt/alloyant reaction) from the molten metal drained to the pool 2 to prevent contamination of the pool 2 thereby. The vacuum box 20 and the melt-filled mold 6 are then separated.

By way of illustration and not limitation, Fig. 2 illustrates an embodiment of the invention used to vacuum countergravity cast an L-4 automobile engine block of pearlitic cast iron weighing about 96 lbs. In particular, a vertically-parted casting mold 106 and barrel slab core 107/water jacket core 109 were assembled to define a mold cavity 114 for receiving the iron melt from an underlying pool like that shown in Fig. 1. The mold 106 was constructed to capture a fill tube 124 having an upper flange portion 124a and a lower tubular portion 124b adapted for immersion in the underlying pool as explained hereinabove with respect to Fig. 1.

The fill tube 124 included an inlet flow passage 126 having a diameter of about $1\frac{1}{2}$ inches and a length of about 12 inches. Porous, ceramic filtering squares 150,152 each having dimensions of about 50 mm width X 50 mm length X 22 mm thickness were disposed across the inlet flow passage 126 spaced about 4 inches apart in the manner shown in Fig. 2 to define an alloyant-receiving chamber 154. The filtering members comprised the aforementioned SEDEX ceramic "sponge" filters (10 pores/in2) available from Foseco Inc. Three spheres or balls 158a of a ferrosilicon (Fe-Si) inoculating agent were disposed between the filtering squares 150,152 as shown in Fig. 2. Each inoculant ball 158a had a diameter of $1\frac{1}{4}$ inches and weighed about 42 grams. The inoculant alloyant had a nominal composition of 75 weight % Fe and 25 weight % Si, and was purchased from Globe Metallurgical Sales, Inc. The as-purchased inoculant alloyant was mixed with a binder material (EXOSIL sand binder available from Foseco Inc.) and formed into the spherical shape shown.

A pearlitic iron melt (not shown) devoid of any inoculating agent was maintained at about 2650 °F in an underlying casting vessel (not shown but similar to that shown in Fig. 1). The iron melt was drawn upwardly from the casting vessel by establishing a suitable vacuum in the vacuum chamber 122 (e.g., about 205 inches of water) when the open end 126a of the flow passage 126 was immersed in the iron melt. The iron melt was drawn upwardly through the flow passage 126, the filtering members 150,152 and the chamber 154 where it reacted (dissolved) the inoculant alloyant spheres 158a. The treated, filtered iron melt was supplied to the mold cavity 114 via gating 129. After solidification of the gating 129, vacuum box 120 was raised to withdraw the fill tube 124 from the iron melt. The vacuum was then released in chamber 122 and the iron melt was drained from the inlet passage 126 through the filtering members 150,152. The solidified engine block casting was sectioned and examined at multiple locations. The casting was found to exhibit an as-cast microstructure with iron carbides (Fe_3C) present in acceptable amounts (e.g., 5 volume percent or less) at all locations examined.

Although the illustrative embodiment of the invention is described hereinabove with respect to the introduction of an inoculating agent to an iron melt to minimize formation of iron carbides in the casting, those skilled in the art will appreciate that the invention can also be employed to introduce a fugative nodularizing agent (such as magnesium) into the iron melt to spherodize the carbon present. Typically, the inoculating agent and nodularizing agent are introduced concurrently to the iron melt using alloyant bodies 58a,158a comprising an Fe-Si-Mg alloy.

Moreover, alloyants such as copper, chromium, manganese, molybdenum, silicon as well as others that are soluble in the melt may be introduced therein during countergravity casting in accordance with the invention. For example, the alloyant bodies 58a,158a in the chamber 54,154 of the above-described embodiments may comprise copper bodies (spheres). A ferritic nodular iron melt (corresponding in composition to the known ferritic nodular iron grade 4010) is drawn upwardly from the casting vessel through the inlet flow passage 26,126, the filtering members 50,52; 150,152 and the chamber 54,154 where copper is introduced into the melt in desired concentration. The filtered, Cu-bearing melt is then drawn into the mold cavity 14,114 in the manner as described hereinabove. The copper is introduced (i.e., dissolved) into the iron melt as it passes through the chamber 54,154 in a sufficient amount (e.g., about 0.4 w/o minimum to about .5 w/o maximum) to impart a microstructure and mechanical properties to the resultant casting corresponding to the known pearlitic nodular iron grade 5203.

The present invention thus envisions producing castings having different compositions/microstructures and resultant mechanical properties from a common underlying melt 4 by successively countergravity casting a plurality casting of molds 6,106 having different alloyants 58,158 in their chambers 54,154 from the common pool 2. A "universal" cupola melt thus can be used to supply the common pool 2. The need to prepare and handle different base melts in one or more melting vessels/ladles is thereby eliminated. Moreover, the flexibility of the vacuum countergravity casting process in meeting ever changing production schedule variations is tremendously improved.

Furthermore, those skilled in the art will recognize that the invention is not limited to the casting of cast irons and may also be used in the differential pressure, countergravity casting of other metal/alloys where selective introduction of one or more alloyants is desired for some purpose. For example, the present invention may be used to introduce (dissolve) known degassing, desulfurizing, deslagging and similar treating agents into aluminum and steel during the vacuum countergravity casting thereof.

While the invention has been described in terms of specific embodiments thereof, it is not intended to be limited thereto but rather only to the extent set forth hereafter in the claims which follow.

Claims

1. Apparatus for the differential pressure, countergravity casting of molten metal, comprising:

a) a mold having a mold cavity, a lower mold portion adapted to engage an underlying source of said molten metal and a molten metal flow passage communicating the mold cavity with the lower mold portion for supplying molten metal drawn from said source into said mold cavity,

b) first and second molten metal filtering means disposed in said flow passage in spaced apart relation to define a chamber therebetween in said flow passage for receiving alloyant, and

c) means for applying a sufficient differential pressure between the mold cavity and the source while the lower mold portion is engaged with said source to urge the molten metal to flow upwardly through said first and second filtering members and said chamber where the molten metal so contacts the alloyant as to introduce said alloyant therein and then to flow into the mold cavity to fill said mold cavity with filtered molten metal containing said alloyant therein.

2. The apparatus of claim 1 wherein the lower mold portion comprises a molten metal fill tube depending from the mold and said flow passage comprises an upstanding inlet passage in said fill tube.

3. The apparatus of claim 2 wherein the first and second filtering members are generally horizontally disposed across the upstanding molten metal inlet passage.

4. The apparatus of claim 2 wherein the molten metal fill tube includes a top side attached to an underside of the mold.

5. The apparatus of claim 4 wherein the first filtering member is disposed between said top side and said underside, and the second filtering member is disposed in the fill tube therebelow.

6. The apparatus of claim 5 wherein the second filtering member includes an outer periphery embedded in the fill tube.

7. The apparatus of claim 3 wherein the mold comprises a plurality of mold cavities each receiving the molten metal from the inlet passage in said fill tube.

8. The apparatus of claim 3 wherein the source of molten metal comprises a molten metal pool and said fill tube is adapted for immersion in said pool.

9. The apparatus of claim 1 wherein the first and second molten metal filtering members each comprises a porous, ceramic member.

10. The apparatus of claim 1 wherein the alloyant comprises a plurality of alloyant bodies confined in said chamber between the first and second filtering members.

11. Apparatus for the differential pressure, countergravity casting of iron, comprising:
a) a mold having a mold cavity, a lower mold portion adapted to engage an underlying source of iron melt and a melt flow passage communicating the mold cavity with the lower mold portion for supplying iron melt drawn from said source into said mold cavity,
b) first and second molten metal filtering members disposed in said inlet flow passage and axially spaced apart to define a chamber therebetween in said flow passage for receiving an iron-treating agent, and
c) means for applying a sufficient differential pressure between the mold cavity and the source while the lower mold portion is engaged with said source to urge the iron melt to flow upwardly through said filtering members and said chamber where the iron melt so contacts the treating agent as to introduce said agent therein and then to flow into the mold cavity to fill said mold cavity with the filtered, treated melt.

12. The apparatus of claim 11 wherein the lower mold portion comprises a fill tube depending from the mold and said inlet passage comprises an upstanding passage formed in said fill tube.

13. The apparatus of claim 12 wherein the first and second filtering members are generally horizontally disposed across the upstanding inlet passage.

14. The apparatus of claim 13 wherein the mold comprises a plurality of mold cavities each receiving the iron melt from the upstanding inlet passage in said fill tube.

15. The apparatus of claim 13 wherein the source of iron melt comprises a molten iron pool and said fill tube is adapted for immersion in said pool.

16. The apparatus of claim 11 wherein the first and second molten iron filtering members each comprises a porous, ceramic member.

17. The apparatus of claim 11 wherein the treating agent comprises at least one of an inoculating agent and a nodularizing agent.

18. A method of differential pressure, countergravity casting molten metal, comprising:
a) forming a mold having a mold cavity, a lower mold portion adapted to engage an underlying source of said molten metal and a molten metal flow passage communicating the mold cavity with the lower mold portion for supplying molten metal drawn from said source into said mold cavity,
b) disposing first and second molten metal filtering members in the flow passage at spaced apart locations to define a chamber therebetween in said flow passage for receiving alloyant,
c) disposing alloyant in the chamber between said filtering members,
d) relatively moving the mold and the source to engage the lower mold portion and the source, and
e) applying a sufficient differential pressure between the mold cavity and the source while the lower mold portion is engaged with said source to urge the molten metal to flow upwardly through said filtering members and said chamber where the molten metal so contacts the alloyant as to introduce said alloyant therein and then to flow into the mold cavity to fill said mold cavity with the filtered molten metal containing said alloyant therein.

19. The method of claim 18 including the additional step of relatively moving the mold and the source to disengage the lower mold portion and the source to allow the molten metal in the flow passage to drain back to the source, said

filtering members preventing any alloyant remaining in said chamber from being discharged to said source.

20. The method of claim 18 wherein the mold is formed with a depending fill tube adapted for immersion in an underlying molten metal pool and said flow passage is formed on said fill tube.

21. A method of differential pressure, countergravity casting of iron, comprising:

a) forming a mold having a mold cavity, a lower mold portion adapted to engage an underlying source of said iron melt and a melt flow passage communicating the mold cavity with the lower mold portion for supplying iron melt drawn from said source into said mold cavity,

b) disposing first and second molten metal filtering members in across the flow passage at spaced apart locations to define a chamber therebetween in said flow passage for receiving an iron-treating agent,

c) disposing the treating agent in the chamber between said filtering members,

d) relatively moving the mold and the source to engage the lower mold portion and the source, and

e) applying a sufficient differential pressure between the mold cavity and the source while the lower mold portion is engaged with said source to urge the iron melt to flow upwardly through said filtering members and said chamber where the iron melt so contacts the treating agent as to introduce said agent therein and then to flow into the mold cavity to fill said mold cavity with the filtered, inoculated melt.

22. The method of claim 21 wherein the treating agent comprises at least one of an inoculating agent and a nodularizing agent.

FIG.1

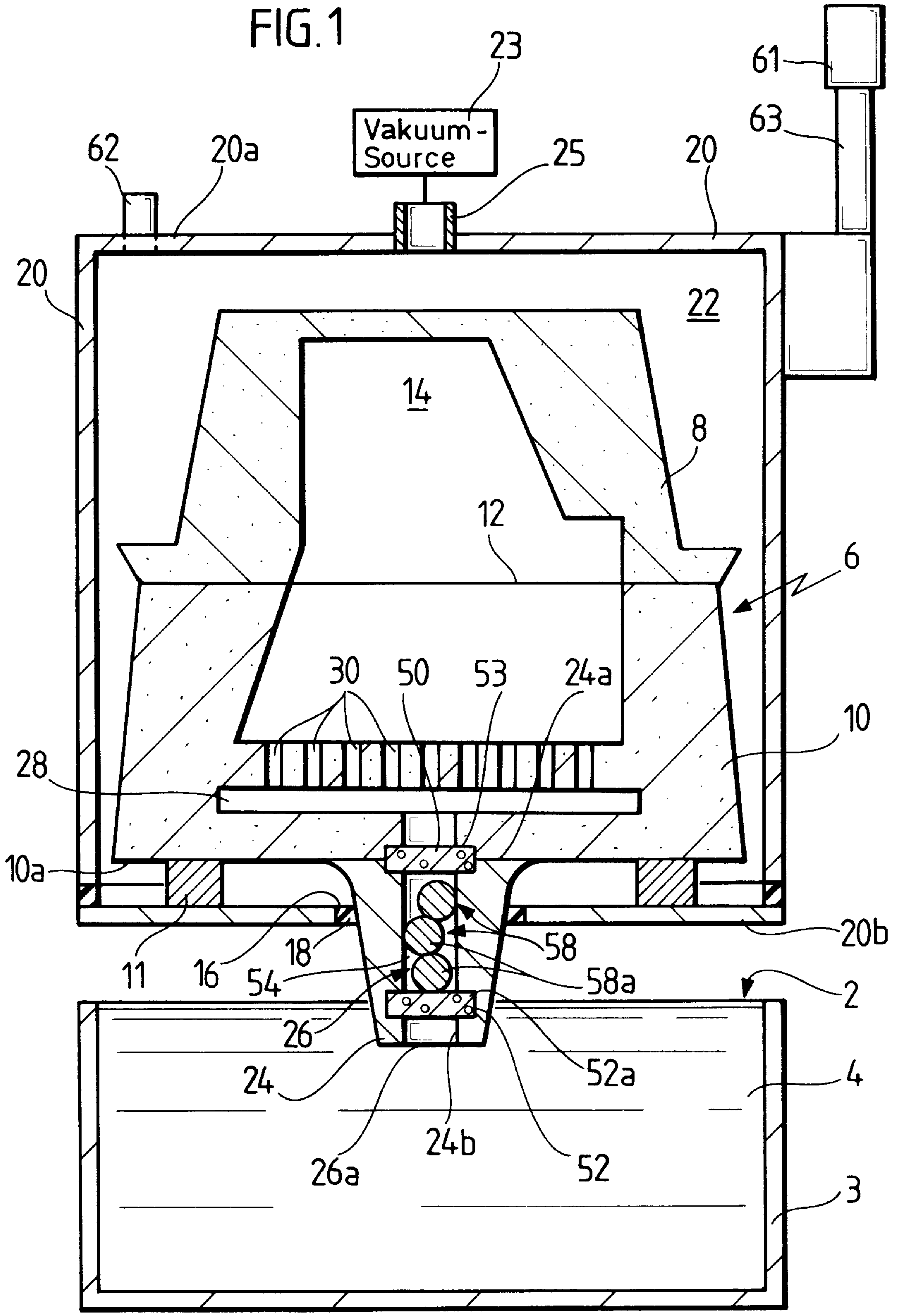
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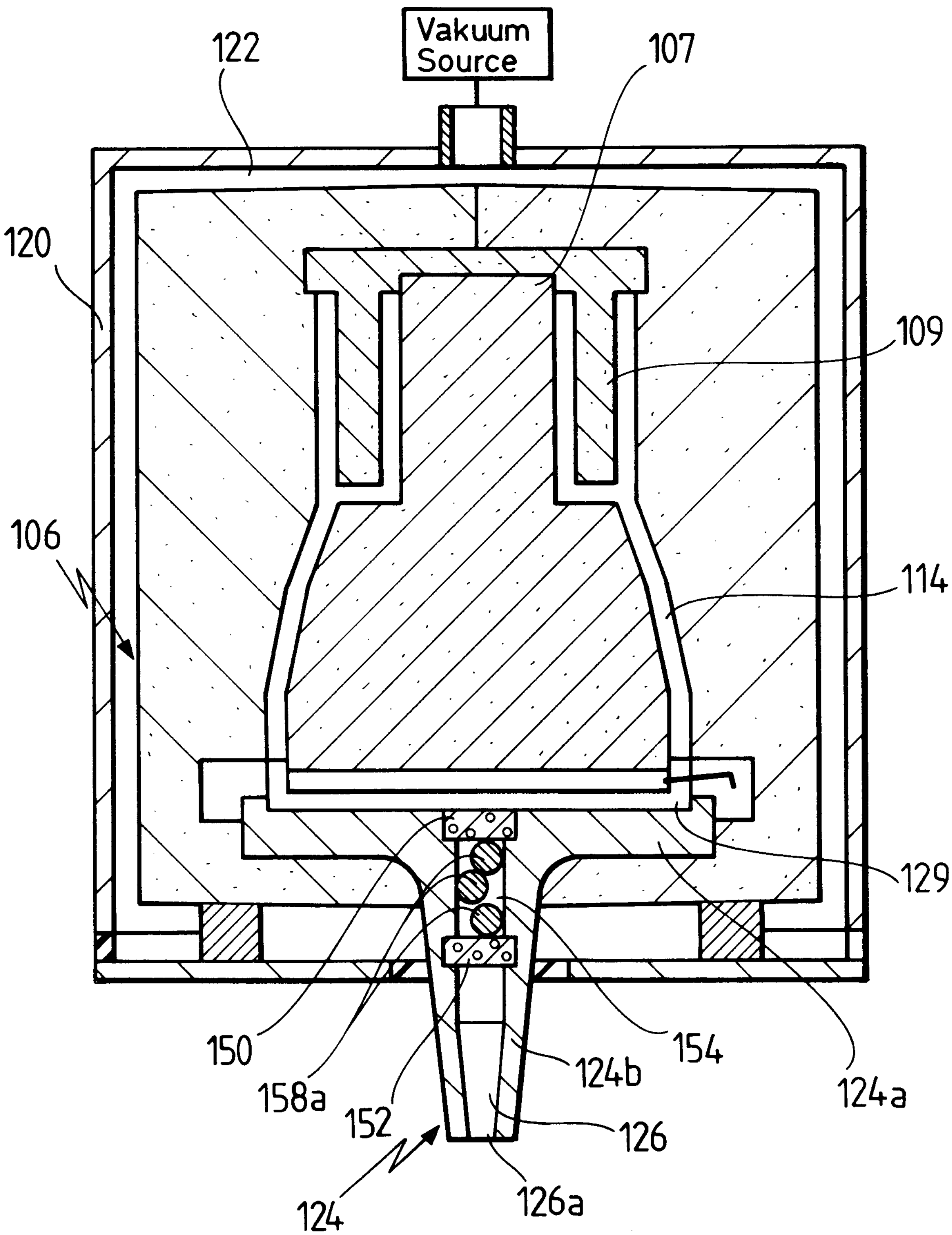
FIG.2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