

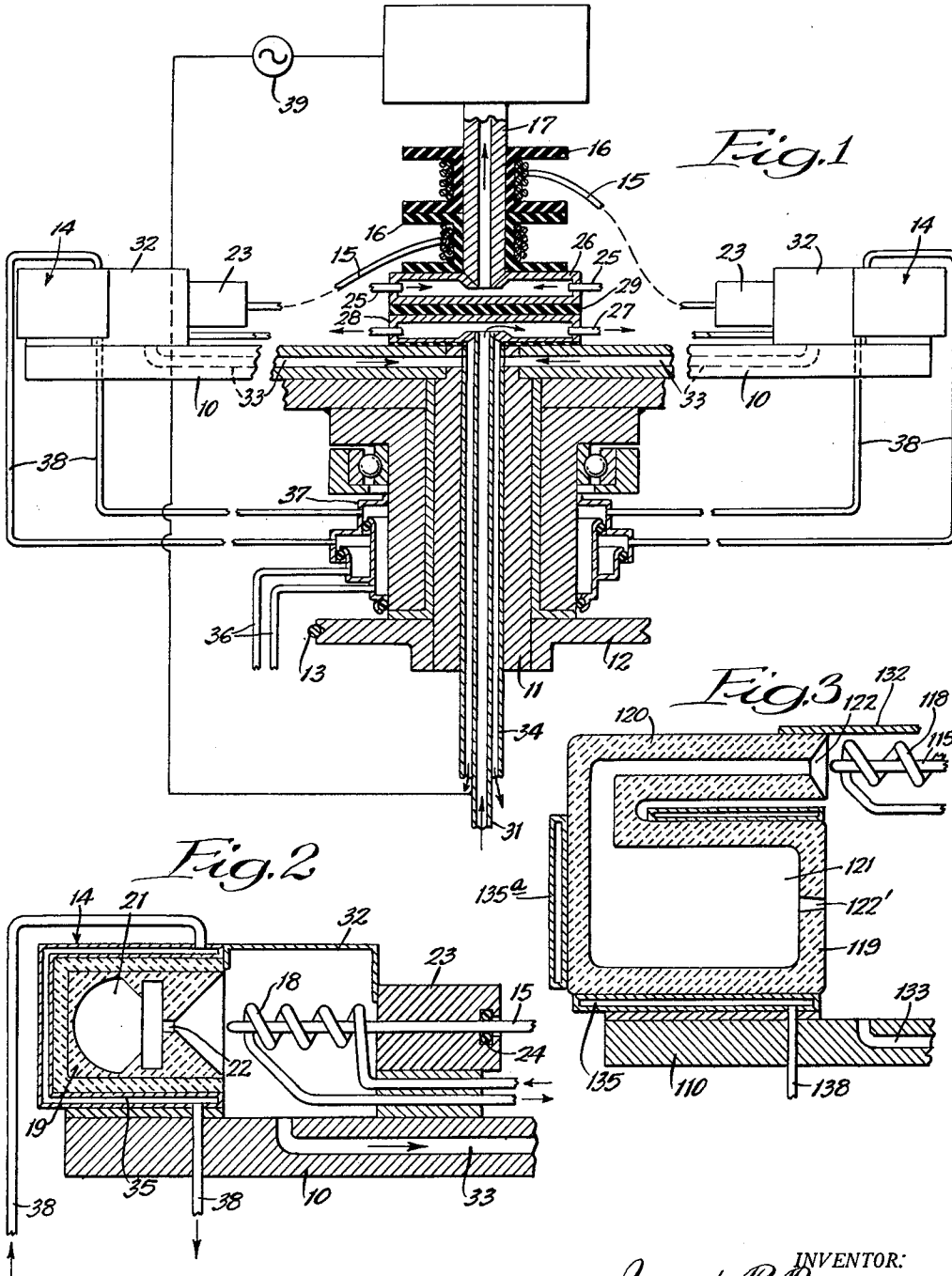
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CENTRIFUGAL CASTING APPARATUS

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CENTRIFUGAL CASTING APPARATUS

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This invention relates to centrifugal casting apparatus and method and more particularly to the casting of metals, such as the Group IV metals which are generally mold reactive.

One difficulty encountered in casting metals which are reactive to molds or crucibles is avoidance of contamination due to reaction developed during molding of the metal in the crucible or gassing of the metal in a mold. Contamination due to reaction of the molten metal with the atmosphere or picking up of foreign matter from crucibles or molds is encountered to some extent with substantially all metals.

It is therefore one of the objects of the of the present invention to provide a centrifugal casting apparatus and method in which the metal is melted adjacent to a rotating mold and is caused to flow immediately into the mold under centrifugal force.

Another object is to provide a casting apparatus and method in which the mold is evacuated and the metal is melted in vacuum thereby eliminating occluded gas, causing faster filling of the mold and eliminating reaction of the molten metal with the surrounding atmosphere.

A further object is to provide a casting apparatus and method in which the mold is chilled prior to filling and during filling so that the molten metal, or at least the outer skin portion thereof which contacts the mold, is quickly chilled when it enters the mold so that reaction with the mold will be eliminated or minimized.

A still further object is to provide a casting method and apparatus in which a rotating mold is filled radially inwardly from its outer end to improve degassing and to eliminate splashing during filling.

The above and other objects and features of the invention will be more readily apparent from the following description when read in connection with the accompanying drawing, in which:

FIGURE 1 is a diagrammatic view with parts in section illustrating a casting apparatus embodying the invention;

FIGURE 2 is an enlarged partial section of the mold and the parts adjacent thereto and

FIGURE 3 is a view similar to FIGURE 2 of an alternative construction.

The apparatus, as shown, comprises a rotatable frame 10 which may be in the form of a plate or of arms extending outwardly from a central rotatable hub 11. The hub is adapted to be driven in any desired manner as, for example, through a sheave 12 and a belt 13 so that the frame will be turned with the hub about the axis thereof.

The frame carries at its outer edge portions, spaced from its axis, a plurality of molds indicated generally at 14 which are adapted to receive molten metal to be cast. The molds may be formed of any desired material, but are preferably made of a material having a relatively high heat conductivity, such as copper or pressed or sintered powdered metal compounds for a purpose to appear hereinafter. Metal to be cast is fed toward the molds in the form of elongated strips and is melted closely adjacent to the molds to flow immediately into the mold cavities. As shown, two molds are provided and the metal to be cast is in the form of rods or wires 15 which are fed into radial registry with the molds from spools 16 mounted on a tubular shaft 17 coaxial with the hub 11. The rods or wires 15 preferably extend

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radially toward the molds as shown although the critical feature is that the ends thereof to be melted are in radial registry with the mold openings.

To melt the metal to be cast induction coils 18 are mounted adjacent to the molds 14 in alignment with the openings therein. As best seen in FIGURE 2, each mold 14 comprises a mold body 19 formed with a cavity 21 and having an opening 22 facing radially inward. The rod or wire 15 is fed through a guide block 23 which preferably contains a fluid tight seal 24 such as an O-ring to seal against the rod or wire as it extends radially toward the opening 22. As shown, the outer end of the wire or rod 15 extends through the coil 18 so that when the coil is energized, the end of the wire or rod will be melted and will flow immediately through the opening 22 into the mold. The coils 18 are preferably formed by relatively small tubes of copper or the like so that cooling liquid may be circulated therethrough. As shown, one end of each coil, indicated at 25, connects to a central hollow block 26 and the opposite end of each coil shown at 27 communicates with a similar block 28. The blocks are insulated from each other by a plate 29 of insulating material.

The upper block 26 has an opening in its top communicating with the hollow shaft 17 and the lower block has an opening in its bottom communicating with a central tube 31 extending upwardly through the hub 11 which is preferably made tubular for this purpose. The joints between the hollow shaft 17 and block 26 and between tube 31 and block 28 may be in the form of slip joints to accommodate relative rotation or, if desired, the connections at these points might be solid and slip joints might be provided at a convenient external position in the shaft 17 and tube 31. In any case, cooling fluid such as water can be circulated in through the tube 31 to the block 28 from the block 28 through the coils and back to the block 26 to flow out through the hollow shaft 17.

According to one feature of the invention, the molds are evacuated and the metal is melted in vacuum to accomplish effective degassing and to prevent contamination from the atmosphere. For this purpose, housings 32 are provided closing the space between the molds, the supports 23 and the frame 10, with the coils 18 lying within the enclosed space, as shown. The enclosed space is adapted to be evacuated through passages 33 formed in the frame 10 communicating at one end with the enclosed space and at their opposite ends with the interior of a tube 34 extending through the hub 11 and surrounding the tube 31. The tube 34 may be connected through the suitable slip joint to a vacuum pump or the like to evacuate the mold cavities and the space around the coils 18. Instead of merely evacuating the molds and space, they may be filled with an inert gas such as argon at reduced pressure on the order of a few inches of mercury. This is especially useful in casting titanium.

According to another feature of the invention, the molds are cooled prior to and during casting so that the metal, or at least the outer skin of the metal, will be chilled rapidly to minimize reaction with the mold. For this purpose, each of the molds 14 is provided with a water jacket 35 enclosing the sides and outer ends of the molds to chill them. The water jackets are supplied with cooling fluid through inlet and exhaust conduits 36 which communicate with rotary seals 37 surrounding the hub 11 and which communicate with the water jackets through conduits 38. In this way a continuous flow of cooling fluid can be maintained through the water jackets while the apparatus is in operation.

The coils 18 are adapted to be energized from any suitable source 39, preferably of high frequency alternating current, which is connected at its opposite sides to the

tube 31 and the hollow shaft 17. The opposite sides of the circuit are insulated from each other by the insulating plate 29 by the use of non-conducting spools 16. The hollow shaft 17 is in conductive relationship to the block 26 and the tube 31 is in conductive relationship to the block 28, with the block 28 being insulated from the outer tube 34 and from the frame 10, as shown. There is thus an electrical circuit from the source through the hollow shaft 17, block 26, coils 18, block 28 and tube 31 back to the source.

In operation, molds are placed on the frame, as shown, with the housing parts 32 connected thereto to surround the coils and with elongated strips of the metal to be cast extending through the guide blocks 23 and the coils. The electric current is initially turned off, but the vacuum source is energized to evacuate the molds and the space around the coils and the power source is energized to rotate the frame. With the frame rotating and with the molds and the space around the coils evacuated and with cooling fluid flowing through the cooling jackets around the molds, the electric current is turned on to energize the coils 18. The high frequency current will quickly melt the ends of the strips 15 and the molten metal will flow immediately into the mold openings 22. Advancing of the strips 15 can be controlled by friction in the guide blocks 23 or by any other desired type of feed means so that the ends of the strips will remain in registry with the coils 18 to be melted thereby or the strips could be advanced before each operation and made of such a size that the end part which is melted when the coil is energized is sufficient to fill the mold.

As the molten metal flows into the molds the outer surface or skin of the metal will be immediately chilled upon contact with the chilled mold to minimize or prevent mold reaction. The metal can flow rapidly into the molds since they are evacuated so that no air or other gas must be displaced therefrom and the metal will be degassed effectively both before, during and after melting by the surrounding vacuum. Thus, the molds can be filled very quickly without any contamination of the molten metal to produce a dense casting which is extremely uniform throughout.

I have found, for example, that utilizing a one-half inch diameter titanium rod as a strip 15 and with the coils 18 energized by 50 kva. of 400,000 cycle current, eight ounces of titanium can be cast in less than twenty seconds from the time the electric current is turned on with a frame 10 approximately two feet in diameter so that each of the molds is about one foot from the axis of rotation and rotating at 250 r.p.m.

In an alternative method, the coil may be energized with higher frequencies on the order of 500 kc. to 20 mc. to melt progressive thin layers of metal a few thousandths of an inch thick which will be thrown off of the rod in particulate form by centrifugal force. In this method the coil is preferably tapered to melt the end of the rod in an outward taper in progressive conical layers as the rod is advanced into the coil. The molten metal can be cast in separate molds, as shown, or could be cast in a continuous mold or traveling belt.

FIGURE 3 illustrates an alternative arrangement of the mold wherein the mold is filled from its outer end with the metal flowing radially inwardly therein. In this construction wherein like parts are designated by the same reference numerals, plus 100, the mold body 119 is connected at its outer end with an elongated filling tube or sprue 120 which terminates in a filling opening 122 facing radially inward. The inner end of the mold body is preferably vented, as shown at 122', to permit escape of any gas which may be in the mold due to incomplete evacuation thereof or which may be given up by the molten metal as the mold fills. The housing 132 encloses the sprue extension and the space around the coil 118 and the strip 115 of metal to be melted extends radially through the coil 118 in alignment with the opening 122. The space within the housing and around the

coil is evacuated through the passage 133. In this construction only the mold body proper is jacketed by a water jacket 135 which surrounds the sides of the mold to the exclusion of the outer end of the mold and the sprue. Thus only the sides of the mold are chilled.

Operation of this construction is substantially similar to that of FIGURES 1 and 2, except that the molten metal enters the mold through the sprue into the outer end of the mold. This arrangement eliminates all possibility of splashing of metal within the mold and further permits degassing of the casting to a greater extent due to the fact that the outer face of the metal as the mold is filled will be molten. As the metal flows into the mold, the sides of the metal casting will be quickly chilled by contact with the chilled mold and the completed casting will be cooled from the outer end in as the mold fills to produce a denser casting. For this purpose a separate cooling jacket 135a may be provided over the outer end of the mold and may have cooling fluid circulated therethrough after the mold is filled or partially filled.

While two embodiments of the invention have been shown and described herein, it will be understood that they are illustrative only and not to be taken as a definition of the scope of the invention, reference being had for this purpose to the appended claims.

What is claimed is:

1. Centrifugal casting apparatus comprising a rotatable frame, molds carried by the frame spaced from the axis thereof, each mold including a filling sprue extending radially of the frame axis and communicating with the radially outer end of the mold and having a radial length at least as great as the radial length of the mold and terminating at its radially inner end in a radially inwardly facing opening, the radially inner end of the mold being formed with a vent opening, means to support strips of metal to be cast radially inwardly of the filling openings, and heating means carried by the frame adjacent to the filling openings to melt the ends of the strips.

2. Centrifugal casting apparatus comprising a rotatable frame, molds carried by the frame spaced from the axis thereof, each mold including a filling sprue extending radially of the frame axis and communicating with the radially outer end of the mold and having a radial length at least as great as the radial length of the mold and terminating at its radially inner end in an inwardly facing opening, means to support strips of metal to be cast radially inwardly of the filling openings, induction coils in inductive relation to the ends of the strips adjacent to the filling openings to melt the ends of the strips, housing means enclosing the molds, filling sprues, induction coils and ends of the strips, and vacuum connections to the housing means to evacuate the molds and the space around the induction coils, the molds being formed with vent openings at their radially inner ends communicating with the housing means.

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