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FLOAT CONTROL VALVE FOR CONTINUOUS CASTING

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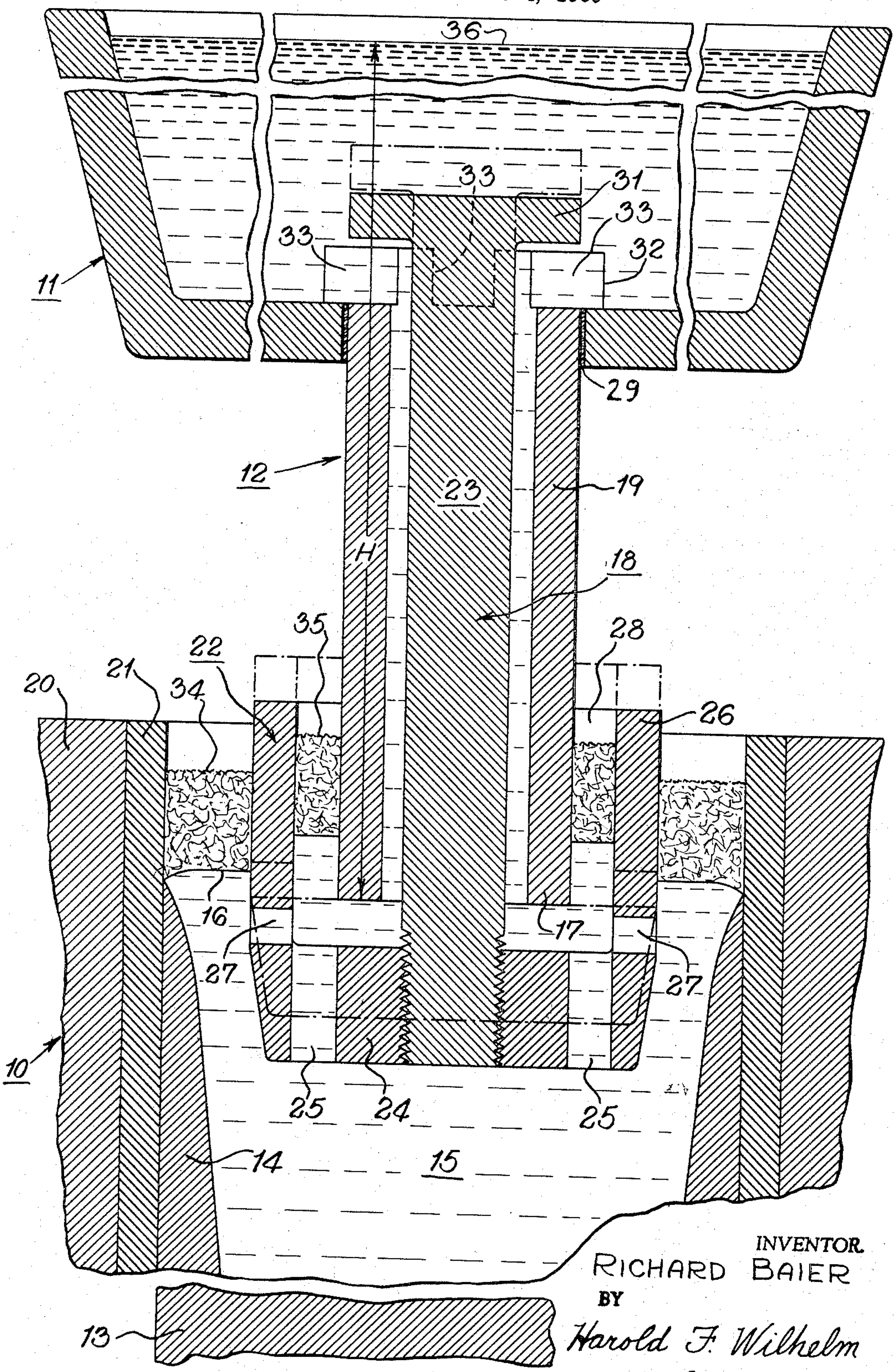

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FLOAT CONTROL VALVE FOR CONTINUOUS CASTING

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ABSTRACT OF THE DISCLOSURE

This application is concerned with a valve for controlling the flow of molten metal to a continuous casting mold. The valve comprises a tube depending from a container for molten metal and extending into the top of a mold placed below the container. Within this tube is a shaft having at its bottom a cup which surrounds the tube. The upper end of the shaft has an abutment or head which holds the shaft and cup assembled to the container so that the container together with the valve may be lifted from the mold as a unit. The movable parts of the valve constitute a movable control member and the specific gravity of this member as a whole is less than the metal being cast. Substantially the entire member is immersed in the molten metal—shaft, abutment, and most of the cup—and thus substantially all parts are available to impart buoyancy to the member. The effect of this buoyancy is to close the feed tube when the metal level in the mold gets too high, and to open the tube when the metal level in the mold gets too low.

The invention relates to the continuous casting of metals, and more particularly to automatically feeding metals to a mold for continuously casting copper base billets and other shapes.

In one conventional system of continuous casting, the mold is spaced below the container holding the molten metal to be cast. The metal flows from the container through a delivery tube into the open top of the mold at a rate corresponding to the rate at which the congealed product is withdrawn from the bottom of the mold. The molten metal in the mold has its own free surface, and care is required to keep this free surface at the proper level. It has heretofore been proposed to provide a valve arrangement for automatically controlling the metal flow into the mold to maintain the free surface at the proper height during the casting operation.

Such valve arrangements comprise a movable stopper member having a valve member contacting a seat on the depending feed tube. The valve member moves toward and away from the seat, providing a variable throttling opening which controls metal flow into the mold.

The prior arrangements have one or more of the following disadvantages. Some stopper members engage stationary parts of the equipment and are not truly free moving. Some use counterweights to balance the weight of the movable stopper. Some have joints which are subject to attack by the molten metal. Some valve members go askew and form imperfect closure. In some cases the valve cannot be removed as a unit from the mold, with the ladle to which it is attached. In still other cases the valve cannot withstand the high melting temperatures and corrosive action of metals such as copper or iron.

It is an object of the present invention to overcome some or all of the above disadvantages, and to provide an arrangement which is simple in construction, and reliable in operation.

According to a preferred form of the invention, the valve comprises a tube depending from the holding container and extending into the top of the mold below its free surface. Within this tube is a shaft having at its bottom a cup which surrounds the tube. The upper end of the shaft has an abutment or head which holds the shaft and cup assembled to the container so that the container and the valve may be removed from the mold as a unit. The movable parts of the valve constitute a stopper member and comprise a material which has less specific gravity than the metal being cast. In the case of a copper base metal, this material is preferably a clay-graphite.

Substantially the entire stopper is immersed in the molten metal—shaft, abutment, and most of the cup—and thus substantially all parts are available to impart buoyancy to the stopper. The effect of this buoyancy is to close the feed tube when the metal level in the mold gets too high, and to open the tube when the metal level in the mold gets too low.

Other objects and features of the invention will be more apparent from the following description when considered with the accompanying drawings, in which

The single figure is a fragmentary central vertical cross section through a holding container and mold with the invention applied thereto. The top of the container and bottom of the mold are broken away for simplicity of disclosure.

In the following description and in the claims, various details will be identified by specific names, for convenience, but they are intended to be as generic in their application as the art will permit.

Referring to the drawing, the apparatus as shown, comprises mold **10**, container **11** (which may be a portable ladle), and automatic valve **12**. The mold **10** comprises a metal jacket **20** having a graphite liner **21**, and may be of the type disclosed and claimed in my U.S. Patent No. 3,098,269, dated July 23, 1963, sometimes referred to as a stable mold.

The present invention is described with special reference to casting phosphorized deoxidized copper, but the invention is applicable to casting other types of copper and other metals. In this description, it is first assumed that the casting operation has been started and the process is functioning at full running speed.

The mold **10** and valve **12** may be circular in horizontal cross section, while the ladle **11** may be of any shape in horizontal cross section. The position of the valve parts shown in the drawing is a normal running position with the valve partially open.

The ladle **11** is filled to a suitable level with molten phosphorized copper. Molten copper flows from ladle **11** to the mold. It freezes in the mold, and the solid billet **13** is withdrawn from the bottom of the mold in any desired way.

At full running speed, the metal is fed and the billet withdrawn at such rate as to cause the metal to freeze in the form of a crater **15**, forming a crater shell **14**. The crater shell **14** is filled with molten metal having its own free surface **16** in the mold. The proper level of molten metal in the mold is maintained by the automatic valve **12**, to be described.

The valve **12** comprises a relatively stationary seat member **17**, and a relatively movable stopper **18**. The seat member **17** comprises a feed tube **19** depending from the bottom of the container **11** and extending below the surface of the molten metal in the mold **10**. The tube **19** has an enlarged upper flange **32** with a plurality of slots **33** permitting molten metal to flow into the tube even when the shaft abutment **31** engages enlargement **32**. Cement **29** holds tube **19** tight in the bottom of container **11**.

The stopper **18** comprises a cup **22** and a shaft **23** with head **31**. Cup **22** has a bottom **24** with a plurality of feed holes 25, a side wall 26 with a plurality of feed holes 27, and an open top 28.

The cup 22 is about half immersed in the molten metal in the mold, and its side wall 26 extends above the top of the mold 10. The shaft 23 passes loosely through the tube 19 and is connected to the bottom 24 of the cup 22. The top of the shaft 23 has a round enlarged upper head 31 engageable with the enlarged top 32 of the tube 19 which projects above the bottom of the ladle 11.

The movable valve stopper 18 (cup and a shaft) is made of clay-graphite which has less specific gravity than the molten copper being continuously cast. Buoyancy is obtained by partial immersion of the cup 22 in molten metal in the mold, by immersion of the abutment 31 in molten metal in the ladle 11, and by immersion of shaft 23 in molten metal in tube 19. The tube 19 may be made of clay-graphite.

For casting phosphorized copper, it is preferred to use a protective layer of discrete particles of carbonaceous material, such as flake graphite, lamp black, pulverized anthracite, etc. floating on the surface of molten metal in the mold. Part of this cover 34 is outside cup 22, and part 35 may be inside the cup. Presence of the cover 35 inside the cup is not especially important.

In operation, so long as the metal level 16 in the mold 10 remains at normal height as shown in the drawing, molten metal will continue to flow down between the feed tube 19 and shaft 23 into bottom of cup 22 and through the outlet holes 25, 27 into the crater 15.

The function of the valve depends upon Archimedes principle which states that a body immersed in a fluid is buoyed up by a force equal to the mass of the fluid displaced. For proper operation, the valve member must rise and fall with the free surface 16 of liquid in the mold. When the free surface rises, the valve member must rise, and when the free surface falls, the valve member must fall.

To make the stopper 18 responsive to change in free surface level, it is necessary to have a part of the stopper projecting above the free surface 16 in the mold at all times. This part, in the form shown, is the upper margin of the valve wall 26. The immersion to a variable extent of this margin is a critical factor, and for this reason, will sometimes be referred to as the vernier portion of the stopper.

As an example of one manner in which the vernier portion operates, let it be assumed that the level of metal in the mold is sufficiently high to close the valve opening (between seat 17 and cup bottom 24). This means that the vernier portion must be immersed sufficiently to impart to the stopper an upwardly acting buoyant force equal to the head H of molten metal extending from the top metal surface 36 in the ladle to the valve seat 17. This stops all metal flow into the mold.

As the congealed casting is withdrawn from the bottom of the mold, the molten level in the mold drops, which decreases the amount of immersion of the vernier margin of the cup 22. This reduces the upward force of buoyancy, permitting the head of molten metal to force the stopper downwardly, opening the valve and permitting molten metal to flow through the cup holes into the mold.

The stopper 18 will of course, continue to descend as long as the metal level in the mold descends; this is accompanied by an increase in metal flow through the valve because of the wider throttle opening. As the stopper descends, and as the increased metal flow into the mold causes the mold level to rise, the vernier margin of the cup becomes immersed to a greater extent, which in turn increases the upward force of buoyancy on the stopper, which in turn tends to close the throttle opening.

This regulating action will, of course, continue during the entire pouring operation—the stopper descending with descent of free surface 16, thereby increasing rate of metal flow into the mold, and the stopper rising with rise of free surface, thereby reducing metal flow through the valve into the mold.

It will be noted that the velocity head of the flowing metal raises the metal level in cup 22 above the free level 16 in the mold. This downward flow of metal produces a downward force on the stopper 18 which is resisted by the force of buoyancy.

The invention has many advantages. The stopper is self-floating in that all movable parts (except the vernier margin) are immersed in the metal being continuously cast, and are of less specific gravity than the metal. The mass density is virtually 100%; no hollow closed portions are necessary to give buoyancy to the movable closure, and no counterweights are necessary to supplement the buoyancy of the movable stopper immersed in the liquid metal. The force of buoyancy is sufficient to overcome the weight of the stopper 18 and the downward force caused by the downward flow of molten metal from the ladle into the mold.

The material of the valve is of high strength; it resists attack by the metal being cast; it is easy to machine, and requires no bolts to hold the parts together.

The flow of metal through the annular space between the feed tube 19 and shaft 23 is subject to the Bernoulli effect, which keeps the shaft centered so that, while the valve is performing its regular function, it is completely self-floating and self-centering in that no moving part of the stopper engages the feed tube or any stationary part of the ladle. In fact, the stopper 18 sometimes rotates due possibly to lack of symmetry in the drilling of the holes in the cup, the streams of liquid passing through these holes being directed at a slight angle from true radial, so that their reaction imparts rotation to the stopper. This is of advantage in that it eliminates any tendency of stationary streams of molden metal issuing from the cup holes from weakening the soft embryo crater shell by hitting it in one place.

A further advantage is the dual submersion of both cup 22 and head 31. In case it is desired to change the shape or size of the cup, a corresponding change can be made to the shaft head to maintain total displacement of the stopper the same, or to change it if desired.

The holes in the distributing cup 22 can have any pattern, and be directed at any angle, depending upon operating conditions such as size of the mold, the metal being cast, and the speed of casting, etc.

The edge of the cup projects above the top of the mold for easy visibility by the operator who may be handling the simultaneous feeding of several molds. The central pilot shaft 23 and upper head 31 hold all parts of the mold together as a unit, enabling the ladle and valve to be removed from the mold, and replaced into the mold, as a unit. When the ladle 11 is raised, it carries all of its valve parts with it. The self-centering action of the pilot shaft holds the cup 22 centered with respect to the tube 19, and with respect to the mold, and prevents tilting or cocking of the cup with respect to the valve seat 17.

The valve is entirely compatible with the carbonaceous cover on the free surface of metal in the mold. The valve does not interfere with the introduction or with the function of the carbonaceous cover, nor does the carbonaceous cover interfere with the function of the valve.

It will be understood that a plurality of valves may be mounted in the bottom of the same holding container for feeding a plurality of molds forming part of a plurality of stands. The valve lends itself especially to running a plurality of stands with minimum attention on the part of the operator.

Prior to starting up a casting operation, the ladle with attached valve is removed from the mold, placed to one side, and heated by a blowtorch. After preheating the ladle and valve, the assembly is returned to the mold to place the valve in operating position in the mold.

It will be understood, of course, that for starting, the mold will have the conventional starting plug inserted in its lower open end for starting purposes.

The molten copper is then fed to the ladle which flows through the valve (since the valve will be in wide-open position) into the empty mold. When the level of metal in the mold reaches proper height, the valve will start functioning to limit further rise of metal level in the mold; at the proper time, the starting plug will be lowered and the continuous casting operation started.

The valve lends itself to change in casting speed. In normal running operation, the casting speed may be determined entirely by the rate at which the congealed casting is withdrawn from the bottom of the mold so long as the ladle is kept adequately filled with molten metal. However, during startup, it may be desired to withdraw the starting plug and congealed casting at a slower rate than regular running rate. In this event, the rate at which molten metal is fed to the mold may be controlled by the speed at which the molten metal is fed to the empty ladle while the valve is at its lowermost full open position.

The valve, including feed tube and stopper, may be made of different materials, depending upon the metal being continuously cast. In any event, the material should resist attack by the molten metal, and the specific gravity of the material of the movable stopper must be less than that of the molten metal.

For casting copper base metals, the valve may be made from any good grade or quality of graphite, including materials containing graphite, such as graphite-coated carbons. Clay-graphite may also be used. An acceptable clay-graphite may comprise about 40% clay and 60% graphite by weight. In general, it is preferred to use a type of graphite which has maximum density and mechanical strength as well as maximum heat conductivity. The term graphite as used in the claims is intended to cover all such materials containing substantial amounts of graphite.

Other acceptable materials for casting copper base metals are the so-called cermets. A suitable cermet is a metal-ceramic comprising powdered chromium and aluminum oxide, as for example, by weight, 77% metallic chromium and 23% aluminum oxide (Al_2O_3). These materials may be made by the well-known slip-casting process and then sintered.

Another material which is satisfactory for casting copper and its alloys is a steatite variety of talc. Steatite occurs in nature in dense formation, and is characterized by its softness. One form of steatite is a hydrated magnesium silicate. It is machined to shape and then fired, resulting in a hard refractory material. Other satisfactory materials for casting copper are carborundum, alundum, magnesia, zirconia and chromite.

Furthermore, it will be understood that the different parts of the stopper may be made of materials having different specific gravity, it being only necessary that the weight of the stopper as a whole be less than the weight of the volume of molten metal displaced. For example, the material of the central shaft may actually be of a specific gravity greater than that of the molten metal in which it is immersed. Parts of the stopper may be hollow.

The invention may be employed to cast other metals and alloys, including but not limited to, steel, silver, nickel, aluminum, and magnesium.

While certain features of the invention have been disclosed herein, and are pointed out in the annexed claims, it will be understood that, in accordance with the doctrine of equivalents, various omissions, substitutions and changes may be made by those skilled in the art without departing from the spirit of the invention.

I claim:

1. In a system for controlling metal flow for continuous casting, a container for holding the molten metal to be cast, continuous casting means spaced from said container and positioned below the latter to receive molten metal therefrom, said continuous casting means being adapted to contain a body of molten metal, a molten metal feed tube in communication with said container and extending down into said continuous casting means, movable valve means cooperating with said tube to control the flow of molten metal through the tube, said movable means comprising a valve member, a shaft disposed within said tube, said shaft being connected to said valve member and extending into said container, said movable means having interlocking means for interlocking said movable means with respect to said container, said movable valve means having a portion adapted to be immersed below the level of said body of molten metal in said continuous casting means with a vernier portion above said level, the specific gravity of the movable means as a whole being less than that of the metal being cast, whereby said shaft displaces molten metal to be cast and thereby contributes the the buoyancy of said movable means.

2. In the apparatus of claim 1, said valve member comprising a cup, said cup having a bottom wall and annular side wall, said side wall surrounding said tube, said cup having openings for distributing the metal in a predetermined manner.

3. In the apparatus of claim 2, said stopper and the parts thereof comprising graphite.

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