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MOLTEN METAL DISPENSING APPARATUS

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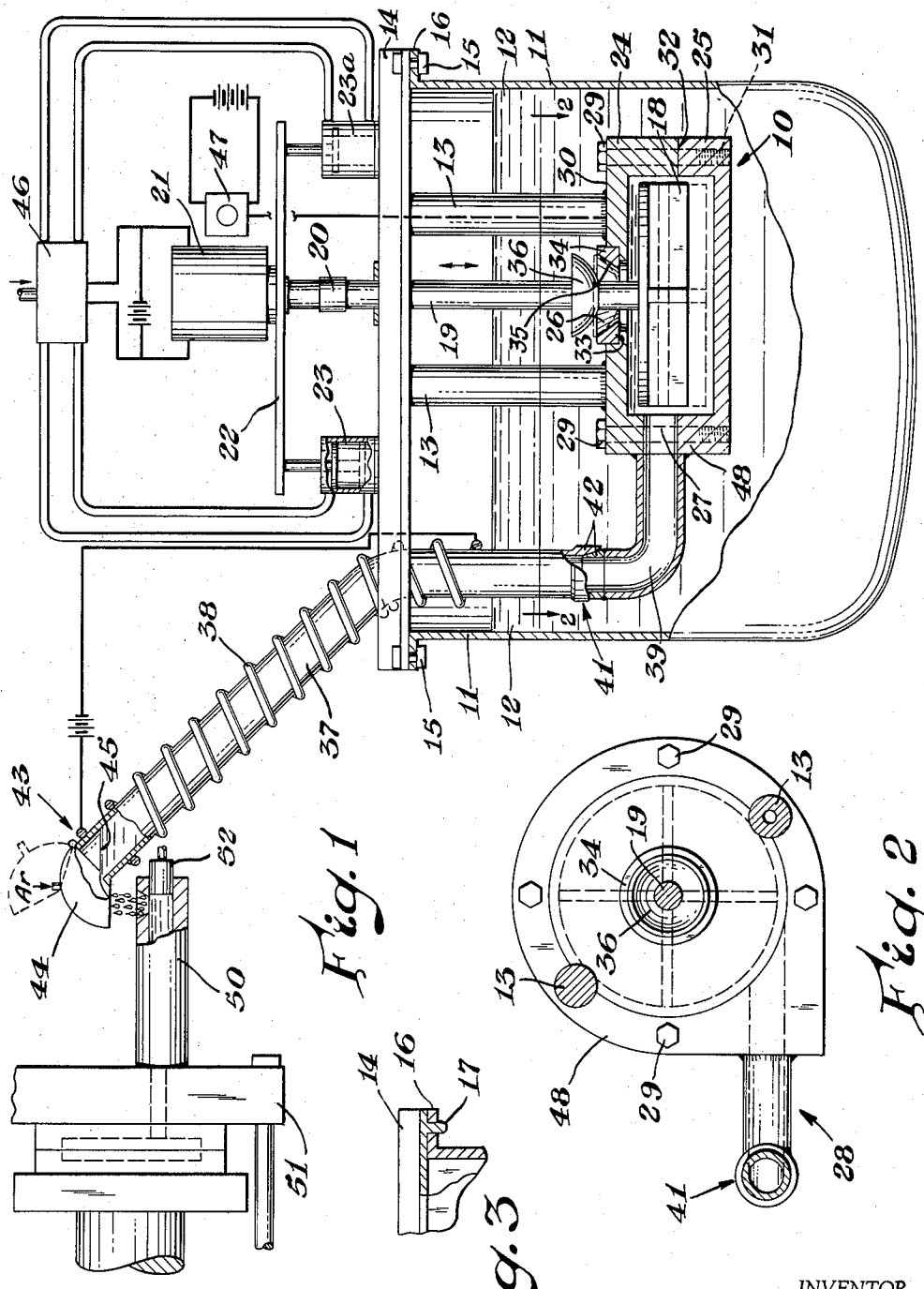


Fig. 1

Fig. 2

Fig. 3

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MOLTEN METAL DISPENSING APPARATUS

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This invention relates to the handling of molten metal and particularly relates to an apparatus for the delivery of successive predetermined amounts of a molten metal to a utilization device.

Several apparatuses have been disclosed concerning the delivery of measured amounts of molten metal to a utilization device. In general, these devices comprise one or more separate components, such as, for example, a valve component and pump component, connected to each other by conduits, the so-connected components in turn being attached to a delivery pipe. In addition, these apparatuses are relatively complex, having usually a number of moving and close tolerance parts and irregular shapes.

Because of these factors, malfunctions and breakdowns are frequent, and fabrication and assembly difficult, thus requiring a high level of maintainance, detailed construction, and experienced operating personnel. In addition, a complex apparatus consisting of several individual components connected to one another by conduits and the like is understandably more difficult to install and to remove from the supply of molten metal in which it is partially or wholly submerged should the apparatus need repair or replacement.

An object of the present invention is to provide an improved, simple and economical apparatus for the delivery of a succession of predetermined substantially equal amounts of molten metal, to for example, the shot well amounts of molten metal to, for example, the shot well of a die casting machine.

A related object is to provide such an apparatus having a minimum of moving and close tolerance parts and a compact integrated pump-valve unit component which will require little maintenance and which will be readily removable as a unit from the supply of molten metal in which it is submerged.

Another object of the invention is to provide an improved apparatus for the delivery of molten metal which during operation will not cause turbulance in the pot containing the supply of molten metal in which the apparatus is partially submerged.

These and other objects and advantages will become apparent from the following detailed description when read in conjunction with the accompanying drawings depicting one embodiment of the invention wherein:

FIGURE 1 is a side elevational view partially cut away and partly in section of an apparatus in accordance with the present invention.

FIGURE 2 is plan view of the integrated pump-valve delivery unit of the apparatus of the present invention taken along line 2—2 of FIGURE 1.

FIGURE 3 is a detailed fragmentary view in side elevation showing a modification of the connection of the lip of the pot with the apparatus of the invention from that shown in FIGURE 1.

Normally, the apparatus of the present invention is used in conjunction with a melting or supply pot containing a supply of the molten metal intended to be dispensed, the apparatus, primarily the integrated pump-valve unit thereof, being at least partially submerged therein. In addition, the pot is normally equipped with a suitable means (not shown) to maintain the metal in said pot in a molten liquid state by the application of heat and may either be opened or closed at the top as

desired or required. An appropriate protective flux cover or inert atmosphere on or immediately above said molten metal in the pot may also be used depending on the nature of the molten metal in the pot.

In general, the molten metal dispensing apparatus of this invention comprises an integrated submersible pump-valve unit having an inlet and outlet means, a valve assembly part and a centrifugal pump portion (including a drive shaft which extends out of said pump through the inlet means), support means for suspending the unit in a supply of molten metal, means to provide power for operating the pump portion of said unit, actuating means for opening and closing the valve assembly part of the integrated pump-valve unit, and, a delivery pipe to which the unit is attached at or near the outlet means provided in the pump-valve unit.

With respect to the aforesaid integrated unit, the pump portion thereof comprises, in general, a rotatable impeller as the core element. The impeller is attached to a drive shaft and is surrounded by a pump casing which has an inlet and outlet for receiving and dispersing molten metal. The pump portion, in addition, serves to hold and position the below described valve seat of the valve assembly portion. The drive shaft extends from the impeller, out of the pump casing, and through said inlet, thus through the valve seat, where it is attached at its other end to the powering means. The valve assembly part comprises, in general, a circular valve seat disposed around and spaced from the aforesaid drive shaft, and a movable rotatable valve head which is attached to the drive shaft immediately above the valve seat and is adapted to engage with the valve seat when the unit is not in operation. Thus, when the pump and drive shaft are not rotating, a substantially tight seal will be made by the engagement of said valve seat and head, thereby preventing molten metal from entering the pump portion. A detailed description concerning the operation of the apparatus in accordance with the present invention follows hereinafter.

Referring now to the figures, one embodiment of the present invention is shown therein, the integrated pump-valve unit **10** of the apparatus being suspended in a supply pot **11** containing molten metal **12** by a plurality of vertical supports **13** which are attached, as by welding, for example, to one or more horizontal cross members **14**. These cross members are in turn attached, for example, by bolts **15** to the lip **16** of the supply pot. Alternatively, it has been found very convenient, particularly when it is desired to remove the entire apparatus from the pot, to attach the cross members **14** to the pot lip **16** by freely movable locators **17** such as shown in FIGURE 3.

The aforesaid pump portion of the integrated unit **10** of the present apparatus comprises a rotatable impeller **18** which is coupled to the lower end of a vertical movable drive shaft **19** which extends upward through the pump casing, indicated generally by the numeral **48**, above the level of the molten metal **12** where, at its upper end, it is preferably quick detachably coupled by means of the coupling **20** to a powering means such as, for example, either an air or electric motor **21**. The motor **21** is rigidly coupled to a yoke plate **22** which in turn is attached at each end thereof to a vertically movable piston device **23** and **23***a*. The devices **23** and **23***a*, when actuated, raise or lower the motor **21** and drive shaft **19** to open or close the valve head **36** on the valve seat **34**, as will be discussed more fully below. Although the longitudinal axis of the drive shaft **19** and impeller **18** is shown as corresponding to that of the pump casing, such correspondence is not critical and, therefore, the axis of the impeller **18** and drive shaft **19** need not be coaxial with that of the pump-valve unit.

Surrounding the impeller **18** is a two-piece, essentially circular, rotary pump casing comprising an inverted cup

shaped top section 24 and a cup shaped bottom section 25, the top section having an inlet bore 26 and an outlet bore 27. The outlet extends more or less tangentially with respect to the peripheral path of the rotating impeller 18 through a projection 28 of the cylindrical vertical wall of the assembled casing and is located as nearly adjacent to the upper impeller position, as is described below, as possible. The casing sections 24 and 25 are held together by threaded bolts 29 from the upper side 30 of the unit and are received by tapped threaded bores 31 in the bottom section 25 of the casing to allow the two said casing sections to be drawn together and sealed tightly at their mating edges 32 to form an assembled pump casing. Of course, other conventional fastening means may also be employed to hold the two said portions together, such as welding, for example.

Constructed in the top section of the pump casing is a circular recess whose edge 33 provides a continuous shoulder to support thereon the valve seat 34 of the valve assembly, as will be more fully described below. The internal cavity of the assembled pump casing which the impeller occupies must be of such depth (longitudinal dimension) as to permit vertical movement of the impeller such that an upper position (as shown by the solid lines in FIGURE 1) and a lower position (shown by dotted lines in FIGURE 1) of both the valve and impeller 18 is permitted. The reason for this will be explained below and will become more obvious as the description of the apparatus proceeds. Preferably, the depth of the cavity should be approximately equal to twice the height of the impeller blades.

The valve assembly part of the apparatus is integrated with the pump portion of the unit to constitute the integrated pump-valve unit component of the present apparatus. The valve assembly comprises a circular valve seat 34 having a beveled edge 35, the seat 34 being symmetrically disposed around and spaced from the drive shaft 19 and held by a friction fit in the aforesaid recessed edge 33 provided in the top section of the pump casing 48, and a movable valve head 36 which is adapted to mate with and engage the valve seat 34 to form therewith a tight seal without a sticking or wedging effect upon being engaged. The valve head 36 is rigidly attached to the drive shaft 19 immediately above the valve seat 34, for example, by welding. When the impeller 18 and drive shaft 19 are in the lowered position, as indicated by the dotted lines in FIGURE 1 (and not rotating), the valve head 36 engages the valve seat to form a substantially tight fit, thereby preventing any molten metal from entering the molten metal inlet 26 provided by the circular opening leading into the casing formed by the valve seat. The valve head 36 is fixed on the drive shaft at a distance sufficiently above the valve seat such that when the impeller and shaft are rotating and thus are in the upper position (raised by devices 23 and 23*a*) as shown in FIGURE 1, a sufficient clearance is provided to allow an adequate supply of molten metal 12 to flow between the valve head 36 and seat through the molten metal inlet 26. As molten metal enters the pump casing, the rotating impeller 18 forces the molten metal ultimately into the receptacle of a utilization device, such as, for example, into the shot well 50 of a die casting machine 51 through a delivery pipe 37.

The delivery pipe 37 is normally equipped with a heating means, such, for example, electric coils 38, to maintain the molten metal in the pipe at a temperature at least slightly above its liquidus. The lower end of the pipe 39 is attached, for example, by welding, to the pump casing at the outlet bore 27 which is housed by the aforementioned projection 28. It has been found convenient to equip the delivery pipe with a slip joint 41 located near the place where the pipe is coupled to the pump casing. The slip joint has rings 42 with conical edges which mate. By so-doing, should it become necessary to withdraw the integrated unit 10 entirely from the molten metal supply either for replacement or repairs, the pipe is easily disconnected from said unit leaving only a short portion of said pipe attached to the unit 10. Preferably the slip joint rings 42 should be constructed of material possessing higher strength at elevated temperatures than that of the thin adjoining delivery pipe walls. Such a material may be, for example, a high temperature tool steel which comprises about 18 percent by weight tungsten, about 4 percent by weight chromium, and about 1 percent by weight vanadium, the balance being essentially iron.

The discharge end 43 of the delivery pipe 37 is preferably equipped with a hinged upwardly swinging shroud 44 within which, immediately above the level 45 of molten metal in the pipe, is maintained an atmosphere of a non-oxidizing gas, such as, for example, argon, in order to prevent burning of the material and formation of an oxide skin on the pipe walls. The upwardly swinging shroud 44 shown in the upward position in FIGURE 1 by the dotted lines conveniently permits rods to be inserted from the discharge end 43 of the pipe to unclog it should that become necessary.

The actuating means for opening and closing the valve assembly portion of the integrated unit, the discussion thereof which has purposely been omitted to this point because it closely relates to operation of the apparatus which is discussed below, comprises, a means such as, for example, dual air operated piston devices 23 and 23*a* rigidly attached together by a yoke plate 22 on which the powering means rests and is attached such that the piston devices 23 and 23*a* raise or lower the motor 21, therefore, also the drive shaft 19 with the valve head 36 attached. The valve assembly either opens or closes depending on the direction and amount of vertical movement of the piston devices 23 and 23*a*. In practice, as will be discussed below, both the air pistons and the motor are coordinated such that when the motor is operating, i.e., the drive shaft and impeller are being rotated, the pistons are in the raised position, as shown in FIGURE 1, thus raising the valve head from the valve seat, whereas, when the motor is not operating, the pistons are in the lower position, as shown by the dotted lines in FIGURE 1, thus closing the valve.

Preferably, the actuating means and powering means are closely coordinated by conventional timing means 46 with, for example, the operation of the die casting machine 51, such that a programmed time sequence is established whereby a rapid succession of predetermined amounts of molten metal can be dispersed to the shot well 50 of said die casting machine 51 or to some other utilization device.

For ease in disassembling the casting apparatus of the present invention, both the impeller and powering means are preferably quick detachably coupled to the lower and upper end of the drive shaft, respectively.

In operating the embodiment of the apparatus of the present invention as depicted in FIGURE 1, the integral pump-valve unit 10 with the delivery pipe 37 attached is submerged, after preheating, into the pot 11 containing the molten metal 12 to be handled so that said unit is below the level of the molten metal and the inlet opening 26 is located substantially at the center of the molten metal supply. When initially submerged, the valve assembly portion of the unit should be open, that is, the impeller should be in the raised position, but the pump impeller should not be rotating at this time. After having submerged the unit 10 the impeller is then rotated to force the molten metal 12 into the heated delivery pipe 37 to the discharge level 45 whereupon the dual air pistons are actuated downward to lower the motor, drive shaft, and impeller with the valve head attached, thereby closing the valve assembly. Having now readied the shot well 50 and die casting machine 51 to receive molten metal, the air pistons are actuated upward to open the valve assembly,

whereupon, the pump impeller is immediately rotated, not only to create enough pressure in the pump to maintain the head of molten metal in the pipe, but also to force additional molten metal into the pipe whereby a like amount overflows by displacement into the shot well of the die casting machine. When the desired amount of molten metal has been dispensed to the shot well, the dual air pistons are again actuated this time to lower the powering means, thus lowering the drive shaft with the valve head attached, thereby closing the valve assembly, whereupon, the rotary action of the pump is ceased. Thereafter, the piston **52** of the shot well **50** is actuated to force the dispersed amount of molten metal therein into the die casting machine mold. After solidification of the dispersed amount of molten metal, the mold is opened and the cast piece ejected, followed by closing the mold, and actuating the air pistons upward again while practically simultaneously operating the impeller to dispense still another shot of molten metal into the shot well followed by closing the valve assembly and again operating the piston of the shot well to force the dispersed molten metal into the mold, thereby to make still another casting. The total operation is repeated in a rapid time-sequenced manner to produce the desired number of cast pieces.

In practice, the rotating action of the impeller should be commenced an instant previous to disengaging the valve head **36** from the seat **34** in order to maintain the desired level **45** of molten metal in the delivery pipe. Conversely, impeller rotation should be continued an instant after the engagement of said valve head and seat for the same reason.

Inasmuch as both the valve seat **34** and valve head **36** are probably subjected to an increased rate of wear due to the fact that in operation the valve head will rotate slightly while in contact with the seat **34**, both when opening the valve assembly and closing it, at least the mating surfaces of these two parts should preferably be Stellite coated, for example, to prolong the operable life of the valve assembly. Such a Stellite coating also serves to reduce deformation of these parts upon impact with each other.

Due to the compactness of the apparatus of the present invention and since it has comparatively few moving and close tolerance parts, repair thereof, or a complete replacement, is easily effected without a time consuming and involved procedure.

For ease in accomplishing temperature determinations, for example, in the integral pump-valve unit **10** of the present invention, one of the vertical support members **13** may be built with a hollow core so that the wire of a thermocouple **47** may be inserted therein and connected to said integral unit to record temperatures. However, other sensory devices and leads may also be employed.

The materials of construction to be employed in the parts of the apparatus which are to contact molten metal such as, for example, the pump casing of the integral unit, vertical supports, and delivery pipe, are those which will be durable in the presence of the molten metal intended to be handled and which are resistant to erosion and corrosion. When employing molten magnesium, for instance, mild steel or, preferably, the high temperature chrome steels such as, for example, 430 stainless are satisfactory for all surfaces which are to contact said molten magnesium. The drive shaft on the other hand should be constructed of the aforementioned tool steel for proper strength.

It should be understood that various changes and modifications can be made in the apparatus of the present invention without departing from the substance and scope thereof, and it is further understood that the present invention is not limited to the embodiment thereof as shown in the appended drawings.

I claim:

1. An apparatus for the delivery of molten metal to a utilization device which comprises a submersible integrated pump-valve unit having a pump assembly portion, said pump assembly portion including a drive shaft having an upper end and a lower end, an impeller, said impeller having the same longitudinal axis as said drive shaft and being coupled to said drive shaft, a pump casing having a top section, bottom section, and side walls, said casing surrounding said impeller and having sufficient depth to permit substantial vertical movement of the impeller in conjunction with the drive shaft, said casing having an inlet bore means in said top section, said drive shaft extending through said inlet bore, and an outlet bore extending through said side wall, a valve assembly part, said valve assembly part including a valve seat disposed in said inlet bore and a valve head, said valve head surrounding and being rigidly coupled to said drive shaft; supporting means to suspend the apparatus in the molten metal to be dispensed; powering means to provide rotary power for the pump portion; actuating means for raising and lowering said drive shaft whereby said valve assembly portion is opened and closed; and a delivery pipe attached to the pump casing at said outlet bore.

2. The apparatus of claim **1** wherein, the longitudinal axis of the pump casing and inlet bore corresponds to that of the impeller and drive shaft.

3. The apparatus of claim **1** wherein, the mating surfaces of both the valve head and seat are provided with a Stellite coating.

4. The apparatus of claim **1** wherein, the valve seat is symmetrically disposed around and spaced from the drive shaft and held by a friction fit on a recessed edge in the inlet bore.

5. The apparatus of claim **1** wherein, the powering means and actuating means are coordinated by way of a timing means such that a succession of predetermined amounts of molten metal can be dispersed and delivered to a utilization device.

6. The apparatus of claim **1** wherein, both the impeller and powering means are quick detachably coupled to the drive shaft.

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