Aug. 27, 1968 R. R. RADER 3,398,697

MOLTEN METAL PUMP

Filed Oct. 25, 1966 4 Sheets-Sheet 1

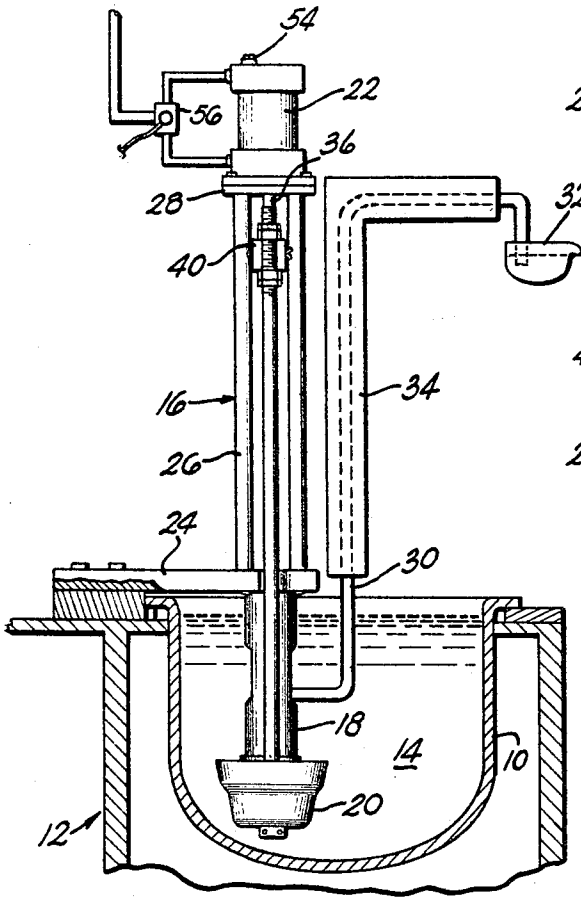


FIG. 1

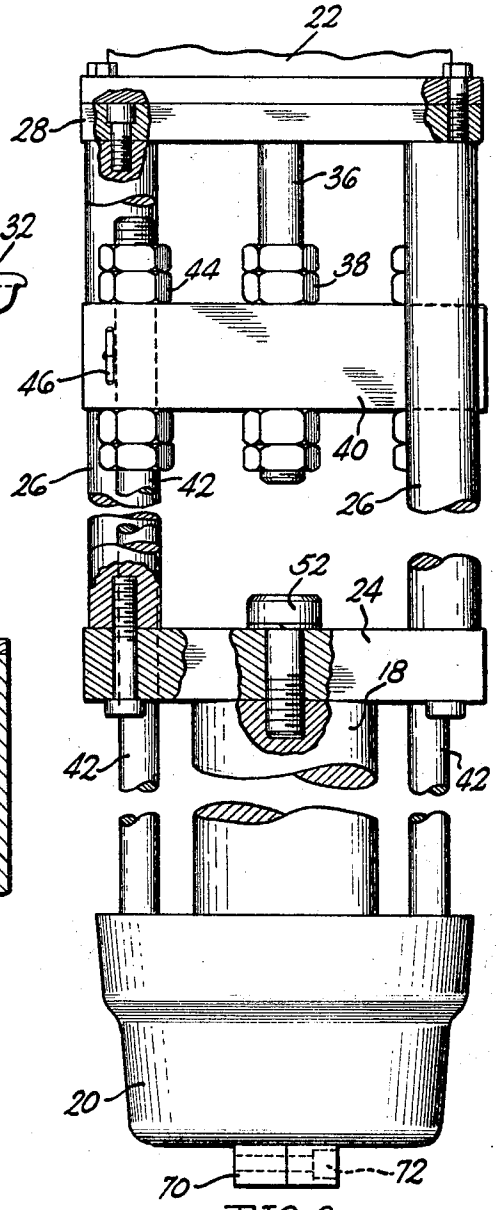


FIG. 2

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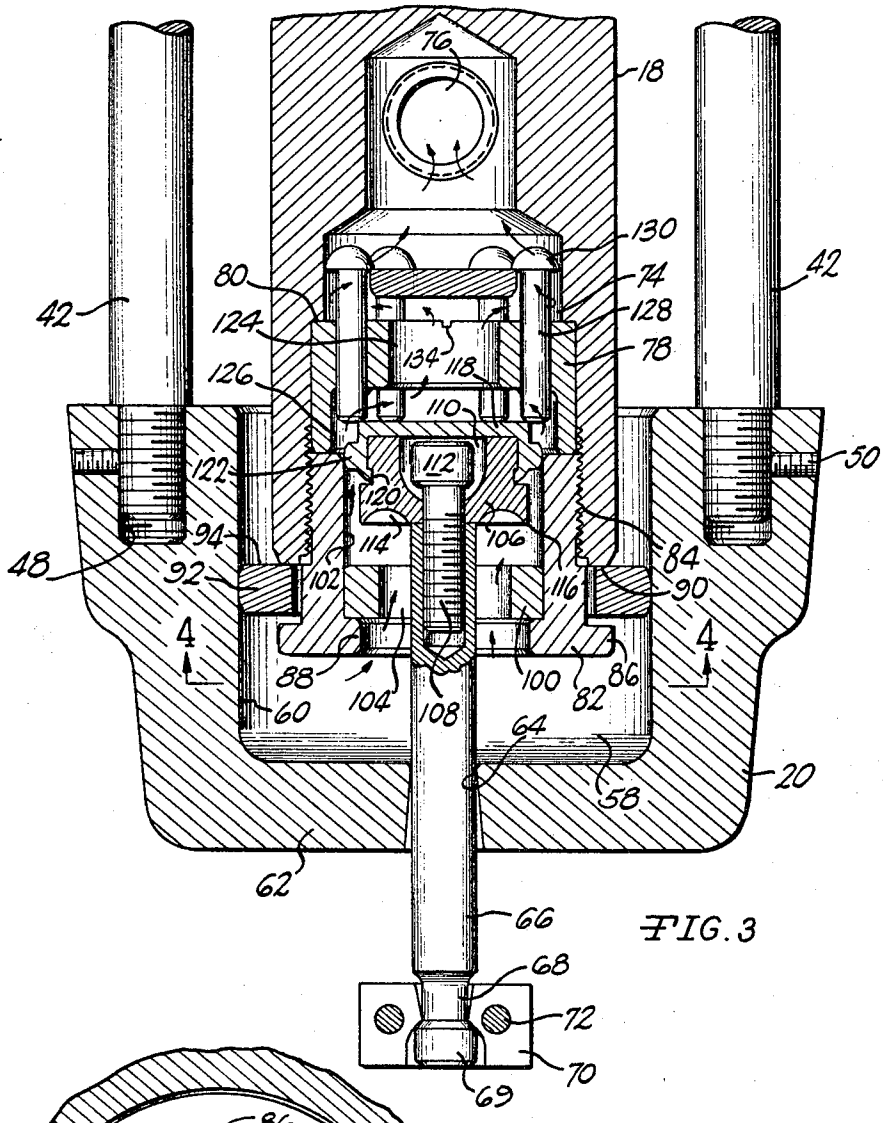


FIG. 3

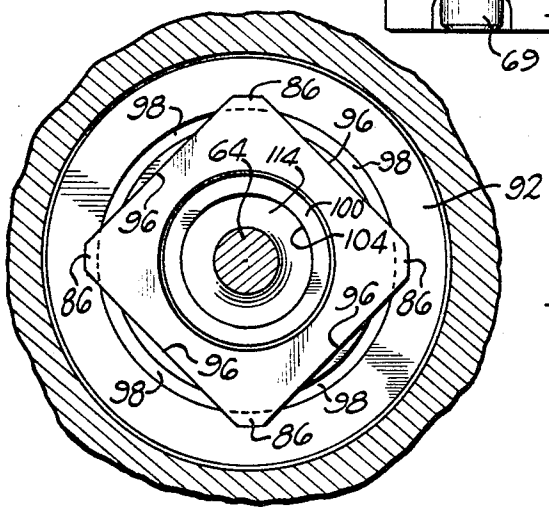


FIG. 4

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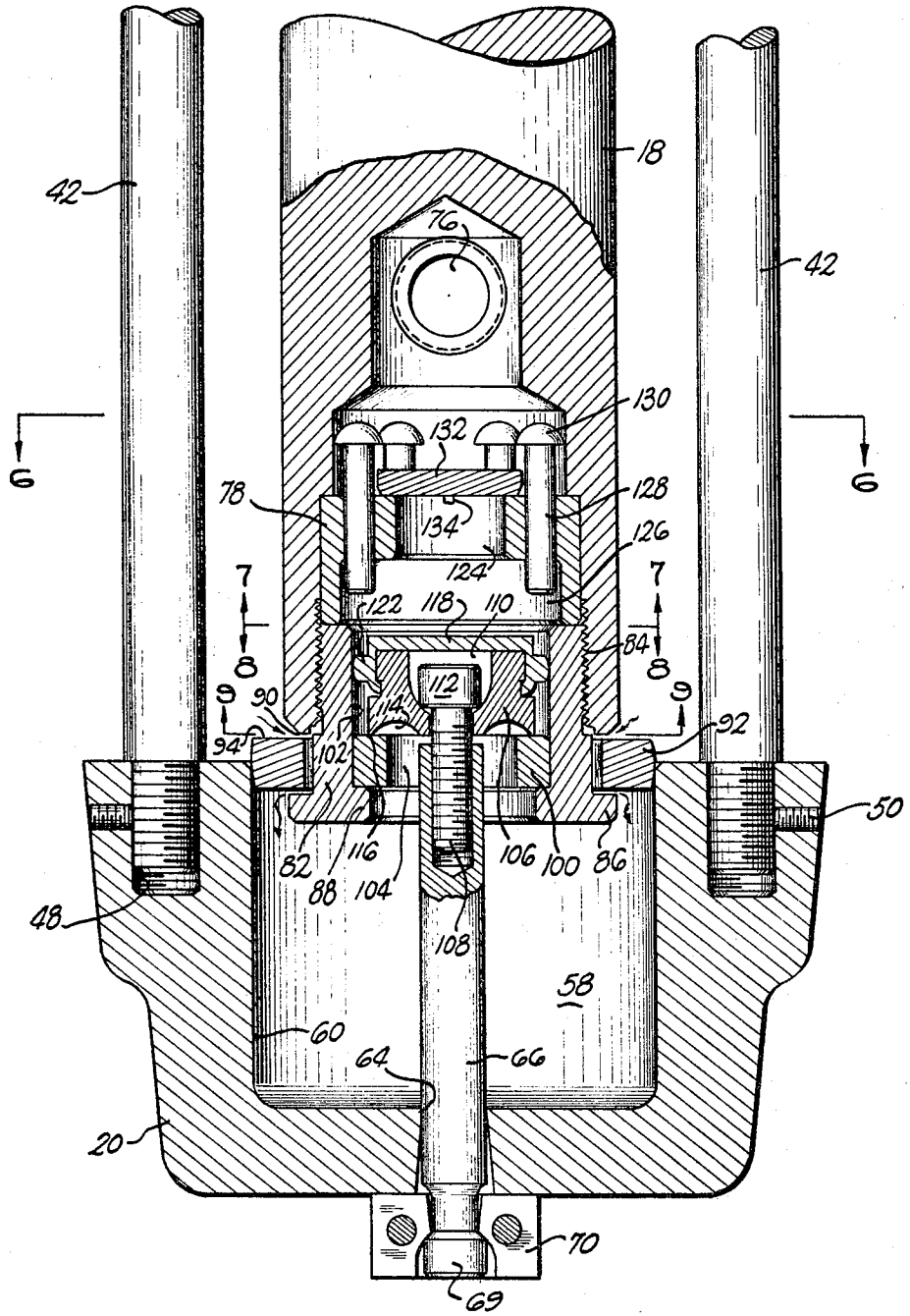


FIG. 5

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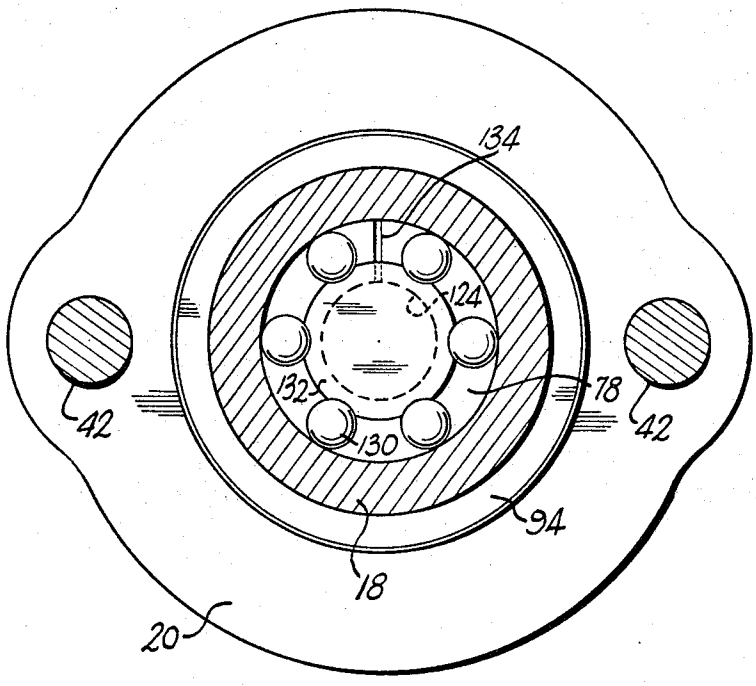


FIG. 6

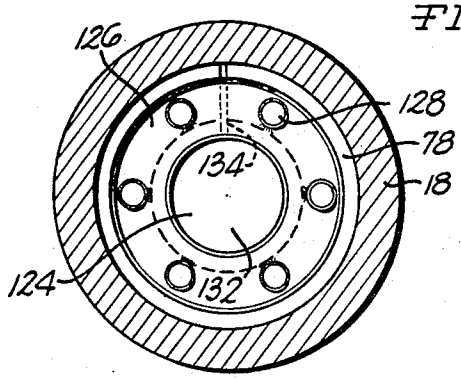


FIG. 7

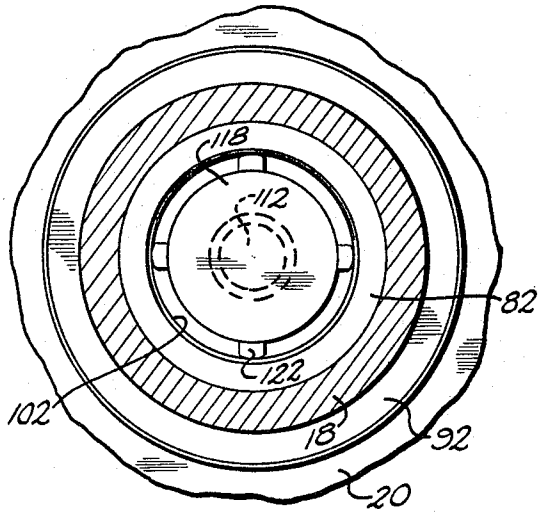


FIG. 8

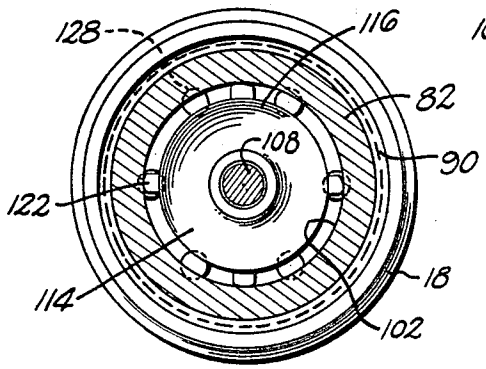


FIG. 9

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3,398,697

MOLTEN METAL PUMP

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Filed Oct. 25, 1966, Ser. No. 589,256
18 Claims. (Cl. 103—158)

This invention relates to a molten metal pump and more particularly to a piston type displacement pump for moving or displacing molten materials such as lead.

It is an object of the present invention to provide a molten metal pump of the type described which includes a discharge valve mechanically connected to a moving cylinder cup so that the power source used to effect the suction or intake stroke of the pump can be utilized to pull the discharge valve to the closed position at the end of the intake stroke and thereby produce a tight shutoff of the discharge line for short or long dwell periods.

Another object of the invention is to provide a pump of the type described with an adjustable volume discharge bleed-back after each power stroke of the pump. This feature of the present pump construction is important in installations where the pump is used to supply an overflow type of ladle. The controlled bleed-back permits heating the molten lead in the discharge line between the pump and the ladle to a higher temperature than the lead pot without continual drippage from the ladle resulting from the expansion of the lead due to its increased temperature.

A further object of the present invention is to provide a pump of the type described wherein the working parts are coaxially aligned so that the working forces are coaxial. This allows various parts of the pump to float without the need of auxiliary sliding guides which might otherwise be required to overcome imbalance and which would be subject to wear.

Another object of the present invention resides in the provision of a pump of the type described having a short compact valve body without stagnant areas therein. By carefully sizing and locating the flow passageways through the pump good velocity without excess pressure drop is achieved. In turn this make for trouble-free operation of the pump over long periods of time as compared with other molten metal pumps which are subject to clogging or accumulating dross.

Another object of this invention is to provide in a pump of the type described a valve member formed of a hard material which is capable of retaining good physical properties at the temperatures encountered and which is sufficiently durable to withstand high loading forces so that it is capable of closing down on agglomerated dross and foreign particles that might be present in the molten metal.

A further object of the present invention is to provide a pump of the type described that is admirably suited for operation by means of fluid power and which does not require any spring loaded parts.

In the drawings:

FIGURE 1 is a side elevational view, partly in section, of a lead pot provided with the pump of the present invention.

FIGURE 2 is a fragmentary side elevational view, with parts in section and other parts broken away, of the pump of the present invention.

FIGURE 3 is a fragmentary secitonal view of the pump

showing the parts in the positions they assume on the power stroke of the pump.

FIGURE 4 is a fragmentary sectional view taken on the line 4—4 in FIG. 3.

FIGURE 5 is a view similar to FIG. 3 showing the parts of the pump in the positions they assume at the end of the intake stroke.

FIGURE 6 is a sectional view along the line 6—6 in FIG. 5.

FIGURE 7 is a sectional view along the line 7—7 in FIG. 5.

FIGURE 8 is a sectional view along the line 8—8 in FIG. 5.

FIGURE 9 is a sectional view along the line 9—9 in FIG. 5.

In FIG. 1 there is illustrated a conventional lead pot **10** which is heated by a suitable heating device **12**, such as a gas or oil fired burner, to maintain a mass of lead **14** within pot **10** in a molten condition. The pump of the present invention is indicated generally by reference numeral **16**. Pump **16** generally includes a pump body **18** and a vertically reciprocable cylinder cup **20** which is driven by an air or other fluid cylinder **22**. More specifically, the pump is supported as by a main support arm **24** so that the cylinder cup **20** and the lower end of the pump body **18** are submerged in the bath **14** of the molten lead. Cylinder **22** is supported over the lead pot **10** in an elevated position by a plurality of vertically extending stand-off rods **26** having their lower ends connected to support arm **24** and their upper ends connected to a cylinder mounting plate **28** on which the cylinder is secured. A discharge line **30** from pump body **18** extends upwardly above lead pot **10** to a ladle **32** which, for example, may be of the overflow type so that during each stroke of the pump a quantity of lead is discharged into ladle **32** which causes the ladle to overflow and discharge into a mold or other device which is being filled with lead. In the arrangement illustrated, a portion of the discharge line **30** extending to ladle **32** is enclosed in a jacket **34** for heating the lead in the discharge line to a temperature higher than the lead in bath **14**. An arrangement of this type is common and in many instances found desirable so that the temperature of the lead pot can be maintained at a lower value than required for the actual casting operation.

As is shown in FIG. 2, cylinder **22** has a piston rod **36** extending downwardly through mounting plate **28** and has connected to its lower end as by nuts **38** a cross bar **40**. The opposite ends of cross bar **40** are provided with outwardly opening recesses which receive the upper ends of a pair of pull rods **42**. Pull rods **42** are secured to cross bar **40** by nuts **44** and are prevented from shifting outwardly in the recesses at the ends of cross bar **40** by cotter pins **46**. The lower ends of pull rods **42** are threaded into sockets **48** in cylinder cup **20** and are locked therein by set screws **50** (FIG. 3). Pump body **18** is secured to support arm **24** by a screw **52**.

The stroke of cylinder **22** is adjusted by any suitable means. In the arrangement illustrated an adjusting screw **54** is provided at the upper end of the cylinder for determining the extent of axial movement of the piston in the cylinder. The admission of fluid under pressure to the opposite ends of cylinder **22** is controlled by a solenoid valve **56** which is actuated by a timer or the like to control the speed of reciprocation of piston rod **36** and the frequency of operation.

Referring now to FIG. 3, cylinder cup **20** has an upwardly opening cavity **58** which provides a pump chamber. The inner periphery of the pump side wall that defines chamber **58** is a cylindrical bore as indicated at **60**. The bottom wall **62** of the cup **20** is centrally apertured as at **64** to slidably receive a pull rod **66**. At its lower end pull rod **66** is fashioned with an inwardly necked portion **68** and a head **69** on which a split retainer block **70** is secured by a pair of screws **72**. When piston rod **36** shifts downwardly, cup **20** is shifted downwardly by pull rods **42** so that the bottom wall **62** of cup **20** engages retainer block **70** and urges pull rod **66** in a downwardly direction.

Pump body **18** has a downwardly opening bore **74** at its lower end. The upper end of bore **74** is formed with radial outlet port **76** to which the lower end of discharge line **30** is connected. Within bore **74** there is arranged a valve retainer **78** which is clamped upwardly against a shoulder **80** by a second valve retainer **82** which is threaded into the lower end of bore **74** as at **84**. Retainer **82** is of a hollow cylindrical shape and at its lower end it is fashioned with a radially outwardly extending flange **86** and a radially inwardly extending flange **88**. Between the flange **86** and the lower end face **90** of valve body **18** there is arranged a plunger ring **92**. The annular end face **90** of body **18** is accurately ground so that the top face **94** of ring **92** is adapted to seat thereagainst and form a seal therebetween. As is shown in FIG. 4, the lower end of retainer **82** is fashioned with a plurality of flats **96** so as to provide annular segment-shaped intake passageways **98** for the flow of metal from the lead pot **10** into the chamber **58** of cylinder cup **22** (FIG. 5).

Plunger ring **92** has a sliding fit with the inner cylindrical surface **60** of the cup **20**. Plunger ring **92** is preferably made of steel; consequently it has a lower specific gravity than molten lead and tends to float upwardly into engagement with the sealing end surface **90** at the lower end of pump body **18**.

Within retainer **82** there is arranged a valve seating ring **100** that is frictionally retained within the bore **102** of the retainer **82** against the shoulder formed by the radially inwardly extending flange **88**. The central aperture **104** accommodates the pull rod **66** which extends upwardly therethrough and has a valve member **106** secured thereto by a screw **108**. A large recess **110** in the upper face of the valve member **106** accommodates the head **112** of screw **108** so that the screw forms a swivel connection between pull rod **66** and valve member **106**. The lower face of valve member **106** is fashioned with an annular groove **114** that forms a narrow land **116** around the outer periphery of valve member **106**. Land **116** is adapted to be brought into tight sealing engagement with the upper face of seating ring **100** as shown in FIG. 5. The upper open end of valve member **106** is closed by a cover **118** which is crimped on valve member **106** as at **120** and which is provided with four radially outwardly extending lugs **122** that engage the bore **102** of retainer **82** and, thus, vertically guide valve member **106** in retainer **82**.

Retainer **78** has a central bore **124** which is enlarged at the lower end of the retainer as at **126**. A plurality of headed rivets or studs **128** extend through retainer **78** and are welded or otherwise secured in place with their lower ends projecting into the enlarged bore **126**. The heads **130** at the upper ends of studs **128** are spaced above the top face of retainer **78** and serve to limit the upward movement of a damper valve disc **132** arranged on the upper face of retainer **78**. The lower ends of studs **128** lie in a common plane and serve as a stop surface for the upward movement of valve member **106**. Damper valve disc **132** is preferably formed of a material such as tungsten-carbide which has a specific gravity greater than molten lead. Thus, damper valve disc **132** normally tends to remain seated on the upper end of retainer **78** to seal bore **124**. However, the upper face of retainer **78** has a radial groove **134** machined therein such that, even when

valve disc **132** is seated on retainer **78**, a certain amount of molten lead is permitted to bleed-back downwardly through the pump through the passageway formed by groove **134**.

In FIG. 3 the parts are illustrated at the end of the power stroke of cylinder cup **20**. During the power stroke cylinder cup **20** is pulled upwardly by pull rods **42**. The buoyant force on plunger ring **92** and the friction between plunger ring **92** and the bore **60** of chamber **58** cause ring **92** to shift upwardly into sealing engagement with the lower end face **90** of valve body **18**. During the power stroke of the pump, cylinder cup **20** shifts vertically from the position shown in FIG. 5 to that shown in FIG. 3. Thus, the pump chamber **58** is progressively reduced in volume and the lead trapped therein is cause to flow upwardly through the pump body, following the path indicated by the arrows in FIG. 3. The discharge passageway from pump chamber **58** comprises central aperture **104** of the valve seating ring **100**, then around valve member **106** and cover **118** to the bore **126** of retainer **78**. The lead then flows upwardly through bore **124** and flows upwardly to the discharge line **30** through the outlet port **76**. The lead flowing upwardly through discharge line **30** is directed to overflow ladle **32**. At the end of the power stroke of the pump, valve disc **132** seats on the upper surface of retainer **78** and prevents a free flow of lead from ladle **32** back into lead pot **10**. However, a controlled amount of bleed-back of lead from ladle **32** to pump chamber **58** is permitted by groove **134** until such time as valve member **106** is caused to seat on ring **100**.

On the intake or suction stroke of the pump, cup **20** is forced downwardly from the position shown in FIG. 3 to the position shown in FIG. 5 by pull rods **42**. As soon as cup **20** starts moving downwardly from the position shown in FIG. 3, the reduced pressure in the enlarging pump chamber **58** and the friction between plunger ring **92** and the bore **60** of cup **20** causes ring **92** to shift downwardly from sealing relationship with the end face **90** of pump body **18** and open the intake passage from the lead pot **10** to the pump chamber **58**, the lead flowing through the arcuate passageways **98** as shown by the arrows in FIG. 5. Eventually the bottom wall **62** of cup **20** engages the retainer block **70** at the lower end of pull rod **66** and shifts the pull rod downwardly. When this occurs, the head **112** of screw **108** engages valve member **106** and shifts it downwardly. Eventually the narrow land **116** around the lower end of valve member **106** is brought into sealed engagement with the upper face of ring **100**. Valve member **106** effectively seals the discharge passageway since the downward force exerted by cylinder **22** is applied as a relatively high unit pressure around the narrow land **116**. This high unit pressure coupled with the swiveled connection between valve member **106** and pull rod **64** effectively closes the discharge passageway at the seating ring **100**.

It is apparent from the forgoing description that valve member **106** can be pulled closed against seating ring **100** by hundreds of pounds of force to assure a tight shutoff of lead flow and the maintenance of a given volume of molten material at a predetermined head height above and beyond valve member **106**. However, as soon as the cylinder cup **20** starts its power or displacement stroke, the seating load on valve **106** drops immediately to zero so that the pump does not have to overcome a seating load on the discharge valve **106** as is the case with spring loaded valves.

The amount of bleed-back which occurs through the groove passageway **134** during the suction stroke of cup **20** can be easily regulated by controlling either the dwell at the end of the pump displacement stroke or the speed of the air cylinder during the suction stroke or both. This bleed-back occurs in the time period between the end of the displacement or power stroke and the end of the suction stroke. Any means for controlling this time interval will necessarily control the amount of bleed-back

from ladle 32 into the pump chamber 58. This controlled bleed-back is an important feature of the present invention when the pump is used in combination with an overflow ladle. In such arrangements the molten lead in the discharge line 30 is normally heated to a temperature above the temperature of the lead in bath 14. Upon heating, the lead expands and, in the absence of a bleed-back of lead to the pump chamber there would be a continual dripping of the lead from the overflow port of the ladle. Thus, by controlling the amount of bleed-back, the discharge from the overflow ladle can be controlled to an accurate amount during each displacement stroke of the pump.

The use of a power cylinder such as shown at 22 is desirable from the standpoint of simplicity, ease of control and ease of removal of the pump assembly from the molten bath. It is apparent, however, that the invention is not limited to operation of the pump by air or other fluid cylinders. Many common arrangements are practical for vertically reciprocating cup 20 including levers, cams, screws, etc.

I claim:

1. A pump adapted to be immersed in a bath of molten material for pumping the material from the bath to a remote delivery point comprising a pump body, means for supporting the pump body in fixed position with an end portion thereof submerged in a bath of molten material, a cup member telescopically arranged with said end portion of the pump body and adapted to form a pump chamber therewith, means for reciprocating said cup member axially to increase the effective size of said pump chamber when the cup member is shifted axially in one direction and to decrease the effective size of the pump chamber when the cup member is shifted axially in the opposite direction, an inlet passageway extending to said pump chamber from exteriorly of the cup member, valve means controlling said inlet passageway and responsive to travel of the cup in said one direction to admit material from the bath in which the pump is immersed to said pump chamber and to prevent discharge of material from said pump chamber through said inlet passageway when the cup member is moved in the opposite direction, a discharge passageway in said pump body communicating at one end with said pump chamber, a discharge valve controlling said discharge passageway and means mechanically interconnecting said discharge valve with said cup member so that the discharge valve is actuated by said cup member to a position closing said discharge passageway when the cup member is shifted axially to the end of its stroke in said one direction, said interconnecting means permitting the discharge valve to shift to a position opening said discharge passageway when the cup member is shifted in said opposite position.

2. A pump as called for in claim 1 wherein the side wall of the cup member at the open end thereof is spaced radially from the telescoped end portion of the pump body and in part defines said inlet passageway, said inlet valve comprising a ring movable axially in said space, said space being defined adjacent one axial end thereof by a valve seat against which said inlet valve is adapted to abut to close said inlet pasageway when the cup member is shifted axially in said opposite direction.

3. A pump as called for in claim 1 including a second valve in said discharge passageway located downstream from said cup member actuated valve, said second valve in the discharge passageway being adapted to close the discharge passageway when the cup member is initially shifted in said one direction and to open the discharge passageway when the cup member is shifted axially in said opposite direction.

4. A pump as called for in claim 3 including means associated with said last-mentioned valve and forming a bleed orifice for permitting a controlled bleed-back of pumped material to said pump chamber when the cup member is shifted in said one direction and prior to the closing of the first-mentioned valve in the discharge passageway.

5. A pump as called for in claim 1 wherein the pump body is supported such that the lower end thereof is adapted to be immersed in said bath of molten material, said cup member being telescoped over the lower end of said body and being disposed with its reciprocating axis extending generally vertically.

6. A pump as called for in claim 4 wherein said one direction is downwardly and said opposite direction is upwardly.

7. A pump as called for in claim 6 wherein the wall of the cup member adjacent its open upper end is spaced radially outwardly from the outer periphery of the lower end portion of the pump body and cooperates therewith to define said inlet passageway, said valve in the inlet pasageway comprising a ring movable vertically in the annular space between the wall of the cup member and the outer periphery of the lower end portion of the pump body.

8. A pump as called for in claim 7 wherein said lower end portion of the pump body has a downwardly facing shoulder thereon against which said ring is adapted to seat to close the inlet passageway.

9. A pump as called for in claim 8 wherein said ring is formed of a material having a lower specific gravity than the bath of molten material in which the pump is adapted to be immersed so that the bouyant force of said molten material will tend to seat said ring on said shoulder.

10. A pump as called for in claim 9 wherein the outer periphery of said ring slidably contacts the inner surface of the wall of the cup member.

11. A pump as called for in claim 1 wherein said discharge passageway is formed with a horizontally disposed seat portion, said cup member being adapted to pull the first-mentioned discharge valve downward into sealing engagement with said seat portion.

12. A pump as called for in claim 1 wherein the axis of reciprocation of the cup member is vertical, said discharge passageway being formed with a horizontally disposed valve seat portion, said cup member being adapted to pull the discharge valve downwardly into sealing engagement with said seat portion when the cup member approaches the lower end of its stroke.

13. A pump as called for in claim 11 wherein said discharge valve has a center opening extending vertically therethrough, said interconnecting means comprising a vertically extending rod connected at its lower end with said cup member such that the cup member is adapted to pull the rod downwardly on its down stroke, said rod extending upwardly through said central opening and having an enlarged head overlying the discharge valve and adapted to seal said central opening when the cup member is shifted downwardly to the lower end of its stroke.

14. A pump as called for in claim 13 wherein said rod has a swivel connection with said discharge valve.

15. A pump as called for in claim 13 wherein said discharge valve member is adapted to be pulled downwardly by said enlarged head into sealing engagement with said horizontally disposed seat portion to limit the downward stroke of said cup member.

16. A pump as called for in claim 6 including a damper valve in said discharge passageway located downstream of said discharge valve, said damper valve being adapted to open said discharge passageway when the cup member is shifted upwardly and to close the discharge passageway when the cup member is shifted downwardly and means associated with said damper valve forming a bleed passageway permitting a controlled bleed-back of pumped material to said pump chamber after said damper valve closes and prior to the closing of said discharge valve.

17. A pump as called for in claim 16 wherein the

damper valve is adapted to open in an upward direction and close in response to gravity, said damper valve being formed of material having a specific gravity greater than that of the molten material in which the pump is adapted to be immersed.

18. A pump as called for in claim **1** wherein the means for reciprocating said cup member comprises a fluid cylinder having a piston rod connected with said cup member, said cylinder being spaced axially of said cup member and connected thereto by axially extending pull rods.

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