Oct. 16, 1962 J. J. PORT, JR., ET AL 3,058,180

APPARATUS FOR POURING MOLTEN METAL

Filed Oct. 11, 1961 3 Sheets-Sheet 1

Fig. 2.

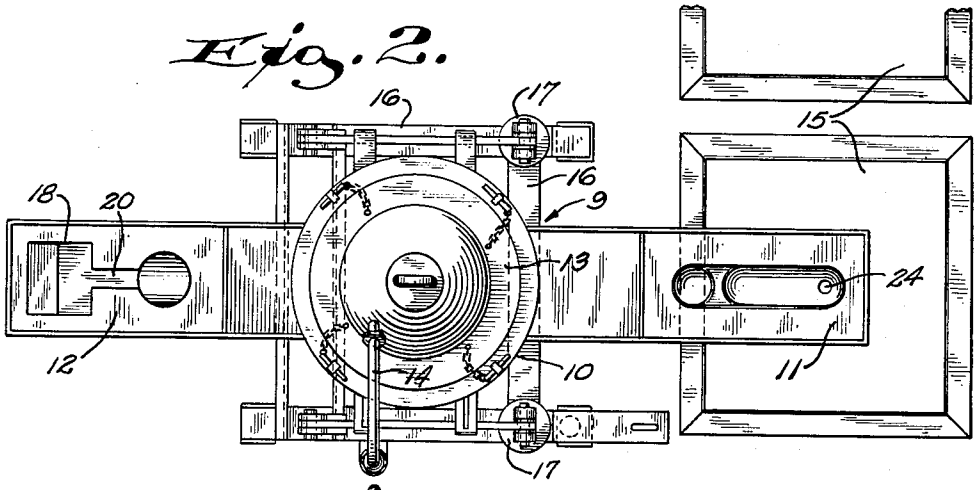


Fig. 1.

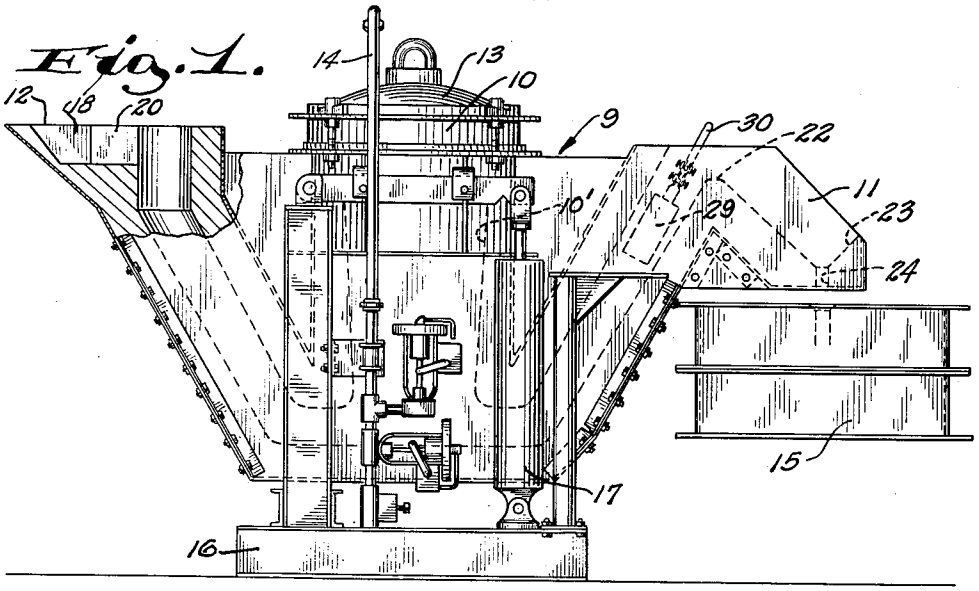
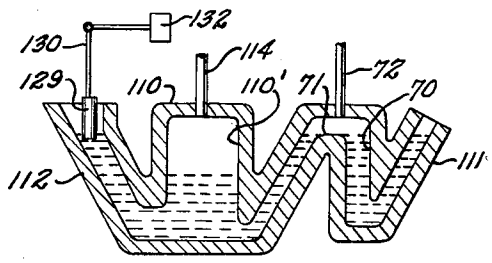


Fig. 4.



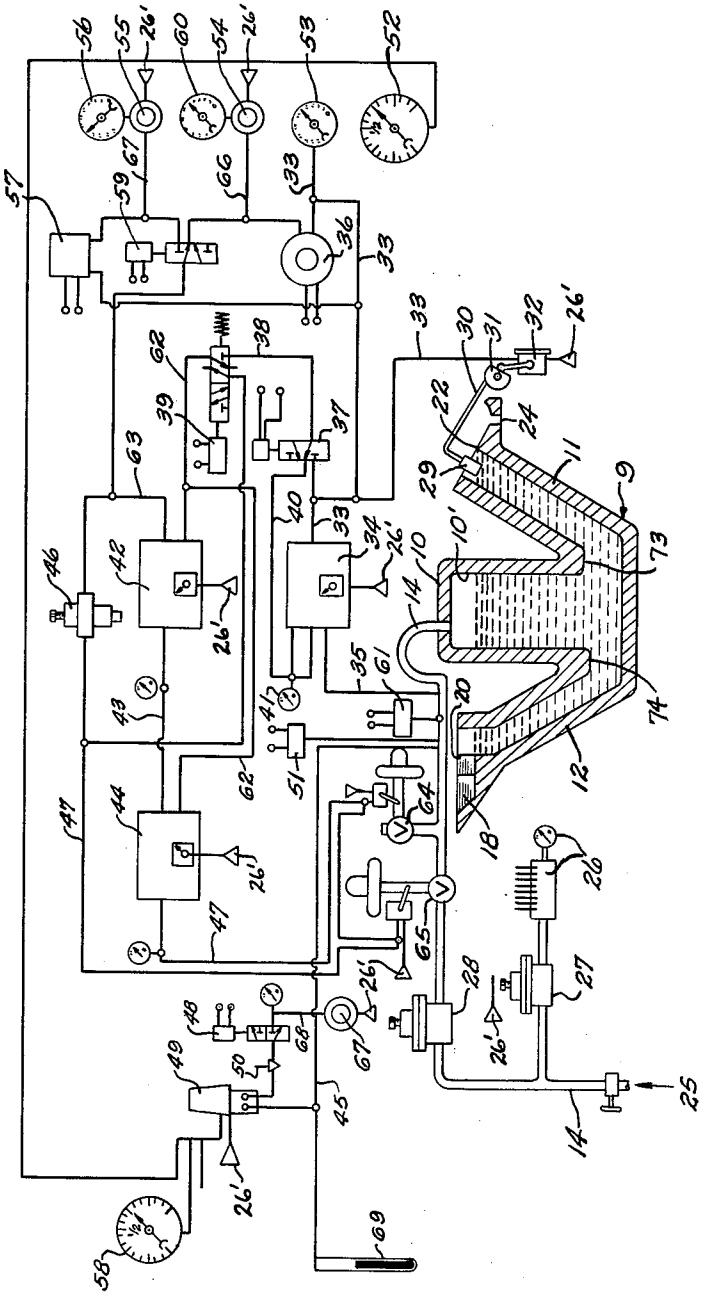
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Fig. 3.



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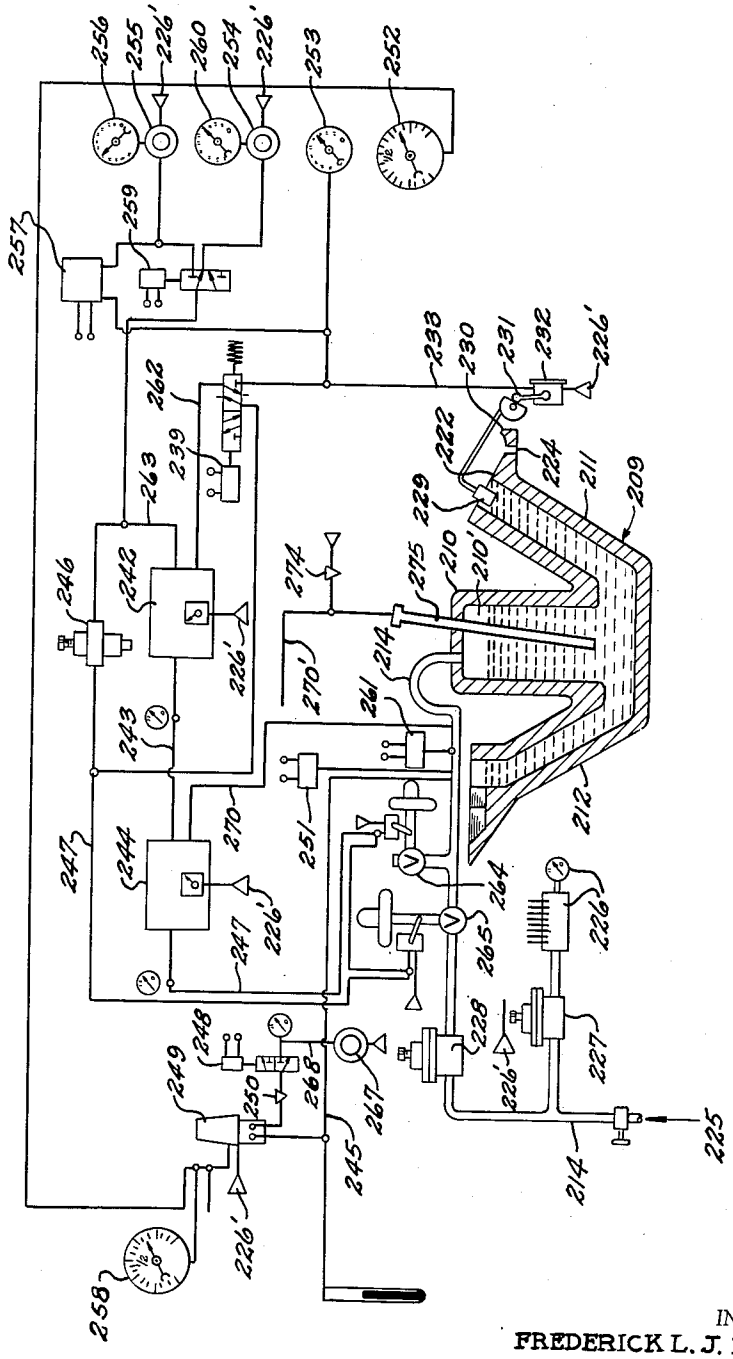
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Filed Oct. 11, 1961

3 Sheets-Sheet 3

Fig. 3.



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3,058,180

APPARATUS FOR POURING MOLTEN METAL

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Filed Oct. 11, 1961, Ser. No. 144,497
6 Claims. (Cl. 22—79)

This invention relates to an improved apparatus for pouring molten metal, and more particularly to an improved pneumatic ladle which is designed to automatically and accurately pour a predetermined volume of molten metal or other material into a plurality of molds.

Heretofore, pouring devices have been designed utilizing air or gas pressure to displace molten material from a ladle and to direct it into a mold, this eliminating the necessity for tilting said ladle and merely letting the molten material spill into the mold, with which method it is difficult to accurately control the volume poured, and which is also extremely hazardous. Such prior pneumatic pouring devices have not proven commercially satisfactory, however, for the reason that they have not been sufficiently refined, and because with such prior devices the volume of material discharged in each pouring operation tends to vary depending on the level of the material in the ladle, and it is impossible to obtain the exactness and precision which is desired.

With the above in mind, the general object of the present invention is to provide an improved pneumatic ladle apparatus having automatic self-adjustment means whereby the volume of molten iron or other material discharged in each pouring cycle is constant and can be accurately controlled regardless of changes in the level of the molten material in the ladle.

A more specific object of the present invention is to provide a pneumatic ladle wherein the pouring operation is actuated by pneumatically raising the metal level in the discharge spout from a certain predetermined level to a higher predetermined level where it will overflow said spout and be directed into a mold therebelow, and wherein means are provided for automatically raising and maintaining the molten metal in said discharge spout at the proper level prior to and during the pouring cycle regardless of the height of the metal in the ladle main chamber.

A further specific object is to provide a pneumatic ladle wherein the volume of metal or other material discharged in each pouring operation can be accurately controlled by a pre-set time switch or other suitable device operatively connected to the pneumatic pump system, which is adapted to vent the ladle and to automatically lower the metal level in the discharge spout below the overflow point after a certain predetermined length of time, or when it is otherwise determined that the mold is filled to the proper height.

A further object is to provide a pneumatic pouring apparatus as described, wherein the pouring rate can be easily and accurately regulated by controlling the distance the metal is raised above the lip of the pouring spout.

A further object of the invention is to provide an improved automatic ladle as described wherein the supply of molten metal in the main chamber of said ladle can be replenished at any time without affecting the accuracy of the pouring operation, thereby eliminating the costly delays and down time for refilling which characterize the use of most prior pneumatic pouring devices.

Still further objects of the present invention are to provide an improved automatic ladle apparatus as described which is efficient and reliable in operation, and which is relatively inexpensive in design and construction.

With the above and other objects in view, the invention

consists of the improved apparatus for pouring molten metal or other material and all of its parts and combinations as set forth in the following specifications and claims, and all equivalents thereof.

In the accompanying drawings, illustrating the preferred form of the invention and two modifications thereof, and wherein like reference numerals designate the same parts in all of the views:

FIG. 1 is a side elevational view of the improved ladle comprising the principal form of the invention, parts thereof being broken away and shown in section;

FIG. 2 is a top plan view of the ladle;

FIG. 3 is a sectional and diagrammatic view of the apparatus showing the pneumatic control system;

FIG. 4 is a sectional view of a modified form of ladle; and

FIG. 5 is a sectional and diagrammatic view similar to FIG. 3 but illustrating a modified form of pneumatic control system.

Referring now more particularly to FIGS. 1 and 2 of the drawings, it will be seen that the ladle **9** employed in the present invention comprises a main body **10** forming a relatively large interior chamber **10'**, there being an inlet or filling spout **12** formed on one side of said body and a discharge or pouring spout **11** on and projecting from the opposite side thereof, said spouts communicating with the lower portion of said main chamber **10'**. While it is appreciated that the device comprising the present invention might be advantageously employed for pouring beer or any other liquid or non-molten material, its principal use is believed to be in foundries, and for this reason the interior of said ladle is ordinarily lined with ceramic or other refractory material adapted to withstand the intense heat of molten metal. As shown, the top of the main chamber **10'** is closed by an air tight, removable cover **13** through which a compressed air or gas line **14** projects, and the entire ladle is pivotally mounted on a base **16** having a hydraulic cylinder and ram assemblage **17** adapted to tilt said ladle to facilitate the draining of the same when it is not in use.

Ordinarily, the ladle is positioned adjacent the mold conveyor line, some distance from the melting furnace, and the molten metal is delivered from the furnace and deposited in the ladle by means of any suitable transportable container. It is to be understood, however, that for some foundry applications a unit similar to that hereinafter described could also be positioned to receive the molten metal directly from the furnace, and the use of the present device is not to be limited in this respect. It is contemplated further that it might be preferred in some instances to include an induction-type heating element within the ladle main chamber to maintain the molten metal therein at a constant temperature prior to the pouring operation, but inasmuch as such a heating element is neither new in the art nor critical to the operation of the present invention, it has not been included in the illustrated structure.

As is shown in said FIGS. 1 and 2, the inlet or filling spout **12** is provided with a receptacle **18** which opens in the top thereof and which communicates with the spout interior channel by means of a relatively narrow lateral channel **20**. In the use of the present invention, molten metal from the furnace is initially poured into said receptacle **18**, said metal flowing through the narrow channel **20**, and into the spout, the restricted nature of said channel **20** causing the metal to flow down the spout and into the ladle main chamber at a smooth steady rate which facilitates the operation of the level control apparatus hereinafter described.

As will be seen in FIGS. 1 and 3, the discharge or pouring spout **11** is provided with an upstanding dam or internal lip **22** which projects above a basin **23**, the latter

having a bottom opening 24 through which the molten metal is discharged into a mold 15 (FIG. 1) therebelow during the pouring operation. Carried within the upper portion of said discharge spout is a float 29 which is designed to float on the surface of the molten metal in the spout, said float also being formed of a ceramic material adapted to withstand intense heat. Said float 29 is connected by means of an arm 30 (FIG. 3) to a cam 31 which, in turn, is operatively connected to a position transmitter 32 designed to transmit a pneumatic signal to the pouring control apparatus in response to movements of said float, and to thereby raise or lower the metal level in said discharge spout, as will be seen. In actual practice, the system has been designed so that the signal sent by said position transmitter varies between three and fifteen pounds per square inch, the higher the float the lower the pressure signal.

With reference now to the pneumatic pump and control apparatus employed in the present invention, attention is directed to FIG. 3 of the drawings. With respect to said FIG. 3, it is to be understood that the various pneumatic gauges, dials, and operator controls illustrated diagrammatically therein, and hereafter described, are preferably housed in a control box or panel located some distance from the ladle, where they can be observed and manipulated by the operator without danger of injury from the molten metal. Moreover, while the electrical swtiches and controls have also been shown in said diagrammatic view, the wiring diagram therefor is conventional and has not been included, but it is to be understood, too, that the various electrical switches and controls incorporated in said electrical circuit may be located at any suitable and convenient location.

In the pneumatic circuit shown in said FIG. 3, the source of compressed air is indicated generally by the numeral 25, and an air manifold 26 is designed to distribute said air supply to the various pneumatic elements. Throughout the circuit the connections between said pneumatic elements and said air supply are shown diagrammatically and designated by the numeral 26'.

In the operation of the present invention, enough metal is first introduced into the ladle main chamber to provide air seals between the chamber and the spouts. The operator then manipulates two pressure regulator knobs 54 and 55 on his control panel to set what are hereinafter referred to as the high and low set points, said low set point representing the pneumatic pressure emitted by the position transmitter 32 when the metal in the discharge spout is at a certain predetermined height prior to the commencement of the pouring cycle, and said high set point representing the pressure emitted by said position transmitter when the metal level is raised to a predetermined point above the lip 22, where it will overflow into the mold at the desired specified rate, which set points are determined by the operator on a trial and error basis by first pouring practice molds to exactly the desired height. As shown, a pair of dials 60 and 56 are included in the control panel to give a visual indication of said high and low set points, and there is another gauge 53 showing the actual metal level in the discharge spout as transmitted by position transmitter 32. After the pressure regulators 54 and 55 have been properly set as described, the electrical controls are energized through a suitable switch on the control panel.

Prior to energizing the electrical controls, the pneumatic signal from the float position transmitter 32 is sent through the line 33 to a controller 34. Said controller is hooked up so that the pressure signal emitted by the same to line 40, or so-called "output," is equal to the pressure or "input" in line 33 plus some predetermined proper constant times the rate the pressure is changing in line 35, the function of which will be hereinafter explained. The output through line 40 goes through a solenoid valve 37, which is not energized, and through line 38 to a solenoid valve 39, which when it is not energized blocks the signal from going further. When the latter valve is not energized it vents the pressure from lines 62 and 47 to the atmosphere.

Upon energization of the electrical controls, the valve 39 is energized, thus preventing further venting of line 47 to the atmosphere, and connects line 38 to line 62, which transmits the measured element signal to controllers 42 and 44. Controller 42 emits a signal or output through line 43 which is the sum of the proper predetermined constant times the difference between the set signal in line 63 and the signal in line 62 and a second predetermined constant times the integration of this difference between lines 63 and 62 with respect to time. The output of the controller 44, which is transmitted through line 47, is a function of the error between lines 43 and 62, similar to controller 42 heretofore explained. The output of said controller 44 is sent through said line 47 to a pair of valves 64 and 65 in the compressed air feed line 14. The valve 64 is designed to vent air from the ladle main chamber and is so arranged that a rise in pressure in line 47 closes said valve, while the valve 65 is designed to admit compressed air to the chamber and is so arranged that an increase in pressure in line 47 causes the same to open.

Before controllers 42 and 44 were connected to receive the signal of position transmitter 32, as modified by controller 34, line 62 had been vented to the atmosphere as described. The resulting zero pressure signal therein corresponds to the float 29 being raised to a very high level (much higher than would ever be used in practice), which signal tells controller 42 that the metal is too high, due to the constants which are preset into said controller. If the output goes to 15 p.s.i. or above, or some other predetermined figure, the controller 44 then senses a very large error between lines 43 and 62, which in turn tells it the metal level is apparently far above the desired level. Due to the constants set in said controller 44, its output in line 47 begins to approach zero, thus closing valve 65 and opening valve 64 to vent the chamber 10', even if it was not for the fact that valve 39 has vented this signal to the atmosphere.

As soon as the valve 39 is closed as hereinabove described, the two controllers 42 and 44 receive a signal from the position transmitter 32, as modified by controller 34, which corresponds to the float 29 being at a level below the low set point previously determined and fixed by means of the knob 54. This causes the output of controller 42, which is sent to the controller 44 through line 43, to lower and in time due to the preset constants in said controllers, and their combined action, the pressure signal from controller 44 starts to raise, thus causing valve 64 to start to close and valve 65 to open. The opening of the latter valve causes the pressure in the ladle main chamber 10' to increase. This increase in pressure is relayed to the controller 34 through the line 35, thus causing the output of 34 to be less than the output of the position transmitter 32, just as though the float 29 were being raised. This decrease in the pressure sent by said controller 34 to the controllers 42 and 44 tends to make the latter controllers respond as though the metal level in the discharge spout were raising the float, and thus causing said controllers 42 and 44 to cut back on the pressure in line 47 so that the pressure in the ladle main chamber 10' does not build up too fast. In this manner the controller 34 effectively controls the rate of pressure built up in the ladle main chamber, so that the metal level in the discharge spout is not raised too fast during the initial start-up.

In time the metal level in the discharge spout will raise sufficiently to contact and raise the float 29, at which time the controller 34 is no longer required. At that point the difference in pressure in line 33 and in line 66, which is the line from the low set point regulator 54, becomes sufficiently small so that a differential pressure switch 36 energizes the solenoid valve 37 and thus auto-

matically takes said controller 34 out of the system. The result is that after the initial start-up the controller 34 is not used and the line 33 feeds the signal from the position transmitter 32 directly to the controllers 42 and 44. The system is then ready to pour a mold.

When a mold is properly positioned beneath the ladle discharge opening 24, the solenoid valve 59 is energized, which can be accomplished either through a manual switch or automatically by means of a switch in the mold conveyor line which is positioned to be tripped by the mold as the same moves into pouring position. Said solenoid disconnects the low set point regulator 54 from the system and automatically simultaneously brings the high set point regulator 55 into the circuit. Consequently, the metal level in the discharge spout is raised automatically to the high level set point, where it overflows the lip 22 and is discharged into the mold therebelow.

The length of time the apparatus is allowed to pour is determined by the requirements of the particular mold, of course, and can be controlled by an automatic timing device or other means adapted to de-energize the solenoid 59, and thus return the low set point to the circuit, when the mold is properly filled. In the latter respect, the volume of molten metal to be poured in the mold can be determined by first pouring a practice mold and then setting the high and low set point regulators and timing switch accordingly, as described. It is contemplated, however, that in some instances it might be preferable to employ a pyrometer or probe which could be inserted into each mold to sense the level of the molten metal therein and to relay a signal to the "stop pour" apparatus when said probe indicates the mold is filled to the proper height. Another possible alternative is to connect the "stop pour" mechanism to a scale which would actuate the same when the mold reached a certain predetermined weight. In other words, the particular means employed for terminating the pouring operation, whether it is a pre-set timing switch, a pyrometer, an operator-controlled, manual switch, or any other suitable device, is not critical to the operation of the present ladle, and the invention is not to be limited in this respect.

From the foregoing detailed description, it will be seen that the novel, automatic pouring ladle comprising the present invention is simple but unique in its operation. Sufficient molten metal is first deposited in the ladle to establish air locks between the ladle main chamber and the filling and pouring spouts. Compressed air or gas is then directed into the main chamber to push downwardly on the metal therein and to raise the metal level in the discharge spout to a predetermined point below the spout lip, or so-called low set point, which point is fixed by the operator. When the metal level in the discharge spout reaches said low set point, it is automatically maintained there through the action of the float, pneumatic circuit, and valves hereinabove described. The pouring operation may then be commenced.

As mentioned, the pouring cycle can be initiated either by means of a manual switch, or by a switch located in the mold conveyor line. When the electrical circuit is thus energized, additional compressed air is admitted to the ladle main chamber to raise the metal level in the discharge spout to a predetermined high set point, where said metal will overflow the spout lip and be directed into the mold, the proper setting of which high set point is previously determined by the operator and is dependent upon the volume requirements of the mold, and the desired pouring rate.

When the exact desired volume of metal has been deposited in the mold, which is determined by either of several alternative devices as hereinabove described, the valve 58 is de-energized and the controls vent air from the ladle main chamber, thus reducing the pressure therein until the level of the metal in the discharge spout returns to its original position below the spout lip, or low set point, and the pouring cycle is then completed. Another mold is then moved into position below the discharge spout and the operation repeated.

In order to permit a determination at all times as to the volume of metal in the ladle main chamber 10', the circuit is provided with a differential pressure cell 49 which is connected through line 45 to the ladle main chamber, said pressure cell being hooked up to a pair of gauges 58 and 52 which are so designed that the difference in pressure between the ladle full and the ladle nearly empty will cause the same to swing from an indicational full to empty position. Because changes in the level of the metal in the discharge spout from low to the high set points would ordinarily cause fluctuations in said gauges 52 and 58, a pressure regulator 67, valve 48, which is energized at the same time as valve 58, and restrictor 50, are also connected to said differential cell. It has been found that when said regulator 67 and restrictor 50 are properly set, as determined by experience, the signal therefrom, which is transmitted to the opposite side of the cell 49, just offsets the signal caused by said level changes in the discharge spout and thus practically eliminates the fluctuations otherwise present in said gauges 52 and 58. The result is that the operator and the men filling the ladle can determine the volume of metal in the ladle with considerable accuracy at all times. In the preferred form of the invention, a mercury monometer 69 is also hooked up to the line to give a further indication, or double check, of the metal level in said ladle main chamber.

In addition to the foregoing operating elements, the control system in the present invention is also provided with several safety features which are designad to eliminate the danger of personal injury to the operator. In this respect, it will be noted in FIG. 3 that a pneumatic relay valve 46 is included in the circuit. Said relay valve is so designed that if the set point pressure in the line 63 should fall below some predetermined desired minimum, due to some failure, said relay valve will automatically open line 47 to the atmosphere, thus lowering the pressure to valves 64 and 65 and causing the air to be vented from the ladle.

Also included in the preferred form of the invention, is a differential pressure switch 57 which is arranged so that in the event the pressure in line 33 indicates that the metal level in the discharge spout is at some predetermined point above the high set point, being the signal transmitted through line 67, then said differential pressure switch 57 will de-energize the electrical controls. The result is that the valve 39 is thus de-energized, the signal in the line 62 is vented to the atmosphere, and the controllers 42 and 44 assume their pre-start up condition. Moreover, the signal in the line 47 is thereby vented to the atmosphere and the valve 64 is caused to open and the valve 65 to close, thus venting the ladle main chamber. In addition to said pressure switch 57, a pressure switch 51 is also hooked up to the electrical control system to accomplish the same purpose, said switch being set to automatically de-energize the circuit and vent the system in case of an unsafe pressure build up indicating the metal level is dangerously low.

In the event the metal level in the ladle main chamber becomes low, a switch 61 is also included in the electrical circuit and is set so that it will permit the completion of the current pouring operation but will not permit the commencement of a new pouring cycle, thus preventing the metal level in the ladle main chamber from reaching the point where the air seal will be broken. If said air seal between the ladle main chamber and the spouts 11 and 12 should somehow be broken, however, the present ladle is so designed that said seal will be broken first with the discharge spout, due to the fact that the lower end 73 of the main chamber wall at the junction with said discharge spout is slightly higher than the corresponding point 74 in the filling spout. If the seal between the ladle and in said discharge spout is broken, the float 29 in said spout

will be raised, of course, and the switch **57** will de-energize the circuits as described. Moreover, in addition to automatically ceasing the pouring operation as described, by ensuring that in the event of a seal break the molten metal will be emitted through the pouring spout, rather than the inlet spout, the danger from flying molten metal is reduced and the safety of the man filling the ladle is greatly promoted.

A further novel feature of the present invention, and as hereinbefore mentioned, is that molten metal can be added to the ladle at any time, including during the pouring operation. Because the float **29** and its related pressure regulating apparatus is designed to constantly maintain the metal level in the discharge spout at a certain height, if metal is added to the ladle said float will tend to rise, of course, but in so doing will send a signal to the controllers **44** and **42** which in turn send a signal to valves **65** and **64** to automatically vent sufficient air from the ladle to reduce the pressure therein and to return the metal level to its proper position. Thus the height of the metal in the discharge spout is maintained at the proper point regardless of fluctuations in the volume of metal in the ladle, and the necessity for halting the pouring operation for refilling, as in conventional automatic ladles, is eliminated.

In addition to the principal form of the invention shown in FIGS. 1 to 3, and hereinabove described, it is contemplated that certain changes or modifications could be advantageously employed for certain pouring operations, and in this respect attention is directed to FIG. 4 of the drawings. In said FIG. 4, all of the structural elements corresponding to those illustrated in FIGS. 1 to 3 are preceded by the digit "1."

As will be noted, in the modified form of the invention illustrated in FIG. 4, the ceramic float **129** is mounted in the filling spout **112**, rather than in the discharge spout **111** as in the principal form of the invention, and said discharge spout is provided with an extra, intermediate section or measurement well **70**. A position transmitter **132** and electrical and pneumatic control units (not shown) similar to those employed in the principal form of the invention are set to maintain the metal level in both the filling and pouring spouts at a constant height (the metal in both of said spouts naturally seeking the same level), which is high enough initially to permit the metal to flow over the cut-off weir **71** and into said measurement well.

In the operation of said modified pouring apparatus, air is vented from the measurement well **70** to permit the same to become substantially filled with molten metal, as shown. The metal is then lowered to a point below the weir **71** either by admitting a low air pressure to said well through the line **72**, which pressure should not be so great as to force the metal out of the top of the pouring spout, or by raising and lowering the set point levels which are transmitted to the controls attached to the float **129**. When a mold is in position to be poured, more air pressure is admitted to the well, either automatically or by the operator, thereby causing the metal to overflow the spout and to be discharged into the mold therebelow. With such a modified ladle design, the pouring rate may be controlled either by regulating the rate of air pressure build-up in the well **71**, or by using another float in the pouring spout and controlling the height the metal is raised above the pouring lip by controlling the gas or air supply to the line **72**. The advantage of this type of ladle is that the pouring operation can be halted at exactly the proper moment merely by connecting the stop-pour mechanism to a valve unit adapted to automatically vent the well **70** after a predetermined pressure has been built up therein. As in the principal form of the invention, the unit of FIG. 4 is also provided with safety features, including an automatic "stop-pour" mechanism in the event there is a failure in the system.

Still other modified versions of the principal form of the present invention are also contemplated, and it is intended that these too come within the scope of the present application. It is appreciated, for example, that in a ladle smiliar to that shown in FIG. 4, a vacuum could be created in the well **70** to raise the metal therein and to actuate the pouring operation, rather than using compressed air or gas to force the metal from the spout. It is intended too that for certain foundries wherein it is desired to simultaneously pour molds on two or more conveyor lines, a ladle similar to that hereinabove described, but having a plurality of pouring spouts, could be used. It is to be understood, in other words, that the present invention is not to be limited or confined to the exact structural details characterizing the ladle illustrated and described herein, but, on the contrary, it is appreciated that numerous changes or modifications might be employed without departing from the spirit of the invention. In this respect it is also contemplated that a simplified form of pneumatic control circuit could also be utilized for certain foundry applications, and in this regard, attention is directed to FIG. 5 of the drawings, wherein all of the elements corresponding to those illustrated in FIG. 3 are preceded by the numeral "2."

In FIG. 5, the "start-up" controller **34** employed in the principal form of the invention (FIG. 3) has been eliminated, and the controller **242** has been set so that an increase in its measured element or input, causes a corresponding increase in its output, while the controller **244** is set so that an increase in measured element causes a decrease in output. Both of said controllers have reset and proportioning action, as in the principal form of the invention, and the remaining elements in the system are all designed to function in exactly the same manner as was hereinabove described in connection with FIG. 3.

In the operation of said simplified control system, the ladle is first filled with sufficient molten metal to insure air seals between the main chamber and the spouts, of course, and the high and low set point regulators **254** and **255** are set as desired. Prior to the energization of the solenoid valve **239**, the windup action in the controller **242** causes the output thereof to be zero, which output is normally transmitted through line **243** to the other controller **244**. The line **270** carries the measured element signal for said controller **244** and the output of said controller has been vented to the atmosphere by valve **239**.

When the electrical controls are turned on, and the solenoid **239** energized, line **233** is connected to line **262**. The controller **242** thus receives a signal through said line **233** which corresponds to the level of the float **229**, and which is initially at a level below the desired low set point. Accordingly, the output of controller **242** will rise slowly, being the product of error of the float level multiplied by time, due to the reset action of said controller **242**. The controller **242** will then adjust its output through line **247**, which is no longer vented, to adjust valves **264** and **265** as hereinabove described. The result is that the pressure in line **270**, which is connected to the air supply line **214**, is as nearly equal to the pressure in line **243** as is possible. The pressure in the latter line continues to rise, of course, until the increased pressure in the ladle main chamber causes the metal in the pouring spout to reach the predetermined low set point. The pouring cycle may then be commenced and is identical to that hereinabove described in connection with the system of FIG. 3.

The simplified control system described is satisfactory for some foundry applications, but it has been found that where the ladle is refilled at a rapid rate the float **229** tends to deviate from the desired set point. This disadvantage could be overcome by disconnecting the line **270** from the air supply line **214** and connecting it instead to a ceramic tube **275** in the ladle main chamber,

through a line 270'. Said tube 275 is designed to receive air or gas, which is bled past a restrictor 274, and to bubble the same out adjacent the bottom of the ladle main chamber. This pressure remains constant for a given metal level in the spout regardless of the volume of metal in the main chamber, and the result is that the controller 242 does not have to control its output over such a wide range between the conditions of ladle full and ladle empty, and the float remains relatively steady.

In addition to the control system illustrated in FIG. 5, it is contemplated that other, still simpler versions might even be satisfactory in some instances, including a pneumatic circuit wherein only a single controller is utilized, and it is to be understood that the unique pouring apparatus comprising the present invention is not to be confined to use with a pneumatic control system exactly as illustrated. Moreover, while the above description has been concerned solely with pneumatic control systems, it is conceivable that electrical or other types of control systems could be designed to perform essentially the same operations, and might even be preferred by some users, and the novel pouring apparatus comprising the present invention is not to be limited in this respect.

From the foregoing detailed description, it will be seen that the present invention comprises an automatic pouring device which is a decided improvement over the ladles now in use. With the present invention it is possible to automatically accurately pour a predetermined volume of molten metal, or any other liquid or semi-liquid substance, into a plurality of molds or other receptacles. Moreover, with the present invention the volume discharged does not vary with each pouring cycle depending on the level of the metal in the ladle main chamber, as frequently occurs with prior pneumatic ladles, and it is even possible to replenish the supply of metal in the ladle during the pouring operation, thus eliminating costly delays for refilling. The present automatic ladle is efficient and reliable in operation, relatively inexpensive in design and construction, and is otherwise especially well adapted for its intended purpose.

As mentioned, it is to be understood that while the preferred form of the improved ladle and several modifications thereof have been illustrated in the drawings and hereinabove described, the invention is not to be limited to a device exactly as that illustrated and described. On the contrary, it is intended that the invention include any and all changes or modifications in said ladle as may come within the spirit of the invention and within the scope of the following claims.

What we claim is:

1. A pouring apparatus, comprising: a ladle having a main chamber and having a discharge spout projecting from said chamber and communicating with the lower portion thereof; pressure means associated with said ladle adapted to raise and lower the liquid level in said discharge spout; means associated with said ladle adapted to determine the liquid level in said discharge spout and to transmit a predetermined corresponding signal; a control system associated with said pressure means and including means adapted to receive said signal and to automatically actuate said pressure means to raise or lower the liquid level in said discharge spout to a predetermined low set point below the top of said spout, and said control system including means adapted to actuate said pressure means to raise the liquid in said discharge spout from said low set point to a predetermined high set point where it will overflow said spout; and means associated with said control system and pressure means adapted to return the level of the liquid in said discharge spout to said low set point after the desired volume of liquid has been discharged.

2. A pouring apparatus, comprising: a ladle having a covered main chamber and having a discharge spout projecting from said chamber and communicating with the lower portion thereof; a compressed gas line leading from a source and communicating with said ladle main chamber; valve means associated with said gas line; level indicating means associated with said ladle adapted to determine the liquid level in said discharge spout and to transmit a predetermined corresponding signal; a control system associated with said valve means and with said level indicating means adapted to receive said signal and to automatically actuate said valve means to admit or release compressed gas in said main chamber to raise or lower the liquid level in said discharge spout to a predetermined low set point below the top of said spout, and said control system including means adapted to actuate said valve means to admit sufficient compressed gas to said ladle to raise the liquid in said discharge spout from said low set point to a predetermined high set point where it will overflow said spout; and means associated with said control system and valve means adapted to return the level of the liquid in said discharge spout to said low set point after the desired volume of liquid has been discharged.

3. A pouring apparatus, comprising: a ladle having a covered main chamber and having a discharge spout projecting from said chamber and communicating with the lower portion thereof; a compressed gas line leading from a source and communicating with said ladle main chamber; valve means associated with said gas line; level indicating means associated with said ladle adapted to determine the liquid level in said discharge spout and to transmit a predetermined corresponding pneumatic signal; a control system associated with said valve means and with said level indicating means adapted to receive said pneumatic signal and to automatically actuate said valve means to admit or release compressed gas in said main chamber to raise or lower the liquid level in said discharge spout to a predetermined low set point below the top of said spout, and said control system including means adapted to actuate said valve means to admit sufficient compressed gas to said ladle to raise the liquid in said discharge spout from said low set point to a predetermined high set point where it will overflow said spout at a predetermined rate; and means associated with said control system and valve means adapted to return the level of the liquid in said discharge spout to said low set point after the desired volume of liquid has been discharged.

4. A pouring apparatus, comprising: a ladle having a covered main chamber and having a discharge spout projecting from said chamber and communicating with the lower portion thereof; a compressed gas line leading from a source and communicating with said ladle main chamber; valve means associated with said gas line; level indicating means associated with said ladle adapted to determine the liquid level in said discharge spout and to transmit a predetermined corresponding signal; a control system associated with said valve means and with said level indicating means adapted to receive said signal and to automatically actuate said valve means to admit or release compressed gas in said main chamber to raise or lower the liquid level in said discharge spout to a predetermined low set point below the top of said spout, and said control system including means adapted to actuate said valve means to admit sufficient compressed gas to said ladle to raise the liquid in said discharge spout from said low set point to a predetermined high set point where it will overflow said spout at a predetermined rate; means associated with said control system and valve means adapted to return the level of the liquid in said discharge spout to said low set point after the desired volume of liquid has been discharged; and safety means associated with said control system and with said valve means adapted to automatically prevent actuation of the pouring cycle in response to predetermined signals from said control system.

5. An automatic pouring apparatus comprising: a ladle having a covered main chamber, and having a discharge spout projecting from said main chamber and communicating with the lower portion thereof; a compressed air

line leading from a source and extending into said ladle main chamber; valve means associated with said ladle and with said air supply line; level indicating means associated with said ladle adapted to determine the liquid level in said discharge spout and to transmit a predetermined corresponding signal; a control circuit associated with said level indicating means and with said valve means; a low set point unit connectible in said control circuit and pre-set to transmit a signal corresponding to the pressure emitted by the position transmitter when the liquid in the discharge spout is at a certain predetermined low set point level; a high set point unit connectible in said circuit and pre-set to transmit a signal corresponding to the pressure emitted by the position transmitter when the liquid in the discharge spout is at a predetermined high set point level where it will overflow said spout at a desired rate; a pre-set controller in the circuit connected to said level indicator and connectible to said set point units, said controller having re-set and proportioning action and being pre-set so that its output signal is the function of error between the signals transmitted by said set point units and said level indicator; means in said circuit adapted to connect either of said set point units to said controller, and to simultaneously disconnect the other set point unit therefrom; and means operatively connecting said controller to said valve means whereby the latter will open or close depending on the predetermined signal transmitted thereto by said controller, and thus raising or lowering the liquid level in the discharge spout until the level of said liquid reaches the desired set point level, as determined by the particular set point unit then in the circuit.

6. An automatic pouring apparatus comprising: a ladle having a covered main chamber, and having a discharge spout projecting from said main chamber and communicating with the lower portion thereof; a compressed air line leading from a source and extending into said ladle main chamber; valve means associated with said ladle and with said air supply line positionable to admit or vent compressed air from said ladle main chamber to raise or lower the molten material level in the discharge spout; a float movably carried in said discharge spout and supportable on the upper surface of molten material in said spout; a pneumatic control circuit; a position transmitter operatively associated with said float and adapted to transmit a signal to said pneumatic control circuit in response to movements of said float; a low set point pressure regulator in said control circuit pre-set to transmit a signal corresponding to the pressure emitted by the position transmitter when the molten material in the discharge spout is at a certain predetermined low set point level; a high set point pressure regulator in said circuit pre-set to transmit a signal corresponding to the pressure emitted by the position transmitter when the molten material in the discharge spout is raised to a predetermined high set point level where it will overflow said spout at a desired rate; a start-up pneumatic controller in the circuit connected to said

pressure regulators and to said position transmitter, said start-up controller having re-set and proportioning action and being pre-set so that the pneumatic signal transmitted thereby varies in predetermined inverse proportion to the rate of pressure change in the ladle main chamber to prevent the pressure in said chamber from building up at a dangerous rate; a second pre-set controller in the circuit connected to said pressure regulators and to said start-up controller, said second controller having re-set and proportioning action and being pre-set so that its output signal is the sum of a proper predetermined constant numerical value multiplied by the difference between its input and a second predetermined constant numerical value multiplied by the difference between said input and the pressure value set by the low set point pressure regulator with respect to time; a third controller in the circuit connected to said second controller, the output signal of said third controller being a function of the error between the input and output of said second controller; means operatively connecting said third controller to said ladle valves, whereby the latter will open or close according to the signal transmitted thereto by said third controller, and thus admitting or releasing compressed air from the ladle to raise or lower the molten material level in the discharge spout until the predetermined low set point level is reached; electrical means in said circuit adapted to disconnect said start-up controller therefrom when the material in the discharge spout reaches said low set point level, and to simultaneously connect the second controller directly to the position transmitter, electrical means in said circuit adapted to disconnect said low point regulator from the controllers and simultaneously connect said high set point regulator to the second controller when the level of the molten material in the discharge spout reaches said low set point level and when a mold is in proper receiving position beneath the ladle discharge spout, the introduction of said high set point regulator into the system causing the pressure in the ladle to be increased and the material in the discharge spout raised to the predetermined high set point level where it will overflow into the mold at a specified rate; and electrical means in the circuit adapted to disconnect said high set point regulator therefrom, and to simultaneously reconnect said low set point regulator to the circuit, when a desired amount of molten material has been deposited in the mold, thus causing the molten material in the discharge spout to return to its low set point level, and terminating the pouring operation.

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