This invention relates generally to ladles for pouring fluid material into molds and more specifically to control means associated with such ladles for indicating when such ladles are ready to be refilled with said fluid material.

This application is a continuation-in-part of my copending application Serial No. 853,316, filed November 16, 1959, now abandoned, which discloses both a novel method and means for pouring fluid material into a mold or molds wherein the material solidifies into a casting or castings.

According to accepted practice, particularly in the art of casting of molten metal, such as steel, the ladle has been subjected to relatively high pressure, as compared to the pressure existing in the mold, so as to cause the molten metal to flow through a pouring tube into the mold.

As a consequence of this general arrangement, it has been necessary to construct the ladle structures substantially totally enclosed so as to be able to either increase or decrease the pressure acting on the molten material therein. A further problem arises from such a totally enclosed ladle structure, that being, the inability to readily detect, from without, the quantity of molten material within the ladle structure.

Accordingly, an object of this invention is to provide means externally of said ladle for indicating the quantity of molten material therein, and more specifically to provide automatic means for indicating when the quantity of molten material has been reduced to such a level as to require re-filling.

Another object of this invention is to provide automatic means for terminating the pouring operation whenever the quantity of molten material within the ladle reduces itself below a predetermined minimum quantity.

Other objects and advantages will become apparent when reference is made to the written description and accompanying drawings wherein:

FIGURE 1 is a side elevational view of a ladle structure constructed in accordance with the teachings of the invention;

FIGURE 2 is a cross-sectional view taken on the plane of line 2-2 of FIGURE 1 and looking in the direction of the arrows;

FIGURE 3 is a fragmentary cross-sectional view taken on the plane of line 3-3 of FIGURE 1 and looking in the direction of the arrows; and

FIGURE 4 is a schematic wiring diagram in conjunction with a valve structure shown in cross-section, illustrating one embodiment of the invention.

Certain elements are omitted from one or more of the said figures for purposes of clarity.

Referring now in greater detail to the drawings, FIGURE 1 illustrates a ladle 10 comprised of a generally cylindrical structure 12, a plurality of chambers 14, pivotally mounted on supports 16 and 18 as by coaxial trunnions 20 and 22. A suitable motor 24 and gear reducer 26 are provided, as on a base 28, for driving, by means of a suitable transmission 30, a pinion gear 32 which cooperates with a ring gear 34 secured to the housing 12. Gears 32 and 34, along with the related structure, are provided in order to at time rotate the ladle 10 about its pivots 20 and 22.

FIGURE 2, a cross-sectional view taken on line 2-2 of FIGURE 1, illustrates the ladle 10 as being comprised of an outer container 36 lined with a suitable refractory 33 and provided with a port 40 which, in pouring position of the ladle shown, is preferably at the bottom of the ladle. Port 49 communicates with conduit 42 of a readily removable pouring tube 44 secured to the container 36 as by means of a flange 46 and nut and bolt assemblies 48.

The pouring tube 44 is illustrated as being comprised of casing segments 50 and 52 containing a high refractory lining 54 surrounded by a highly permeable refractory back-up, such as CO₂ sodium silicate bonded sand. The segments 50 and 52 may be provided with vents 56 to release gases developed in the back-up 58 by heat of the molten steel poured through the tube into a mold 60 mated with the upper end of tube 44. Conduits 62, formed on segments 50 and 52, may be held in abutting relationship to each other as by means of split ring clamps 64. An additional support bracket 66 may be provided as between the container 36 and tube 44 and secured to both in any suitable manner.

The ladle is provided with a filling and access hatch 68 having a cover 70 releasably clamped against a sealing gasket 72 as by clamps 74. Additionally, a drain hole 76 (see FIGURE 1 and 3), releasably closed by a cover 78 compressed against a sealing gasket 80 as by means of a hand operated clamp screw 82, is also provided. Screw 82 may be threaded into a bracket 84, one end of which is pivoted at 88 to the ladle 10. The opposite end of the bracket 84 is releasably connected to the ladle by a readily removable pin 86. Gaskets 72 and 80 are provided in order to create a gas tight seal about hatch 68 and hole 76, respectively.

A suitable source 90 of relatively high pressure gas is in controlled communication with chamber 14 as by means of conduits 92, 94, 95 and 96. Conduits 92 and 94 may be connected to each other as by means of a suitable elbow 98 while a combination sealed swivel joint and quick disconnect assembly 100 serves to connect conduits 94 and 95. A solenoid valve assembly 102 is connected serially between conduits 95 and 96 and is adapted to respond to a signal generated by the cooperative action of a source of radiation 104 and a radiation sensing or collector unit 106 in response to a predetermined level of molten metal within the ladle 10. A second valve structure 108 also connected serially in conduit 96 at a point intermediate of source 90 and valve assembly 102, may be provided for manual control over the application of high pressure gas to chamber 14.

FIGURE 4 schematically illustrates wiring circuitry suitable to the practice of the invention. The fragmentary portion of tube 44, shown in cross-section and taken on the plane of line 4-4 of FIGURE 2, is illustrated as having a source of radiation 104 and a radiation sensing device 106 located on opposite sides thereof. Both devices 104 and 106 are preferably secured to the wall 10 as illustrated in FIGURE 1. Radiation device 104 may contain any suitable source therein such as, for example, Co⁶⁰ or Cs¹³⁷ which are readily available and have a sufficient gamma-radiation half-life.

The radiation sensing unit 106 has its output terminals connected to conduits 112 and 114 which in turn are connected to a suitable amplifier 116. A suitable source of electrical power 118 is electrically connected to amplifier 116 as by means of conductors 120 and 122. The output terminals of amplifier 116 are connected in a circuit comprised of conduits 124 and 126, zener diode 130, and coil 128. The zener diode is, as well known, in the charging current flow circuit until a minimum threshold voltage is attained.

Valve assembly 102 may be comprised of a housing 132 having a cylindrical chamber 134 containing a spool-type...
valve member 136 therein which has valving portions 138 and 140 interconnected by a portion 142 of reduced diameter. Portion 140 may in turn be connected to the core 144 of a solenoid 146 as by means of a step-diameter portion 148 which is suitably secured at its opposite ends to the respective members. Conduit 155 may also be provided between the ends of chamber 154 so as to balance the pressures therein.

Preferably, a stop member 152 is provided so as to determine the extent of movement of member 156 when electrical energy is supplied to the windings 154 of solenoid 146. Spring 156 is provided to move valve member 136 upwardly, whenever the supply of electrical current to windings 154 is terminated, to a point determined by shoulder 158, causing the upper end of valve portion 158 to assume a position generally illustrated by dotted line 160. Consequently, the communication between conduit 96 and conduit 95, which leads to the inner chamber 14 of ladle 10, is terminated.

A solenoid-type switch assembly 162, which may be provided in order to control the application of electrical energy to the valve assembly 162, may be comprised of a movable core member 164, having suitably insulated contacts 166 and 168 therein, normally unconnected by spring 170 and cooperating spring pad 172 in the position illustrated. At this time, the circuit described by conductors 122, 174, 175, 176, 154, 178 and 120 is completed as by the closing of contact member 166 with contacts 189 and 182.

Whenever coil 128 is energized, core member 164 is moved upwardly against the resistive force of spring 170 until member 166 closes contacts 192 and 194. Simultaneously, member 168 will close contacts 196 and 198. Consequently, while the previously described circuit containing contacts 180 and 182 is opened, circuit 122, 174, 204, 178 and 120 and circuit 122, 174, 200, 206, 214, 210, 212, 178 and 180 are closed. As a result of this, coil 208 is energized thereby keeping core 164 in its upper-most position and maintaining contacts 192 and 194 and contacts 196 and 198 closed.

For the purposes of discussion, let it be assumed that the ladle 10 is filled with molten steel to approximately its midpoint. At this time the level of the molten steel will be substantially above that level determined by the radiation emitting from the source 104 as schematically illustrated by the dotted lines 220 of both FIGURES 1 and 4. Consequently, a major portion of the gamma radiation will be absorbed by the molten metal within conduit 42 of the radiation actually sensed by unit 106 will be insufficient to cause a high enough voltage to overcome the threshold voltage of zener diode 130.

Therefore, core 164 and member 166 will remain in their lower-most position, as illustrated, allowing solenoid 146 to be energized by the flow of electrical current through the windings 154 causing valve member 136 to assume the position illustrated so as to complete communication between conduits 95 and 96.

Subsequently, valve 108, which may be actuated by any desired means, but for purposes of illustration will be considered as being manually operated, is opened thereby admitting gas under relatively high pressure into chamber 14 as by means of conduits 16, 95, 94, and 93. The admission of such high pressure gas causes the molten steel in chamber 14 to be forced downwardly through orifice 40 and out through conduit 42 of tube 44 into the cavity of mold 60. When the cavity is filled, the admission of high pressure gas can be completely terminated or partially reduced in order to stop the flow of molten steel out of tube 44. The admission of high pressure gas is, of course, resumed after another empty mold is brought into mating relationship with tube 44.

The above described process is repeated until the level 222 of the molten steel within the ladle 10 is reduced to a point below the line determined by the radiation emitting from source 104, as schematically illustrated by the dotted lines 220 of FIGURE 4. This may actually occur during the cycle of operation wherein the mold 60 is being filled, since gas under high pressure is forcing the molten steel upwardly out of tube 44.

However, once the level 222 drops below lines 220, the unit 198 senses an increase in radiation which in turn causes a greater electrical signal on conductors 112 and 114. This electrical signal, amplified by amplifier 116, in cooperation with power source 118, is sufficient to overcome the threshold voltage of zener diode 130 thereby causing current flow in coil 128. Energization of coil 128 in turn causes conduit 96 to move upwardly closing contacts 192, 194 by means of member 166 and contacts 196, 198 by means of member 168.

Consequently, current flow through solenoid 146 is terminated allowing spring 156 to move valve member 136 upwardly thereby terminating communication between conduits 96 and 95 while at the same time completing communication between conduit 95 and conduit 218 which leads to the atmosphere. Accordingly, the flow of high pressure gas is terminated and the venting of chamber 14 to the atmosphere is simultaneously accomplished.

It should be noted that the possible increase in level 222 of molten steel, upon the termination of high pressure gas, is of no consequence since the subsequent loss of a signal sufficient to activate coil 128 has no effect on the position of core 164. That is, once core 164 has moved to its upper-most position, coil 208 which is energized holds the core 164 and associated contact members in the upper-most position.

At this time, the operator noticing that the bulb 216 is lit realizes that the ladle 10 is ready for re-filling. Accordingly, valve 198 may be shut and the ladle transported to its re-filling station. Since the ladle is provided with a quick-disconnect coupling 100, it may be lifted from supports 16 and 18 by its trunnions and carried away while another re-filled ladle is lowered into its place. This, of course, possible since the source of radiation 104 and the radiation detector are separate from the ladle 10.

However, for purposes of illustrations let it be assumed that only a single ladle is involved. Accordingly, after chamber 14 has been vented to the atmosphere, as described above, cover 78 may be removed and ladle 10 rotated counterclockwise approximately 165° from the position illustrated in FIGURE 2. At this time, the slag remaining in ladle 10 can be drained through orifice 76. After the draining is completed, cover 78 may be replaced and the ladle 10 rotated clockwise to a position wherein filling hatch is approximately 75° away from the position illustrated in FIGURE 2, as measured in the counterclockwise direction. The cover plate 70 is, of course, removed and chamber 14 filled with molten steel to the desired level.

After the ladle is filled it is rotated clockwise to the position illustrated in FIGURE 2 which is the position assumed during pressure pouring of molten steel into molds 60. However, as was previously stated, communication between conduits 95 and 96 is still terminated by virtue of holding coil 208 being energized. Accordingly, in order to start the process, the operator must first depress a normally closed switch 214 thereby opening the circuit containing coil 208. When this happens, current flow through coil 208 is terminated allowing core 164 to return to its lower-most position thereby energizing solenoid 146 and allowing communication between conduits 95 and 96.

Even though only one embodiment of the invention has been disclosed and described, it is apparent that other modifications of the invention are possible within the scope of the appended claims.

1 claim:

1. A control apparatus for a pressure pouring ladle having a chamber containing liquid material therein exposed
to a source of relatively high pressure gas, said apparatus comprising a source of radiation located at one side of said liquid material, a radiation sensing device disposed within the said liquid material in a manner oppositely disposed to said source of radiation, a source of electrical potential, conduit means communicating between said source of high pressure gas and said chamber, solenoid operated valve means serially connected in said conduit means for at times terminating the communication between said chamber and said source of high pressure gas, a first circuit including first and second electrical contacts therein electrically connecting said solenoid valve means to said source of electrical potential, a solenoid switch assembly including first and second electrical coils and first and second switch members, a second electrical circuit operatively connecting said radiation sensing device to said first coil for energization thereof, a third electrical circuit including third and fourth electrical contacts therein connecting said second coil to said source of electrical potential, said first switch member being so located as to close said first and second electrical contacts whenever said first coil is energized, and to open said first and second electrical contacts when said first coil is energized, said second switch member being so located as to open said third and fourth electrical contacts upon energization of said first coil, said second coil being effective to maintain said second switch member in a position maintaining said third and fourth electrical contacts closed upon subsequent deenergization of said first coil.

2. A control apparatus for a pressure pouring ladle having a chamber containing liquid material therein exposed to a source of relatively high pressure gas and a pouring tube with a portion thereof formed in a generally downwardly depending relationship to said chamber, said apparatus comprising a source of radiation located at one side of said depending portion, a radiation sensing device located at another side of said depending portion in a manner oppositely disposed to said source of radiation, a source of electrical potential, conduit means communicating between said source of high pressure gas and said chamber, solenoid operated valve means serially connected in said conduit means for at times terminating the communication between said chamber and said source of high pressure gas, a first circuit including first and second electrical contacts therein electrically connecting said solenoid valve means to said source of electrical potential, a solenoid switch assembly including first and second electrical coils and first and second switch members, a second electrical circuit operatively connecting said radiation sensing device to said first coil for energization thereof, a third electrical circuit including third and fourth electrical contacts therein connecting said second coil to said source of electrical potential, said first switch member being so located as to close said first and second electrical contacts whenever said first coil is energized, and to open said first and second electrical contacts when said first coil is energized, said second switch member being so located as to open said third and fourth electrical contacts upon energization of said first coil, said second coil being effective to maintain said second switch member in a position maintaining said third and fourth electrical contacts closed upon subsequent deenergization of said first coil, means for de-energizing said second coil, and spring means for urging said solenoid valve means in a direction terminating communication between said source of high pressure gas and said chamber when said first electrical circuit is opened.

4. A control apparatus for a pressure pouring ladle having a chamber containing liquid material therein exposed to a source of relatively high pressure gas and a pouring tube with a portion thereof formed in a generally downwardly depending relationship to said chamber, said apparatus comprising a source of radiation located at one side of said depending portion, a radiation sensing device located at another side of said depending portion in a manner oppositely disposed to said source of radiation, a source of electrical potential, conduit means communicating between said source of high pressure gas and said chamber, solenoid operated valve means serially connected in said conduit means for at times terminating the communication between said chamber and said source of high pressure gas, a first circuit including first and second electrical contacts therein electrically connecting said solenoid valve means to said source of electrical potential, a solenoid switch assembly including first and second electrical coils and first and second switch members, a second electrical circuit operatively connecting said radiation sensing device to said first coil for energization thereof, a third electrical circuit including third and fourth electrical contacts therein connecting said second coil to said source of electrical potential, said first switch member being so located as to close said first and second electrical contacts whenever said first coil is energized, and to open said first and second electrical contacts when said first coil is energized, said second switch member being so located as to open said third and fourth electrical contacts upon energization of said first coil, said second coil being effective to maintain said second switch member in a position maintaining said third and fourth electrical contacts closed upon subsequent deenergization of said first coil, manually operated switch means for de-energizing said second coil, and spring means for urging said solenoid valve means in a direction terminating communication between said source of high pressure gas and said chamber whenever said first electrical circuit is opened.

5. A control apparatus for a pressure pouring ladle having a chamber containing liquid material therein exposed to a source of relatively high pressure gas and a pouring tube with a portion thereof formed in a generally
downwardly depending relationship to said chamber, said apparatus comprising a source of radiation located at one side of said depending portion, a radiation sensing device located at another side of said depending portion in a manner oppositely disposed to said source of radiation, an electrical amplifier, first electrical conducting means operatively connecting said amplifier to said radiation sensing device, a source of electrical potential, second electrical conducting means operatively connecting said source of electrical potential to said amplifier, conduit means communicating between said source of high pressure gas and said chamber, solenoid operated valve means serially connected to said conduit means for at times terminating the communication between said chamber and said source of high pressure gas, a first circuit including first and second electrical contacts therein electrically connecting said solenoid valve means to said source of electrical potential, a solenoid switch assembly including first and second electrical coils and first and second switch members, a second electrical circuit connecting said amplifier to said first coil for energization thereof, a bulb, a third electrical circuit including third and fourth electrical contacts therein connecting said bulb to said source of electrical potential, a fourth electrical circuit including fifth and sixth electrical contacts therein connecting said second coil to said source of electrical potential, said first switch member being so located as to close said first and second electrical contacts whenever said first coil is not energized and to close said third and fourth electrical contacts when said first coil in energized, said second switch member being so located as to close said fifth and sixth electrical contacts upon energization of said first coil so as to close said fourth electrical circuit thereby energizing said second coil, said second coil being effective to maintain said second switch member in a position maintaining said fifth and sixth electrical contacts closed upon subsequent deenergization of said first coil, manually operated switch means for de-energizing said second coil, and spring means for urging said solenoid valve means in a direction terminating communication between said source of high pressure gas and said chamber whenever said first electrical circuit is open.

6. A pressure casing arrangement comprising a ladle assembly rotatably mounted on spaced support members, said ladle assembly comprising a ladle body, a chamber formed within said ladle body for the reception of molten metal therein, a filling hatch and pouring tube assembly formed atop said ladle body, a discharge orifice communicating at one end with said chamber formed in a lower portion of said ladle body, an upwardly extending pouring tube assembly formed externally of said ladle body and having its lower end secured to said ladle body in sealed communication with said discharge orifice while having its upper end at times connected to the inlet of a mold assembly, said pouring tube assembly being formed to provide a portion generally depending downwardly from said discharge orifice; a source of fluid pressure; conduit means connecting said source of fluid pressure and said chamber; valve means serially connected in said conduit means; spring means for normally urging said valve means toward a position terminating communication between said chamber and said source of fluid pressure; a source of electrical potential; an electrical amplifier; a source of radiation secured in a non-rotatable manner at one side of said depending portion; a radiation sensing device secured in a non-rotatable manner and oppositely disposed about said depending portion with respect to said source of radiation; solenoid means for positioning said valve means; a first electrical circuit connecting said sensing device and said amplifier; a second electrical circuit connecting said amplifier and said source of electrical potential; a third electrical circuit connecting said solenoid means and said source of electrical potential; a switch member connected in said third circuit; and a fourth electrical circuit for actuating said switch member, said fourth circuit including diode means for preventing current flow through said fourth circuit until the voltage across said diode means attains a predetermined minimum value; said switch member being effective upon actuation by said fourth circuit to terminate current flow to said solenoid means thereby permitting said spring means to move said valve means to a closed position.

7. A control device for a rotatable pressure pouring ladle assembly having a chamber containing fluid material therein and an external upwardly directed pouring tube having its lower end inverted and in communication with a lower portion of said chamber, comprising a source of superatmospheric pressure, first conduit means communicating between said source of pressure and said chamber, valve means including a valve member serially connected in said first conduit means for controlling the degree of communication between said source of pressure and said chamber, spring means associated with said valve means for normally maintaining said valve member in a closed position thereby terminating communication between said source of pressure and said chamber, solenoid means operatively connected to said valve member and effective upon energization to move said valve member to an open position thereby allowing communication between said source of pressure and said chamber, a source of electrical potential, first electrical circuit means connecting said source of potential and said solenoid for maintaining said valve member in said open position, switch means effective upon actuation to open said first circuit means thereby de-energizing said solenoid means, and a second electrical circuit for at times actuating said switch means, said second circuit comprising electrical gating means for preventing the flow of electrical current therefrom until a minimum electrical voltage thereacross is attained, and sensing means responsive to either the attainment of a predetermined absolute minimum level within said inverted portion of said pouring tube or the rotation of said ladle assembly and pouring tube out of pouring position and thereupon effective to cause an electrical signal resulting in a voltage across said gating means equivalent to at least said minimum electrical voltage for actuation of said switch means.

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