United States Patent

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[31] **15610/67**

[54] **COLD CHAMBER PRESSURE CASTING MACHINE**
16 Claims, 5 Drawing Figs.

[52] **U.S. Cl.** **222/64,** 164/156, 164/312
[51] **Int. Cl.** **B67d 5/08,** B22d 17/32
[50] **Field of Search** 164/4, 113, 155, 156, 312, 315, 335; 103/1; 222/53, 64, 67, 319, 385

[56] **References Cited**

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ABSTRACT: A cold chamber pressure casting machine includes a mold charge injector, a melting or heat retaining crucible and a piston pump extending into the crucible and connected to the injector, the piston pump having a pump chamber communicating with a feed opening which is beneath the level of melt in the crucible. A displacement means is operatively associated with the melt in the crucible to control the level thereof, and a control means controls operation of the displacement means. A melt level feeler is positioned in the crucible in the range of the melt surrounding the piston pump, and influences operation of the control means. The displacement means may comprise a solid body which may be inserted into or retracted from the melt, or may comprise an inverted bell means connected to a source of fluid under pressure and communicating with the melt in the crucible. A float may be provided in the bell. The melt level feeler may comprise one or more electrodes, a pressure responsive means connected to a pressure fluid type operator of a control valve, or a float operated switch.

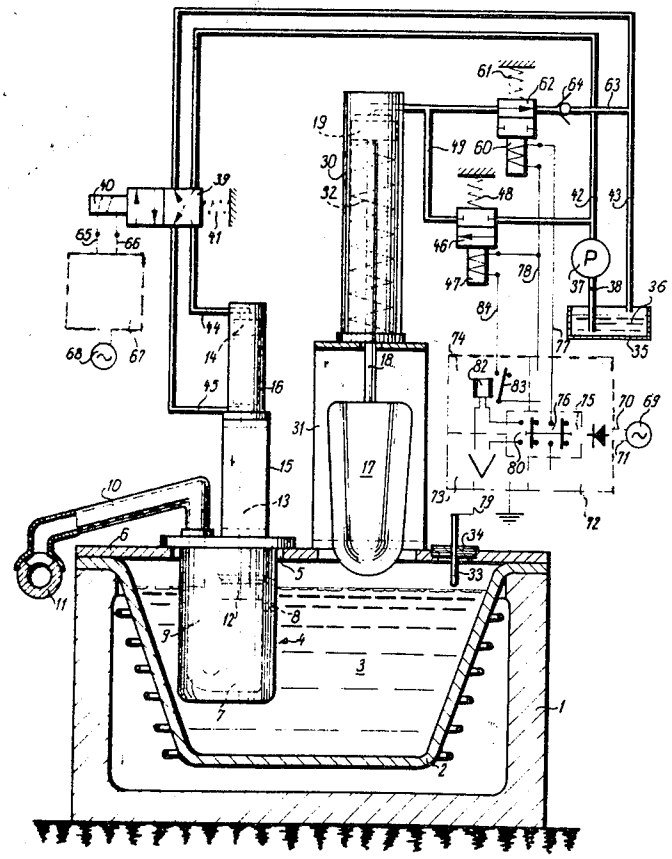
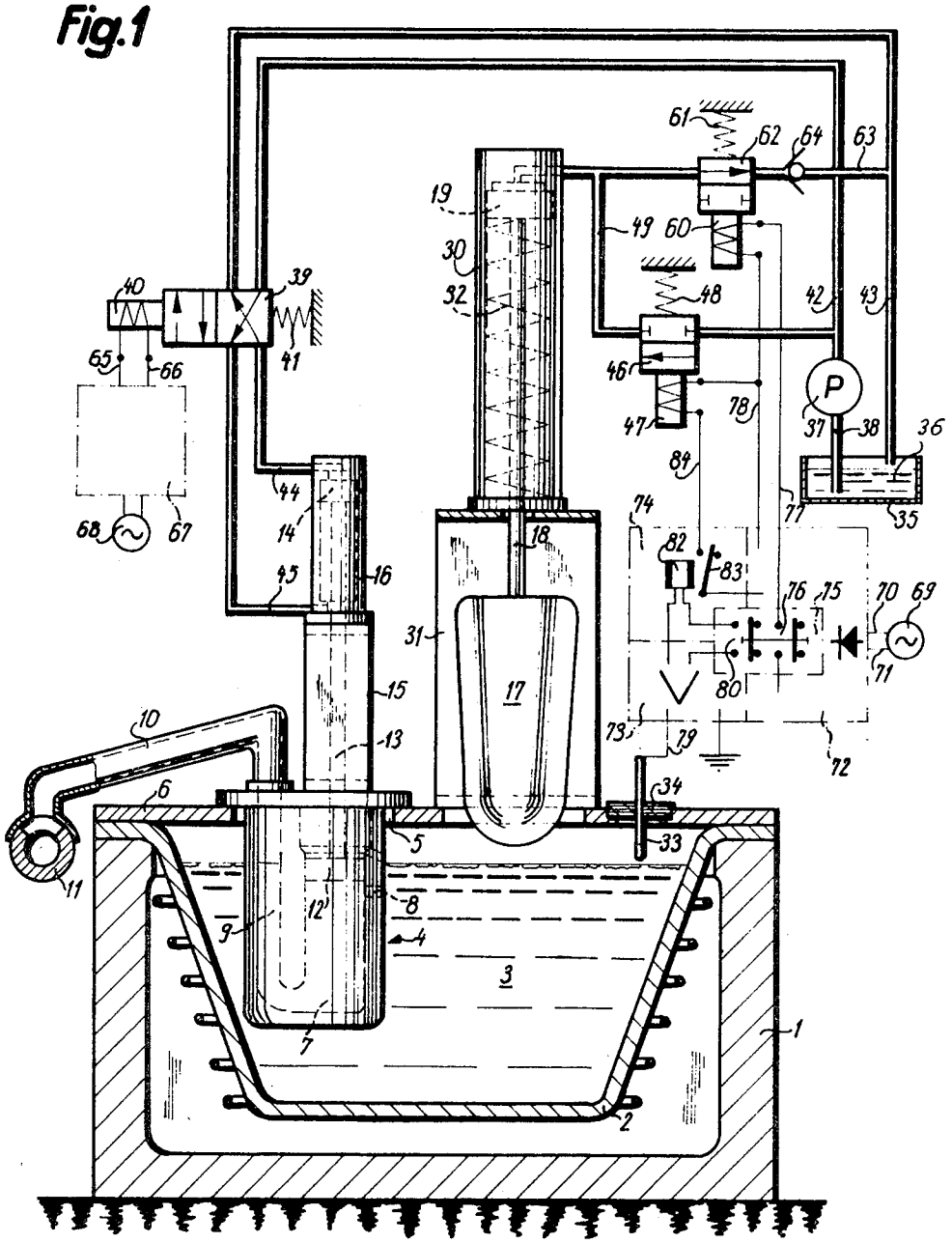


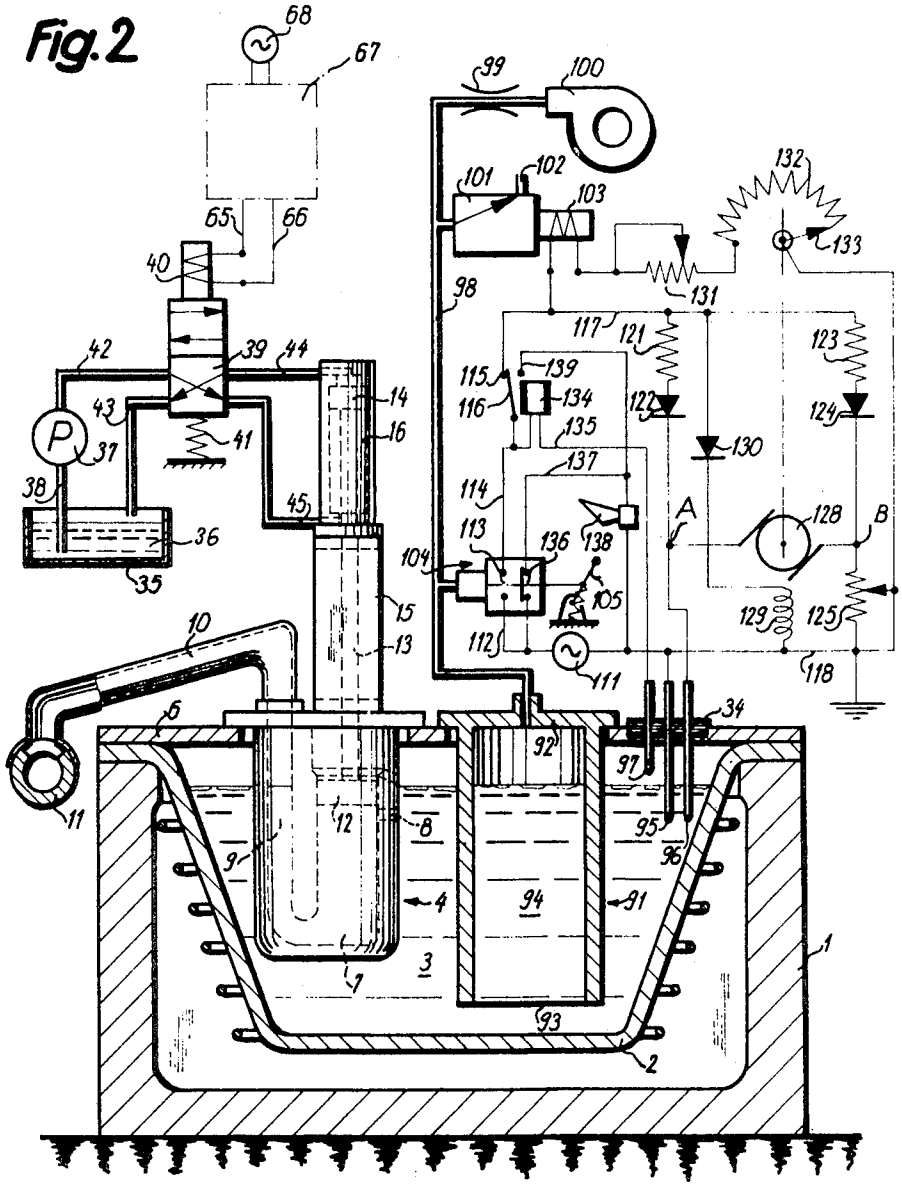
Fig.1



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Fig. 2



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Fig.3

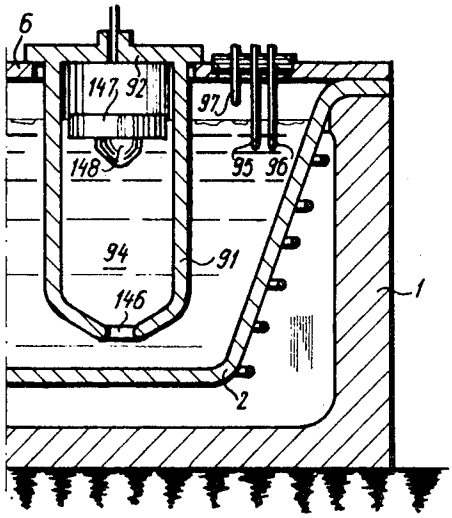
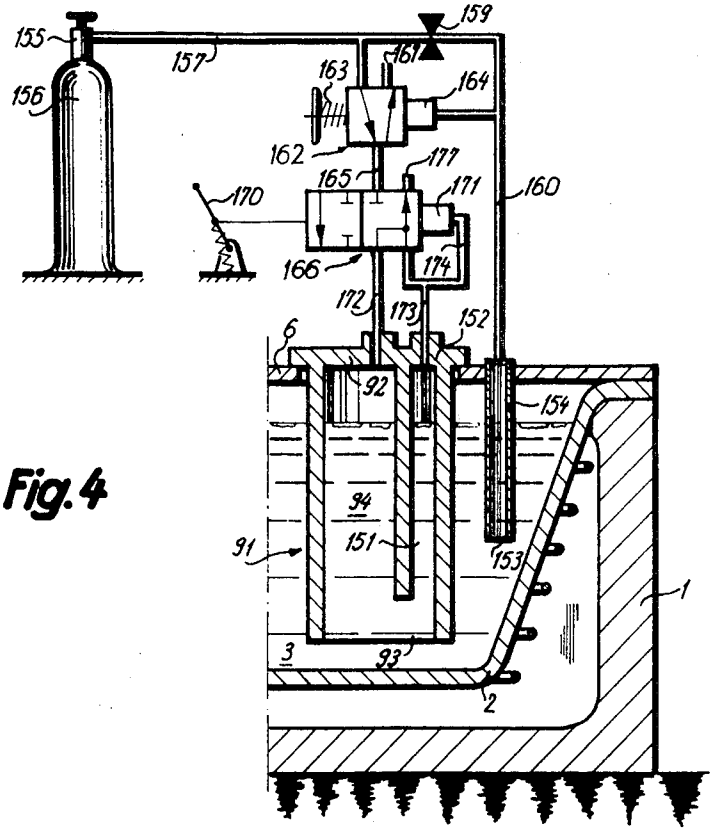


Fig.4

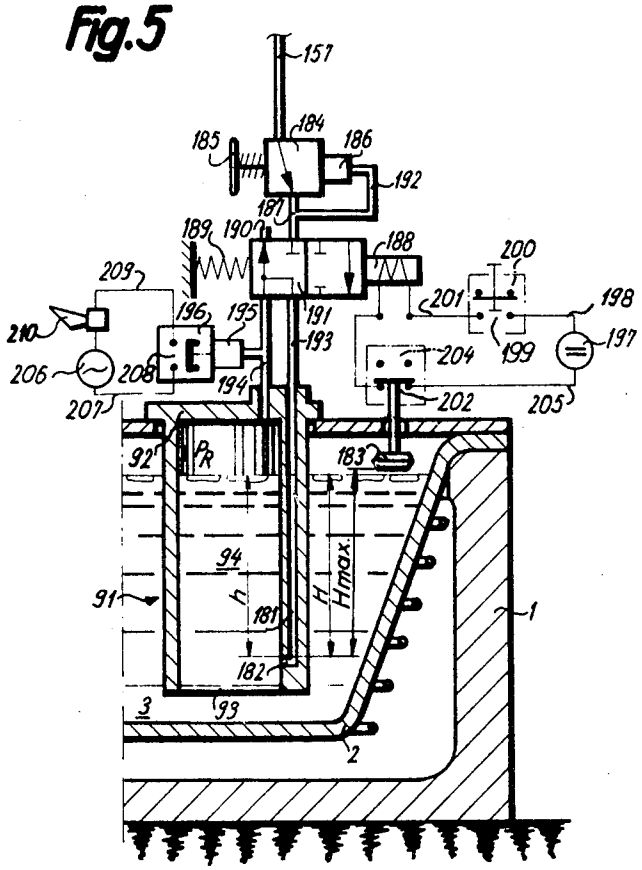


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Fig.5



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COLD CHAMBER PRESSURE CASTING MACHINE

BACKGROUND OF THE INVENTION

Italian Pat. No. 557,374 discloses a piston pump with an antechamber which is arranged in a furnace or the like for maintaining the heat in the material to be cast. Feed openings serve to supply the melt from the antechamber into the pump chamber. A melting crucible is arranged in another furnace, and a melt conveyor pipe interconnects the lower portion of the melting crucible and the antechamber. In the melting crucible, there is arranged an immersion body which serves to move the melt from the melting crucible into the antechamber, this immersion body being operated by means of a spindle.

By means of this melt conveyor pipe, the piston, with its antechamber, associated with the cold chamber pressure casting machine, and the melting crucible, form communicating vessels as long as sufficient melt is displaced by the immersion body. This arrangement has disadvantages. With each feed of the pump after each delivery, considerable fluctuations in level occur in the antechamber. These level fluctuations in the antechamber can be equalized only very slowly, due to the long melt conveyor pipe. There is no direct influence on the melt level in the antechamber by the means for displacing the melt. Depending on the time interval from one pump feed to the next, the melt level in the antechamber differs from that in the melting crucible. Thus, the prerequisite that the melt level in the antechamber be maintained constant during operation of the piston pump is not assured.

Additionally, a separate furnace is required for the piston pump which is arranged outside the melting crucible. The melt conveyor pipe also must be heated. Thus, the maintenance of a constant temperature in all parts carrying the melt is difficult. The melt conveyor pipe has a coupling which is arranged beneath the operating level of the melt. In order to disassemble the pump from the heat maintaining furnace, this coupling must be disengaged, and this requires evacuation of the melting crucible. During disassembly of the pump, there is the danger that a part of the melt still contained in the antechamber will be discharged.

SUMMARY OF THE INVENTION

This invention relates to cold chamber pressure casting machines and, more particularly, to a novel and improved cold chamber pressure casting machine having novel means controlling the melt level adjacent the inlet opening to the pump chamber forming part of a piston pump for feeding a mold charge injector.

The objective of the present invention is to eliminate the above-mentioned disadvantages of known cold chamber pressure casting machines. For this purpose, the cold chamber pressure casting machine of the invention comprises the combination of a melt level feeler in the range of the melt surrounding the piston pump, displacement means acting on the melt surrounding the piston, and a control, for the operation of the displacement means, which is influenced by the level feeler.

The cold chamber pressure casting machine of the present invention has many advantages. The level feeler is influenced by the melt level, which determines the dosing accuracy of the piston pump. The displacement device or means is effective on the melt surrounding the piston pump. Thus, a slow equalization of the melt level is avoided. Since the melting crucible has a large volume, compared to the pump chamber, the melt level varies only slightly with each pump feed. Thus, great accuracy of the dosing of the piston pump is achieved.

The displacement device can be designed as an immersion body dipping into the melting crucible, and this body is closed on all sides, at least in the range of its contact with the melt. For the operation of the immersion body, there can be provided a piston moving in a cylinder, and a spring associated with the piston which biases the piston to the return position. If there is no pressure on the piston, lowering of the immersion body into the melt is prevented by the spring.

The displacement device or means can also be in the form of an insert which is fixedly mounted in the melting or heat-retaining crucible, and having a closure above the operating level of the melt thus to form a chamber that can be supplied with pressure gas. An open end of this insert is disposed below the maximum displacement level of the melt. Since this insert has a small exposed surface, heat losses are avoided to a great extent. The open end of the insert can be provided with a restriction in order to avoid building up transient processes during the level regulation, while still providing the possibility of regulation of a plurality of dosing deliveries from the crucible.

Furthermore, the insert may be provided with a piston designed as a float which closes the open end when the maximum displacement level is reached, and thus prevents issuance of pressure gas into the melting crucible.

A control influenced by the melt level feeler means, and effecting the admission of pressure gas to the insert, can be provided with a pressure limiting device, adjoining the chamber of the insert, and supplied with pressure gas to insure automatic limitation of the maximum melt displacement. This arrangement also prevents escape of pressure gas through the open end of the insert.

The insert can also have a measuring chamber which is connected, on the one hand, with the insert in the range of the open end of the latter and, on the other hand, with the pressure limiting means. The maximum melt displacement in the insert thus can be determined independently of the specific gravity of the melt.

In order to supply pressure gas to the insert, there can be arranged, in the insert, a pressure gas feed pipe connected to a pressure gas line, and the opening of this feed pipe is in the range of the maximum displacement of the melt. A pressure followup valve, serving concurrently as a level feeler and as a control influenced by it, and fixed in accordance with the operating level and the specific gravity of the melt, is connected with the pressure gas line.

An object of the invention is to provide an improved cold chamber pressure casting machine.

A further object of the invention is to provide such a cold chamber pressure casting machine which is free of the disadvantages of prior art cold chamber pressure casting machines while being greatly simplified in construction and improved in efficiency.

A further object of the invention is to provide such a cold chamber pressure casting machine which includes a mold charge injector, a melting or heat-retaining crucible, and a piston pump extending into the crucible and connected to the injector, the piston pump having a pump chamber communicating with a feed opening which is beneath the level of melt in the crucible.

Another object of the invention is to provide such a cold chamber pressure casting machine including the displacement means operatively associated with the melt in the crucible to control the level thereof.

A further object of the invention is to provide such a cold chamber pressure casting machine including control means controlling operation of the displacement means.

A further object of the invention is to provide such a cold chamber pressure casting machine including melt level feeler means positioned in the crucible in the range of the melt surrounding the piston pump and influencing operation of the control means.

A further object of the invention is to provide such a cold chamber pressure casting machine in which equalization of the melt level in the pump chamber and in the crucible is effected very rapidly, and in which the level varies only slightly with each feed of the pump.

Another object of the invention is to provide such a cold chamber pressure casting machine assuring great dosing accuracy of the piston pump.

For an understanding of the principles of the invention, reference is made to the following description of typical embodiments thereof as illustrated in the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings:

FIG. 1 is a vertical sectional view of a first embodiment of cold chamber pressure casting machine, with a feeding device and control, in accordance with the invention;

FIG. 2 is a view, similar to FIG. 1, illustrating a second embodiment of a cold chamber pressure casting machine in accordance with the invention;

FIG. 3 is a partial sectional view of a third embodiment of cold chamber pressure casting machine, in accordance with the invention, illustrating a part of a crucible similar to that shown in FIG. 2;

FIG. 4 is a view, similar to FIG. 3, of a fourth embodiment of cold chamber pressure casting machine in accordance with the invention; and

FIG. 5 is a view, similar to FIGS. 3 and 4, of a fifth embodiment of a cold chamber pressure casting machine in accordance with the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring first to FIG. 1, a casing 1 has arranged therein a crucible 2 containing melt 3, and suitable heating means may be provided in operative association with crucible 2 to retain the heat in melt 3. A piston pump 4 extends into crucible 2 through an opening 5 of a partial covering 6 of the crucible. Piston pump 4 has a piston receiving bore serving as a pump chamber 7, and has at least one feed opening 8 arranged beneath the operating level of melt 3. A duct 9 connects pump chamber 7 with an outlet trough 10 serving to supply melt to a mold charge injector cylinder 11 of a pressure casting machine which has not been shown in detail. A pump piston 12, movable in pump chamber 7, is connected by a bar or piston rod 13 with an operating piston 14 that may have pressure applied to its opposite sides. Operating piston 14 is displaceable in a cylinder 16 secured on an upright support 15.

An immersion body 17, which has a closed formation in the range of its contact with melt 3, is connected, through the medium of a bar or rod 18, with a regulating piston 19 that can be subjected to gas under pressure on one side. Regulating piston 19 is mounted for displacement in a cylinder 30, which is mounted on an upright support 31. A compression spring 32, biasing regulating piston 18 to the return or upper position, is arranged between piston 18 and the lower end of the cylinder 30, spring 32 being prestressed.

A level feeler 33 extends into crucible 2 through a dielectric part 34 of covering 6. The end of feeler 33 in crucible 2 is set to the operating level of melt 3.

A suction line 38 extends from a tank 35, containing pressure medium 36, to the inlet of a pump 37. A reversing valve 39, having a reversing magnet 40 and a biasing spring 41, is connected with pump 37 by a supply line 42 and with tank 35 by a return line 43. A supply line 44 and a return line 45 connect reversing valve 45 to cylinder 16.

In addition, a regulating valve 46 is connected to pressure line 42, and has an operating solenoid 47 and a biasing spring 48. A line 49 connects regulating valve 46 with cylinder 30, and a relief valve 62 is connected with line 49 and thus with cylinder 30, and can be actuated by a solenoid 60 and a biasing spring 61. A one-way pressure relief valve 64 is connected in an intermediate line 63 connecting relief valve 62 to return line 43. Reversing solenoid 40 is connected through conductors 65 and 66 with the machine control 67 of the pressure casting machine, which latter is connected to a source 68 of electrical potential.

The elements provided for control of the level regulating will now be described. A supply device 72 is connected to a current source 69 through conductors 70 and 71. Supply device 72 has connected therewith an amplifier 73, a relay switch 74 and a main switch 75. Solenoid 60 of relief valve 62 is connected with supply device 72 through a pair of make or front contacts 76 of main switch 75 and through a control line 77. A return line 78 closes its circuit to supply device 72. Amplifier 73 is grounded. A measuring line 79 connects level feeler 33 to amplifier 73, and amplifier 73 is connected, on the one hand, with one contact of an additional pair of make or front contacts 80 of the main switch 75 and, on the other hand, with a terminal of a relay coil 82. The other terminal of relay coil 82 is connected with the second contact of this additional pair of make or front contacts 80.

Relay coil 82 controls a changeover switch 83 connected, on the supply side, with supply device 72 and including a normally open or front contact connected by a line 84 to one terminal of solenoid 47 of regulating valve 46. The other terminal of solenoid 47 is connected to the return line 78 leading to supply device 72.

The embodiment of the invention shown in FIG. 1 operates in a manner which will now be described. Pump 37 delivers pressure medium 36 from tank 35 into pressure line 42 and, through reversing valve 39 and fluid pressure line 45, to the chamber of cylinder 16 beneath piston 14. The chamber of cylinder 16 above piston 14 is connected through line 44, reversing valve 39 and return line 43 with tank 35 and is thus free of pressure. Piston 14 lifts pump piston 12 into the upper dead center position. Melt flows through feed opening or openings 8 into pump chamber 7 and duct 9 until the melt level in duct 9 is equalized with the melt level in crucible 2 surrounding piston pump 4.

After the divided mold of the pressure casting machine, which has not been shown, is closed, solenoid 40 is energized by machine control 67 and actuates reversing valve 39 against the bias of spring 41. Pump 37 now delivers pressure medium 36 through pressure line 42, valve 39 and line 44 to cylinder 16 above piston 14. Piston 14 thus moves pump piston 12 down through the piston rod 13. Pump piston 12 closes feed opening or openings 8, and thus pump chamber 7, from crucible 2, so that no melt 3 can now flow from pump chamber 7 into crucible 2. The melt is forced through duct 9 and outlet trough 10 into charging device 11.

After the melt has been supplied to the pressure casting machine, machine control 67 deenergizes solenoid 40 and spring 41 moves reversing valve 39 back into the rest position shown in FIG. 1. Pressure medium 36 delivered by pump 37 through pressure line 42 to reversing valve 39 now flows through line 45 and into the chamber of cylinder 16 beneath piston 14, and pump piston 12 is moved into the other or upper dead center position. The melt supplied to charging device 11 is forced, by the charging unit of the pressure casting machine, into the mold cavity.

A constant dosing accuracy of piston pump 4 with a fixed stroke of pump piston 12 is ensured only with a constant operating level of the melt 3 surrounding the pump 4. This constancy of the level is attained in a manner which will now be described.

Melt flowing from crucible 2 into piston pump 4, after supplying of the pressure casting machine has been completed, effects a drop of the melt surface or level in crucible 2, and this must be compensated. Upon starting the pressure casting machine, main switch 75 is closed and solenoid 60 is energized, from current supply device 72, through front contacts 76 of switch 75 and supply line 77, so that relief valve 62 closes. When switch 75 is closed, relay coil 82 is connected to the output of amplifier 73 through front contacts 80. A drop in the level of melt 3 influences amplifier 73 through level feeler 33. Amplifier 73 excites relay 82 to close switch 83. Solenoid 47 is energized responsive to closing of switch 83, and regulating valve 46 is opened against the bias of spring 48.

Regulating valve 46 and regulating line 49 of regulating piston 19 are now supplied with pressure medium 36 by pump 37, the pressure medium acting against the bias of spring 32. Immersion body 17 thus is lowered into crucible 2 through the piston rod 18 connected to piston 19. An immersion body 17

dips into melt 3, the melt is displaced, resulting in a rise in the level of melt 3. When the level attains the desired operating level, level feeler 33, which is set to this desired operating level, influences amplifier 73 to deenergize relay coil 82 and switch 83 opens. Solenoid 47 is deenergized and spring 48 biases regulating valve 46 into the closed or rest position shown in FIG. 1. The supply of pressure medium 36 from pressure line 42 through regulating line 49 into cylinder 30 is interrupted. Immersion body 17 is thus retained in the position set for maintaining the operating level of melt 3, such retention being effected, on the one hand, by spring 32 and, on the other hand, by pressure medium 36 in cylinder 30.

After a working cycle of the pressure casting machine has been completed and the mold is reclosed, machine control 67 effects another feed of melt 3 to charging device 11 through the medium of piston pump 4, as explained above. By opening main switch 75, solenoids 47 and 60 are deenergized, and regulating valve 46 and relief valve 62 are biased by their respective springs 48 and 61 into the rest position. The supply of pressure medium 36 to regulating line 49 into cylinder 30 is interrupted. Pressure medium 36 flows through regulating line 49, relief valve 62, one-way valve 64 and return line 43 into tank 35. Compression spring 32 biases regulating piston 19, and thus the immersion body 17, back into the rest position. The level of the melt 3 in crucible 2 drops, and melt can be supplied into crucible 2.

Since level feeler 33 is influenced by the melt 3 directly surrounding piston pump 4, and as the immersion body 17 lifts this melt directly, equalization is effected rapidly and without overriding, which could happen with a prolonged flow. Since crucible 2 has a large volume, compared to the volume of pump chamber 7 which is fed directly from crucible 2, the melt level varies only slightly during feeding operation of the pump. A great dosing accuracy of piston pump 4 is thus ensured, even in an equalization with a somewhat greater time constant.

If current source 69 fails, regulating piston 19 is relieved of pressure through relief valve 62 because of the immediate deenergization of solenoid 62, and compression spring 32 biases regulating piston 19, and thus immersion body 17, into the rest position. The level of melt 3 drops, in any case. Accidents, due to rising of the melt above the operating level, are thus positively prevented. For the same purpose, main switch 75 also serves as an emergency switch.

In the second embodiment of the invention, shown in FIG. 2, the parts for actuating piston pump 4, as well as the pump itself, correspond to those shown in FIG. 1 and described above. An insert 91 which is fixedly mounted in crucible 2 and secured on at least partial covering 6 thereof, serves as a displacement device or means. Above the operating level of melt 3, insert 91 has a closure 92 and, below the maximum displacement level of melt 3, insert 91 has an open end 93. A chamber 94, which can be supplied with a pressure medium such as a gas under pressure or an inert fluid under pressure, is formed within insert 91 and beneath closure 92. Two electrodes 95, 96 extend partly into melt 3, and consist of electric resistance material. These electrodes extend through a dielectric part 34 in which they are fixedly mounted. The bottom end of a third electrode 97, also mounted in dielectric part 34, is slightly above the operating level of melt 3.

Chamber 94 is connected to a blower 100 through a pressure gas pipe 98 and a throttle 99. A gas pressure regulating valve 101 is connected to pressure gas pipe 98 and is provided with an exhaust 102. Valve 101 can be controlled by a solenoid 103. In addition, a pressure switch 104 is connected to pressure gas pipe 98 and has associated therewith a hand or manual control 105.

A pair of front or make contacts 113 of pressure switch 104, an intermediate line 114, a back or rest contact 115 of a safety switch 116, a distribution line 117 and an electric bridge connection are connected to a current source 111 through a supply line 112. A return line 118 leads from the bridge connection to current source 111. The bridge connection includes a first leg or branch, consisting of a resistance 121 and a diode 122, connecting diagonal point *A* to distribution line 117. The bridge connection further includes a second leg or branch, consisting of a resistance 123 and a diode 124, connecting diagonal point *B* to distribution line 117. A third leg or branch extends from diagonal point *A* to return line 118, this third leg or branch including the electrodes 95 and 96. The fourth leg or branch of the bridge connection extends from diagonal point *B* to the grounded return line 118, and includes a balancing resistance 125.

The bridge diagonal extends from point or junction *A* to point or junction *B* and includes the collector or armature circuit of a motor 128 having a field coil 129. One end of field coil 129 is connected through a diode 130 to distribution line 117. The other terminal of field winding 129 is connected directly to the grounded return line 118. A control circuit is connected in parallel with the bridge circuit, and includes solenoid 103, an adjustable limiting resistance 131 and a rheostat or potentiometer 132, this control circuit being connected between distribution line 117 and grounded return line 118. The adjustable sliding contact 133 of rheostat 132 is mechanically connected with the shaft of motor 128.

A relay coil 134 of safety switch 116 has one end connected to intermediate line 114 and its other end connected, by a line 135, with electrode 97. This safety circuit can be closed, at a high melt level, by electrode 97, melt 3, electrode 95, and grounded return line 118 connected to current source 11. Another safety circuit has one end connected to current source 111 and includes back or rest contacts 136 of pressure switch 104, a branch line 137, a signal horn 138 and grounded return line 118. Line 137 is also connected to the front or make contact of safety switch 116.

The embodiment of the invention shown in FIG. 2 operates in the manner which will now be described. To set the operating level, balancing resistance 125, in the bridge leg or arm extending from junction point *B* to grounded return line 118, is adjusted until the effective resistance value is equal to the sum of the resistances of electrode 95, melt 3 and electrode 96. When this occurs, the voltage gradient from junction point *A* to junction point *B* is zero, so that the collector circuit of motor 128 has no current flowing therethrough. To set the maximum level of melt displacement, the excitation of solenoid 103 is adjusted by adjusting limiting resistance 131, with rheostat 132 shorted out, and taking into account the characteristic of gas pressure regulating valve 101 and the specific gravity of melt 3. Crucible 2 is filled with melt 3 to a level corresponding approximately to the operating level.

By operating pressure switch 104, the bridge connection is connected to current source 111 through contacts 113. If the sum of the resistances from junction point *A* to return line 118 is greater, at the filling level than at the operating level, and thus with respect to balancing resistance 125, there is a voltage gradient in the path 117–A which is greater than the voltage gradient in the path 117–B, and thus there is a voltage gradient, across the bridge diagonal, from junction point *A* to junction point *B*. Motor 128 thus is excited and gas pressure regulating valve 101 is adjusted to a higher pressure value. Accordingly, pressure gas at higher pressure is supplied to chamber 94, so that melt 93 is displaced from chamber 94 to raise the level of the melt 3 in the crucible 2. Thereupon, the sum of the resistances from electrode 95 through melt 3 to electrode 96 is correspondingly decreased. When the level of the melt has reached the operating level, the sum of these resistances equals the value of the balancing resistance 125. The voltage gradient across bridge diagonal A–B is thus reduced to zero and no current flows through the armature 128 of the motor. The start of the pressure casting machine effects, through machine control 67, supplying of melt 3 by piston pump 4 to charging device 11, as described in connection with the embodiment of the invention shown in FIG. 1. The level of melt 3 in crucible 2 drops. The next rise of the melt level to the operating level is effected in the same manner as the rise in the melt level from the filling level to the operating level, by increasing the pressure of the gas supplied to chamber 94.

When the maximum displacement level of melt 3 has been attained, pressure switch 104 is brought, by the maximum gas pressure, into the rest position to open front or make contacts 113 and close back or rest contacts 136. Solenoid 103 of gas pressure regulating valve 101 is thus deenergized, so that this valve moves back to the pressure setting "zero" with the pressure gas discharged from chamber 94 through exhaust port 102. At the same time, the closed contacts 136 energize signal horn 138 to indicate that melt must be supplied to crucible 2. Pressure switch 104 can be brought into the rest position by the manual control 105.

When melt is supplied to crucible 2 during operation of the casting machine, the level of melt 3 in the crucible rises beyond the operating level. The resulting lower resistance from junction point *A* to return line 118, with respect to the fixed resistance from junction point *B* to return line 118, effects an unbalance of the potential at the opposite ends of the diagonal A–B, and a voltage gradient is thus formed from junction point *B* to junction point *A*. Motor 128 is thus energized in a direction which is reversed with respect to that described above. Motor 128 controls sliding contact 133, so that the resistance between limiting resistance 131 and sliding contact 133 of rheostat 132 is increased. The current, and thus the excitation, of solenoid 103 is decreased, and gas pressure regulating valve 101 is thus set to a lower pressure value. Pressure is relieved from chamber 94 through exhaust port 102 of valve 101 until the pressure in chamber 94 equals the setting of valve 101. At the same time, the displacement level of melt in chamber 94 increases, thus effecting a drop of the melt level in crucible 2. The sum of the resistances from junction point *A* to return line 118 increases. When the melt level has dropped to the operating level, the sum of these resistances corresponds to the setting of balancing resistance 125. The voltage gradient from junction point *B* to junction point *A* is reduced to zero, so that no current flows through rotor or armature 128 of the motor.

When the melt level rises to a level outside the regulating range of the control, relay coil 134 is energized over a circuit extending from return line 118 through electrode 95, electrode 96, line 135, relay coil 134, line 114, front contacts 113 and line 112 to source 111. Safety switch 116 is thus operated to disengage contact 115 and to engage contact 139. This deenergizes solenoid 103 of pressure regulating valve 101 and energizes signal horn 138.

Due to the small free surface of insert 91, heat losses are avoided to a great extent. If blower 100 fails, or if the pressure gas pipe 98 leaks, the displacement level of melt 3 in chamber 94 rises, resulting in a drop of the melt level in crucible 2. The excitation of solenoid 103 of gas pressure regulating valve 101 can be set easily to the maximum displacement level of melt 3 in chamber 94 using limiting resistance 131. Pressure switch 104 likewise limits this maximum melt displacement, so that the discharge of pressure gas through the open end 93 of insert 91 is positively prevented.

In the third embodiment of the invention, shown in FIG. 3, the open end of insert 91 has a restricted orifice 146. A piston 147, designed as a float, is provided in insert 91, and has a protuberance or extension 148 facing orifice 146. Due to the throttling effect, building-up processes are avoided during level regulation by the constriction 146, without narrowing the regulating range. Piston 147, through its extension 148, prevents escape of gas under pressure from insert 91 through orifice 146 when the level of the displaced melt 3 drops below the maximum displacement level set on gas pressure regulating valve 101. Piston 147 thus serves as a safety device against the escape of gas under pressure through restriction 146 and independently of the control.

In the fourth embodiment of the invention, as shown in FIG. 4, insert 91 has, in addition to chamber 94, a measuring chamber 151 which communicates with chamber 94 adjacent the open end 93 and particularly in the range of the maximum melt displacement. Above the operating level, measuring chamber 151 has a closure 152. As a melt level feeler means, a pipe 154 is connected with the cover 6, and this pipe has a closed upper end and an open lower end 153 in the range of melt 3. Pipe 154 extends into melt 3 and is supplied with pressure gas through a port in its closed upper end. As a source of pressure gas, particularly protective gas at a constant pressure, there is provided a pressure gas tank 156 associated with the pressure reducing valve 155. A gas pipe 157 is connected to pressure reducing valve 155 and to feeler pipe 154 through a diaphragm 159 and a measuring pipe 160. Pressure gas pipe 157 is also connected to a regulating valve 162 which can be controlled, on the one hand, mechanically, for example by a spring 163, and, on the other hand, by a pneumatic operating element 164 connected to measuring pipe 160.

An intermediate pipe 165 connects regulating valve 162 to a reversing valve 166. Regulating valve 162 has flow ducts arranged therein in such a manner that, in one switching position, a connection is established from pressure gas pipe 157 to intermediate pipe 165 and, in the other switching position, a connection is established from intermediate pipe 165 to an exhaust port 167. For the control of reversing valve 166, the latter has associated therewith a first control element 170, in this case a mechanical control element, and a second control element 171 which is a pneumatic control element. A displacer pressure pipe 172 extends from reversing valve 166 into chamber 94 of insert 91, and a relief pipe 173 extends into measuring chamber 151. A control pipe 174 is branched from relief pipe 173 to pneumatic control element 171 of reversing valve 166. Reversing valve 166 has, in one switching position, a closure for intermediate pipe 165 and flow ducts from displacer pressure pipe 172 and relief pipe 173 to exhaust port 177. In the other position, reversing valve 166 has closures for relief pipe 173 and exhaust port 177, on the one hand, and a flow duct from intermediate pipe 165 into displacer pressure pipe 172, on the other hand.

The method of operation of the embodiment of the invention shown in FIG. 4 will now be described. By actuating reversing valve 166, chamber 94 of insert 91 is connected with regulating valve 162. Pressure gas flows from pipe 157 through diaphragm 159 and measuring pipe 160 into pipe 154, serving as a level feeler, so that melt is displaced from pipe 154. The gas pressure in measuring pipe 160 should correspond to the static pressure of the melt column between opening 153 and the operating level of the melt 3 in crucible 2. Variations of the operating level influence the pneumatic operating element 164 of regulating valve 162. If the melt level drops below the operating level, the gas pressure in measuring pipe 160 drops, due to the increasing escape through melt 3, and regulating valve 162 opens, under the bias of spring 163, the connection from pressure gas pipe 157 into intermediate pipe 165. Pressure gas is supplied to chamber 94 and melt is displaced from the latter, so that the melt level in insert body 91 drops and the melt level in crucible 2 rises. The gas pressure in measuring pipe 160 rises with the increasing level of melt 3 in crucible 2. When the melt level has reached the operating level, regulating valve 162 closes both connections provided therein.

When the maximum displacement level is attained in chamber 94, pressure gas flows from the latter into measuring chamber 151, and this pressure gas acts, through control pipe 174, on control element 171 which moves reversing valve 166 back into the rest position. Pressure gas is discharged from chamber 94 and measuring chamber 151 through relief pipe 173 and exhaust port 177. The levels of the melt 3 in crucible 2 and in chamber 94 are thus equalized. If necessary, reversing valve 166 can also be moved into the rest position by hand control, as indicated at 170.

If melt is supplied to crucible 2 before the maximum displacement level is reached, with reversing valve 166 being opened, the melt level rises in crucible 2 beyond the operating level. The pressure in measuring pipe 160 is correspondingly increased, and valve 162 opens, under the influence of operating element 164, the connection from intermediate pipe 165 to exhaust port 167. The gas in chamber 94 is discharged through exhaust port 167, and the melt level in insert 91 rises

so that the melt level in crucible 2 drops. The gas pressure in measuring pipe 160 is decreased again. When the melt level in crucible 2 has dropped to the operating level, regulating valve 162 closes both connections provided therein. The maximum displacement of melt 3 from insert 91 into crucible 2 is determined by the position of the open end 93 of measuring chamber 151, and is thus independent of the specific gravity of melt 3 and of the pressure setting of regulating valve 162.

In the fifth embodiment of the invention, shown in FIG. 5, a specially constructed insert 91 is used in the cold chamber pressure casting machine shown in FIG. 4. This embodiment of the invention also includes crucible 2, piston pump 4 inserted therein and outlet trough 10 leading to the charge injection device 11. In this special insert 91, there is provided a pressure medium supply line 181 whose lower end 182 opens into chamber 94 of insert 91 in the range of the maximum displacement of melt 3 from chamber 94 into crucible 2. A float 183 is positioned in crucible 2 and has a rest position which is slightly above the operating level of melt 3. The switching element of a float switch 204 is connected with float 183.

A pressure followup valve 184, with an adjustment element 185 and a pneumatic control element 186, is connected to pressure gas pipe 157. Through an intermediate line 187, valve 184 is connected with a reversing valve 191 which is controlled by a solenoid 188 and a spring 189, and is provided with an exhaust port 190. A control line 192 is branched from intermediate line 187 and connected to pneumatic element 186 of valve 184. A line 193 connects reversing valve 191 to pressure medium supply line 181 in insert 91. Chamber 94 of insert 91 is connected, through a pipe 194 in its upper closure 92, with reversing valve 191. In addition, a pneumatic operating element 195 of a switch 196 is connected to pipe 194.

A solenoid 188 is associated with reversing valve 191, and is connected to current source 197 through a circuit including supply conductor 198, front or make contacts 199 of switch 200, an intermediate conductor 201, solenoid 188, back or rest contacts 202 of float switch 204 associated with float 183, and a return conductor 205. Another circuit is provided, and comprises a current source 206, a supply conductor 207, a pair of make or front contacts 208 of pressure switch 196, a return conductor 209 and a signal horn 210.

For all the different embodiments of the invention, the problem to be solved consists in keeping the melt level constant in a melting or melt-heat-retaining crucible associated with a pressure casting machine, in order to ensure constant amounts of melt for feeding this machine by a piston feed pump of fixed stroke and which is inserted into the crucible. While, in the embodiments previously described, the solution of the problem consists in displacing melt by suitable means dipping into the melt in varying depth, or acting on the melt in different ways, these different means being controlled by a level feeler whose constant readjustment requires a control influencing the means, the following conditions were recognized for the embodiment of the invention shown in FIG. 5: on the one hand, the operating level should be constant with respect to any point in the crucible 2. Consequently, the static pressure at this point should be constant. On the other hand, so much melt always should be displaced by a pressure medium supplied through a closed chamber 94 above an opening in the range of crucible 2, that the operating level in crucible 2 is maintained constant. This means that the sum of the pressures above the melt and of the pressure medium acting on it should likewise be constant. However, since the melt varies its level in chamber 94, the pressure of the pressure medium in chamber 94 must also be varied.

The embodiment of the invention illustrated in FIG. 5 utilizes, for this purpose, the following relations to meet the foregoing conditions automatically:

The static pressure of the opening 182 of pressure medium supply line 181 into chamber 94 of insert 91, as resulting from the melt 3 in crucible 2, is $p_M=Hk$ where k is the value of the specific gravity of the melt. For the operating level, there applies $p_{Mo}=H_o\times k=Constant$.

At the same time, the pressure of the melt 3 to be displaced, above the opening 182, acts on this opening from chamber 94 in insert 91, as also does the gas pressure p_R on this melt. From this, there arises the relation $p_M=p_R=haPk$.

However, since H is always to be made equal to H_0, by displacement of melt from insert 91, and therefore by the value h, and due to the increase of p_R, h and p_R are variables. However, for the operation there applies $p_{Mo}=H_o\times k=p_R+h\times k$-Constant.

This means that, on the one hand, a constant gas pressure must be present at the opening 182 for supply of the pressure medium, that is, the pressure gas, through the pressure medium supply line 181 into the insert 91 but that, on the other hand, and at the same time, the variables h and p_R are set automatically to the constant summation value $p_M=p+h\times k$. The pressure followup valve 184 therefore can be adjusted substantially to the fixed pressure value $H_o\times k$. As long as the geometry of apparatus remains constant, this setting depends strictly on the specific gravity of the melt.

Taking into account these physical conditions, the following operation is possible: reversing valve 191 is reversed upon energization of solenoid 188 through operation of switch 200. The connection from pressure followup valve 184 to opening 182 of pressure medium supply line 181 is established. It can be assumed that the operating level $H=H_o$ of the melt 3 in crucible 2 has been reached. At the opening 182 to chamber 94 in insert 91 there act, simultaneously and in equilibrium, the fixed gas pressure $H_o\times k$ from pressure followup valve 184 and, from chamber 94, the sum of the pressures $p_{Ro}+h_o\times k$ and, from crucible 2, the pressure $H_o\times k$.

After supplying of the pressure casting machine and refilling of piston pump 4, the pressure H_o in crucible 2 drops to H_1, so that $H_1\times k$ is therefore less than $H_o\times k$. Immediately, $p_{Ro}+h_o\times k$ is greater than $H_1\times k$, so that an equalization of melt 3 from insert 91 into crucible 2 occurs in such a manner that h_o decreases to h_x, and H_1 increases to H_x. With the drop of h_o to h_x, the pressure p_{Ro} drops to p_{Rx}. There occurs instantly $H_x\times k=(h\times k+P_{Rx})$ less than $H_o\times k$=setting of the pressure followup valve 184.

Under the spring bias, pressure followup valve 184 therefore opens, with respect to the lower gas pressure $H_x\times k$ in the pneumatic element 186. Pressure gas flows into pressure gas supply pipe 181 and bubbles into chamber 94, raising the pressure p_{Rx} to thus displace melt 3 from chamber 94 into crucible 2 until the level of melt 3, in crucible 2, has risen from H_x to H_o and the following new relation applies: $H_o\times k=h_2\times k$=setting of the pressure followup valve 184. h_2 is less than h_o, and p_{R2} is greater than p_{Ro}) The pressure followup valve 184 closes.

When the maximum melt displacement has been reached with respect to insert 91, the level of the displaced melt will be at the opening 182 of pressure medium supply line 181, and the gas pressure p_R, prevailing in chamber 94, is $p_{R\,max}=H_oaPk$. Pressure switch 196, set to this pressure, is actuated to close the contacts 208 and energize signal horn 210. Switch 200 is to be reversed.

If melt is refilled as long as the normal operation continues, the melt level in crucible 2 rises beyond the operating level H_o. At H_{max}, float 183 will open the associated float switch 204, and solenoid 188, associated with reversing valve 191, is deenergized. Under the bias of spring 189, reversing switch 191 moves to the rest position. Pressure gas flows immediately from pressure medium supply line 181 and from chamber 94, so that the level of the melt in chamber 94 rises while the level of the melt in crucible 2 drops. As soon as float switch 204 again closes, reversing valve 191 is brought into the operating position by the reenergized solenoid 188. Chamber 94, sealed from the exterior, and pressure medium supply line 181, to the pressure followup valve 184, are switched, for the new level of regulation, to H_o=constant, due to the setting of this valve $H_o\times k$=constant.

Such a cold chamber pressure casting machine has the advantage that the expenditure for control is very low, since the measuring elements and control elements are combined. In

order to simplify the entire system, the setting device of the pressure followup valve can be calibrated both in values of the specific gravity of the melt and in concrete data of the melts to be processed (name of the alloy or its abbreviated symbol), as it is given to the machinist. That is, it can be provided with such a setting scale. For such a calibration, it is logical that the geometry of the crucible, the insert and the piston pump must be constant. Corresponding to the setting on the pressure followup valve, the operating level is thus constant for any type of melt.

For the control of the reversing valve, it is possible to provide, instead of the electric circuit, a pneumatic control system branching off from the pressure gas pipe, with a pneumatic switch in place of the switch 200 and a pneumatic float switch in place of the switch 204. Furthermore, instead of pneumatic displacement of the melt, hydraulic displacement also can be used with the same results, by using an inert fluid. It will be obvious that this can lead to certain changes which are at the discretion of the designer.

It is essential, for the invention, that the piston pump associated with the cold chamber pressure casting machine, the displacement means and the melt level measuring means be arranged in one and the same crucible in order to avoid the above-mentioned difficulties. Apart from the stable behavior of the overall device, this also results in a very favorable heat balance.

I claim:

1. In a cold chamber pressure casting machine with a mold charge injector, a melting or heat-retaining crucible, and an injector supplying piston pump extending into the crucible, the piston pump having a pump chamber communicating with a feed opening which is beneath the level of the melt in the crucible: the improvement comprising, melt displacement means operatively associated with the melt in said crucible to maintain the level thereof substantially constant in the range of said piston pump; control means for controlling the effect of said displacement means on the melt level; and melt level feeler means positioned in said crucible in the range of the melt surrounding said piston pump for providing an indication of the melt level to said control means.

2. In a cold chamber pressure casting machine with a mold charge injector, a melting or heat-retaining crucible, and an injector supplying piston pump extending into the crucible, the piston pump having a pump chamber communicating with a feed opening which is beneath the level of the melt in the crucible: the improvement comprising, melt displacement means operatively associated with the melt in said crucible to maintain the level thereof substantially constant in the range of said piston pump; control means for controlling the effect of said displacement means on the melt level; and melt level feeler means positioned in said crucible in the range of the melt surrounding said piston pump for providing an indication of the melt level to said control means; said displacement means comprising an immersion body mounted for lowering into said crucible and closed on all sides at least in the range of its contact with the melt.

3. In a cold chamber pressure casting machine with a mold charge injector, a melting or heat-retaining crucible, and an injector supplying piston pump extending into the crucible, the piston pump having a pump chamber communicating with a feed opening which is beneath the level of the melt in the crucible: the improvement comprising, in combination, melt displacement means operatively associated with the melt in said crucible to maintain the level thereof substantially constant in the range of said piston pump; control means for controlling the effect of said displacement means on the melt level; melt level feeler means positioned in said crucible in the range of the melt surrounding said piston pump for providing an indication of the melt level to said control means; said displacement means comprising an insert mounted in said crucible and including a lateral wall and a closed upper end forming a pressure medium chamber having an open end below the maximum displacement level of the melt in a downward direction; and a pressure medium supply line connected to said insert and communicating with said pressure medium chamber; said control means also being for controlling flow of pressure medium through said supply line to maintain the melt level constant in the range of said piston pump.

4. In a cold chamber pressure casting machine with a mold charge injector, a melting or heat-retaining crucible, and an injector supplying piston pump extending into the crucible, the piston pump having a pump chamber communicating with a feed opening which is beneath the level of the melt in the crucible: the improvement comprising, in combination, melt displacement means operatively associated with the melt in said crucible to maintain the level thereof substantially constant in the range of said piston pump; control means for controlling the effect of said displacement means on the melt level; melt level feeler means positioned in said crucible in the range of the melt surrounding said piston pump for providing an indication of the melt level to said control means; said displacement means comprising an insert mounted in said crucible and including a lateral wall and a closed upper end forming a pressure medium chamber having an open end below the maximum displacement level of the melt in a downward direction; a pressure medium supply line connected to said insert and communicating with said pressure medium chamber; said pressure medium supply line having, in the range of the maximum displacement level of the melt in a downward direction and in said insert, an opening; and a pressure followup valve connected to said pressure medium supply line and serving as said control means and said melt level feeler means; said pressure followup valve maintaining the pressure in said pressure medium chamber at a value corresponding to the hydraulic pressure of the melt between the nominal level of the melt in the crucible and said opening, said opening being at the lowest displacement level of the melt in said crucible.

5. In a cold chamber pressure casting machine, the improvement claimed in claim 2, including a piston mounted for movement in a cylinder and connected to said immersion body; said control means supplying pressure fluid to one side of said piston to immerse said body in the melt.

6. In a cold chamber pressure casting machine, the improvement claimed in claim 5, including a spring biasing said piston in a direction to elevate said immersion body.

7. In a cold chamber pressure casting machine, the improvement claimed in claim 3, including a piston designed as a float within said insert.

8. In a cold chamber pressure casting machine, the improvement claimed in claim 3, in which the open end of said insert is closed except for a restricted port.

9. In a cold chamber pressure casting machine, the improvement claimed in claim 8, including a piston, designed as a float, in said chamber.

10. In a cold chamber pressure casting machine, the improvement claimed in claim 3, in which said control means comprises a pressure limiting device connected to said pressure medium chamber.

11. In a cold chamber pressure casting machine, the improvement claimed in claim 10, in which said insert is formed with a measuring chamber having an open end communicating with said pressure medium chamber adjacent the open end of the latter, and having its opposite end connected with and communicating with said pressure limiting device.

12. In a cold chamber pressure casting machine, the improvement claimed in claim 3, in which said pressure medium is a protective gas.

13. In a cold chamber pressure casting machine, the improvement claimed in claim 4, in which said pressure medium supply line is a passage formed in the lateral wall of said insert; said opening communicating with said pressure medium chamber.

14. In a cold chamber pressure casting machine, the improvement claimed in claim 4, in which said pressure followup valve is set to a fixed pressure value.

15. In a cold chamber pressure casting machine, the improvement claimed in claim 4, in which the upper wall of said insert is formed with a closable opening above the operating level of the melt.

16 In a cold chamber pressure casting machine, the improvement claimed in claim 15, including a float in said crucible in the range of the operating level of the melt and controlling said closable opening.