United States Patent

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[54] **FOUNDRY APPARATUS**
19 Claims, 16 Drawing Figs.

[52] **U.S. Cl.** **141/137,** 141/160, 141/232, 164/136, 214/43
[51] **Int. Cl.** **B22d 35/00,** B22d 37/00
[50] **Field of Search** .... 141/135, 137, 140, 141, 159, 160, 231—233, 129, 352, 360—362; 164/337, 335, 133, 136, 281; 214/43

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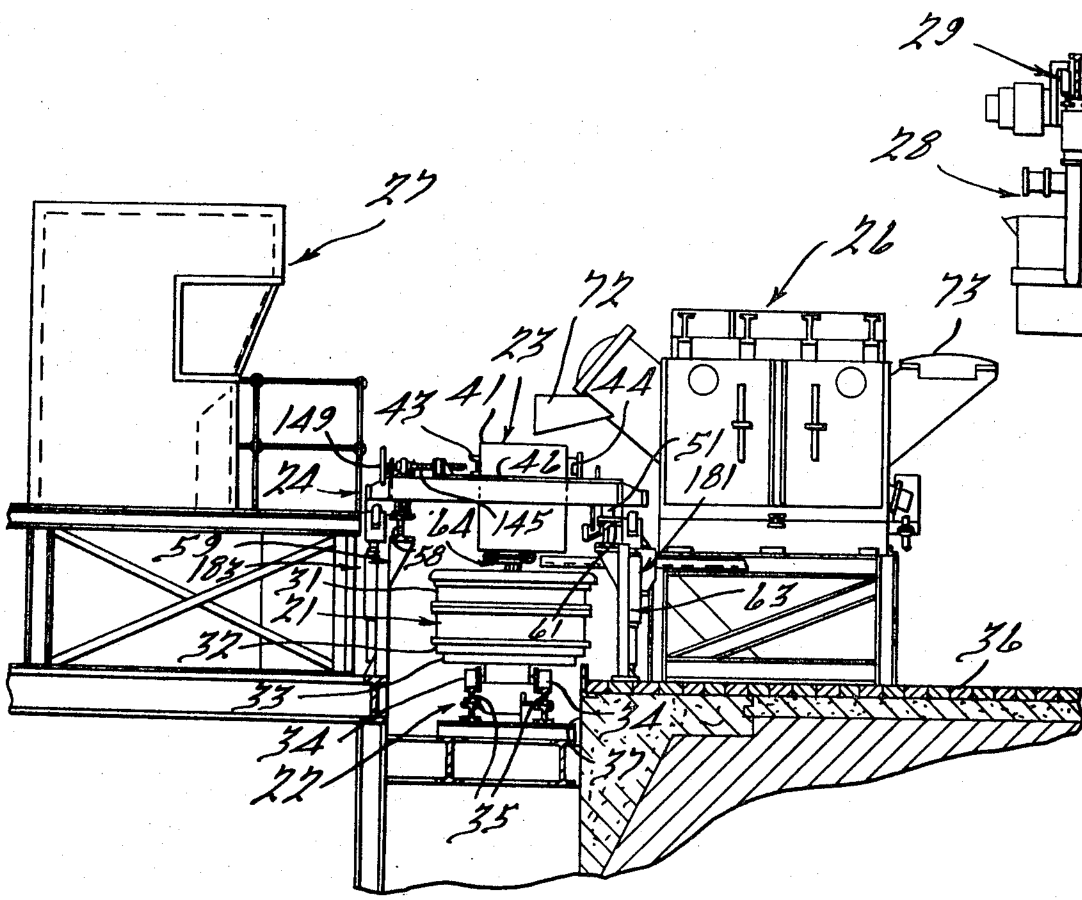
ABSTRACT: A foundry apparatus for filling molds as they move along a conveyor line. The apparatus is comprised of a ladle that is supported for movement above the mold and a driving mechanism that includes a drive cylinder for moving the ladle in sequence with the mold. A bottom positioned nozzle in the ladle discharges molten metal into the mold and a flow control device permits selective control of the amount of molten metal poured into the mold and the time sequence of the pouring. In one embodiment of the invention a sensing device is carried by the ladle and is adapted to engage the mold to sense the presence of the mold under the pouring nozzle of the ladle prior to the initiation of pouring. An operator control console is positioned on one side of the ladle and a holding furnace is positioned on the other side. An operator may selectively control the operation of the pouring apparatus as well as the discharge of the holding furnace into the ladle to maintain a relatively constant head of molten metal in the ladle.



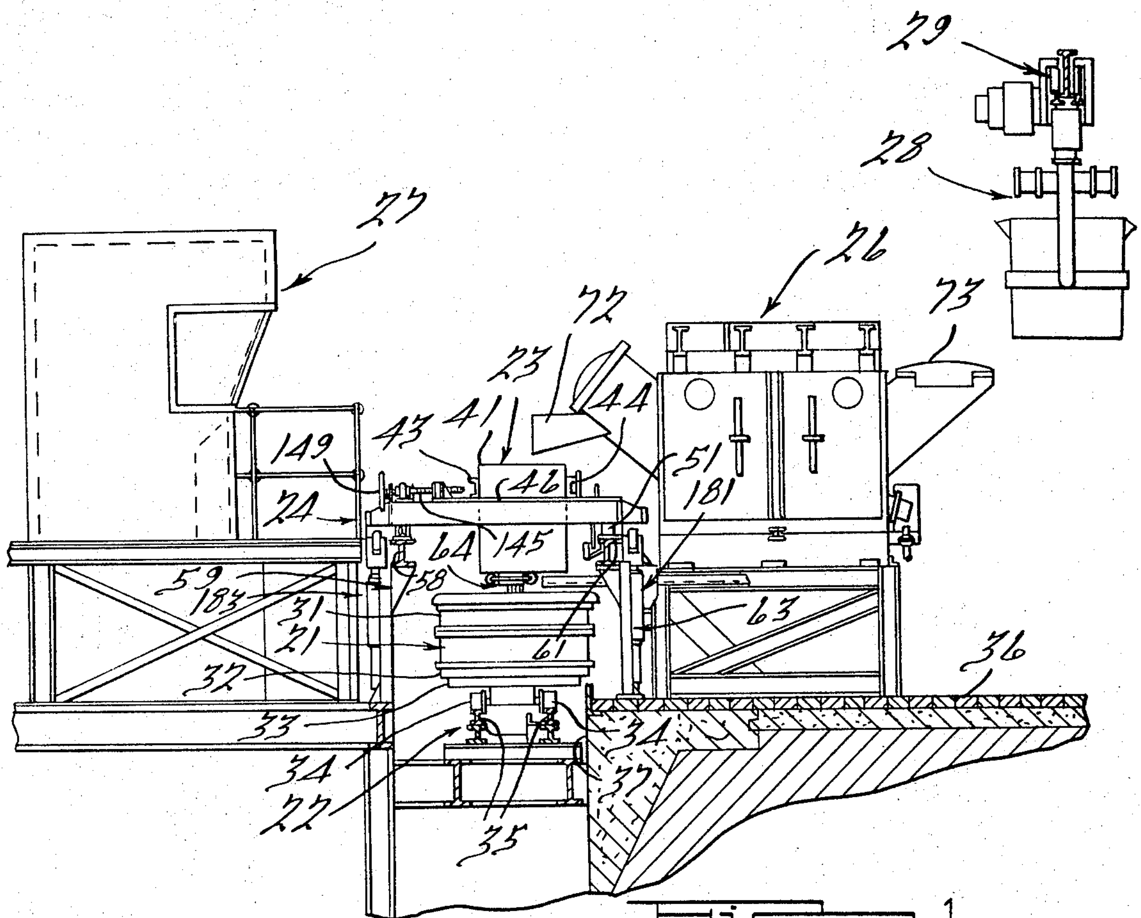


FIG. 1.

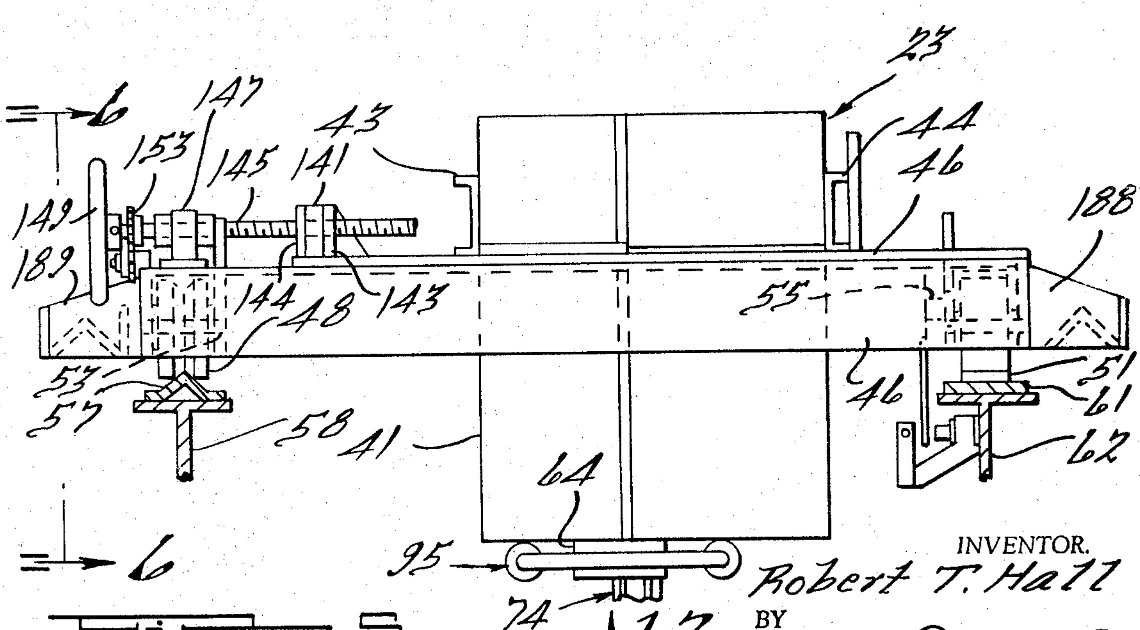


FIG. 5.

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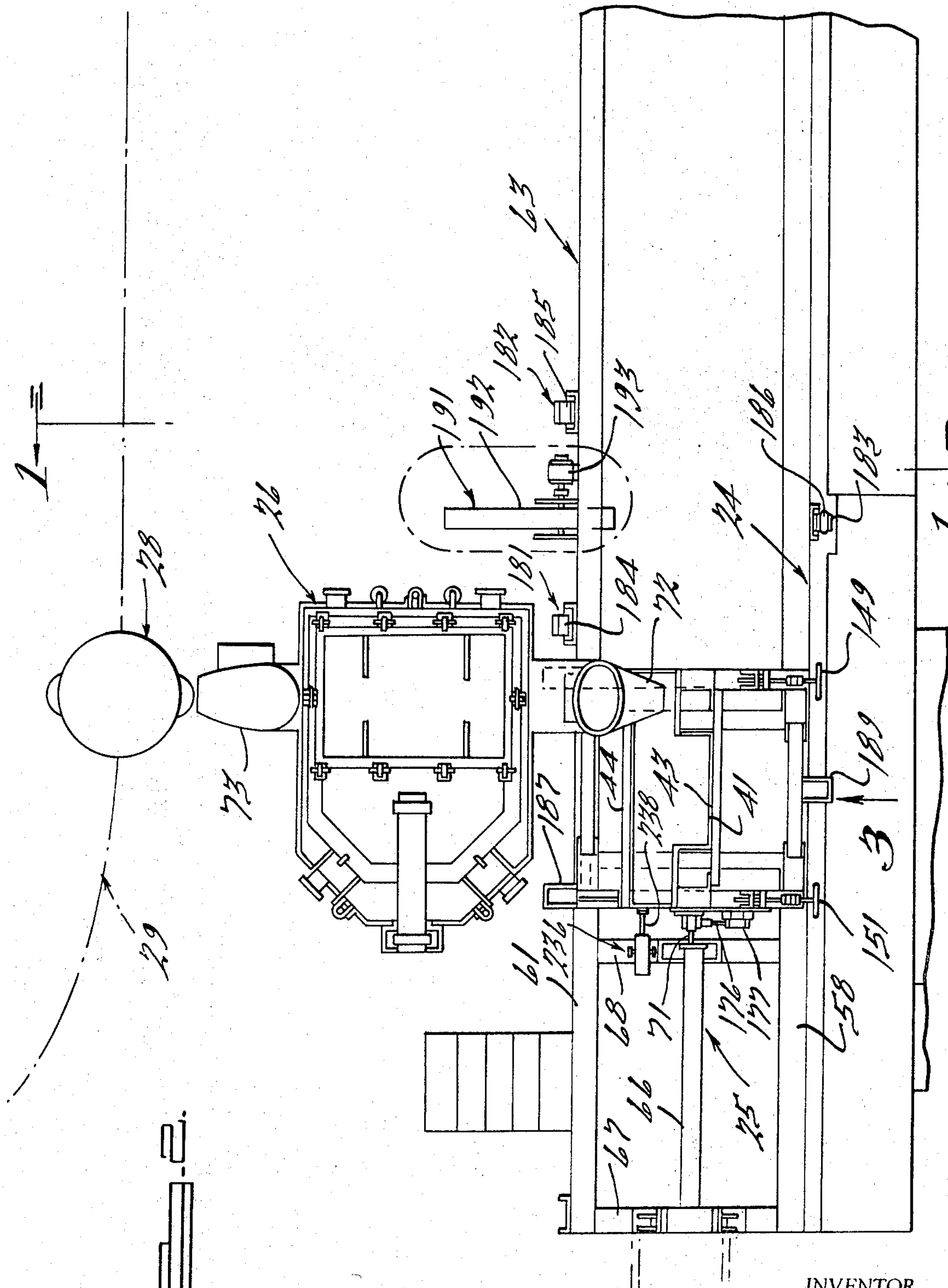

FIG. 2

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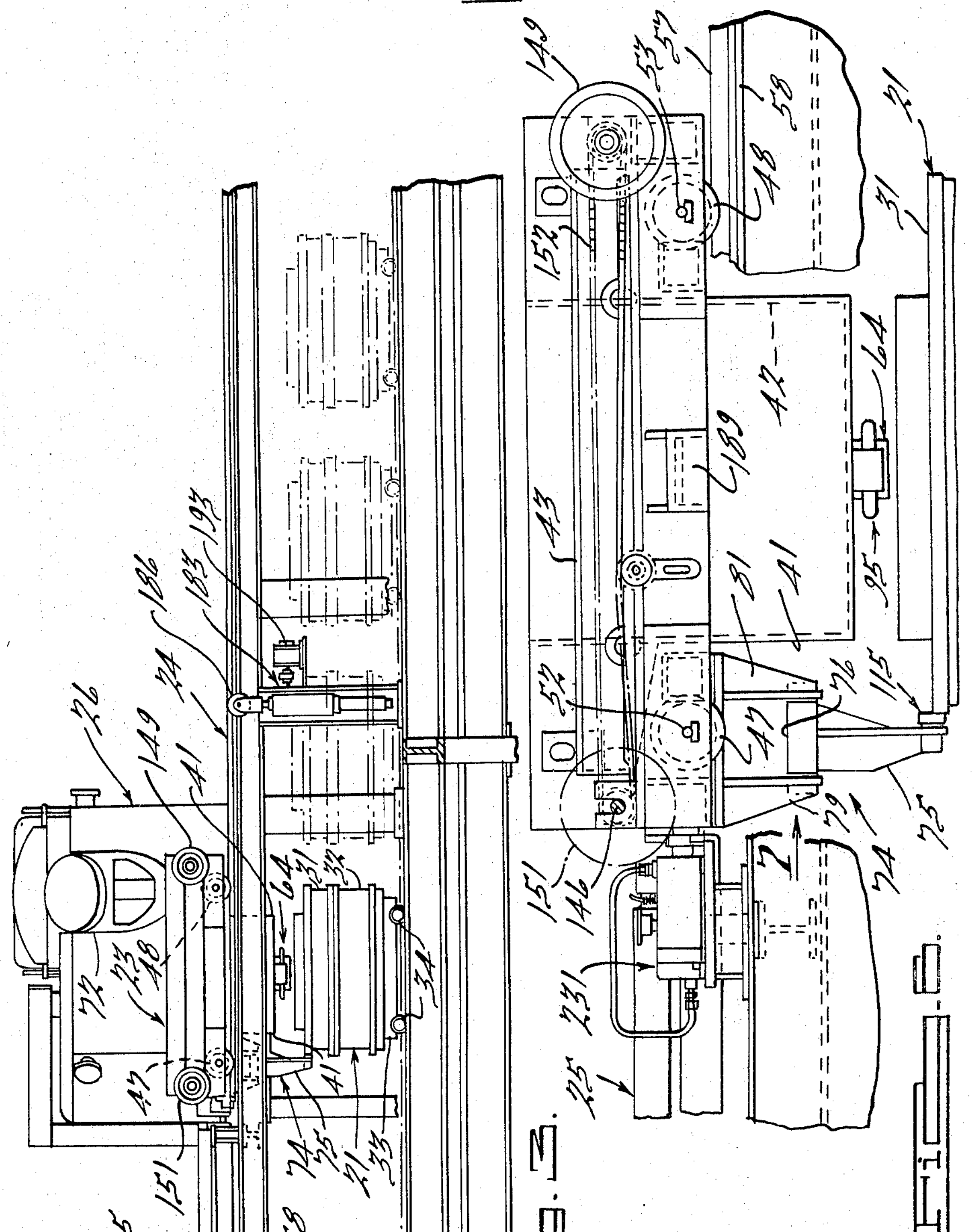

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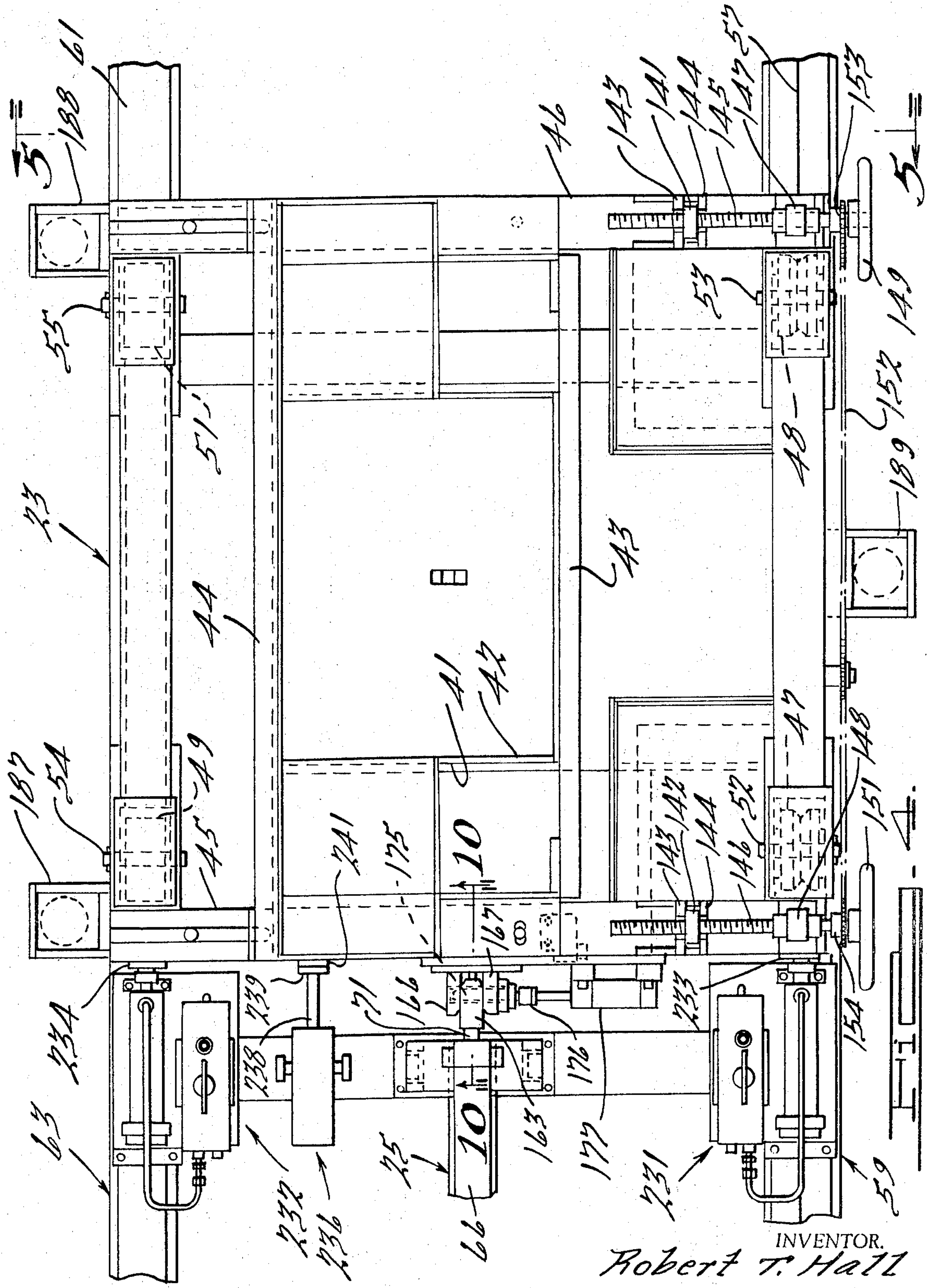

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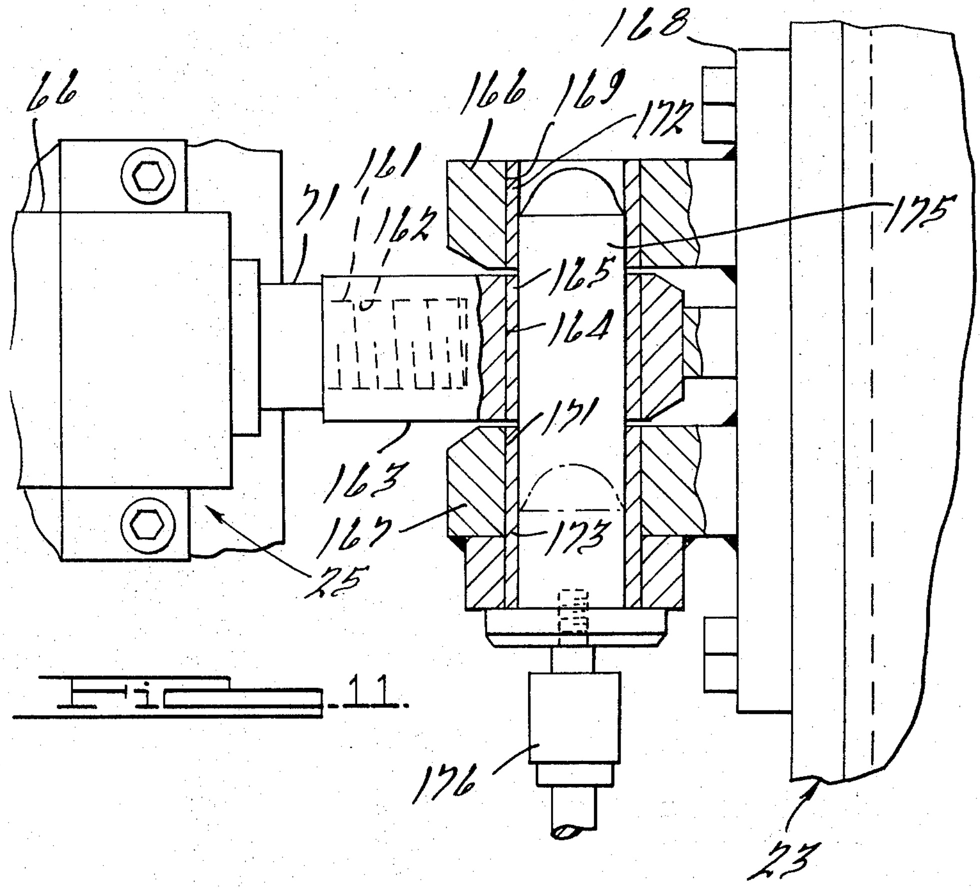

FIG. 11

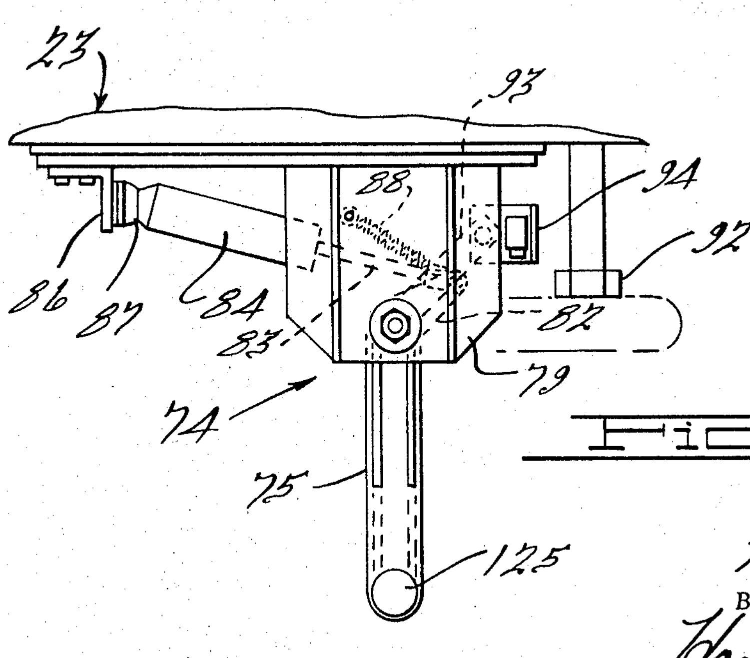

FIG. 7

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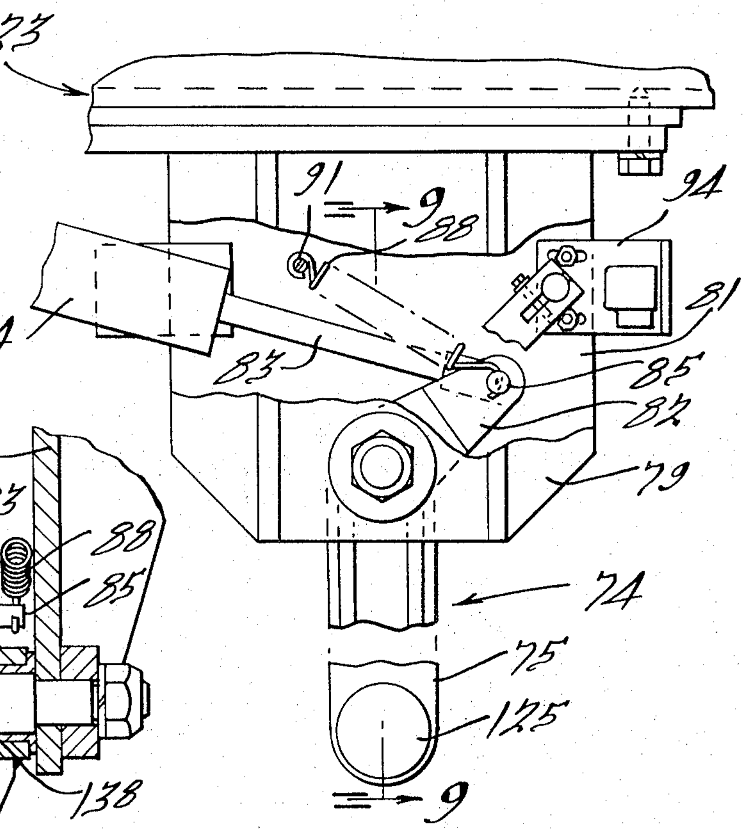
FIG. 8.



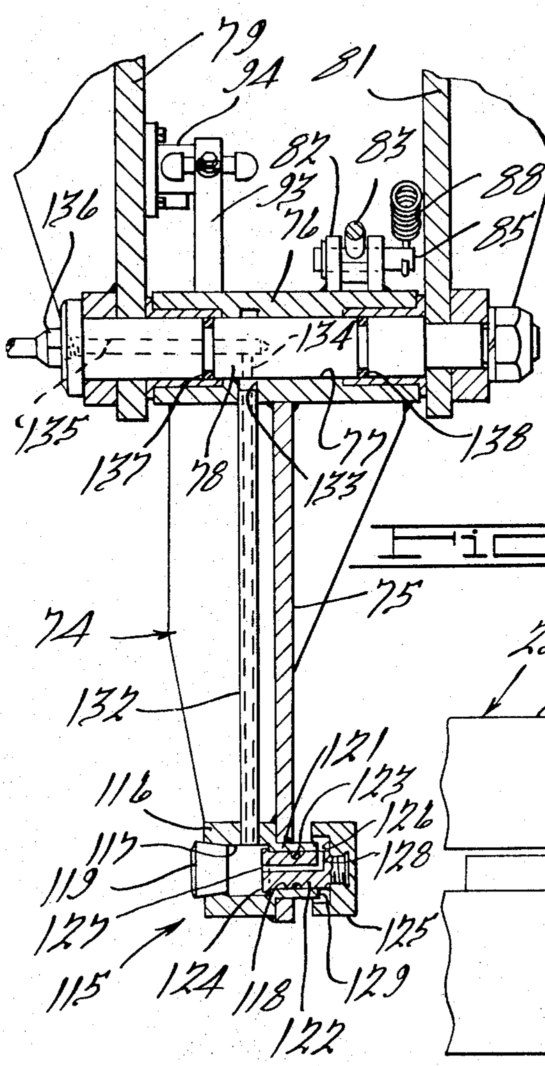


FIG. 9.

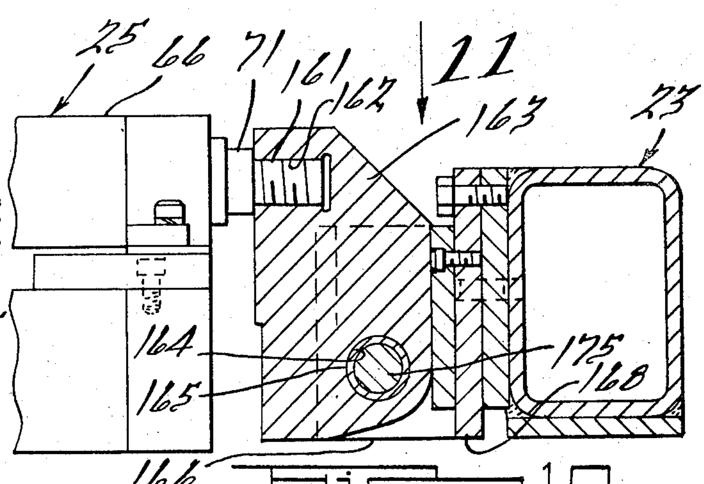


FIG. 10.

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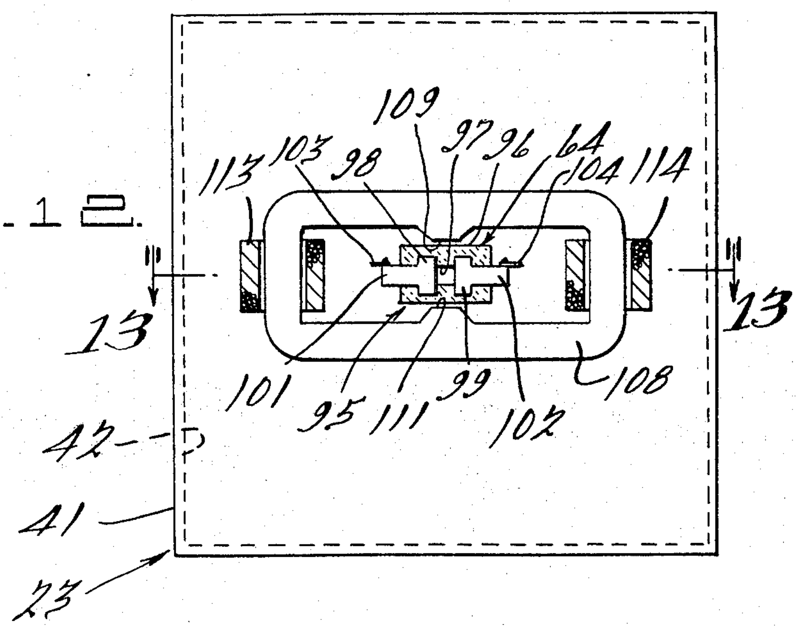
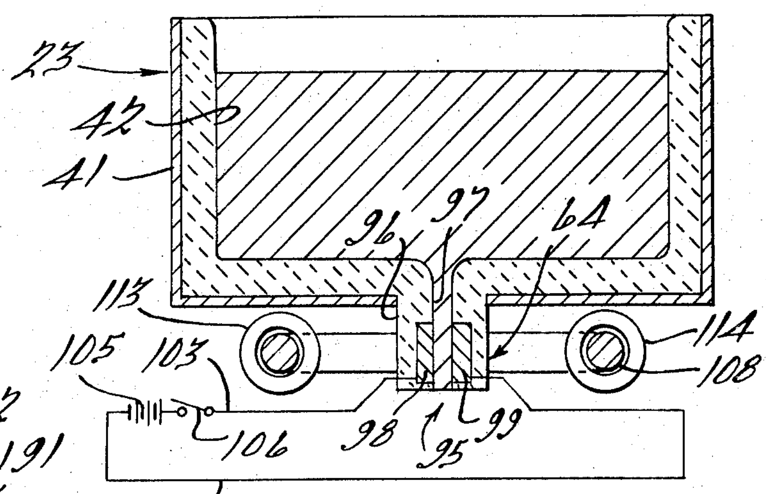
FIG. 12.





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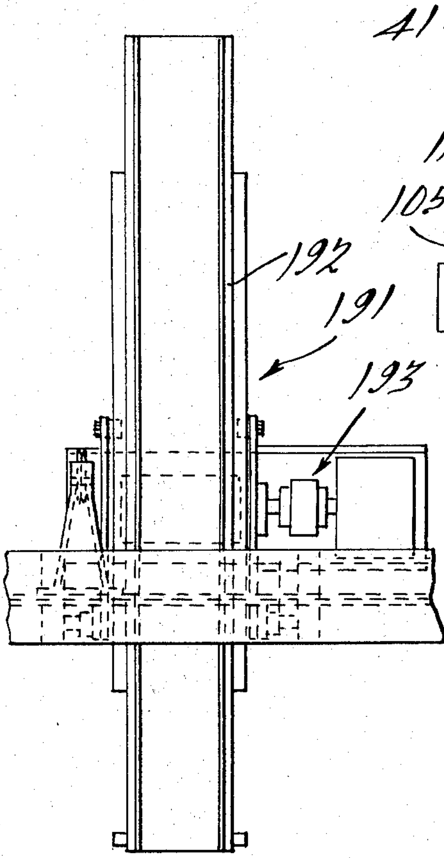

FIG. 14.

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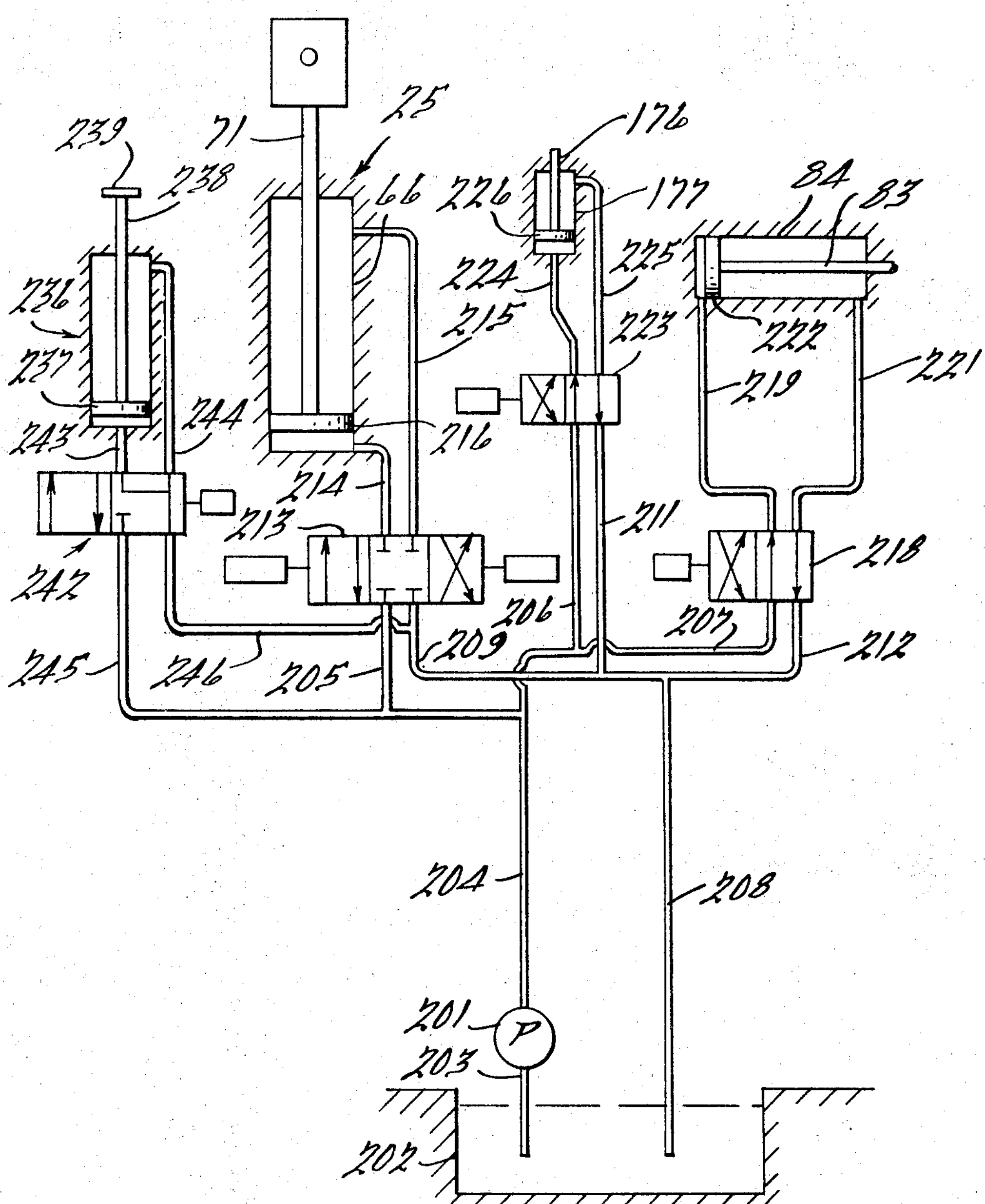

FIG. 15.

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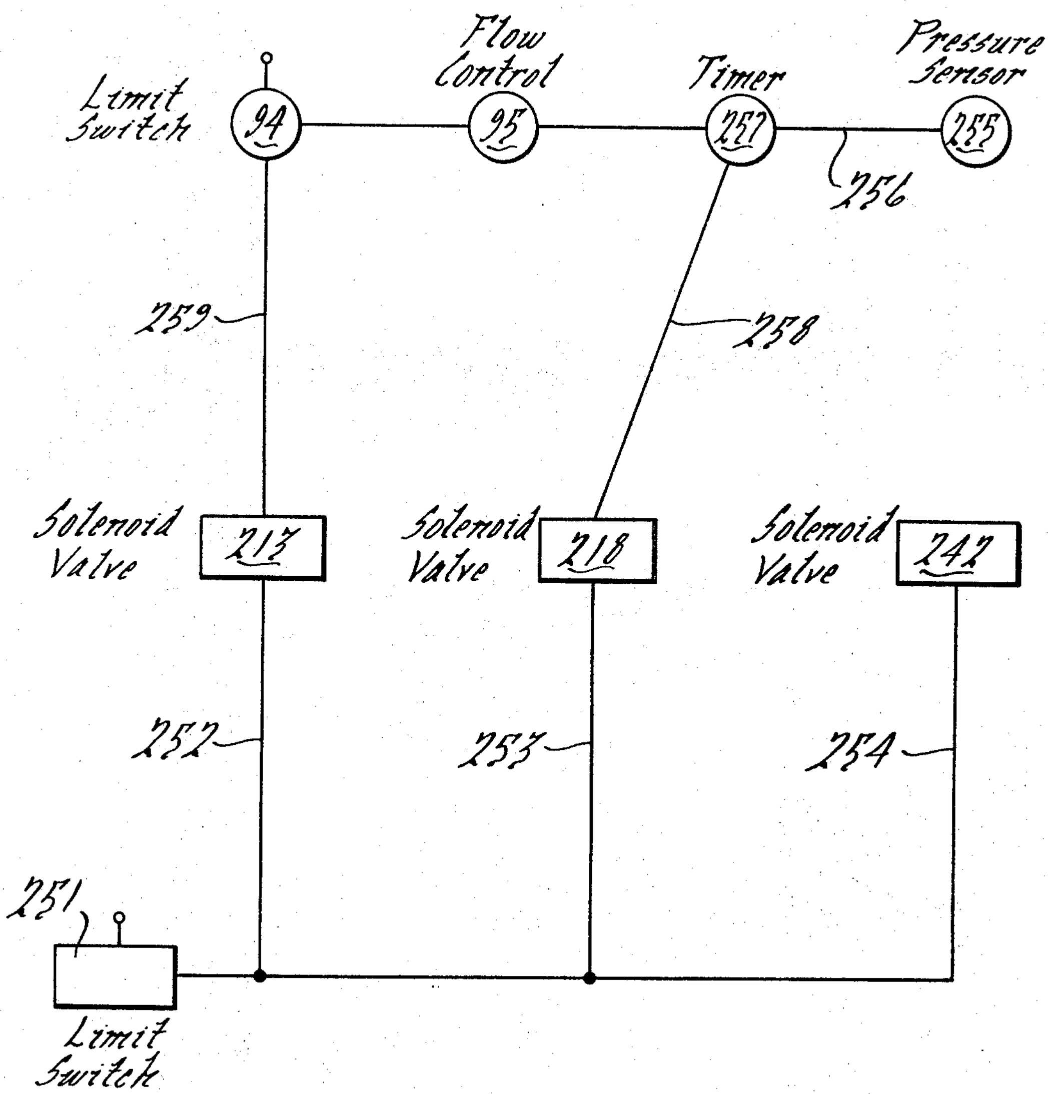

FIG. 16.

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FOUNDRY APPARATUS

BACKGROUND OF THE INVENTION

This invention relates to a foundry apparatus and more particularly to an improved bottom pouring ladle and associated flow control device, to an improved device for pouring a mold during the transfer of the mold and to a method of controlling the flow of a molten metal.

In the foundry field as in most other arts, there has been considerable emphasis toward automation. An automated foundry will increase production, decrease final unit cost and generally will improve the overall quality of the articles being cast. Although machines have been employed for automatically preparing foundry molds, the actual pouring operation is, for the most part, done by hand. Hand pouring of high production rate mold lines usually involves costly spillage, casting defects due to improper filling rate, and serious environmental problems such as intense radiant heat, smoke, gas, and splashing metal.

It is, therefore, an object of this invention to provide an improved, automated pouring apparatus for a foundry.

It is another object of this invention to provide an automatic apparatus for pouring molten metal into a mold while the mold travels along a conveyor.

A frequent cause of scrappage in cast articles is the inclusion of slag or other drosses in the finished casting. This problem is particularly acute with hand pouring from a ladle having a top spout since these drosses normally are lighter than the poured metal and float to its top. Thus, the top pouring from such ladles increases the tendency for drosses and slag to be present in the finished casting. Although bottom pouring of molten metals from a nozzle at the bottom or lower portion of the ladle has been proposed, some form of flow control device must be employed to start and stop the flow through the nozzle.

It is, therefore, another object of this invention to provide an improved bottom pouring ladle for a foundry apparatus.

It is a yet further object of this invention to provide an improved flow control device for a bottom pouring ladle.

It is a still further object of this invention to provide a flow control device for a bottom pouring ladle that employs no moving parts.

SUMMARY OF THE INVENTION

A foundry apparatus embodying this invention is particularly adapted for use in pouring a molten metal into a mold during movement of the mold along a conveyor. The foundry apparatus includes a ladle having a pouring nozzle adapted to convey molten metal to a mold positioned upon the mold conveyor. Means support the ladle for movement along a path wherein the pouring nozzle is maintained in registry with an associated mold traveling along its conveyor. Actuating means are employed to move the ladle along this path in synchronism with the associated mold for filling the associated mold during its movement along the conveyor.

A flow device embodying this invention is particularly adapted for controlling the gravity induced flow of a fluid from a container having a discharge nozzle opening through one of its walls. This flow control device is particularly adapted for use in a foundry apparatus of the type described in the immediately preceding paragraph and includes means for generating opposing magnetic fields in the fluid present in the nozzle sufficient to preclude flow of the fluid through the discharge nozzle. Means are employed for selectively decreasing the strength of one of the opposing magnetic fields for establishing a flow of the fluid from the discharge nozzle.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a reduced scale end elevational view of a foundry apparatus embodying this invention and taken generally along the line 1–1 of FIG. 2.

FIG. 2 is an enlarged top plan view of the foundry apparatus shown in FIG. 1.

FIG. 3 is a side elevational view of the foundry apparatus taken generally in the direction of the arrow 3 in FIG. 2.

FIG. 4 is an enlarged top plan view showing the pouring ladle of the foundry apparatus.

FIG. 5 is a cross-sectional view taken along the line 5–5 of FIG. 4.

FIG. 6 is a side elevational view taken in the direction of the lines 6–6 in FIG. 5.

FIG. 7 is an end elevational view taken in the direction of the arrow 7 in FIG. 6.

FIG. 8 is an elevational view, with portions broken away, similar to FIG. 7 but taken on a larger scale.

FIG. 9 is a cross-sectional view taken along the line 9–9 of FIG. 8.

FIG. 10 is an enlarged cross-sectional view taken along the line 10–10 of FIG. 4.

FIG. 11 is a view taken in the direction of the arrow 11 in FIG. 10 with portions shown in section.

FIG. 12 is a bottom view of the pouring nozzle of the ladle and is taken generally in the direction of the arrow 12 in FIG. 5.

FIG. 13 is a cross-sectional view taken along the line 13–13 of FIG. 12 and showing certain of the electrical apparatus schematically.

FIG. 14 is an enlarged top plan view of encircled areas in FIG. 2.

FIG. 15 is a schematic view showing the hydraulic circuit of the foundry apparatus.

FIG. 16 is a schematic view showing the relationship of certain of the elements.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring first in detail to FIGS. 1 through 3, a foundry apparatus embodying this invention is particularly adapted to fill molds, indicated generally by the reference numeral 21 as they pass along a conveyor 22. The molds 21 are filled from a bottom pouring ladle assembly 23 that is supported for movement along a path coincident with the path traversed by the molds 21 by means of a supporting track assembly 24 and which ladle assembly 23 is reciprocated by a drive assembly 25. The bottom pouring ladle assembly 23 may be periodically refilled from a holding furnace 26 that is positioned on one side of the conveyor 22 and track assembly 24 at the direction of an operator stationed within a control room 27 positioned at the other side of the track assembly 24 and conveyor 22. The furnace 26 itself may be refilled periodically with molten metal from a ladle 28 that is supported for movement along an overhead crane rail 29 in a known manner.

The molds 21 may be of the conventional sand type or any other known type of mold and are depicted as being of the former type. Each mold 21 includes a cope flask 31 and drag flask 32 that are filled with sand and define one or more cavities in the form of the objects to be cast. The molds 21 may be formed in any known manner and preferably by some form of automatic mold forming mechanism that is positioned before the described apparatus in the path of flow along the conveyor 22. Each mold 21 is supported upon a pallet or trolley car 33 having wheels 34 that are supported upon a pair of spaced tracks 35. The car 33 is positioned approximately at the level of a floor 36 of the foundry with the tracks 35 being positioned in a recess 37 formed in the floor 36. The conveyor 22 may be of any known type to move the cars 33 and associated molds 21 along the tracks 35 with the movement being either continuous or intermittent.

Referring now additionally to FIGS. 4 through 6, the pouring ladle assembly 23 is comprised of a container 41 having a generally rectangular cross section and defining a refractory lined cavity 42 adapted to receive and hold molten metal. The container 41 is supported by a frame assembly comprised of a pair of longitudinally extending channel members 43 and 44 and transversely extending members 45 and 46 (FIGS. 4 and 5). As will become more apparent as this description proceeds, the container **41** is transversely adjustable with respect to the members **45** and **46**. A pair of respective rollers **47** and **48** and **49** and **51** are positioned at each side of the ladle frame assembly. The rollers **47** and **48** have a generally V-shaped groove, while the rollers **49** and **51** are substantially flat. Each of the rollers **47, 48, 49** and **51** is supported for rotation upon a respective relatively short stub shaft **52, 53, 54** and **55** and coacts with the track assembly **24** to support the ladle assembly **23**.

The V-shaped grooves of the rollers **48** and **49** coact with a complementary shaped track **57** that extends parallel to the mold conveyor tracks **35**. The track **57** is supported on the upper flange of an I-beam **58** that extends parallel to the tracks **35** and is supported above the floor **36** on a frame assembly, indicated generally by the reference numeral **59**. The rollers **49** and **51** coact with a generally flat track **61**, which is supported on the upper flange of an I-beam **62** that extends parallel to the tracks **35** and is supported above the floor **36** by means of a frame assembly, indicated generally by the reference numeral **63**. The tracks **57** and **61** are supported on opposite sides of the floor cavity **37** at a level higher than the top of the molds **21** that pass beneath the ladle assembly **23**.

A pouring nozzle **64** extends downwardly from the bottom of the ladle assembly **23** and is adapted to register with a pouring basin (not shown) formed in the top of the molds **21**. As the molds **21** are fed along the conveyor assembly **22** beneath the pouring ladle assembly **23**, the pouring ladle assembly **23** is moved in sequence along a coincident path. The drive assembly **25** which moves the ladle **23** along this path is comprised of a hydraulic or pneumatic cylinder **66** that is affixed to a pair of cross frame members **67** and **68** which are, in turn, affixed at their opposite ends to the frame assemblies **59** and **63**, respectively. The cylinder **66** actuates a piston rod **71** that is connected in a manner which will become more apparent as this description proceeds to the ladle assembly **23**.

The holding furnace **26** may be of any known type such as an electric furnace and is provided with a discharge spout **72** that overlies the upper end of the ladle cavity **42** when the ladle assembly **23** is in a retracted position or is otherwise appropriately positioned. The interior of the furnace **26** may be connected to some source of high pressure air to permit the selective forcing of molten metal from the spout **72** into the ladle assembly **23** to maintain the desired height of the molten metal in the cavity **42**. Other alternative apparatus for transferring molten metal from the furnace **26** to the ladle assembly **23** may be employed. The holding furnace **26** also has an inlet spout **73** so that molten metal may be periodically poured into the holding furnace **26** from the ladle **28**.

An arm assembly, indicated generally by the reference numeral **74** and shown in most detail in FIGS. **6** through **9**, is provided for timing the movement of the ladle assembly **23** with the molds **21** and for sensing the presence of a mold **21** beneath the ladle pouring nozzle **64**. The arm assembly **74** is comprised of a fabricated arm **75** carrying a bushing **76** at its upper end. The bushing **76** defines an internal bore **77** that is pivotally journaled on a pivot pin **78** that is fixed to a pair of depending brackets **79** and **81**, affixed to the rear end of the ladle assembly **23**. The pivot pin **78** defines a pivotal axis for the arm **75** that extends parallel to the direction in which the ladle assembly **23** is reciprocated by the drive assembly **25**. A bifurcated actuating lever **82** is affixed to the arm bushing **76** and extends upwardly toward the lower surface of the ladle assembly container **41**. An actuating piston rod **83** of a hydraulic or pneumatic cylinder **84** is pivotally connected to the outer end of the actuating lever **82**, as by means of a pivot pin **85**. The cylinder **84** is supported for pivotal movement upon the ladle assembly **23** by means of a bracket **86** and pivotal joint **87**. Actuation of the cylinder **84** will cause reciprocation of the piston rod **83** and pivotal movement of the arm **75**.

A coil tension spring **88** is fixed at one of its ends to the pivot pin **85** and at its other end to a pin **91** that is fixed to the bracket **81**. The spring **88** exerts a tension upon the arm **75** that tends to rotate it to a retracted position as shown in the dotted line view of FIG. **7**. In this position, the arm assembly **75** contacts an adjustable stop member **92** carried by the ladle assembly **23** to limit the degree of pivotal movement. An indicating lever **93** is also affixed to the bushing member **76** and is adapted to contact a microswitch **94** to indicate when the arm **75** is in its retracted position.

In the depicted embodiment, the flow through the ladle pouring nozzle **64** is controlled by an electromagnetic flow control device, indicated generally by the reference numeral **95**, and shown in most detail in FIGS. **12** and **13**. The pouring nozzle **64** of the ladle assembly is defined by a downwardly extending portion **96** of the ladle refractory material that defines a flow passage **97** having a generally square cross-sectional configuration (FIG. **12**). A pair of graphite terminals **98** and **99** are supported in the refractory material adjacent the passage **97** on opposite sides of the latter. The graphite terminals **98** and **99** have outwardly extending portions **101** and **102** that are connected by means of conductors **103** and **104** across a direct current electrical source **105**. A switch **106** is interposed in the conductor **103** to control the flow from the source **105** to the terminals **98** and **99** through the conductors **103** and **104**. The molten metal in the ladle cavity **42** and in the passage **97** offers a conductive path between the terminals **98** and **99** and, as is well known, the current flowing through this material will generate a magnetic force field.

A magnetic yoke **108** encircles the pouring nozzle **64** and defines a pair of poles **109** and **111** that are juxtaposed to the nozzle **64** and interposed between the terminals **98** and **99**. Electric coils **113** and **114** encircle the short legs of the yoke **108** and are connected in any suitable manner (not shown) to a source of electric current.

The flow control device **95** operates by generating opposing magnetic fields in the molten metal in the nozzle passage **97** to selectively preclude the flow through the passage **97**. The magnetic field created by the current flow across the terminals **98** and **99** is opposed by the magnetic field generated in the yoke **108** across the poles **109** and **111**. When these fields are balanced, the opposing forces generated on the molten metal in the passage **97** will preclude its discharge through the opening at the lower end of this passage. By decreasing the relative strengths of one of these fields, preferably that generated in the yoke **108**, flow will be permitted. The amount of flow may also be controlled by selectively altering the respective strengths of the fields. Thus, it should appear readily clear that the flow is controlled without the use of any moving parts and accurate control may be established.

The electromagnetic flow control device **95** which has been described is of the conduction type, that is, it operates through the utilization of the magnetic field generated by passing a current through an electrically conductive fluid such as molten metal. An induction type flow control device also may be used. With the induction type of flow control device, an induction coil would extend around the pouring nozzle portion **96** and an alternating current would be passed through this induction coil. The current flow through this coil sets up a magnetic force field and eddy currents would be set up in the fluid in the nozzle portion **96**. By properly selecting the field strength of the coil the flow through the pouring nozzle **64** may be controlled.

As still another embodiment of the invention, a mechanical type valve may be used in lieu of either the induction or conduction electromagnetic flow control devices. Such a mechanical valve would comprise reciprocally supported stopper that would depend into the cavity **42**. The lower end of this stopper would coact with a complementary valve seat positioned at the mouth of the pouring nozzle **64** and in the bottom of the ladle. The stopper would, in turn, be operated by means of an electric solenoid or fluid cylinder supported in a suitable manner at the side of the ladle assembly **23** for moving the stopper between its opened and closed positions. It is to be understood that the detailed description of the operation of the disclosed embodiment contemplates the use of either of the electromagnetic flow control devices or a mechanical type valve. In a like manner, the claims which are not specific to the illustrated embodiment are intended to encompass these other described types of flow control devices.

As has been noted, the drive assembly 25 moves the ladle assembly 23 along a path with and above the molds 21 as they pass along their respective conveyor 22. A sensing device, indicated generally by the reference numeral 115 and shown in most detail in FIG. 9, is carried at the lower end of the arm assembly 74 for indicating the presence of a mold 21 in the ladle assembly 23. The sensing device 115 comprises a bushing member 116 that is affixed to the lower end of the arm 75. The bushing member 116 is formed with a counterbored opening comprised of a large diameter portion 117 and a smaller diameter portion 118. The outer end of the portion 117 is closed by a plug 119. A reciprocating valve member, indicated generally by the reference numeral 121, has a small diameter portion 122 that is slidably supported in the bore portion 118 and sealed therewith by means of an O-ring seal 123. An enlarged diameter portion 124 is positioned within the bore portion 117 to limit the outward movement of the valve member 121 with respect to the bushing member 116. An enlarged headed portion 125 is fixed to the outer end of the portion 122 and defines a generally annular opening 126.

An axially extending passage 127 is formed in the valve member portion 122 and is intersected at its outer end by a radially extending passage 128 formed adjacent the headed portion 125. The passage 128 is displaced outwardly of an outer end 129 of the bushing member 116 when the portion 124 is in engagement with the shoulder formed at the end of the bore portion 117. Compressed air is admitted to the bore portion 117 by means of a conduit 132 that is fixed at its upper end to the bushing 76 in registry with an annular groove 133 formed in the latter. The groove 133 registers with a radially extending passage 134 formed in the pivot pin 78. The other end of the passage 134 terminates at an axially extending passage 135 formed in the pivot pin 78. The outer end of the passage 135 is connected to a high pressure air line 136. O-ring seals 137 and 138 are received in grooves formed in the pivot pin 78 on opposite sides of the groove 133 to preclude air leakage.

Air under pressure is introduced from the air line 136 through passages 135, 134 and conduit 132 to the bore portion 117. This air pressure forces the valve member 121 to the position shown in FIG. 9 wherein the air will leak from the passages 127 and 128 to the atmosphere through the gap defined by the annular opening 126. When the enlarged head portion 125 of the valve member 121 contacts a mold, the valve member will be displaced inwardly cutting off the air leakage. Thus, a pressure will be established in the conduit 136 that indicates the presence of the mold 22 beneath the pouring ladle 23.

When the ladle 23 is positioned above the mold 21 it is essential that the pouring nozzle 64 be in registry with the pouring basin of the mold. As has been previously noted, the ladle container 41 may be adjusted transversely with respect to its supporting frame assembly to insure this alignment by means of the structure shown in most detail in FIGS. 4 and 5. The side frame members 43 and 44 that are connected to the ladle container 41 have cross members at their ends that are supported on ways defined by the cross frame members 45 and 46. Upstanding internally threaded members 141 and 142 are fixed to the cross members of the container 41 in any known manner, for example, between upstanding trunnions 143 and 144. Threaded screw shafts 145 and 146 pass through the threaded members 141 and 142, respectively. The shafts 145 and 146 are journaled in bearing members 147 and 148, respectively, and carry hand wheels 149 and 151 at their outer ends. The shafts 145 and 146 are interconnected for simultaneous rotation by means of a chain 152 that is threaded around sprockets 153 and 154 carried by the shafts 145 and 146, respectively. Rotation of either of the hand wheels 149 or 151 will, therefore, effect transverse movement of the container 41 with respect to the tracks 57 and 61. Thus, the pouring nozzle 64 may be transversely adjusted by operating either of these hand wheels.

Referring now to FIGS. 10 and 11, the connection between the piston rod 71 of the cylinder 66 and the pouring ladle assembly 23 provides for a rapid disconnect. The piston rod 71 is provided with a threaded end 161 that is received in a complementary tapped opening 162 formed in a connecting member 163. The connecting member 163 is formed with a bore 164 that carries an antifriction bushing 165. The connecting member 163 is interposed between a pair of spaced trunnion members 166 and 167 that are connected in any suitable manner, as by a bracket 168, to the rear end of the ladle supporting assembly. The trunnions 166 and 167 are formed with bores 169 and 171, respectively, into which antifriction bushings 172 and 172 are inserted. The bushings 172 and 173 are aligned and a connecting pin 175 is adapted to extend through these bushing members and through the bushing 165 to form a connection between the piston rod 71 and the ladle assembly 23. The connecting pin 175 is connected to a piston rod 176 of a hydraulic cylinder 177 (FIG. 4) that is supported upon the ladle assembly 23. In the extended position of the piston rod 176, the piston rod 71 is coupled to the ladle assembly 23, as shown in the solid line view of FIG. 11. When the cylinder 177 is actuated to retract the piston rod 176, the connecting pin 175 will be withdrawn to the dotted line position shown in FIG. 11. In this position, the piston rod 71 will be uncoupled from the ladle assembly 23.

Under some circumstances it may be desired to raise the ladle assembly 23 from the tracks 57 and 61. This is normally accomplished after the piston rod 71 has been uncoupled from the ladle assembly 23 in the manner described in the immediately preceding paragraph. When so disconnected, the ladle assembly 23 may be raised by means of three hydraulic cylinder assemblies, indicated generally by the reference numerals 181, 182 and 183. The cylinder assemblies 181 and 182 are disposed adjacent the frame assembly 63 on the outer side of the track 61. The cylinder assembly 183 is disposed halfway between the cylinder assemblies 181 and 182 on the opposite side of the floor cavity 37 and adjacent the frame assembly 59. Each of the cylinder assemblies 181, 182 and 183 carries a roller member 184, 185 and 186 at the upper end of its respective piston rod which roller is adapted to be received in a respective inverted channel shaped member 187, 188 and 189 carried by the ladle assembly 23 (FIG. 4). When the ladle assembly 23 is juxtaposed to the cylinders 181, 182 and 183 it may be raised by simultaneous actuation of the cylinders 181, 182 and 183.

A launder assembly, indicated generally by the reference numeral 191 and shown in more detail in FIG. 14, is disposed between the cylinders 181 and 182. The launder assembly 191 includes a generally trough-shaped member 192 that may be extended inwardly beneath the pouring nozzle 64 of the elevated ladle assembly 23 by actuation of a drive assembly, indicated generally by the reference numeral 193. By so raising the pouring ladle assembly 23 and by extending the launder 191 beneath the ladle nozzle 64 the flow of the discharge nozzle 64 may be accurately adjusted before pouring into the respective molds.

In some instances, there may be periods of time when the ladle assembly 23 is not pouring into molds. The launder 191, holding furnace 26, cylinder assemblies 181, 182 and 183 and ladle 28 may be used in conjunction to hold the temperature of the molten metal in the ladle assembly 23. Under these circumstances, the ladle assembly 23 may be raised by the cylinder assemblies 181, 182 and 183 and the launder 191 positioned beneath the pouring nozzle 24. A portion of the charge in the ladle container 41 can then be poured into the ladle 28 across the trough-shaped member 192 of the launder assembly. This charge may then be returned to the holding furnace 26 through the inlet spout 73 for reheating. The ladle assembly 23 can then be returned into registry with the holding furnace discharge spout 72 for refilling. This transfer of metal will assist in holding the temperature within the ladle assembly 23. If this procedure were not followed, the metal in the ladle assembly 23 might cool sufficiently to solidify or, alternatively, the ladle assembly 23 might have to be completely emptied.

A hydraulic circuit which may be used in conjunction with the described apparatus is shown schematically in FIG. 15. The hydraulic system includes a positive displacement pump 201 that is adapted to draw hydraulic fluid from a sump 202 through a conduit 203. The pump 201 discharges into a main discharge conduit 204 that terminates in branch conduits 205, 206 and 207. A main return line 208 leads to the sump 203 from branch lines 209, 211 and 212. The lines 205 and 209 lead to a solenoid controlled two-way valve 213 from which conduits 214 and 215 lead. The conduits 214 and 215 extend to the cylinder 66 on opposite sides of a piston 216 that is connected to the piston rod 71. The conduits 207 and 212 lead to a solenoid operated two-way valve 218 from which conduits 219 and 221 extend. The conduits 219 and 221 lead to the hydraulic cylinder 84 and enter into the same on opposite sides of a piston 222 that is connected to the piston rod 83. In a like manner, the conduits 206 and 211 lead to a two-way solenoid operated valve 223 from which conduits 224 and 225 extend. The conduits 224 and 225 terminate in the cylinder 177 on opposite sides of a piston 226 that is connected to the piston rod 176.

OPERATION

Assuming that pouring from the ladle of assembly 23 has not been commenced, the piston rod 71 associated with the cylinder 66 will be retracted and the ladle assembly 23 will have been drawn against hydraulic cushioning assemblies 231 and 232 (FIG. 4) supported at opposite sides of the ladle assembly 23 upon the frame assemblies 59 and 63, respectively. The cushioning assemblies 231 and 232 may be of any known type and include buffer members 233 and 234 that are adapted to be contacted by the frame cross member 45 of the ladle assembly 23 to cushion the return movement of the ladle assembly 23, as will become more apparent as this description proceeds. In addition, the arm assembly 74 will have been rotated to the retracted position shown by the dotted line view of FIG. 7 to allow free movement of the molds 21 beneath the ladle assembly 23. The flow control device 95 will also be actuated to preclude the flow of molten metal from within the ladle assembly 23. At this time, an operator positioned within the control console 27 may visually check the level of molten metal in the ladle assembly 23 and replenish it from the holding furnace 26 if necessary.

Molds 21 will be fed continuously along their respective conveyor 22 beneath the ladle assembly 23. As a mold 21 passes beneath the ladle assembly 23, a limit switch or other sensing device 251 (FIG. 16) will be actuated. This sensing device 251 is in circuit with the solenoid valve 213 by any suitable circuit, as indicated schematically by the line 252 in FIG. 16 and causes the solenoid valve 213 to be actuated to deliver high pressure oil through the conduit 214 to one side of the piston 216. Simultaneously, the conduit 215 will be vented to the sump through the valve 213. This drives the piston rod 71 outwardly causing the ladle assembly 23 to move in the same direction as the traveling molds 21. At the same time, the solenoid valve 218 which is also in circuit with the limit switch 251 as indicated schematically by the line 253 will be actuated to pressurize the conduit 219 and vent the conduit 221 to the sump. This will cause the piston 222 and its associated piston rod 83 to move outwardly. This outward movement pivots the arm assembly 74 in a clockwise direction as viewed in FIG. 7, to bring the sensing device 115 into registry behind the rear edge of the mold 21. Initially, the sensing device 115 will be positioned to the rear of the cope flask 31. The cylinder 66 and its associated piston 216 tends to move faster than the speed of the conveyor 22 so that the sensing device 115 will subsequently be brought into engagement with the rear edge of the cope flask 31. The cylinder 66 is not sufficiently powerful, however, to overdrive a mold 21, hence there is no danger that it will push the mold 21 from its transporting cart 33.

Although the cylinder assembly 66 will not overdrive the mold 21, it has sufficient power to maintain the lower end of the arm assembly 74 in engagement with the mold 21. Thus, after initial contact of the arm 74 with the mold 21, the cylinder 66 will tend to drive the ladle assembly 23 at the same rate of speed as the speed at which the mold 21 moves along its conveyor 22. The discharge nozzle 64 of the ladle assembly 23 will thus be maintained in registry with the mold pouring basin during pouring.

Due to the relatively low power of the drive cylinder 66, there might be considerable time lag before the ladle pouring nozzle 64 came into registry with the mold pouring basin. To eliminate this time delay, a helper cylinder assembly 236 (FIGS. 4 and 15) is employed to overcome the inertia of the ladle assembly 23. The helper cylinder assembly 236 has a piston 237 and associated piston rod 238. The helper cylinder 236 is supported upon the frame adjacent the drive cylinder 66 and a pad 239 carried at the outer end of the piston rod 238 is adapted to engage a corresponding pad 241 (FIG. 4) that is fixed to the rear end of the ladle assembly 23.

The helper cylinder 236 is actuated by means of a solenoid operated valve 242 (FIG. 15), which is also in circuit with the limit switch 251 as indicated schematically by the line 254 (FIG. 16) that coacts with a pair of conduits 243 and 244 that lead into the cylinder 236 on opposite sides of the piston 237. In addition, a high pressure conduit 245 extends from the pump conduit 205 to the valve 242 and a sump conduit 246 leads from the valve 242 to the sump return conduit 209.

Simultaneous with actuation of the cylinder 66, the solenoid valve 242 is actuated to expose the conduit 243 to high pressure fluid and to expose the conduit 244 to the sump. This causes the piston 237 to be driven outwardly and assist in the initiation of movement of the ladle 23. The helper cylinder 236 has a relatively short stroke as compared to the stroke of the drive cylinder 66. Hence, it will reach the end of its travel well before the end of the travel of the drive cylinder piston 216. Preferably, the helper cylinder piston 237 reaches the end of its stroke either at or just prior to the time that the lower end of the arm assembly 74 contacts the mold 21. Continued movement of the ladle assembly 23 is possible, however, since the pad 241 on the ladle assembly 23 merely moves away from the corresponding pad 239 of the helper cylinder piston rod 238. At this time, the solenoid valve 242 is released so that both the conduits 243 and 244 are vented to the sump via the conduit 246.

When the sensing device 115 contacts the cope flask 31, the valve member 121 will be displaced inwardly. This will preclude the air leakage to the atmosphere and a suitable sensing device indicated schematically as 255 (FIG. 16) will then actuate the flow control device 95 by means of a circuit indicated schematically by the line 256 to commence pouring. When pouring is commenced, the field of strength in the magnetic yoke 108 is decreased sufficiently so that the molten metal will pour from the nozzle opening 97 into the associated mold 21. The pouring time is continued for a preset length of time sufficient to fill the associated mold 21, which time may be previously determined and set by a timer means, indicated schematically at 257 and interposed in the circuit 256 (FIG. 16).

As has been noted, the sensing device 115 is employed in the depicted embodiment. The use of such a sensing device may be eliminated if desired. When such a sensing device is not employed, pouring can be commenced either after a given time interval from the initiation of the operation of the cylinder 66 or after the piston 216 of the cylinder 66 has traveled a certain portion of the length of its stroke. When a system of the type described is placed into operation, it can be observed that the lower end of the arm 74 will contact each mold 21 within a given time after the cylinder 66 is actuated or after a given length of travel of the piston 216. Initiation of the pouring can be started after either of these factors has been reached by means of either a time delay switch or a limit switch according to the respective condition. In a like manner, as has been previously noted, the initiation of pouring may be done by means of a mechanical valve that is suitably operated or by other types of electromagnetic flow control devices.

When it is desired to cease the pouring, the field strength in yoke **108** is increased thus stopping the flow through the nozzle passage **97**. If other types of flow control devices are employed, the pouring will be stopped in an appropriate manner. The arm assembly **74** is then drawn upwardly by reversing the position of the solenoid valve **218**, which is controlled by the timer **257** via means including a circuit indicated schematically by the line **258** (FIG. **16**) so that the passage **221** is vented to pump pressure and the passage **219** is vented to sump. This will drive the piston **222** inwardly into the cylinder **84**, drawing the piston rod **83** with it. Thus, the arm assembly **74** will be withdrawn to its retracted position. The spring **88** will assist in this movement and will, in fact, return the arm to this position in the event of failure of the cylinder **84**. When the arm assembly **74** is returned to its home position, the microswitch **94** will be actuated. Actuation of the microswitch sends a signal to the circuit controlling the solenoid valve **213** via a circuit indicated schematically by the line **259** (FIG. **16**) indicating that the ladle **23** may be retracted. It should be readily apparent that retraction should not be effected until the arm assembly **74** is retracted to preclude the interference with the next adjacent mold. The solenoid valve **213** is then actuated to vent the line **214** to sump and expose the line **215** to pump pressure. This will cause the piston **216** and its associated piston rod **71** to be withdrawn along with the ladle assembly **23**. At the finish of the retraction stroke, the ladle assembly **23** will contact the hydraulic buffers **233** and **234** of the cushioning assemblies **231** and **232**, respectively. These cushioning assemblies will, therefore, cushion the final retraction of the ladle assembly. The apparatus is now ready for the next cycle. As the ladle assembly **23** approaches its at-rest position, the pad **241** will contact the piston rod pad **239**. Continued movement of the ladle assembly **23** will then drive the piston **237** of the helper cylinder assembly **236** to its home position.

In certain instances it may be desirable to employ the pouring ladle **23** for filling only every other mold **21** passing along the conveyor assembly **22**. In this instance, duplicate pouring apparatus may be spaced at staggered locations along the conveyor line with each apparatus servicing every other mold.

The specific control circuit for performing the described sequence of operation has not been described since it forms no part of this invention and any known circuitry may be employed by those skilled in the art. Various other changes and modifications may be made without departing from the spirit and scope of the invention, as defined by the appended claims.

I claim:

1. A foundry apparatus for pouring a molten metal into a mold during movement of the mold along a conveyor, said foundry apparatus comprising a ladle having a pouring nozzle adapted to convey molten metal to a mold, means supporting said ladle for movement along a path wherein said pouring nozzle is maintained in registry with an associated mold traveling along its conveyor, abutment means carried by said ladle and adapted to engage the associated mold, and drive means for moving said ladle along said path and for bringing said abutment means into engagement with the associated mold for driving of said ladle in synchronism with the associated mold for filling the associated mold during its movement along the conveyor.

2. A foundry apparatus as set forth in claim **1** further including means for controlling the flow of molten metal through the ladle pouring nozzle and timing means for controlling said last named means for measuring a predetermined quantity of molten metal poured into the associated mold.

3. A foundry apparatus as set forth in claim **2** wherein the abutment means includes means for sensing the presence of a mold adjacent the ladle pouring nozzle and for initiating the operation of the timing means when a mold is present adjacent said pouring nozzle.

4. A foundry apparatus as set forth in claim **1** wherein the abutment means is supported for movement relative to the ladle from a retracted position adjacent said ladle to an extended position wherein said abutment means is adapted to engage a mold.

5. A foundry apparatus as set forth in claim **1** wherein the ladle is supported for movement above the mold conveyor, the pouring nozzle being positioned in a lower face of said ladle for bottom pouring of molten metal from said ladle into the associated mold.

6. A foundry apparatus as set forth in claim **5** further including electromagnetic flow control means for generating opposing magnetic fields in the fluid in the pouring nozzle for controlling the flow therethrough.

7. A foundry apparatus as set forth in claim **6** wherein the electromagnetic flow control means comprises a pair of terminals disposed on opposite sides of the pouring nozzle, said terminals being in electrical contact with the molten metal present in said pouring nozzle contiguous to said terminals, means for establishing an electric current flow across said terminals and through the molten metal to establish a magnetic force field in the molten metal, means for establishing an opposing magnetic field in opposition to said magnetic force field generated by said electric current flow sufficient to preclude the flow of molten metal through said pouring nozzle, and means for decreasing the strength of one of said magnetic fields for establishing a flow of molten metal from said pouring nozzle into the associated mold.

8. A foundry apparatus as set forth in claim **7** further including means responsive to the positioning of a mold adjacent the pouring nozzle for selectively decreasing the strength of one of the magnetic fields.

9. A foundry apparatus as set forth in claim **5** wherein the means for supporting the ladle for movement along the path defines a substantially linear path and the drive means for moving said ladle along said path comprises means for reciprocating said ladle, the movement of said ladle in one direction taking place while the mold is being filled with the movement in the return direction taking place when metal is not flowing from the pouring nozzle.

10. A foundry apparatus as set forth in claim **9** further including means for initiating the pouring from the ladle upon a predetermined movement of said ladle in the one direction.

11. A foundry apparatus as set forth in claim **9** further including sensing means carried by the abutment means for sensing the presence of a mold beneath the pouring nozzle and for controlling the flow through said pouring nozzle in response to the positioning of a mold therebeneath.

12. A foundry apparatus as set forth in claim **11** wherein the abutment means is supported for movement relative to the ladle between an extended position in which the sensing means is adapted to engage a mold to a retracted position adjacent said ladle and means for moving said abutment means from its extended position to its retracted position upon the completion of the movement of said ladle in the first direction.

13. A foundry apparatus as set forth in claim **12** further including means for moving the abutment means from its retracted position to its extended position when a mold is brought into registry beneath the ladle by the mold conveyor.

14. A ladle assembly for a foundry apparatus adapted to pour a molten metal into a mold traveling along a conveyor, said ladle assembly comprising a container for molten metal, a pouring nozzle extending from said container and adapted to discharge molten metal to a moving mold, means supporting said container for movement along a path with the associated mold, abutment means for engaging a mold positioned adjacent said pouring nozzle, and means for supporting said abutment means for movement relative to said container from a retracted position wherein a mold may move past said ladle to an operative position in which said contact means is adapted to engage a mold adjacent said pouring nozzle.

15. A ladle assembly as set forth in claim 14 wherein the means for supporting the abutment means comprises an arm pivotally supported upon the ladle assembly and further including sensing means being carried by said arm at its outer end for sensing the presence of a mold adjacent the pouring nozzle.

16. A ladle assembly as set forth in claim 15 wherein the sensing means comprises a valve assembly having a movable valve member movable between an open and a closed position in response to contact with a mold.

17. A foundry apparatus for pouring a molten metal into a mold during movement of the mold along a conveyor, said foundry apparatus comprising a ladle having a pouring nozzle adapted to convey molten metal to a mold, track means supporting said ladle for movement along a path wherein said pouring nozzle is maintained in registry with an associated mold traveling along its conveyor, abutment means supported for movement relative to said ladle from a retracted position wherein molds may pass beneath said ladle to an extended position wherein said abutment means is adapted to engage a mold, a first drive means operatively connected to said ladle for moving said ladle along said track means, said first drive means being adapted to maintain said abutment means in engagement with a mold when said abutment means is in its extended position for maintaining said ladle in registry with the mold, second drive means, means providing a lost motion connection between said second drive means and said ladle for simultaneous drive of said ladle by said first drive means and by said second drive means during the initial movement of said ladle and for drive of said ladle by said first drive means and independent of said second drive means for the remaining travel of said ladle in one direction.

18. A foundry apparatus as set forth in claim 17 further including control means for sensing the presence of a mold beneath the ladle, for moving the abutment means from its retracted position to its extended position in response to the sensing of a mold beneath the ladle, for operating the first and second drive means, and for moving said abutment means from its extended position to its retracted position at the completion of the movement of said ladle in one direction of its travel.

19. A foundry apparatus for pouring molds traveling along a mold conveyor comprising spaced parallel tracks disposed on opposite sides of and above the mold conveyor, a ladle assembly having a bottom pouring nozzle and means for controlling the flow through said pouring nozzle, means supporting said ladle assembly upon said tracks for movement in a path coincident with the movement of the molds along their conveyor, a hydraulic cylinder supported between said tracks at one end thereof, a piston supported for reciprocation within said cylinder, means detachably connecting said piston to said ladle assembly for reciprocating said ladle assembly along said tracks, sensing means comprising a supporting arm assembly, means supporting said arm assembly for pivotal movement with respect to said ladle assembly from a retracted position adjacent said ladle assembly to an extended position in which said arm depends beneath said tracks toward a mold disposed beneath said ladle assembly, sensing means carried at the outer end of said arm and adapted to engage a mold, means for moving said arm between its retracted and its operative positions, and control means responsive to the positioning of a mold adjacent said ladle assembly for actuating said cylinder to drive said ladle assembly in a first direction coincident with the direction of travel of the mold, for moving said arm from its retracted to its operative position, for operating said flow control means to initiate pouring upon the sensing of the presence of a mold adjacent said ladle assembly by said sensing means, for terminating the pouring after a predetermined time, for moving said arm from its extended position to its retracted position and for actuating said cylinder to return said ladle assembly after said arm has been moved to its retracted position.