United States Patent

Lawrence et al.

[15] **3,707,166**

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[54] **UNIT VALVE FOR HYDRAULIC ELEVATOR CONTROL**

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[21] Appl. No.: **142,639**

[52] **U.S. Cl.**.....**137/596.16**, 60/52 HD, 60/52 US, 91/444

[51] **Int. Cl.**.....**F16k 11/10**

[58] **Field of Search**....60/52 HD, 52 US; 91/47, 361, 91/444, 468; 137/486, 596.16

[56] **References Cited**

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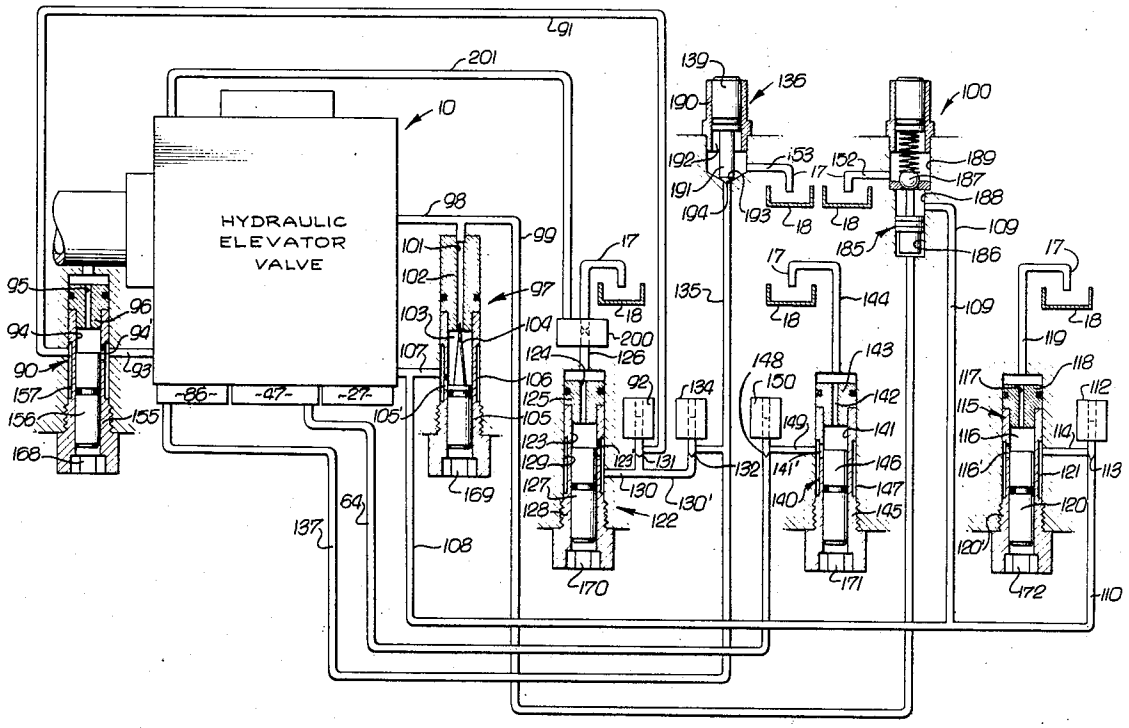
[57] **ABSTRACT**

A unit valve assembly for operation of a hydraulic elevator including three separate valve devices for performing four valve functions, for controlling up bypassing, main down, down leveling and checking are all being made part of a single housing. Controls respectively for up acceleration, up transition, up level, down full speed, down leveling and stop are also mounted on the housing in position, such that adjustments for all said valve devices and controls are located for ready accessability on one side of the housing. A special up level valve having a progressively graduated orifice control is hydraulically actuated to improve the smoothness of up leveling of the elevator.

21 Claims, 8 Drawing Figures



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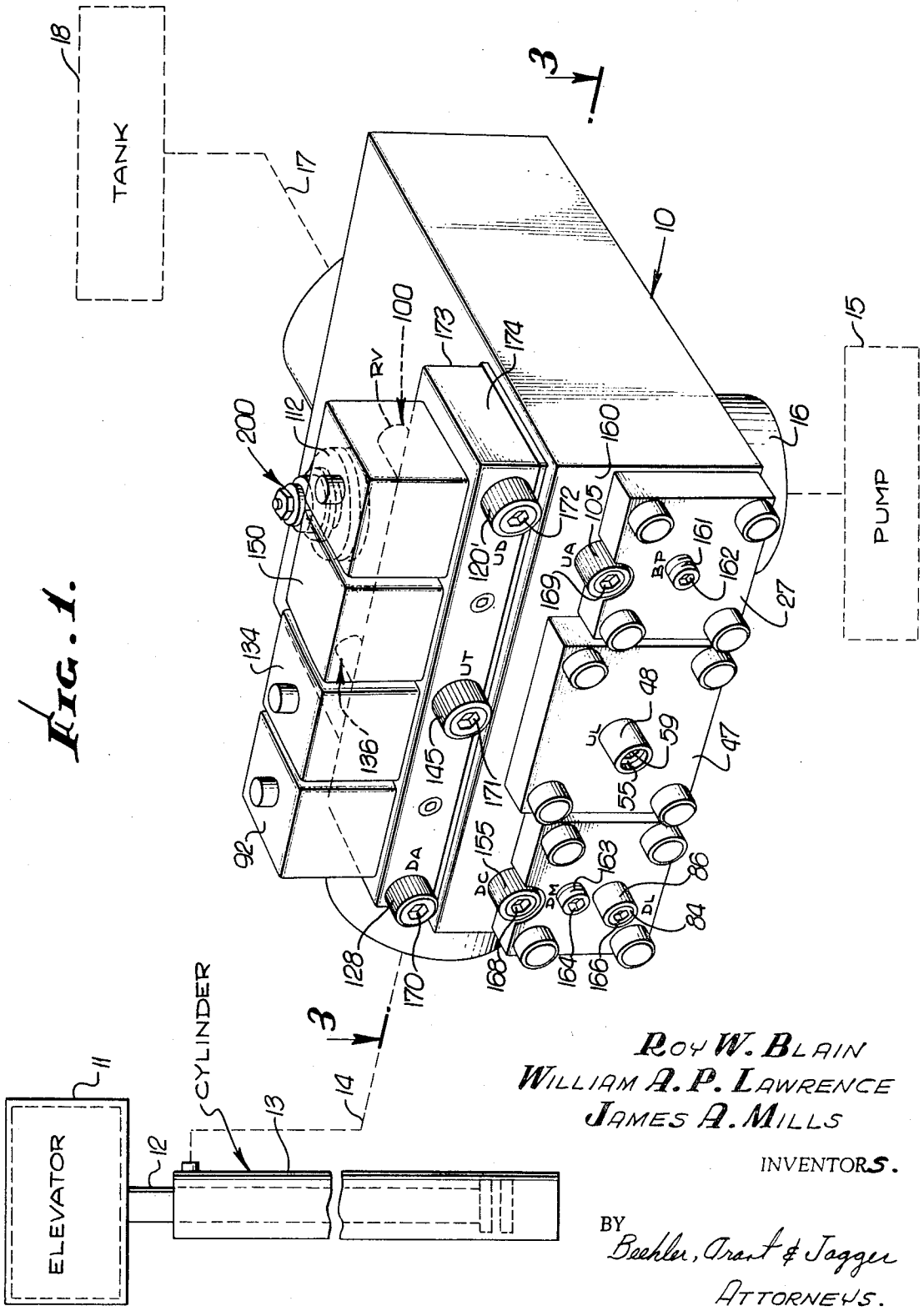

FIG. 1.

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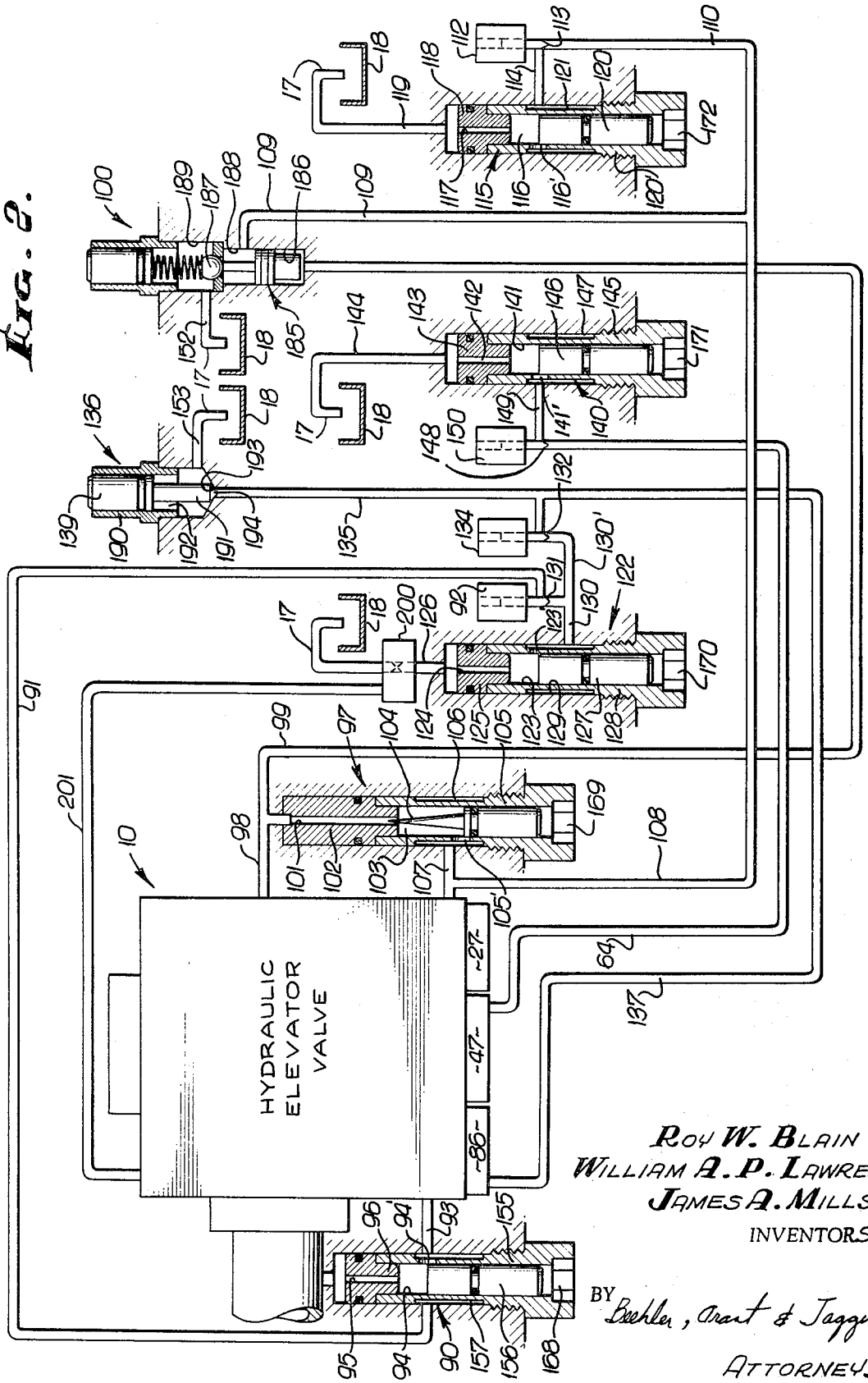
FIG. 2.



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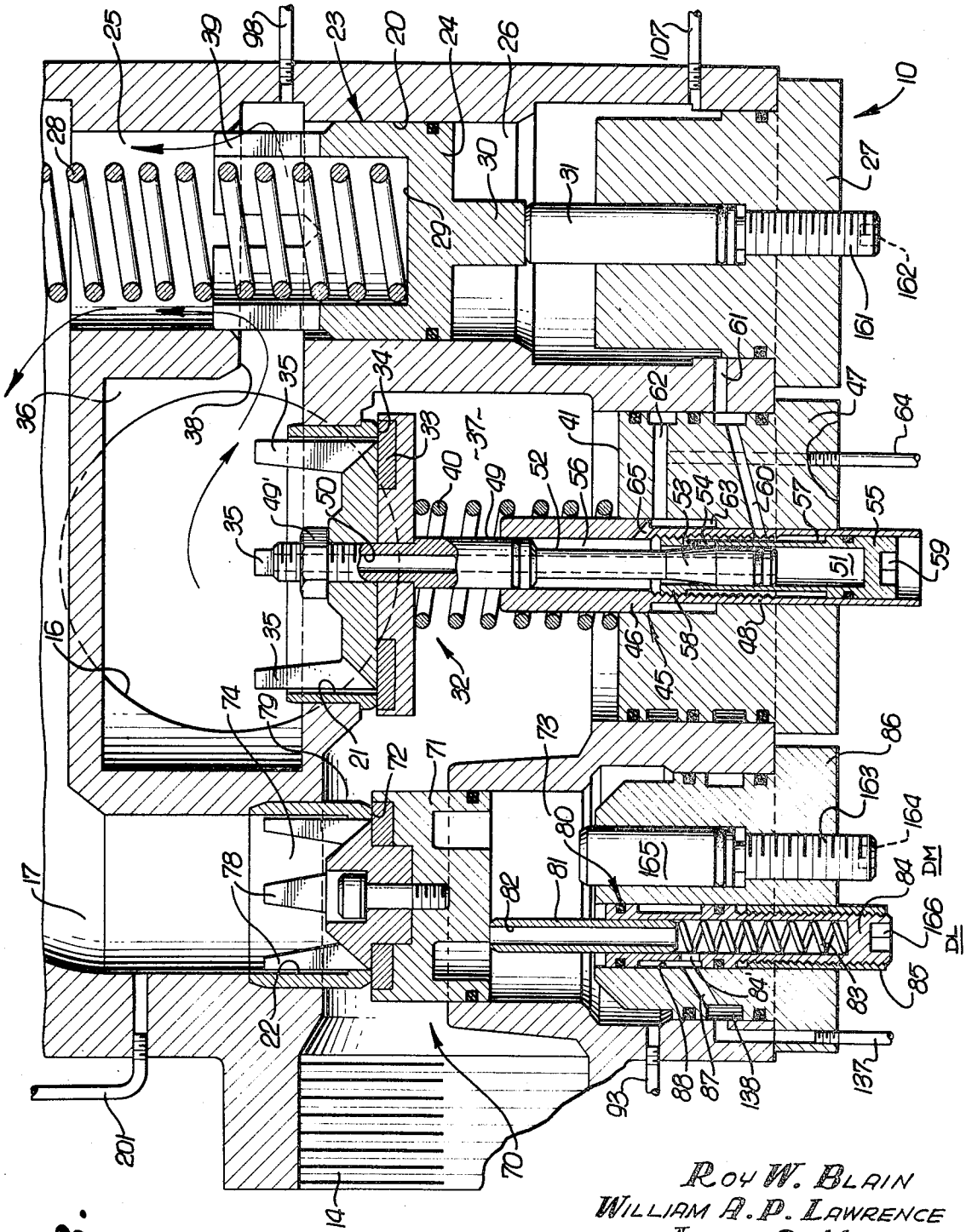

FIG. 3.

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FIG. 4.

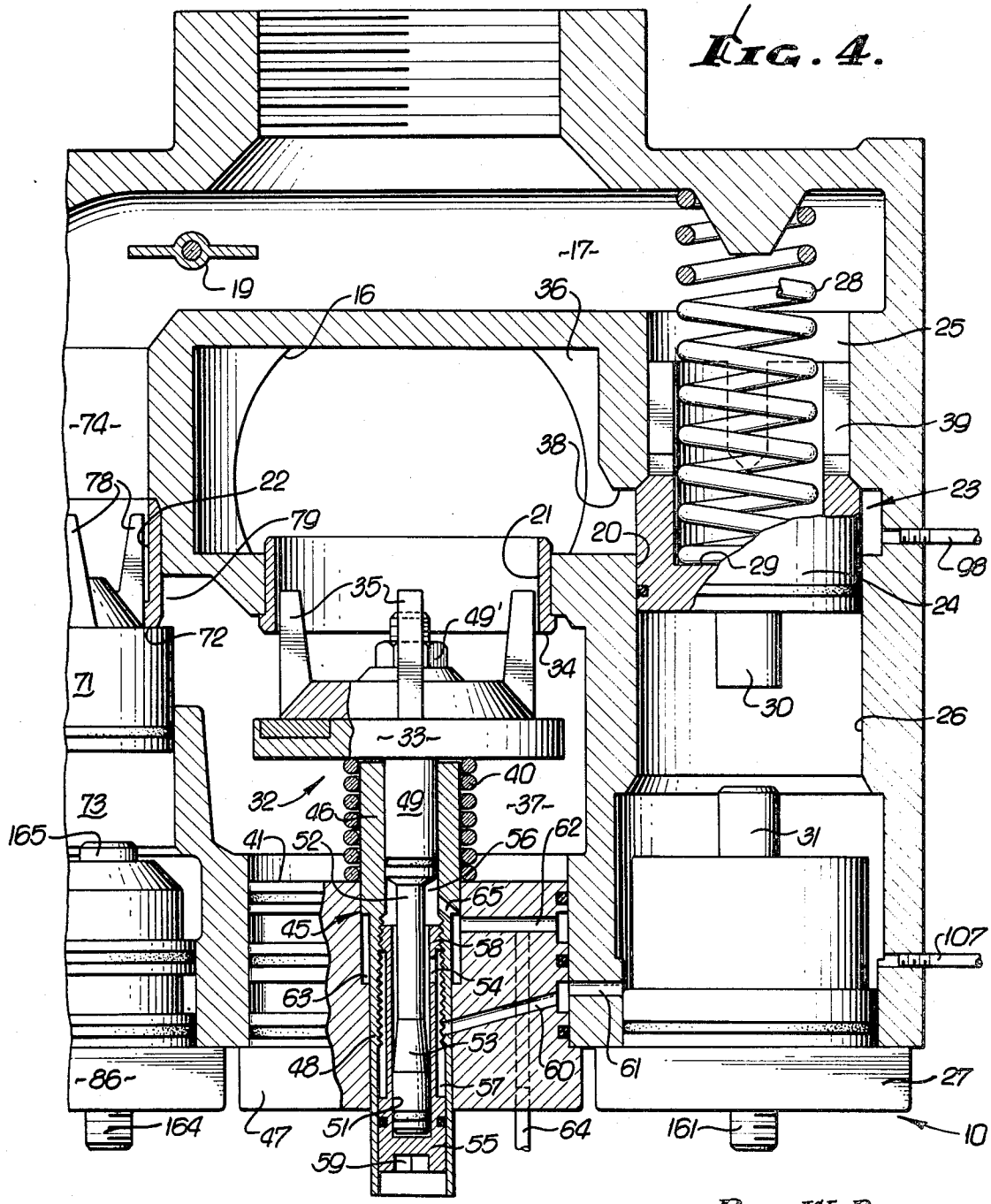

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FIG. 5.

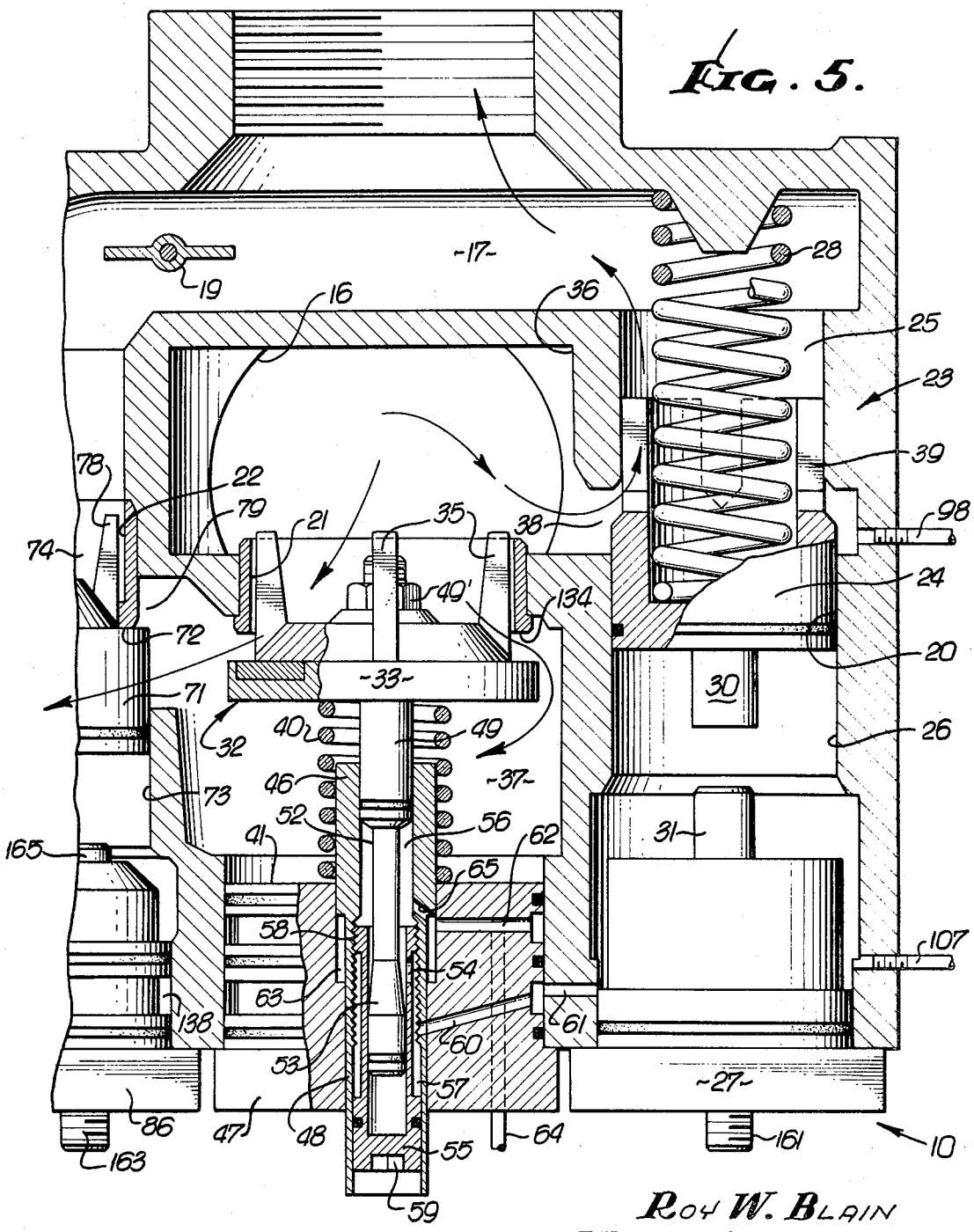

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FIG. 6.

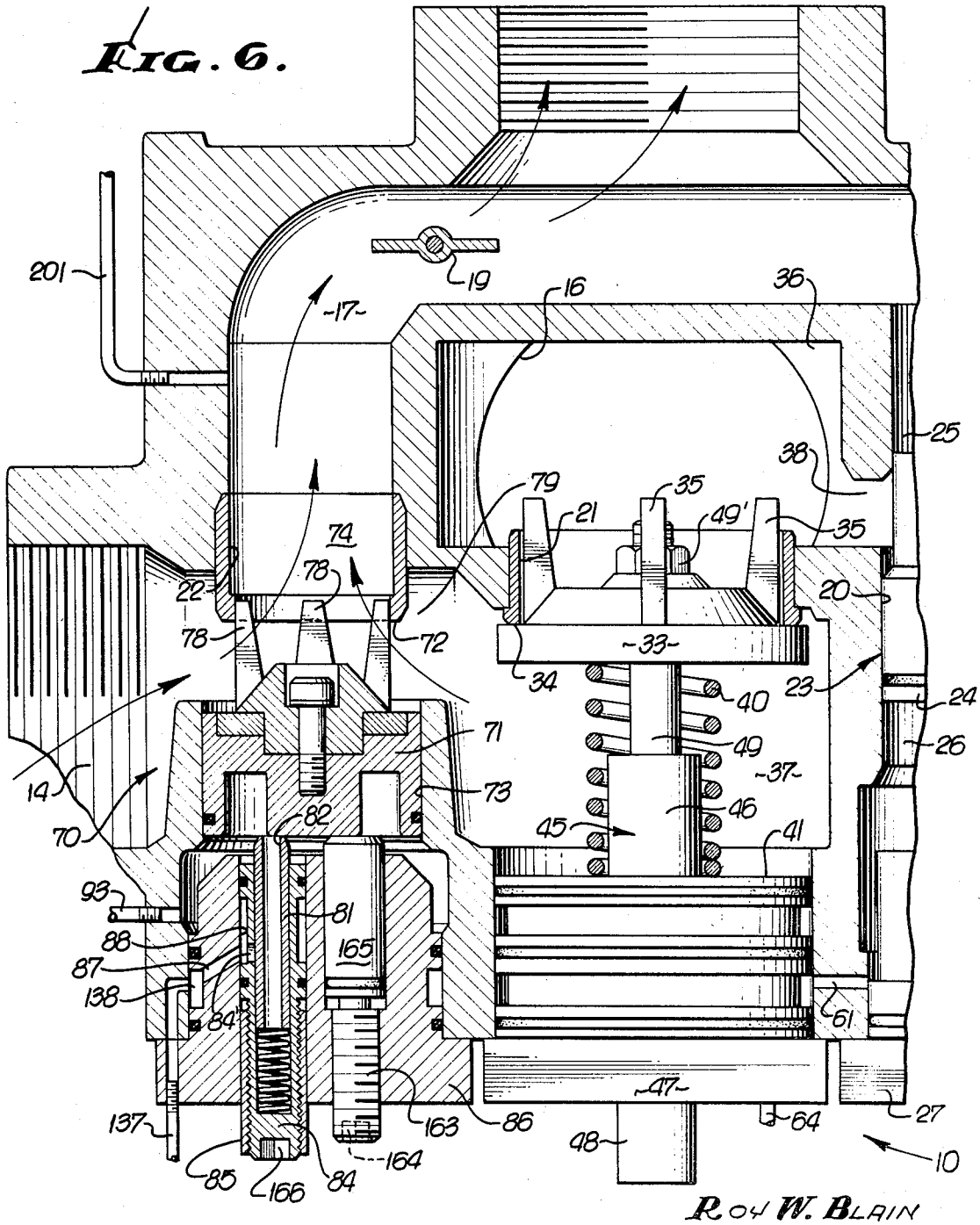

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FIG. 7.

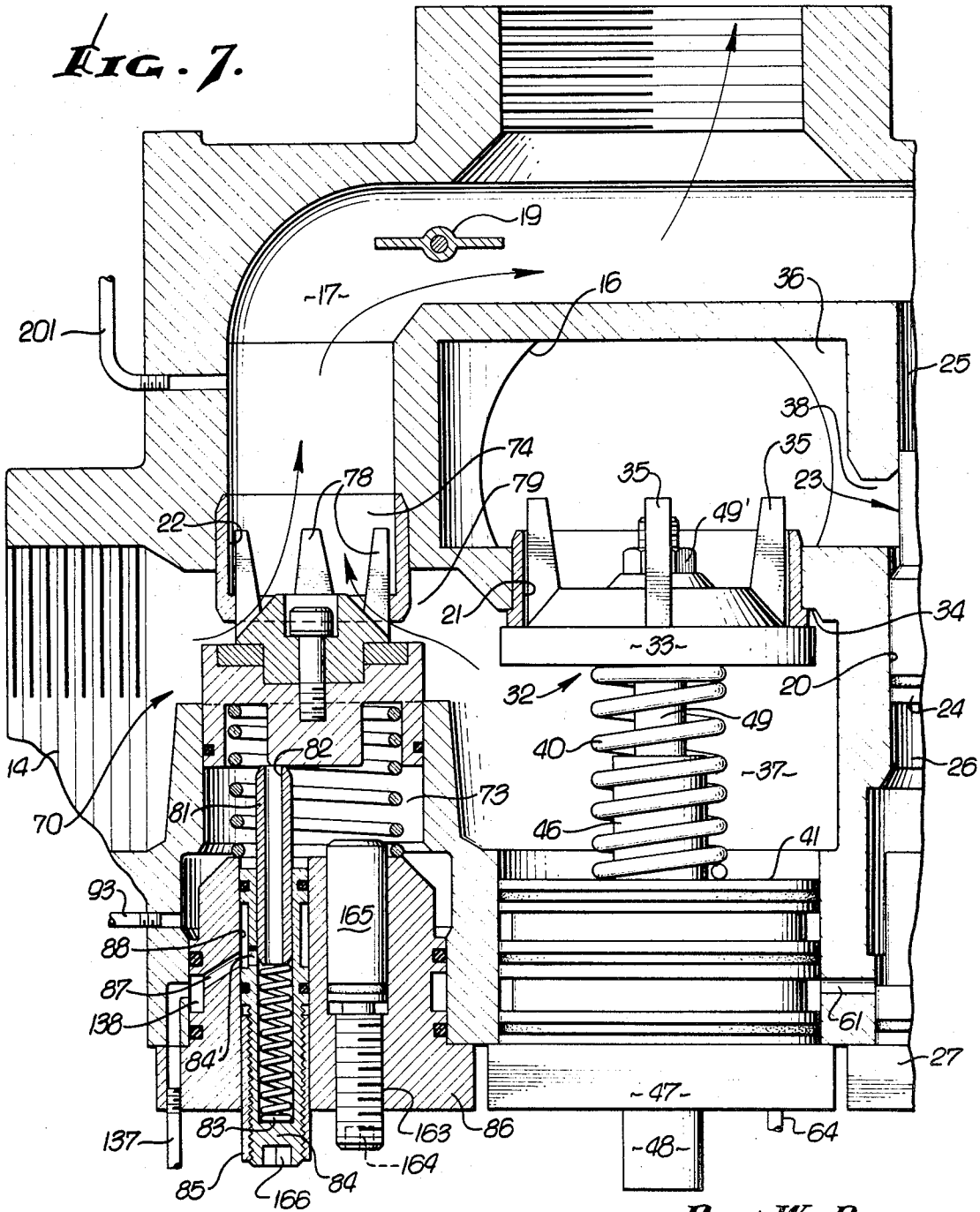

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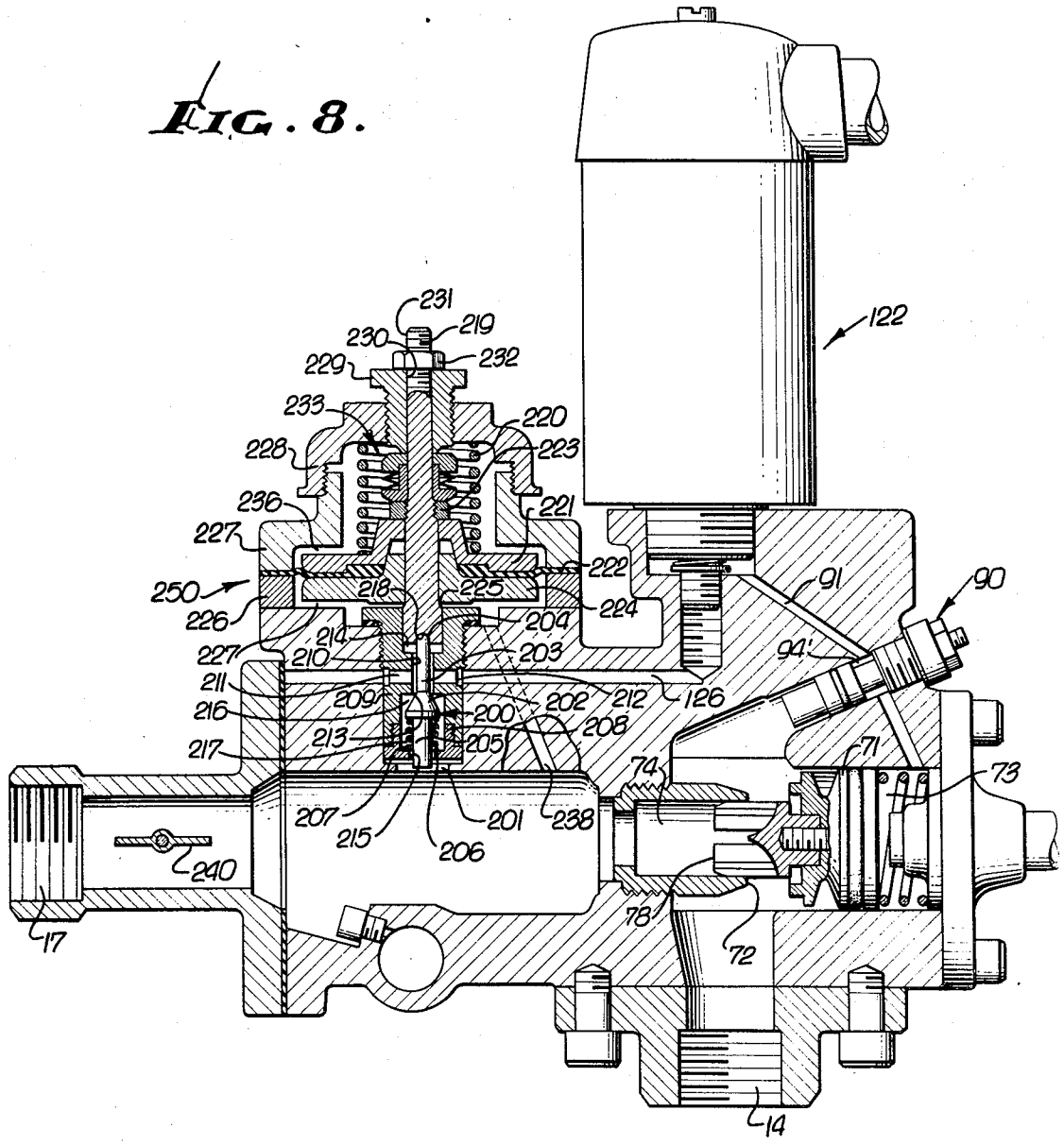
FIG. 8.



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UNIT VALVE FOR HYDRAULIC ELEVATOR CONTROL

Hydraulic elevators are commonly used for lifts limited in general to a building height no higher than a feasible and practical length for a hydraulic ram, which must be sunk below the surface, a distance approximately equal to the height of the building. Hydraulic fluid under pressure is supplied through a cylinder in which the ram reciprocates to lift the elevator, gravity being relied upon to lower the elevator. In other words, to have such elevators operate efficiently it is desirable that the ram move as rapidly as possible throughout most of the distances between floors. To enjoy such rapid movement, however, it becomes desirable to decelerate as the elevator approaches a stop, whether moving upwardly or downwardly, and to stop precisely at floor level, quickly and accurately, and with relatively little hunting for the correct level.

Various hydraulic valves have been devised heretofore in an effort to achieve these results. Inasmuch as valves adapted to control the desired functions heretofore made use of have been constructed and assembled individually, hydraulic circuits for operating them have been somewhat complex, difficult to install, troublesome to maintain, and consequently the efficiency of such systems has not been as high as desired. Inasmuch as considerable adjustment is needed whenever an installation of such equipment is made and since appreciable readjustment is necessary from time to time, to maintain proper efficiency the making of such adjustments has presented appreciable problems. Furthermore since the weight of the load on such an elevator varies considerably during normal periods of use and since the variation in weight produces a very considerable effect upon hydraulic pressures needed for operation, considerable adjustment is needed to compensate for such variations.

It is therefore among the objects of the invention to provide a new and improved unit valve for the control of a hydraulic elevator which is of such construction and configuration that virtually all of the individual valve devices can be compactly located in a central housing whereby to eliminate many of the troublesome deficiencies heretofore prevalent.

One of the objects of the invention is to provide a new and improved unit valve for the control of a hydraulic elevator wherein the individual valve devices are compactly arranged at a single location and in such orientation that virtually all adjustments can be handily managed from a single location on the housing.

Still another object of the invention is to provide a new and improved unit valve construction for the operation of the hydraulic elevator of such construction that a cartridge type relief valve can be used.

Further included among the objects of the invention is to provide a new and improved unit type hydraulic valve wherein three individual valve chambers or cavities capable of handling all of the hydraulic fluid under pressure are of such construction that they can be located side by side in a single horizontal plane whereby to minimize interconnections and to greatly facilitate the operation.

Another object of the invention is to provide a new and improved unit type valve for hydraulic elevator control in which the three required valve devices are compactly arranged whereby to minimize passages and pressure drop, wherein there is a constant mechanical force influencing bleed orifice openings, wherein pressure responsive bleed orifice operating means is located in the main valve housing and wherein such pressure responsive devices as are needed for other functions of the system are likewise located in the main valve housing.

Further included among the objects of the invention is to provide an orifice control for up leveling which has a variable orifice coefficient whereby to improve performance and make possible a more precisely regulated and quieter operation.

Included further among the objects of the invention is to provide a new and improved unit type device for hydraulic elevator control wherein when a loaded elevator is descending, a speed sensitive device may be employed to vary the hydraulic flow thereby to positively and dependably limit down speed travel of the elevator.

Also included among the objects of the invention is to provide a new and improved unit type hydraulic control device for hydraulic elevators wherein a single tool is required for all adjustments and wherein the adjusting means are so located that they can be effectively sealed between service calls.

With these and other objects in view, the invention consists of the construction, arrangement, and combination of the various parts of the device, whereby the objects contemplated are attained, as hereinafter set forth, pointed out in the appended claims and illustrated in the accompanying drawings.

In the drawings:

FIG. 1 is a front perspective view of the unit valve housing and showing sundry conventional parts schematically.

FIG. 2 is a diagram of the hydraulic circuit functionable with the unit valve.

FIG. 3 is a longitudinal sectional view on the line 3—3 of FIG. 1 showing valve positions at rest.

FIG. 4 is a fragmentary longitudinal sectional view similar to FIG. 3 but showing valve positions occupied during the full speed upward travel.

FIG. 5 is a fragmentary longitudinal sectional view similar to FIG. 3 but showing valve positions occupied during up leveling.

FIG. 6 is a fragmentary longitudinal sectional view similar to FIG. 3 but showing valve positions occupied during downward travel at full speed.

FIG. 7 is a fragmentary longitudinal sectional view similar to FIG. 3 but showing valve positions occupied during down leveling of the elevator.

FIG. 8 is a longitudinal sectional view of a poppet valve which can be interconnected with the system for additional control.

In the embodiment of the invention chosen for the purpose of illustration, there is shown a unit valve construction comprising a housing indicated generally by the reference character **10** which is set up to operate a hydraulic elevator **11** powered by a cylinder **13** which operates a ram **12** supplied by a hydraulic line **14**. A pump **15** supplies hydraulic liquid through a pressure line **16** to the housing **10** and a discharge line **17** carries hydraulic fluid away to a tank or reservoir **18**. In the discharge line **74** is located a butterfly type valve **19** which can be set to control the effective size of the line.

As readily seen in FIG. 2 a hydraulic circuit interconnects the sundry hydraulic valves which, in actuality, are normally housed within the housing 10.

As shown in FIG. 3, the housing 10 contains a plurality of chambers, namely, a bypass chamber 20, an up level chamber 21 and a combination chamber 22. A bypass valve device indicated generally by the reference character 23 includes a bypass valve element 24 which separates said bypass chamber into a first bypass cavity 25 and a second bypass cavity 26. A plug 27 closes the forward end of the bypass cavity 26. A spring 28 seated at one end against a portion of the housing (not shown) is seated in a recess 29 of the bypass valve element 24 and normally urges the bypass valve element 24 forwardly into the bypass cavity 26 until a projection 30 engages an adjusting shaft 31 thereby to fix the open position of the bypass valve element.

In the up level chamber 21 is an up level valve device indicated generally by the reference character 32 which includes an up level valve element 33 adapted to cooperate with an up level valve seat 34. Teeth 35 serve as a sliding guide for movement of the valve element and provide a variable opening through the valve device, depending on the degree of its setting.

The up level valve element 33 is located intermediate a first up level valve cavity 36 and a second up level valve cavity 37. The pressure line 16 from the pump is in communication with the first up level valve cavity 36 and this cavity 36 is adapted to communicate with the first bypass cavity 25 through a passage 38. Teeth 39 on the bypass valve element 24 serve as guides and provide a degree of control for the flow between the cavities 36 and 25 depending upon the setting of the bypass valve element 24. A spring 40 acting between the up level valve element 33 and a bottom 41 of the second up level valve cavity 37 serves normally to urge the up level valve element 33 to a closed position against the seat 34.

In communication also with the up level valve element 33 is an up level control assembly indicated generally by the reference character 45. The up control assembly 45 includes a tubular jacket 46 extending for a portion of its length into the second up level valve cavity 37 and for another portion of its length into a plug 47 in the forward side of the housing 10. A neck 48 of the tubular jacket is interiorly threaded, and the neck moreover extends forwardly of the outermost end of the plug so as to be accessible from the exterior. A spool 49 is carried by the up level valve element 33 and extends through the element 33 so that a central bore 50 in the spool can communicate between the first up level valve cavity 36 and a cavity 51 at its forward end. A nut 49' secures the spool in place. The spool 49 has a reduced portion 52 and adjacent the forward end the spool 49 is a frusto-conical surface 53 which provides a progressively graduated closure for a port 54 formed in an end piece 55 whereby to provide communication between an interior annular space 56 surrounding the reduced portion 52 and an exterior annular space 57. An exteriorly threaded head 58 is adapted to engage the interior threaded portion of the neck 48 whereby to adjust the location of the port 54 relative to the frusto-conical surface 53. A hexagonal socket 59 at the forward end of the end piece 55 receptive of a hexagonal wrench (not shown) is utilized for adjusting purposes. The adjustment is effective irrespective of the direction of flow through the port 54.

A passage 60 in the plug 47 communicates between the annular space 57 and a passage 61 in the housing which in turn communicates with the second bypass cavity 26. Another passage 62 communicates between an annular recess 63 and a hydraulic control circuit line 64, the annular recess 63 in turn being in communication through a passage 65 with the interior annular space 56.

In the combination chamber 22 previously referred to is located a combination down level and down main valve indicated generally by the reference character 70 featuring a pilot operated combination valve element 71 adapted to seat upon an annular combination valve seat 72. The combination valve element 71 separates the combination chamber into a first combination cavity 73 and a second combination cavity 74. Guide teeth 78 on the upper side of the combination valve element 71 serve both to guide the valve element during operation and also to modify flow into the second combination cavity 74.

A passage 79 serves to provide communication between the second up level valve cavity 37 and the hydraulic line 14 as shown in FIG. 6.

Cooperating with the combination valve is a down level hydraulic control assembly indicated generally by the reference character 80 consisting in part of a reciprocating sleeve 81 through which extends a bore 82. The sleeve is normally urged rearwardly by a spring 83 bearing at one end on the sleeve 81 and at the other end against an end piece 84. The end piece 84 threadedly engages plug 86 so that by adjusting the position of the end piece 84 the location of the slot 84' relative to the adjacent end of the sleeve 81 is varied thereby to adjust action of the down level hydraulic control assembly. A port 87 in plug 86 is in communication with an annular recess 88 of the end piece 84 and further communicates with an annular recess 138, and hydraulic control circuit line 137, in the plug 86.

For manipulation of the various valves comprising the unit valve, there is provided a hydraulic circuit shown in schematic form in FIG. 2 in which are located hydraulic control valves, in addition to the valve assemblies 45 and 80, some of which are hydraulically actuated and others of which are immediately responsive to solenoid control. As shown schematically in FIG. 2, a down closing and stop valve assembly indicated generally by the reference character 90 is in communication through a hydraulic line 91 with a main down solenoid 92, and also through a hydraulic line 93 with the first combination cavity 73 of the combination down level and down main valve device 70. A valve chamber 94 is in communication with the hydraulic line 14 through a bore 95 in a plug 96. A slot 94' provides communication between the chamber 94 and the hydraulic lines 91 and 93.

An up acceleration valve assembly indicated generally by the reference character 97, and which like the down closing and stop valve assembly 90 is regularly mounted in the housing 10, is in communication by means of a hydraulic line 98 with passage 38. An adjacent hydraulic line 99 is in communication with a relief valve device 100. The hydraulic lines 98 and 99 are

in communication with the bore **101** in a plug **102**, the bore **101** having access to a valve chamber **103**. The lower end of the bore **101** serves as a valve seat upon which a needle valve element **104** is adapted to seat. A neck **105** in which is a slot **105'**, is provided with an annular recess **106** in communication with a hydraulic line **107** and thus in communication with the second bypass cavity **26**, as shown in FIG. **3**. By means of a hydraulic line **108** and **109** there is communication with another portion of the relief valve device **100**. Moreover by an interconnected hydraulic line **110** communication is established with an up dump solenoid **112** which controls a normally open up dump solenoid pilot valve **113**. By means of a hydraulic line **114** communication is established with an up dump valve assembly indicated generally by the reference character **115**. A Valve chamber **116** in the up dump valve assembly communicates through a bore **117** in a plug **118** with a hydraulic line **119** leading to a portion of the discharge line **17** and thence to the pump **18**. In the up dump valve assembly is a ram **120** slidably mounted in a neck **120'**, the neck being provided with an annular recess **121**, communicating through a slot **116'** with the chamber **116**.

For down operation there is provided a down control valve assembly indicated generally by the reference character **122** in which is a chamber **123** in the wall of which is a slot **123'**. The chamber **123** communicates through a bore **124** in a plug **125** with a hydraulic line **126** which leads to a portion of the discharge line **17**. A ram **127** is reciprocatably mounted in a neck **128**, the neck being provided with an annular recess **129**. Through a hydraulic line **130**, the annular recess **129** is in communication first with a normally closed main down pilot valve **131** and through a hydraulic line extension **130'** with a normally closed down level pilot valve **132**. The main down solenoid **92** operates the pilot valve **131** and a down level solenoid **134** operates the pilot **132**.

Through a hydraulic line **135** the hydraulic line **130** and its extension **130'** communicate with a manual lowering valve indicated generally by the reference character **136**. In the opposite direction through a hydraulic line **137** communication is established with an annular recess **138** in the plug **86** and in that way with the port **87** in plug **86** and annular recess **89** of the end piece **84** of the control assembly **80**.

To establish up transition operation of the hydraulic elevator ram and hence the elevator, there is provided an up transition valve assembly indicated generally by the reference character **140**. The up transition valve assembly has a chamber **141** in communication through a bore **142** in a plug **143** with a hydraulic line **144** and thus the discharge line **17**. A neck **145** slidably contains a ram **146**, and an annular recess **147** in the neck communicates through a slot **141'** with the chamber **141** and is in communication with a normally open up level check valve **148** through a hydraulic line **149**. The check valve is subject to control by an up level solenoid **150**. On the opposite side of the up level pilot valve **148** is the hydraulic line **64** which, as shown in FIG. **3**, is in communication with the up level valve assembly **45** through the passage **62** in the plug **47**.

The relief valve **100** is a substantially conventional spring pressed ball relief, however incorporating a differential area piston assembly **185** slidably mounted so as to reciprocate in a bore **186** in communication with passage **38** through hydraulic circuit lines **99** and **98**. A ball **187** is located intermediate a first relief cavity **188** and a second relief cavity **189** which first relief cavity **188** communicates with the second bypass cavity **26** through hydraulic circuit lines **109**, **108** and **107** and which second relief cavity **189** communicates with the discharge line **17** through hydraulic circuit line **152**. Somewhat similarly the manual lowering valve, indicated generally by the reference character **136** which includes ram **139** with a reduced portion **191** is slidably mounted in a neck **190** with the reduced portion **191** creating an annular recess **192**. The recess **192** communicates through port **193** with the hydraulic circuit line **135**. The port **193** being effectively sealed by a conical surface **194** at the terminus of the reduced portion **191** of plug **139**, spills into the discharge line **17** through hydraulic circuit line **153** thereby to send the car down under control of the down level valve assembly **80**.

The down closing and stop valve assembly **90** previously described is made up of a neck **155** in which is slidable a ram **156**, therebeing provided an annular recess **157** in the neck **155** by means of which communication is established with the hydraulic lines **91** and **93**.

Attention is directed expressly to the fact that, as shown in FIGS. **1**, **2** and **3** for example, all of the valve devices and valve assemblies have their axes in a parallel relationship and all are compactly assembled in the housing **10**. Moreover, except for manual lowering valve **136** and relief valve **100** all single tool hex key adjustments face forwardly on a forward wall **160** of the housing **10**. For ease in making adjustments those members of the sundry valve devices and assemblies which require occasional adjustments are provided with hex key sockets, all of the same size, so that all adjustments can be made by use of a single hex key wrench from one side of the housing.

For adjusting throw of the bypass valve element **24** a sleeve **161** having hex key socket **162** is in threaded engagement with the plug **27**. In this fashion by adjusting the sleeve **161** the endwise position of the adjusting shaft **31** can be shifted to a desired position of adjustment. Similarly a sleeve **163** in threaded engagement with the plug **86** is provided with a hex key socket **164** by means of which the lengthwise position of an adjusting shaft **165** can be varied thereby to adjust the throw of the combination valve element **71** in the combination down level and down main valve device **70**.

A hex key socket **166** in the end piece **84** provides for its adjustment and a hex key socket **59** in the end piece **55**, acting in threaded engagement with the neck **48** provides for adjustment of the position of the port **54** with respect to the frusto-conical surface **53** of the spool **49** thereby to vary the effect of the port **54**.

Carrying through with the idea of employment of a single hex key for all adjustments, the neck **155** of the down closing and stop valve assembly **90** is provided with a hex key socket **168**. The neck **105** of the up acceleration valve assembly **97** is provided with hex key socket **169** and the neck **128** of the down acceleration valve assembly **122** is provided with a hex key socket **170**. A hex key socket **171** of similar size is formed in the neck **145** of the up transition valve assembly **140**

and a hex key socket 172 is provided in the neck 120' of the up dump valve assembly 115. The relative location of these various hex key sockets is illustrated in FIG. 1, all being on the forward wall. Only the adjustment for the manual lowering valve 136 and the relief valve 100 are located toward the rear, these being on a rear face 173 of a block 174 at the top of the housing 10.

OPERATION

NON-OPERATIVE POSITION

In the schematic representation of FIG. 2, normal conditions of the solenoids and their respective valves are shown, namely, the main down solenoid 92 and valve 131 is normally closed. The down level solenoid 134 and valve 132 is normally closed. The up level solenoid 150 and valve 148 is normally open and the up dump solenoid 112 and valve 113 is normally open. Non-operative conditions of the three valve devices which actually guide the hydraulic fluid are shown in FIG. 3. The bypass valve element 24 is moved downwardly by its spring 28 so that the passage 38 is full open. The up level valve device 32 is closed and the combination valve element 71 is closed. When the pump 15 is started, hydraulic liquid at full pressure is delivered through the pressure line 16 to the first up level valve cavity 36 and this liquid then passes through the passage 38 into the dump line 17 and thence back to the tank 18. Ram pressure in the system remains static, whatever it may be and other portions of the circuit are vented to atmosphere and therefore at ambient, or atmospheric pressure.

In this setting of valves and valve assemblies as shown in FIG. 3, the frusto-conical surface 53 is in a position extending over the port 54, thus modifying the capacity of the port 54 to pass hydraulic fluid between the passages 60 and 61 and second bypass cavity 26 and the interior annular space 56, passage 65, passage 62, and the hydraulic line 64 which goes to the up level pilot valve 148 and up transition valve assembly 140.

FULL SPEED UP

When the elevator is to be sent in an upward direction both up solenoids are energized, namely, the up level solenoid 150 and the up dump solenoid 112. This changes the condition of the pilot valve 148 from normally open to closed and the condition of the pilot valve 113 from normally open to closed. As a consequence, pressure in the hydraulic lines 108, 110 and 64 will change from atmospheric pressure to pump pressure. As a consequence, there will be pump pressure in the second bypass cavity 26 which will cause the bypass valve element 24 to move upwardly against the tension of its spring 28 until it closes off passage 38. Pump pressure will then force the up level valve element 33 downwardly to open position as shown in FIG. 4 and hydraulic fluid under pump pressure will then pass from the second up level valve cavity 37 to the passage 79, around the combination valve element 71 and into the hydraulic line 14 and thence to the cylinder 13 and ram 12 to lift the elevator 11. This is the condition of upward acceleration or full speed up.

UP TRANSITION AND UP LEVELING

As the elevator approaches some specified floor level the speed needs to be slowed down before the elevator is finally stopped. This means a transition from full upward speed to a slow upward speed. To accomplish this the up level solenoid 150 is de-energized causing it to assume open position for the pilot valve 148 but the up dump solenoid 112 remains energized and the up dump pilot valve 113 remains closed. At a rate according to the relative positions of ram 146 with respect to slot 141' and needle valve element 104 with respect to bore 101, pressure in the second bypass cavity 26 will be modified to less than that in passage 38, and as pressure in the second bypass cavity 26 tends to lower, bypass valve element 24 will shift, by action of the spring 28, from a position of closing off the passage 38 to a position partially opening the passage 38 as shown in FIG. 5. As a consequence, some, but not all, of the liquid from the pump which is sent into the first up level valve cavity 36 travels through the passage 38 and thence into the first by-pass cavity 25 from which it passes through the dump line 17. The subsequent modification of pressure in the passage 38 is likewise reflected in the first up level cavity 36, the reduction in pressure resulting in reduction of the force urging the up level valve element 33 downward against the pressure of the spring 40. The spring 40 then urges the up level valve element 33 upward towards its seat 34 carrying with it the spool 49 with its reduced portion 52 and frusto-conical surface 53. At this stage of operation, pressure in the second bypass cavity 26 will tend to be modified by the action of the spool 49 moving the frusto-conical surface 53 across the port 54 so that further reduction of pressure in the second bypass cavity 26 is restricted to an amount such that the bypass valve element 24 is hydraulically restrained from further opening of the passage 38. Accordingly a balance of forces is established with the up level valve element 33 in closer proximity to its seat 34 according to the relative position of the port 54 as established by the axial positioning of the end piece 55 by means of a hex key in socket 59. The rest of the fluid flows past the partially opened up level valve element 33 thence into the second up level valve cavity 37 and from there through the passage 79 to the hydraulic line 14 and hydraulic cylinder 13. Since the flow and pressure is diminished the upward speed of the elevator is slowed as it approaches its stop. Presence of pump pressure in the cavity 51, the effect of which is communicated to the forward side of the valve element 33 is a compensating factor, and when in loaded condition, upward travel is speeded up to a degree. Stalling out under load in the up level phase is substantially minimized.

UP STOP POSITION

When the elevator reaches its desired level the up dump solenoid 112 which heretofore remained energized is de-energized and the up dump pilot valve 113 is then opened, resuming the position initially occupied in the position described as non-operative. As a consequence pressure in the hydraulic line 108 is reduced to atmospheric. This means that pressure in the second bypass cavity 26 is reduced to atmospheric and the spring 28 will then become operative to move the bypass valve element 24 downwardly to the position shown in FIG. 3 in which position all hydraulic fluid from the pump is bypassed back to the tank in the path previously described. Since in this position pressure in the second up level valve cavity 37 is greater than pressure in the first up level cavity 36, the up level valve

element 33 will close and trap all of the hydraulic fluid at fluid pressure in the cylinder thereby to hold the ram 12 and the elevator 11 at its stop.

When the elevator is to be moved from the level just described to a still higher level the procedure heretofore described is merely repeated.

DOWN TRAVEL

When the elevator is to be moved downwardly to a lower level both down solenoids are energized and both up solenoids remain de-energized. This is to say that the main down solenoid 92 and main down pilot valve 131 are moved from normally closed to open position, and down level solenoid 134 and down level pilot valve 132 are moved from normally closed to open position. As a consequence, hydraulic fluid in the line 137 is passed through the down acceleration valve assembly 122 where it approaches atmospheric pressure modified slightly. This results in a reduction in pressure in the first combination cavity 73. Ram pressure being greater on the upper side of the combination valve element 71 as shown in the upper side of FIG. 6, the combination valve element 71 moves downwardly against the tension of spring 83 and hydraulic fluid from the cylinder 13 traveling through the hydraulic line 14 is diverted into the second combination pocket 74 from which it passes to the dump line 17 and thence back into the tank 18. In this condition of the unit valve, the elevator is moving downwardly at full speed.

DOWN LEVEL AND STOP

As the elevator begins to approach a selected stop position during its downward travel it needs to be decelerated gradually and progressively before coming to a full stop. To accomplish this the main down pilot valve solenoid 92 is deenergized allowing the main down pilot valve 131 to move to closed position. The down level solenoid 134 remains energized and the down level pilot valve 132 remains open, but since the sleeve 81 is in a position such that port 84' is closed off, fluid in the first combination cavity 73 previously at substantially atmospheric pressure, modified slightly, now is trapped and pressure from the hydraulic line 14 passing through the down closing and stop valve assembly 90 serves to increase pressure in the first combination cavity 73 and this pressure assisted by pressure of spring 83 serves to move the combination valve element 71 upwardly thereby to partially close the opening between the pilot operated combination valve element 71 and the combination valve seat 72 until the port 84' is partially opened by the action of sleeve 81 moving upwardly upon the insistence of spring 83, holding the sleeve 81 intimately in contact with combination valve element 71. This re-establishes communication between first combination cavity 73 and discharge line 17 through the hydraulic circuit line 137 and the down acceleration valve assembly 122 where hydraulic fluid from first combination cavity 73 again approaches atmospheric pressure, modified slightly. As a consequence, hydraulic fluid from the cylinder 13 escapes less rapidly and the speed of the ram and elevator is slowed down.

When the elevator reaches a desired level, the down level solenoid is de-energized and the down level pilot valve 132 then moves to closed position. This prevents any escape of liquid pressure through the hydraulic circuit line 137 and hence pressure in the first combination cavity 73 builds up with the assistance of spring pressure 83 until the combination valve element 71 seats upon the valve seat 72 shutting off flow from the cylinder entirely to cause the ram to stop and the elevator to come to its desired stop position.

LOADED DOWN SPEED CONTROL, STRUCTURE AND OPERATION

For down speed control of a loaded elevator there is supplied a poppet valve indicated generally by the reference character 200 in communication with the first combination cavity 73 through hydraulic line 126 and in further communication with the second combination cavity 74 through a passage 201.

As shown in FIG. 8 the poppet valve 200 has at one end a frusto-conical surface 202 joining a reduced portion 203, the reduced portion terminating in a hemispherical surface 204. At the other end, axially concentric with the frusto-conical surface 202 and reduced portion 203 is another reduced portion 205. The reduced portion 205 is surrounded for a portion of its length by a spring 206 which abuts interiorly against a surface 207 formed in a plug 208 engaged threadedly into a poppet valve body 209. In the body 209 is a chamber 210 and the chamber 210 in cooperation with the reduced portion 203 forms an annular orifice terminating at one end in a seat 213 and at the other end in a chamber 214.

The plug 208 has an axially concentric opening 215 in its lower end through which the reduced portion 205 of the poppet 200 passes in guided relationship.

The annular chamber 210 communicates with the dump line 17, previously referred to, through the passage 201. More particularly the line of communication is through a chamber 216 in the poppet valve body 209, which surrounds the poppet valve, thence through what may be termed a chamber 217 to the opening 215 in the plug 208 and from there to the passage 201.

The hydraulic line 216 communicates with the annular chamber 210 through an annular recess 212 and a radial passage 211, both formed in and through poppet valve body 209. The hemispherical surface 204 intimately engages a recess 218 in a stem 219 through the action of the spring 206 urging the poppet 200 upwards. A spring 220 urges an upper diaphragm plate 221 downward, the diaphragm plate 221 being held compressively against a diaphragm 222 and a lower diaphragm plate 224 by a nut 223 threadedly engaging the stem 219. The lower diaphragm plate 224 is further restrained by a shoulder 225 on the stem 219. The diaphragm 222 is circumferentially enclosed and sealed between a body adaptor 226 and an upper regulator housing 227 by means of suitable fasteners not shown. Positioned as described the diaphragm establishes a relatively closed diaphragm cavity 236 and a relatively open diaphragm cavity 237. The cavity 237 communicates through a hydraulic line 238 with the second combination cavity 74. The lower end of the spring 220 abuts the upper diaphragm plate 221 and is restrained at its upper end by a spring retainer cap 228. The cap 228 is threadedly engaged at one end to the upper regulator housing 227 and at the other end to an up leveling adjustor not 229, the adjustor nut having an axial bore 230 through which stem 219 slides in close proximity. By the structure just described axial concentricity is assured. The stem 219 terminates at its upper end in a

thread 231 on which is a transition nut 232. The up leveling adjustor nut 229 is in a position of engagement with a beveled spring washer assembly 233. Since the spring 220 is stronger than the spring 206, the stem 219 is urged downwardly until the nut 232 is moved against the nut 229.

Proper positioning of the nuts 232 and 229 will result in a degree of opening between seat 213 and the frusto-conical surface 202 such that the area formed is larger than that of slot 94' in the down closing and stop valve assembly 90 (see FIG. 2) such that when the main down solenoid 92 is energized, and the down pilot valve 131 is moved from normally closed to open position and the pressure in first combination cavity 73 (see FIG. 3) will fall to a figure substantially below that in the passage 79. The combination valve element 71 will move downwardly as previously detailed in the paragraph treating with down travel, but now, as the fluid in the second combination cavity 74 passes through the area of the hydraulic line 238, fluid pressure which was at atmospheric is now modified slightly by the positioning of a butterfly vane 240 such that this pressure acting upon the area of the diaphragm 222 displaces the upper diaphragm plate 221 upwards against the insistence of spring 220, carrying with it the stem 219, thereby releasing the poppet valve 200 to move upwards under the urging of the spring 206. The upward movement brings the frusto-conical surface 202 into intimate contact with the seat 213 which contact effectively closes off hydraulic line 126, thereby trapping fluid in first combination cavity 73 previously at atmospheric pressure, modified slightly, such that pressure from hydraulic line 14 passing through down closing and stop valve assembly 90 serves to increase pressure in the first combination cavity 73. This pressure assisted by spring 83 serves to move the combination valve element 71 upwardly thereby to partially close the opening between the pilot operated combination valve element 71 and the combination valve seat 72 until the flow of fluid through second combination cavity 74 is decreased and a balance of forces exists between fluid pressure in cavity 237 acting upon diaphragm 222 and spring 220 in conjunction with bevelled spring washer assembly 233, thereby effectively limiting the "rate" of fluid flow through second combination cavity 74 which in turn limits the downward speed of the elevator 11.

Reference is made at this time to U.S. Pat. No. 3,474,811 issued Oct. 28, 1969 citing temperature compensation applicable to this control.

While the invention has herein been shown and described in what is conceived to be a practical and effective embodiment, it is recognized that departures may be made therefrom with the scope of the invention, which is not to be limited to the details disclosed herein but is to be accorded the full scope of the claims so as to embrace any and all equivalent devices.

Having described the invention, what is claimed as new in support of Letters Patent is:

1. A unit valve assembly for operation of a hydraulic elevator ram comprising a housing having a plurality of valve chambers, a bypass valve element in one of said chambers separating said chamber into first and second bypass cavities, an up level valve element separating another of said chambers into first and second up level cavities and a combination down level and down main valve element separating still another of said chambers into first and second combination cavities, communicating passages in said housing between said chambers, and adjusting means for said respective valve elements located all on one side of said housing.

2. A unit valve as in claim 1 wherein the valve chambers are elongated and with axes of the chambers in parallel relationship and the up level valve element has an open operative condition establishing communication between the cavities of the respective chamber.

3. A unit valve as in claim 1 wherein the up level valve has an open operative condition establishing communication between the cavities of the respective chamber and the combination valve element has an open operative condition establishing communication between one of the cavities of the respective chamber and said ram.

4. A unit valve as in claim 1 wherein the adjusting means for said up level valve element includes a progressively variable orifice means comprising two mutually adjustable elements adapted to be set at selective positions relative to each other whereby to selectively vary the rate of deceleration of said ram.

5. A unit valve assembly for operation of a hydraulic elevator ram comprising a housing having a plurality of valve chambers therein, a bypass valve having a bypass valve element in one of said chambers, an up level valve having an up level valve element in another of said chambers and a combination down level and down main valve having a combination valve element in still another of said chambers, a supply of fluid under pressure to said up level valve and an up level control assembly in operating engagement with said up level valve, a plurality of electrically initiated hydraulic control valves in operating relationship with said ram, said control valves being respectively for up level acceleration, up transition, up dump, down acceleration, and down stop, a hydraulic circuit interconnecting said hydraulic control valves, said down level hydraulic control assembly and said up level control assembly, said hydraulic control valves and assemblies having adjusting elements responsive to manual adjustment, manual adjusting elements respectively for said bypass valve element and said combination valve element, a majority of said adjusting elements being located on and accessible from one side of said housing.

6. A unit valve assembly as in claim 5 wherein said control valves and said control assemblies have longitudinal axes in parallel relationship in said housing.

7. A unit valve assembly for operation of a hydraulic elevator ram comprising a housing having a plurality of valve chambers therein, a bypass valve having a bypass valve element intermediate opposite bypass cavities in one of said chambers, an up level valve having an up level valve element intermediate opposite up level cavities in another of said chambers and a combination down level and down main valve having a combination valve element intermediate opposite combination cavities in still another of said chambers, a bypass outlet from one of said bypass cavities, a supply of fluid under pressure to one of said up level cavities and a passage in said housing in communication between said last two cavities and subject to control by said bypass valve, an up level control assembly in operating engagement with

said up level valve element and in communication respectively with said one up level cavity and the other bypass cavity, one of said combination cavities being in communication with said bypass outlet, a down level hydraulic control assembly in communication with the other of said combination cavities, a plurality of electrically initiated hydraulic control valves in operating relationship with said ram, said control valves being respectively for up acceleration, up transition, up dump, down acceleration and down stop, a hydraulic circuit interconnecting said hydraulic control valves, said down level hydraulic control assembly and said up level control assembly, said hydraulic control valves and assemblies having adjusting elements responsive to manual adjustment, manual adjusting elements respectively for said by pass valve element and said combination valve element, most of said adjusting elements being located on and accessible from one side of said housing.

8. A unit valve assembly for operation of a hydraulic elevator ram comprising a housing having a plurality of valve chambers therein, a bypass valve having a bypass valve element intermediate opposite bypass cavities in one of said chambers, an up level valve having an up level valve element intermediate opposite up level cavities in another of said chambers and a combination down level and down main valve having a combination valve element intermediate opposite combination cavities in still another of said chambers, a bypass outlet from one of said bypass cavities, a supply of fluid under pressure to one of said up level cavities and a passage in said housing in communication between said last two cavities and subject to control by said bypass valve, an up level control assembly in operating engagement with said up level valve element and in communication respectively with said one up level cavity and the other bypass cavity, a valve seat in cooperation with said up level valve element adapted when open to interconnect said up level cavities, a valve seat in cooperation with said combination valve element adapted when open to interconnect the other of said bypass cavities and said ram, one of said combination cavities being in communication with said bypass outlet, a down level hydraulic control assembly in communication with the other of said combination cavities, a plurality of electrically initiated hydraulic control valves in operating relationship with said ram, said control valves being respectively for up acceleration, up transition, up dump, down acceleration and down stop, a hydraulic circuit interconnecting said hydraulic control valves, said down level hydraulic control assembly and said up level control assembly, said hydraulic control valves and assemblies having adjusting elements responsive to manual adjustment, manual adjusting elements respectively for said bypass valve elements and said combination valve element, all of said adjusting elements being located on and accessible from one side of said housing.

9. A unit valve for control of a hydraulic elevator comprising an up transition valve assembly, a housing having an up level chamber and a bypass chamber therein, an up level valve element in said chamber separating said chamber into a first up level cavity and a second up level cavity, and a valve seat between said cavities in operating relationship with said up level valve element, a bypass valve element separating said bypass chamber into a first bypass cavity and a second bypass cavity, a supply means for hydraulic fluid under pressure to said first up level cavity, a bypass passage from said first up level cavity to said first bypass cavity and a passage from said second up level cavity to pass fluid to said elevator, an up level valve assembly comprising a tubular jacket in said housing in axial alignment with said up level valve element, a spool slidably mounted in said jacket and secured to said up level valve element, said spool having a bore therethrough communicating between said first up level cavity and the interior of said tubular jacket, an annular hollow neck within said tubular jacket and surrounding a portion of said spool, means forming an exterior annular space around said neck and a passage between said space and said second bypass cavity, a port through the wall of said neck communicating between said space and the interior of said tubular jacket, a reduced portion of said spool including a progressively variable port restricting portion, said reduced portion being movable with said spool in response to movement of said up level valve element to present different portions thereof to said port whereby to vary the capacity of said port to pass hydraulic fluid, and a hydraulic line communicating between said exterior annular space and said up transition valve assembly.

10. In a hydraulic elevator control system including a pump, a ram, a reservoir and valves for upward and downward control of said ram, the combination of an up level valve assembly comprising a housing having a chamber and an up level valve element on a valve seat separating said chamber into first and second up level cavities, said valve assembly comprising a casing having a space therein opposite portions of which are in communication respectively with a bypass valve assembly and an up transition valve assembly, one portion of said space being an interior space and another portion of said space being an exterior space, a port interconnecting said interior and exterior spaces, and a spool having a part thereof of progressively varying configuration adjacent said port, and means for shifting said part whereby to vary the passages of fluid between said interior and exterior spaces.

11. A system as in claim 10 wherein said interior and exterior spaces are concentric annular spaces.

12. A system as in claim 10 wherein an end of said spool has a sliding sealed fit in said interior space and forms a cavity, and a bore through said spool in communication respectively with said cavity and one of said up level cavities.

13. A system as in claim 12 wherein said spool is mounted on and carried by said up level valve element.

14. A unit valve assembly for operation of a hydraulic elevator ram comprising a housing having a plurality of valve chambers therein, a bypass valve having a bypass valve element intermediate opposite bypass cavities in one of said chambers, an up level valve having an up level valve element intermediate opposite up level cavities in another of said chambers, and a combination down level and down main valve having a combination valve element intermediate opposite combination cavities in still another of said chambers, a bypass outlet from one of said bypass cavities, a supply of fluid under pressure to one of said up level cavities, and a passage in said housing in communication

between said last two cavities and subject to control by said bypass valve, a down close and stop valve assembly in communication with said ram and with said down level and main valve assembly, and an electrically initiated hydraulic control valve for down acceleration, said hydraulic control valve for down acceleration and said down close and stop valve assembly each having a variable orifice therein and manual adjusting means for said orifice, whereby to control full down speed operation of said ram.

15. A system as in claim 14 including a reservoir for fluid from said valve assembly, a hydraulic discharge line between said hydraulic valve for down acceleration and said reservoir, an auxiliary hydraulic line from one of said combination cavities on an outflow side of said combination down level and down main valve, and a poppet valve in the hydraulic discharge line, said poppet valve being in communication with said auxiliary line, whereby to limit down speed of said ram by control of flow through said discharge line.

16. A system as in claim 15 including a manual control on said poppet valve whereby to set the limit of operation of said poppet valve and the top down speed of said ram.

17. A valve assembly for operation of a hydraulic elevator ram comprising a housing having a plurality of valve chambers therein, a combination down level and down main valve having a combination valve element intermediate opposite combination cavities in one of said chambers, a down close and stop valve assembly in communication with said ram and with said down level and main valve assembly, and an electrically initiated hydraulic control valve in communication with the outlet side of said down close and stop valve assembly for down acceleration, said hydraulic control valve for down acceleration and said down close and stop valve assembly each having a variable orifice therein, whereby to control full down speed operation of said ram, and a loaded down speed control poppet valve assembly having one line of communication with the outlet side of said hydraulic control valve and having another line of communication with the outlet side of said combination down level and down main valve, whereby to modify the full down speed operation of said ram under load.

18. A valve as in claim 17 wherein there is a valve stem for the poppet valve and a valve element and valve seat operatively associated with said stem, chambers in said valve on opposite sides of said valve seat, one of said chambers being in communication with the outlet side of said hydraulic control valve and the other of said chambers being in communication with the outlet side of said combination down level and down main valve.

19. A valve as in claim 18 wherein there are resilient means respectively of greater and lesser bias operatively associated with said stem on opposite sides of said poppet valve and acting in opposite directions whereby to normally bias the poppet valve toward open position.

20. A valve as in claim 19 wherein there is a diaphragm on the stem, a diaphragm chamber surrounding said diaphragm and separated by said diaphragm into a closed diaphragm cavity and an open diaphragm cavity, the resilient means of greater bias being in the closed diaphragm cavity, said open diaphragm cavity being in communication with the outlet side of said down level and down main valve.

21. In a valve assembly for operation of a hydraulic elevator ram comprising a housing having a plurality of valve chambers, a bypass valve element in one of said chambers separating said chamber into first and second bypass cavities, an up level valve element separating another of said chambers into first and second up level cavities, and a combination down level and down main valve element separating still another of said chambers into first and second combination cavities, communicating means in said housing between said chambers, a poppet valve assembly having a valve element therein located on said housing, and a control valve for down acceleration on said housing, opposite sides of said poppet valve being in communication respectively with the outlet side of the control valve for down acceleration and the outlet side of the combination down level and down main valve element, and adjusting means for a majority of said valve elements located on substantially one side of said housing.

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