Oct. 9, 1962 W. M. RUSSELL ET AL 3,057,160

HYDRAULIC ELEVATOR CONTROL SYSTEM

Filed March 28, 1960 3 Sheets-Sheet 1

FIG. 1

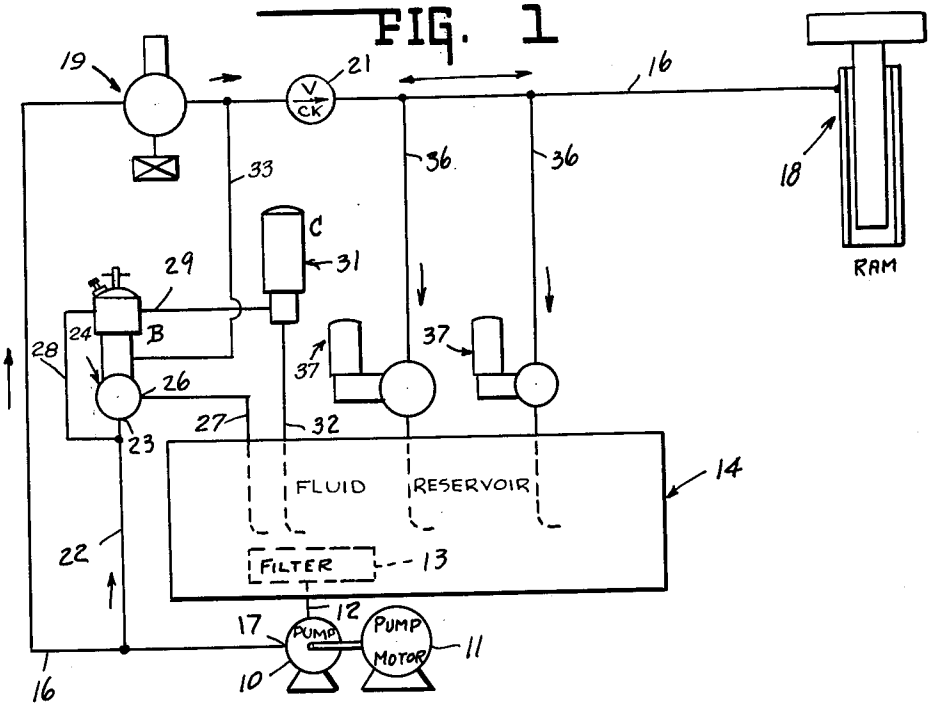
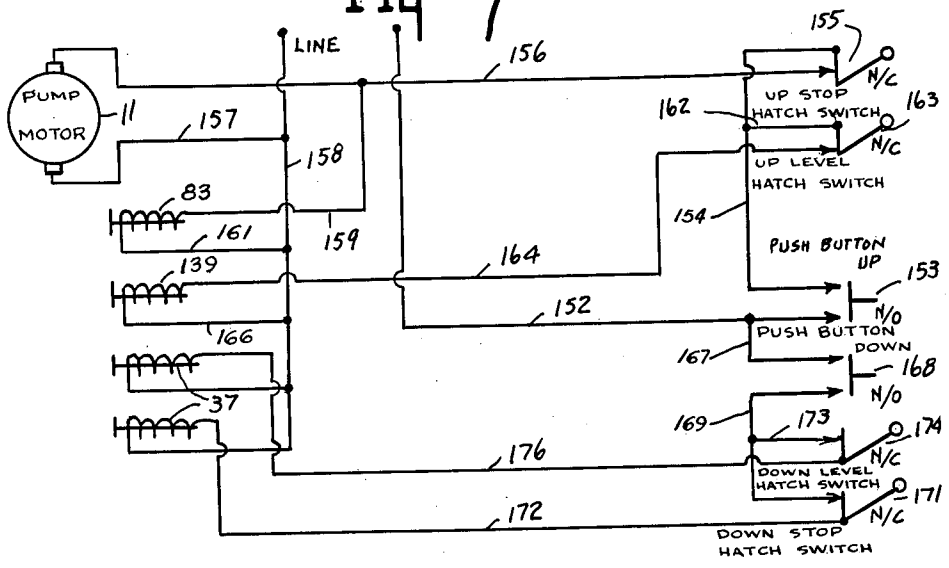


FIG 7



INVENTORS.
WILLIAM M. RUSSELL.
BY A. P. WILLIAM LAWRENCE.
Lockwood, Woodard, Smith & Weikart.
ATTORNEYS.

Oct. 9, 1962 W. M. RUSSELL ET AL 3,057,160

HYDRAULIC ELEVATOR CONTROL SYSTEM

Filed March 28, 1960 3 Sheets-Sheet 2

FIG. 2

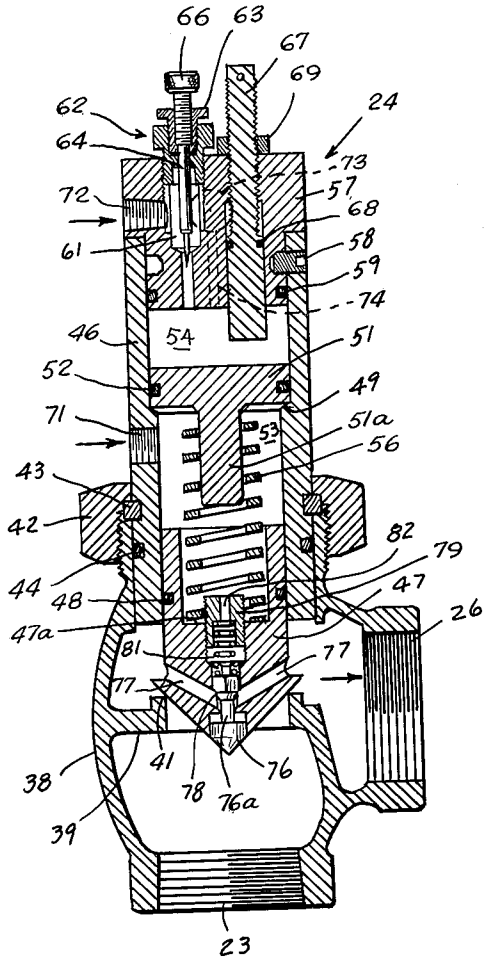


FIG. 3

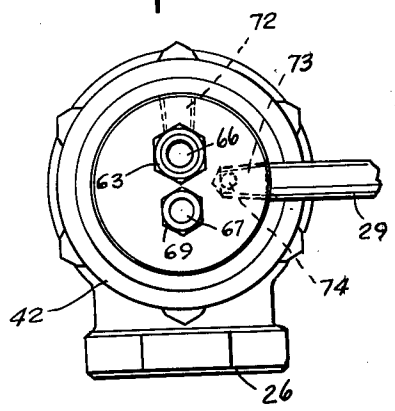
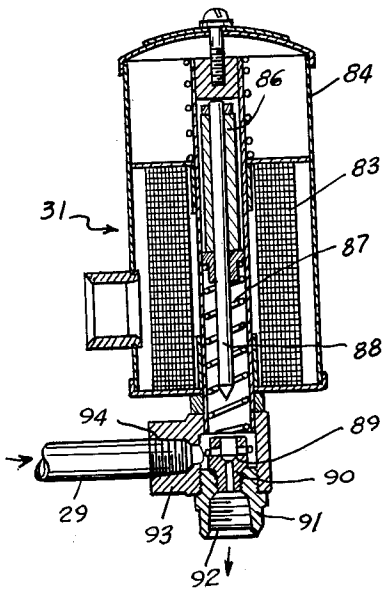


FIG. 4



INVENTORS.
WILLIAM M. RUSSELL.
A. P. WILLIAM LAWRENCE.

BY

Lockwood, Woodard, Smith & Weikart.
ATTORNEYS.

Oct. 9, 1962 W. M. RUSSELL ET AL 3,057,160

HYDRAULIC ELEVATOR CONTROL SYSTEM

Filed March 28, 1960 3 Sheets-Sheet 3

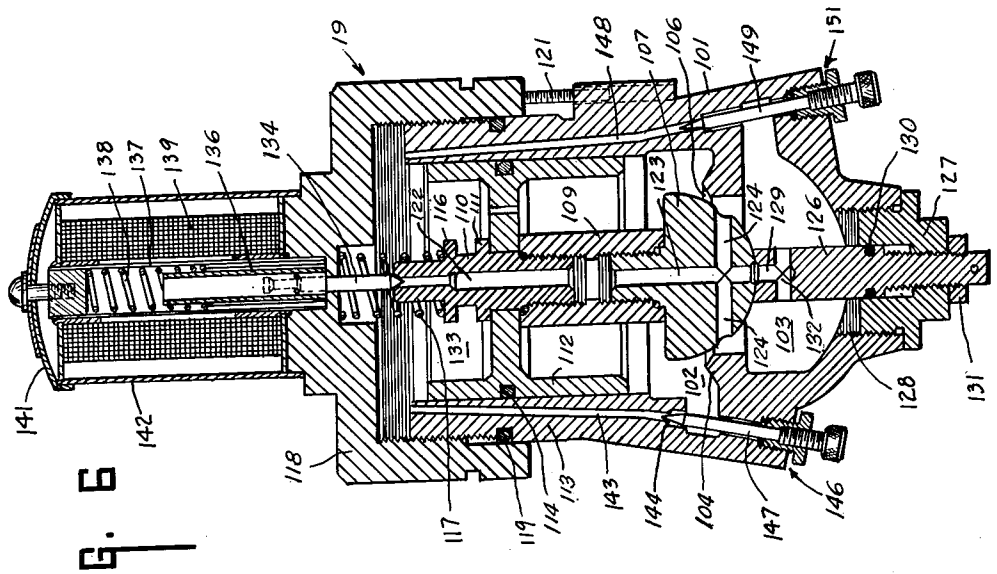


FIG. 6

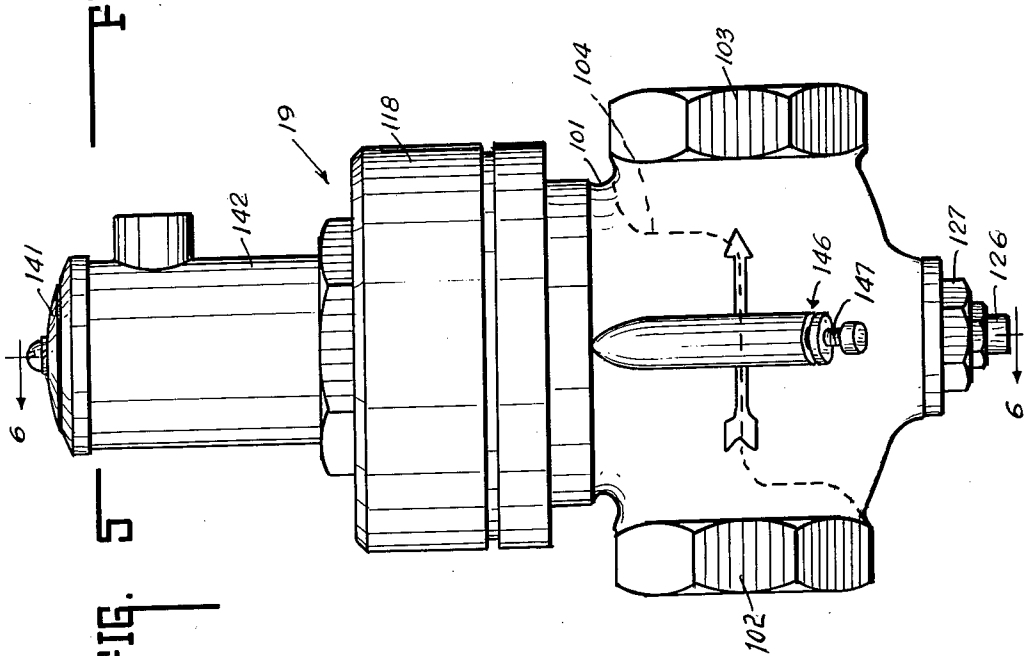


FIG. 5

INVENTORS.
WILLIAM M. RUSSELL,
A. P. WILLIAM LAWRENCE.
BY
Lockwood, Woodard, Smith & Weikart.
ATTORNEYS.

United States Patent Office 3,057,160 Patented Oct. 9, 1962

3,057,160

HYDRAULIC ELEVATOR CONTROL SYSTEM

William M. Russell and Anthony P. W. Lawrence, Indianapolis, Ind., assignors to J. D. Gould Company, Indianapolis, Ind., a copartnership

Filed Mar. 28, 1960, Ser. No. 18,160
10 Claims. (Cl. 60—52)

This invention relates generally to control systems for hydraulically-operated ram type elevators, and particularly to a system for accomplishing two-speed leveling and stopping of the ram as it moves in the up direction.

In conventional practice several methods are utilized for up-leveling a hydraulic elevator. The more common of these requires raising the elevator car somewhat above the floor level at which it is to be stopped and then lowering the car to the proper floor level by means of the downward motion control valves. This system was used primarily because pressure variations due to the various loads on the elevator car affect the control accuracy much less in the downward movement of the car.

The system of the present invention provides a two-way up-leveling control arrangement, that is, the system accomplishes an accurate leveling of the elevator car while moving only in the up direction independently of the loading of the elevator car. The system incorporates various valves and hydraulic connections so as to start the elevator car from rest in the up direction with a gradually accelerated motion until full up speed is reached. As the car reaches a predetermined point below the desired floor level, the car is decelerated to a constant, predetermined leveling speed and is then stopped at the floor level. The system maintains a constant leveling speed as the elevator car approaches its stop position independently of the load on the elevator.

The fundamental component in the system is a multiple position flow restricting means which meters the flow of hydraulic fluid to the elevator ram. Conventional practice utilizes one or more bypass valves to divert a portion of the hydraulic fluid pump capacity from the elevator ram when the lower speed is desired. Since the flow rate through a given valve or restriction varies as the pressure drop across the valve, varying loads on the elevator cause variation in the system pressure and, therefore, cause the conventional bypass valves to admit a greater amount of fluid at increased loads and a lesser amount of fluid at decreased loads. The system of the present invention maintains a substantially constant pressure drop across the flow restricting means which meters fluid to the ram and thus provides the elevator with a constant speed regardless of the load on the elevator. The system further includes means to start the elevator with gradual acceleration to full speed and to slow to levelling speed as required. The system further includes means to bypass back to the hydraulic fluid reservoir the full flow capacity of the pump so as to halt the elevator accurately at the desired floor level.

The control system utilizes a positive displacement hydraulic fluid pump whose suction side is connected to a hydraulic fluid reservoir. The discharge side of the pump is connected through a spring-loaded check valve to the elevator ram. The multi-position flow restricting means is interposed in the hydraulic line between the pump and the check valve. A bypass valve is connected into a hydraulic line leading from the pump discharge side to the fluid reservoir. Initially when the pump is started the total flow is bypassed through the bypass valve to the reservoir. At an adjustably timed period thereafter the bypass valve closes, starting gradually accelerated flow to the elevator ram and the car moves upward at a uniform speed. At a predetermined point below the desired floor level for the car the flow restricting means is moved to a position in which the flow to the elevator ram is throttled and the car is slowed to leveling speed. As the flow restricting means throttles flow to the ram, the bypass valve opens sufficiently to maintain a predetermined pressure drop across the flow restricting means and this pressure drop is maintained substantially constant independently of the loading of the elevator car. The car is thus provided with a constant speed in the leveling zone. At the desired stopping point for the car the bypass valve is completely opened to bypass the full capacity of the pump to the reservoir, and the pump drive motor is simultaneously de-energized. Any coasting of the motor, pump and accompanying mechanical components is absorbed in pumping fluid to the reservoir and does not affect the accuracy of the elevator stop.

The primary object of the present invention is, therefore, to provide a hydraulic control system for a ram type hydraulic elevator or other positioning means in which a multi-position flow restricting means is utilized to meter flow to the elevator ram. To provide the desired ram speed, the pressure drop across the flow restricting means, and consequently the speed of the elevator is maintained substantially constant independently of the loading of the elevator.

A further object of the present invention is to provide a system of the type referred to which includes means to start the elevator with gradual acceleration to full speed, to slow the elevator to leveling speed, and to stop the elevator at a given point accurately and constantly, regardless of car load or system pressure.

A further object of the present invention is to provide a bypass valve adapted to be utilized in the elevator control system, the valve having a pressure responsive actuator for operation thereof, resilient means biasing the valve closure toward closed position, and pressure responsive means for removing the bias of the resilient means for the valve closure.

A further object of the present invention is to provide a bypass valve of the type referred to having means responsive to abnormally high pressure at the bypass valve inlet for passing fluid even though the valve closure is in closed position.

A further object of the present invention is to provide a multi-position flow restricting means operated by an electrically energized pilot valve and having adjustable means for timing the period between assumption of its minimum flow position and the energization of its pilot operator.

The full nature of the invention will be understood from the accompanying drawing and the following description and claims:

FIG. 1 is a schematic view of the hydraulic system of the present invention.

FIG. 2 is a side sectional view of the bypass valve component of the system.

FIG. 3 is a top plan view of the valve of FIG. 2.

FIG. 4 is a side sectional view of a solenoid operated pilot valve forming a component of the system of FIG. 1.

FIG. 5 is a side view of the multi-position flow restricting means or valve which is a part of the system of FIG. 1.

FIG. 6 is a sectional view taken generally along the line 6—6 of FIG. 5.

FIG. 7 is a schematic wiring diagram of the electrical connections for the system.

Referring initially to FIG. 1 the system includes a conventional, positive displacement pump **10** driven by an electric motor **11**. The suction line **12** of the pump communicates through a filter **13** with a hydraulic fluid reservoir indicated generally at **14**. A primary hydraulic line **16** joins the pump discharge line **17** with a con-

ventional elevator-operating hydraulic ram indicated generally at **18**. The line **16** has interposed therein a flow restricting means indicated generally at **19**, and, downstream thereof a check valve **21**. A hydraulic line **22** connects the line **16** to the inlet passage **23** of a bypass valve generally indicated at **24**. The outlet passage **26** of the valve **24** communicates with the fluid reservoir by means of a line **27**.

A line **28** connects the line **22** to a chamber within the valve **24** to be subsequently described. A line **29** provides communication between this internal chamber and the inlet side of a pilot valve **31**. The outlet side of the pilot valve **31** is connected by means of a line **32** to the fluid reservoir. A hydraulic line **33** provides communication between a further chamber within valve **24**, to be subsequently described, and a point in the primary line **16** between the flow restricting means **19** and the check valve **21**.

One or more return lines **36** provide communication between the primary line **16** and the fluid reservoir downstream of the check valve **21**. Interposed in these return lines are control valves **37** which are utilized to control the downward movement of the elevator car. Control of the downward motion of the elevator car is not the subject of the present invention and the valves **37** are therefore not disclosed herein in detail. They may take the form of the valve disclosed and claimed in Russell Patent 2,926,882, issued March 1, 1960, and assigned to the assignee of the present invention.

Referring to FIGS. 2 and 3, the construction of the bypass valve **24** will now be described in detail. The valve structure includes a valve body **38** having the inlet passage **23** and the outlet passage **26**. As will be evident from FIG. 1, the inlet passage communicates with the line **22** and the outlet passage communicates with the line **27** to the fluid reservoir. The passages are separated by a bridge **39** having an aperture therein bounded by a valve seat **41**. The upper end of the body is threaded to receive a bonnet nut **42** which, by means of a clamp ring **43** and sealing ring **44**, supports a cylindrical element **46** on the valve body. Reciprocable within the lower end of the element **46** is a piston valve or closure member **47** whose lower end is conically shaped and cooperates with the valve seat **41**. An O-ring **48** provides a seal between the member **47** and the adjacent sides of the element **46**. The central bore within the element **46** is enlarged at its upper end to provide a shoulder **49**, the shoulder providing a downward limit for a piston **51** reciprocable within the enlarged upper portion of the bore. A sealing ring **52** carried by the piston **51** engages adjacent sides of the element **46**. The piston **51** thus divides the central bore in the element **46** into a two-way ram pressure chamber **53** and a pump pressure chamber **54**. A central downwardly-extending portion **51***a* of the piston **51** retains a helical compression spring **56** which at its upper end bears against the piston and at its lower end bears against the inset face **47***a* of the closure member **47**.

The upper end of the element **46** has a cap or closure **57** which is rigidly secured in place by means of lock screws as indicated at **58**. A sealing ring **59** seals off the upper end of the element **46**. The cap **57** is provided with a vertical passage **61** which communicates with the chamber **54**, the cap being threaded adjacent the upper end of the passage to accommodate the needle valve assembly **62**. The needle valve assembly is of conventional type and includes a lock nut **63**, and a needle **64** having a knurled head **66**. The lower end of the needle cooperates with a reduced-diameter portion of the passage **61** to provide an adjustable restriction in the passage. The cap **57** is further provided with a threaded aperture which accommodates an adjustment screw **67** which extends through the cap and into the chamber **54** and O-ring **68** seals the entry of the screw and a lock nut **69** clamps the screw in adjusted position.

The central portion of the element **46** is provided with a radially-extending threaded aperture **71** which accommodates a fitting (not shown) for securing the line **33** (FIG. 1) thereto. The aperture **71** thus provides for the introduction of ram pressure, that is, the pressure downstream of the flow restricting means **19**, into the chamber **53**. The cap **57** is provided with a radially extending threaded aperture **72** which receives a fitting (not shown) coupling the line **28** (FIG. 1) to the passage **61**. The aperture **72** thus introduces pump pressure into the upper portion of the passage **61**. The fluid flow resulting from this pressure must pass the restriction provided by the needle **64** before entering the chamber **54**. Any changes in pump pressure thus are reflected in the chamber **54**, but only after a time delay which is proportional to the adjustment of the needle **64**. As indicated in FIG. 3, the cap **57** is provided with a further radially extending aperture **73** which communicates with a vertical passage **74** formed in the cap and terminating at the chamber **54**. The aperture **73** accommodates the line **29** (FIG. 1), this hydraulic line extending to the inlet passage of the pilot valve **31** shown in detail in FIG. 4.

A high pressure relief valve structure is provided in the closure member **47** and includes a piston **76** reciprocable within an axial aperture in the closure member. The closure member aperture is connected with the annular extending passages **77** communicating with the central aperture and a conically-shaped valve member **78** closes the central aperture against the passages **77**. The valve member **78** accommodates a portion of the reduced upwardly-extending end **76***a* of the piston **76** and its upper portion is four-sided to provide communication between the upper portion of the central aperture through the element **47** and the inclined passages **77** when the piston moves the member **78** upwardly. A threaded adjusting member **79** seats a compression spring **81** whose lower end bears against the member **78** and urges it downwardly into closed position. An axial passage **82** in the member **79** provides communication to the chamber **53**. Adjustment of the position of the member **79** with relation to the member **47** thus varies the force exerted by the spring **81** and adjusts the pressure in the inlet passage **23** required to move the piston **76** sufficiently to unseat the member **78**. Unseating of the member **78** relieves the pressure in the chamber **53** and permits the now unbalanced pressure in the inlet passage **23** to move the member **47** upwardly to unload the pump.

Referring now to FIG. 4, the pilot valve **31** will be described in detail. The pilot valve **31** is of conventional type and includes an electrically energized coil **83** accommodated within a housing **84**. The coil axially accommodates a magnetic plunger **86** which is urged upwardly by a spring **87**. The plunger carries a valve closure member **88** whose lower end cooperates with the frusto-conically shaped valve seat **89**. The seat **89** is formed in a fitting **90** threaded into an element **91** which is apertured to provide the outlet passage **92** for the valve. The element **91** is threaded into a valve body element **93** which is apertured to provide the inlet passage **94** for the valve **31**, this passage communicating with the hydraulic line **29**. The pilot valve **31** is of the normally open type and when the coil **83** is de-energized fluid may flow freely between the inlet passage **94** and the outlet passage **92**. When the valve is energized, the plunger **86** and closure member **88** are moved outwardly so that the closure member shuts off the flow of fluid through the valve. The outlet passage **92** of the pilot valve communicates with the hydraulic line **32** (FIG. 1) to the fluid reservoir.

The flow restricting means or metering valve **19** will now be described with reference to FIGS. 5 and 6. The valve includes a body portion **101** having an inlet chamber **102** and an outlet chamber **103**. The inlet chamber and outlet chamber are separated by a bridge **104** which is apertured to provide a valve seat **106**. Cooperating with the valve seat is a valve closure **107** having a thread-

ed portion received within a sleeve 109. The upper end of the sleeve accommodates an element 110 having an annular flange 111 which serves to clamp the piston 112 to the stem formed by the sleeve 109 and the element 110. The piston is slidably received within the central bore of the upper tubular portion 113 of the valve body 101, a seal being maintained between the piston and the bore by means of an O-ring 114. The element 110 is further provided with an annular flange 116 which supports one end of a compression spring 117, the upper end of the spring 117 engaging the base of a central, depressed portion of a bonnet or cap 118. The cap is threadedly received upon the upper end of the valve body portion 113, an O-ring maintaining a seal therebetween. A set screw 121, threaded through an aperture in the valve body and engaging the lower margin of the cap 118, determines the depth to which the valve body portion 113 may enter the cap 118.

A central passage 122 extends through the element 110 and an aligned passage 123 extends through the valve closure 107. Sidewardly extending passages 124 in the valve closure communicate with the passage 123. The lowermost position of the valve closure is determined by a stem or abutment 126 which is threaded through and extends exteriorly of a plug 127. The plug is received within a threaded aperture 128 at the base of the valve body 101. An O-ring 130 provides a seal between the stem and the plug. A lock nut 131 threaded on the extending portion of the stem locks the stem in adjusted position. The stem is provided with a central passage 129 which communicates with a sidewardly extending passage 132. As may be seen in FIG. 6, when the closure member 107 is in engagement with the stem 126, the passage 123 is aligned with the passage 129.

Communication between the chamber 133, located above the piston 112, and the passage 122 is prevented by a closure member 134 which engages the beveled upper end of the element 110. The closure member has a conventional, lost-motion connection with a magnetically permeable plunger 136 which is reciprocable within a non-permeable sleeve 137, the plunger being urged to its lowermost position within the sleeve by means of a compression spring 138. Mounted on the cap 118 and enclosing the sleeve 137 is a solenoid coil 139. A conventional cap 141 and housing body 142 enclose the solenoid. The arrangement of the solenoid coil and the closure member 134 is such that when the coil is de-energized, as shown in FIG. 6, the closure member blocks the upper end of the passage 122. When the coil 139 is energized, the closure member 134 is lifted from the upper end of the passage 122 and communication is established with the chamber 133.

Extending through one side of the valve body 101 is a passage 143 whose upper end communicates with the chamber 133 and whose lower end is beveled to provide a throttling aperture 144 communicating with the valve inlet chamber 102. Cooperating with the throttling aperure is a conventional needle valve assembly 146 which includes an adjustable, positionable stem 147. The stem cooperates with the throttling aperture to obstruct flow from the chamber 102, through the passage 143, and into the chamber 133. On the opposite side of the valve housing there is provided a similar passage 148 whose upper end communicates with the chamber 133 and whose lower end is closed by the tapered end of an adjustable stem 149, forming a part of a conventional needle valve assembly 151.

As will be evident from FIG. 6, with the inlet chamber 102 accommodating hydraulic fluid under pressure and with the passage 122 blocked by the closure member 134, the structure in the chamber 133 will be at the same pressure as the structure in the chamber 102, that is, the pressure on opposite sides of the piston 112 will be equal. Under these conditions, the spring 117 will hold the closure member 107 against the stem 126, that is, in its lowermost position, as shown in FIG. 6. Upon energization of the solenoid coil 139, the closure member 134 will be moved upwardly to open the pasage 122, relieving the pressure in the chamber 133 above the piston. The piston will thereupon be moved upwardly until it engages the inner, end face of the cap 118, thereby moving the closure member 107 into its uppermost position. Upon subsequent de-energization of the coil 139, the closure member 134 will close the passage 122 whereupon the pressure in the chamber 133, above the piston will rise to the pressure of the inlet chamber 102, permitting the spring 117 to return the closure member 107 to its lowermost position. The time interval between closure of the passage 122 by the member 134 and the engagement of the closure member 107 with the stem 126 is determined by the position of the stem 147 with relation to the throttling aperture 144 of the passage 143. Adjusing the stem 147 inwardly increases the time interval and adjusting it outwardly away from the aperture 144 decreases the time interval.

The stem 149 provides a manual means for establishing communication between the chamber 133 above the piston and the outlet chamber 103 and is intended for emergency use only, that is, under conditions wherein, for example, the solenoid coil 139 is disabled or its circuit broken so that it cannot be energized.

The electrical interconnection between the system components will now be described with reference to FIG. 7. One side of the electrical source of power is connected by means of the input line 152 to one side of a normally open push button switch 153 physically located in the elevator car. The other side of the switch 153 is connected by means of a wire 154 to one side of a normally closed, up-stop switch 155. The switch 155 is cammed into open position as the elevator car reaches the proper stop level during its upward travel. The other side of the switch 155 is connected by means of a wire 156 to the pump motor 11, the motor being further connected by means of a wire 157 to an input line 158. A wire 159 connects one side of the pilot valve coil 83 to the wire 156, the other side of the coil 83 being connected by means of a wire 161 to the input line 158. The wire 154 is connected by means of a wire 162 to one side of a normally closed up-level switch 163.

The switch 163 is cammed to open position as the elevator car reaches the leveling zone in its upward travel and prior to the opening of switch 155. The other side of the switch 163 is connected by means of a wire 164 to one side of the solenoid coil 139 incorporated in the flow restricting valve 119. The other side of the coil 139 is connected by means of a wire 166 to the input line 158. The wire 152 is connected by means of a wire 167 to one side of a normally open, push button, down switch 168 which is physically located in the elevator car. The other side of the switch 168 is connected by means of a wire 169 to one side of a normally closed, down-stop switch 171. The switch 171 is cammed to open position as the elevator car reaches the desired stop level in its downward motion. The other side of the switch 171 is connected by means of a wire 172 to one side of one of the operating coils for the control valves 37. The wire 169 is connected by means of a wire 173 to one side of a normally closed, down-level switch 174. The switch 174 is cammed to open position as the elevator car reaches the leveling zone in its downward travel and prior to the opening of the switch 171. The other side of the switch 174 is connected by means of a wire 176 to the solenoid operating coil of another of the control valves 37. All of the control valves 37 are connected to the input line 158 by appropriate wiring.

As previously mentioned, since the downward leveling of the elevator car or ram is not a part of the present invention, the function of the switches 168, 174 and 171 and the functioning of the control valves 37 is not described in detail herein. It will be understood that FIG. 7

is a schematic illustration only, and the various control components might be placed in a low voltage circuit and the pump might be provided with three phase power and controlled through an appropriate relay arrangement. Further, it will be understood that the normally open push button switch 153 is provided with suitable hold-in contacts so that the switch push button need be only momentarily actuated to maintain its contacts in closed condition, opening of the up-stop switch 155 serving to return the contacts of the switch 153 to open position.

Operation

The operation and adjustment of the system, with primary reference to FIGS. 1 and 7, will now be described. With the electrical circuit in a quiescent state as indicated in FIG. 7, all of the solenoid operating coils and the pump motor will be deenergized, the energizing circuit being broken at the switch 153. Since the pilot valve operator coil 83 is deenergized this valve will be open and the pressure above the piston 51 of the bypass valve 24 will be relieved. The piston valve 47 will therefore be in its upper position, that is, displaced away from the valve seat 41. Manual closure of the push button upswitch 153 energizes the pilot valve coil 83 and also energizes a coil 139 which is incorporated in the flow restricting valve 19 together with the motor pump 11. The pump pressure is thereupon developed by the pump. However, the full flow capacity of the pump is initially bypassed through the open valve 24 to the fluid reservoir 14. Energization of solenoid coil 83 closes pilot valve 31 and this closure causes the pressure in the chamber 54, acting upon the piston 51 in the valve 24, to build up. The rate of build-up of pressure in the chamber 54 is determined by the rate of admission of fluid through the line 28 into the chamber 54. This rate of fluid admission is dependent upon the adjustment of the needle 66 forming a part of the needle valve assembly 62 (FIG. 2). The timed increase of pressure in the chamber will cause the piston valve 47 to move downwardly and approach its seat 41. As the piston valve 47 approaches its seat, hydraulic fluid flow is diverted to the main line 16 and, since the solenoid coil 139 of the flow restricting valve 19 is energized, the piston 112 of the valve 19 will be moved to its uppermost position, removing the valve closure 107 away from its seat 106. Hydraulic fluid is thereupon admitted through valve 19 from the inlet chamber 102 to outlet chamber 103 to the check valve 21 and to the ram 18, starting the upward movement of the ram. It will be noted that the elevator car does not attain full velocity until the bypass cycle of the valve 24 is completed and the rate of acceleration of the car from immobility to full upward velocity is determined by the adjustment of the needle valve 62. It should be noted that the valve 19 meters the flow directly to the ram 18. The position of the cap 118 of the valve 19 is adjusted with relation to the valve body portion 113 so as to fix the upper position of the valve closure 107 at a point where the valve 19 will pass 100% of the pump capacity at an inlet to outlet pressure differential or pressure drop of the order of 40 to 50 p.s.i.g., this pressure differential being necessary to insure proper valve response.

As the elevator car travels upwardly it will eventually enter the up-leveling zone determined by the opening of the up-level switch 163. The opening of switch 163 deenergizes the solenoid coil 139 of the valve 19, permitting the closure member 134 to move to its position of FIG. 6, closing the passage 122. This causes the pressure in the chamber 133 above the piston 112 in the valve 19 to build up. Increase in pressure in the chamber 133, that is, the equalization of the pressure on opposite sides of the piston 112 causes the member 107 to move toward its extreme lower position of FIG. 6. This downward motion of the valve member 107 decreases the flow of fluid to the elevator ram and slows the car to a leveling speed whose ultimate magnitude is determined by the adjusted position of the stem 126 which fixes the lowermost position of the member 107. The rate of deceleration from full up velocity to leveling zone velocity of the car is determined by the adjustment of the needle 147 with relation to the aperture 144 in the passage 143. This will be evident from FIG. 6, wherein it will be noted that the rate of pressure build-up in the chamber 133, above the piston 112, upon closure of the passage 122 is determined by the degree of obstruction of the passage 143.

As the valve member 107 of the valve 19 approaches its lowermost position, as described above, the pressure in the line 22 (FIG. 1) communicating with the valve 24 begins to rise, that is, the pressure differential across the valve 19 tends to rise. Since the piston valve closure 47 in the bypass valve 24 is held in closed position by ram pressure (introduced into the chamber 53 by means of the line 33 and the aperture 71) plus the force exerted by the spring 56, as the pressure in the line 22 rises the piston valve member 47 will be lifted off its seat so as to bypass through the line 27 to the fluid reservoir sufficient fluid to maintain the pressure drop across the valve 19 at substantially the same value as the pressure drop thereacross prior to movement of the member 107 in the valve 19 to its lowermost position. It should be noted that during the upward motion of the piston valve member 47 the piston 51 remains in its position of FIG. 2 and the relative motion of the valve member 47 with respect to the piston 51 is accommodated by flexure of the spring 56. Because of the reduced flow to the ram, the elevator car proceeds through the leveling zone at a reduced speed. As the car reaches the desired stop-level, the switch 155 is cammed open, breaking the circuit to the pump motor and to the pilot valve operating coil 83. The consequent opening of the pilot valve 31 relieves the pressure in the chamber 54 above the piston 51 in the bypass valve 24, thereby permitting the piston valve member 47 to move to its furthermost open position. This opening of the bypass through the valve 24 to the fluid reservoir simultaneously with shutting down the pump motor permits any coasting of the pump and associated mechanical parts to merely pump fluid to the reservoir rather than increasing the flow in the line 16.

As previously mentioned, the needle valve 62 in the bypass valve 24 determines the magnitude of the acceleration of the elevator car from immobility to full-up velocity. The adjusting screw or stem 67 determines the pilot pressure or minimum pressure. It is preferably adjusted so that it establishes a maximum open position for the bypass valve 24 such that with the elevator car empty and with the pump operating, the elevator car will remain immobile. In the event of an abnormal rise in pressure at the pump discharge line, the piston 76 will be moved upwardly to relieve the pressure in the chamber 53 and thereby permit the unbalanced pressure in the inlet chamber 23 of the valve 24 to move the member 47 upwardly to unload the pump. It will be noted that the system of the present invention provides a two-position orifice or flow restriction which meters hydraulic fluid flow directly to the ram. The change in flow of the fluid to the ram and the resulting increase in pressure upstream of the flow restricting or metering valve 19 is compensated by the bypass valve 24 in such fashion as to maintain the pressure drop across the valve 19 at substantially the same value independently of whether the valve 19 is in its minimum flow or maximum flow position. The arrangement is such that the fluid flow to the ram is varied directly to provide variations in car speed. Since the pilot valve 31 is open when de-energized, immediately upon the loss of electrical power to the pilot valve, whether from power failure or from switch actuation, the pilot valve will be opened to permit the bypass valve 24 to relieve the pump. It will be understood that as to the functioning of the system the various components such as the pilot valve 31, bypass valve 24 and flow metering valve 19, might be separated into separate components or might all be collected in a single composite

housing. The scope of the present invention is intended to include any such obvious variations.

While the invention has been disclosed and described in some detail in the drawings and foregoing description, they are to be considered as illustrative and not restrictive in character, as modifications may readily suggest themselves to persons skilled in this art and within the broad scope of the invention, reference being had to the appended claims.

The invention claimed is:

1. A hydraulic control system for positioning the movable element of a fluid motor to operate a ram-type hydraulic elevator or the like comprising a source of hydraulic fluid **14** and a positive displacement pump **10** having its suction side communicating with said source, a primary hydraulic line **16** providing communication between the discharge side of said pump and said fluid motor **18**, flow restricting means **19** interposed in said primary line for metering fluid flow to said fluid motor, said flow restricting means including a throttling member **107** movable between a first position providing maximum fluid flow and a second position providing minimum fluid flow, electrically energizable means **139** operable so as to permit movement of said member to maximum flow position when energized and to minimum flow position when deenergized, a by-pass valve **24** having its inlet side in communication with said primary line at a point upstream from said flow restricting means and having its outlet side communicating with said fluid source, said by-pass valve including a closure member **47** movable to control fluid flow between the inlet and outlet sides of said valve, said by-pass valve further including means providing a first chamber **54** and a second chamber **53** separated by a first movable wall **51**, a second movable wall **47***a* for said second chamber, said closure member being rigidly connected to and movable with said second movable wall, resilient means **56** extending between said first and second movable walls for exerting a biasing force tending to move said closure member to shut off flow between the inlet and outlet sides of said by-pass valve, means **33** providing fluid communication between said second chamber and the downstream side of said flow restricting means, means **28** providing fluid communication between said first chamber and the upstream side of said flow restricting means, and electrically energizable valve means **31** for relieving said first chamber, said last mentioned means comprising a normally open valve providing fluid communication between said first chamber and said fluid source, whereby with said electrically energizable valve means deenergized, the system is in a quiescent state with said by-pass valve returning substantially all of the capacity of said pump back to said source, subsequent energization of said electrically energizable valve means and said electrically energizable means causing said by-pass valve closure member to move to reduce fluid flow through said by-pass valve thus providing fluid flow to said fluid motor as determined by a predetermined pressure drop across said flow restricting means in maximum flow position, subsequent deenergization of said electrically energizable means moving said throttling member to said minimum flow position, the consequent rise in pressure upstream of said flow restricting means causing said by-pass valve closure member to move toward open position to thereby substantially maintain said predetermined pressure drop across said flow restricting means with reduced fluid flow to said fluid motor.

2. A hydraulic control system as claimed in claim 1 having means for adjustably restricting fluid flow through said means providing fluid communication between said first chamber and the upstream side of said flow restricting means whereby adjustment can be accomplished of the rate at which fluid flow through said by-pass valve is reduced upon energization of said electrically energizable valve means and said electrically energizable means.

3. A hydraulic control system for positioning the movable element of a fluid motor to operate a ram-type hydraulic elevator or the like comprising a source of hydraulic fluid and a positive displacement pump having its suction side communicating with said source, a primary hydraulic line providing communication between the discharge side of said pump and said fluid motor, flow restricting means interposed in said primary line for metering fluid flow to said fluid motor, said flow restricting means including a throttling member movable between a first position providing maximum fluid flow and a second position providing minimum fluid flow, electrically energizable means operable so as to permit movement of said member to maximum flow position when energized and to minimum flow position when deenergized, a by-pass valve having its inlet side in communication with said primary line at a point upstream from said flow restricting means and having its outlet side communicating with said fluid source, said by-pass valve including a closure member movable to control fluid flow between the inlet and outlet sides of said valve, said by-pass valve further including pressure responsive means for moving said closure member, means providing fluid communication between said pressure responsive means and both the upstream and downstream side of said flow restricting means, and electrically energizable valve means for relieving said pressure responsive means, said last mentioned means comprising a normally open valve providing fluid communication between said pressure responsive means and said fluid source, whereby with said electrically energizable valve means deenergized the system is in a quiescent state with said by-pass valve returning substantially all of the capacity of said pump back to said source, subsequent energization of said electrically energizable valve means and said electrically energizable means causing said by-pass valve closure member to move to reduce fluid flow through said by-pass valve thus providing fluid flow to said fluid motor as determined by a predetermined pressure drop across said flow restricting means in maximum flow position, subsequent deenergization of said electrically energizable means moving said throttling member to said minimum flow position, the consequent rise in pressure upstream of said flow restricting means causing said by-pass valve closure member to move toward open position to thereby substantially maintain said predetermined pressure drop across said flow restricting means with reduced fluid flow to said fluid motor.

4. A system for controlling the flow of hydraulic fluid to a hydraulically positioned device subjected to loads of various magnitude, comprising a source of hydraulic fluid and a positive displacement pump having its suction side communicating with said source, a hydraulic line providing communication between the discharge side of said pump and said positioned device, two-position flow restricting means having a flow controlling member movable between maximum flow and minimum flow positions interposed in said line, said flow restricting means having a predetermined pressure drop thereacross when in its maximum flow position, said flow controlling member being movable to its said minimum flow position in response to application of the pressure in said line thereto, first timing means for timing the application of line pressure to said flow control member, and means including a by-pass line for by-passing a portion of the capacity of said pump back to said fluid source when said flow controlling member is in said minimum flow position to thereby substantially maintain said predetermined pressure drop across said flow restricting means whereby the fluid flow to said positioned device is independent of the loading thereof, said last mentioned means further including a pressure responsive valve member responsive to pressure in said line and movable in response to such pressure to obstruct flow through said by-pass line, and second timing means for timing the application of line pressure to said pres-

sure responsive member, whereby the acceleration of said hydraulically positioned device may be varied by said second timing means and the deacceleration thereof may be varied by said first timing means.

5. A system for controlling the flow of hydraulic fluid to a hydraulically positioned device subjected to loads of various magnitude, comprising a source of hydraulic fluid and a pump having its suction side communicating with said source, a hydraulic line providing communication between the discharge side of said pump and said positioned device, two-position flow restricting means having a flow control member movable between maximum flow and minimum flow positions interposed in said line, said flow restricting means having a predetermined pressure drop thereacross when said flow controlling member is in its maximum flow position, said flow controlling member being movable to its said minimum position in response to application of the pressure in said line thereto, first adjustable means for timing the application of line pressure to said flow control member, and means for bypassing a portion of the capacity of said pump back to said fluid source when said flow controlling member is in said minimum flow position to thereby substantially maintain said predetermined pressure drop across said flow restricting means whereby the flow to said positioned device is independent of the loading thereof, said last mentioned means further including a pressure responsive valve member responsive to pressure in said line and movable in response to such pressure to obstruct flow through said by-pass line, and second adjustable means for timing the application of line pressure to said pressure responsive valve member, whereby the acceleration of said hydraulically positioned device may be varied by said second adjustable means and the deacceleration thereof may be varied by said first adjustable means.

6. A hydraulic control system for positioning the movable element of a fluid motor to operate a ram-type hydraulic elevator or the like comprising pressure means supplying hydraulic fluid under pressure, a primary hydraulic line providing communication between said pressure means and said fluid motor, flow restricting means interposed in said primary line for metering fluid flow to said fluid motor, said flow restricting means including a throttling member movable between a first position providing maximum fluid flow and a second position providing minimum fluid flow, electrically energizable means operable to move said member to maximum flow position when energized and to minimum flow position when deenergized, a by-pass valve having its inlet side in communication with said primary line at a point upstream from said flow restricting means and having its outlet side communicating with said pressure means, said bypass valve including a closure member movable to control fluid flow between the inlet and outlet sides of said valve, said by-pass valve further including means providing a first chamber and a second chamber separated by a first movable wall, a second movable wall for said second chamber, said closure member being rigidly connected to and movable with said second movable wall, resilient means extending between said first and second movable walls for exerting a biasing force tending to move said closure member to shut off flow between the inlet and outlet sides of said by-pass valve, means providing fluid communication between said second chamber and the downstream side of said flow restricting means, means providing fluid communication between said first chamber and the upstream side of said flow restricting means, and electrically energizable valve means for relieving said first chamber, said last mentioned means comprising a normally open valve providing fluid communication between said first chamber and said fluid source, whereby with said electrically energizable valve means deenergized the system is in a quiescent state with said by-pass valve dumping substantially all of the fluid flow from said pressure means, subsequent energization of said electrically energizable valve means and said electrically energizable means causing said by-pass valve closure member to move to reduce fluid flow through said by-pass valve thus providing fluid flow to said fluid motor as determined by a predetermined pressure drop across said flow restricting means in maximum flow position, subsequent deenergization of said electrically energizable means moving said throttling member to said minimum flow position, the consequent rise in pressure upstream of said flow restricting means causing said by-pass valve closure member to move toward open position to thereby substantially maintain said predetermined pressure drop across said flow restricting means with reduced fluid flow to said fluid motor.

7. A hydraulic control system as claimed in claim 2 having means for adjustably restricting fluid flow through said means providing fluid communication between said first chamber and the upstream side of said flow restricting means whereby adjustment can be accomplished of the rate at which fluid flow through said by-pass valve is reduced upon energization of said electrically energizable valve means and said electrically energizable means.

8. A hydraulic control system for positioning the movable element of a fluid motor to operate a ram-type elevator or the like comprising a source of hydraulic fluid and pumping means having its suction side communicating with said source, a primary hydraulic line providing communication between the discharge side of said pumping means and said fluid motor, flow restricting means interposed in said primary line for metering fluid flow to said fluid motor, said flow restricting means including a throttling member movable between a first position providing fluid flow of a predetermined magnitude and a second position providing fluid flow of a lesser magnitude, actuating means operable to move said member to said first position when energized and to said second position when deenergized, a by-pass valve having its inlet side in communication with said primary line at a point upstream from said flow restricting means and having its outlet side communicating with said fluid source, said by-pass valve including a closure member movable to control fluid flow between the inlet and outlet sides of said valve, said by-pass valve further including pressure responsive means for moving said closure member, means providing fluid communication between said pressure responsive means and both the upstream and downstream side of said flow restricting means, and valve means for relieving said pressure responsive means by providing fluid communication between said pressure responsive means and said fluid source, whereby with said valve means passing fluid the system is in a quiescent state with said by-pass valve returning substantially all of the capacity of said pumping means back to said source, subsequent blocking of fluid flow by said valve means and operation of said actuating means causing said by-pass valve closure member to move to reduce fluid flow through said by-pass valve thus providing fluid flow to said fluid motor as determined by a predetermined pressure drop across said flow restricting means in said first position, further operation of said actuating means moving said throttling member to said second flow position, the consequent rise in pressure upstream of said flow restricting means causing said by-pass valve closure member to move toward open position to thereby substantially maintain said predetermined pressure drop across said flow restricting means with reduced fluid flow to said fluid motor.

9. A system for controlling the flow of hydraulic fluid to a hydraulically positioned device subjected to loads of various magnitude, comprising a source of hydraulic fluid and pumping means having its suction side communicating with said source, a hydraulic line providing communication between the discharge side of said pumping means and said positioned device, a multi-position flow restricting means interposed in said line and having a flow control member movable between a first position

permitting flow of a predetermined magnitude and at least one further position permitting flow of a lesser magnitude, said flow restricting means having a predetermined pressure drop thereacross when said flow control member is in its first position, said flow controlling member being movable to its said further position in response to application of the pressure in said line thereto, first adjustable means for timing the application of line pressure to said flow control member, and means for bypassing a portion of the capacity of said pump back to said fluid source when said flow controlling member is in its said further position to thereby substantially maintain said predetermined pressure drop across said flow restricting means whereby the fluid flow to said positioned device is independent of the loading thereof, said last mentioned means further including a pressure responsive valve member responsive to pressure in said line and movable in response to such pressure to obstruct flow through said by-pass line, and second adjustable means for timing the application of line pressure to said pressure responsive valve member, whereby the acceleration of said hydraulically positioned device may be varied by said second adjustable means and the deacceleration thereof may be varied by said first adjustable means.

10. A hydraulic control system for positioning the movable element of a fluid motor to operate a ram-type hydraulic elevator or the like comprising a source of hydraulic fluid and a positive displacement pump having its suction side communicating with said source, a primary hydraulic line providing communication between the discharge side of said pump and said fluid motor, flow restricting means interposed in said primary line for metering fluid flow to said fluid motor, said flow restricting means including a throttling member movable between a first position providing maximum fluid flow and a second position providing minimum fluid flow, electrically energizable means operable so as to permit movement of said member to maximum flow position when said electrically energizable means is actuated in one sense and to minimum flow position when actuated in the opposite sense, a by-pass valve having its inlet side in communication with said primary line at a point upstream from said flow restricting means and having its outlet side communicating with said fluid source, said by-pass valve including a closure member movable to control fluid flow between the inlet and outlet sides of said valve, said by-pass valve further including pressure responsive means for moving said closure member, means providing fluid communication between said pressure responsive means and both the upstream and downstream side of said flow restricting means, and electrically energizable valve means for relieving said pressure responsive means, said last mentioned means comprising a valve providing fluid communication between said pressure responsive means and said fluid source, whereby with said electrically energizable valve means actuated in one sense the system is in a quiescent state with said by-pass valve returning substantially all of the capacity of said pump back to said source, subsequent actuation of said electrically energizable valve means in the opposite sense and said electrically energizable means in its said one sense causing said by-pass valve closure member to move to reduce fluid flow through said by-pass valve thus providing fluid flow to said fluid motor as determined by a predetermined pressure drop across said flow restricting means in maximum flow position, subsequent actuation of said electrically energizable means in its said opposite sense moving said throttling member to said minimum flow position, the consequent rise in pressure upstream of said flow restricting means causing said by-pass valve closure member to move toward open position to thereby substantially maintain said predetermined pressure drop across said flow restricting means with reduced fluid flow to said fluid motor.

References Cited in the file of this patent

UNITED STATES PATENTS

2,102,865	Vickers	Dec. 21, 1937
2,331,026	Harrington	Oct. 5, 1943
2,694,544	Hall	Nov. 16, 1954
2,815,921	Bigelow	Dec. 10, 1957
2,894,525	Erickson	July 14, 1959
2,905,190	Oyster	Sept. 22, 1959