Aug. 16, 1966 R. F. LOUGHRIDGE 3,266,382

HYDRAULIC ELEVATOR CONTROL SYSTEMS

Filed Sept. 24, 1964 3 Sheets-Sheet 1

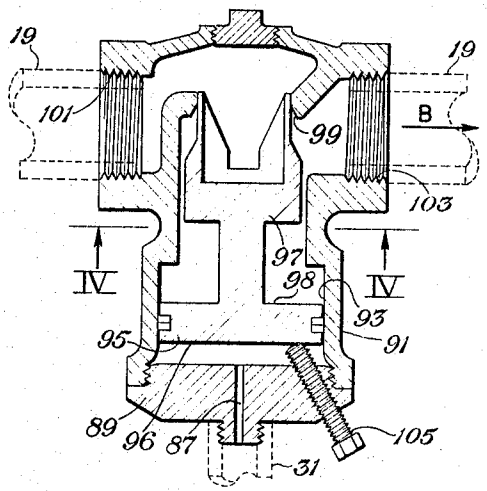


Fig. 1

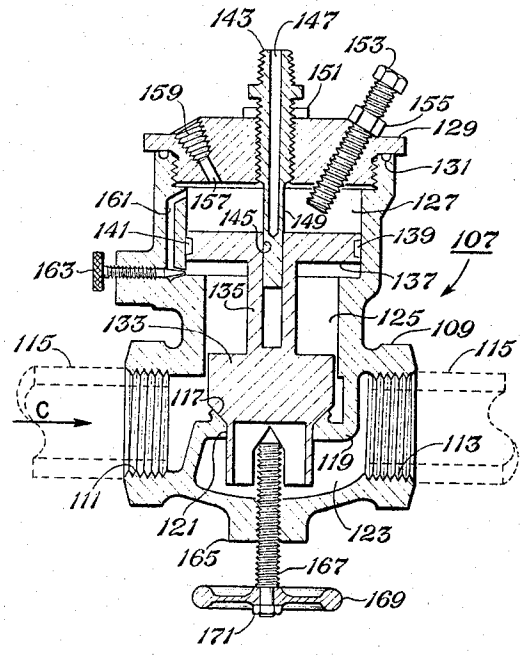


Fig. 2

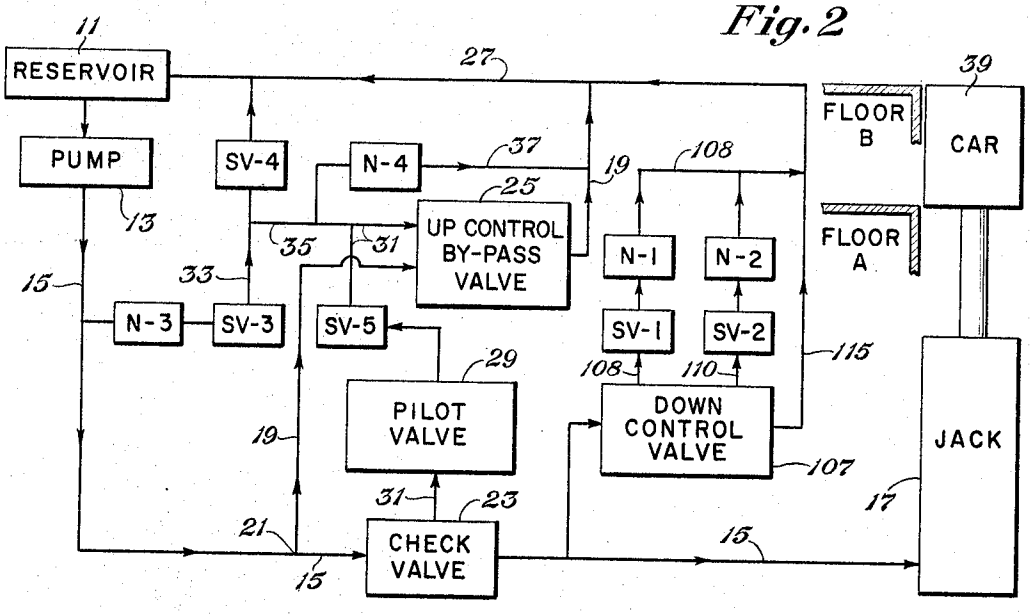


Fig. 3

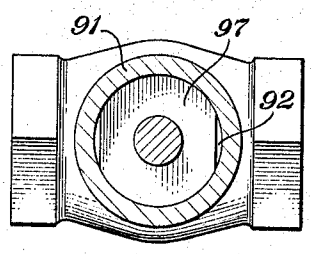


Fig. 4

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HYDRAULIC ELEVATOR CONTROL SYSTEMS

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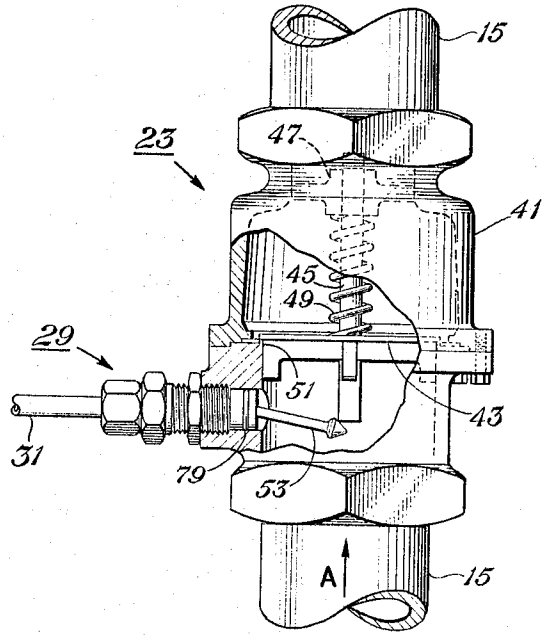


Fig. 5

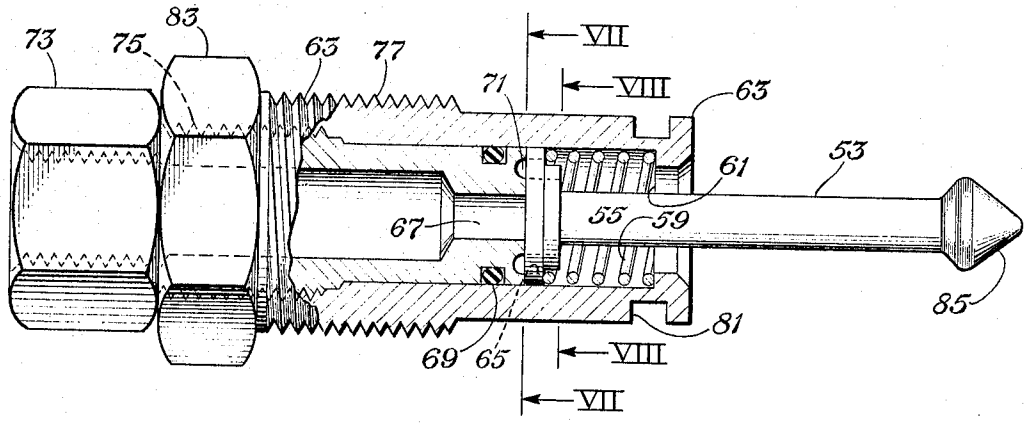


Fig. 6

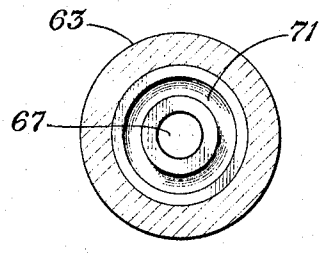


Fig. 7

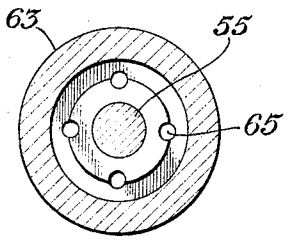


Fig. 8

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HYDRAULIC ELEVATOR CONTROL SYSTEMS

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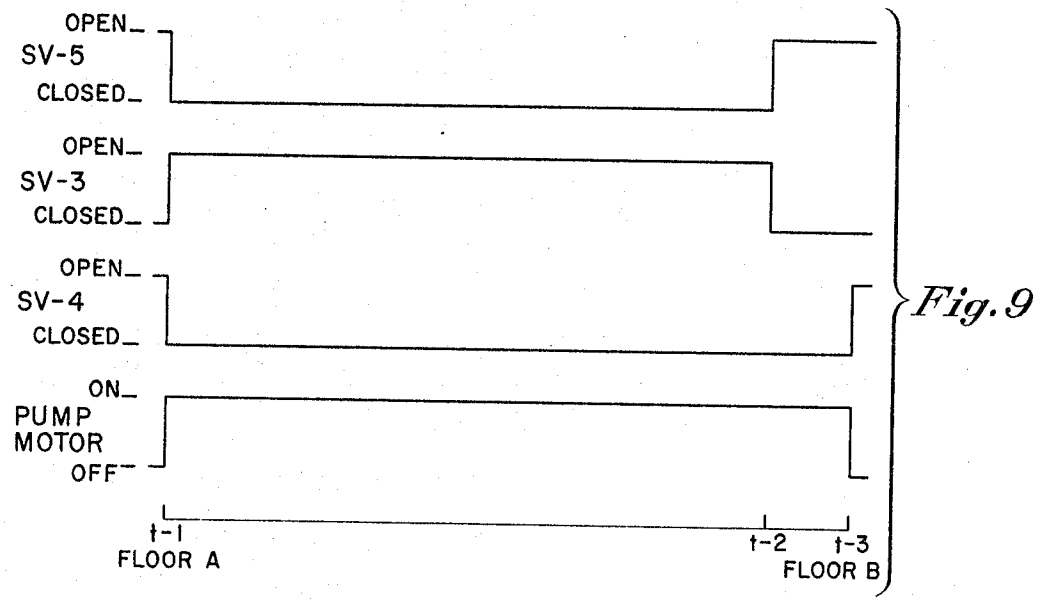


Fig. 9

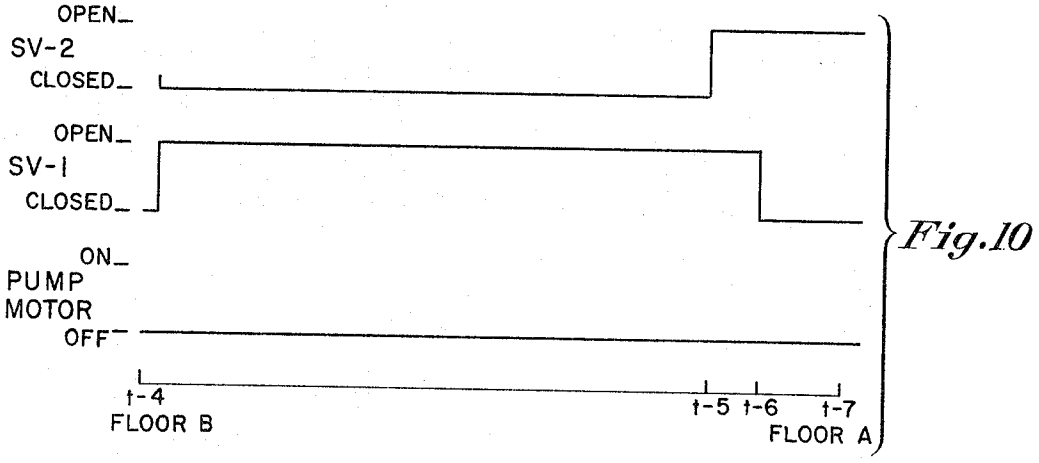


Fig. 10

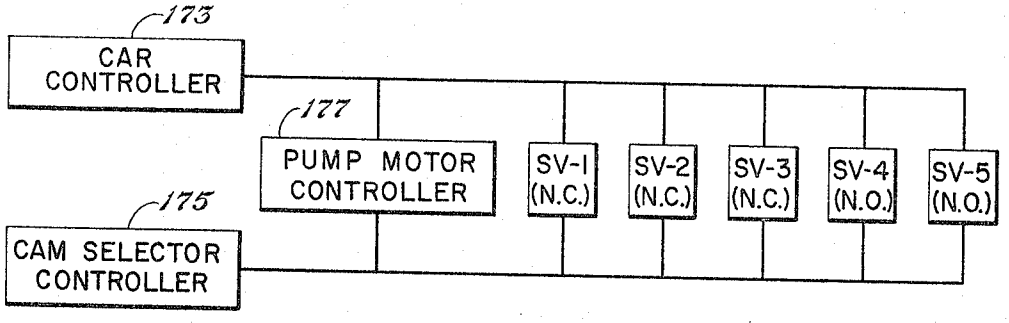


Fig. 11

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3,266,382

HYDRAULIC ELEVATOR CONTROL SYSTEMS

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Filed Sept. 24, 1964, Ser. No. 398,924
8 Claims. (Cl. 91—468)

My invention relates in general to hydraulic control systems for elevators, and more particularly to hydraulic elevator control systems which are used to control the speed of the elevator while moving in the upward direction.

One of the most successful systems for controlling the speed of elevator cars travelling in an upward direction, particularly during levelling, utilizes one or more by-pass valves to divert the flow of fluid from the hydraulic jack or ram that propels the elevator car. The speed of the elevator is, of course, a function of the quantity or flow rate of the fluid which passes to the hydraulic jack. Thus the by-pass valve is used to control the rate of fluid flow to the hydraulic jack. However, such systems controlled in accordance with the teachings of the prior art of which I am aware, are subject to some disadvantages. For one thing, it is difficult to achieve a constant elevator speed during uplevelling. This problem is often the result of variations in system pressure due to variations in elevator load. That is, changes in elevator load alter the fluid pressure in the hydraulic jack and this pressure variation is not effectively reflected by the control system.

The general object of my invention is to provide an improved up-control system for hydraulic elevators.

Another object of my invention is to provide a hydraulic elevator up-levelling control system that is capable of dealing effectively with pressure variations in the elevator jack.

Another object of my invention is to provide an improved hydraulic elevator control system that is capable of producing constant up-levelling speeds independant of variations in elevator loads.

Another object of my invention is to provide a simplified up-levelling control system by decreasing the complexity of the principal components of the system. The accomplishment of this object will, of course, lead to increased economy by decreasing initial costs and maintenance problems.

These and other objects of my invention will become apparent from the following description, taken in accordance with the accompanying drawings, in which:

FIG. 1 is a schematic longitudinal sectional view of an up-control by-pass valve constructed in accordance with a preferred embodiment of my invention.

FIG. 2 is a schematic longitudinal section of a down-control valve.

FIG. 3 is a schematic diagram of the fluid system of a hydraulic elevator in accordance with a preferred embodiment of my invention.

FIG. 4 is a sectional view taken along the line IV—IV of FIG. 1.

FIG. 5 is a fragmentary side elevational view of a flow responsive or check valve with a pilot valve assembly therewith.

FIG. 6 is a sectional view which shows in better detail the structural features of the pilot valve shown to some extent in FIG. 5.

FIGS. 7 and 8 are sectional views taken respectively along the lines VII—VII and VIII—VIII of FIG. 6.

FIGS. 9 and 10 are graphs that aid in the explanation of the operation of the hydraulic fluid system shown in FIG. 3.

FIG. 11 is a schematic diagram of electrical controls which pertain to the system of FIG. 3.

Referring now to the drawings and initially to FIG. 3 for an over-all description of the apparatus, the numeral **11** designates a fluid reservoir which is preferably located in an elevated position with respect to a fluid pump **13**, normally operated by an electric motor (not shown). A primary conduit **15** connects a pump **13** with a hydraulic jack **17**. A by-pass conduit **19** communicates with primary conduit **15** and the junction **21**, it will be noticed, is located upstream (i.e., toward the pump) from a check valve **23**. The by-pass conduit **19** communicates with an up-control by-pass valve **25** and ultimately with a return line **27** that is connected with fluid reservoir **11**.

A pilot valve **29** is interposed in a pilot conduit **31** that connects the check valve **23** with the up-control by-pass valve **25** by way of a solenoid valve SV–5.

A dump line **33** communicates with primary conduit **15** upstream from the point of communication **21** between by-pass conduit **19** and primary conduit **15**, said dump line communicating with the return line **27** through needle valve N–3, solenoid valve SV–3, and solenoid valve SV–4. The dump line **33** and the up-control by-pass valve **25** are connected by a conduit **35**, which in turn is connected by a conduit **37** to the by-pass conduit **19**. The conduit **37** contains a needle valve N–4.

That part of the system thus far described constitutes the up-control system of the over-all elevator control system. The down-control system will be described in detail later to provide a basis for a more complete understanding of my invention but it should be understood that my present invention is directed to the up-control system.

The purpose of the up-control system is to control the movements of the car **39** while moving in the upward direction. The car speed is controlled by the flow rate of the fluid which reaches the hydraulic jack **17** by means of primary conduit **15**. The speed of the car may be reduced by diverting the fluid from the primary conduit **15** through the by-pass conduit **19** by opening the up-control valve **25**. A critical time for accurate speed control is during the uplevelling period of the cycle. The uplevelling period of the cycle is that period during which the elevator approaches a floor (such as floor A in FIG. 3) at a pre-selected reduced rate of speed. The system of controlling the uplevelling speed, in accordance with the embodiment shown, utilizes the check valve **23**, which may be broadly described as a flow responsive device, in conjunction with the pilot valve **29** which actuates and thus controls the setting of the up-control valve **25**. Before a comprehensive operational description of my system is given, the structural detailed description of the check valve or flow responsive device **23**, the pilot valve **29**, and the up-control by-pass valve **25** will be given.

Referring now to FIG. 5 of the drawing it will be seen that the check valve **23** includes the body **41** which is interposed in and connected with the primary conduit **15**. Fluid flows through the flow responsive device or valve **23** in the direction as indicated by the letter A. Inside the interior of the body **41** is a flow responsive member or movable element **43**, the position of which is directly controlled by the flow rate of the fluid passing through the valve **23**. Movable element **43** has a stem **45** which is slidably mounted on support arm **45**. A coil spring **49** surrounds the stem **45** and engages support arm **47** and movable element **43** to urge the movable element downward into engagement with the annular lip **51**. In the preferred embodiment the flow responsive valve **23** is in reality a check valve since the fluid can flow only in the direction indicated by the arrow A. As will be more apparent in view of the following discussion, my invention is not limited to use with check valves per se but may be

used with flow responsive devices in general which have movable elements that respond to changes in flow rate.

The pilot conduit **31** communicates between the flow responsive valve **23** and the up-control by-pass valve **25** as was previously explained. The pilot valve **29** is interposed in pilot conduit **31** and has a control arm **53** which is actuated by the movable element **43** of the flow responsive valve. Arm **53** has a stepped flange which is urged against a valve core **57** by means of a coil spring **59**, one end of which engages a lip **61** on a valve body **63** as is apparent in the sectional view illustrated in FIG. 6.

Stepped flange **55** has a plurality of apertures **65**, as is apparent in FIG. 8. With the control arm **53** in a horizontal position as shown in FIG. 6, the stepped flange **55** sealingly engages the end of valve core **57**, preventing fluid from passing through the aperture **67** in the valve body. An O-ring **69** or other suitable sealing means is provided to prevent fluid from leaking past the space between valve core **57** and valve body **63**. Thus, when the flow rate of the fluid passing through the check valve or flow responsive device **23** is large, the movable element or flow responsive member **43** will be moved away from the control arm **53**. Consequently, no fluid will pass through pilot valve **29** due to the sealing engagement of the stepped flange **55** of the control arm and the end of the valve core **57**. As the rate of fluid flow through flow responsive valve **23** decreases, however, the movable element **43** moves downward and ultimately into engagement with the control arm **53**. This engagement tilts control arm **53** as shown in FIG. 5 and permits fluid to flow through the pilot valve **29** and to the up-control bypass valve **25**.

To prevent suction and to enable the stepped flange **55** to easily move away from the end of the valve core **57**, an annular groove **71** is provided in the end of the core **57**. At the opposite end of the valve core **57** is a grasping means **73** which can be used to engage or disengage the valve core **57** and the valve body **63**, such members being in this embodiment mutually engageable by means of the threads **75**. The valve body **63** is threaded at **77** on the exterior thereof so that it may be attached to the flow responsive valve **23**. To effect a better seal therewith, an O-ring **79** is provided in the groove **81** which surrounds the forward end of the body. The valve body has a head **83** which may be grasped and rotated to extend or retract the pilot valve into or from the body **41** of the flow responsive valve **23**. This also enables adjustment of the levelling speed of the elevator since the end of the control arm **53** is contoured to have a conical surface as designated by the numeral **85** so that axial extension or retraction determines the extent of the deflection of the arm by the cooperation of movable element **43** for any given flow rate passing through the primary conduit **15** and the flow responsive valve **23**.

As was explained previously, the fluid flows through pilot valve **29** and solenoid valve SV–**5** during up-leveling of the elevator car to control the flow of fluid to, and thus the setting of, the up-control by-pass valve **23**. Referring now to FIG. 1 of the drawings for a detailed description of the structure of a preferred embodiment of the up-control by-pass valve **25**, it will be seen that the pilot conduit **31** communicates with a passage **87** that extends through a lower plug **89** attached to the valve body **91**. A cylindrical cavity **93** is formed on the interior of the body **91** and slidably engages a piston **95**, which is the lower portion of a floating valve element **97**. This floating valve element is adapted to engage a valve seat **99** which is formed on the interior of the valve body **91**. Thus, the amount of fluid flowing through pilot conduit **31** and passage **87** of the lower plug **89** controls the setting of the floating valve element **97** and thus the amount of fluid which flows through the by-pass conduit **19** as shown in general by the arrow B in FIG. 1. The valve body **91** has an inlet aperture **101** and an outlet aperture **103** so that it may be easily inserted in the by-pass conduit **19**. A speed adjustment means is provided in the form of a cap screw **105** which engages and limits the stroke of the floating valve element **97**. When piston **97** engages the set screw **105**, no greater amount of fluid can flow through the up-control by-pass valve **25**.

Referring again to the drawings, FIG. 2 illustrates a down-control valve **107**, which includes a valve body **109** having a threaded inlet aperture **111** for the entry of fluids generally in the direction of the arrow C, and a threaded outlet aperture **113**. These apertures are, of course, connected to the down-control conduit **115** which communicates with the primary conduit **15** and the return line **27** as shown in FIG. 3. Internally, the valve **107** is fitted with a valve seat **117** supported by structure **119** integrally attached to the valve body **109**, and a valve aperture **121** through which fluids may flow. The valve body **109** has a main valve cavity **123**, a mid-body cavity **125** and an upper body cavity **127** and a threadedly connected valve body cap **129**. An O-ring gasket **131** effectively seals the joint between the valve body **109** and the body cap **129**.

Within the mid-body cavity **125** there is a valve disc **133**. This disc is integrally connected by a cylinder **135** to a piston **137**, preferably of circular shape and larger in diameter than the valve disc **133**. The piston **137** is sildeable in the upper body cavity **127** and has a groove **139** in its periphery which is adapted to receive a sealing device **141** to prevent the flow of fluids thereby.

Centered in the valve body cap **129** is an adjustable elongated spindle **143**, the upper portion of which is threaded into the valve body cap **129**, while the lower portion is cylindrical and is slideable in a central cavity **145** which is located both in the piston **137** and in the cylinder **135**. The spindle **143** has a central longitudinal cavity **147** extending for approximately three-quarters of its length from the top end, and there is an orifice **149** in the tubular wall near the bottom of the cavity **147** which affords communication with the upper body cavity **127** and the central cavity **147**. A lock nut **151** encircles the adjustable spindle **119** and holds it in fixed relation to the piston **137**.

An adjustable stop bolt **153** and lock nut **155** are inserted through the valve body cap **129** a sufficient distance to limit the upper movement of the piston **137** when the valve opens. (FIG. 2 illustrates the valve **107** in the closed position.) The valve body cap is also fitted with a passage **157** and threaded cavity **159** which affords communication between the upper body cavity **127** and a threadedly connected conduit means (not shown).

A series of connected passages **161** afford communication between the mid-body cavity **125** and the upper body cavity **127**. An adjustable needle valve **163** is provided in a convenient location to regulate the flow of fluid through the passages **161**.

The lower periphery of the valve body **109** is fitted with an axially threaded boss **165** to which an adjustable rotatable stem **167** is threaded. The lower extremity of the stem **167** is provided with a rotating means, preferably a hand wheel **169**, secured to the stem **167** by a nut **171**.

The electrical controls illustrated with the schematic diagram of FIG. 7 include a car controller **173**, a cam selector controller **175**, a pump motor controller **177** and the solenoid valves SV–**1** through SV–**5**. The function of these controls will become subsequently apparent during the description of the operation of the system.

To understand the manner in which my improved hydraulic elevator up-control system operates, it will be helpful to consider the sequence of operation required to move an elevator car **39**, initially at rest, from floor A to floor B, and then to lower the car from floor B to floor A.

With a car at floor A and at rest, the following conditions prevail: The system is full of hydraulic fluid and the reservoir **11** is filled to its normal operating level; the down-control valve **107** is closed and the load on the car **39** and jack **17** is held by the check valve **23** which is closed. The pilot valve **29** is thus held in the open posi-

tion since the control arm 53 is pivoted downwardly by the engagement of the closed movable element 43 of check valve 23, as is shown in FIG. 5. At this stage the pump is not in operation since no fluid is flowing in the system.

To start upward, the up button (not shown) but a part of the car controller generally indicated as a block 173 in FIG. 11, is pushed at time T–1 in FIG. 5, whereupon power is applied to the motor (not shown) starting the pump 13. Electrical power is applied to the solenoid valves SV–3, SV–4 and SV–5. Valve SV–4 closes, which prevents fluid from flowing through the dump line 33, to shunt all of the control fluid into the up-control by-pass valve 25. Solenoid valve SV–5 closes, cutting off the flow of fluid from the pilot valve 29 during the initial starting of the elevator. This is beneficial in preventing fluid in the vicinity of check valve 23 from affecting the up acceleration of the elevator. Solenoid valve SV–3 opens, allowing fluid to flow through the needle valve N–3 into the up-control by-pass valve 25. The resulting increased fluid pressure exerted on the lower side of the piston 95 through the passage 87 in the lower plug 89 of the up-control by-pass valve 25 (see FIG. 1) causes the valve to close. Consequently, the quantity of fluid flowing to the hydraulic jack 17 through primary conduit 15 is maximized and the car quickly accelerates to full speed.

As the car 39 approaches floor B, a stopping sequence is initiated by cam selector controller 175 at time T–3 and at this time solenoid valves SV–3 and SV–5 are de-energized. Valve SV–3 closes, shutting off the flow of control fluid from the needle valve N–3 to the up-control by-pass valve 25, and solenoid valve SV–5 opens. The fluid now bleeds from the up-control by-pass valve 25 through the slow-down orifice or needle valve N–4. Thus the upward force exerted on the piston 95 by the control fluid is decreased and the up-control by-pass valve 25 begins to open. Since this event enables fluid to flow through the by-pass conduit 19 and to the reservoir 11 via the return line 27, the flow of fluid through the primary passage 15 and to hydraulic jack 17 is decreased and the car begins to slow down. As the speed of the car decreases, the movable element 43 in the check valve 23 begins to close. As the speed of the car continues to decrease, the movable element 43 of check valve 23 will close enough to begin opening the pilot valve 29 by tilting the control arm 53. When this happens, fluid will flow through pilot valve 29, pilot conduit 31, solenoid valve SV–5, and passage 87 in the lower plug 89 of the up-control by-pass valve 25. The flow of fluid from the pilot valve 29 to the by-pass valve will cause a buildup of pressure on the lower surface 96 of the piston 95 until such time as the resulting force acting on the piston lower surface 96 equals that acting on the piston upper surface 98, at which time the floating valve element 97 will cease its downward (opening) movement, thus establishing the preselected up-levelling speed for the elevator car. This preselected up-levelling speed is maintained essentially constant by the regulating action of the control system. More particularly, if the up-levelling speed tends to increase or decrease, the flow rate of fluid passing through the check valve 23 will tend to increase or decrease, causing movement of the check valve movable element 43 and consequent opening or closing movement of the pilot valve 29 so as to produce a pressure charge on the lower surface 96 of the by-pass valve piston 95. This pressure charge will affect the position of the floating valve element 97 in a manner which will tend to maintain the flow rate of fluid passing through the check valve 23 constant, with the result that the up-levelling speed of the elevator car will be maintained essentially constant.

The car 39 will continue to travel at a constant up-levelling speed until floor B is reached, at which time the electrical circuit to the pump motor controller 177 opens and the solenoid valve SV–4 opens. Opening solenoid valve SV–4 dumps the control fluid from the up-control by-pass valve, which then opens to divert all fluid flow through the by-pass conduit 19, thus stopping the car.

In order to describe the operation of the down-control system when lowering the car 39 from floor B to floor A, reference is made to FIGS. 2, 3 and 6.

The following conditions prevail when the car 39 is at rest at floor B. The pump 13 is not operating; the check valve 23 is closed and holding the car 39 and its load, if any, at floor B; the down-control valve 107 is closed and both the solenoid valves SV–1 and SV–2 are closed.

The purpose of down-control valve 107 may be understood more completely by observing that, while closed, the fluid in the system entering the valve in the direction of the arrow C, flows past the flat sides of the valve disc 133 (similar to the apertures 92 shown in FIG. 4) and fills the mid-body cavity 125 below the piston 137. Fluid passing the needle valve 163 enters the passage 161 and fills the upper body cavity 127. Fluid in this cavity has two possible routes of flow; via the outlet 157 which communicates via line 108 with the solenoid valve SV–1, or via the orifice 149 which communicates via the central cavity 145 and the line 110 with the solenoid valve SV–2. Since the area of the upper side of the piston 137 is greater than the area of the underside thereof, the down-control valve 107 remains in a closed position.

To start downward, the down button (on car controller 173) is pushed at time T–4 (see FIG. 10), whereupon the solenoid valve SV–1 opens while solenoid valve SV–2 remains closed. Fluid in the upper body cavity 127 flows via line 108 through the solenoid valve SV–1 to the return line 27 and thus to the fluid reservoir 11. Since the pressure differential holding the down-control valve 107 closed no longer exists, the down-control valve begins to open. Fluid can flow from the hydraulic jack 17 through the partially open down-control valve 107, and this causes the elevator car 39 to begin to move downward. As fluid flows through the down-control valve 107 and via line 177 back to the reservoir 11, the down-control valve 107 continues to open until piston 137 strikes the adjustable stop bolt 153. In this position the piston 137 covers orifice 149 and no fluid flows through it.

As the elevator car approaches floor A, at time T–5, a cam on the cam selector controller 175 actuates a switch which closes an electric circuit energizing the solenoid valve SV–2, which then opens.

While car 39 continues to descend and approach floor A, at time T–6, another cam on the cam selector controller 175 actuates a switch which de-energizes solenoid valve SV–1, which closes. Fluid, nevertheless, continues to flow into the upper body cavity 127 and, since there is no open passage by which it can escape, the fluid pressure builds up on the upper surface of the piston 137. Immediately, the pressure builds up and the piston moves downward toward the closed position; however, when the orifice 149 is uncovered again, fluid flows through it at a rate equal to the flow past the needle valve 163 and through the passages 161 into the cavity. Fluid now flows via the line 110 and the solenoid valve SV–2 into the down-control conduit 115, through return line 27 and to the fluid reservoir 11. At this moment, the downward movement of the piston 137 ceases; the down-control valve 107 is partially closed, and the car descends from floor B at a uniform levelling speed, which is some proportionate part of the open valve speed.

At the moment the car reaches the level of floor A, at time T–7 of FIG. 10, another cam on the cam selector controller 175 actuates a switch which opens a circuit causing the solenoid valve SV–2 to close. The closing of the valve SV–2 produces immediately a buildup of differential pressure downward on the piston 137, and the down-control valve 107 closes. In this situation all the fluid in the hydraulic jack 17 is held by the check valve 23 and the car 39 remains at floor A.

It should be apparent from the foregoing that I have provided a hydraulic elevator up-control system having significant advantages.

My invention derives from the realization that if the flow rate of fluid passing into the elevator jack is maintained constant, then the speed of the elevator car will be maintained constant. In accordance with the principles of my invention, the rate of fluid flow to the jack is sensed directly and within a region wherein the flow rate sensed is in effect the flow rate of fluid into the jack. This manner of flow rate sensing obviates complications, complexities and other disadvantages which have accompanied prior art techniques.

It should be understood that the foregoing disclosure and the showings made in the drawings are merely illustrative of the principles of my invention and are not to be interpreted in a limited sense. The flow rate sensing device (flow responsive valve or device) may be disposed anywhere within the region of the primary conduit that is intermediate the hydraulic jack and the junction of the primary and by-pass conduits. The flow rate sensing device may be any device that is capable of directly sensing the flow rate. If the flow rate sensing device is a check valve, then of course it must be disposed upstream (on the pump side) of the junction of the primary and down-control conduits.

I claim:

1. In a hydraulic elevator up-control system of the type having a primary conduit that connects a pump to a hydraulic jack, and a by-pass conduit which communicates with said primary conduit and which includes by-pass valve means for diverting a portion of the flow of fluid from said pump away from said hydraulic jack as a means of controlling the speed of the elevator, the improvement comprising:

(a) a flow responsive valve interposed in said primary conduit at a region intermediate the hydraulic jack and the junction of the primary and bypass conduits, said flow responsive valve having a movable element the position of which is directly controlled by the flow rate of the fluid passing through said valve;

(b) a pilot conduit communicating between said flow responsive valve and said by-pass valve means; and

(c) a pilot valve attached to said flow responsive valve and having a control arm that is biased to urge said pilot valve toward its closed position, said arm extending into engagement with the movable element of said flow responsive valve to actuate the pilot valve to control said by-pass valve means.

2. The invention as defined by claim 1, wherein said flow responsive valve is a check valve.

3. In a hydraulic elevator up-control system of the type having a primary conduit that connects a pump to a hydraulic jack, and a by-pass conduit which communicates with said primary conduit and which includes by-pass valve means for diverting a portion of the flow of fluid from said pump away from said hydraulic jack as a means of controlling the speed of the elevator, the improvement comprising:

(a) a flow responsive valve interposed in said primary conduit at a region intermediate the hydraulic jack and the junction of the primary and by-pass conduits, said flow responsive valve having a movable element the position of which is directly controlled by the flow rate of the fluid passing through said valve;

(b) a pilot conduit communicating between said flow responsive valve and said by-pass valve means; and

(c) a pilot valve interposed in the pilot conduit and having a control arm that engages the movable element of said flow responsive valve to actuate the pilot valve to control said by-pass valve means.

4. The invention as defined by claim 3, wherein said flow responsive valve is a check valve.

5. In a hydraulic elevator up-control system of the type having a primary conduit that connects a pump to a hydraulic jack, and a by-pass conduit which communicates with said primary conduit and which includes by-pass valve means for diverting a portion of the flow of fluid from said pump away from said hydraulic jack as a means of controlling the speed of the elevator, the improvement comprising:

(a) a flow responsive valve interposed in said primary conduit at a region intermediate the hydraulic jack and the junction of the primary and by-pass conduits, said flow responsive valve having a movable element the position of which is directly controlled by the flow rate of the fluid passing through said valve;

(b) a pilot conduit communicating between said flow responsive valve and said by-pass valve means; and

(c) a pilot valve interposed in the pilot conduit and actuated by the movable element of said flow responsive valve to control said by-pass valve means.

6. The invention as defined by claim 5, wherein said flow responsive valve is a check valve.

7. In a hydraulic elevator up-control system of the type having a primary conduit that connects a pump to a hydraulic jack, and a by-pass conduit which communicates with said primary conduit and which includes by-pass valve means for diverting a portion of the flow of fluid from said pump away from said hydraulic jack as a means of controlling the speed of the elevator, the improvement comprising:

(a) a flow responsive device interposed in said primary conduit at a region intermediate the hydraulic jack and the junction of the primary and by-pass conduits, said flow responsive device having a movable element the position of which is directly controlled by the flow rate of the fluid passing through said device;

(b) a pilot conduit communicating between said flow responsive device and said by-pass valve means; and

(c) a pilot valve interposed in the pilot conduit and actuated by the movable element of said flow responsive device to control said by-pass valve means.

8. The invention as defined by claim 7, wherein said flow responsive device is a check valve.

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