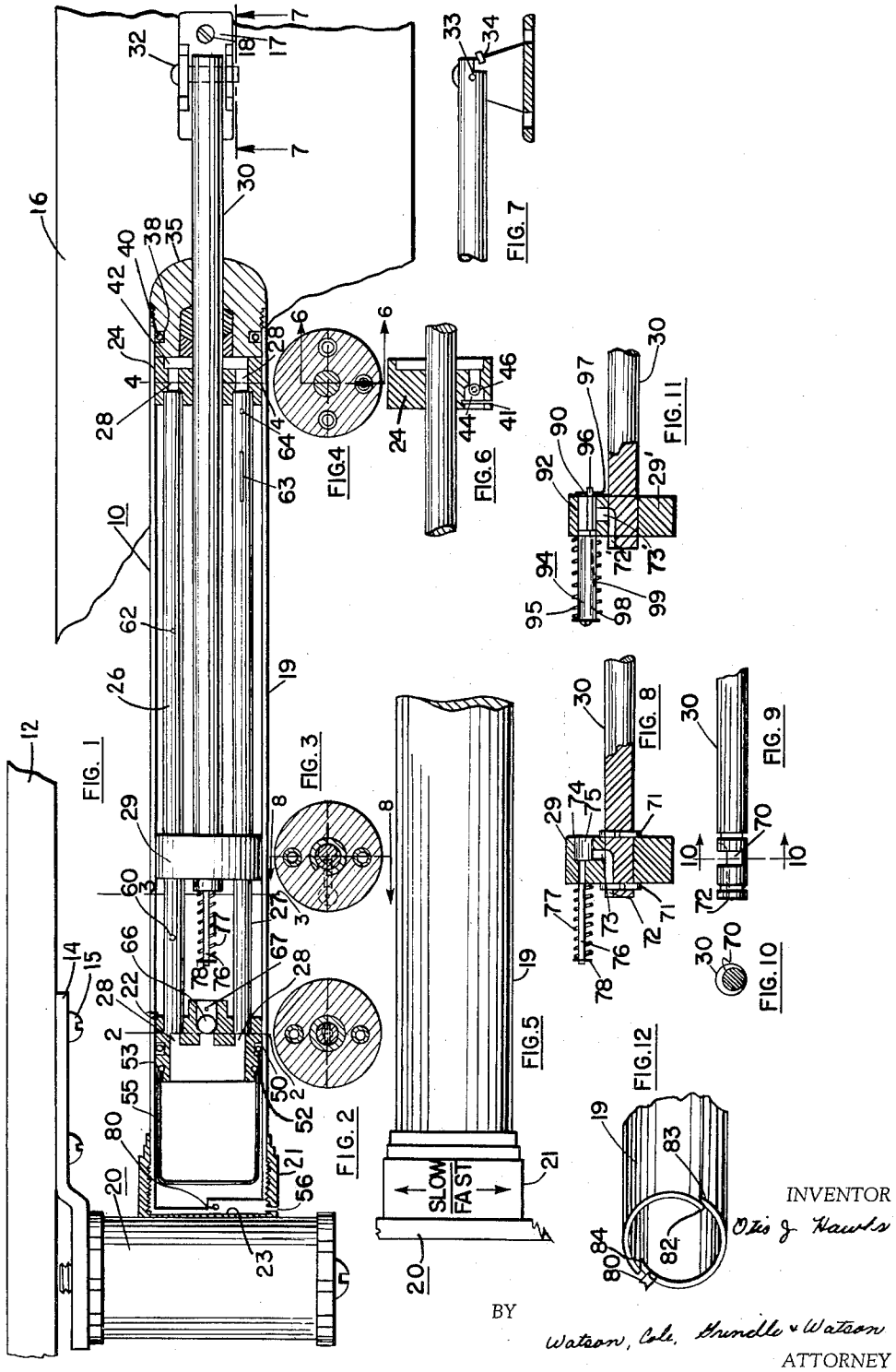
March 20, 1962 O. J. HAWKS 3,025,558

HYDRAULIC DOOR CONTROL DEVICE

Filed July 24, 1958 3 Sheets-Sheet 1



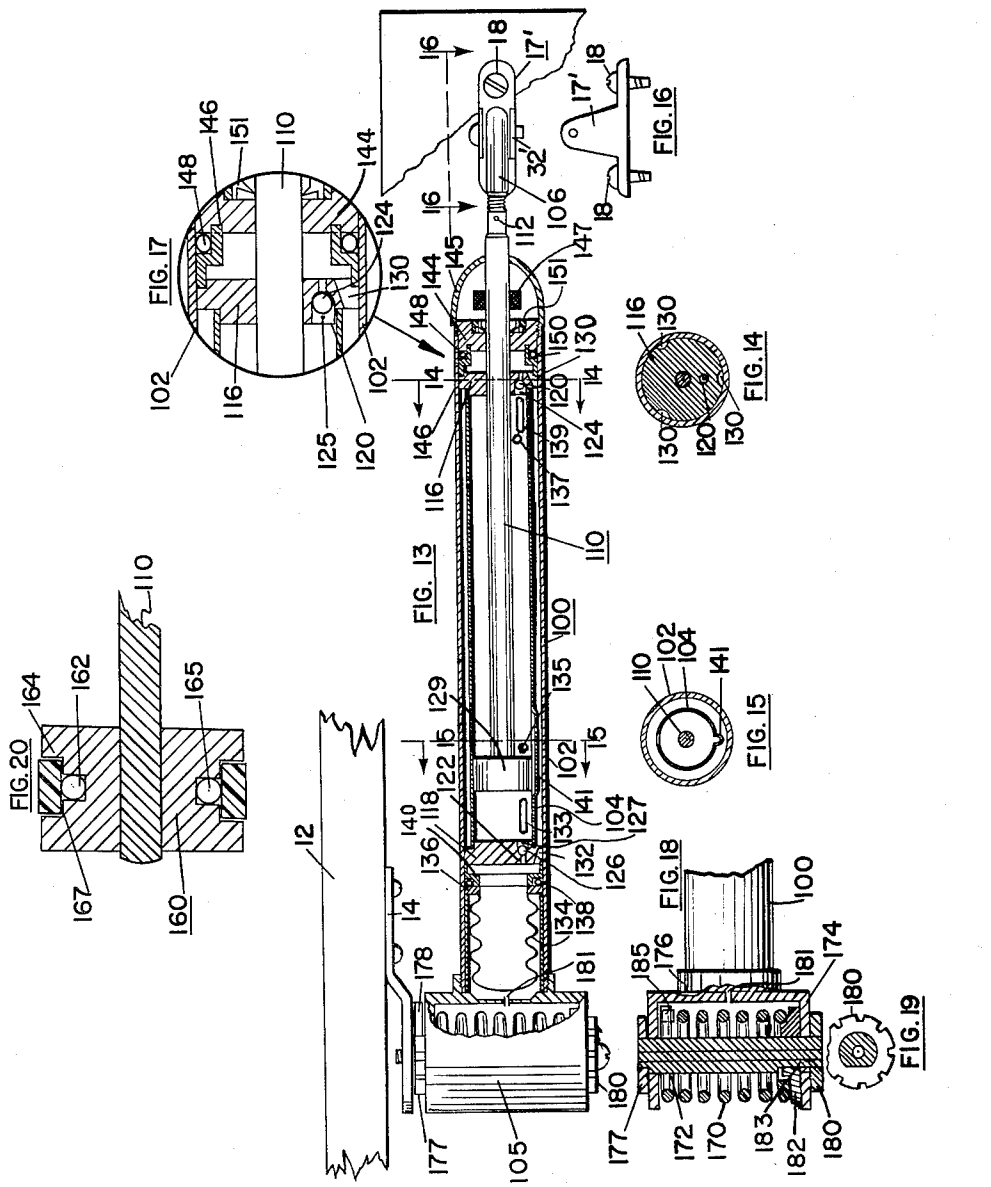
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HYDRAULIC DOOR CONTROL DEVICE

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HYDRAULIC DOOR CONTROL DEVICE

Filed July 24, 1958 3 Sheets-Sheet 3

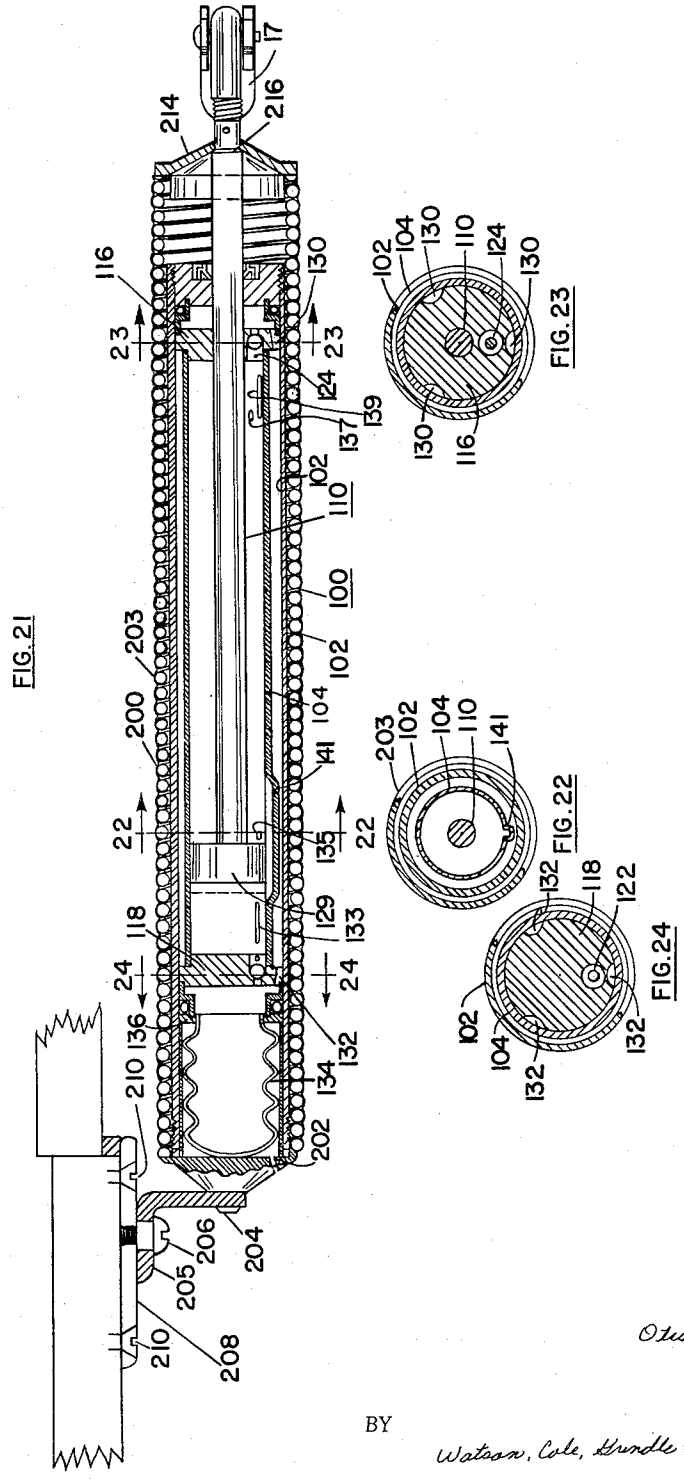


FIG. 21

FIG. 23

FIG. 22

FIG. 24

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HYDRAULIC DOOR CONTROL DEVICE

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Filed July 24, 1958, Ser. No. 750,629
22 Claims. (Cl. 16—51)

This invention relates to door control devices and more particularly to hydraulic door control devices.

Numerous door control devices have been disclosed for use primarily with storm or screen doors which are known in the art as the "bicycle pump" type. Devices of this type comprise a tubular cylinder containing a piston attached to a piston rod which is coaxial with the cylinder and travels axially of the cylinder to compress fluid only on the inward stroke of the piston. These devices exhibit numerous disadvantages. For example, an outwardly opening door to which one of these devices is connected may be blown outwardly by sudden winds and these devices incorporate no means for checking the door momentum until the limit of travel of the piston rod is reached. For this reason, strong winds will tear the closure or control device off of the door and often ruin the door at its point of attachment to the hinges. In order to prevent this type of accident, a chain and an interconnected compression spring are sometimes connected between the door and the door frame, independent of the control device. Also, attempts have been made to incorporate a compression spring within the control device. However, the compression spring begins to act only on the last few inches of travel and when the spring is fully compressed, it exhibits no further resilience, thus the same type of accident may occur in this combination of control device and compression spring.

Still another disadvantage in the use of pneumatic type devices arises from the compressibility of the air. With such an arrangement, it is necessary to have control of the ingress and egress of air and the extensive movement of the door is required before control takes place. When a door employing the pneumatic type control begins to close, it closes rapidly over an extensive portion of its movement and often hits the legs of persons passing through the door. There is virtually no control over the movement of the door from its open position to at least half-way closed since the air is being compressed during this portion of the movement and pressure must build up over a considerable portion of the stroke of the piston.

Hydraulic type control devices are also disclosed in the prior art. These hydraulic control devices also exhibit numerous disadvantages. Since the hydraulic type closure must be completely filled with liquid accurately to control the door movement, changes of ambient temperature cause the liquid to expand and contract. The expansion and contraction of the fluid often causes the devices to "breathe," that is, eject liquid and admit air under high and low pressure, respectively. Also, since the piston applies high pressure to fluid on one side and reduced pressure on the other side during one stroke and these relative pressures are reversed on the opposite stroke, the fluid seals around the exterior of the device are subjected to large pressure differentials, often causing leakage of the liquid. Further, fluid is frequently carried by the piston rod beyond the fluid seal or packing which surrounds the rod because of the repeated movement of the rod through the seal and the previously mentioned high pressure adjacent the rod. Further, none of these known hydraulic control devices of the type previously described provide means for controlling both the opening and closing operations of the door. Still further, in order to construct a satisfactory hydraulic type closure device, it is necessary to employ a very complex and expensive

structure. Also, present hydraulic type closure devices are extremely bulky and not adapted to fit between a screen or storm door and the inner door.

Accordingly, it is an object of this invention to provide an improved door control device.

It is another object of this invention to provide an improved hydraulic door control device.

It is another object of this invention to provide a hydraulic door control device which controls both the opening and the closing movements of the door.

It is another object of this invention to provide a hydraulic door control device which is not subject to the disadvantages of prior control devices.

A further object of this invention is to provide a resilient, collapsible fluid container to act as a volumetric stabilizer which automatically deposits fluids in the high pressure tube as the piston rod is withdrawn to prevent a vacuum from being formed due to the loss of the volumetric content of the amount of rod that has been withdrawn. Also, as the piston rod is caused to re-enter the high pressure tube, its equivalent cubic content in fluid is redeposited in the volumetric stabilizer to prevent a rise in pressure.

A further object is to provide a free flow of fluid from the stabilizer completely around the high pressure tube and behind it to assure an equalized pressure at all points within the closure but outside of the high pressure tube.

It is still a further object of this invention to provide a hydraulic door control device which is simple in construction and therefore economical to build.

It is still a further object of this invention to provide a door control device in which the seals around the exterior of the device are never subjected to large pressure differentials thereby eliminating leakage problems.

It is still a further object of this invention to provide a hydraulic door closure device which is readily adjusted from the exterior of the device such that the control operation may be accurately adjusted.

A further object of the invention is to provide a simple but highly effective method of sealing the fluid within the high and low pressure tubes so that the device may be assembled very quickly from parts having relatively wide ranges of tolerances, with assurance that no leakage will be encountered.

A further object is to provide a means of controlling the static pressure within the entire device so that such pressure will always remain at the atmospheric level to which the closer is subjected and thereby have no tendency to breathe. That is, for the fluid to be subjected to first positive pressure then negative pressure whereby fluid tends to be forced out of the closure device upon a rise in pressure and air drawn in when the pressure falls. This action is quite common in devices containing a fluid where a piston rod is packed at its point of projection from the liquid case.

Briefly, in accordance with aspects of this invention a resilient fluid reservoir is connected to the piston enclosing cylinder of the door closure device and this resilient reservoir acts as a "volumetric equalizer" to equalize the pressure of the fluid outside of the cylinder, such that the fluid on the outside of the cylinder never experiences a pressure appreciably greater than one atmosphere. Advantageously, the volumetric equalizer or reservoir will expand and contract in response to changes in liquid pressure during movement of the piston due to volumetric changes caused by displacement of fluid by piston rod. Further, this resilient reservoir may expand and contract in response to changes in pressure due to changes in the ambient temperature such that when the temperature rises and the liquid expands, the liquid seals of the device are not subjected to additional pressure which might cause

leakage. Still further, this resilient reservoir is connected through suitable fluid passages to selected points on the piston enclosing cylinder so that the fluid from the high pressure side of the piston may return to the reservoir during each stroke of the piston.

In accordance with other aspects of this invention, the fluid passages within the device are so shaped and located as to provide several ranges of resistance to liquid flow and thus variably control the speed of movement of the piston. For example, during the opening stroke the piston experiences a relatively low resistance through the first portion of its stroke, a higher resistance during the intermediate portion of the stroke and a still higher resistance during the last portion of the outward stroke. Advantageously, this last mentioned resistance increases somewhat linearly as the piston approaches the end of its stroke. All of these speeds are controlled by liquid passages. Advantageously, these liquid passages are arranged so that their effective cross sectional area is controlled by the movement of the piston. In certain instances, these liquid passages are oval in cross section and movement of the piston covers the oval passage so that the area of the passage is decreased with the movement of the piston and thereby changes the area through which the fluid may be discharged from the high pressure side of the piston.

In accordance with another aspect of this invention an eccentric orifice is defined through the piston and this orifice communicates with a recess in the piston rod. The effective cross sectional area of this passage may be variably controlled by rotation of the piston with respect to the piston rod. This control may conveniently be accomplished by rotating the outer cylinder or by rotating the piston rod, either of which achieves relative rotation between the rod and the piston.

In accordance with still other aspects of this invention a fluid passage is provided between a first orifice in the region of the mid-point of the cylinder and connecting with a second orifice adjacent one end of the cylinder and with the fluid reservoir to provide a low pressure passage for fluid around the piston during that portion of each piston stroke in which the piston is between these orifices. During this portion of each stroke, the piston experiences a relatively low liquid resistance. Thus, the piston moves relatively fast between those orifices. Since this fluid passage communicates with the fluid reservoir, the passage is effective when the piston is beyond either orifice (during the terminal portions of the strokes).

In accordance with still other aspects of this invention a passage is provided by a deformed wall to permit the rapid passage of fluid around the piston during a portion of the stroke of the piston and thereby permit a relatively fast movement of the piston between the terminal points of this deformed section. Advantageously, the period on the piston stroke during which this fast movement takes place may be varied from the exterior of the device by merely varying the effective length of the piston rod.

According to another aspect of this invention, the concept of high velocity and low pressure is employed in the hydraulic control device as opposed to low velocity and high pressure employed in the known types of devices. This concept simplifies the problem relevant to the liquid seals and also remarkably improves the degree of control obtainable.

In accordance with other aspects of this invention, elongated orifices are provided adjacent each end of the cylinder and the effective cross sectional area is controlled by the piston as it approaches the ends of the stroke since the piston slowly covers each passage as it approaches the end of each stroke and thus causes the liquid pressure to progressively increase such that the movement of the piston is slowly arrested.

In accordance with other aspects of this invention, a flexible fluid reservoir or pressure equalizing chamber and a pair of bulkheads are mounted within a cylinder and fluid passages are provided between the ends of the bulkheads and the reservoir or chamber and a piston is slidably mounted between the bulkheads. Variations in the pressure of the liquid on either side of the piston are transmitted to the flexible reservoir or pressure equalizing chamber, such that the liquid pressure on the sides of the bulkheads remote from the piston never exceeds a value of the order of one atmosphere even though high and low pressures exist between the bulkheads. Advantageously, these fluid passages may comprise one or more feeder tubes positioned longitudinally of the piston. The piston may surround these tubes such that orifices in the tubes are selectively covered by the piston during movement of the piston relative to the tube thereby to control both the opening or outward and closing or inward strokes of the piston. Advantageously, in certain illustrative embodiments, the external fluid seals, that is, the seals between the exterior and the interior of the control device are located on the sides of the bulkheads which are remote from the piston and are therefore not subjected to excessive fluid pressure. Accordingly, these fluid seals are not subjected to leakage to the same degree as are the prior art type devices.

In accordance with still other aspects of this invention, the device comprises a first external or outer cylinder, a second or inner cylinder, a piston slidably mounted within the second cylinder, a pair of bulkheads within the outer cylinder, defining fluid seal ends on the inner cylinder and a pressure equalizing reservoir communicating with the inside of the external cylinder such that the reservoir receives fluid during movement of the piston in either direction due to the volumetric change caused by the piston rod entering or leaving the pressure cylinder.

In accordance with still other aspects of this invention, a helical spring surrounds the fluid containing cylinder and acts in tension to return the piston to its initial position thereby closing the door. Advantageously, this helical spring is connected to the adjacent ends of the closure device and is enclosed in a flexible plastic material, thereby to act as a weather covering for the closure device.

In accordance with still other aspects of this invention, a first cylinder supports an inner or second cylinder between a pair of bulkheads and fluid controlling apertures in the wall of the second cylinder define passages between the inner cylinder and the outer cylinder, which apertures are positioned in the path of the piston and are selectively closed by movement of the piston. Also, advantageously, the time during the piston stroke at which these apertures are controlled may be changed by relative rotation of the piston rod and piston at a point external of the first cylinder. With this arrangement the closing stroke of the piston may be accurately controlled by varying the initial position of the piston.

These and various other objects and features of this invention will be more completely understood from a reading of a detailed description in connection with the drawings in which:

FIGURE 1 is a view in elevation, partially in section, of one illustrative embodiment of this invention;

FIGURE 2 is a view in section, taken along the line 2—2 of FIGURE 1;

FIGURE 3 is a sectional view taken along the line 3—3 of FIGURE 1;

FIGURE 4 is a sectional view taken along the line 4—4 of FIGURE 1 and rotated 90° in a counter-clockwise direction;

FIGURE 5 is a view in elevation of a portion of the device disclosed in FIGURE 1;

FIGURE 6 is a view in section taken along the line 6—6 of FIGURE 4;

FIGURE 7 is a fragmentary plan view taken along the lines 7—7 of FIGURE 1;

FIGURE 8 is a view in section taken along line 8—8 of FIGURE 3;

FIGURE 9 is a fragmentary view in elevation of the piston rod 30 of FIGURE 8;

FIGURE 10 is a view in section taken along the line 10—10 of FIGURE 9;

FIGURE 11 is a view similar to that of FIGURE 8 showing another illustrative embodiment of the piston and valve integral therewith;

FIGURE 12 is a view in perspective of the left-hand end of the outer cylinder 19 as shown in FIGURE 5;

FIGURE 13 is a view in elevation, partly in section, of another illustrative embodiment of this invention;

FIGURE 14 is a view taken along the line 14—14 of FIGURE 13;

FIGURE 15 is a view taken along the line 15—15 of FIGURE 13;

FIGURE 16 is a view taken along the line 16—16 of FIGURE 13;

FIGURE 17 is a fragmentary view, to an enlarged scale, of the right-hand portion of FIGURE 13;

FIGURE 18 is a fragmentary view, partially in section, of the left-hand portion of FIGURE 13;

FIGURE 19 is a fragmentary view of the spring tension controlling member shown in section in FIGURE 18 and in elevation in FIGURE 13;

FIGURE 20 is a view in section of a piston in accordance with one illustrative embodiment of this invention;

FIGURE 21 is a view in elevation, partially in section, of still another illustrative embodiment of this invention;

FIGURE 22 is a view in section taken along the line 22—22 of FIGURE 21;

FIGURE 23 is a view in section taken along the line 23—23 of FIGURE 21.

Referring now to FIGURE 1, there is depicted one illustrative embodiment of this invention. As therein depicted, a door control device 10 is secured to the door jamb 12 by means of a suitable bracket 14 and screws 15. The control device 10 is also secured to door 16 by means of a suitable bracket 17 and screws, such as 18.

The door control device comprises a hollow liquid containing cylinder 19 in which the hydraulic control mechanism is located and a spring or other resilient mechanical return assembly 20 secured to one end of the cylinder 19 by means of a cup-shaped member 21. The details of spring assembly 20 will be described in detail with respect to FIGURE 18. Member 21 threadably engages the end of cylinder 19 and is secured to spring assembly 20 by suitable means (not shown) such as a bolt or rivet extending through the end wall 23 of cylindrical member 21. The spring assembly is tensioned during the opening of the door 16 and releases this energy to provide a force to close the door after the door has been released. The hydraulic control system acts to control both opening and closing of the door by presenting different values of liquid resistance to the piston which is slidably mounted within cylinder 19.

Within the cylinder 19, which is filled with liquid, there is provided a pair of bulkheads 22 and 24, which may be made of any suitable material such as polystyrene. A pair of hollow balance tubes 26 and 27 are connected between bulkheads 22 and 24 and these tubes communicate with suitable passages 28 through the bulkheads. Advantageously, these tubes contain apertures which define passages for the liquid as will be subsequently explained. A piston 29 is slidably mounted within cylinder 19 between bulkheads 22 and 24. Advantageously, piston 29 has a pair of cylindrical passages extending axially therethrough at diametrically opposite points, such that the piston slides on the outer periphery of balance tubes 26 and 27. It will be apparent that during its inward and outward strokes, the piston selectively controls the effective cross sectional area of these apertures or passages.

A piston rod 30 is connected to the piston to move the piston relative to the cylinder 19. Piston rod 30 is connected to bracket 17 by means of a suitable pivot pin 32 which extends through an aperture 33 in the end of the piston rod. A stop 34 is fixed to bracket 17 and co-operates with the end of rod 30 to prevent the installer from rotating the piston rod 30 relative to the bracket 17. One end of cylindrical member 19 is enclosed by a threaded cap 35 which threadably engages the inner periphery of tube 19 adjacent its outer end. Cap member 35 has an annular recess 38 therein and an O-ring 40 is positioned within this recess to define a fluid seal between cap member 35 and cylinder 19. Between bulkhead 24 and cap member 35 a space 42 is provided to permit the passage of fluid between tubes 26 and 27 to allow the egress or escape of fluid between the piston rod 30 and bulkhead 24. A ball check valve 44 is positioned in an opening 46 in bulkhead 24 and is retained in the open position by a suitable pin 41. Bulkhead 22 has an annular recess 50 around its periphery and an O-ring seal 52 is secured in this annular notch to define a fluid seal between bulkhead 22 and cylinder 19.

Secured to bulkhead 22 by means of a suitable annular locking ring 53 of well-known construction is a flexible liquid reservoir or pressure balance camber 55. This reservoir is subjected to atmospheric pressure through an opening 56 extending radially through the cylindrical member 21. The purpose of this reservoir or chamber is to expand and contract in response to liquid pressure variations on the inside of the reservoir due primarily to volumetric changes resulting from removal and re-insertion of the piston rod and also variations in the temperature and pressure on the outside of the reservoir. With this arrangement, the fluid seals 52 and 40 are never subjected to a static pressure greater than one atmosphere. Differences in atmospheric pressure do not cause a difference in liquid pressures between the bulkheads 22 and 24. Pressures which are due to piston movement or liquid pressure on either side of the bulkheads remote from the piston are immediately compensated by expansion or contraction of the flexible fluid reservoir.

Balance tubes 26 and 27 contain numerous orifices extending radially through their walls and defining fluid passages. Tube 26 has a first aperture 60 adjacent its left-hand end, as viewed in FIGURE 1, and a second orifice 62 in the region of the mid-point of the tube. Orifices 60 and 62 permit passage of fluid between both sides of piston 29 and the reservoir 55 during that portion of the travel of the piston between these orifices, regardless of the direction of travel of the piston. Accordingly, while the piston is moving between orfices 60 and 62 it may do so at a relatively rapid rate. However, when the piston reaches a position to cover one of these orifices, the passage defined by the one orifice closes, while the other orifice provides a passage for the liquid to the reservoir. When both orifices are on one side of the piston 29 and the piston is moving toward the orifices, liquid will be forced through both orifices, through the tube 26 to the flexible reservoir 55. Balance tube 27 has an oval aperture 63 adjacent the right-hand end, as viewed in FIGURE 1, and this oval aperture 63 provides a passage which decreases in cross sectional area during the terminal portion of the outward stroke of the piston. A second orifice 64, which may be round in cross sectional area, is located in tube 27 immediately adjacent bulkhead 24. It will be apparent from the observation of the location of apertures 63 and 64 that these apertures control the movement of fluid from the cylinder 19 to the reservoir 55 and to the space 42 during the movement of the piston in the outward stroke. When the piston begins to cover oval aperture 63, the effective cross sectional area of the passage is progressively decreased causing the liquid to exert a greater resistance to the movement of the piston as the piston approaches the bulkhead 24. After the piston 29 has completely covered

oval aperture 63, only the aperture 64 provides an exit passage for the liquid. Accordingly, a very high resistance is experienced by the piston. It is during this portion of the travel of the piston that provision is made to prevent the wind from suddenly blowing the door off its hinges or tearing the bracket 17 from the door by reason of this very high resistance which is nevertheless decreasing.

Bulkhead 22 is provided with a ball check valve 66 which is prevented from leaving the fluid passage 20 by pin 67. The ball check valve is seated in a restricted orifice in such a manner to prevent passage of fluid through the valve as the piston moves to the left during the closing of the door. Ball 66 is unseated during the movement of the piston 29 to the right during the opening stroke. Similarly, ball check valve 46 in bulkhead 24, as best seen in FIGURES 4 and 6 is positioned in a restricted orifice in bulkhead 24 such that the ball 46 will be unseated by the fluid pressure during the movement of piston 29 from right to left, as seen in FIGURE 1, that is, during the closing stroke. These ball check valves permit the fluid pressure of the low pressure side of the piston quickly to equalize so that the fluid seals 38 and 52 are never subjected to reduced pressure or to a pressure less than one atmosphere.

Since these ball check valves are positioned in restricted orifices which open of face inwardly toward the piston from the bulkhead, these balls prevent the build-up of liquid pressure beyond the piston side of the bulkheads. The actual piston control functions are accomplished primarily by the orifices 60, 62, 63 and 64, as was previously explained.

During the last portion of the closing stroke of the piston after the orifice 60 is covered by the piston, the pressure on the fluid between piston 29 and bulkhead 22 would increase to a point where the piston would be unable to move if no fluid outlet were provided. It is during this portion of the cycle that accurate control must be had over the entrapped liquid if satisfactory closing of the door is to take place and this control must be easily variable by some means on the exterior of the control device. In order to achieve the necessary variable control, eccentric passages 70 and 72 are provided circumferentially and longitudinally of the piston rod 30, as best seen in FIGURES 8, 9 and 10. These eccentric passages 70 and 72 communicate at right angles with each other and passage 72 communicates with a passage 73 extending radially through a portion of piston 29 and communicating with a cylindrical aperture 74 extending axially of the piston 29. Split rings 71 do not impede the flow of fluid through passage 72, since the open end of the outermost ring is aligned with passage 72. Positioned within aperture 74 is a cylindrical valve member 75. This valve member 75 has a rod 76 extending through piston 29. A suitable helical spring 77 is positioned between piston 29 and a suitable pin 78 extending diametrically through rod 76. As the piston 29 aproaches the bulkhead 22, rod 76 engages bulkhead 22 and rod 76 is moved to the right, as viewed in FIGURE 8. This movement opens the passage 70—72—73—74 to permit the passage of fluid from the left-hand side of the piston to the right-hand side, as viewed in FIGURES 1 and 8. Piston 29 is retained on rod 30 by split rings 71 which engage circumferential notches therein shown in FIG. 9.

It will be apparent that as piston 29 approaches bulkhead 22, the valve 75 will be opened. Such an arrangement permits the door to move relatively rapidly immediately prior to the time that the door latch-bolt engages the keeper so that sufficient momentum is provided to oppose the latch spring. Since the passage 70 is somewhat eccentric, as best seen in FIGURE 9, the cross sectional area of the fluid passage defined by the intersection of the passage 73 and the eccentric aperture 70 can be readily controlled by relative rotation between piston 29 and piston rod 30. This rotation may advantageously be accomplished by rotating cylindrical member 19 in the desired direction as indicated by the indicia shown in FIGURE 5.

For example, if during the latter portion of the closing stroke, a faster movement is desired, then the cylinder 19 is rotated in a downward direction as seen in FIGURE 5. If, however, it is desired to reduce the speed of this portion of the closing stroke, cylinder 19 is rotated in an upward direction, as seen in FIGURE 5. To prevent cylinder 19 from being rotated more than 180 degrees, cylinder 21 is provided with a pin 80 extending radially inwardly, as seen in FIGURES 1 and 12. This pin engages a slot or cut-out portion 82 of cylinder 19, which cut-out portion terminates in a pair of axially extending abutments 83 and 84. Thus, it is possible to rotate the cylinder 19 one hundred and eighty degrees with respect to cylindrical member 21.

Another illustrative hydraulic piston-supported valve is disclosed in FIGURE 11. The apertures 73′ and 72′ are unchanged as compared to apertures 73 and 72 of FIGURE 8, but a different valve operation is obtained by a substantially flat annular ring or washer. Ring 90 is held over the aperture 92 by means of a suitable rod 94 which has a reduced portion 96 connected to ring 90 by means of a suitable pin 97. When the rod 94 engages the bulkhead 22 during the movement of the piston 24 toward the bulkhead 22, the valve is rapidly opened permitting a relatively rapid piston movement by reason of the increased fluid passage provided around the reduced portion 96 of rod 94. When the enlarged portion 98 of rod 94 reaches the aperture 72′, further movement of the enlarged portion 98 begins to restrict the fluid passage through the opening 72′. Rod 98 has a cut-out portion indicated by the dotted line 99 such that a very small passage is provided through the cutout portion after the end of rod 98 has passed over opening 72′. Accordingly, fluid will pass very slowly through this passage during the last portion of the stroke. Here again, the point of initiation of the piston-valve stroke may be readily controlled by rotation of the piston rod 30 relative to piston 29′. This rotation may advantageously be accomplished in the manner previously described, i.e., by rotation of cylindrical member 19. Relative rotation between piston 29 and piston rod 30 could also be accomplished by making piston rod 30 rotatable with respect to connecting pin 32. For example, rod 30 might be threadably coupled to a sleeve which is pivotally connected by pin 32′ in a manner which will be described in connection with one of the other embodiments of this invention. Rod 94 is retained in the position shown in FIGURE 11 by means of spring 95.

It is to be noted that when the piston rod is withdrawn from cylinder 19, a partial vacuum is created which might otherwise cause air to be drawn in through the various fluid seals. However, the capacity of the reservoir 55 is in excess of the total volume of the piston rod. Accordingly, the reservoir quickly equalizes the pressure by supplying liquid to the low pressure side through the appropriate ball check valve 66 or 46. Accordingly, the seals will not be subjected to these pressure variations.

Referring now to FIGURE 13, there is depicted another illustrative embodiment of this invention. In this particular embodiment, the hydraulic assembly 100 includes a pair of concentric cylinders 102 and 104. The connections of the control device between the door 16 and the door frame 12 are similar to those described in connection with FIGURE 1. Also, the spring return mechanism 105 is similar to that disclosed in FIGURE 1.

A threaded sleeve 106 is pivotally mounted on bracket 17′ by means of a pin 32′ which extends diametrically through sleeve 106. Threaded in sleeve 106 is one end of piston rod 110. An aperture 112 is drilled in piston

rod 110 so that a suitable tool may be inserted in the aperture 112 to rotate rod 110 relative to sleeve 106. Rotation of rod 110 adjusts the rod axially, thereby controlling the relative location of points on the piston stroke at which the liquid resistance to piston movement changes in a manner which will be subsequently explained.

Cylinder 104 has fluid control passages 133, 135, 137 and 139 extending radially therethrough and a fluid control passage 141 extending axially along its inner periphery to provide control functions for the fluid flow in a manner similar to the fluid control achieved by the combination of the balance tubes 26, 27 and the piston-supported valve of FIGURE 1. Bulkheads 116 and 118 seal the opposite ends of cylinder 104 and support cylinder 104 in coaxial relationship with respect to cylinder 102. Bulkheads 116 and 118 each have a single fluid passage 120, 122, communicating with the interior of cylinder 104, in which passages ball check valves 124 and 126, respectively, are retained by pins 125 and 127, respectively. These ball check valves operate to admit liquid from the reservoir to the low pressure side of the piston in the same manner as that of ball check valves 46 and 66 of FIGURE 1.

Three fluid passages 130 are provided in the periphery of bulkhead 116, as best seen in FIGURE 14. Similar passages, such as passage 132, shown in FIGURE 13, extend axially through bulkhead 118. Resilient fluid reservoir or pressure equalizing chamber 134 is mounted on an annular ring 136, which ring abuts against an annular ring 138 and is secured thereto. A vent port 181 is provided through the wall of spring assembly 105 so that air at atmospheric pressure surrounds reservoir 134. An O-ring type fluid seal 140 is positioned between a portion of annular ring 138 and ring 136 to define a fluid seal.

The opposite end of the cylinder 104 is closed by means of an annular threaded plug 144 which snugly engages the periphery of rod 110 and threadably engages the inner periphery of cylinder 102. Annular ring 146 is held in a snug engagement with recessed surfaces on bulkhead 116 and plug 144. On the outer periphery of the reduced portion of anular ring 146 an O-ring 148 is positioned to define a fluid seal. Advantageously, O-ring 148 does not move in response to movement of the piston or changes in fluid pressure since the changes in fluid pressure exerted upon this seal are relatively small. The relatively constant pressure is due to the passages 130 which permit liquid to return to volumetric equalizing reservoir 134 from the space between bulkhead 116 and plug 144 by way of the annular passage between cylinders 102 and 104.

The annular aperture 150 between bulkhead 116 and plug 144 communicates with passages 130 to permit the flow of fluid around the outer periphery of cylinder 104 and through passages 132 to the reservoir 134 in a manner similar to the fluid passages provided by balance tubes 26 and 27 of FIGURE 1.

The operation of the embodiment of FIGURE 13 is as follows: When the door 16 is opened, bracket 17 moves with the door and withdraws piston 129 from the position indicated to a position to the right, as viewed in FIGURE 13. During the first portion of the movement of piston 129, fluid is admitted to cylinder 104 through passage 122 in bulkhead 118, because ball check valve 126 opens since liquid pressure to the left of piston 129 is lower than the liquid pressure in reservoir 134. The fluid which is on the high pressure side, or to the right of piston 129 passes through circular apertures 135 and 137 and oval aperture 139 in cylinder 104. When piston 129 is intermediate the terminals of the by-pass portion 141 of cylinder 104, fluid passes immediately around the piston 129. During the time that this portion 141 provides a path around the piston, the liquid offers the least resistance to the movement of piston 129. This allows rapid opening of the door with no appreciable fluid resistance. Liquid which is leaving cylinder 104 by means of apertures 135, 137 and 139, passes into cylinder 102 and returns to reservoir 134 by means of passages 132.

After piston 129 has traveled a sufficient distance to cover circular opening 135, the liquid resistance on the high pressure side of the piston begins to increase and after the piston has passed beyond the right-hand terminal of enlarged portion 141, the fluid resistance increases still further. The fluid to the right of piston 129, as viewed in FIGURE 13, continues to pass through circular aperture 137 and oval aperture 139. When the piston approaches the end of its outward stroke, or to the right, as viewed in FIGURE 13, aperture 137 is covered by the piston and the only exit for the fluid from the high pressure side of the piston is oval aperture 139. At this point in the outward or opening stroke the effective cross sectional area of the liquid exit passage from the right-hand, or high pressure side of the piston is very small and this effective area decreases with continued movement of the piston to the right. Accordingly, the liquid resistance increases with each increment of outward movement of the piston. The liquid nevertheless demonstrates an apparent resilience to the force opening the door such that a high wind will not tear the bracket 17 from the door 16. This apparent liquid resilience, or apparent compressibility occurs because the resilient reservoir 134 expands and contracts in response to variations in the liquid pressure within the reservoir.

When the door is released and starts to close in response to the spring pressure device 105, piston 129 begins the closing or return stroke to the left, as viewed in FIGURE 13, and the reduced pressure on the right-hand side of piston 129 unseats ball check valve 124 permitting liquid to flow through passage 120. The liquid to the left of piston 129 may leave cylinder 104 by means of circular passage 135 and oval passage 133. The effective liquid outlet passage area does not change until the right-hand side of piston 129 passes beyond the right-hand terminal of passage 141. During that portion of the return or closing stroke before the piston 129 uncovers the right-hand terminal of enlarged portion 141, a substantially uniform fluid resistance is exerted upon piston 129 and therefore piston 129 moves at a substantially uniform speed.

After the trailing edge of piston 129, that is, the right-hand edge as viewed in FIGURE 13, passes beyond the edge of enlarged portion 141, fluid is permitted to pass directly from the high pressure side to the low pressure side of the piston through enlarged portion 141, that is, from left to right as viewed in FIGURE 13. During this portion of the closing stroke, the least amount of fluid resistance is exerted upon the piston and the door is permitted to close relatively rapidly. This portion of the closing stroke corresponds to movement of the door immediately prior to the engagement of the latch-bolt with the catch and permits sufficient momentum to be developed to overcome the resistance of the latch spring. After the mid-point of piston 129 has passed the longitudinal mid-point of enlarged portion 141, the effective cross sectional area of portion 141 is being slowly reduced and only the oval slot 133 permits liquid from the high pressure side of piston 129 to pass from cylinder 104 to cylinder 102. Accordingly, the fluid resistance exerted on piston 129 is increased for each increment of movement of the piston from the right to the left beyond this longitudinal mid-point of passage 141, as viewed in FIGURE 13. Accordingly, the piston moves very slowly until the door has reached its closed position.

During each stroke of the piston, liquid is drawn from pressure balance reservoir 134 and this reservoir immediately equalizes the pressure between the fluid on the inside of cylinder 102 and the atmosphere, even though the liquid in cylinder 104 on the opposite sides of the piston undergoes sufficient pressure differentials accurately to control the movement of the door. Advantageously, because of the operation of reservoir 134, the pressure in

cylinder 102 does not vary substantially in response to the movement of the piston 129, or in response to change in atmospheric pressure, the fluid seals, such as 140 and 148, are not subjected to large pressure differentials which might otherwise cause leakage.

Advantageously, the control cycle is variable by a convenient means located external to the cylinder 102. In this illustrative embodiment, a nail or other suitable pointed device may be inserted in aperture 112 and piston rod 110 rotated to change the initial position and length of stroke of piston 129 relative to cylinder 104 since piston rod 110 threadably engages threaded sleeve 106. Changes in the initial position of the piston change the liquid resistance transition points of the piston stroke. For example, if the initial position of piston 129 is moved to the left, then the low liquid resistance portion of the closing stroke, namely, that period of the stroke during which piston 129 is between the terminals of enlarged portion 141, will occur at a sooner point in time. If, however, it is desired to make this accelerated portion of the stroke occur at a later point in time, then the piston is moved to the right, as viewed in FIGURE 13, by rotating rod 110 such that it moves towards threaded sleeve 106. It is also to be noted that this movement of the initial position of piston 129 controls the point on the outward stroke at which orifice 137 is covered by piston 129, and thus controls the associated liquid resistance transition point at which the piston experiences an increasingly higher fluid resistance. Accordingly, it is apparent that rotation of the piston rod relative to sleeve 106 controls the location of the liquid resistance transition on both strokes of the piston.

In order to protect piston rod 110 from moisture and dust, a wiper 147 is provided which may advantageously be an annular ring of felt or other absorbent material saturated with oil during assembly. As the rod 110 is withdrawn from cylinder 104, wiper 147 moves into engagement with threaded dust cap 145 and lubricates the rod as it passes. A piston rod seal 151 of well-known construction is inserted in an annular recess in plug 144 to prevent the passage of fluid around the piston rod 110 and through plug 144. It will be apparent, however, that relatively little liquid will tend to pass through plug 144 and seal 151 since the fluid in chamber 150 is at a relatively low pressure in comparison to the atmospheric pressure due to the direct communication between chamber 150 and the flexible reservoir 134. Accordingly, these liquid seals around the rod 110 prevent any substantial amount of fluid from being lost. The oil deposited by wiper 147 prevents rust on the portion of the rod 110 which is between the dust cap 145 and the seal 151 when the door is in the closed position.

Referring now to FIGURE 20, there is shown in section one illustrative embodiment of a piston which may be used in control devices of this type. Piston 160 has a pair of annular recesses 162 and 164 on its outer periphery in the region of the longitudinal mid-point of the piston. An O ring type resilient seal 165 is positioned in recess 162 and this O-ring 165 has a diameter slightly greater than the depth of recess 162. An annular ring 167 rests in recess 164 and rides upon the outer periphery of O-ring 165. Advantageously, piston 160 and piston ring 167 may be made of a suitable plastic material such as polystyrene and ring 167 may be split by a diagonal cut so that it may be slipped over piston 160. Such a diagonal cut would permit the passage of only a very small amount of fluid around the piston and therefore would not materially affect the operation of the control device. Piston 160 may be provided with a suitable fluid passage and valve, such as that shown in the piston in FIGURE 1.

The helical spring assembly 105 employed to close the door is best seen in FIGURE 18. As therein depicted, a helical spring 170 is mounted upon spring spindle 172 and held in position in a U-shaped bracket 174, which bracket is secured to cylinder 102 by means of a threaded tubular portion 176. An orifice 181 extends through bracket 174 to permit the passage of ambient air around flexible fluid reservoir 134. A pawl and ratchet 177 and 178, respectively, best seen in FIGURE 13, are employed to lock the spring under tension. The spring tension may be increased by rotating ratchet 180 by means of a suitable tool (not shown). The rotation of ratchet 180 also rotates spring winder 182 since both ratchet 180 and spring winder 182 are keyed to spring spindle 172 by means of a suitable key 183. The opposite or upper end of spring 170 is locked to bracket 174 by means of a spring anchor pin 185. The configuration and operation of this spring assembly 105 are similar to known types of spring actuated door closures presently employed in combination with pneumatic door control devices.

Referring now to FIGURE 21, there is depicted another illustrative embodiment of this invention. As therein depicted, the hydraulic mechanism 100 is substantially identical with that disclosed in FIGURE 13. The principal distinctions between the device in FIGURE 21 and that in FIGURE 13 are the positioning and operation of the spring to force the door to return to its closed position. The device disclosed in FIGURE 21 is encircled by a coaxial helical spring 200. This spring engages an annular recess in the end member 202, which end member is secured to the door jamb by means of an angle bracket 204 and a screw 206, which screw engages a metallic plate 208 secured to the door jamb by means of suitable screws 210. Bracket 204 has an enlarged aperture 205 through which screw 206 passes to permit bracket 204 to pivot when the door is opened. The opposite end of spring 200 is secured to a similar end cap 214 in a manner similar to the connection to end member 202. Cap 214 encircles a reduced portion 215 of piston rod 110 and rides upon an enlarged portion or shoulder 216. Obviously, adjustment of the spring tension may be obtained by threadably engaging cap 214 with suitable threads on piston rod 110. In such a modification, the shoulder 216 would be obviated.

Advantageously, spring 200 is covered by a resilient plastic sleeve 203 which may be of polyethylene. This sleeve extends over the entire length of the spring 200 and engages annular ridges on the end caps 202 and 214. This sleeve completely encloses the hydraulic assembly of the control device to prevent the admission of moisture and dust which might otherwise shorten the life of the device. Advantageously, this cover 203 also encloses the rod 110 including that portion which is removed from the cylinder 102 during the outward stroke of the piston. Accordingly, moisture which otherwise might be deposited on the rod 116 when it is removed from cylinder 102 and carried into the cylinder 102 during the return or closing stroke is prevented from reaching the piston rod 110.

From the foregoing example, it will be apparent that I have devised a remarkably improved hydraulic control device which is simple in construction and operation and exhibits numerous advantages including that of being free of breathing and leakage of hydraulic fluid.

While I have shown and described various embodiments of my invention, it is understood that the principles thereof may be extended to many and varied types of machines and apparatus. The invention therefore is not to be limited to the details illustrated and described herein.

I claim:

1. A hydraulic door control device comprising cylinder means, fluid reservoir means having a flexible wall connected to said cylinder means for compensating for volumetric changes in the fluid within said cylinder, piston means including a piston rod in said cylinder means and fluid passage means communicating with said reservoir

means and both ends of said cylinder means for controlling the movement of said piston means.

2. A hydraulic door control device comprising a cylinder, a piston in said cylinder, means for returning said piston to an initial position corresponding to a closed door position, fluid passage means communicating with both ends of said cylinder for permitting movement of fluid from one side of said piston to the other side of said piston, and resilient walled fluid reservoir means communicating with said fluid passage means for receiving fluid to equalize the fluid pressure due to changes of the fluid in said system, said reservoir means defining a fluid seal having one side exposed to the ambient atmospheric pressure.

3. A door control device in accordance with claim 2 wherein said fluid passage means comprises a first fluid passage along the wall of said cylinder means whereby said passage permits a relatively short by-pass for said fluid relative to said piston thereby causing said piston to move relatively rapidly during a portion of its stroke.

4. A hydraulic door control device in accordance with claim 3 wherein said fluid passage means further comprises a second fluid passage communicating with said reservoir and the end of said cylinder approached by said piston on its outward stroke whereby said second passage controls the movement of said piston on its outward stroke.

5. A device in accordance with claim 2 further comprising variable means for controlling the movement of said piston during the latter portion of its inward stroke, said means comprising a fluid passage coacting with the piston to by-pass fluid from one side of the piston to the other side of the piston during a short portion of the stroke and means for controlling the point of operation of said last mentioned passage relative to said stroke, said last mentioned variable control means comprising means for rotating said piston rod relative to said cylinder.

6. A device in accordance with claim 5 wherein said first fluid passage comprises an enlarged portion on said cylinder defining a by-pass around said piston, thereby to cause said fluid to present a relatively low resistance to the movement of said piston while said piston is moving between the terminal points of said enlarged portion.

7. A hydraulic door control device filled with liquid comprising a first cylinder, a second cylinder concentric with said first cylinder, a piston in said second cylinder, a piston rod connected to said piston, fluid passages connecting said first and said second cylinders, and located in the path of said piston whereby the liquid controls both the outward and inward strokes of said piston and a fluid reservoir having a flexible wall and communicating with said cylinders with one side of said flexible wall exposed to the ambient atmosphere to provide compensation for changes in fluid volume while preventing the escape of fluid from said device.

8. A device in accordance with claim 7 wherein said second cylinder is provided with a first and a second aperture adjacent each terminal position of said piston to provide outlet apertures of decreasing effective cross sectional area as said piston approaches said terminal positions, whereby the entrapped liquid presents an increasing resistance to the movement of said piston as said piston approaches its terminal positions.

9. A device in accordance with claim 8 further comprising an enlarged portion in said second cylinder extending axially of said cylinder and providing a by-pass for liquid relative to said piston when said piston is in a position intermediate the ends of said enlarged portion.

10. A device in accordance with claim 9 wherein said second cylinder is provided with a first and a second aperture intermediate the ends of said cylinder, said first and second apertures defining ports for the liquid when the piston is moving along the intermediate portion of its strokes between said first and said second apertures, whereby said liquid presents a relatively low resistance to the movement of said piston.

11. A hydraulic control device comprising a first cylinder, a pair of bulkheads in said cylinder, a second cylinder secured between said bulkheads in liquid sealing relationship, piston means within said second cylinder and movable between said bulkheads, fluid passage means, and liquid volume equalizing reservoir means filled with liquid and communicating through certain of said fluid passage means with said first cylinder and said second cylinder for maintaining a substantially constant liquid pressure in said first cylinder, while the liquid pressure in said second cylinder varies between a high value on one side of the piston means and a low value on the other side of said piston means, whereby liquid from said reservoir means controls the movement of said piston means in both directions of piston travel, said reservoir means being of flexible material and having one side exposed to the ambient atmosphere.

12. A hydraulic control device in accordance with claim 11 wherein said fluid passage means comprises a plurality of apertures in said second cylinder communicating with said first cylinder and a passage through the one of said bulkheads which is between said second cylinder and said reservoir, said passage permitting fluid flow between said first cylinder and said reservoir means, said apertures being positioned in the path of said piston means whereby said piston means selectively covers said apertures.

13. A hydraulic control device in accordance with claim 12, said fluid passage means further comprising a first aperture through said one of said bulkheads communicating with said first cylinder and said reservoir means and a ball check valve in said last mentioned aperture positioned to admit fluid from said reservoir means to said second cylinder when said piston means moves away from said one bulkhead.

14. A hydraulic control device in accordance with claim 13, said fluid passage means further comprising a first aperture in the other of said bulkheads and a ball check valve in said last mentioned aperture, a chamber between said other bulkhead and said first cylinder, whereby said last mentioned ball check valve admits fluid to said second cylinder from said chamber when said piston means is moving away from said other bulkhead.

15. A hydraulic control device in accordance with claim 14, said chamber comprising an annular plug secured to said first cylinder and a fluid seal between said plug and said other bulkhead, said other bulkhead having a passage therethrough communicating with said first cylinder and said chamber to permit the flow of fluid therebetween when said piston moves away from said other bulkhead.

16. A hydraulic control device in accordance with claim 11 further comprising a door, a door frame, said device being connected between said door and door frame, spring means encircling said first cylinder and connected to said first cylinder and to said door frame whereby said spring applies a returning force to said first cylinder.

17. A hydraulic control device in accordance with claim 16 wherein said piston means includes a piston and a piston rod having one end connected to said piston and having a reduced portion adjacent the other end and further comprising a cap member encircling said reduced portion and engaging one end of said spring means on the end of said first cylinder adjacent said door and a cap member on the oppoiste end of said first cylinder adjacent said door frame and engaging the other end of said spring, whereby said spring is elongated when the door is open and acts under tension to return the door to its closed position.

18. A hydraulic control device in accordance with claim 11 further comprising means for controlling the speed of movement of said piston in both directions, said

last mentioned means comprising means for achieving relative rotation between said cylinder and said piston rod.

19. A hydraulic control device in accordance with claim 15 wherein said fluid seal comprises an annular ring secured between said plug and said second bulkhead and a resilient annular ring secured between said first mentioned annular ring and said first cylinder.

20. A hydraulic control device in accordance with claim 19 wherein said first mentioned annular ring engages recesses in the surfaces of said plug and said second bulkhead.

21. A hydraulic control device in accordance with claim 20 wherein said first mentioned annular ring comprises two portions having different outer diameters, said resilient annular ring being mounted on the portion having the smaller outer diameter, said last mentioned portion being positioned adjacent said plug.

22. A hydraulic door control device comprising a first cylinder, a second cylinder concentric with said first cylinder and having liquid therein, a piston in said second cylinder, a piston rod connected to said piston, resilient walled pressure relief means communicating with said first cylinder, said second cylinder having apertures adjacent opposite ends thereof defining liquid passages connecting said first and said second cylinders, whereby the liquid controls the rate of both strokes of said piston.

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