Nov. 18, 1969 P. W. MARTIN 3,478,468

AUTOMATIC DOOR OPERATOR

Filed July 29, 1968 5 Sheets-Sheet 1

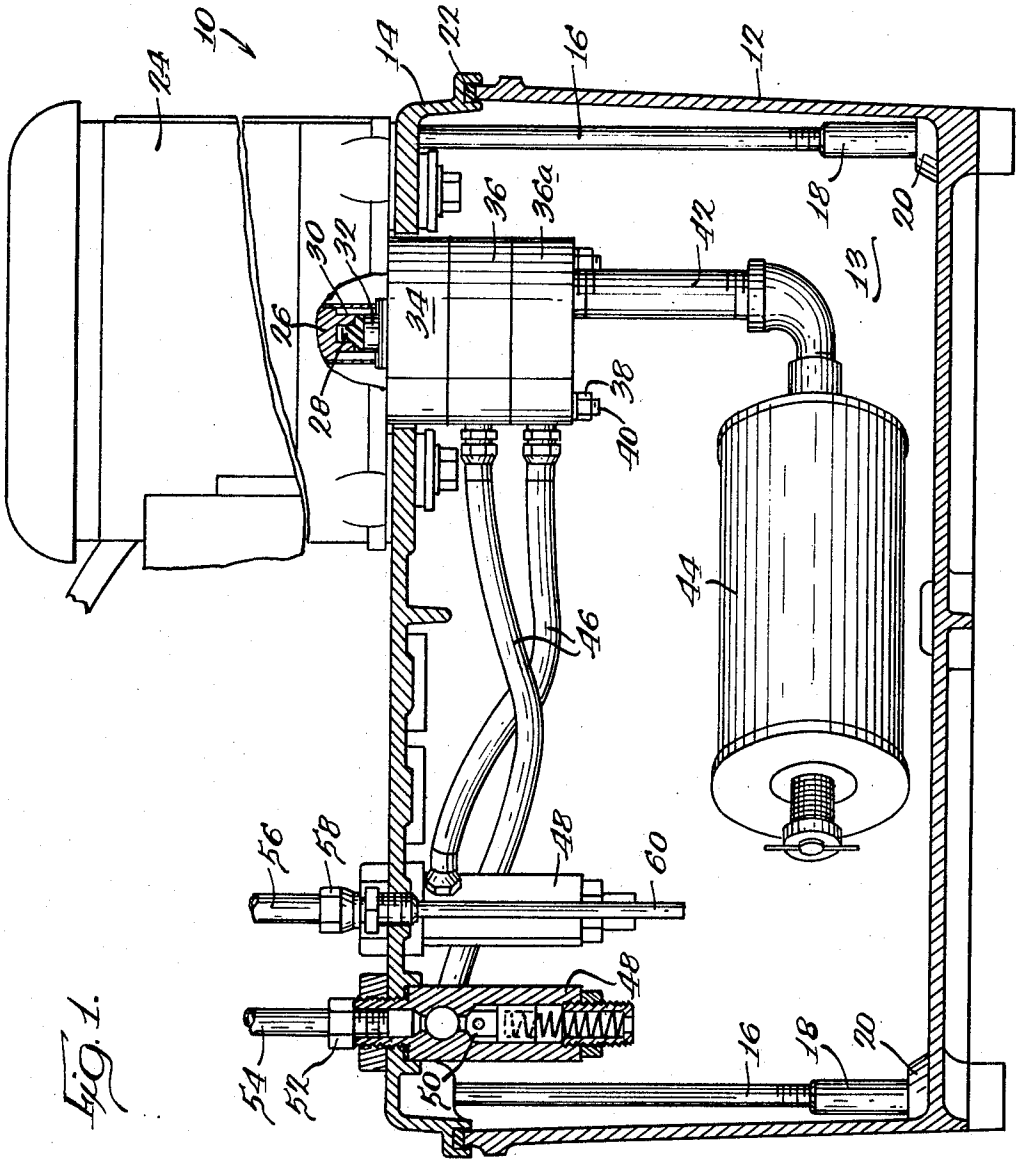


Fig. 1.

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AUTOMATIC DOOR OPERATOR

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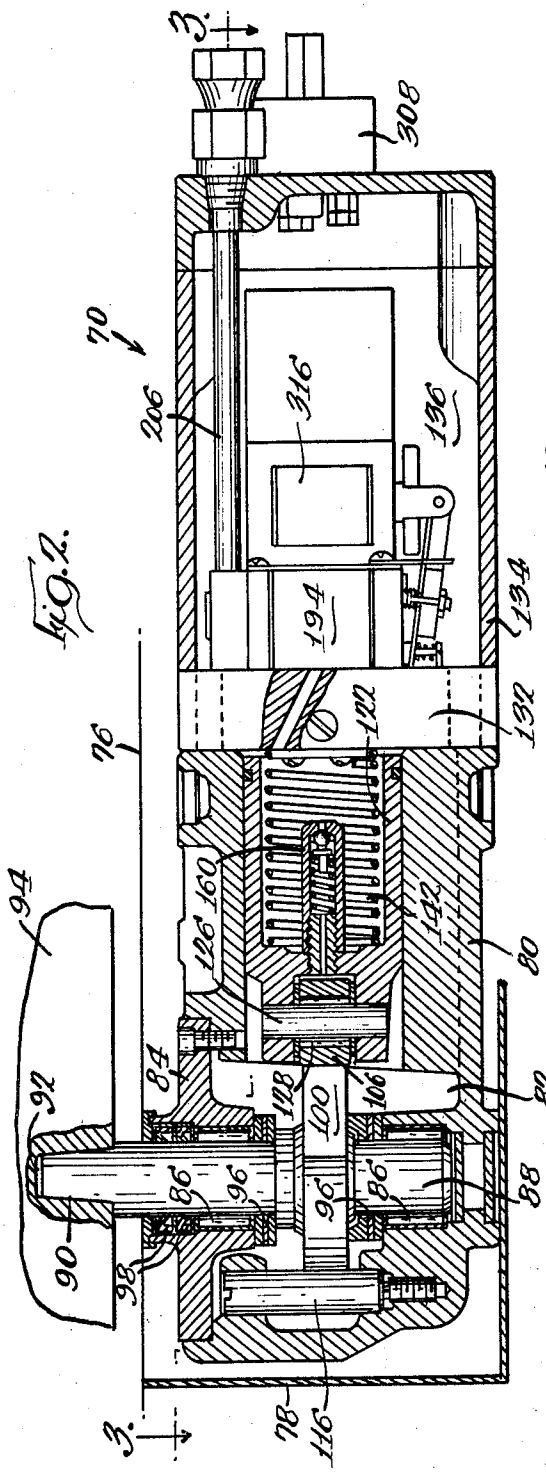


Fig. 2.

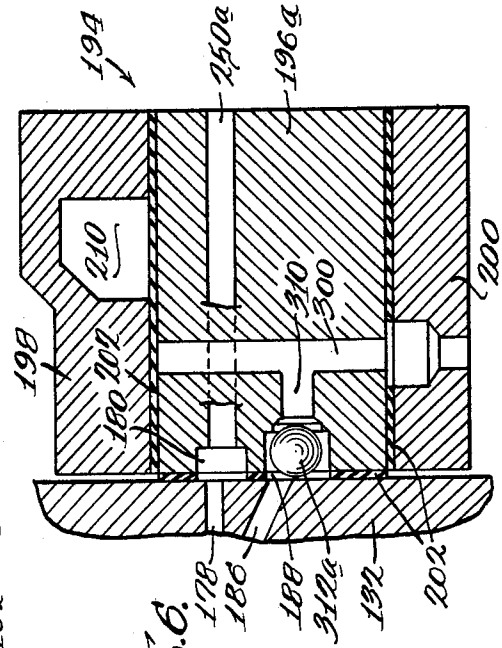


Fig. 6.

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AUTOMATIC DOOR OPERATOR

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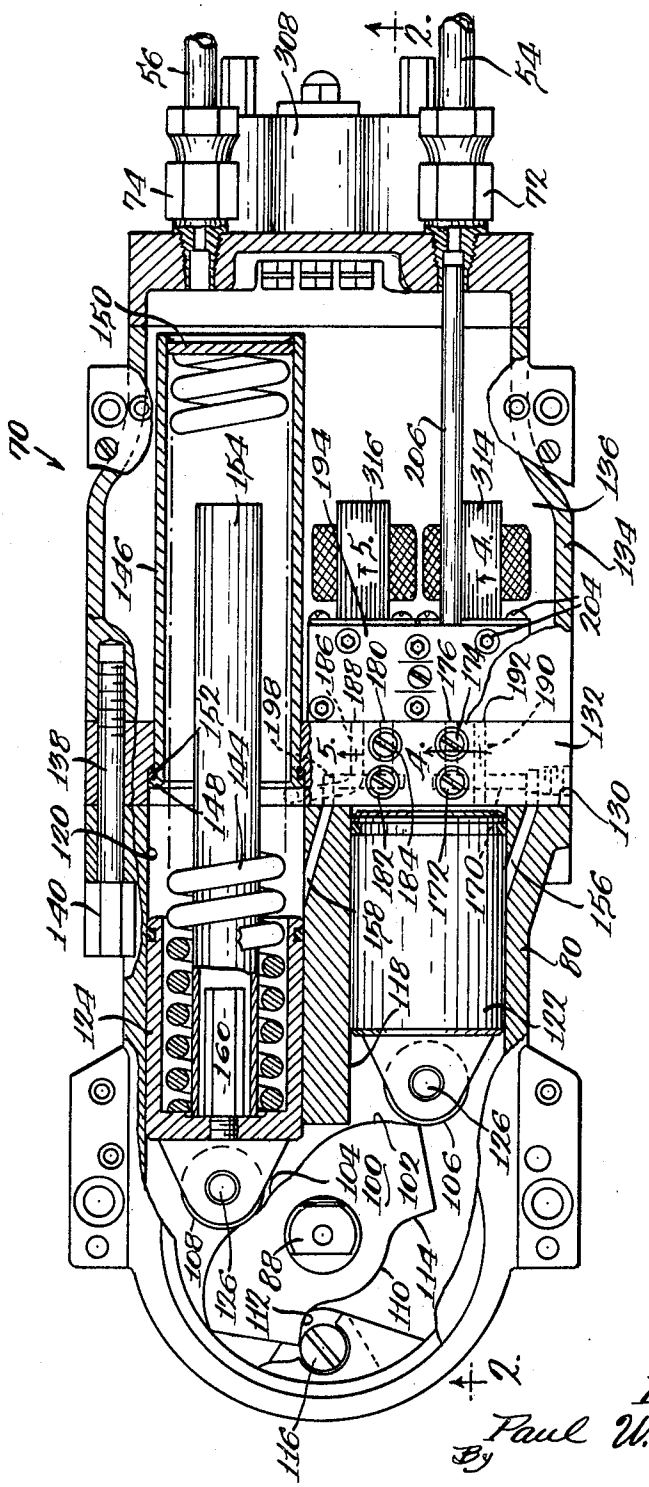


Fig. 3.

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AUTOMATIC DOOR OPERATOR

Filed July 29, 1968 5 Sheets-Sheet 4

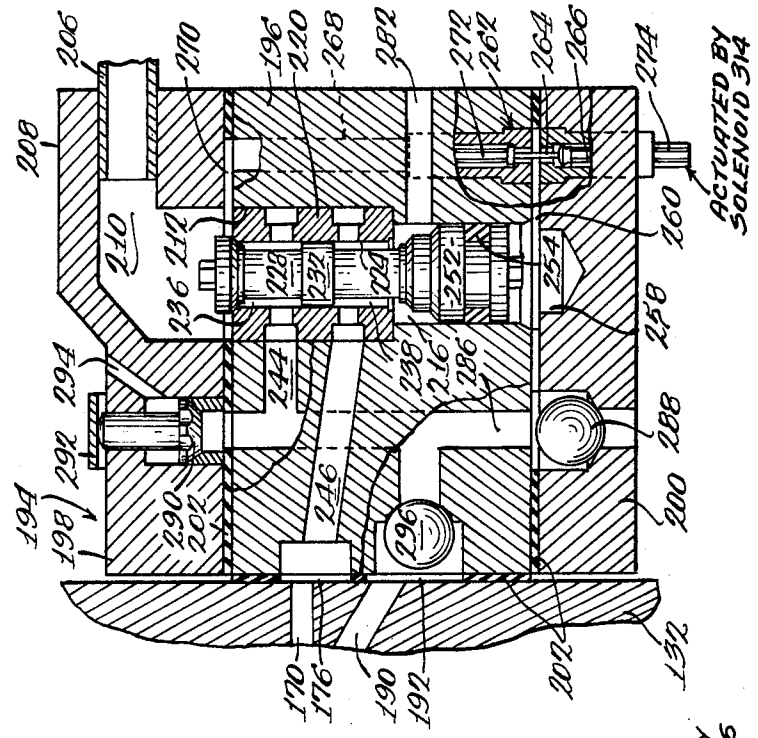


Fig. 4.

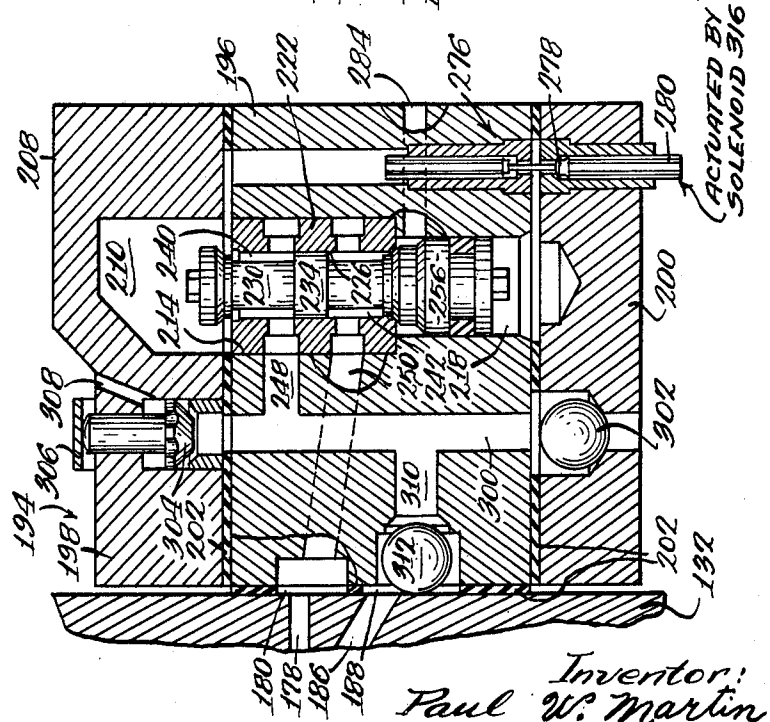


Fig. 5.

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AUTOMATIC DOOR OPERATOR

Filed July 29, 1968 5 Sheets-Sheet 5

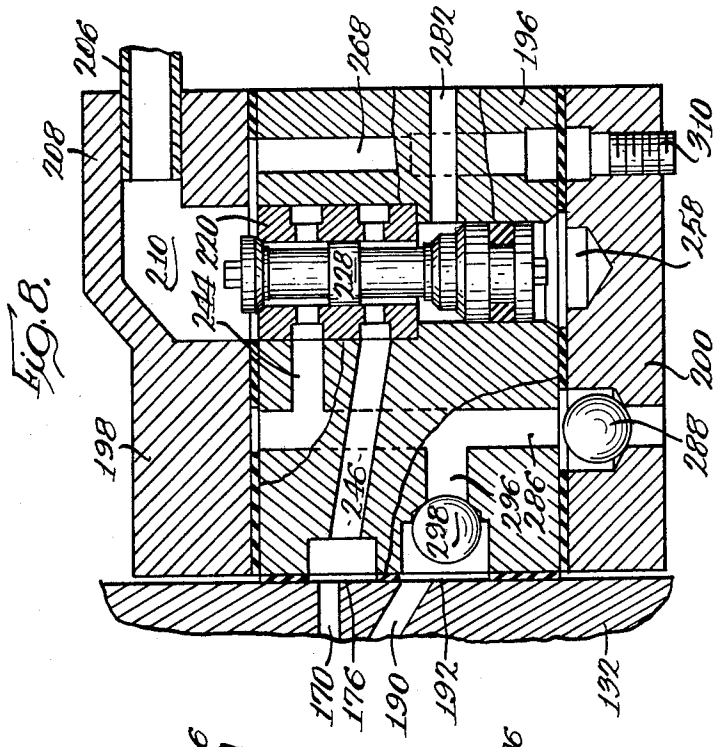


Fig. 8.

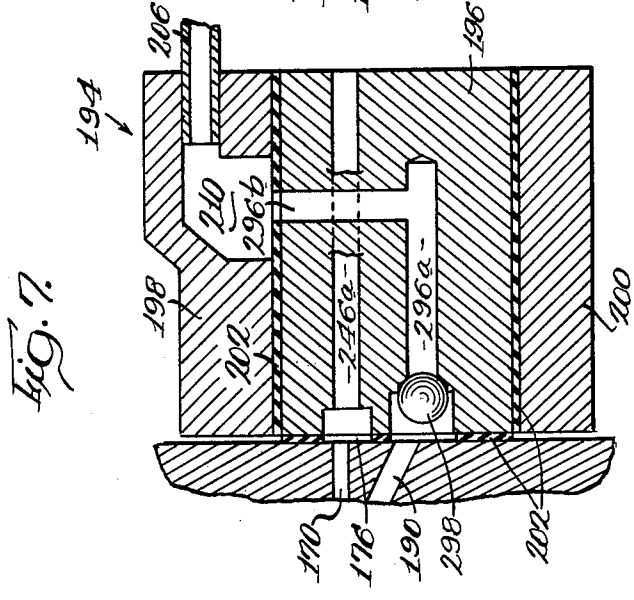


Fig. 7.

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United States Patent Office 3,478,468 Patented Nov. 18, 1969

3,478,468

AUTOMATIC DOOR OPERATOR

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Filed July 29, 1968, Ser. No. 748,529
Int. Cl. E05f 15/02
U.S. Cl. 49—137 11 Claims

ABSTRACT OF THE DISCLOSURE

A door operator of the hydraulic automatic type with a wide range of adaptability to different situations by the interchange of accessories to the major unit or units. Situations provided for are right or left door swinging, power opening with spring closing including hydraulic damping, power opening with power closing including power hold closed with spring closing and spring hold closed as a failsafe feature. Also provided is adaptability to single or multiple unit pump use and continuous or intermittent pump operation. Safety features are provided to prevent injury to persons passing improperly and to prevent obstruction of door way in the event of power failure, and optionally a traffic sensor may be provided with the continuous running pump option to shift the pump mechanism to intermittent operation when traffic density is light.

FIELD OF THE INVENTION

Automatic swinging door operators of the hydraulic type for use primarily in public buildings.

DESCRIPTION OF THE PRIOR ART

No known prior art is relevant to the concept of this invention, but certain of its capabilities have been available in prior limited purpose automatic door operators. For instance, U.S. Patents Nos. 2,789,814 and 2,739,808, show hydraulic operators of the intermittent pump running, power opening, spring closing, spring hold closed type, and suitable control systems therefor. Certain other accessories of a nature now commonly in use with door operators and door closers and which, therefore, will need no description here, but which may be incorporated in one form or another in a particular completed installation are shown for purpose of reference in the following U.S. patents: No. 3,354,497, "Panic Release Door Arm"; No. 2,954,446, "Mat Type Floor Switch"; No. 3,031,546 "Toe Actuated Safety Device for Automatic Doors"; No. 2,923, 962 "Break-Away Door Control Mechanism"; No. 2,910,741 "Safety Device for Swinging Doors"; No. 2,890,475 "Safety Door Stop"; No. 2,603,818 "Door Check Mechanism"; No. 2,595,187 "Adjustable Door Support."

SUMMARY OF THE INVENTION

Automatic door operators are called upon to meet many different duty situations and until now those available have not been fully responsive to all requirements. In some applications they have been successful, but in others they have been inefficient or have been lacking in some desirable attribute. One problem is that if they are designed to meet the most stringent requirements they then become too expensive or inefficient for other uses. If the attempted answer is to supply many different models, then manufacturing and inventory cost become excessive. In general, the unsatisfactory answer has been to provide a few models for the more common applications and ignore the areas where the more serious problems lie.

One commonly available operator starts a pumping motor when a person actuates a control, usually by stepping upon a mat switch, sometimes referred to as a carpet. The motor than comes up to speed, builds up the hydraulic pressure supplied to a motor mechanism which swings the door open. After the person has passed through, the motor is de-energized, coasts to a stop, drops the hydraulic pressure and a spring mechanism closes the door against the checking action of a hydraulic dash-pot. Usually one piston cylinder combination serves both as the power cylinder and the checking cylinder. If two or four or more doors are to be automatically operated, the entire mechanism is duplicated for each door. This leads to expensive duplication of motor and pumping equipment, and additionally, motors which are required to start and stop frequently on short duty cycles and need to supply high torque quickly and at starting speeds are almost necessarily of the capacitor start, induction run type. These have starting contacts subject to service difficulties and cost about 20% more than permanent split capacitor motors which have no contacts. Permanent split capacitor motors have lower starting torque and are designed primarily for long life, efficient, continuous or semicontinuous running. This later type motor also places much less peak load upon the electrical circuits because of the lower torque starting characteristics. If the need for high starting torque can be avoided, they are generally to be preferred.

One of the objects of this invention is to provide a door operating system which is intended primarily for continuous pump running, but which can be used where intermittent operation is more practical. The system is also adaptable for single or multiple door operation with only minor changes in the system and with minor modification can swing doors either right or left.

It is also an object to provide automatically for continuous pump operation during periods of heavy traffic and to switch to intermittent operation under conditions of light traffic.

Another problem encountered with prior art door operators of the spring closing type is that under some conditions the doors will not remain closed. In windy locations and under some other conditions the air pressure within a building may be considerably different than the ambient and this differential sometimes causes a door to be held slightly open or more commonly, to hunt between closed and partly open positions.

It might be thought that a heavier closing spring would be the answer to this problem, but springs of the capacity sometimes required would overpower and endanger persons improperly in the doorway. In this connection it should be appreciated that when the door is closed, the spring is in its most relaxed condition and least able to exert closing or holding torque, and that it is then that air pressure differential has the greatest opening effect upon the door, since the door is partially sealed.

It is, therefore, an object to provide a door operator mechanism having the features outlined previously and which is also adaptable for both power opening and power closing, so that the closing torque can easily be kept constant. It is also an object to provide for power closing without excessive torque, but to arrange the mechanism such that once the door is closed, the holding torque is higher than the closing torque, thereby in effect latching the door in place and preventing hunting or rattling or whistling of the wind around the slightly open door.

BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings

FIG. 1 is a vertical sectional view through the hydraulic pressure producing unit forming a portion of the system;

FIG. 2 is a longitudinal vertical sectional view through the hydraulic motor and door support portion of the system, including a portion of the control system for one

form of the invention, and may be considered as taken in the direction of the arrows substantially along the line 2—2 of FIG. 3;

FIG. 3 is a horizontal sectional view through the motor and related mechanism of FIG. 2 and may be considered as taken in the direction of the arrows substantially along the line 3—3 of FIG. 2;

FIG. 4 is a somewhat diagrammatic longitudinal vertical sectional view through a valving mechanism attached to the basic motor mechanism for the purpose of providing for continuous hydraulic fluid circulation for power opening and power closing action. The view may be considered as taken substantially along the line 4—4 of FIG. 3 in the direction indicated by the arrows and shows valve elements in the positions they assume during the opening cycle;

FIG. 5 is a view similar to that of FIG. 4, but taken in a parallel plane as indicated by the arrows and line 5—5 of FIG. 3. In this view emphasis is upon the valve elements principally concerned with door closing action, in FIGS. 4 and 5 some of the passages have been reoriented slightly so as to put them in a common plane with other connecting passages, thus making the fluid flow more apparent;

FIGS. 6 and 7 are similar to FIGS. 4 and 5, but show variations in the structure; and

FIG. 8 is structurally similar to FIG. 4 as modified to be the equivalent of FIG. 7.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Mechanically, the mechanism of this invention breaks down into several interconnected units which form the system. One of these is the pumping unit which is used to power the door motor, or motors in a multiple door installation. To promote adaptability to various requirements, it may be set up for various fluid delivery capacities. Primarily it is intended for continuous running, but it may be operated intermittently. The pumping unit forms the subject of FIG. 1.

The second major mechanism is the door support and hydraulic motor unit shown primarily in FIGS. 2 and 3.

A control system interconnects the pumping unit and door motor, or motors, and responds to variously received signals which reflect conditions within and exterior to the system. The control system may vary considerably depending upon the requirements of the application, but uses interchangeable elements and in all cases makes connections to the pumping unit and hydraulic motor or motors which are substantially identical for all applications. The pumping unit and the hydraulic motor are, of course, the most highly specialized elements and, therefore, the portions of the system requiring the major special tooling, manufacturing and stocking facilities, and which constitute the major expense in the total organization. It is standardization in this major expense area, therefore, that leads to an overall saving.

Taking first the pumping unit, it includes a casing **10** to which the other elements are secured. The casing is made up of a deep cast tray **12**, which provides a fluid sump **13**, and a cast cover **14** secured thereto by through bolts **16** and threaded sleeves or nuts **18**. Although not shown, the sleeves **18** have rectangular heads which slip into T slots formed in bosses **20** located internally near the bottom of the tray **12**. A gasket **22** is interposed between the tray **12** and the cover **14** to effect a seal.

An electric motor **24** is attached to the cover and has a vertical shaft **26** which extends downwardly and has a slotted connection through a resilient coupling **30** to a pump shaft **32** passing through a housing **34**. The pump shaft is in turn similarly connected to the drive shaft, not shown, of a pump deck **36**. Several of these pump decks can be connected in a stack, with the shaft of one having a direct drive connection to the next in the stack. For purpose of illustration, two of these decks are shown, the second being indicated at **36*a***.

The pump decks **36** and **36*a*** are identical, and each one is designed to power a single door. The number of doors powered from a single pumping organization, therefore, determines the number of decks to be included in the assembly. Whatever number of decks are needed in the pack are assembled and secured by nuts **38** and studs **40** of the proper length.

Ordinarily, from one to four decks will be used, because, usually it is not customary to have more than four doors clustered near a single pumping unit. Experience indicates that if more than four doors are present it is usually more economical to provide a separate unit rather than run long hydraulic and control lines. My preference, therefore, is for a pumping unit which is adaptable for up to four doors. If provision for more than four doors is believed to be more fitting, this of course, can be arranged simply by deepening the pan or tray **12** and providing more decks **36**, **36*a*** and outlet and inlet fittings to be mentioned presently.

The construction of the pump decks **36**–**36*a*** may be conventional and such decks are available from several sources that supply the complete unit. They, therefore, need no detailed description. My preference at present is for pumps of the vane type, but other suitable pumps may be had.

The pump intakes manifold together when the decks are stacked and are connected to a pipe **42** leading to an intake filter **44** positioned near the bottom of the pan **12**. The pan **12** serves as the sump or reservoir and normally is kept about two thirds full of hydraulic fluid.

The pump outlets, one for each deck are connected by pressure hoses **46** and suitable fittings to outlet fittings **48** which extend through the cover **14**. Each of the outlet fittings **48** includes an adjustable pressure relief valve **50**, which may be of conventional construction. Its purpose is to limit the maximum pressure available at the outlet fitting connection **52**, any excess fluid being bypassed back to the reservoir **12**. The pressure hoses and tubing **54** leading from the pumping unit to the door motor units are joined to the outlet connections **52**. The return lines **56** from the door motors are connected to fittings **58** which extend through the cover **14** and have tubular extensions **60** which pass the hydraulic fluid back into the pool within the reservoir **12** at a position beneath the surface thereof so as to prevent foaming.

One of the door operating motors **70** is shown in FIGS. 2 and 3 and has connections **72** and **74** to one set of the pressure lines **54** and return lines **56** respectively of the pumping unit **10**.

The motor unit **70** is mounted beneath the floor surface, indicated at **76**, within a box **78**, commonly referred to as a cement case. The cement case is set into the floor when the latter is laid, or subsequently, to provide a cavity within which the motor unit can be installed whenever it is convenient, it being located and secured therein in any well known fashion which needs no discussion here. This motor unit has as its principal structural elements a group of machined castings which are secured together by studs, nuts, cap screws and the like. The casting **80**, to the left in FIGS. 2 and 3, provides a cavity **82** at the left end which is open at the top. This top opening is closed by a cover plate **84**.

The cover **84** and the inside base of the casting **80** are machined to take bearings **86** in alignment which are fitted to a vertical shaft or spindle **88**. The shaft **88** extends through the cover **84** and is provided at its upper end with tapered flats **90** which fit a socket **92** of a door or door control arm **94** which may be according to standard practice. The weight of the door is therefore carried by the shaft or spindle **88** and endwise movement of the spindle **88** is prevented by thrust bearings indicated at **96**. Resilient cup washers or other rotary seals to prevent leakage around the spindle are also provided at **98**. Rotation of the spindle **88**, therefore, swings the door open or closed.

At about its midpoint within the cavity **82**, the spindle

88 is provided with a two lobe cam disc or wing cam 100 welded thereto. This cam has opening 102 and closing 104 peripheral faces which engage cam following rollers 106 and 108 respectively. These cam surfaces face toward the right of FIG. 3 and the back side of the cam disc 100 is cut away as at 110 to provide stop faces 112 and 114 which at the limits of spindle rotation engage a vertical stop pin 116.

The casting 80 is also machined to provide a pair of parallel horizontal cylinder bores 118 and 120 extending to the right of the spindle. The center lines of these cylinders intersect the periphery of the cam disc 100 on each side of the spindle 88. The cylinders 118 and 120 are the same size and have fitted pistons 122 and 124 respectively which carry respectively the previously referred to rollers 106 and 108 on cross pins 126 and needle bearings 128. In the configuration shown, the piston 122 and cylinder 118 are the opening piston and cylinder combination. That is, movement of the piston 122 toward the left under the influence of hydraulic pressure causes its roller 106 to run along the cam face 102 so as to rotate the spindle 88 clockwise as seen in FIG. 3, to open the door. The piston 124 and cylinder 120 similarly act against the cam to close the door. In FIGS. 2 and 3 the door is shown in closed position. This same mechanism, with the cam 100 turned over on its spindle so that it is reversed from right to left conditions the major motor structure for operation of a door that swings open counterclockwise rather than clockwise, since the pistons and rollers are the same and the differences in the casting 80 are only minor, a pair of simple straight drilled passages to be mentioned presently.

The right face 130 of the casting 80 is flat, intersects the cylinders 118 and 120 and is square with their axes. Fitted to it is the face of a relatively thin cast plate 132, less than an inch thick in the embodiment shown. The two faces of the plate are parallel and the opposite face is fitted to a cast cup shaped member 134 which provides clearance space 136 for various elements to be mentioned and acts as a fluid sump for the motor. To prevent leakage, appropriate gaskets, not shown, are interposed between these three castings and the casting assembly is clamped together by studs 138 and nuts 140. The requirements of the casting 134 are indifferent as to right or left hand door swinging and, therefore, only one casting of this type need be made and stocked. The plate 132 casting is the same for all models, but upon how it is drilled and otherwise machined and upon what is secured to it depends the right or left door opening capability and the various other adaptabilities of the system.

Whichever piston supplies the torque for door opening, piston 122 of the drawing should have provision to insure that its roller always follows the cam 100. A light coil return spring 142 is shown for this purpose and bears with its opposite ends against the plate 132 and the inside head surface of the hollow piston.

Similarly, a coil spring 144 is required to keep the roller 108 against its cam surface, but this spring should be much heavier than spring 142 since it preferably should be able to close the door in a reasonable time in the event of power failure. Since this spring 144 is heavier, and in the interest of reasonable linearity of spring action, it is much longer than spring 142. To provide for its accommodation, the plate 132 is drilled and recessed annularly on the piston side in alignment with the door closing cylinder, cylinder 120 as shown, and a deep cup 146 having an outwardly turned flange 148 is inserted from the left through this drilled opening with the cup flange in the recess, such that the cup bottom at 150 serves as the base for spring 144. To prevent leakage, a gasket 152 is interposed between the bottom of the recess and the flange 148. The opposite end of the spring 144 bears against the inside surface of the head of piston 124 and to keep this longer spring in alignment, a spring guide tube 154 is loosely fitted to the internal diameter of the spring and has its end press fitted, welded or otherwise attached to the head of piston 124. The opposite end of the spring is guided by the side wall of the cup 146.

To provide for right or left door swinging movement, the plate 132 can be drilled and spot faced around the opening on either side of the center line to take the spring cup 146. Also, to prevent needless repetition from hereon, the passages and the like formed in the plate 132 will be described as shown, but it will be appreciated that for door opening in the opposite direction, the various passages, plate attachments and internal elements will be the reverse complement of those described.

From the description so far, it will be understood that when hydraulic fluid under pressure is admitted from the right to cylinder 118, and cylinder 120 is exhausted to the sump 136 piston 122 will move to the left and swing the door open. Conversely, when cylinder 118 is exhausted to the sump and pressure is applied to cylinder 120 and piston 124 the door will swing shut. In the event that power fails and neither cylinder 118 or 120 receives hydraulic fluid under pressure and both are exhausted to the sump 136, the door will be closed, but more slowly than normal, by the spring 144. The sump 136, incidentally, is drained of hydraulic fluid excess by way of the previously mentioned fitting 74. This fitting communicates through the end wall of the casting 134 and interconnects the motor sump 136 with the pump sump 13 by way of line 56.

The description up to now has been principally of those elements which are the same or essentially the same for all applications. Thus, the castings, pistons, spindle, pumps, fittings, etc., are universal, but more than one pump deck 36–36*a* may be required, and a set of hoses 46, fittings 52–58, etc., will be necessary for each door motor.

The principal elements having to do with adaptation of the system for various applications essentially consist of passages formed in the plate 132 and equipment attached to or located within this plate. Some other minor variations are also contemplated and some of these have been mentioned, such as the variation necessary to switch the system between clockwise and counterclockwise door swinging. One other change necessary for this adaptability that should be mentioned at this point in the interest of completeness concerns a pair of passages 156 and 158 drilled in the main door motor casting 80. Both of these are drilled from the flat face 130 of this casting on the side which is aligned with the opening cylinder 118. Passage 156 extends from the casting face 130 through into door opening cylinder 118, and passage 158 similarly extends from the face 130 into the closing cylinder 120. Both of these passages intersect their cylinder walls in positions such that the cylinder ports thus formed are covered by the pistons shortly before the pistons are moved all the way to their retracted positions, see FIG. 3 where piston 122 covers its passage 156 outlet. Since these two passages 156 and 158 both intersect the casting face 130 on the side opposite the long closing spring 144, it is necessary to drill them from one side or the other of face 130, depending upon whether particular casting 80 is to be used for a right hand or left hand door. In the interest of being specific in this description, regardless from which side the passages are drilled, it will be assumed that passage 156 leads to the opening cylinder and passage 158 to the closing cylinder.

To limit possible hydraulic pressure surge within the cylinders 118 and 120 to some predetermined maximum, when the pistons reach the limit of their travel, or if the door traps someone in the doorway, pressure relief valves are provided. These conveniently can be of the common spring loaded ball type and are mounted upon and communicate through the piston heads. One of these is shown at 160 in FIG. 3 and cut away and in greater detail in

FIG. 2. Since their construction is not unusual no detailed description is necessary.

The structure within the plate **132** is shown principally in FIG. 3 and that within a valve body attached to the plate in detail in FIGS. 4 and 5. Within the plate, passages are drilled such that one indicated at **170** intersects the passage **156** in the casting **80** and leads through a pair of adjustable needle valves, or their equivalent, in tandem at **172** and **174** to the opposite side of the plate to form a port at **176**. Similarly, a passage **178** connects the passage **158** in the casting **80** with a port **180** on the opposite side of the plate **132** by way of adjustable needle valves **182** and **184** in tandem. A third passage **186** leads from cylinder **120**, at a point beyond the limit of travel of piston **124**, to a port **188** on the right face of plate **132** and a fourth passage **190** extends through the plate from the closed end of cylinder **118** to a port **192**.

A valve body **194** is fastened to the back (right hand) face of the plate **132** and has passages which communicate with each of the ports **176**, **180**, **188** and **192**. Although most of the variation in structure as between units adapted for different purposes is largely concentrated in this valve body and its attachments, the basic body structure is the same in all cases. Its principal element is made up of three die castings, to facilitate machining. There is a central portion **196** which has a flat face to mate with the plate casting **132** and top and bottom flat faces normal thereto which mate with top and bottom caps indicated at **198** and **200** respectively. Gaskets **202** are used at the three faces and the assembly is held together and to the plate **132** by cap screws **204** suitably located. To avoid confusion, the screws are not shown in the diagrammatic views, FIGS. 4 and 5.

The hydraulic fluid inlet to the valve body is by way of a straight tube **206**, one end of which is pressed into an opening drilled through a boss **208** in the upper cap **198**. The other end of the tube **206** mates with the inlet fitting **72** previously mentioned. Bosses **208** are provided on the die casting at each end of the cap **198** so that when the valve body is assembled to the other end of the plate **132**, to change between right and left door swinging, the tube **206** can line up with the fitting shown at **74** in FIG. 3 when the other boss is drilled to take the tube **206**. Under these conditions, the fitting shown at **74** in FIG. 3 becomes the inlet and the drain or return fitting is at **72**. The fittings **72** and **74** are identical and the tube **206** can connect with either during final assembly. With either option, the fluid enters a passage **210** that extends transversely of the cap **198** behind the bosses **208** and is open against the upper face of the middle casting **196**.

Beneath the passage **210**, the central casting **196** is machined at each side to provide a pair of parallel identical cylindrical recesses **212** and **214** intersected at their bottoms by smaller coaxial cylinders **216** and **218** respectively. The cylinders **216** and **218** open at the bottom of the casting **196** and are closed by the cap **200**.

A valve body **220** is pressed into the recess **212** and an identical valve body **222** is pressed into the recess **214**. These valve bodies have an axial cylindrical passage **224** and **226** respectively through which a double poppet headed valve **228** and **230** passes. When the valve moves up it seals the lower end of the valve body passage **224**, **226** and when it moves down it seals the upper end of the passage. Clearance is provided around the valve stem between the poppet heads excepting for a larger diameter stem portion **232**, **234** at the center which fits the passage and isolates the upper and lower annular spaces **236** and **238** for valve **228** and **240** and **242** for valve **230**. These spaces communicate through ports and annular grooves formed in the external surface of the valve body with passages drilled in the central body casting **196** as follows. Space **236** connects to passage **244**, space **238** with passage **246**, space **240** with passage **248**, and space **242** with passage **250**.

The lower end stem of valve **228**, below the lower poppet head, is joined to a piston **252** which fits the cylinder **216**. To effect a seal, the piston **252** has an O ring **254** seated in a peripheral groove. An identical piston **256** is connected to the valve **230** and fits the cylinder **218**.

The lower chamber **258**, beneath the piston **252** is connected by a passage **260**, conveniently formed as a slot in the lower gasket **202**, with a pilot valve at **262**. This pilot valve is of the double headed poppet type. When the movable valve element **264** thereof is in the normal down position, the passage **260** and hence the chamber **258** is vented to the motor sump **136** by way of a downwardly exhaust passage **266** and instead is connected to a coaxial moved upwardly, the passage **260** is isolated from the exhaust passage **266** and instead is connected to a coaxial passage **268** which extends upwardly through the central casting **196** and communicates at the top by way of a slot **270** in the top gasket **202** with the inlet chamber **210**.

Normally the pilot valve element **264** is held in the downward position by the weight of the movable valve element, the pressure differential between the inlet chamber **210** and the sump **136**, and the weight of a hexagonal or fluted stem **272** which loosely fits the passage **268** and engages the top of the movable valve element **264**. A fluted stem **274** is located beneath the valve element **264** and moves this valve member upwardly when the stem **274** is raised. Thus, when the valve element **264** is normally down, the chamber **258** is exhausted to the motor sump **136** and the piston **252** and valve member **270** are moved to the down position under the influence of the pressure in inlet chamber **210**. When the stem **274** is raised, pressure from the inlet chamber **210** is communicated through the pilot valve **262** and applied to the underside of piston **252**, thus moving the piston **252** and valve element **270** upwardly. Note that the piston **252** area is considerably greater than the sealed areas at the poppet heads at the top and bottom of valve elements **228**.

The pilot valve assembly and communicating passages at **262** for valve **252** are duplicated at **276** for valve **256**. Pilot valve **276** has a movable element **278** which is similarly actuated by a fluted stem **280**, both of which are the equivalents of valve element **264** and stem **274** respectively of the pilot valve of FIG. 4.

The space beneath the annular valve chamber **238**, which communicates with the chamber **238** when the valve **270** is down, is connected to the sump by way of passage **282**. A similar passage **284** connects the valve chamber **242**, when the valve member **230** is down, with the sump. The passage **246**, previously mentioned, connects to the port **176** and passage **170**. Similarly passage **250** leads to the port **180** and passage **178**. Passage **244** intersects a vertical passage **286** through the central casting **196**. At the lower end this passage **286** communicates with a ball check valve **288** in the cap **200** which permits flow upwardly from the sump into passage **286**, but prevents flow in the opposite direction. At its upper end the passage **286** leads to a pressure relief valve **290** held against its seat by a leaf spring **292**. Whenever the pressure within the passage **286** rises to some preset level, the valve **290** will be lifted from its seat and excess fluid will escape through a port **294**. A branch **296** from passage **286** leads past a ball check valve **298** to the port **192** and passage **190** in the cast plate **132**. The check valve **298** is oriented to permit flow from passage **286** to passage **190**, but to prevent reverse flow.

Counterparts in FIG. 5 of the elements just described with reference to FIG. 4 are vertical passage **300** having at its lower end a check valve **302** and at its upper end a relief valve **304** having biasing spring **306** and escape port **308**. Branch passage **310** intersects passage **300** and leads past check valve **312** to port **188** and passage **186** in the plate **132**.

A pair of electrically energized solenoid actuators **314** and **316**, the details of which need not be given since they may be conventional, are mounted upon the back face of the valve body **196**. They are arranged such that when

solenoid **314** is energized it will move pilot valve actuating stem **274** upwardly and similarly, when solenoid **316** is energized, it moves valve actuator **280** upwardly. De-energization of either permits its actuator **274** or **280**, as the case may be, to move downwardly.

The system as just described is for continuous pumping, power opening, power closing and power hold closed actuation of a door with which it is associated. It also has failsafe features which permit manual door opening and automatic spring closing with hydraulic checking in the event of power failure. The system operates as follows, beginning with the door closed and the pump unit running.

When the door is closed, its system, beginning with its particular pump deck **36**, for instance, idles at a pressure of say 120 to 150 pounds per square inch hydraulic pressure. At that time the control system is energizing solenoid **316** which lifts actuator **280** and holds pilot valve **276** in the up position. Simultaneously, solenoid **314** is de-energized and pilot valve **264** is, therefore, in the down position. The opening cylinder **118** is at sump pressure, essentially ambient, by way of passages **156** and **170** (including needle valves **172, 174**) port **166**, passage **246**, valve space **238**, open lower poppet of valve **270** and passage **282**. This is because pilot **264** in its lower position connects the space **258** beneath the valve piston **252** with the sump and causes the inlet pressure at **210** to push the valve **228** downwardly and hold it there. Although the passage **156** enters the cylinder **118** in a position covered by the retracted piston **122**, there is sufficient leakage around the piston so that the pressure within the cylinder **118** soon drops to sump pressure. The motor sump **136** is in turn connected through the fluid return line **56** to the pump sump **13**.

At this time (door closed) pilot valve **278** is up, thereby closing communication between the sump **136** and the space **218** beneath valve piston **256**. Instead the space **218** is connected by way of the pilot valve passages with the inlet pressure chamber **210**. The piston **256**, therefore, is up so as to close the valve **230** lower poppet and open the top poppet. Pressure from the chamber **210** is communicated in series through the passages **248, 300, 310, 188, 186** to the closing cylinder **120**. Under these pressure conditions, ball valve **312** is open and the valve **302** is closed. Also, once the door closing piston **124** has reached the limit of its travel in door closing direction, to the left in FIG. 3, the pressure relief **304** is lifted from its seat and the hydraulic fluid escapes through the vent passage **308**. Meanwhile, the side port **158** of closing cylinder **120** is cut off from the sump as follows. From passage **158**, through passage **178** including needle valves **182** and **184** to port **180** and passage **250** to the lower poppet of valve **230** which is closed.

In a representative embodiment of this invention the torque when the door is closed and the motor system stalled with the relief valve **304** lifted from its seat is 72 to 78 foot pounds. This then is the torque available for holding the door closed. The system continues in this condition until a person steps upon the entering door mat switch or otherwise signals the door to open.

When this happens, the electrical control system de-energizes solenoid **316** and energized solenoid **314**. The pilot valves **264** and **278**, therefore, change positions and piston **252** and valve **228** rise while piston **258** and valve **230** move downwardly.

Pressure from chamber **210** is communicated in series through valves, ports and passages as follows. From chamber **210**, through the space beneath top poppet of valve **228**, through passages **244, 286, 296, 192, 190** to opening cylinder **118**. Meanwhile, the side port and passage **156**, of cylinder **118** is cut off at the closed lower poppet of valve **228**. Pressure is, therefore, brought to bear against opening piston **122**. At this time closing cylinder **120** passage **186** is closed at the ball chack valve **312**, but passage **158** is open through passage **178**, including needle valves **182** and **184**, port **180**, passage **250** and the opening through lower poppet of valve **230** to the sump passage **284**. The opening piston **122**, therefore, advances and the closing piston retracts and the door swings open under control at a rate determined by the setting of the needle valves **182** and **184**. As the door swings open and the piston **124** retracts, the piston **124** will cover the end of passage **158** shortly before the door is all the way open. When this happens, flow through the passage **158** is limited to leakage around the piston **124**. Door swinging movement in the opening direction is, therefore, checked slightly before the door is fully open and the door thus creeps without shock the last few degrees to a stop ultimately determined by cam face **114** and stop pin **116**. When the door is fully open, or rather when it shifts to creeping speed just before the stop, relief valve **290** is lifted from its seat and the system stabilizes with the door open where it is held until the signal to close is received.

The closing signal reverses the energization of the solenoids **314** and **316** and establishes the hydraulic connections originally described as existing when the door is held closed. When this happens, hydraulic fluid flows from chamber **210** through under top poppet of valve **230**, through passages **248, 300**, valve **312**, port **188**, and passage **186** to closing cylinder **120**. At this time, passage **158, 178, 180** and **250** is blocked at the lower poppet of valve **230**.

Meanwhile opening cylinder **118** passage **190** is blocked at the check valve **298**, but the passage **156** is open through passage **170**, needle valves **172, 174**, and passage **246** to the open lower poppet of valve **232** and sump passage **282**. The rate of door closing movement is, therefore, established by the setting of the needle valves **172, 174** and, thus, the opening piston, cylinder combination **122, 118** acts as a checking mechanism to control the closing door movement.

While the door is swinging closed under these conditions, the relief valve **290** remains seated, since the balance as between the pump delivery rate and the needle valve **172, 174** exhausting rate does not permit the pump to develop full stalling pressure. Closing torque in a typical embodiment is, therefore, 55 to 58 foot pounds.

When the door is almost closed, piston **122** covers the opening to passage **156**. This limits the closing rate to the rate of leakage of fluid around the piston **122**. The door, therefore, creeps the last few degrees to closed position and the pressure rises until relief valve **304** is unseated. This increase in pressure raises the torque from 55 to 58 foot pounds, the closing torque, to the hold closed torque of 72 to 78 foot pounds. The door is, therefore, held tightly shut without the need for a detent in the cam surface (an expedient commonly used) and thus there is not the usual shock or click when the door is next opened, which is caused in the usual organization by the cam follower being overpowered and snapped out of its latching detent.

In the event of power failure, both solenoid **314** and **316** will be de-energized and both valves **228** and **230** will be in their lower positions. Thus, both cylinders **118** and **120** will communicate with the sump by way of their needle valve controlled passages **170** and **178**. The door will, therefore, normally be closed under the influence of the spring **144**. If now someone manually swings the door in the opening direction, the opening piston **122** follows its cam face under the influence of spring **142**. This evacuates the passages **190** and **192**, unseats the ball **298**, evacuates the passage **286** and unseats the ball **288**, thus filling the opening cylinder system from the sump **136**. Meanwhile, the closing piston **124** moves toward the right of FIG. 3 and hydraulic fluid in cylinder **120** exhausts through the passages **158, 178, 250** and the open poppet at the bottom of valve **230**. Normally, a person manually swinging the door, so as to go through, will not swing it sufficiently to reach the slow down condition with passage **158** covered by piston **124**, but if he does, the slow down mechanism will protect the door against shocks.

When the manually opened door is released, it will close under the influence of spring **144** with a torque of about 32 to 36 foot pounds in a typical application. Cylinder **120** will refill as piston **124** advances by way of passages **186, 188, 310, 300** and ball check valve **302**. As the door closes, its action will be checked by limited flow through passage **156** and those previously mentioned as connected thereto including needle valves **172**, and **174**. Flow through passage **190** is blocked at the ball valve **298**.

Although the system just described is intended primarily for continuous pump operation with an adaptation for manual operation in emergencies, it will be appreciated that the system can stand by with the power off, as for manual operation, and have the pump motor energized whenever necessity for opening is signaled. When this happens, the pump will start, solenoid **314** will be energized and opening and subsequent closing will take place as described earlier. This latter cycle can be used to advantage when traffic is light.

To avoid confusion, the electrical leads from a terminal box **308**, at the back of the sump housing **134**, to the solenoid actuators **314** and **316** have been omitted from the drawings, but their placement will be understood. The reason for using needle valves in tandem as at **182–184** and **172–174**, is that it makes it easy to make a coarse adjustment with one valve and refine the setting with the other. To facilitate this, the characteristics of the two valves in a set are different.

There are occasions when it is convenient to have a multiple pumping installation of the type described which operates some doors on the above discussed power open, power close, power hold close continuous pumping cycle and to have other doors which are conveniently near the pumping unit operated on a continuous pumping cycle, but with power opening, spring closing, spring hold close as the mode of operation. As an example, two outside, side by side doors might advantageously use the power close, power hold close feature whereas two inside doors in line with the outside doors might not need high torque closing and holding. Such four door units are common and all can be close to a single multiple pump installation of the constantly running type.

One of the features of this invention is to provide a minor modification of the basic system which results in a lower cost motor unit that uses hydraulic fluid under pressure from a continuously running pump only for the door opening portion of the cycle. This can be used in the multiple door arrangement mentioned above or for all doors connected to the pumping unit. An accompanying advantage is that under most conditions more than one door can be thus operated from a single pump deck, since the hydraulic pressure door actuating portion of the cycle is short and hydraulic pressure is not needed to hold the door closed.

To modify the basic motor for continuous pumping, spring closing, spring hold closed operation, a slightly different cam **100** is used to accommodate the non-linear characteristics of the closing spring and usually to provide a hold closed detent, also the closing spring at **144** is made heavier. The other changes are in the valve body **194***a*, which is like **194** excepting as noted, and its attachments. The power opening valve mechanisms may be the same as that shown in FIG. 4. The power closing solenoid **316** is omitted along with the pilot valve **276** and the double poppet valve **230** and their various passages. The recess **214** which takes the poppet valve mechanism **230** is not drilled or otherwise machined and the relief valve at **304** and its biasing spring **306** are not needed. No recess in the cap **208** to take the relief valve is, therefore, needed. Passage **250***a* is drilled straight through the casting **196***a* to the outside (to the sump). Otherwise, the system can remain the same excepting that only one ball check valve **302** or **312** need be provided, say the valve at **312***a* which is shown. This arrangement is illustrated in FIG. 6.

Whether the top and bottom gaskets **202** have cutouts for the absent passages and recesses is a matter of indifference, excepting that it may be less expensive to use interchangeable gaskets for both models. Such gasket cutouts, if provided, serve no functional purpose, however, and are not shown in FIG. 6. Note, that as indicated hereafter, the structure need not be physically revised to the extent indicated in the interest of interchangeability of parts.

This arrangement operates as follows. The opening cycle is as previously described with the closing piston **124**, needle valves **182** and **184** checking the opening action by way of passages **158, 178** and **250***a*. When the door is signalled to close, solenoid **314** is de-energized and the spring at **144** swings the door closed, hydraulic fluid to fill the cylinder **120** being drawn in around check valve **312***a*. As in the previous example, closing action is checked by expelling fluid from cylinder **118** through needle valves **172, 174**. In the event of power failure, the door when manually swung open draws hydraulic fluid past check valves **298** and **288** to keep cylinder **118** full. Note that passages **310** and **300** are shown essentially as in FIG. 5. If desired, the passage **310** can simply be drilled straight through parallel to passage **250***a*, since there is no need for the check valve **302** or the pressure relief valve **308** at opposite ends of passage **300**.

Under some conditions, it may be desirable (in the interest of limiting manufacturing effort to one basic model) to supply a door motor mechanism with minimum alteration of the basic design, but of the power open spring close, spring hold closed character which is powered by an intermittent pumping system, of the type shown in previously referred to Patents Nos. 2,789,814 and 2,739,808 for instance. With such systems, the signal to open the door starts the pumping motor which runs until the door opens and subsequently is to close. The motor then stops and the door closes under spring influence.

The motor mechanism for this type operation can be as last described and the closing cylinder **120** can be connected through passages and check valves as shown in FIG. 6. The opening cylinder **118** passages and check valves in the valve body **194** can be as shown in FIG. 7. Here the port **176** for passage **170** simply communicates with the sump by way of passage **246***a*. Passage **296***a*, the counterpart of passage **296** can be drilled to intersect a branch **296***b* leading to the pressure space **210**. Check valve **298** can be as in FIG. 4.

When the signal for the door to open starts the pumping motor, pressure in chamber **210** is communicated to the opening cylinder **118** by way of passages **296***b*, **296***a*, check valve **298** and the previously mentioned pasages leading therefrom. Meanwhile the opening checking system described in conjunction with FIG. 6 limits the opening rate. When the door is to close, the pump stops, the valve **298** seats, and fluid flow through passage **246***a* is limited by needle valves **172, 174**, closing action being under the influence of spring **144**.

Variations, depending upon the balance as between the cost of machining the castings all alike on the one hand and the cost of making and stocking several versions of similar parts are contemplated. For instance, castings **196** and **200** can be machined all alike and only a minor variation made in casting **198**, and at the time of final assembly certain of the openings not used can be plugged with pins and certain parts omitted for the less expensive models. As an example, in FIG. 8 one passage in the casting **200** has a plug at **310** and the cap **198** has not been machined for the relief valve **290** of FIG. 4. As thus prepared, the valve assembly is the functional equivalent of FIG. 7.

The specific electrical control systems suitable for the several versions described above need not involve invention and may be of straightforward design. The general approach to various aspects of the problem are well understood and are suggested by the previously referred

to patents for example. One feature which may be incorporated in the electrical control system to advantage, however, which I believe to be novel for door operators is the provision of an electronic timer of any suitable design in the circuit of the pump motor for the continuous running pump version. The timer is set to measure an interval of about one minute and is connected so that each time someone signals the door to open, the timer is reset to zero. So long as people pass through the doorway more often than one every minute, the timer will not complete its timing interval and the pump motor runs continuously. If more than a minute intervenes between persons passing, the timer completes its cycle at the end of one minute and de-energizes the pump motor. Thereafter, so long as traffic density is low, less than one person per minute, the motor starts and runs only when an occasional person wishes to pass. Whenever traffic density again increases, the system reverts to continuous pump motor operation.

From the above description it will be apparent that the basic system forming the subject of this invention has a wide range of capabilities and adaptabilities while requiring very little in the way of alternative parts for the various versions, thus saving considerably on the overall cost of supplying a line of equipment to meet the various problems associated with automatic door operation.

Having described the invention, what I claim as new and useful and desire to secure by Letters Patent of the United States is:

1. A hydraulic door opening and closing mechanism comprising a door opening piston and cylinder combination, a door closing piston and cylinder combination, a continuously operating supply system for providing hydraulic fluid under pressure, means including an opening valve and an opening passage connected to supply fluid from said supply system to said opening combination when said opening valve is actuated, means including a closing valve and a closing passage connected to supply fluid from said supply system to said closing combination when said closing valve is actuated, means providing a first restricted passage connected to the opening combination for venting said opening combination, means providing a second restricted passage connected to said closing combination for venting said closing combination, control means adapted when energized to actuate said opening valve and simultaneously to close said first restricted passage, second control means adapted when energized to actuate said closing valve and simultaneously to close said second restricted passage, means for preventing reverse flow through said opening passage and said closing passage, means for energizing said first control means and de-energizing said second control means or in the alternative energizing said second control means and de-energizing said first control means in response to alternative control signals, and means responsive to flow of fluid under pressure to one of said combinations for opening the door and to the other of said combinations for closing said door.

2. The combination called for in claim 1 including a fluid sump, means providing a branch passage leading from said sump to said opening passage, a check valve in said branch passage oriented to permit flow from said sump through said branch passage but to prevent reverse flow, means providing a second branch passage leading from said sump to said closing passage, and a check valve in said second branch passage oriented to permit flow from sump through said second branch passage but to prevent reverse flow.

3. The combination called for in claim 2 including excess pressure relief valves for each of said branch passages, said excess pressure relief valves being set at pressures higher than the opening and closing pressures but lower than the stalling pressure of said continuously operating fluid supply system so that the pressure at said opening or closing combination is higher when the door is respectively opened or closed than when the door is swinging between open and closed positions in either direction.

4. A hydraulic door opening and closing mechanism comprising a door opening piston and cylinder combination, a door closing piston and cylinder combination, a continuously operating supply system for providing hydraulic fluid under pressure, means including an opening valve and an opening passage connected to supply fluid from said suply system to said opening combination when said opening valve is actuated, means including a closing valve and a closing passage connected to supply fluid from said supply system to said opening combination when said opening valve is actuated, means including a closing valve and a closing passage connected to supply fluid from said supply system to said closing combination when said closing valve is actuated, means providing a first restricted passage connected to the opening combination for venting said opening combination, means providing a second restricted passage connected to said closing combination for venting said closing combination, control means adapted upon a call for door opening to actuate said opening valve and simultaneously to close said first restricted passage, second control means adapted upon a call for door closing to actuate said closing valve and simultaneously to close said second restricted passage, and means responsive to flow of fluid under pressure to said opening combination for opening the door and to the closing combination for closing said door.

5. The combination called for in claim 4 including a fluid sump, means providing a branch passage leading from said sump to said opening passage, a check valve in said branch passage oriented to permit flow from said sump through said branch pasasge but to prevent reverse flow, means providing a second branch passage leading from said sump to said closing passage, and a check valve in said second branch passage oriented to permit flow from sump through said second branch passage but to prevent reverse flow.

6. The combination called for in claim 4 including a timer set to measure a selected time interval, said timer being reset to zero each time there is a call for door opening, and means to interrupt operation of the continuously operating fluid supply system upon the timer completing its interval of time measurement.

7. A hydraulic door opening and closing mechanism comprising a motor unit having a door opening piston and cylinder combination adapted to open a door when hydraulic fluid under pressure is applied thereto, a door closing piston and cylinder combination adapted to close a door when hydraulic fluid under pressure is applied thereto, means providing a first restricted passage connected to vent said opening combination, means providing a second restricted passage connected to vent said closing combination, spring means connected for closing a door when both said combinations are vented and no hydraulic fluid is being supplied under pressure to either of said combinations, and a valve mechanism incorporated in a separate body attachable to said motor unit for supplying and controlling the flow of hydraulic fluid to the motor unit so that the operating characteristics of the motor unit can be variable depending upon the characteristics of the valve mechanism in said separate attachable body.

8. The structure called for in claim 7 in which said valve body has valve mechanism for opening said vent passage and closing said first vent passage and for applying pressure to said opening combination for opening a door in response to a call for door opening, and for opening said first vent passage and closing said second vent passage and applying pressure to said closing combination for closing the door in response to a call for door closing.

9. The combination called for in claim 7 in which said valve body has valve mechanism for closing said first vent

passage and for applying pressure to said opening combination for opening said door in response to a call for door opening and for opening said first vent and removing the pressure from said opening combination for closing said door in response to a call for door closing.

10. The combination called for in claim **8** in which means provides additional vent passages for said combinations, the last said passages including check valves oriented to permit flow to said combinations, but to prevent reverse flow.

11. A hydraulic door opening and closing mechanism comprising a motor unit having a door opening piston and cylinder combination adapted to open a door when hydraulic fluid under pressure is applied thereto, a door closing piston and cylinder combination adapted to close a door when hydraulic fluid under pressure is applied thereto, means providing a first restricted passage connected to vent said opening combination, means providing a second restricted passage connected to vent said closing combination, spring means connected for closing a door when both said combinations are vented and no hydraulic fluid is being supplied under pressure to either of said

combinations, and a separate valve body attachable to said motor unit having a passage for supplying hydraulic fluid under pressure to the motor unit to apply pressure to said opening combination, and a vent for the last said passage including a check valve oriented to permit flow to the last said passage but to prevent flow from the last said passage by way of the last said vent.

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J. KARL BELL, Primary Examiner

U.S. Cl. X.R.

49—29, 264, 334; 60—52

UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,478,468 November 18, 1969

Paul W. Martin

It is certified that error appears in the above identified patent and that said Letters Patent are hereby corrected as shown below:

Column 8, line 12, "exhaust" should read -- extending --; lines 12 to 14, cancel "and instead is connected ... and instead is connected to a coaxial" and insert instead -- . When the valve element 264 is moved upwardly, the passage 266 and instead is connected to a coaxial --. Column 9, line 73, "ball chack" should read -- ball check --. Column 12, line 51, "pasages" should read -- passages --. Column 14, line 11, "suply" should read -- supply --; lines 12 to 15, cancel "means including a closing . . . said opening valve is actuated"; line 35, "pasasge" should read -- passage --.

Signed and sealed this 23rd day of June 1970.

(SEAL)
Attest:

EDWARD M.FLETCHER,JR.
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