March 27, 1956 M. CARLSON 2,739,808

AUTOMATIC DOOR OPERATOR

Filed Dec. 24, 1952 4 Sheets-Sheet 1

Fig. 1.

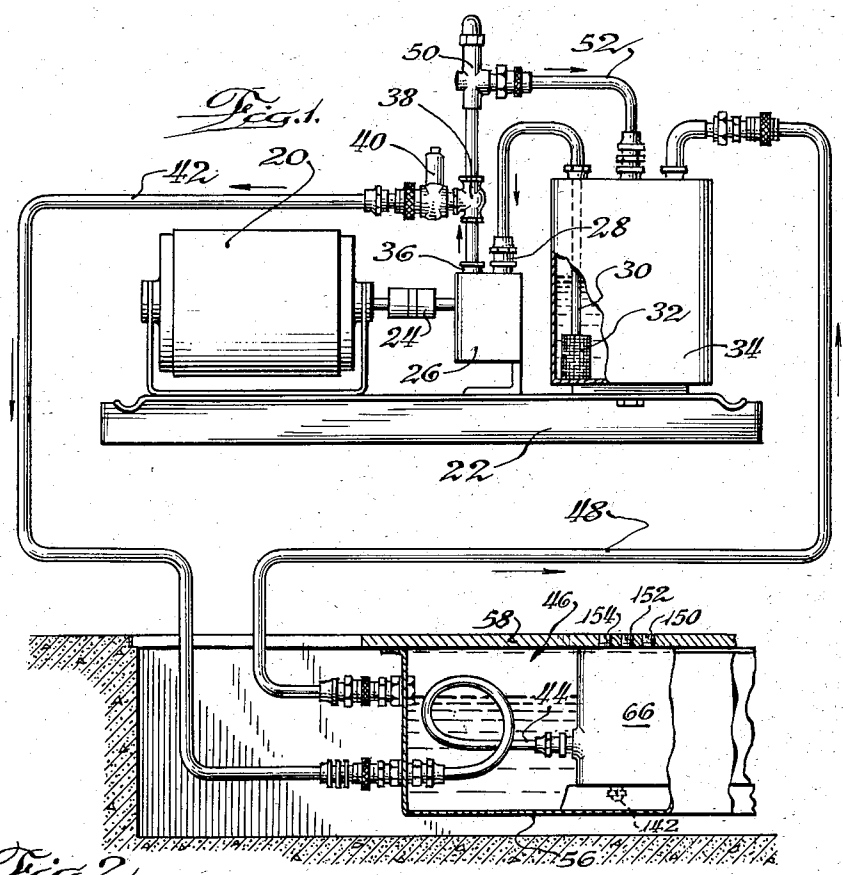
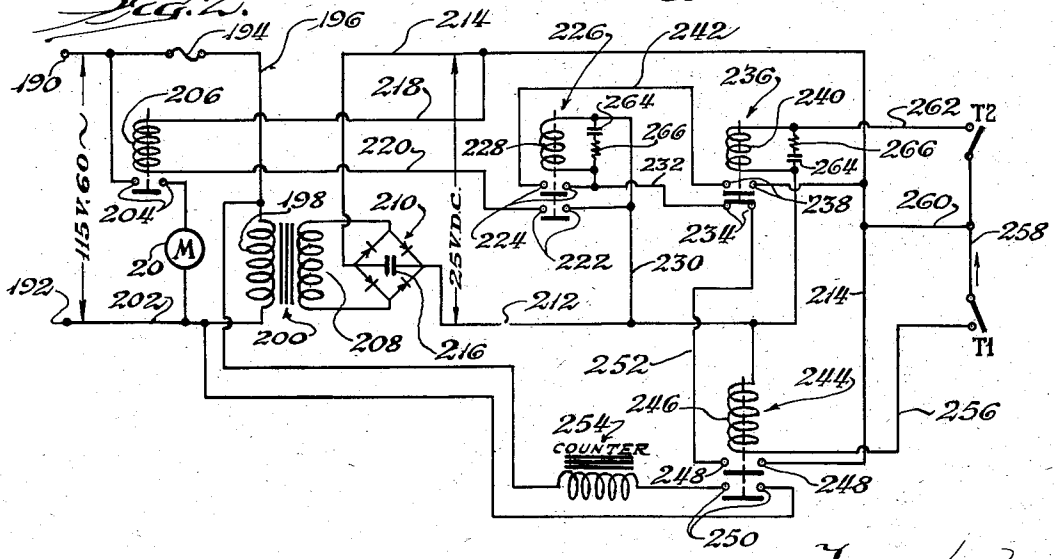


Fig. 2.



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Fig. 3.

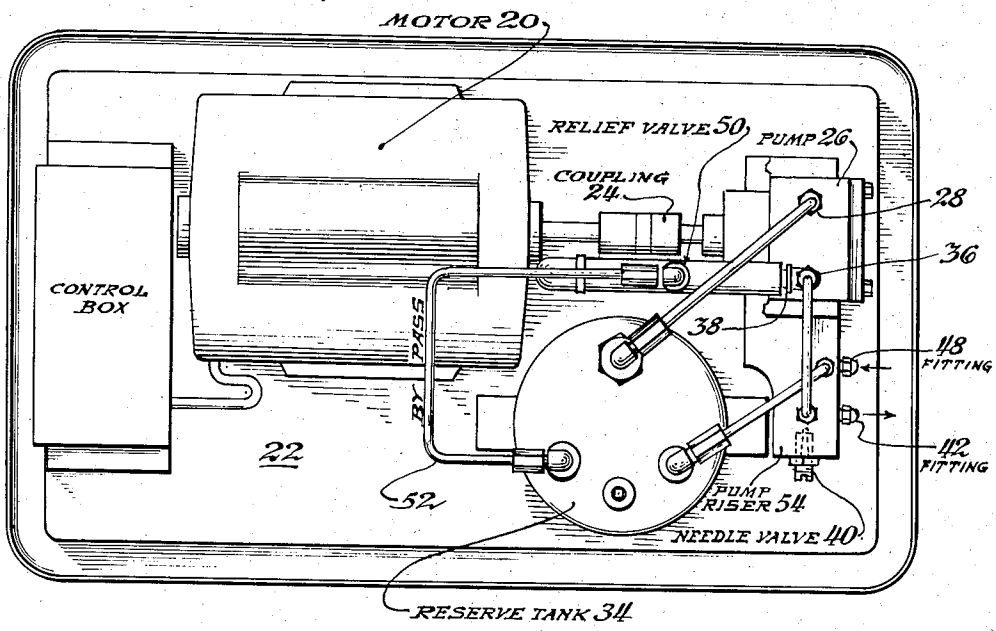
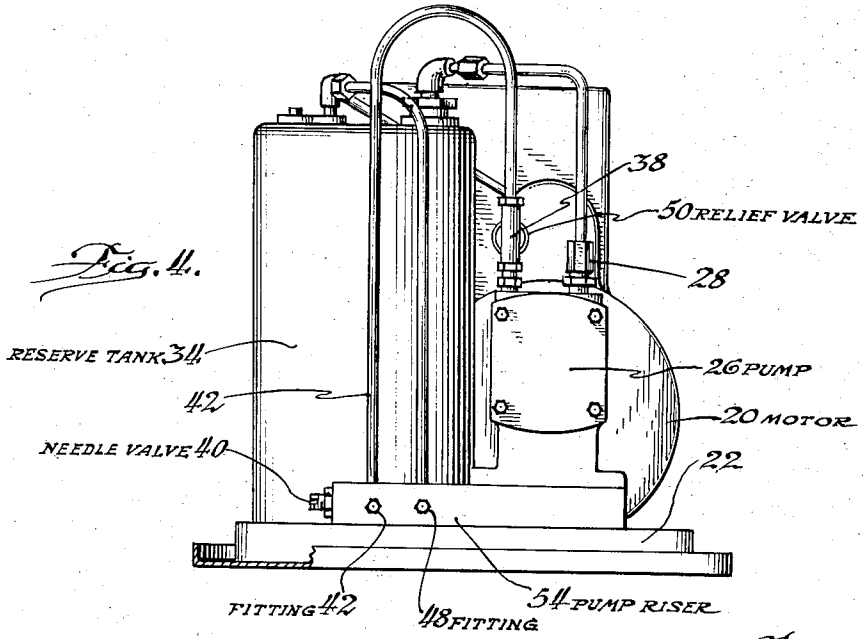


Fig. 4.



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AUTOMATIC DOOR OPERATOR

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Fig. 5.

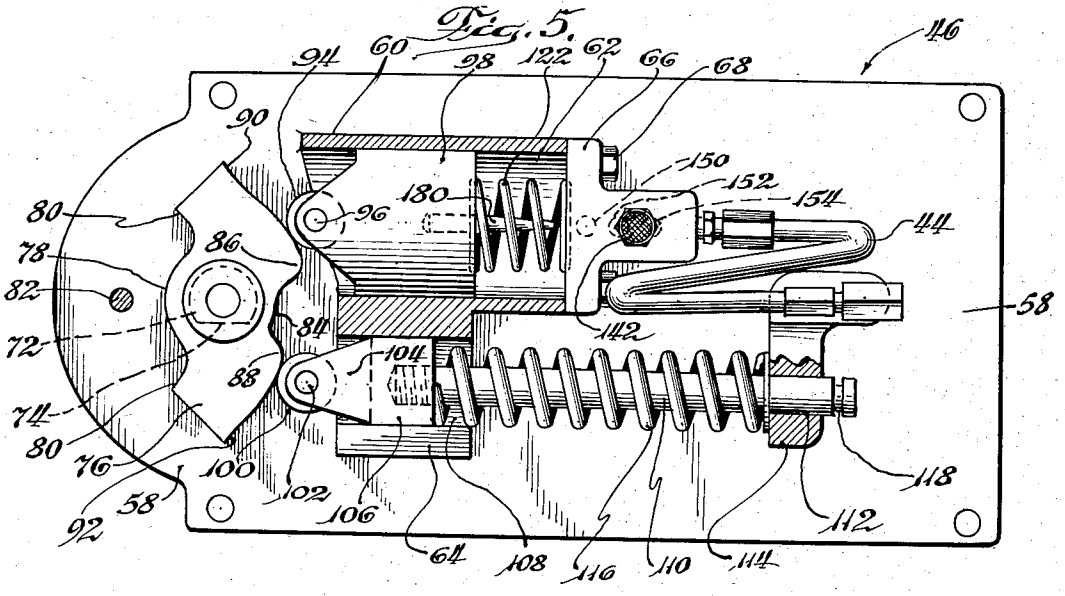


Fig. 6.

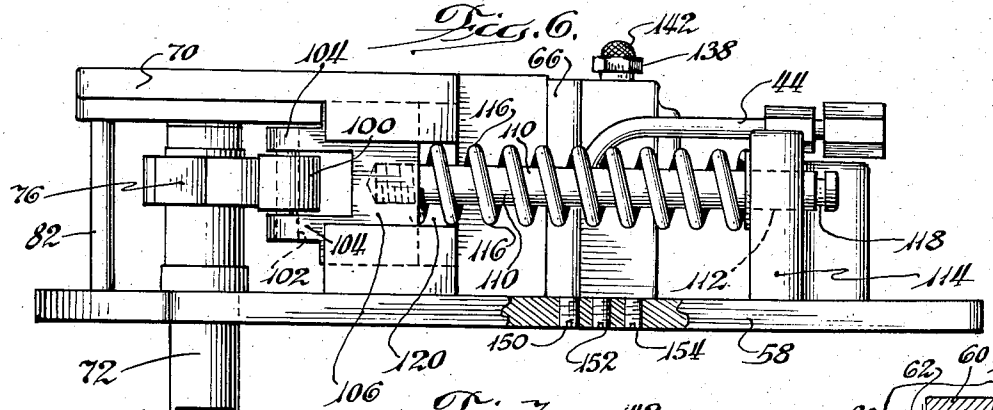


Fig. 7.

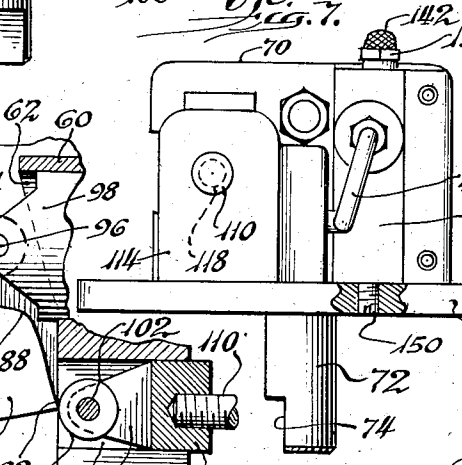


Fig. 8.

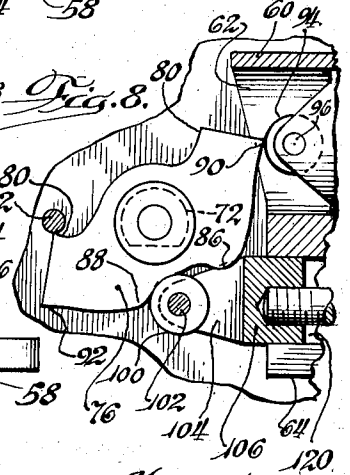


Fig. 9.

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AUTOMATIC DOOR OPERATOR

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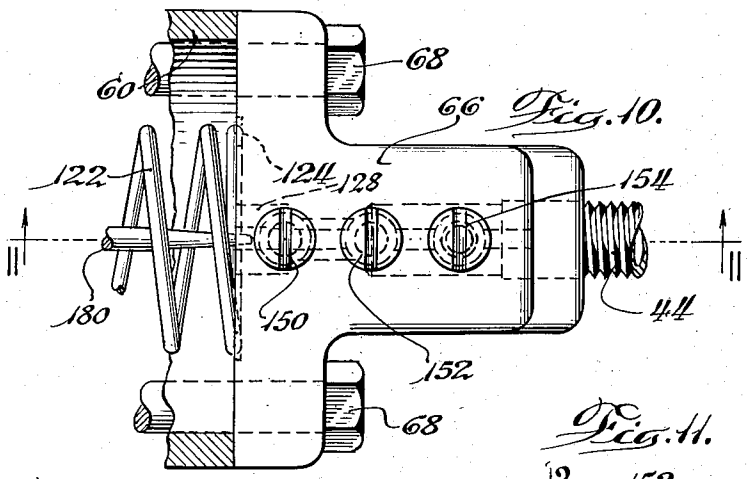
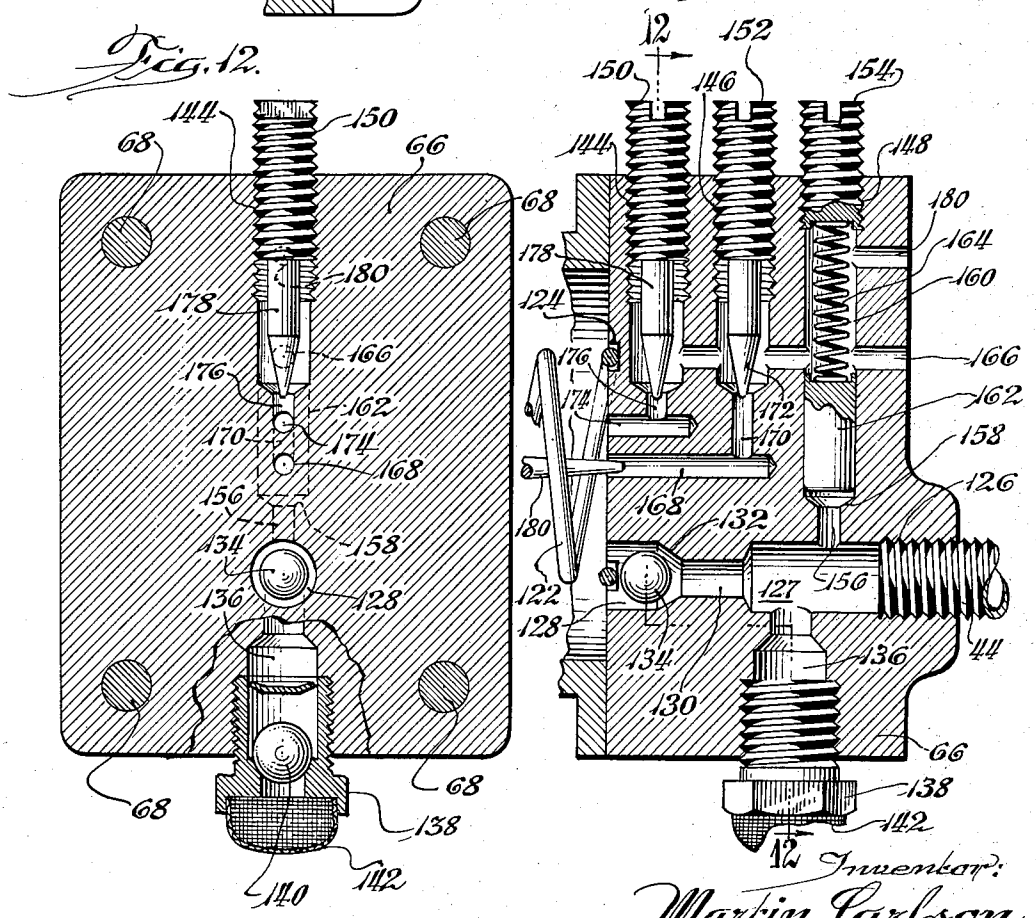


Fig. 10.

Fig. 11.

Fig. 12.



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United States Patent Office 2,739,808 Patented Mar. 27, 1956

2,739,808

AUTOMATIC DOOR OPERATOR

Martin Carlson, Brookfield, Ill., assignor to George W. Houlsby, Jr., Chicago, Ill.

Application December 24, 1952, Serial No. 327,835

6 Claims. (Cl. 268—34)

The present invention relates to automatic door operators of the type which swing a door to open position whenever a person approaches and which close the door after the person has passed.

One of the objects of the present invention is to provide a novel automatic door operator of the type described which is fully hydraulic in operation, which is relatively simple in construction and which, therefore, can be manufactured and sold at a reasonable cost.

An additional object is to provide an improved door operator of the type described which is reliable and has a long and trouble-free service life.

Yet another object is to provide an improved door operator of the character described in which the mechanism is fully concealed.

Yet another object is to provide a novel automatic door operator of the above character which permits the door to be manually opened as a free swinging door with a hydraulic check return, in the event that the power supply fails.

Still another object is to provide a novel door operator of the type described which has simple automatic counting mechanism adapted to keep a cumulative record of the number of people passing through the door opening in spite of the fact that some of the people passing may be so close together that the door will on occasion remain open for intervals long enough to permit two or more to pass.

Yet another object is to provide a novel hydraulically actuated door operator in which the hydraulic pumping mechanism can be located at a remote point and in which there is only one pressure line to the mechanism associated directly with the door, this one pressure line along with an atmospheric pressure return line, accomplishing both opening and closing of the door.

Still another object is to provide a novel hydraulic door operator which cannot open when a person inadvertently approaches the door from the wrong side and is in a position where he might be hit by the swinging door.

Other objects and advantages will become apparent from the following description of a preferred embodiment of my invention which is illustrated in the accompanying drawings.

In the drawings, in which similar characters of reference refer to similar parts throughout the several views:

Fig. 1 is a diagrammatic hydraulic circuit showing the general layout and arrangement of the several units comprising the mechanism;

Fig. 2 is an electrical circuit diagram for the electrical apparatus forming a portion of the mechanism;

Fig. 3 is a top view of a physical embodiment of the remotely located portion of the apparatus;

Fig. 4 is an end view thereof;

Fig. 5 is a view partly in plan and partly in horizontal section, taken from the bottom of the mechanism associated directly with the door after the principal assembly

comprising this portion of the operating mechanism has been removed from its case;

Fig. 6 is a side view projected from Fig. 5;

Fig. 7 is an end view thereof;

Fig. 8 is a fractional, elevational view oriented as in Fig. 5 with some of the mechanism shown in horizontal section of a portion of the actuating mechanism shown in the "at rest" or "door closed" position;

Fig. 9 is a view similar to Fig. 8 but showing the same parts in the positions they assume when the door is open;

Fig. 10 is a top view of a hydraulic valve fitting used at one end of a hydraulic motor cylinder shown in association with a portion of the piston and cylinder mechanism;

Fig. 11 is a longitudinal vertical sectional view and may be considered as taken in the direction of the arrows substantially along the lines 11—11 of Fig. 10; and

Fig. 12 is a vertical transverse sectional view that may be considered as taken in the direction of the arrows substantially along the line 12—12 of Fig. 11.

The automatic door operator of this invention is comprised physically of two principal units along with the necessary control and connecting mechanism. The general layout is illustrated in Fig. 1, where it will be seen that a remotely located electric motor 20 is mounted upon a base 22 and is connected through a flexible coupling 24 to drive a hydraulic pump 26. The pump has its inlet port 28 connected to a suction tube 30 which in turn has its inlet opening covered by a screen 32 positioned near the bottom of a hydraulic fluid reservoir 34. The outlet connection 36 of the pump leads by way of a T fitting 38 and needle valve 40 to a pressure line 42 connected to the inlet 44 of the motor unit 46 immediately associated with the door. The hydraulic return line from the motor unit is designated by the numeral 48 and leads directly to the hydraulic reservoir 34. In order to prevent the pressure at the pump outlet from rising above a predetermined working maximum, one of the openings of the T fittings 38 is connected back to the reservoir by way of a relief valve 50 which may be of any suitable type.

By referring to Figs. 3 and 4, which show the physical embodiment of the pressure producing mechanism with the principal components thereof labeled for convenience, it will be seen that the inlet and outlet fittings indicated at 48 and 42, as well as the needle valve 40, are formed by drilling and tapping passages in a block 54 which also serves as the physical support for the pump 26. This arrangement is somewhat more convenient than the diagrammatic setup illustrated at the top of Fig. 1, but is the equivalent thereof from the standpoint of operation. As shown, the block 54 has two holes drilled thereinto from the side, into which the fittings 42 and 48 are threaded. These holes are in turn intersected by other holes drilled downwardly from the top, which are threaded to take tube fittings connected in turn to the line leading to the reservoir 34 and to the line leading to the pump outlet 36. There is also a third hole, which is drilled and tapped so as to intersect the bore connected to the outlet side of the pump. This last opening contains the needle valve 40 which may be adjusted with a screw driver so as to determine the rate at which fluid is pumped through the fitting 42 to the motor mechanism. The other portions of the mechanism illustrated in Figs. 3 and 4 may be comprised of conventional units which need no special discussion, since they are common elements of hydraulic circuits. It is necessary to understand simply that the pumping mechanism illustrated and described is capable of forcing hydraulic fluid through the line 42 whenever the motor 20 is energized, that the pressure in this line will not exceed some predetermined set value, and that the rate

of flow through this line will be determined by the setting of the needle valve 40. There will also be some backward leakage through the pump when it is not running and its outlet port is under pressure. It is also apparent that fluid can be returned to the reserve tank 34 at substantially atmospheric pressure.

Referring now to Figs. 5 to 12, in which the motor mechanism is illustrated, it will be seen that the general organization used is similar to that illustrated in my Patent No. 2,603,818 wherein there is provided a generally rectangular box or tank 56 illustrated in Fig. 1, to which a cover 58 is attached. This cover is installed flush with the floor and all of the working mechanism is attached to and suspended beneath the cover 58. By removing screws, not shown but which are similar to those used in the patent previously mentioned, the cover plate 58 and all of the associated mechanism may be removed as a single unit from the tank or sump 56 after which the working mechanism can be turned over for easy inspection and servicing. The cover and the associated mechanism is shown in this position in Figs. 5, 6 and 7, since it is more easily visible with this orientation and since this is the position in which it ordinarily will be seen. This motor unit is mounted in the floor as shown in my Patent No. 2,603,818 and then the door is supported thereon as shown in that patent or in my Patent No. 2,595,187. Inasmuch as the mounting for the door is well disclosed in these patents, no additional discussion of that feature need be given here.

The cover plate 58 has its lower face secured against a casting 60 by countersunk screws which are not shown. This casting is cored and machined to provide a longitudinally extending horizontal cylinder 62 and a rectangularly slotted guide 64 which lies in a position alongside the cylinder. A cast member which is machined to provide a hydraulic inlet fitting and the housing for certain valves, is indicated at 66 and serves also to close the head end of the cylinder. As best shown in Fig. 10, four studs or cap screws 68 pass through the corners of the head casting 66 and are threaded into the body of the main casting 60 so as to form a rigid assembly of these parts.

As will be seen particularly from Fig. 6, a forward extension 70 of the main casting 60 journals the lower end of a stub shaft 72 which acts as the door spindle. The opposite end portion of this spindle 72 extends through suitable bearings in the top plate 58 and at its outer end is provided with one or more flat spots 74 which fit into a similarly shaped recess in the lower edge of the door. The spindle therefore supports the weight of the door and acts as a drive for rotating it about an axis established by the center line of the spindle 72.

In a position between the two journals for the stub shaft 72 this spindle carries a cam 76 which I prefer to form as an integral portion of the stub shaft 72 by forging.

The back surface of the cam 76 (the portion to the left in Fig. 5) is cut away as indicated at 78 so as to provide abutments 80 at each end which engage the sides of a vertical pin 82 supported at its opposite ends in the casting 70 and to plate 58. The diameter of the pin 82 and the spacing between the abutments 80 is such that the cam 76 is limited to a total rotation of approximately 95°.

On the opposite side of the spindle 72 from the cut away portion 78, the cam surface is cut away at the center to a position close to the spindle 72 as indicated at 84. From this central recess 84 the cam surface at both sides thereof slopes rather sharply outwardly so as to form a nose 86 at one side of the recess 84 and a similar nose 88 at the other side thereof. From these positions 86 and 88 the cam surface slopes out more gradually so that its distance from the center of the spindle 72 gradually increases with rotation of the cam. At the ends of the camming surfaces, indicated at 90 and 92, both these surfaces are farthest from the center of the stub shaft 72. As may be seen from a comparison of Figs. 8 and 9, these end portions 90 and 92 are somewhat more than normal with respect to the lines of action against the camming surface. For instance, in Fig. 8, note the direction of the force imposed by the roller 94 which is journaled upon a cross pin 96 carried by the end of a piston 98 which is fitted to the cylinder 62. Note also in Fig. 9 the second roller 100 journaled upon a transverse pin 102 which extends across a slot 104 in the nose of a sliding block 106. This block is guided for movement in the slotted guide 64 previously mentioned. For convenience, the slot in this guide is indicated by the numeral 108.

The lines of action of the two rollers 94 and 100 are parallel to each other and on either side of the center of rotation of the cam 76, and therefore with the cam conformation shown, either of these rollers will act (when urged with a greater force than the other) to cause rotation of the cam 76 throughout an angular displacement of about 95°. For instance, with the cam in the starting position shown in Fig. 8, which represents the door in closed position, the roller 94 is acting almost normal to the camming surface at the end 90 thereof. As this roller moves toward the left, it is for the first portion of the cam's displacement acting nearly normal to the camming surface, but at a position well to the side of the center of rotation of the cam. As the roller 94 approaches the position shown in Fig. 9, it rolls around the end of the nose 86 until, toward the end of its stroke (as the stop 80 approaches the pin 82) the roller 94 is again acting almost normal to the cam face. The action of the roller 100 against its portion of the cam face is substantially similar and opposite to that described above. This combination of displacing the lines of action of the rollers well to the side of the center of rotation of the cam, used in conjunction with the cam outline shown, makes it possible to obtain displacement of the order of 95° or more with a camming surface which is a small portion of the cam disc. In a device of this character this is an important advantage, since it permits a door to be swung from the closed position to the open position throughout a wide displacement without the use of any motion multiplying lever means or other complicated schemes.

The slot 108 as previously mentioned is rectangular and fits the guide block 106 so as to permit longitudinal movement only. A round rod 110 is fixed at one end in a threaded recess in the back surface of the block 106 and at its opposite end slides in a drilled hole 112 in an abutment 114 which is secured in any suitable fashion to the top plates 58 as by screws not shown. A coil spring 116 surrounds the rod 110 and bears with its ends against the sliding block 106 and the forward face of the abutment 114 so as to urge the block 106 and roller 100 toward the left against the surface of the cam 76.

The spring 116 is quite heavy and therefore, to promote assembly and disassembly of the unit, the rearward end of the rod 100 is provided with an annular groove 117 which extends beyond the rearward face of the abutment 114 when the block 106 is moved somewhat toward the right of its fully extended position. It is thus possible to partially compress the spring 116 by opening or partially opening the door, after which a simple C-shaped ring, not shown, can be slid into the groove 118. Thereafter when the door is permitted to swing toward the closed position the C-shaped ring is brought against the rearward face of the abutment 114. Thereafter this abutment, together with the rod 110 and spring 116, as well as the block 106 and roller 100, can be removed from the device as a single unit. During reassembly, after the elements have been put in place, the door can be partially opened to move the rod 110 toward the right so that the C-shaped ring can be removed from the groove 118, thereby placing the device back in operation.

Further, to facilitate assembly and disassembly of the device, a slot 120, as best seen in Fig. 6, is formed through the exterior side wall of the guide 64. This slot 120 permits the rod 110 to be moved laterally inwardly or outwardly after the sliding block 106 has been moved end-

wise sufficiently to clear the ends of the guide member 64.

Because of the pressure exerted by the spring 116 urging the roller 100 against its portion of the camming surface of the cam 76, this spring will always tend to return the door to closed position with the shoulder 80 closest to the camming surface 92 against the stop pin 82. This position is shown in Fig. 8.

The piston 98 and cylinder 62 act both as a motor means for opening the door and as a hydraulic check when returning the door to closed position. The roller 94 is maintained in contact with its portion of the camming surface by a spring 122 which is light in comparison with the spring 116. It is positioned within the cylinder 62 with one end bearing against the rearward face of the piston 98 while the other end bears against the forward face of the block 66 which acts as a closure for the cylinder 62.

As best seen in Figs. 10 to 12, the spring 122 is maintained in axial alignment within the cylinder 62 by an annular groove 124 formed in the forward face of the block 66 which acts as the spring base. A similar groove or a recess to perform a similar purpose may be formed in the rearward face of the piston 98.

The hydraulic pressure line 44 for operating the mechanism is connected into a threaded opening 126 in the back surface of the block 66 as best seen in Fig. 11. This recess 126 is connected to or forms a portion of a drilled passage 127 which extends straight through the fitting 66 so as to have its opposite opening indicated at 128 in the forward face of the block 66 in a position such that it intersects the annular groove 124 which acts as the base for the spring 122. The cylinder end of the opening 128 is somewhat larger than an intermediate portion 130 of the passage and is joined to this intermediate portion by a conical section 132 which acts as a seat for a ball valve 134. This ball 134 is retained in its cavity by the overlying end of the spring 122 as is best seen from Fig. 11. The ball valve 134 therefore, does not inhibit flow through the passage 130 into the cylinder, but prevents flow in the opposite direction.

The passage 127 is intersected by a passage 136 which forms a recess leading downwardly to the exterior lower surface of the block 66. The outer portion of this recess is threaded and receives a fitting 138 having a passage therethrough containing a ball check valve 140. This ball seats in a downwardly direction and therefore prevents flow from the recess 126 downwardly to the outside. Flow in an inwardly direction, however, is not inhibited. In order to protect the system against solid foreign matter, the exterior opening below the ball is preferably covered by a fine mesh screen 142.

Three vertical drilled and tapped recesses 144, 146 and 148 are formed in the upper surface of the block 66 in a line extending longitudinally of the cylinder 62. Each of these recesses is provided with an adjusting screw 150, 152 and 154, respectively, which are for the purpose of adjusting the apparatus to the particular operating conditions. They therefore should be accessible through the plate 58 and therefore openings in the plate large enough to clear these screws should be formed in alignment with the recesses 144, 146 and 148. If preferred, a single large circular opening may be provided, the opening being threaded and closed by a plug in the manner shown in my Patent No. 2,603,818.

The recess 148, which is closest to the rearward or right hand end of the fitting 66 is drilled downwardly to uniform size almost to the passage 127 and at its lower end is connected to the latter passage by a smaller diameter port 156 so as to form a shoulder 158 therebetween. The portion above the shoulder 158, of uniform and larger diameter, forms a cylinder 160 which contains a piston 162 normally held downwardly against the shoulder 158 by a coil spring 164. This spring bears against the upper end of the piston 162 at one end while its opposite end is seated against the lower end of the adjusting screw 148. Thus by turning the screw 148 the downwardly biasing pressure exerted upon the piston 162 can be adjusted.

A drilled opening 166 extends from the rearward face of the fitting 66 longitudinally toward the left so that it passes through the cylinder 160 in a position just above the top of the piston 162 when the piston is in the lowermost position. It continues on so as to cross the lower portion of the recess 146 and into the recess 144. The recesses 144, 146 and the cylinder 160, all therefore communicate to the outside.

At the axis of the cylinder 62 there is a drilled passage 168 which extends horizontally into the fitting 66 from the forward face thereof into a position below the center of the recess 146. At this point it is intersected by a downwardly extending passage 170 from the lower end of the recess 146 so that the intersection of the recess 146 with the upper end of the passage 170 forms a seat for a needle valve 172 formed at the lower end of the adjusting screw 152. Thus by turning the screw 152 inwardly or outwardly the rate of flow through the passage 168 can be determined.

Still another passage 174 is drilled horizontally into the forward face of the fitting 66 in a position just above the passage 168 and into a position beneath the recess 144. It similarly is connected to its recess 144 by a vertical port 176 so as to form a seat for a second needle valve 178 formed at the lower end of the adjusting screw 150.

The piston 98 carries an axially aligned, rearwardly extending, tapered pin 180 which is in a position to enter the drilled passage 168 when the piston 98 nears its retracted position. When the piston is fully retracted, this pin 180 almost completely fills the entrance to the opening 168 and therefore substantially prevents communication from the cylinder through the passage 168.

The hydraulic system operates in the following manner. When the pump motor 20 is started and the pump 26 therefore causes fluid to flow under pressure into the line 42 and 44, this fluid is prevented from escaping from the recess 126 downwardly through the passage 136 by the ball valve 140. It therefore must flow through the horizontal passage 127—130, around the ball valve 134 and into the cylinder 62. Inasmuch as the door will be in closed position under these conditions with the pin 180 substantially plugging the passage 168, almost no fluid can escape through the passage 168. The needle valve 178, for a reason to be pointed out presently, is adjusted so the flow through the passage 174 can be at only a very low rate. Under these conditions, since the capacity of the pump is far greater than the leakage capacity of the system, the piston 162 will be forced upwardly against the pressure of the spring 164. This upward movement of the piston 162 closes the port 166 so as to cut off all communication from the cylinder to the outside by way of either of the passages 168 or 174. In order to facilitate quick movement of the piston 162 the upper end of the recess 148 is vented to the outside through an intersecting passage 180.

Inasmuch as the piston 162 closes the passage 166, and since the ball valve 140 closes the only remaining escape from the passage 127, the hydraulic pressure will be exerted in the cylinder 62 so as to urge the piston 98 toward the left as seen in Fig. 5. In the manner previously described, its roller 94 acting against the cam 76 causes the door to be swung to the open position until the abutment 80 closest to the camming surface 90 is brought against the stop pin 82. In this position the door is wide open and the piston 98 assumes the position shown in Fig. 9. Since the piston can move no farther, the relief valve 50 opens so as to permit hydraulic fluid to pass from the pump outlet to the reservoir 34. The door therefore remains in open position with the motor running.

As soon as the motor is deenergized so as to stop the pump 26 the hydraulic fluid will start to flow in a reverse direction through the pressure line represented by the

numerals 42 and 44. This reverse flow through the passage 127 immediately causes the ball valve 134 to engage the seat 132 thereby preventing further flow from the cylinder through the passage 127. The pressure within the passage 127 therefore drops rapidly. Soon this pressure reaches a level such that the spring 164 is enabled to urge the piston valve member 162 downwardly, thereby opening the passage 16 to the outside. As soon as this takes place, fluid flows rapidly from the cylinder, through the passage 168, around the needle valve 172 and to the outside by way of the passage 166. This flow takes place of course under the influence of the heavy return spring 116 urging the roller 100 into engagement with its portion of the cam 76.

The needle valve 172 is adjusted to permit rapid flow and provides the principal means of escape for fluid during the rapid closing portion of the door cycle. Thus rapid swinging of the door accompanied by rapid emptying of the hydraulic fluid from the cylinder 62 takes place until the tapered pin 180 enters the passage 168 and quickly diminishes the flow through this passage until it almost shuts off this escape route completely. Under these conditions the principal escape route remaining is by way of the passage 174 and needle valve 178 which is adjusted as previously mentioned to provide for only a low flow rate. It has almost no influence upon movement of the door until the door is almost closed. It then comes into action to prevent banging of the door and may of course be adjusted to give the desired rate to the final closing movement of the door.

If at any time it is desired to open the door manually, customary pushing upon the door so as to swing it toward the open position will cause the spring 122 to force the piston 98 to follow the movement of the cam 76 so that contact of the roller 94 with the cam face will not be lost. This of course tends to evacuate the cylinder 62 thereby unseating the ball valve 140 and permitting hydraulic fluid to flow inwardly through the screen 142 so as to maintain the cylinder 62 full. No resistance, therefore, is offered to opening movement of the door other than that imposed by the closing spring 116. As soon as the door is released, the ball valves 140 and 134 seat and hydraulic fluid escapes under control through the passages 168 and 174 as previously described.

Hydraulic fluid pumped through the line 42 and 44 eventually escapes through the passage 166 to the outside of the fitting 66 and is caught in the pan or sump 56 which encloses the working apparatus attached to the cover plate 58. When the level of the oil in the sump 56 rises to a position near the top thereof, it escapes through an opening connected to a fitting which is at the entrance end of the return line 48. The hydraulic fluid therefore returns at atmospheric pressure to the reservoir 34 with the level of the oil in the sump 56 always being maintained at the level of the outlet fitting. All of the working parts of the apparatus are therefore well bathed in oil and friction and wear are therefore kept at a minimum.

The electrical control and operating circuit for the apparatus is illustrated in Fig. 2, where it will be seen that a conventional 115 volt power line is connected to a pair of terminals 190 and 192. The terminal 190 in turn is connected through a fuse 194 to a line 196 leading to one end of the primary 198 of a step-down transformer 200 used for control purposes. The other side of this primary is connected by a lead 202 to the other terminal 192. A pair of normally open relay contacts 204 are connected in series with the pump motor 20 across the terminals 190 and 192 so that the motor 20 is energized whenever the relay contacts 204 are closed by energization of the relay coil indicated at 206.

The low voltage transformer secondary 208 is connected to the input terminals of a full wave bridge type rectifier 210, the output direct current terminals of which are represented by direct current leads 212 and 214. The rectifier 210 I prefer for this purpose uses selenium rectifying units and is conventional and preferably has a filter capacitor 216 connected across its output.

The D. C. line 214 is connected by a branch 218 to one end of the relay coil 206 the other end of which is connected by lead 220 to one of a pair of normally open relay contacts 222. Relay contacts 222 are one of a set of two (the others being indicated at 224) of a normally open, double pole, single throw relay 226. Both sets of these contacts 222 and 224 are closed whenever the coil 228 of this relay is energized.

As mentioned, the lead 220 is connected to one of the relay contacts 222, the other contact of this set being connected to a branch 230 which is connected in turn to the other side of the direct current circuit at 212 and to one end of the relay coil 228. The lead 232 at the other end of this relay coil is connected to one of the relay contacts 224 and to a normally closed contact 234 of a third relay 236.

This relay has two sets of contacts, indicated at 234 and 238, which are so arranged that whenever the coil 240 of the relay 236 is deenergized, contacts 234 will be closed and contacts 238 open. When on the other hand relay coil 240 is energized, contacts 234 open while contacts 238 close. Of the two relay contacts 224, the one not connected to the lead 232 is connected to a branch 242 which leads to one of the normally open contacts 238 of the relay 236.

A fourth relay is indicated at 244 and may be identical to the relay 226. It consists of a coil 246 which closes two sets of normally open contacts 248 and 250 when energized. Of these, one of the contacts 248 is connected by a line 252 to the contact 234 not connected to line 232, while the other contact 248 is connected to the contact 238 of relay 236 not connected to line 242 and to the side of the direct current circuit represented by the line 214.

The contacts 250 are connected in series with an electrically actuated counter mechanism 254 and across the alternating current power leads represented by the lines 202 and 196. Thus whenever the relay coil 246 is energized an alternating current impulse will be impressed upon the counter mechanism 254 so that this mechanism will register one count. Since counters of this type are conventional devices and well understood, this device need not be described. The specific counter mechanism forms no part of my invention and it is necessary to understand only that it is of the type which accumulates a total which is the sum of the total number of impulses impressed upon it over a period of time.

The door is actuated preferably by the customarily used treadle mechanism. Such mechanisms consist of a thin rubber pad with electrical contacts therein which are so arranged that when a person steps anywhere upon the pad contacts are closed so as to close a circuit connected thereto. Two of these treadles, which electrically are single pole switches of the normally open type, are used. One of these at the approach side of the door is indicated on the circuit diagram by the designation T–1. A similar treadle at the outlet side of the door is indicated by the designation T–2. Treadles of this type are well known in this art and therefore they need no specific description here, inasmuch as the treadles used form no portion of the present invention beyond their placement and use in the system.

The treadles T–1 and T–2 are connected into the circuit as follows: One end of relay coil 246 is connected to one side of the direct current circuit at 212, while the other end of this coil is connected by a lead 256 to one of the contacts of the treadle switch T–1. The other contact of treadle switch T–1 is connected to a lead 258 which extends to one of the contacts of the treadle switch T–2 and also by way of a branch 260 to the other side of the control circuit at 214. The other treadle switch contact T–2 is connected by a line 262 to one end of relay coil 236, the other end of which as

previously mentioned is connected to the other side of the direct current circuit at 212. To prevent sparking at the relay contacts involved, a capacitor 264 and resistor 266 are shown connected in series across each of the relay coils 226 and 236.

This circuit operates in the following manner: Assuming that the terminals 190 and 192 are energized so as to energize the primary 198 of the control transformer 200, it will be seen that only the transformer primary 208 and rectifier 210 will be energized. All other leads are connected to open switch terminals.

If now a person steps upon the treadle T–1, direct current power flows by way of the line 214, branch 260, lead 258, switch T–1, lead 256 to relay coil 244, and thence by way of lead 212 to the other side of the direct current circuit. This closes relay contacts 248 and 250. Contacts 250 are connected in the circuit of the counter 254 and across the alternating current power leads and therefore the counter 254 will register one count. Since contacts 248 are closed, power will be supplied from the lead 214 by way of contacts 248 to branch 252, and thence by way of normally closed relay contacts 234 to lead 232 and one side of relay coil 228. Since the other side of this coil is connected by lead 230 to the other side of the direct current power line, relay coil 228 will be energized so as to close contacts 224 and 222. Current therefore flows from the direct current lead 214 by way of line 218, relay coil 206, line 220 and by way of contacts 222 and branch 230 to the other side of the direct current line. Relay coil 206 therefore closes motor contacts 204 so as to start the pump motor 20 into operation, thereby causing the door to swing to the open position. Inasmuch as one of the contacts 244 is connected by lead 242 to one of the open contacts 238 of relay 236, closure of contacts 244 does not affect the circuit excepting to condition it for future operation.

As the person progresses through the doorway he steps off treadle T–1 and on to treadle T–2. As soon as this happens, power is supplied from line 214 by way of leads 260 and 258 to switch T–2 and thence through lead 262 to one end of relay coil 240. Inasmuch as the other end of this relay coil is connected to the other side of the circuit at 212, relay coil 240 is energized so as to close contact 238 and open contact 234. Closing of contacts 238 supplies power by way of the line 214 and these contacts to lead 242 and thence by way of contacts 224 to lead 232 connected to one side of relay coil 228, the other side of which is connected by line 230 to the other side of the D. C. circuit at 212. Thus the relay coil 228 is retained energized even though contacts 234 have been separated, because the time interval between that at which contacts 234 open and contacts 238 close is too short to permit relay 226 to drop open and separate contacts 224. The motor 20, therefore, remains in operation even though contacts T–1 separate, although the separation of contacts T–1 deenergizes relay coil 246, since line 256 will be unconnected. The counter 254 therefore is conditioned to receive an additional counting impulse.

If a second person follows the first onto the mat, T–1, before the first has stepped off the mat T–2, the relay coil 246 is reenergized so as to cause the counter 254 to make an additional count and also relay 256 is reenergized before relay coil 228 can become deenergized by opening of contacts T–2. Therefore, if several people walk through the doorway in succession, the door will remain open with the motor circuit continuously energized as long as a person is standing on either treadle T–1 or T–2 or both. The counter 254, however, will register the number of times the contacts T–1 have been closed. Thus, the door may open only once for several people to pass, but the counter 254 will have registered the passage of each.

When a person steps off the treadle T–2 under conditions such that no one is standing on treadle T–1, opening of the switch T–2 deenergizes line 262 and therefore deenergizes relay coil 240. This permits contacts 234 to reclose and contacts 238 to reopen. Under these conditions lead 232, which supplies energy to relay coil 228, will be deenergized at relay contacts 248 and at relay contacts 238. Relay 226, therefore, falls open so as to separate contacts 222 and deenergize the motor relay coil 206. This stops the motor 20, permits the door to close, and reconditions the circuit for another cycle of operation.

If a person accidentally approaches the door from the wrong direction and steps on treadle T–2, this energizes relay coil 240 thereby closing relay contacts 238 and opening contacts 234. If during this interval a second person steps upon the treadle T–1, so as to energize relay coil 244 and lead 252, the relay 226 cannot operate since contacts 234 are open. The door, therefore cannot swing under these conditions when it might hit the person standing on treadle T–2. The system remains in this inoperable condition until the person inadvertently standing upon treadle T–2 has stepped back out of danger, whereupon relay 236 will return to its normal unenergized condition, thereby permitting the door to open.

From the above it can be seen that the door operator of the present invention will open doors and hold them open if a person approaches from the right side until he has passed therethrough, and that if several persons pass close together such that the door should remain in open position during the passage of all, it will not attempt to close during this interval but will nevertheless count the number of people passing. Further, if a person approaches from the wrong side of the door and thereby inadvertently gets into a danger zone where he might be hit by the opening door, the system cannot swing the door even though a person approaches from the right side until the person on the wrong side of the door has moved out of danger.

From the above it will be seen that the door operator of the present invention accomplishes all of the objectives set forth for it. It is apparent also that variations and substitutions may be made in this mechanism without departing from the spirit or scope of the invention and that therefore the scope of the invention is to be measured by the scope of the accompanying claims.

I claim:

1. In an automatic door operator, electric motor driven pump means adapted to supply hydraulic fluid under pressure from the pump outlet when said electric motor is energized and to permit a slow return leakage through said pump when said electric motor is deenergized, a hydraulic motor unit, conduit means connecting said hydraulic motor unit to said pump outlet, said hydraulic motor unit comprising means forming an expansible chamber connected to receive hydraulic fluid from said conduit means, a check valve in said conduit means oriented to prevent flow from said expansible chamber to said pump outlet, but to permit flow in the opposite direction, means forming a sump, means forming a passage communicating between said expansible chamber and said sump, pressure responsive valve means for preventing flow through said passage when said pressure responsive means is subjected to pressure, resilient means biasing said pressure reponsive means to passage opening position, means connecting said pressure responsive means to said conduit upstream of said check valve so that said pressure responsive means prevents flow through said passage when the pressure in said conduit exceeds a predetermined level and overcomes said biasing means, regulating valve means for controlling the rate of flow through said passageway, a second check valve connected between said conduit upstream of said first check valve and said sump and oriented to permit flow from said sump to said conduit but to prevent flow in the opposite direction, means forming a second passage communicating between said expansible cham-

ber and said first passage, a flow controlling valve arranged in said second passage, means actuated by said expansible chamber for substantially closing the chamber inlet to the first said passage when said expansible chamber approaches its contracted condition, means connected to said expansible chamber and adapted for connection to a door for opening the latter when said chamber is expanded, resilient means for contracting said expansible chamber and closing said door when the pressure in said expansible chamber is below a certain minimum, and means forming a return line connecting said sump to said pump inlet.

2. In an automatic door operator, electric motor driven pump means adapted to supply hydraulic fluid under pressure from the pump outlet when said electric motor is energized and to permit a slow return leakage through said pump when said electric motor is deenergized, a hydraulic motor unit, conduit means connecting said hydraulic motor unit to said pump outlet, said hydraulic motor unit comprising means forming an expansible chamber connected to receive hydraulic fluid from said conduit means, a check valve in said conduit means oriented to prevent flow from said expansible chamber to said pump outlet, but to permit flow in the opposite direction, means forming a sump, means forming a passage communicating between said expansible chamber and said sump, pressure responsive valve means for preventing flow through said passage when said pressure responsive means is subjected to pressure, resilient means biasing said pressure responsive means to passage opening position, means connecting said pressure responsive means to aid conduit upstream of said check valve so that said pressure responsive means prevents flow through said passage when the pressure in said conduit exceeds a predetermined level and overcomes said biasing means, regulating valve means for controlling the rate of flow through said passageway, means actuated by said expansible chamber for restricting the flow from said chamber into said passage when said expansible chamber approaches its contracted condition, means connected to said expansible chamber and adapted for connection to a door for opening the latter when said chamber is expanded, resilient means for contracting said expansible chamber and closing said door when the pressure in said expansible chamber is below a certain minimum, and means forming a return line connecting said sump to said pump inlet.

3. In an automatic door operator, electric motor driven pump means adapted to supply hydraulic fluid under pressure from the pump outlet when said electric motor is energized and to permit a slow return leakage through said pump when said electric motor is denergized, a hydraulic motor unit, conduit means connecting said hydraulic motor unit to said pump outlet, said hydraulic motor unit comprising means forming an expansible chamber connected to receive hydraulic fluid from said conduit means, a check valve in said conduit means oriented to prevent flow from said expansible chamber to said pump outlet, but to permit flow in the opposite direction, means forming a sump, means forming a passage communicating between said expansible chamber and said sump, pressure responsive valve means for preventing flow through said passage when said pressure responsive means is subjected to pressure, resilient means biasing said pressure responsive means to passage opening position, means connecting said pressure responsive means to said conduit upstream of said check valve so that said pressure responsive means prevents flow through said passage when the pressure in said conduit exceeds a predetermined level and overcomes said biasing means, regulating valve means for controlling the rate of flow through said passageway, means forming a second passage communicating between said expansible chamber and said first passage, a flow controlling valve arranged in said second passage, means actuated by said expansible chamber for substantially closing the chamber inlet to the first said passage when said expansible chamber approaches its contracted condition, means connected to said expansible chamber and adapted for connection to a door for opening the latter when said chamber is expanded, resilient means for contracting said expansible chamber and closing said door when the pressure in said expansible chamber is below a certain minimum, and means forming a return line connecting said sump to said pump inlet.

4. In an automatic door operator, electric motor driven pump means adapted to supply hydraulic fluid under pressure from the pump outlet when said electric motor is energized and to permit a slow return leakage through said pump when said electric motor is deenergized, a hydraulic motor unit, conduit means connecting said hydraulic motor unit to said pump outlet, said hydraulic motor unit comprising means forming an expansible chamber connected to receive hydraulic fluid from said conduit means, a check valve in said conduit means oriented to prevent flow from said expansible chamber to said pump outlet, but to permit flow in the opposite direction, means forming a sump, means forming a passage communicating between said expansible chamber and said sump, pressure responsive valve means for preventing flow through said passage when said pressure responsive means is subjected to pressure, resilient means biasing said pressure responsive means to passage opening position, means connecting said pressure responsive means to said conduit upstream of said check valve so that said pressure responsive means prevents flow through said passage when the pressure in said conduit exceeds a predetermined level and overcomes said biasing means, regulating valve means for controlling the rate of flow through said passageway, a second check valve connected between said conduit upstream of said first check valve and said sump and oriented to permit flow from said sump to said conduit but to prevent flow in the opposite direction, means actuated by said expansible chamber for restricting the flow from said chamber into said passage when said expansible chamber approaches its contracted condition, means connected to said expansible chamber and adapted for connection to a door for opening the latter when said chamber is expanded, resilient means for contracting said expansible chamber and closing said door when the pressure in said expansible chamber is below a certain minimum, and means forming a return line connecting said sump to said pump inlet.

5. In an automatic door operator, electric motor driven pump means adapted to supply hydraulic fluid under pressure from the pump outlet when said electric motor is energized and to permit a slow return leakage through said pump when said electric motor is deenergized, a hydraulic motor unit, conduit means connecting said hydraulic motor unit to said pump outlet, said hydraulic motor unit comprising means forming an expansible chamber connected to receive hydraulic fluid from said conduit means, a check valve in said conduit means oriented to prevent flow from said expansible chamber to said pump outlet, but to permit flow in the opposite direction, means forming a return line connected to said pump inlet, means forming a passage communicating between said expansible chamber and said return line, pressure responsive valve means for preventing flow through said passage when said pressure responsive means is subjected to pressure, resilient means biasing said pressure responsive means to passage opening position, means connecting said pressure responsive means to said conduit upstream of said check valve so that said pressure responsive means prevents flow through said passage when the pressure in said conduit exceeds a predetermined level and overcomes said biasing means, regulating valve means for controlling the rate of flow through said passageway, means actuated by said expansible chamber for restricting the flow from said chamber into said passage when said expansible chamber approaches its contracted condition, means connected to said expansible chamber and adapted for connection

to a door for opening the latter when said chamber is expanded, and resilient means for contracting said expansible chamber and closing said door when the pressure in said expansible chamber is below a certain minimum.

6. In an automatic door operator, hydraulic means adapted when called upon to supply hydraulic fluid under pressure and to permit a slow return leakage when not called upon, a hydraulic motor unit, conduit means connecting said hydraulic motor unit to said hydraulic means, said hydraulic motor unit comprising means forming an expansible chamber connected to receive hydraulic fluid from said hydraulic means, means in said conduit to prevent flow from said expansible chamber to said hydraulic means, but to permit flow in the opposite direction, means forming a return line connected to said hydraulic means, means forming a passage communicating between said expansible chamber and said return line, means for preventing flow through said passage when the pressure in said conduit exceeds a predetermined minimum, regulating valve means for controlling the rate of flow through said passage, means actuated by said expansible chamber for restricting the flow from said chamber into said passage when said expansible chamber approaches its contracted condition, means connected to said expansible chamber and adapted for connection to a door for opening the latter when said chamber is expanded, and resilient means for contracting said expansible chamber and closing said door when the pressure in said expansible chamber is below a certain minimum.

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