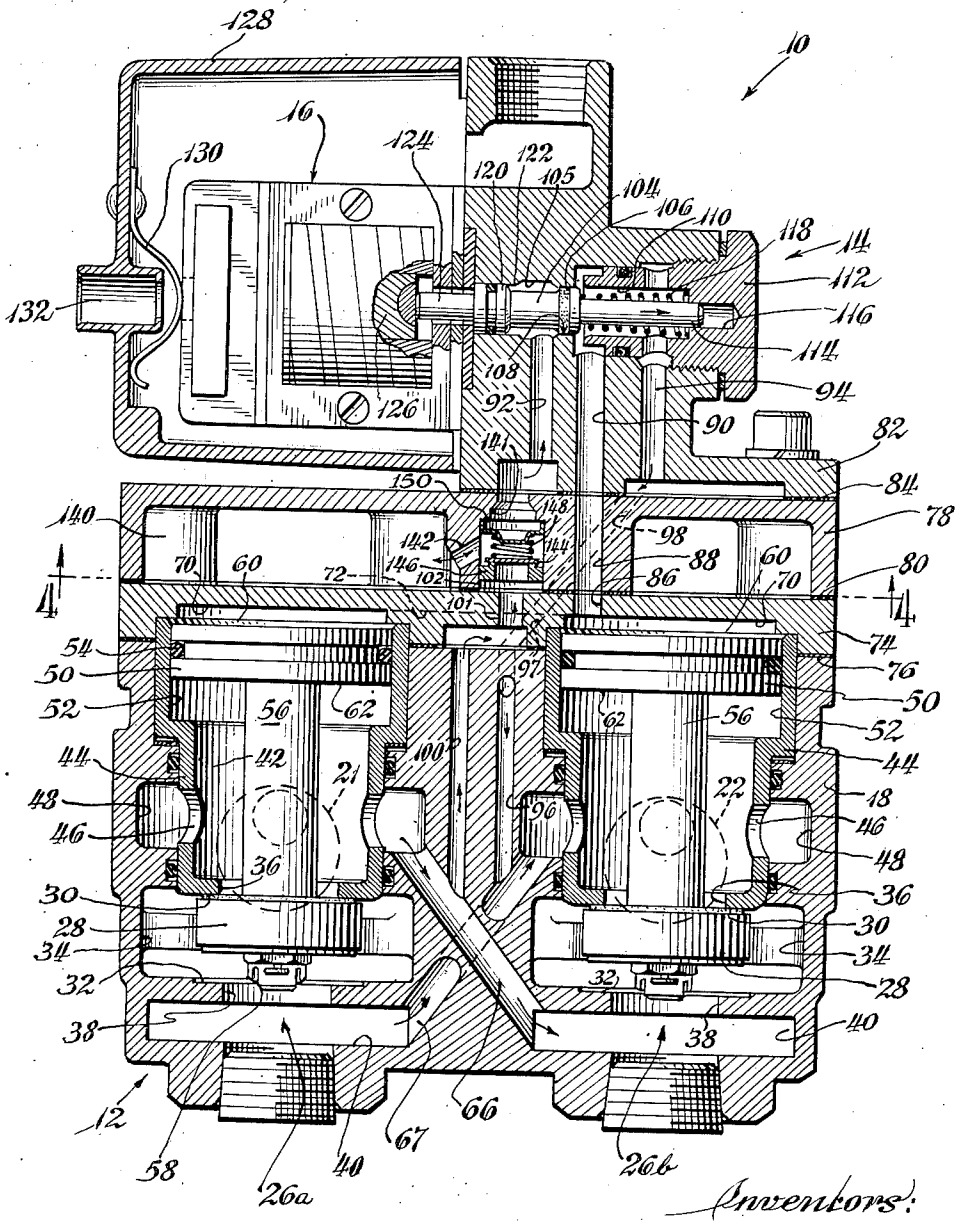
June 12, 1962 Z. J. LANSKY ETAL 3,038,500

PILOT-MASTER VALVES WITH PRESSURE ACCUMULATORS

Filed March 10, 1958 4 Sheets-Sheet 1

Fig. 1.



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PILOT-MASTER VALVES WITH PRESSURE ACCUMULATORS

Filed March 10, 1958

4 Sheets-Sheet 2

Fig. 2.

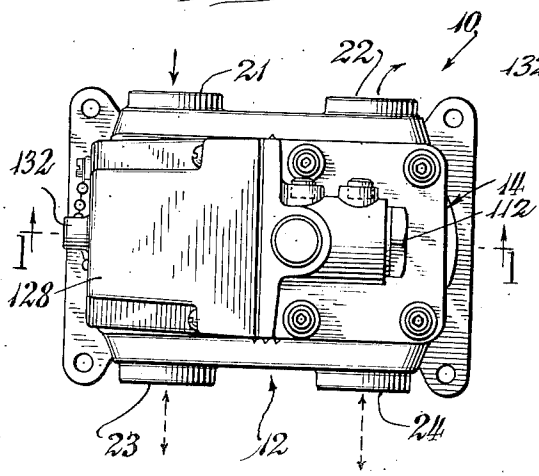


Fig. 3.

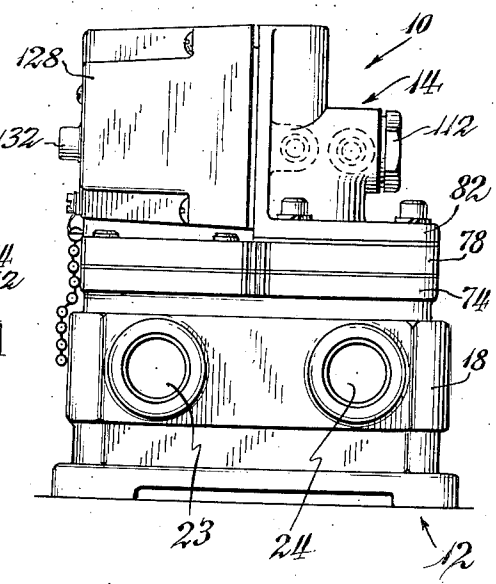
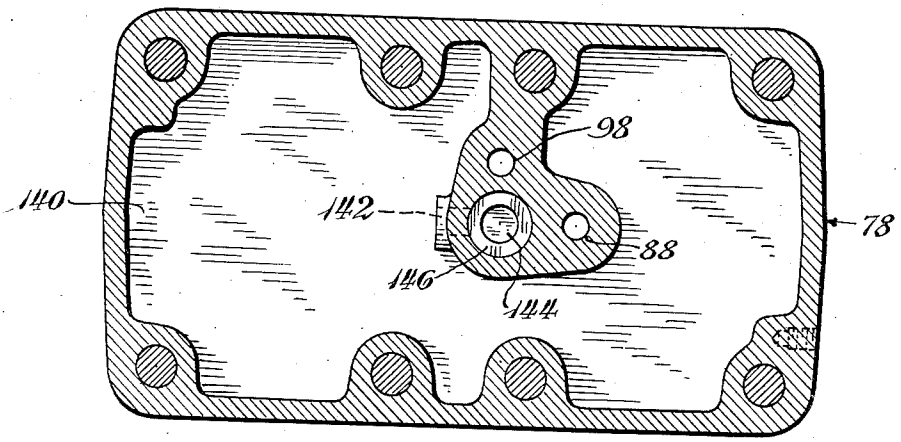


Fig. 4.



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PILOT-MASTER VALVES WITH PRESSURE ACCUMULATORS

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Fig. 5.

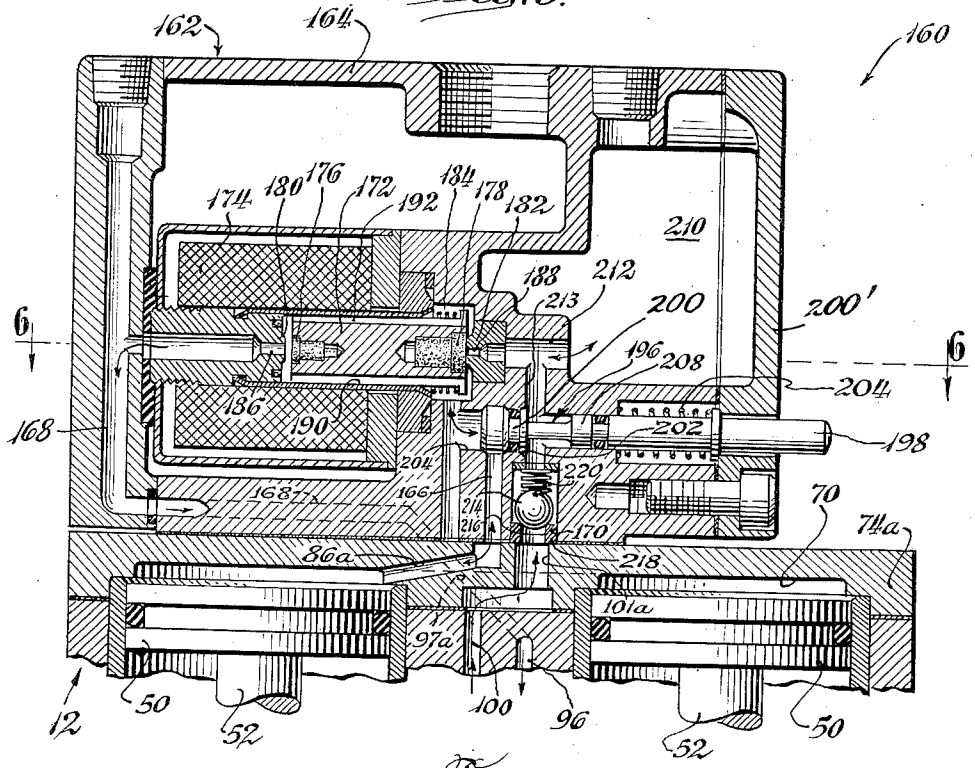
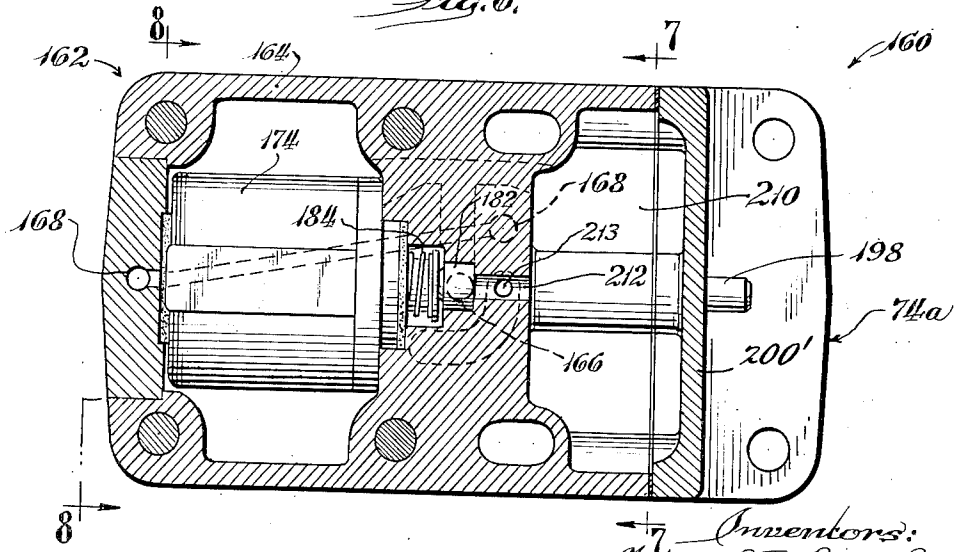


Fig. 6.



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PILOT-MASTER VALVES WITH PRESSURE ACCUMULATORS

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Fig. 7.

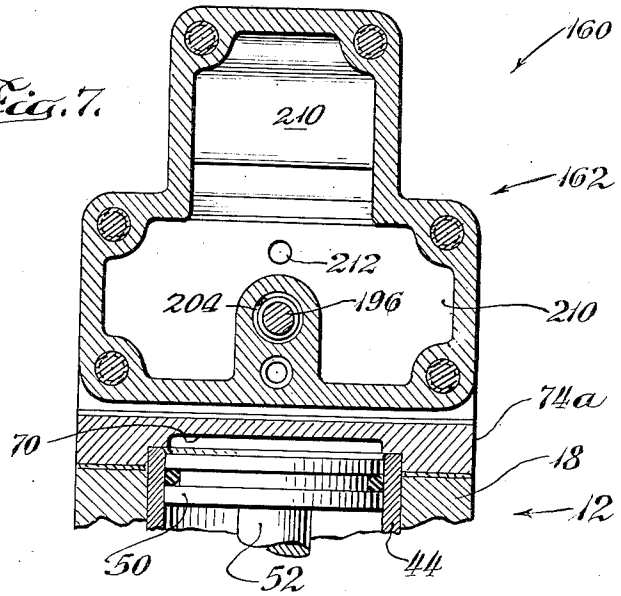
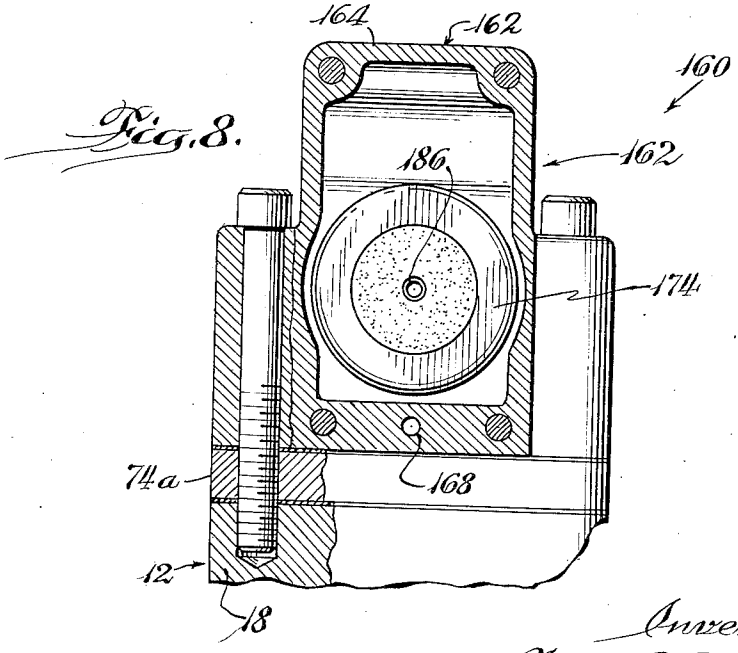


Fig. 8.



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3,038,500
PILOT-MASTER VALVES WITH PRESSURE ACCUMULATORS

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Filed Mar. 10, 1958, Ser. No. 720,293
4 Claims. (Cl. 137—625.27)

This invention relates to valves of the type adapted to be operated by fluid pressure, usually under the control of a small pilot valve.

One object of the present invention is to provide a new and improved pilot-master valve which is so arranged as to provide an ample supply of pressure fluid at sufficient pressure to operate the master valve in a positive manner, despite any momentary drop in the working pressure of the pressure fluid, due to the actuation of the master valve or other factors.

A further object is to provide a new and improved pilot-master valve having means for accumulating the pressure fluid at full line pressure during the idle portions of the valve cycle, so that ample fluid pressure will be assured to operate the master valve in a positive manner.

Another object is to provide a new and improved pilot-master valve of the foregoing character in which the accumulator is arranged to minimize drop in the fluid pressure available for operating the master valve.

Still another object is to provide the advantages of the present invention at extremely low cost and in a manner such as to facilitate the manufacture of the pilot-master valves.

Further objects and advantages of the present invention will appear from the following description, taken with the accompanying drawings, in which:

FIG. 1 is a central elevational sectional view of a pilot-master valve constituting an illustrative embodiment of the present invention, the view being taken generally as indicated by a line 1—1 in FIG. 2.

FIG. 2 is a top view of the valve of FIG. 1.

FIG. 3 is an elevational view of the valve of FIG. 1.

FIG. 4 is a horizontal sectional view, taken generally along the line 4—4 in FIG. 1.

FIG. 5 is a fragmentary central elevational sectional view, similar to FIG. 1, but showing a modified embodiment of the present invention.

FIG. 6 is a horizontal sectional view, taken generally along a line 6—6 in FIG. 5.

FIG. 7 is an elevational sectional view taken generally along a line 7—7 in FIG. 6.

FIG. 8 is an elevational view, partly in section along the broken line 8—8 in FIG. 6.

It will be seen that FIG. 1 illustrates a valve 10 which is of the pilot-master type. Thus, the valve 10 comprises a master valve unit 12 which is operable by a pilot valve unit 14. In this case, the pilot valve 14 is mounted on the master valve 12.

Most details of the master and pilot valve units 12 and 14 may be varied as desired. In other words, the invention may be applied to master and pilot valve constructions of various types. The illustrated master valve is of the general type illustrated in Patent No. 2,754,840, issued July 17, 1956, particularly FIGS. 9–18 of said patent. In most respects, the pilot valve 14 is also of the type illustrated in said patent. Said patent may be referred to for extensive and detailed disclosure of the master and pilot valves 12 and 14. Other features of the pilot valve 14 are disclosed and claimed in Patent No. 2,821,355, issued January 28, 1958.

In general, the master valve unit 12 is adapted to be operated by fluid pressure, under the control of the

pilot valve unit 14. The operation of the pilot valve 14 may be under the control of any suitable means, such as the illustrated solenoid 16. Thus, the pilot valve 14 is adapted to be remotely operated, and in turn is adapted to control the operation of the master valve 12.

While the construction of the master valve 12 may be varied, it will be of interest to outline the general features of the illustrated valve unit 12. In this case, the valve unit 12 is of the dual type, adapted to function as a four-way valve. Thus, the illustrated valve unit 12 has a body 18 with four main ports therein (FIG. 2), constituting a supply port 21, an exhaust port 22, a first outlet port 23 and a second outlet port 24. It will be understood that the supply or inlet port 21 is adapted to be connected to an airline or other suitable source of working fluid, such as air, under pressure. The port 22 is adapted to discharge exhaust air to the atmosphere. The outlet ports 23 and 24 are adapted to be connected to the device (not shown) to be controlled by the valve. Such device may, for example, be a double-acting air cylinder or the like, in which case the ports 23 and 24 will be connected to the opposite ends of the cylinder.

As explained in the previously mentioned Patent No. 2,754,840, the valve 10 may readily be rearranged so that the port 22 will function as the inlet port, with the port 21 functioning as the exhaust port. This reverses the normal condition of the outlet ports 23 and 24, as between supply and exhaust. This change involves reversing the position of the pilot valve unit 14 from left to right, or, in other words, rotating the pilot valve through 180 degrees. This feature is fully covered in the patent and need not be discussed further in this application.

The dual master valve 12 has two main valve units, 26*a* and 26*b*, which are the same in construction. Thus, for the most part, it will suffice to describe the unit 26*a*. The corresponding elements of the two valve units 26*a* and 26*b* are given the same reference characters in the drawings.

The illustrated valve unit 26*a* has a valve member 28 which is of the poppet type and is movable between upper and lower seats 30 and 32 in an outlet chamber 34. The outlet ports 23 and 24 are connected to the outlet chambers 34 of the twin valve units 26*a* and 26*b*, respectively.

Upper and lower ports 36 and 38 are formed through the valve seats 30 and 32 and are adapted to be closed by the valve member 28. The lower port 38 leads to a lower chamber 40 in the valve body 18, while the upper port 36 leads to an upper chamber 42, formed within a shell or insert 44 mounted in the body 18. It will be seen that the seat 30 is formed on the lower end of the insert 44. Lateral ports 46 extend through the insert 44 into the chamber 42 and are connected to a chamber 48 in the body 18. The inlet and exhaust ports 21 and 22 are connected to the chambers 48 for the twin valve units 26*a* and 26*b*, respectively. Thus, the chamber 42 of the valve unit 26*a* is connected to the source of fluid pressure, while the chamber 42 for the unit 26*b* is connected to exhaust.

The valve member 28 is adapted to be operated by a piston 50 which is slidable vertically in an enlarged bore 52 formed in the upper end of the insert 44. A sealing ring 54 is provided on the piston. In this case, the piston 50 is solidly connected to the valve member 28 by means of a piston rod or stem 56, which extends through the lower portion of the bore 52, the chamber 42, and the port 36.

Taken together, the piston 50, the stem 56, and the poppet valve 28 may be considered as a differential piston unit 58. It will be noted that the piston 50 has an upper side 60 which is substantially larger in area than either end of the poppet valve 28. Because of the provision

of the stem 56, the piston 50 has a lower side 62 which is smaller than the upper side 60.

The poppet valve 28, the shell 44, the piston 50, and the stem 56 constitute a cartridge which may be removed from the valve body 18 and replaced as a unit, thus facilitating maintenance of the valve.

In the illustrated master valve 12, the lower chambers 40 are cross-connected to the chambers 48, by means of passages 66 and 67. Thus, the passage 66 runs between the inlet chamber 48 of the valve unit 26*a* and the lower chamber 40 of the valve unit 26*b*. The passage 67 runs between the lower chamber 40 of the valve unit 26*a* and the exhaust chamber 48 of the valve unit 26*b*. With the valve members 28 engaging the upper seats 30, as shown, the inlet port 21 is connected to the outlet port 24, through the passage 66 and the chamber 40, the port 38, and the chamber 34 of the valve unit 26*b*. Similarly, the outlet port 23 is connected to the exhaust port 22 through the chamber 34, the port 38 and the chamber 40 of the valve unit 26*a*, and thence through the passage 67.

Normally, the pressure of the working fluid at the inlet port 21 maintains the valve members 28 in their illustrated positions, against the upper seats 30. In the case of the valve unit 26*a*, the force of the working fluid on the underside 62 of the piston 50 exceeds the force on the upper side of the poppet valve 28, because of the greater area of the underside 62, with the result that the piston 50 and the poppet valve 28 are forced upwardly. As to the valve unit 26*a*, the force of the working fluid on the underside of the poppet valve 28 holds the poppet valve and the piston 50 in their upwardly displaced position.

The poppet valves 28 may be forced downwardly against the lower seats 32 by applying inlet pressure to the upper sides 60 of the pistons 50. Due to the greater area of the upper sides 60 on the pistons 50, the force of the working fluid is greater on each of the upper sides 60 than it is on the underside 62 of the valve unit 26*a*, or on the underside of the poppet valve 28 of the valve unit 26*b*. Thus, the pressure of the working fluid is effective to drive the pistons 50 downwardly. The inlet port 21 is then connected to the outlet port 23, through the port 36 and chamber 34 of the valve unit 26*a*. The outlet port 24 is connected to the exhaust port 22 through the chamber 34 and the port 36 of the valve unit 26*b*.

As already indicated, the application of working fluid to the upper sides 60 of the pistons 50 is controlled by the pilot valve 14. It will be seen that chambers 70 are provided above the pistons 60. These chambers are connected together by a suitable passage 72. In this case, the chambers 70 are formed in a first adaptor plate 74 mounted on the top of the body 18. A gasket 76 forms a seal between the body 18 and the plate 74.

For a purpose to be made clear shortly, the illustrated valve 10 is fitted with a second adaptor plate 78, which is mounted on top of the first adaptor plate 74, with a gasket 80 therebetween. The pilot valve 14 has a body 82 which is mounted on top of the second adaptor plate 78, with a gasket 84 therebetween. In this case, the piston chambers 70 are connected to the pilot valve 14 by means of aligned passages 86, 88, and 90 extending through the plate 74, the plate 78, and the body 82, respectively. The passage 90 constitutes the outlet passage of the pilot valve 14. It will be seen that the pilot valve body 82 is also formed with an inlet passage 92 and an exhaust or vent passage 94. In general, the function of the pilot valve 14 is to connect the outlet passage 90 to either the exhaust passage 94 or the inlet passage 92. As diagrammatically indicated in FIG. 1, the exhaust passage 94 may be connected to the main exhaust port 22 by means of aligned passages 96, 97 and 98 in the body 18, the plate 74, and the plate 78, respectively. In this case, the passage 96 connects with the passage 67. The pilot valve inlet passage 92 may

be connected to the main inlet port 21 by means of aligned passages 100, 101, and 102 in the body 18, the plate 74, and the plate 78, respectively. As shown, the passage 100 is connected to the passage 66.

As already indicated, the pilot valve 14 may be arranged in various ways. In this case, the pilot valve comprises a valve plunger or spool 104 which is movable in a bore or passage 105 formed in the body 82. As shown, the valve spool 104 comprises an enlarged valve member 106 which is normally positioned in an intermediate portion 108 of the bore 105. It will be seen that the inlet passage 92 and the outlet passage 90 enter the bore 105 on opposite sides of the valve member 106, when thus normally positioned. Accordingly, the outlet 90 is normally cut off from the inlet 92. By translation of valve plunger 104 to the right, as seen in FIG. 1, the valve member is moved out of the bore 108 and into an aligned bore 110, formed in a plug or insert 112 which is screwed into or otherwise mounted in the body 82. Such movement of the valve member 106 establishes communication between the inlet 92 and the outlet 90. The exhaust passage 94 communicates with the bore 110 to the right of the translated position of the valve member 106. Thus, the outlet passage 90 is connected to the exhaust 94, with the valve member 106 normally positioned, but is cut off from the exhaust when the valve member is in its translated position. At its right-hand end, the valve plunger 106 has a guide stem 114 which slides in a reduced bore 116 formed in the plug 112. The valve plunger 104 is biased into its normal position by a spring 118, which, in this case, is coiled around the stem 114 between the plug 112 and the valve member 106.

To prevent the pressure of the working fluid in the inlet passage 92 from moving the valve member 106, the valve plunger 104 is formed with an enlarged compensating piston 120 of substantially the same area as the valve member 106. The piston 120 is slidable in a portion 122 of the bore 105. As shown, the inlet passage 92 enters the bore 105 between the valve member 106 and the piston 120, so that the pressure of the working fluid is applied to opposite sides of the valve member and the piston.

The illustrated valve spool 104, at its left-hand end, is formed with an operating stem 124 which extends out of the body 82 and into the solenoid unit 16. It will be seen that the solenoid 16 has an armature 126 which is adapted to push the stem 94 to the right when the solenoid is energized. In this way, the pilot valve 14 is operated. The solenoid 16 is mounted in a removable housing 128 and is normally held against the body 82 by a spring 130, disposed between the housing and the solenoid. In this case, the housing 128 has an opening 132 through which a rod or the like may be inserted to engage the armature 126 and push the armature and the valve stem 124 to the right. In this way, the valve 14 may be operated manually without removing the housing 128 and the solenoid 16.

The provision of the differential pistons 50 in the master valve 12 makes it unnecessary to employ any springs, or to rely on gravity, to hold the main valve poppets 28 in their normal positions, against the upper seats 30. This affords an added safety factor, because there is no chance that the master valve will malfunction due to a broken spring. When the working fluid is supplied to the master valve at adequate pressure, and with a supply line having adequate capacity, the master valve will function positively, even when the air cylinder or other device controlled by the valve requires a large flow of working fluid. However, if the supply line pressure is marginally low, or if the supply line has substantially inadequate capacity, the pressure at the inlet port 21 may drop to quite a low value when the poppet valves 28 are moved away from the upper seats 30, assuming the device controlled by the valve requires a large amount of air. The pressure drop is due to the large flow of air through the master valve and the supply line, when the poppet valves 28 start to transfer. Under acute conditions of low supply pressure or inadequate supply capacity, the pressure at the inlet may drop to a value in-

sufficient, in itself, to complete the strokes of the pistons 50. Without the provision of the present invention, the poppet valves 28 may, on occasion, stop at intermediate positions, between the upper and lower seats 30 and 32. The air or other working fluid will then blow through the ports 36 and 38 to the exhaust, without operating the air cylinder or other device controlled by the valve. It will be noted that such failure to function does not affect the safety of the valve, because the air cylinder or other device is not operated. However, such misfunctioning can be inconvenient and can result in loss of time.

As already indicated, the object of the present invention is to assure an adequate supply of pressure fluid to complete the downward strokes of the pistons 50 in a positive manner, so that the poppet valves 28 will firmly engage the lower seats 32. To this end, the pilot valve 14 is provided with an accumulator space 140 for storing the air or other working fluid at virtually the full supply pressure. In this case, the accumulator space 140 takes the form of a cavity in the second adaptor plate 78. The cavity 140 is connected to the upper portion 141 of the inlet passage 102 through a passage 142. In general, the accumulator 140 is filled with a working fluid when the valve 10 is idle. When the pilot valve 14 is operated, the working fluid in the accumulator 140 is available to drive the pistons 50 downwardly.

To prevent the accumulated working fluid in the accumulator 140 from flowing back from the inlet 102 into the master valve 12, a check valve 144 is provided in the lower portion of the inlet 102, between the passage 142 and the master valve. The check valve 144 may take various forms, but is shown as a light disk, adapted to seat against the upper side of a disk or ring 146 which is mounted in the lower end of the inlet 102. The disk 144 may be made of plastic or other light material so as to operate quickly and open easily when the pressure from the main inlet port 21 exceeds the pressure in the accumulator space 140. The check valve 144 is biased lightly against the seat 146 by means of a weak spring 148, which is disposed between the disk 144 and an apertured spider 150 in the upper end of the inlet 102. The force of the spring 148 is made very slight, so as to be just sufficient to seat the disk 144. The force of the spring is much less than the normal force of the working fluid on the under side of the disk 144, so as to minimize pressure drop through the check valve. In this way, the pressure in the accumulator 140 is only very slightly less than the maximum supply pressure at the inlet port 21.

During the portion of the valve cycle when the main poppet valves 28 are normally positioned and the pilot valve 14 is not operated the working fluid from the main inlet port 21 flows into the accumulator space 140 through the check valve 144, until the pressure in the accumulator is virtually the same as the maximum working pressure. When the pilot valve 114 is operated, the air or other working fluid flows out of the accumulator 140 through the passage 142, and thence through the pilot valve to the piston chambers 70. Even if the pressure at the main inlet port 21 drops momentarily to a very low value, as the poppet valves 28 start to move, the pressure fluid in the accumulator 140 will positively complete the downward strokes of the pistons 50. The accumulator 140 will then be refilled through the check valve 144.

FIGS. 5–8 illustrate a modified pilot-master valve 160 constituting another illustrative embodiment of the present invention. The valve 160 may employ the same master valve 12 as in the first embodiment. Thus, the master valve has been shown merely in fragmentary fashion in FIGS. 5–8. The first adaptor plate 74 may also be the same as in the first embodiment, but it is shown in a slightly different fashion in FIGS. 5–8, and hence is designated 74*a*. The piston chambers 70 are shown the same as in the first embodiment. An outlet passage 86*a*, an exhaust passage 97*a*, and an inlet passage 101*a* are provided in the adaptor plate 74*a*. These passages are functionally the same as the corresponding passages 86, 97 and 101 of the first embodiment. For convenience, they are shown diagrammatically in a slightly different manner than in the first embodiment.

The modified valve 160 omits the second adaptor plate 78 and employs a somewhat different pilot valve 162. As illustrated, the pilot valve 162 has a body 164 which is mounted on top of the adaptor plate 74*a*. An outlet passage 166 is formed in the body 164 to register with the outlet passage 86*a*. Similarly, an exhaust passage 168 is provided in the body 164 to register with the passage 97*a*. An inlet passage 170 in the body 164 registers with the passage 101*a*. As before, the function of the pilot valve 162 is to connect the outlet 166 to either the exhaust 168 or the inlet 170.

The illustrated pilot valve 162 is of the concentric solenoid type. Thus, the valve 162 has a valve member or spool 172, operable by a solenoid 174 which is concentric with the spool. Actually, the spool 172 constitutes the armature of the solenoid. As shown, the opposite ends of the spool 172 are provided with sealing inserts or members 176 and 178, adapted to engage seat members 180 and 182. A spring 184 normally biases the spool against the seat member 182. It will be seen that the seat members 180 and 182 are formed with axial ports 186 and 188, adapted to be closed by the sealing inserts 176 and 178. The port 186 is connected to the exhaust passage 168, while the port 188 is in communication with the inlet passage 170. As shown, the spool 172 is slidable in a bore or passage 190, which is in communication with the outlet passage 166. Longitudinal grooves 192 or the like are formed in the spool so that the air or other pressure fluid may flow freely along the length of the spool.

When the spool 172 is in its normal position against the seat 182, the inlet port 188 is closed, while the exhaust port 186 is open. Thus, the outlet passage 166 is connected to the exhaust passage 168. Energization of the solenoid 174 moves the spool 172 to the left, until it closes the exhaust port 186. The outlet passage 166 is then in communication with the inlet passage 170. To provide for manual control of the master valve 12, the pilot valve 162 is equipped with a separate valve spool or plunger 196 having an operating stem 198 extending outwardly beyond an end plate 200 mounted on the valve body 164. It will be seen that the valve spool 196 has an enlarged valve member 200 which normally occupies a bore 202 extending between the inlet passage 170 and the outlet passage 166. A spring 204 is provided to bias the valve spool 196 into this normal position. By pushing inwardly on the operating stem 198, the valve member 200 may be moved out of the bore 202 and into a bore 204 constituting a portion of the outlet passage 166. The inlet passage 170 is thereby connected to the portion of the outlet passage 166 running to the master valve 12. At the same time, the valve member 200 prevents flow of air from the outlet passage to the bore 190. Thus, the valve member 200 prevents loss of air to the exhaust passage 168. The valve spool 196 has a piston portion 208 opposed to the valve member 200 so as to counterbalance most or all of the force of the working fluid inlet passage 170, and thereby assist the spring 204 in preventing the working fluid from shifting the valve.

In order to accumulate or store the working fluid to assure positive operation of the main valve pistons 50, the pilot valve 162 is provided with an accumulator chamber or space 210 which is formed partly in the body 164 and partly in the end closure plate 200. A passage 212 extends between the accumulator space 210 and the upper portion 213 of the inlet passage 170, adjacent the port 188. To prevent back flow of fluid from the accumulator space 210 through the inlet passage 170, a check valve 214 is disposed in the lower portion of the inlet passage, adjacent the adaptor plate 74*a*. In this case, the check valve 214 takes the form of a valve ball, adapted to seat over a port 216 which is formed in a ring or other seat member 218 mounted in the lower end of the inlet pas-

sage 170. A light coil spring 220 biases the ball 214 against the seat 218. Here again, the spring 220 is made as light as possible, only strong enough to insure seating of the ball 214 over the port 216. The force of the spring 220 is made as small as possible with respect to the force exerted by the working fluid on the ball 214. In this way, the pressure drop through the check valve is minimized, so that the pressure in the accumulator 210 will build up to a value substantially the same as the maximum value at the main inlet port 21.

When the valve 160 is in its normal condition, with the solenoid 174 de-energized, the air or other working fluids fills the accumulator 210 through the check valve 214, to a pressure only very slightly less than the maximum supply pressure. When the pilot valve 162 is operated, the working fluid 210 in the accumulator is available to assure that the main pistons 50 will be driven downwardly through their full strokes, so that the main poppet valves 28 will seat firmly against the lower seats 32. The check valve 214 prevents back flow of air from the accumulator 210 into the main supply port 21. Even if the supply pressure at the main port 21 drops to a rather low value when the main valves 28 start to move, the air pressure in the accumulator 210 will assure completion of the operating strokes of the main valve pistons 50. When the supply pressure at the inlet port 21 recovers to its normal value, the accumulator space 210 will be refilled through the check valve 214.

It will be apparent that the present invention provides a built-in auxiliary supply of working fluid for operating the main valves when the pilot valve is operated. This is accomplished with a minimum of additional equipment, and at extremely low cost. The advantages of the invention may be provided in an adaptor which may be employed with existing pilot-master valves. Alternatively, the features of the invention may be provided in new valves of this type.

Various other modifications, alternative constructions and equivalents may be employed without departing from the true spirit and scope of the invention as exemplified in the foregoing description and defined in the following claims.

We claim:

1. In a valve device, the combination comprising a master valve unit having a body with inlet and outlet ports therein, a master valve member movable in said body for controlling communication between said ports, fluid pressure operable means movable in said body for operating said master valve member, said body having third and fourth ports therein, means in said body connecting said third port to said inlet port, means in said body connecting said fourth port to said fluid pressure operable means, an accumulator unit having an accumulator body with fifth and sixth ports therein, said accumulator body being mounted against said master valve body with said fifth and sixth ports registering respectively with said third and fourth ports, said accumulator body having seventh and eighth ports therein, said accumulator body having an accumulator space of substantial size therein connected to said seventh port, a check valve in said accumulator body connected between said fifth port and said accumulator space for admitting expansible pressure fluid to said accumulator space while preventing back-flow of the expansible pressure fluid through said fifth port, said accumulator body having a passage therein connecting said eighth port to said sixth port, a pilot valve unit having a pilot valve body mounted against said accumulator body, said pilot valve body having ninth and tenth ports therein registering respectively with said seventh and eighth ports, said pilot valve body having a pilot valve member movable therein for controlling the flow of the expansible pressure fluid between said ninth and tenth ports and thereby selectively applying the expansible pressure fluid to the fluid pressure operable means in said master valve body, said accumulator space being effective to accumulate the expansible pressure fluid to provide for positive operation of said fluid pressure operable means, said accumulator space having a volume greatly exceeding the volume of said ports and passage connected thereto.

2. In a valve device, the combination comprising a master valve unit having a body with inlet and outlet ports therein, a master valve member movable in said body for controlling communication between said ports, fluid pressure operable means movable in said body for operating said master valve member, said body having third and fourth ports therein, means in said body connecting said third port to said inlet port, means in said body connecting said fourth port to said fluid pressure operable means, an accumulator unit having an accumulator body with fifth and sixth ports therein, said accumulator body being mounted against said master valve body with said fifth and sixth ports registering respectively with said third and fourth ports, said accumulator body having seventh and eighth ports therein, said accumulator body having an accumulator space of substantial size therein connected to said seventh port, a check valve in said accumulator body connected between said fifth port and said accumulator space for admitting expansible pressure fluid to said accumulator space while preventing back-flow of the expansible pressure fluid through said fifth port, said check valve comprising a seat facing toward said accumulator space, a check valve member movable in said accumulator body against said seat, and an extremely light spring biasing said check valve member against said seat with a force which is an insubstantial minor fraction of the force of the expansible pressure fluid on said check valve member at working pressure so as to minimize pressure drop through said check valve, said accumulator body having a passage therein connecting said eighth port to said sixth port, a pilot valve unit having a pilot valve body mounted against said accumulator body, said pilot valve body having ninth and tenth ports therein registering respectively with said seventh and eighth ports, said pilot valve body having a pilot valve member movable therein for controlling the flow of the expansible pressure fluid between said ninth and tenth ports and thereby selectively applying the expansible pressure fluid to the fluid pressure operable means in said master valve body, said accumulator space being effective to accumulate the expansible pressure fluid to provide for positive operation of said fluid pressure operable means, said accumulator space having a volume greatly exceeding the volume of said ports and passage connected thereto.

3. In a valve device, a body having a portion formed with a supply port, a main supply passage leading from said supply port, an outlet port, and an exhaust port; a master valve in said body for alternately connecting said outlet port to said main supply passage and said exhaust port; fluid pressure operable means in said body for operating said master valve; said body having a portion with a pilot valve therein; said body having a portion formed with inlet, outlet, and exhaust passages for said pilot valve; said inlet passage leading to said pilot valve from said main supply passage and being connected thereto at a point therealong located between said supply port and said master valve; said outlet passage leading from said pilot valve to said fluid pressure operable means; said pilot valve including means for alternately connecting said outlet passage to said inlet and exhaust passages; a check valve in said inlet passage for permitting fluid under pressure to flow through said inlet passage from said main supply passage to said pilot valve while preventing backflow of fluid from said pilot valve to said main supply passage; said body having a portion formed with an accumulator chamber therein having a single connection to said inlet passage at a point therealong between said check valve and said pilot valve whereby fluid under pressure passes directly through said inlet passage from said check valve to said pilot valve when

said accumulator chamber is filled with fluid under pressure; said accumulator chamber having a volume greatly exceeding the volume of that portion of said inlet passage which is downstream from said check valve; said accumulator chamber serving to accumulate the expansible pressure fluid from said inlet passage to provide for positive operation of said fluid pressure operable means even though the pressure in said main supply passage may be abnormally low; said master valve, said pilot valve, said check valve, said accumulator chamber, and all of said passages being disposed entirely within said body.

4. In a valve device, a body having a portion formed with a supply port, a main supply passage leading from said supply port, an outlet port, and an exhaust port; a master valve in said body for alternately connecting said outlet port to said main supply passage and said exhaust port; fluid pressure operable means in said body for operating said master valve; said body having a portion with a pilot valve therein; said body having a portion formed with inlet, outlet, and exhaust passages for said pilot valve; said inlet passage leading to said pilot valve from said main supply passage and being connected thereto at a point therealong located between said supply port and said master valve; said outlet passage leading from said pilot valve to said fluid pressure operable means; said pilot valve including means for alternately connecting said outlet passage to said inlet and exhaust passages;

a check valve in said inlet passage for permitting fluid under pressure to flow through said inlet passage from said main supply passage to said pilot valve while preventing backflow of fluid from said pilot valve to said main supply passage; said body having a portion formed with at least one accumulator chamber therein having a single connection to said inlet passage at a point therealong between said check valve and said pilot valve whereby fluid under pressure passes through said inlet passage from said check valve to said pilot valve without passing through said accumulator chamber when said accumulator chamber is filled with fluid under pressure; said accumulator chamber serving to accumulate the expansible pressure fluid from said inlet passage to provide for positive operation of said fluid pressure operable means even though the pressure in said main supply passage may be abnormally low; said master valve, said pilot valve, said check valve, said accumulator chamber, and all of said passages being disposed entirely within said body.

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