

March 21, 1961

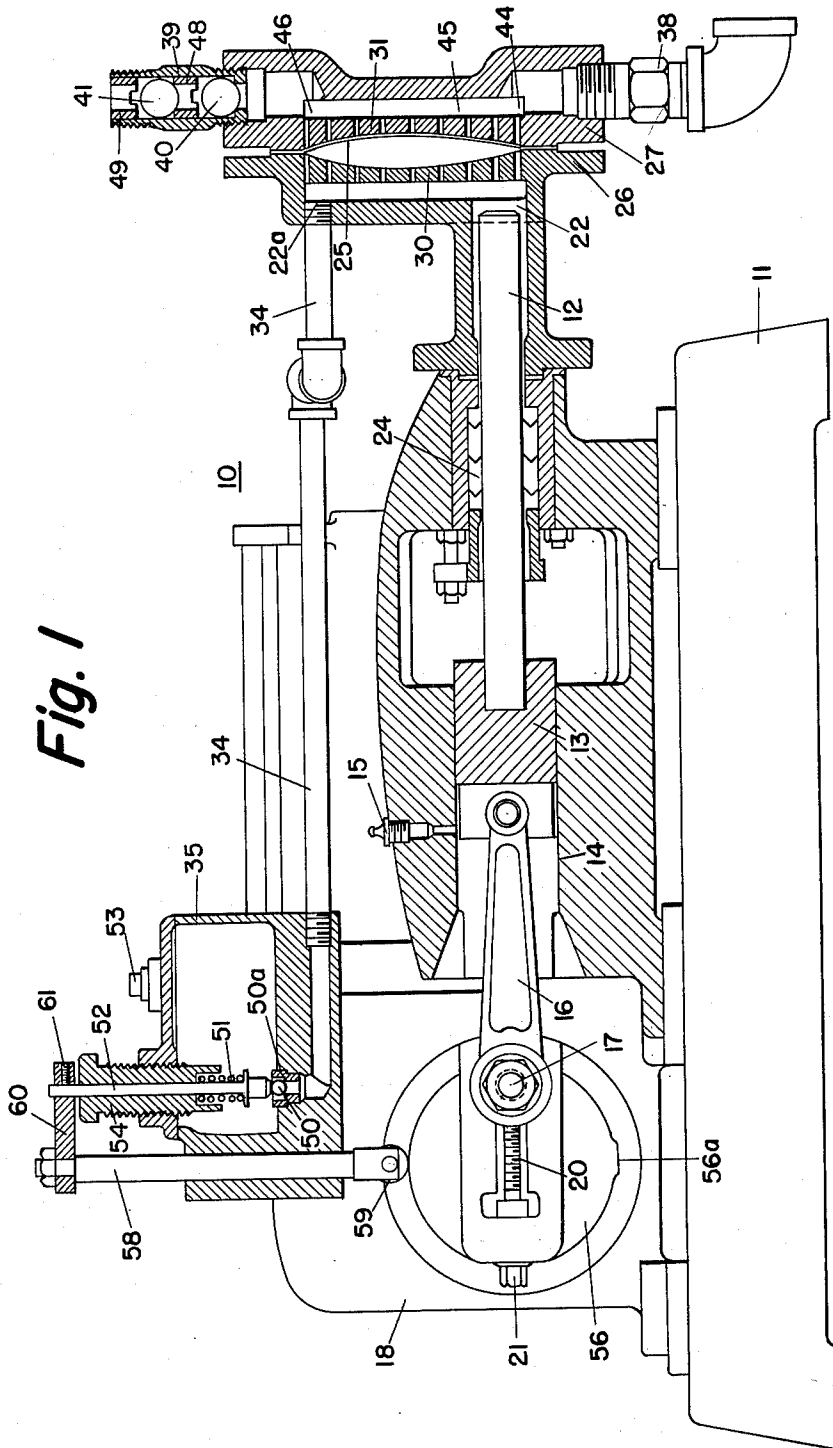
R. A. BENNETT

2,975,599

PUMP WITH FLUID TRANSMISSION

Filed Nov. 27, 1957

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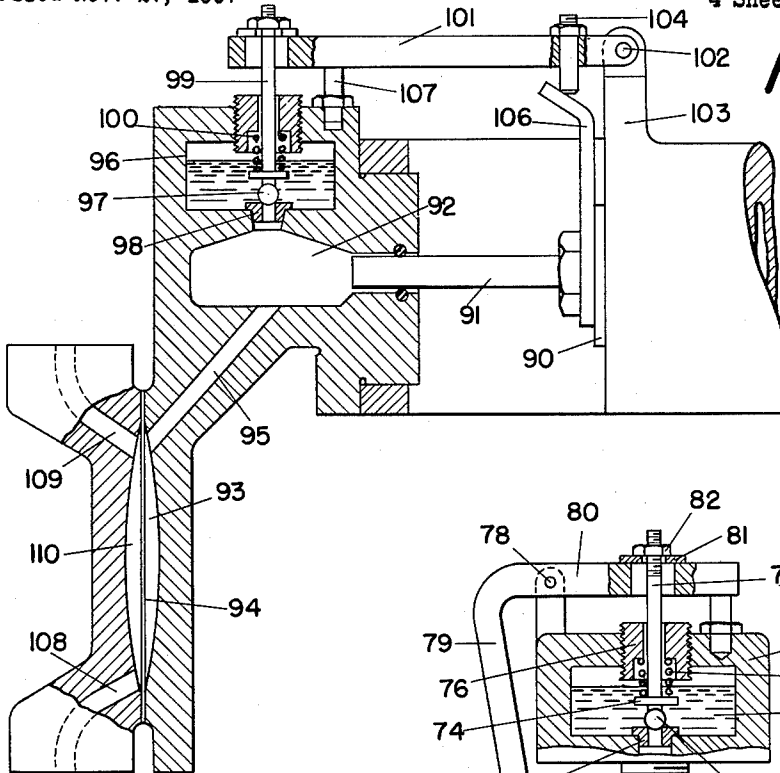


Fig. 3

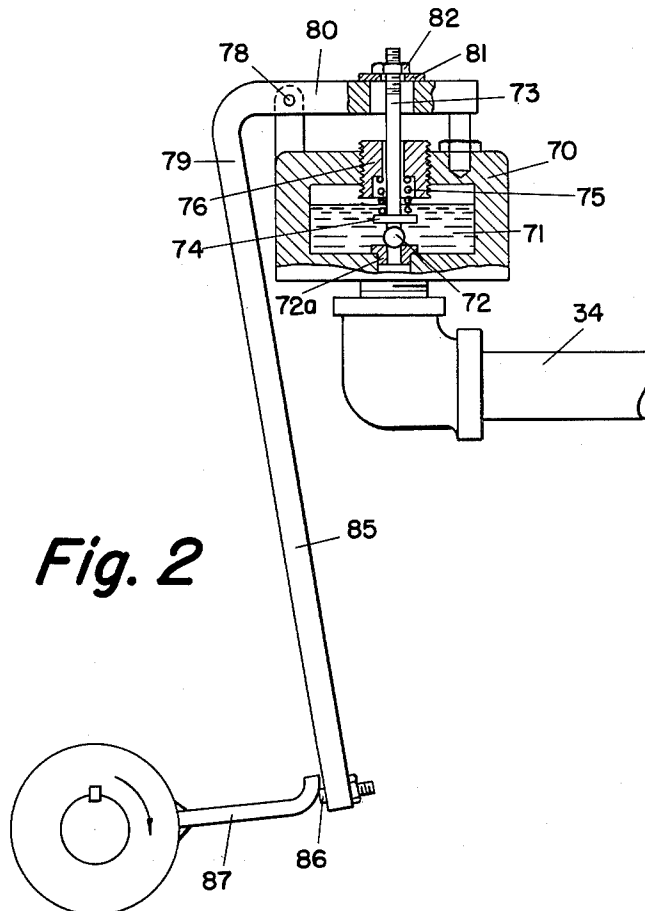


Fig. 2

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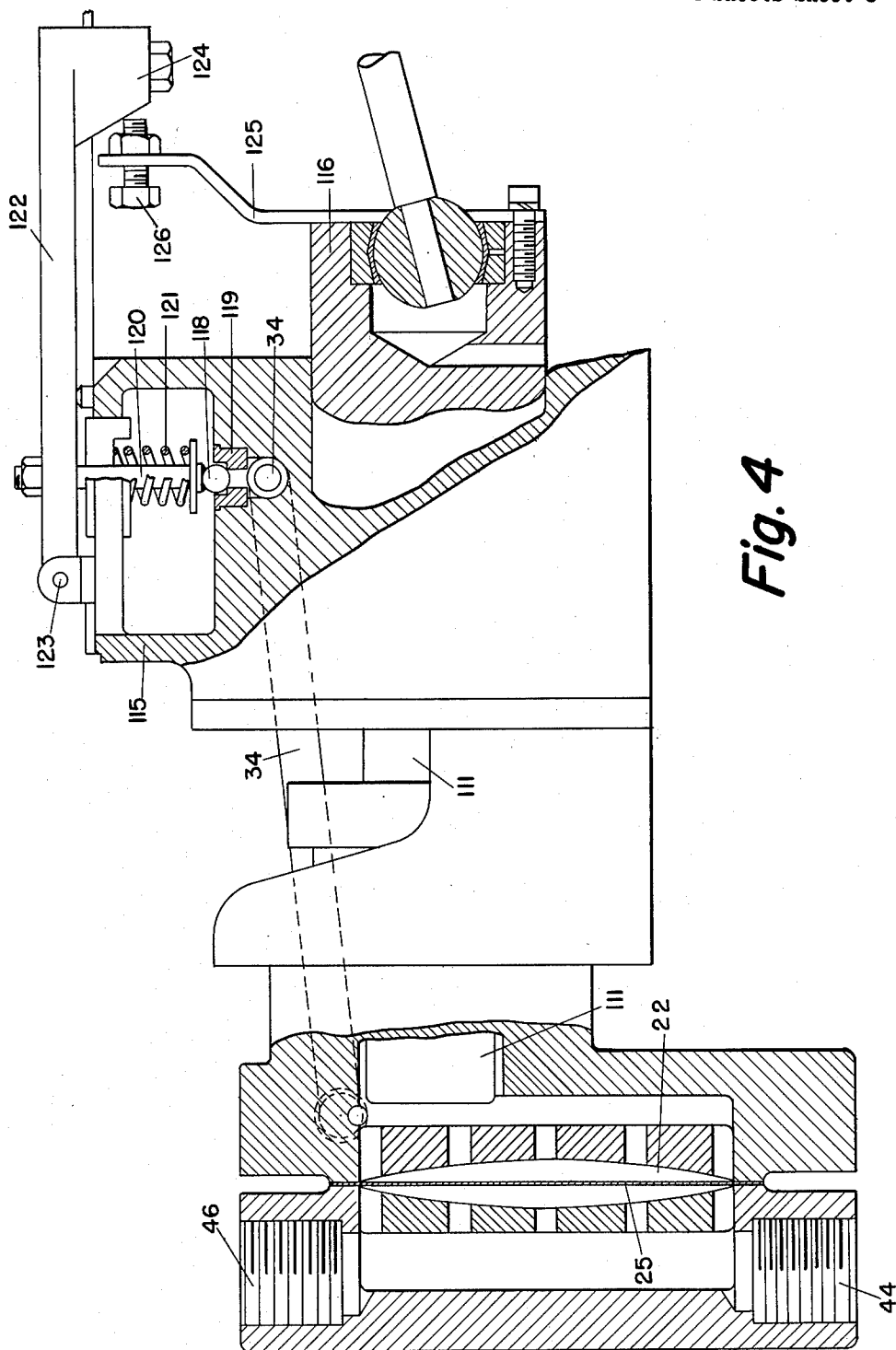
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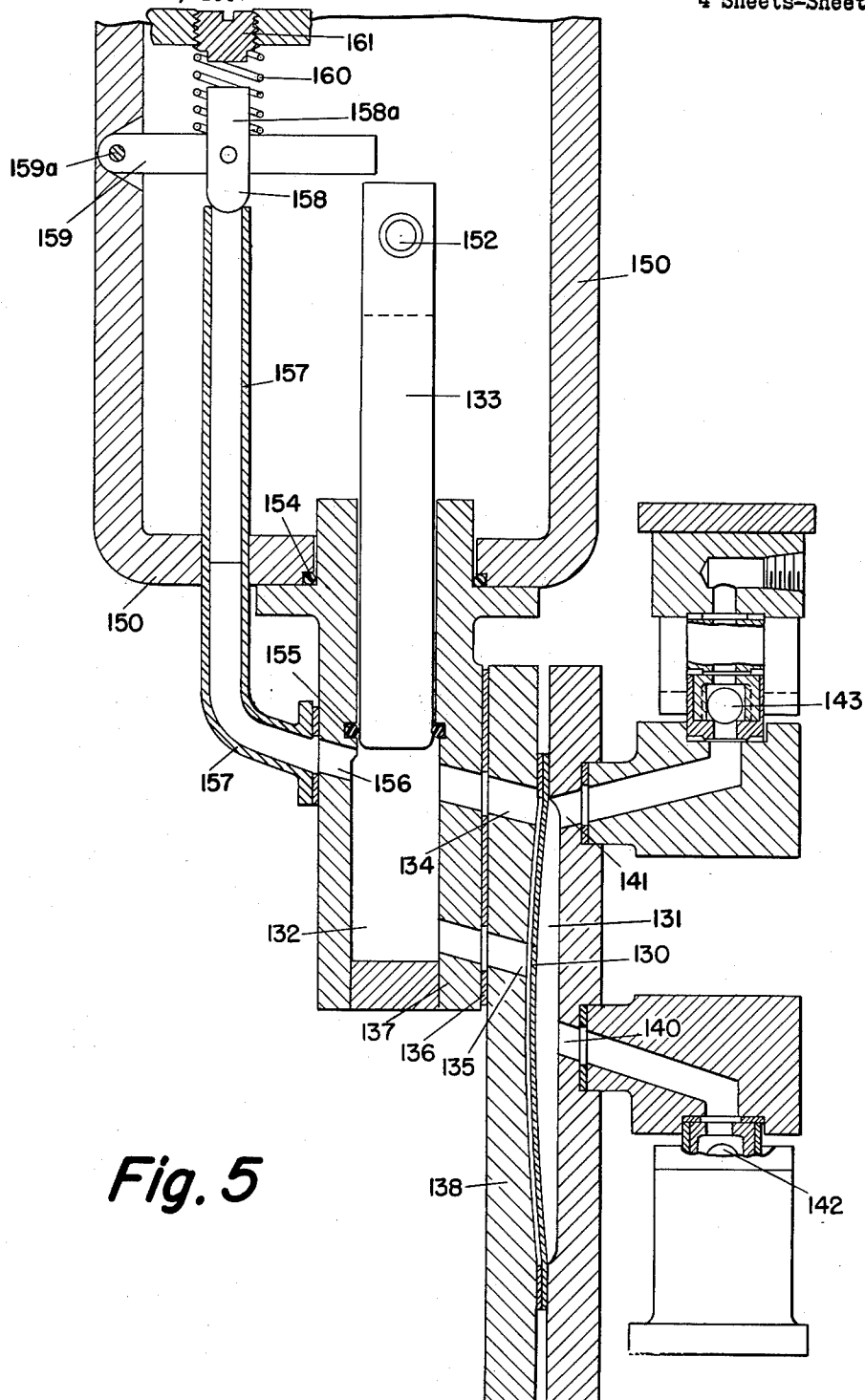


Fig. 5

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2,975,599

PUMP WITH FLUID TRANSMISSION

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9 Claims. (Cl. 60—54.6)

This invention relates to pumps with a fluid transmission, and particularly to accurate metering pumps of the positive displacement type which employs a hydraulic fluid between a piston and a diaphragm for actuating the latter.

Pumps of this type are particularly useful in dispensing chemical liquids and other fluids, and it is important that they have a high degree of accuracy. In pumps of this type, including a hydraulic transmission, air bubbles frequently occur in the hydraulic fluid; and if the bubbles are allowed to remain in the system, they will be compressed on the pressure stroke of the pump and there results a loss in the metering accuracy.

In accordance with the present invention, there is provided a mechanically-operated arrangement effective at a predetermined position in each cycle of the pump operation to correct any expansion or contraction or leakage of the transmitting liquid so as to eliminate any errors in metering due to the hydraulic transmission.

More particularly, and in accordance with the present invention, there is provided a flow passage, or conduit, which at one end connects with the liquid interconnecting a pump plunger and a moving wall and at the other end connects to a reservoir of the liquid which is open to atmosphere. A check valve is located in the conduit at the end adjacent the reservoir and mechanical means is provided for controlling the operation of the check valve by the actuator for the pump plunger.

Further in accordance with the invention, the conduit is adapted to be connected to the chamber for the hydraulic liquid at a location adjacent the uppermost area of the moving wall. The conduit is inclined upwardly toward its opposite end where it communicates with the liquid reservoir which is at an elevation above the liquid engaging the moving wall. With this arrangement, any air bubbles which form in the liquid transmission will rise to the zone adjacent the top of the moving wall and on the compression stroke of the piston the air bubbles will be discharged from the motion-transmitting liquid and allowed to escape through the check valve which is adapted to be opened at the end of the suction stroke. The check valve is adapted to be spring-loaded in closed position during the remainder of the pump cycle, the restraining means being adapted for operation by the actuator for the pump plunger. By reason of this novel arrangement, the check valve serves the dual function of a pressure relief valve during the complete pump cycle, and at the end of each suction stroke it serves as a combination "make-up" or "bleed" valve for the transmission liquid.

For a more detailed disclosure of the invention and for further objects and advantages thereof, reference is to be had to the following description taken in conjunction with the accompanying drawings in which:

Fig. 1 is a vertical cross-section of a pump with a hydraulic transmission in accordance with the present

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invention, the pump plunger being shown at the end of the compression or discharge stroke;

Fig. 2 is a fractional view of a modification of the invention showing another form of mechanical control for the check valve; and

Figs. 3-5 are fractional views similar to Fig. 2 showing further modifications of the invention.

Referring to Fig. 1, there is shown a pump mechanism 10 mounted on a base 11 and including a reciprocable piston or plunger 12. The plunger 12 is connected at the rear end to a crosshead 13 which is adapted to slide on a crosshead-guide 14 and is lubricated at 15. The crosshead 13 is connected by way of a link 16 which in turn is connected to a crank 17 which is adapted for rotation by a motor 18 about a central axis 20. The length of the crank arm may be suitably adjusted by means of stroke-adjustment mechanism indicated at 21. This actuating mechanism for the plunger 12 is adapted to reciprocate the plunger within a chamber 22 which is adapted to hold a motion-transmitting liquid. The plunger 12 is adapted to be sealed along its surface by packing 24 which holds the hydraulic transmission fluid within the chamber or cylinder 22.

In communication with the chamber 22 is a flexible moving wall which has been illustrated in the form of a diaphragm 25, the outer edges of which are adapted to be held between flanges 26 and 27. The diaphragm 25, which is formed from suitable material, for example rubber, forms the moving wall of the chamber 22 and is protected in its two limited positions by spaced perforated walls 30 and 31 as well known in the art. The hydraulic transmission fluid fills all of the space in the chamber 22 to the left of the diaphragm 25 and also fills the passage or conduit 34 which extends from the upper end of the chamber 22 to the reservoir 35 for the transmission fluid. This motion-transmitting liquid may be in the form of oil or a mixture of glycerine or water or any other suitable hydraulic liquid.

The moving wall or diaphragm 25 is adapted to be actuated from the plunger 12 by way of the fluid transmission to cause the diaphragm 25 to draw fluid through the inlet 38 and discharge it through the outlet 39. The inlet and outlet 38 and 39 are each provided with a pair of ball check valves 40 and 41, as shown in detail, in connection with the outlet or discharge section 39. The inlet ball check valves in series connect from the inlet port 44 near the bottom of the pump chamber 45. In similar manner, the two ball check valves 40 and 41 in series connect from an outlet port 46 near the top of the pump 45 to an outlet connection, not shown. As may be seen, the balls 40 and 41 rest on seats and are limited in their upward movement by plugs, or ball guides 48 and 49 disposed in the valve casings above the balls.

The fluid or liquid being handled by the pump is adapted to be drawn into the chamber 45 through the inlet 38 when the plunger is moving toward the left on the suction stroke, and this liquid is then adapted to be discharged from the chamber 45 and out through the discharge valves 39 when the pump plunger 12 moves to the right on its discharge stroke.

During the foregoing operation of the pump 10, the motion-transmitting liquid in the chamber 22 is subject to variations in temperature by reason of changes in ambient conditions and also due to heat created from friction in the transmission liquid itself. During such operation, there may also occur an excess of air within the pumping chamber 22. By reason of such temperature changes, and the creation of bubbles in the transmission liquid, there are resultant changes in volume of the fluid being discharged from the pump chamber 45, thus introducing errors in the metering of this fluid. In

order to eliminate these errors, there is provided, in accordance with the present invention, a valve arrangement which during each cycle of the pump functions to connect the motion-transmitting liquid to atmosphere and to a reservoir of such liquid, thus enabling correction due to expansion or contraction or leakage of the motion-transmitting liquid by continuously readjusting the amount of motion-transmitting liquid in the system.

As shown in Fig. 1, there is a conduit 34 which is inclined upwardly from the uppermost end 22a of the pumping chamber 22 to the liquid reservoir 35. The upper end of the conduit 34 terminates with a ball check valve 50 which is secured to the lower end of an operating rod 52 and is adapted normally to be held in closed position by means of a compression spring 51. When the ball valve 50 is in closed position, the liquid in the reservoir 35 is sealed with respect to the conduit 34 and also to atmosphere, the latter connection being by way of the plug 53. The foregoing sealing action is effective so long as the pressure in conduit 34 does not exceed the pressure of compression spring 51. Thus, it will be seen that valve 50 serves the additional function of a pressure relief valve during the complete cycle of the pump.

The rod 52 is adapted for reciprocation within a vertical plug 54 inserted in the top of the reservoir 35. The actuation for the rod 52 is derived from a cam 56 which is mounted on a shaft 20 of the pump actuator and is adapted to be rotated in timed relation with the crank 17. It will be noted that the cam 56 is provided with a rise 56a which is of relatively short length and is positioned at approximately 90° from the angular position of the crank 17. Directly above the cam 56 and adapted to ride on the cam surface is an actuating rod 58, the lower end of which is provided with a roller or cam-follower 59. The member 58 is adapted for vertical reciprocation in the casting which includes the reservoir 35, and at the upper end of the rod 58 there is provided an arm 60 which is secured at its opposite ends respectively to the rod 58 and by way of a set screw 61 to the upper end of rod 52.

As may be seen in Fig. 1, the pump plunger 12 is at the forward end of its discharge stroke. As the crank 17 and the cam 56 continue to rotate in a clockwise direction, they will assume a position exactly 180° from the illustrated position. In this position, which is at the end of the suction stroke, the plunger 12 will have been completely retracted preparatory to moving again to the right to the forwardmost position shown in Fig. 1. When in a retracted position, the cam rise 56a will have moved into engagement with the cam-follower 59, thereby raising the rod 58 upwardly and in turn raising the rod 52 which lifts the ball valve 50 from its seat 50a. At this time the conduit 34 will be opened, thus connecting the interior of chamber 22 with the liquid in the reservoir 35 and with atmosphere during the time ball valve 50 is off of the seat 50a. When the plunger 12 starts another discharge stroke, the cam rise 56a moves beyond the cam-follower 59, thus permitting the rods 58 and 52 to move downwardly to their position shown in Fig. 1 and again close the ball valve 50 with respect to its seat 50a under the bias of compression spring 51.

By reason of this arrangement, the actuator for the pump plunger always provides a positive actuation of the check valve 50 in the conduit 34 which insures that during each cycle of the pump the motion-transmitting liquid will be connected to the reservoir and to atmosphere so as to readjust the transmission liquid as may be required.

While the moving wall of the chamber has been illustrated in the form of a flexible diaphragm, it is to be understood that it may also take other forms, for example in the form of a bellows. Such bellows may be constructed of any suitable resilient material, preferably metallic, such for example as stainless steel or the like.

The actuation of the check valve may also be performed by electro-mechanical means. For example, the cam 56 may actuate an electrical switch in circuit with a solenoid

to raise and lower the valve operator 52, the latter being connected to the armature of the solenoid.

The present invention is also applicable to other types of diaphragm pumps which employ a plunger and hydraulic transmission fluid for actuating the diaphragm. Referring to Fig. 2, the conduit 34 has been illustrated as being connected to a reservoir 70 which contains a supply of the motion-transmitting liquid 71. The conduit 34 is sealed with respect to atmosphere and the liquid 71 within the reservoir 70 by means of the ball valve 72 which is carried by the lower end of a plunger or rod 73. The rod 73 is provided with a shoulder 74 against which one end of the compression spring 75 engages, the other end of the spring 75 being in engagement with a threaded plug 76 which extends through the upper wall of the reservoir 70. The reservoir 70 is provided with a pivotal support 78 for a substantial L-shaped lever 79. The upper arm 80 of the lever is provided with an opening through which extends the upper end of rod 73. The arm 80 provides a support for the rod 73 and is adapted to be engaged by a washer 81, which is held against the arm 80 by a nut 82, which is carried by the upper end of rod 73. The depending arm 85 of the lever 79 is provided with an adjustable screw member 86 which is adapted to be engaged by the rotating arm 87 which is driven by the actuator for the pump plunger, not shown. With each rotation of the crank or the pump plunger, there is a corresponding rotation of the arm 87, the latter being angularly positioned with respect to the crank arm so as to cause the ball valve 72 to be raised off from its seat 72a at the end of the suction stroke of the pump plunger. Thus, the liquid 71 and the reservoir 70 will be connected to the conduit 34 once during each cycle of the pump in a manner similar to that described above in connection with Fig. 1. The valve 72 also functions as a relief valve in the same manner as described in connection with Fig. 1.

Referring to Fig. 3, there is shown another modification of the invention where the conduit which connects the pump chamber adjacent the flexible diaphragm with the reservoir is formed integral with casting for the chamber. In Fig. 3, the crosshead 90 for the pump plunger 91 is adapted to be reciprocated by a suitable actuator where the pump plunger always occupies the same position at the end of the suction stroke regardless of the length of stroke. The outer end of the plunger 91 is adapted to reciprocate in a cylinder 92 which is in communication with the chamber 93 adjacent the moving wall or diaphragm member 94. The passageway or conduit 95 communicates with the chamber 93 at one end, and the opposite end is adapted for communication with a reservoir 96 by way of a ball valve 97 and a ball valve seat 98. The ball valve 97 is carried at the lower end of a rod 99 which is similar in construction to the arrangement shown in Fig. 2. The rod 99 is normally biased downwardly to hold the ball 97 on the seat 98 under the bias of a compression spring 100. The upper end of the rod 99 is supported at one end of a lever 101, the opposite end of which is pivotally connected at 102 to a support 103. The lever 101 is provided with an adjustable projection in the form of a set screw 104 near the pivot 102. The projection 104 is adapted to be engaged by a cam surface on a member 106 which is adapted for movement by the actuating mechanism for the pump plunger 91. Another adjustable projection, in the form of a set screw 107, is threaded into the housing of the reservoir 96 and is adapted to engage the lever 101. By adjustment of the set screws 104 and 107, the lever 101 can be properly positioned to bring the ball valve 97 in proper relationship to its seat 98.

As may be seen in Fig. 3, when the pump plunger 91 is at the end of its suction stroke, the cam member 106 will engage the projection 104 and raise the ball valve 97 off from its seat 98, thereby connecting pump chamber 93 and the conduit 95 with the liquid in the reservoir

and to atmosphere. As the pump plunger 91 moves forward on the discharge stroke, the member 106 moves out of engagement with member 104, thus permitting the spring 100 to again move the ball valve 97 into engagement with the seat 98 and close the pump chamber with respect to the reservoir and atmosphere. The opposite side of the diaphragm 94 forms a moving wall for a liquid chamber 110 having an inlet port 108 and an outlet port 109 similar to that described in connection with Fig. 1.

Referring to Fig. 4, there is shown a further modification of the invention. In this modification, the driving mechanism for the pump plunger may be generally of the type disclosed in copending application Serial No. 533,616, filed September 12, 1955, by Royal Bartlett Saalfrank, now United States Letters Patent No. 2,892,352 with provision for the plunger to occupy the same position at the end of each suction stroke regardless of the length of stroke. A liquid reservoir 115 is provided in the frame of the pump through which the crosshead 116 for the plunger 111 reciprocates. As in the case of Fig. 1, the conduit 34 is connected at one end to the uppermost part of the pump chamber 22 adjacent the diaphragm 25 and is inclined upwardly to a location where it connects beneath a check valve at the bottom of the liquid reservoir 115. The check valve has been illustrated in the form of a ball 118 which is adapted to rest on a seat 119. The ball 118 is carried at the lower end of a vertical reciprocal rod 120 which is surrounded by a compression spring 121. The upper end of the rod 120 is supported from a lever 122 which is pivoted at 123 to the top of the housing for the reservoir 115. The outer end of the lever 122 is provided with a cam surface 124 which is adapted to be engaged by cam structure movable in timed relation with the actuator for the pump plunger. The cam structure comprises a vertical member 125 at the upper end of which there is provided an adjustable member in the form of a screw 126 which is adapted to engage the cam surface 124. When the crosshead 116 is at the end of the suction stroke, the screw 126 will engage the cam surface 124, causing the spring 121 to be compressed and raising the ball 118 off from its seat 119. This action connects the liquid in the reservoir 115 with the liquid in the pump chamber 22 communicating with the moving wall 25, such connection being by way of conduit 34. When the crosshead 116 moves to the left, as shown in Fig. 4, on the discharge stroke, the member 126 will move out of engagement with the cam surface 124, thus permitting the ball valve 118 to close on its seat 119 and seal conduit 34 with respect to the reservoir 115. As in the previous modifications, it will be noted that the liquid reservoir 115 is disposed at an elevation higher than the pump chamber 22 which includes the diaphragm 25 and that the conduit 34 is inclined upwardly from a location at the upper end of the diaphragm chamber 22 to the motion-transmitting liquid reservoir 115.

In the modification shown in Fig. 5, the pump plunger is disposed for vertical operation rather than horizontal operation as in the preceding modifications. The flexible diaphragm 130 forms a moving wall for the pump chamber 131 and also for the cylinder 132 which houses the piston 133. The cylinder 132 has a pair of passages 134 and 135 which enable the motion-transmitting liquid to communicate with the moving wall 130. A gasket 136 is disposed between the housing 137 and the pump casting 138 and forms a seal around the flow passages 134 and 135. The pump chamber 131 is provided with suitable inlet and outlet ports 140 and 141 which in turn are provided with suitable check valves illustrated in the form of ball valves 142 and 143 respectively. As in the case of the arrangement shown in Fig. 1, double ball valves are preferred.

The make-up liquid for the motion-transmitting liquid is contained in the reservoir 150 and surrounds the upper

end of the plunger 133. The plunger 133 is connected at 152 to suitable actuating mechanism preferably including a provision for stroke adjustment, as in the case of Figs. 3 and 4. As in the previous arrangements, the liquid in the reservoir 150 is open to atmosphere and a suitable liquid seal, such for example as an O-ring 154, forms a seal between the reservoir 150 and the plunger housing 137. The lower end of the plunger 133 is adapted to reciprocate through suitable packing indicated at 155.

Directly opposite the flow passage 134 is a flow passage extension 156 which extends through the housing 137 and connects with the lower end of a conduit 157 which is inclined upwardly and at its opposite end connects with the liquid in reservoir 150. At the upper end of conduit 157 is a check valve 158 which is carried at its stem portion 158a by a pivotal arm 159 and is adapted to be held in closed position against the end of conduit 157 by means of a compression spring 160. A threaded plug member 161 engages the upper end of the compression spring 160 for adjusting the spring pressure.

As shown in Fig. 5, the actuator for the plunger 133 has moved the plunger upwardly on the compression stroke. It has been illustrated in the position just prior to reaching the end of the compression stroke preparatory to engagement with the free end of the lever arm 159. As the plunger 133 moves further in an upward direction to the end of the compression stroke, it engages the arm 159, causing the latter to pivot about the pivot pin 159a, thereby compressing spring 160 and causing the check valve 158 to be moved off from its seat on the upper end of conduit 157. This action automatically connects the motion-transmitting liquid in the cylinder 132 with the liquid in the reservoir 150 and to atmosphere to permit readjustment of the volume of the liquid in the cylinder 132 due to any expansion or contraction of the liquid. In all of the arrangements of Figs. 1-5, it will be seen that the check valves serve the additional function of a pressure-relief valve.

Thus, it will be seen in the modification of Fig. 5, as in the preceding modifications, provision has been made for a positive mechanical operation of the check valve at the end of the suction stroke in each cycle of the plunger. This arrangement insures that once during each cycle of the plunger the reservoir of motion-transmitting liquid will be connected by way of a conduit to the motion-transmitting liquid which is in communication with the moving wall or flexible diaphragm so as to correct for any expansion or contraction of the transmitting liquid and thereby eliminate any errors in metering due to the hydraulic transmission. By including a positive mechanical connection to the check valve from the pump actuator, there is avoided the necessity of relying upon pressure for operation of the check valve or for friction or other non-positive means. This novel arrangement assures that the check valve will be operated at the same predetermined time or position of the plunger in each cycle of the pump mechanism.

As pointed out above, the positive operation of the check valves may be completely mechanical or electro-mechanical and the term mechanical in the claims is used generically to encompass both forms.

It should be understood the invention is not limited to the specific arrangements shown and that changes and modifications may be made within the scope of the appended claims.

What is claimed is:

1. In pumping apparatus of the hydraulic transmission type, a chamber for transmission liquid, actuating means including a plunger for actuating the transmission liquid by reciprocation of said plunger in and out of said transmission chamber, reservoir for the transmission liquid connecting with said chamber by way of a conduit, a pressure relief valve in said conduit, said pressure relief valve being normally biased to closed position at a pre-

determined pressure to seal said reservoir from said chamber for all pressures below said predetermined pressure during the pressure stroke of said plunger, said pressure relief valve being automatically moved to open position at any pressure above said predetermined pressure, and mechanical means including a valve operator operated by said actuating means in opposition to the pressure of said normal bias to open said valve when said plunger is at the end of the suction stroke thereby connecting said transmission chamber with said reservoir during each cycle of said pumping apparatus to permit readjustment of the volume of transmission liquid in said transmission chamber.

2. In a pumping apparatus according to claim 1 wherein said conduit is connected at one end to said chamber adjacent the top thereof, said conduit being inclined upwardly toward its opposite end where it communicates with said liquid reservoir which is at an elevation above the liquid in said chamber so that any air bubbles in the transmission liquid rise to the upper surface of the liquid in said chamber and escape through said valve when it is opened at the end of the suction stroke.

3. In a pumping apparatus according to claim 1 wherein said mechanical means includes a movable support secured to said valve operator, and rotatable means moving in timed relation with said actuating means for operating said movable support.

4. In a pumping apparatus according to claim 3 wherein said movable support comprises a reciprocating member having a cam-follower adapted for engagement with said rotatable means.

5. In a pumping apparatus according to claim 3 wherein said movable support comprises a pivoted lever, one end of which is adapted to support said valve operator and the other end of which is provided with cam-follower means adapted for engagement with said rotatable means, said movable support being pivoted intermediate the ends thereof.

6. In a pumping apparatus according to claim 1 wherein said mechanical means includes a movable support comprising a lever pivoted at one end, the opposite end of said lever providing a support for said valve operator, cam-follower means carried by said lever intermediate the ends thereof, and cam means carried by said actuating means and engageable with said cam-follower for pivoting said lever to open and close said valve.

7. In a pumping apparatus according to claim 6 wherein said conduit and said chamber are both formed in a common housing.

8. In a pumping apparatus according to claim 1 where-

in said mechanical means includes a movable support comprising a lever pivoted at one end, cam-follower means carried by said lever at the opposite end thereof, the intermediate portion of said lever providing a support for said valve operator, and cam means carried by said actuating means and engageable with said cam-follower for pivoting said lever to actuate said valve operator for opening and closing said valve.

9. In a pump mechanism, housing structure forming a chamber for a motion-transmitting liquid, a plunger reciprocable in said housing chamber, an actuator for reciprocating said plunger, a conduit extending from a reservoir of said liquid which is open to atmosphere to a location in said housing chamber, valve means within said conduit between said reservoir and said housing chamber, spring-biasing means responsive to the pressure in said housing chamber for normally holding said valve means in closed position during the pressure stroke of said plunger, said valve means being adapted for movement to open position against the opposing bias of said spring-biasing means by the pressure in said housing chamber when said pressure exceeds a value predetermined by said spring-biasing means, and mechanical means operable by said actuator in timed relation with said plunger to move in opposition to the force of the spring bias on said valve means at the end of the suction stroke of said plunger so as to open said conduit with respect to said housing chamber and connect said liquid in said housing chamber with the reservoir and atmosphere to permit readjustment of the volume of said liquid in said housing chamber due to any expansion or contraction or leakage of said liquid.

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