

July 15, 1958

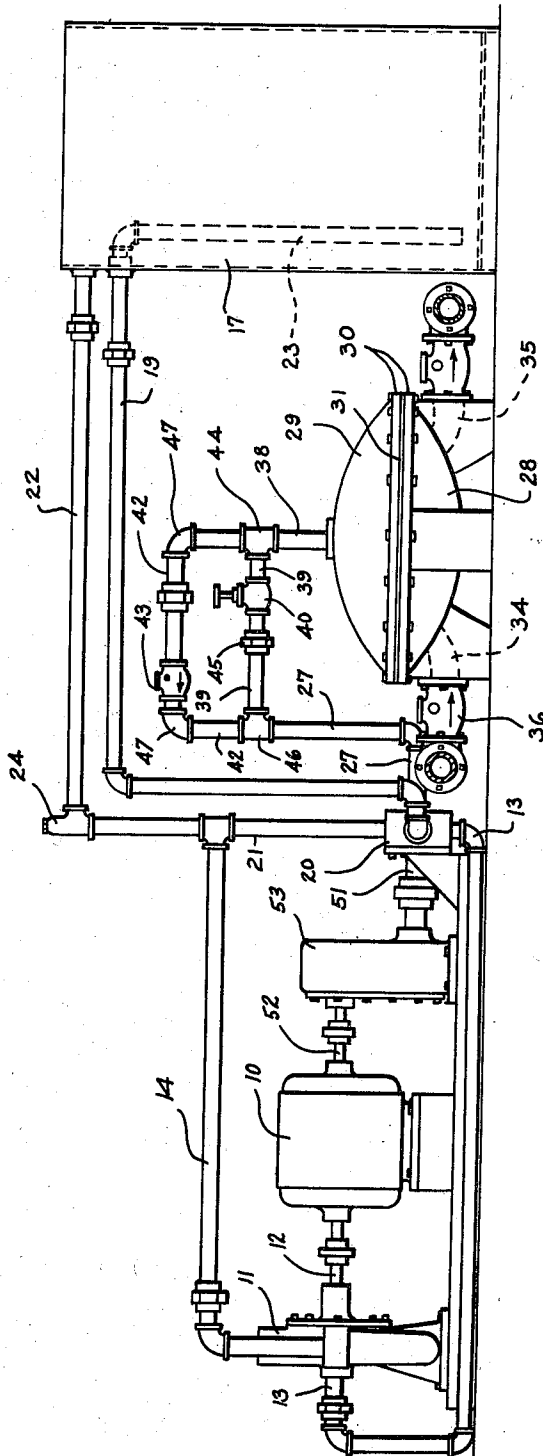
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2,843,050

DIAPHRAGM SLUDGE OR CHEMICAL PUMP

Filed Feb. 15, 1954

4 Sheets-Sheet 1



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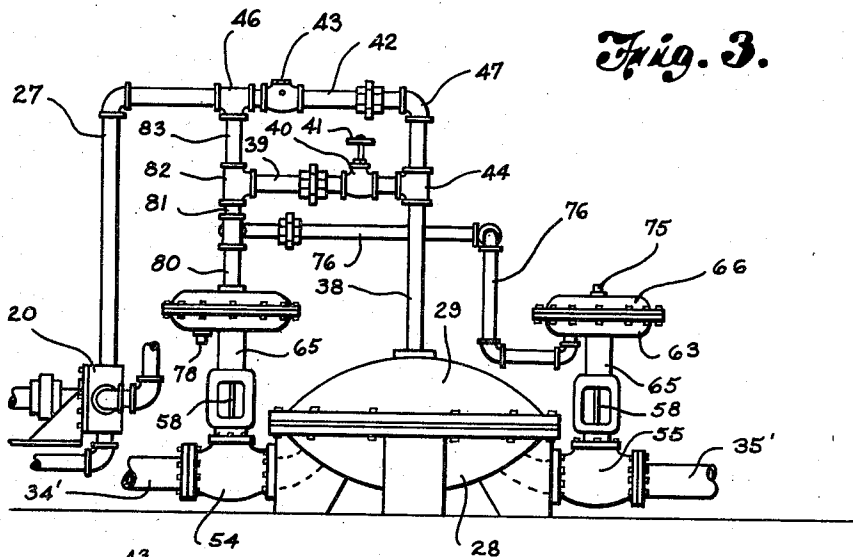


Fig. 3.

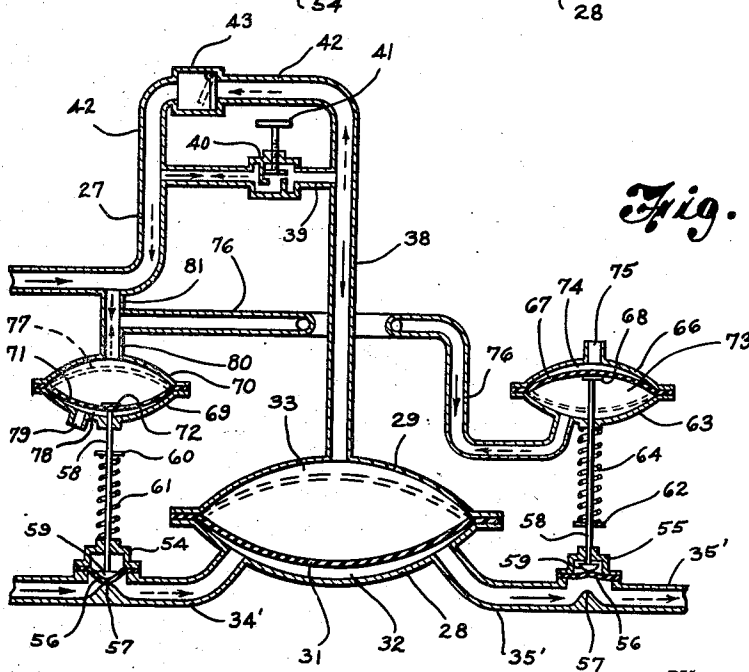


Fig. 4.

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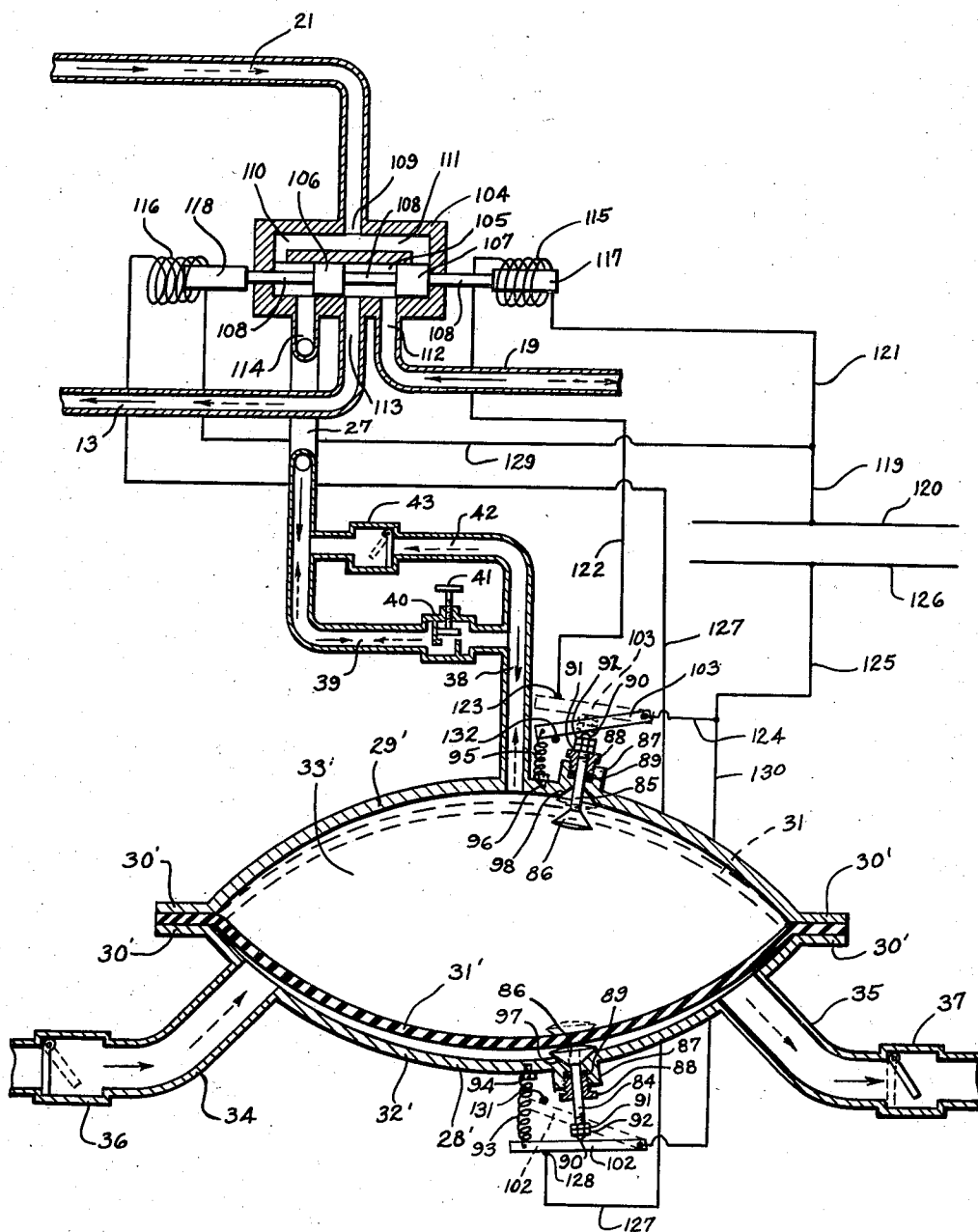


Fig. 5.

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DIAPHRAGM SLUDGE OR CHEMICAL PUMP

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7 Claims. (Cl. 103—152)

My invention relates to pumping apparatus, and more particularly to diaphragm pumps for sludge or chemicals.

My improved pumping apparatus is adapted for use in pumping chemicals or sludge, and is particularly adapted for use where the material being pumped is to be introduced into a pipe or other conduit in which liquid, such as water, for example, contained therein, is under relatively high pressure.

In order to accomplish this purpose without the use of pumps of large capacity, that are expensive and require considerable power to operate the same, I have provided a pumping apparatus in which a relatively small pump, which may be referred to as a "booster" pump, supplying operating fluid to a diaphragm pump operating chamber at a relatively high pressure, is utilized to cause discharge of the sludge or chemical that is to be introduced into the conduit from the pumping chamber of the diaphragm pump at a pressure higher than that in the conduit or pipe into which it is introduced.

More specifically my pumping apparatus comprises a diaphragm chamber that has a free floating diaphragm therein dividing said diaphragm chamber into an operating chamber and a pumping chamber, said pumping chamber being connected with the conduit or other container into which the chemical or sludge is to be pumped by suitable conduit means provided with means for preventing flow except in a predetermined direction in said conduit means, and said operating chamber being provided with means for alternately supplying operating fluid thereto and withdrawing operating fluid therefrom.

The particular means for supplying to and withdrawing operating fluid from the operating chamber of the diaphragm pump comprises means for circulating the operating fluid and means for controlling flow between the circulating means and the operating chamber so as to alternately supply and withdraw the operating fluid.

Preferably the means for controlling such flow comprises valve means that has a position for supplying operating fluid to the operating chamber and a position for withdrawing operating fluid from the operating chamber, and means for alternately moving the valve means from one position to the other. This can be accomplished by providing a four-way rotary valve means that is constantly driven so as to alternately connect the operating chamber with the intake and discharge side of a pump, which preferably, is a constantly operating pump, such as a vane type or gear type pump, or suitable diaphragm actuated valve means may be provided, which will alternately connect the pump that is constantly operating with the diaphragm chamber to either withdraw operating fluid therefrom or supply operating fluid thereto.

While a pump may be provided for circulating the operating fluid, other means may be provided for circulating said fluid in combination with valve means for controlling the supply of operating fluid to the operating chamber or withdraw operating fluid from the operating chamber.

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It is a further purpose of my invention to provide, in connection with pumping apparatus of the above mentioned character, means for controlling the rate of pumping comprising conduit means having a valve therein controlling the flow of operating fluid to the operating chamber and a by-pass around said valve provided with means, such as a check valve, for providing more rapid flow of operating fluid from the operating chamber during discharge therefrom.

It is another purpose of my invention to provide means for determining unidirectional flow in the conduit means, that supplies the material being pumped to the conduit or other container, which is either in the form of check valves or valves that are actuated in accordance with or controlled by the fluid pressure in the operating chamber of the diaphragm pump, said valves being preferably diaphragm operated valves connected with the diaphragm operating chamber through suitable conduit means.

Other objects and advantages of my invention will appear as the description of the drawings proceeds. I desire to have it understood, however, that I do not intend to limit myself to the particular details shown or described, except as defined by the claims.

In the drawings:

Fig. 1 is a view in side elevation of my improved pumping apparatus.

Fig. 2 is a diagrammatic vertical sectional view through the same.

Fig. 3 is a fragmentary elevational view of a modification.

Fig. 4 is a diagrammatic sectional view of the modification shown in Fig. 3, and

Fig. 5 is a fragmentary diagrammatic view partly in section, showing a pump diaphragm operated valve means for controlling the supply of operating fluid to and discharge of operating fluid from the operating chamber of the diaphragm pump.

Referring in detail to the drawings, in Fig. 1 is shown a motor 10 which drives a rotary pump 11 through the shaft 12, which pump has an inlet or suction conduit 13 and a discharge pipe or conduit 14. Referring to Fig. 2, said pump is shown as having a rotor provided with blades or vanes 15 operating within the casing 16. The particular type of rotary pump may be varied as may be found desirable.

A reservoir 17 for operating fluid, which is shown as being a tank, is provided, said operating fluid being a liquid shown at 18 in Fig. 2, and said reservoir is provided with a conduit 19 leading therefrom to a valve 20, which serves as means for controlling the flow of operating liquid to and from the operating chamber of the diaphragm pump. Also connected with said valve is a pipe or conduit 21, which connects with a pipe or conduit 22 leading into the upper portion of said reservoir 17, the pipe 19 having a downward extension 23 opening at its lower end near the bottom of the reservoir 17. Preferably a pressure relief or by-pass valve 24 of a suitable character is provided for establishing communication between the conduits 21 and 22, the same having a valve member 25 that is held against its seat by a spring 26. A pipe or conduit 27 also extends from the valve 20 and the pipe or conduit 13 is connected with said valve, as shown diagrammatically in Fig. 2.

The pumping apparatus further comprises a diaphragm pump member that has a casing made up of a pair of members 28 and 29, which are flanged as indicated at 30, said flanges 30 clamping a flexible diaphragm 31 between the same. The diaphragm divides the pump into a pumping chamber 32 and an operating fluid chamber 33. Suitable means is provided for entrance of the liquid to be pumped into and discharge of said liquid from the pumping chamber 32, this being shown in the drawings as

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comprising an inlet conduit 34 and a discharge conduit 35, said discharge conduit 35 being connected with a suitable pipe, conduit or other container into which the liquid being pumped is fed and the conduit 34 extending from a suitable container for said liquid. The liquid may be of any suitable character, such as a sludge or a chemical in a liquid condition or in solution. In order to provide unidirectional flow in the conduit means comprising the conduits 34 and 35 a check valve 36 is provided which opens in the direction of the chamber 32, and a check valve 37 is provided, that opens in a direction away from the chamber 32.

Connected with the operating chamber 29 is a conduit 38, which is connected with a conduit 39 that in turn is connected with the conduit 27. Interposed in the conduit 39 is a valve 40, which is provided with suitable means 41 for adjusting the same to control the flow of liquid through the conduit 39. Also connected with the conduit 38 is a conduit 42, which is provided with a check valve 43 therein permitting flow in the conduit 42 only in the direction indicated by the dotted arrow appearing therein in Fig. 2, or in a direction away from the operating fluid chamber 33. Flow through the conduit 39 occurs both in a direction toward the operating chamber 33, this being indicated by the full line arrow in Fig. 2, and in the opposite direction, as indicated by the dotted line arrow in Fig. 2. Thus the conduit 42 serves as a by-pass around the valve 40 during discharge of operating fluid from the chamber 33. In Fig. 1 of the drawings the conduit 38 is shown as comprising a pair of pipe lengths connected by means of a T 44 with each other and with the conduit 39, which is shown as being made up of suitable pipe lengths connected by means of a union 45, a T 46 being provided connecting the conduit 42, made up of a number of pipe lengths and elbows 47, with the conduit 27, and said T 46 also connecting said conduit 27 with the conduit 39. The other conduits are made of suitable pipe lengths, elbows, T's and unions, as is customary in pipe fitting practice, the particular arrangement of connections between the various conduits being immaterial as long as the connections with the valve 20, with the reservoir 17, with the pump 11 and with the diaphragm chamber 33 are provided in the manner disclosed in the drawings, and the by-pass connection around the valve 40 is provided as above described.

The valve 20 is shown as being provided with a rotor 48, which is provided with diametrically aligned vanes 49 operating in the housing 50, with which the various conduits are connected, as shown in Fig. 2. The rotor 48 is mounted on a shaft 51, which is driven by the motor 10 through the shaft 52 and a reduction gearing 53.

Assuming that the parts move in a clockwise direction as viewed in Fig. 2, the rotor is shown in a full line position in which the conduit 19 is connected with the conduit 13, the conduit 19 thus acting as a suction or intake line for the pump 11. The conduit 14 is at the same time connected through the conduit 21 and the valve 20 with the conduit 27 and the liquid pumped by the pump 11 thus will flow through the conduit 39 at a controlled rate determined by the valve 40 to the operating fluid chamber 33 of the diaphragm pump. As the valve 40 will restrict flow to the operating fluid chamber 33 and the pump 11 would be operating at a constant rate, means is provided for relieving excess pressure or by-passing excess liquid back to the tank 17, this being accomplished by means of the valve 24. The flow while the valve 20 is in the position shown in Fig. 2 is indicated in all of the various conduits by means of the full line arrows in Fig. 2.

As the valve member rotates in a clockwise direction it passes from the full line position shown in Fig. 2 to the dotted line position shown in Fig. 2. The connections between the conduits existing for the dotted line position of the rotor of said valve taking place after the

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vanes 49 pass the openings into the valve casing 50 leading from the conduits 19 and 27. When this occurs the valve 20 connects the conduit 27 with the conduit 13 and the conduit 19 with the conduit 21 and thus with the conduit 14. The pump then operates to withdraw operating fluid from the operating chamber 33, returning it to the reservoir or tank 17. This continues until the vanes 49 pass the openings leading from the conduits 21 and 13 into the valve casing 50, whereupon the same connections, between the pump and the reservoir and operating fluid chamber 33, are restored, as shown for the full line position of the rotor in Fig. 2.

It will be thus obvious that alternately the pump 11 supplies operating fluid to the chamber 33 and withdraws operating fluid therefrom. It will also be noted that when the operating fluid is being withdrawn from the operating chamber 33 this takes place at a comparatively rapid rate, because not only is the operating fluid withdrawn through the conduit 39 and valve 40, but also through the by-pass conduit 42 and check valve conduit 43. The direction of flow for the dotted position of the rotor vanes 49 is shown by the dotted arrows appearing in Fig. 2. It will thus be apparent that the diaphragm 31 will be moved alternately toward and away from the wall 28 of the diaphragm pump, thus alternately decreasing and increasing the size of the pumping chamber 32 and thus causing flow of the liquid that is to be fed to a suitable body of liquid under pressure through the conduits 34 and 35 in the direction indicated by the arrows appearing in Fig. 2.

Instead of providing the check valves 36 and 37 for controlling the flow of the material being pumped through the conduits 34 and 35 the means for obtaining unidirectional flow through said conduits shown in Figs. 3 and 4 may be provided. In said figure the conduits leading to the valve 20 and to the diaphragm pump operating fluid chamber 33 are of the same character and similarly arranged to those described in connection with Figs. 1 and 2 and function in the same manner, the same reference numerals being applied to the corresponding parts in Figs. 3 and 4 as in Figs. 1 and 2. However, in order to provide suitable means for controlling the flow of liquid being pumped, a slight variation in the pipe connections is necessary, as the valve means for controlling the unidirectional flow of the material being pumped is diaphragm operated and the diaphragm means for operating said valves is responsive to the pressure of the operating liquid in the operating fluid chamber of the diaphragm pump.

The pumping chamber 32 shown in Fig. 4 has the conduits 34' and 35' connected therewith in a similar manner to the conduits 34 and 35, previously described in connection with Figs. 1 and 2, and the valve means serves to provide unidirectional flow in the same direction as in Figs. 1 and 2. Said valve means comprises a valve 54 interposed in the conduit 34' and a valve 55 interposed in the conduit 35'.

Each of said valves 54 and 55 is provided with a flexible diaphragm 56, which is adapted to engage with a raised seat 57 to close off the passage through the valve. Each of the valves is also provided with a valve stem 58, which is provided with a head 59 that engages the flexible member 56 to move it into closing position. The valve 54 is provided with a suitable abutment 60 on the valve stem 58 between which and the valve casing a coil compression spring 61 is mounted, the valve stems 58 being slidable through suitable openings provided in the valve casings. The valve stem 58 of the valve 55 is provided with an abutment 62, between which and the housing portion 63 of a diaphragm chamber the compression coil spring 64 is mounted. The springs in actual practice are mounted within suitable tubular housings 65, the showing in Fig. 4 being diagrammatic. Cooperating with the housing portion 63 is a housing portion 66, said housing portions 63 and 66 being flanged to clamp a flexi-

ble diaphragm 67 therebetween. The stem 58 of the valve 55 is secured to the diaphragm 67 at 68 in any suitable manner so as to be moved therewith. The valve stem 58 of the valve 55 extends into the diaphragm chamber 63 slidably through a suitable opening and the valve stem member 58 of the valve 54 similarly extends through the housing portion 69 of another diaphragm chamber having the housing portion 70 cooperating therewith to clamp a diaphragm 71 therebetween. The valve stem 58 of the valve 54 is secured to the diaphragm 71 at 72 in any suitable manner so as to move therewith.

The diaphragm 67 divides the diaphragm chamber into a chamber 73 and a chamber 74, the chamber 74 having an outlet 75 open to the atmosphere, while a conduit 76 connects with the chamber 73 in a suitable manner. The diaphragm 71 similarly divides the diaphragm chamber having the wall portions 69 and 70 into a chamber 77 and a chamber 78, said chamber 78 having an outlet connection 79 open to the atmosphere, and the chamber 77 having a conduit 80 opening into the same. The conduits 76 and 80 are connected with the conduit 27 through a suitable conduit means 81, as shown diagrammatically in Fig. 4. The actual pipe connections for accomplishing this can be as shown in Fig. 3, in which a T 82 is provided connected with a pipe 83 extending from the T 46 and having connected therewith the pipe 81, which is the conduit portion 81 shown in Fig. 4. Said conduit portion 81 is connected with the conduit 76 and with the conduit 80 by means of a T, said conduit 76 being made up of a number of pipe fittings and pipes, as will be obvious from Fig. 3.

Referring to Fig. 4, it will be noted that the conduits 76 and 80 are connected with the chamber 33 through the conduit 27, the valve 40 and the conduits 39 and 38, as well as through the by-pass 42 and the check valve 43. Accordingly the diaphragms 67 and 71 will be responsive to the pressure in the chamber 33. As the pressure in the chamber 33 increases due to the position of the valve 20, previously described, connecting the chamber 33 with the discharge side of the pump or circulating means for the operating fluid, the diaphragm chambers 73 and 77 will be supplied with the operating fluid under a corresponding pressure and the diaphragms 67 and 71 will be moved to the full line positions shown in Fig. 4 against the action of the springs 61 and 64, air in the chamber 67 and in the chamber 78 being discharged through the outlets 75 and 79. Upon the valve 20 assuming its alternative position which will cause flow of the operating fluid out of the chamber 33 in the direction indicated by the dotted arrows in Figs. 4, the operating fluid will be withdrawn from the valve operating diaphragm chambers 73 and 77 and the springs 64 and 61 will move the diaphragms 67 and 71 toward the dotted line position shown in Fig. 4.

It will be obvious that when the diaphragm 31 is being moved in a position to decrease the size of the pumping chamber 32, the operating fluid moving in the direction of the full line arrow shown in Fig. 4 will cause the valve 54 to be closed and the valve 55 to be opened, and that when reverse movement of the diaphragm 31 begins the drop in the pressure of the operating fluid will cause the springs 61 and 64 to open the valve 54 and close the valve 55, permitting the liquid to be pumped to enter through the conduit 34' and preventing any reverse flow through the conduit 35' beyond the valve 55.

Instead of providing a rotating valve means such as shown in Figs. 1 and 2, a diaphragm actuated solenoid operated valve having alternative positions may be provided, as shown in Fig. 5. The conduits 13, 21, 19, 27, 38, 39 and 42 are connected with the various apparatus in the same manner as described in connection with Figs. 1 and 2, and said conduit 39 is provided with a valve 40 for the same purpose as previously described, while

the conduit 42 is provided with a check valve 43 for the same purpose as previously described. The conduit 34 and the conduit 35 are also provided for the same purpose as in the form shown in Figs. 1 and 2 and have check valves 36 and 37 for the same purpose as previously described. The diaphragm chamber is made up of wall portions 28' and 29' that are flanged at 30' to clamp the diaphragm 31' therebetween, said diaphragm 31' corresponding to the diaphragm 31 previously described, and dividing the diaphragm chamber into an operating liquid chamber 33' and a pumping chamber 32' corresponding to the chambers 33 and 32 previously described, and similarly connected with the conduits 34, 35 and 38.

Suitable means is associated with the diaphragm chamber for controlling the position of a valve to be described below, said means comprising suitable plungers 84 and 85, which are slidably mounted in suitable openings in the housing portions 28' and 29', as shown in Fig. 5 of the drawings. Said plungers may have suitable mushroom heads 86 with which the diaphragm 31' engages. The housing portions 28' and 29' have sleeve-like projections 87 thereon concentric with the openings through which the plungers extend. Cooperating therewith are the packing glands 88 to provide a liquid tight seal around said plungers by means of the packing material 89. The outer ends of the rods each have a rounded threaded end 90 thereon, suitable stop nuts 91 being provided for adjustment on the threaded portions of said plungers and these are held in adjusted position by lock nuts 92. The wall portions 28' and 29' are preferably provided with conical recesses 97 and 98 to receive the plunger heads 86.

Cooperating with the plunger 84 is a switching member 102, and cooperating with the plunger 85 is a switching member 103. The switching member 102 is normally urged or biased toward the dotted line position thereof shown in Fig. 5, by the coil spring 93 secured at one end to the member 102 and at the other end to the wall 28' by a securing element 94, while the switching member 103 is normally urged or biased toward the full line position thereof shown in Fig. 5, this being accomplished by the coil spring 95 secured at one end to the switching element 103 and at the other end to the wall 29' by the securing element 96. The switching elements 102 and 103 serve to control suitable electrically operated valve means, the valve means shown in Fig. 5 being by way of example, being shown as being a solenoid valve.

Said valve means comprises a valve casing 104, which has a valve chamber 105 therein, in which the valve members 106 and 107 are slidably mounted, said valve members being mounted on a common stem 108 to move in unison. The conduit 21 enters the valve casing 104 at 109 and passages 110 and 111 extend from the inlet 109 to opposite ends of the valve chamber 105. Also extending into the valve chamber 105 is the conduit 19, which opens into the same through an inlet 112, the conduit 13, which enters through an inlet 113 and the conduit 27, which enters the valve chamber through an inlet 114.

Suitable windings 115 and 116 are provided for said valve, with which the cores 117 and 118 cooperate to move the valve assembly in opposite directions. A conductor 119 extends from the line wire 120 and a conductor 121 extends from the conductor 119 to one end of the winding 115, the other end of the winding 115 being connected through a conductor 122 with a stationary contact 123, with which the switching member 103 is adapted to engage, a conductor 124 extending from said switching member to a conductor 125 connected with the line wire 126. A conductor 127 extends from the stationary contact 128 with which the switching member 102 is adapted to engage to one end of the winding 116, the other end of the winding 116 being connected with the conductor 119 and thus with the line wire 120 through a conductor 129. A conductor 130 extends from the

switching element 102 to the conductor 125 and is thus connected with the line wire 126.

It will accordingly be obvious that when the diaphragm 31' is in the position shown in Fig. 5 the plunger 84 will have moved into such a position as to cause the switching element 102 to engage with the contact 128, thus closing the circuit energizing the winding 116, said circuit being from the line conductor 126 through the conductors 125 and 130, switching element 102, conductor 127, winding 116, conductor 129 and conductor 119 to the line wire 120. This will cause the solenoid valve members 106 and 107 to be moved to the left from the position shown in Fig. 5, the position of the parts being that just before movement of the valve has taken place under the action of the solenoid 116. In the position shown in Fig. 5 the valve means connects the conduits 19 and 13 and the conduits 27 and 21 corresponding to the full line position of the rotary valve shown in Fig. 2. However, when the circuit is closed to energize the winding 116 the valve means moves to the left so that the valve member 106 is in engagement with the left end wall of the valve casing, as shown in Fig. 5, whereupon the passage 110 will be closed and the passage 111 will be opened and the valve member 106 will be out of a blocking position between the inlets 113 and 114, while the valve member 107 will be interposed between the inlets 112 and 113. Thus the conduits 21 and 19 will thereupon be connected by the valve member 104 and the conduits 13 and 27 will be connected, the position of the valve then corresponding to the dotted position of the rotary valve shown in Fig. 2. The flow then will be in the direction of the dotted arrows in Fig. 5. However, when the movement of the diaphragm 31' toward the wall 29' is sufficient for the switching member 103 to engage the contact 123, the winding 115 will be energized, the circuit being completed from the line wire 126 through the conductors 125, 124, switching element 103, contact 123, winding 115, conductor 121 and conductor 119 to the line wire 120.

The switching elements 102 and 103 are provided with the stop lugs or dead contacts 131 and 132 toward which the same are biased. Accordingly when the valve 104 has moved to the alternative position to that shown in Fig. 5, due to energization of the solenoid 116 and the diaphragm 31' moves toward the dotted line position thereof shown in Fig. 5, the switching member 102 moves toward its dotted line position and into engagement with the dead contact 131. The circuit to both solenoids remains open until the switching element 103 is moved into contact with the stationary contact 123 to close the circuit to the winding 115. The circuit to the winding 115 will again be opened after the diaphragm moves away from the wall 29', upon engagement of the switching element with the dead contact 132. The circuit to both solenoids will then remain open again until the diaphragm again reaches the position shown in full lines in Fig. 5, whereupon the winding 116 will again be energized. Thus the windings 115 and 116 will be alternately energized to alternately move the valve 104 from the one to the other position thereof.

What I claim is:

1. Pumping apparatus of the character described comprising walls forming a diaphragm chamber, a diaphragm therein dividing said chamber into a pumping chamber and an operating chamber, conduit means connected with said pumping chamber having means determining unidirectional flow therein, and means for supplying operating fluid to and withdrawing operating fluid from said operating fluid chamber comprising circulating means for said fluid, valve means controlling flow between said circulating means and said operating fluid chamber, said valve means comprising a valve member having an operating fluid supplying position and an operating fluid withdrawing position, means for alternately moving said valve member into each of said positions, and conduit

means between said valve means and said operating fluid chamber having an adjustable valve between said valve means and said operating fluid chamber and a bypass around said valve having a check valve therein opening in a direction away from said fluid operating chamber.

2. Pumping apparatus of the character described comprising walls forming a diaphragm chamber, a diaphragm therein dividing said chamber into a pumping chamber and an operating chamber, conduit means connected with said pumping chamber having means determining unidirectional flow therein, and means for supplying operating fluid to and withdrawing operating fluid from said operating fluid chamber comprising circulating means for said fluid, valve means controlling flow between said circulating means and said operating fluid chamber, said valve means comprising a valve member having an operating fluid supplying position and an operating fluid withdrawing position, means for alternately moving said valve member into each of said positions, and means between said operating fluid chamber and said valve means providing more rapid discharge of fluid from than supply to said operating chamber, comprising a conduit between said valve means and operating chamber having a valve therein and a by-pass around said valve having means therein determining unidirectional flow through said by-pass in a direction away from said operating chamber.

3. Pumping apparatus of the character described comprising walls forming a diaphragm chamber, a diaphragm therein dividing said chamber into a pumping chamber and an operating chamber, conduit means connected with said pumping chamber having means determining unidirectional flow therein, and means for supplying operating fluid to and withdrawing operating fluid from said operating fluid chamber comprising circulating means for said fluid, valve means controlling flow between said circulating means and said operating fluid chamber, said valve means comprising a valve member having an operating fluid supplying position and an operating fluid withdrawing position, means for alternately moving said valve member into said supplying and withdrawing positions, and conduit means between said valve means and said operating fluid chamber having an adjustable valve therein controlling flow of fluid toward said operating fluid chamber and a bypass around said valve having means therein determining unidirectional flow of fluid in said by-pass away from said operating fluid chamber.

4. Pumping apparatus of the character described comprising walls forming a diaphragm chamber, a diaphragm therein dividing said chamber into a pumping chamber and an operating chamber, conduit means connected with said pumping chamber, fluid pressure controlled valves therein determining unidirectional flow in said conduit means, and means for supplying operating fluid to and withdrawing operating fluid from said operating chamber comprising operating fluid circulating means, an operating fluid reservoir connected therewith, conduit means connecting said operating chamber with said circulating means and valve means in said operating fluid conduit means between said circulating means and said operating chamber, said last mentioned valve means comprising a valve member having an operating fluid supplying position and an operating fluid withdrawing position, and means for alternately moving said last mentioned valve member into supplying and withdrawing positions, said fluid pressure controlled valves being connected with said operating fluid conduit means between said valve member having said supplying and withdrawing positions and said operating chamber.

5. Pumping apparatus of the character described comprising walls forming a diaphragm chamber, a diaphragm therein dividing said chamber into a pumping chamber and an operating chamber, conduit means connected with said pumping chamber, fluid pressure controlled diaphragm actuated valves determining unidirectional flow

in said conduit means having operating fluid conduits leading thereto, and means for supplying operating fluid to and withdrawing operating fluid from said operating chamber and said last mentioned operating fluid conduits comprising circulating means for said fluid, operating fluid conduit means between said circulating means and said operating chamber, valve means therein between said circulating means and said operating chamber and between said circulating means and said valve operating fluid conduits controlling flow between said circulating means and said operating chamber and said valve operating fluid conduits, said last mentioned valve means having a valve member having an operating fluid supplying position and an operating fluid withdrawing position, and means for alternately moving said last mentioned valve member into said supplying and withdrawing positions.

6. Pumping apparatus of the character described comprising walls forming a diaphragm chamber, a diaphragm therein dividing said chamber into a pumping chamber and an operating chamber, conduit means connected with said pumping chamber having means determining unidirectional flow therein comprising inlet and outlet valves in said conduit means, diaphragm means controlling the position of said inlet and outlet valves, and means for supplying operating fluid to and withdrawing operating fluid from said operating chamber comprising circulating means for said fluid, operating fluid conduit means between said circulating means and said operating chamber, valve means in said operating conduit means controlling flow between said circulating means and said operating chamber, said last mentioned valve means comprising a valve member having an operating fluid supplying position and an operating fluid withdrawing position, and means for alternately moving said valve member into said supplying and withdrawing positions, said means for controlling the position of said inlet and outlet valves being connected with said operating fluid conduit means between said operating chamber and said valve means

controlling flow between said operating chamber and said circulating means.

7. Pumping apparatus of the character described comprising walls forming a diaphragm chamber, a diaphragm therein dividing said chamber into a pumping chamber and an operating chamber, conduit means connected with said pumping chamber having means determining unidirectional flow therein, and means for supplying operating fluid to and withdrawing operating fluid from said operating chamber, comprising a rotary pump, means for supplying operating fluid to said pump, operating fluid conduit means connecting said pump and operating chamber, a valve in said operating fluid conduit means between said pump and said operating chamber, a movable valve member in said valve having alternate positions in one of which said operating chamber is connected with the outlet of said pump and in the other of which said operating chamber is connected with the inlet of said pump, electrical actuating means for said valve member, means for energizing said actuating means to move said valve member alternately into a position to connect said operating chamber with the inlet and with the outlet of said pump, comprising an operating circuit having diaphragm actuated contact members therein controlling the condition of said circuit, and an adjustable valve in said operating fluid conduit means controlling flow of operating fluid to said operating chamber.

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