

E. R. GLASGOW ET AL

CONTAINER MOUNTED FLUID PRESSURE DISPLACEMENT PUMP

3 Sheets-Sheet 1

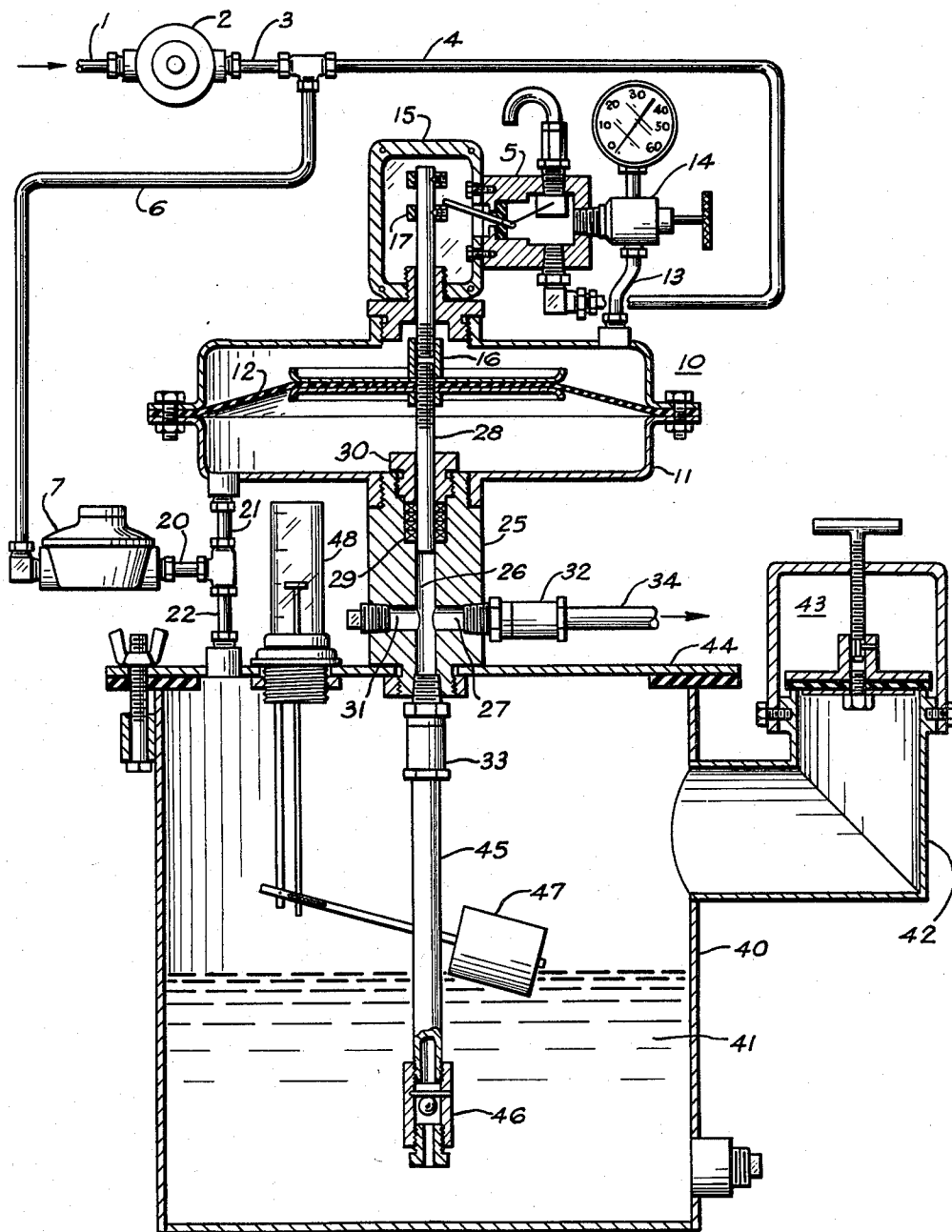


Fig. 1.

INVENTORS
EDSEL R. GLASGOW
CLARENCE O. GLASGOW
BY *Arthur L Wade*
ATTORNEY

July 5, 1960

E. R. GLASGOW ET AL

2,943,765

CONTAINER MOUNTED FLUID PRESSURE DISPLACEMENT PUMP

Filed July 20, 1959

3 Sheets-Sheet 2

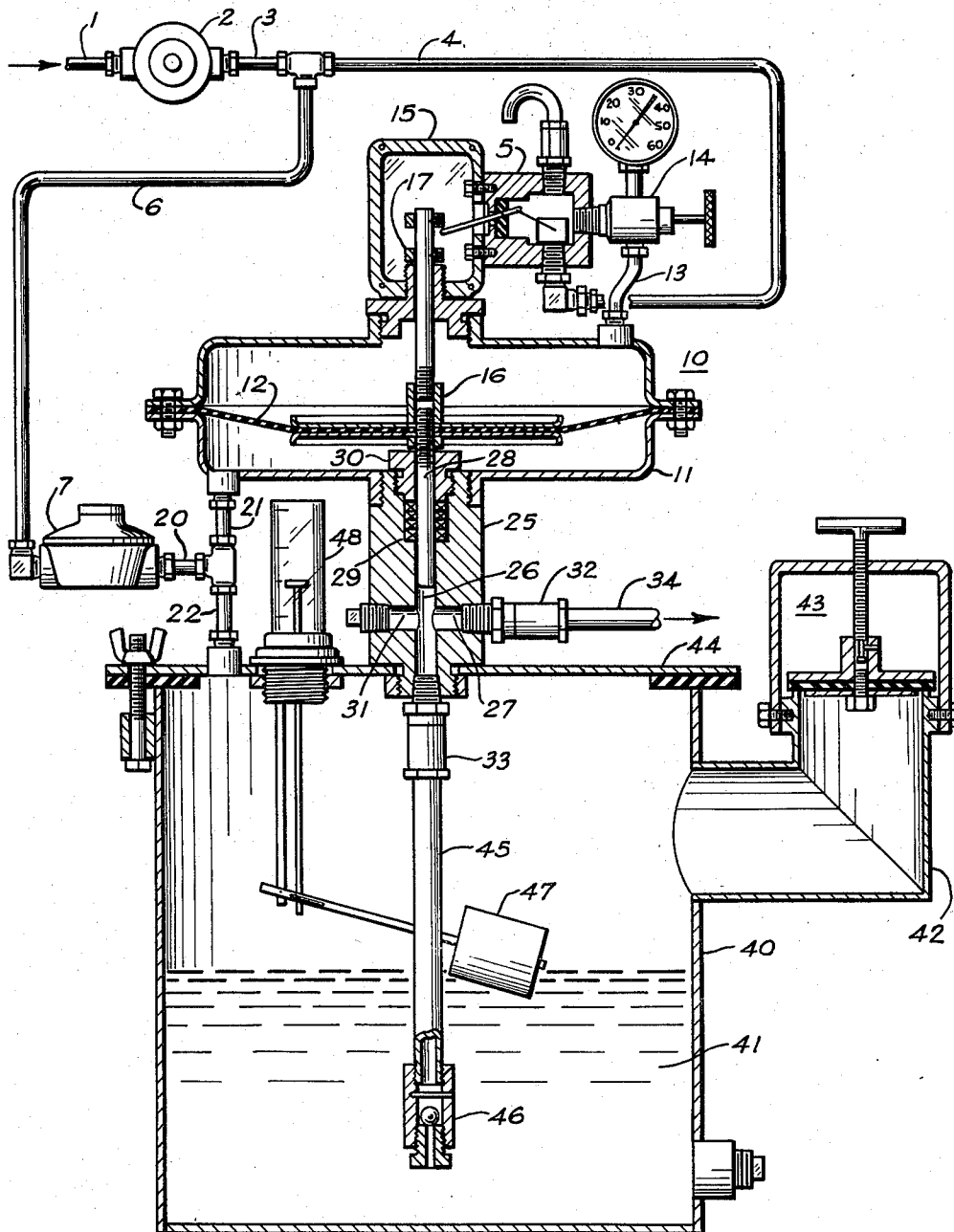


Fig. 2.

INVENTORS
EDEL R. GLASGOW
CLARENCE O. GLASGOW
BY
Arthur L. Wade
ATTORNEY

July 5, 1960

E. R. GLASGOW ET AL

2,943,765

CONTAINER MOUNTED FLUID PRESSURE DISPLACEMENT PUMP

Filed July 20, 1959

3 Sheets-Sheet 3

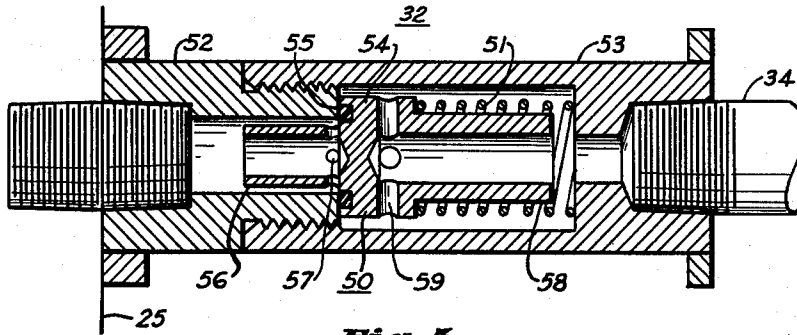


Fig. 5.

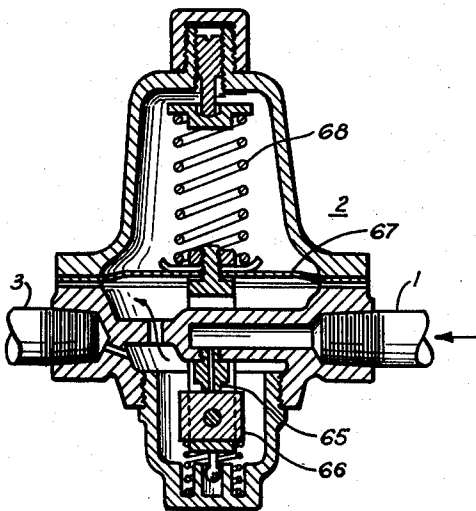


Fig. 4.

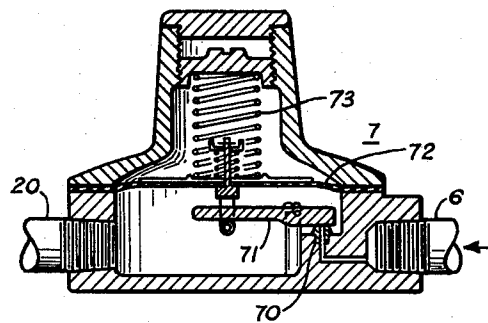


Fig. 5.

INVENTORS
E. R. GLASGOW
CLARENCE O. GLASGOW
BY
Arthur L. White
ATTORNEY

1

2,943,765

CONTAINER MOUNTED FLUID PRESSURE DISPLACEMENT PUMP

Edsel R. Glasgow and Clarence O. Glasgow, both of
2620 Yorktown St., Tulsa, Okla.

Filed July 20, 1959, Ser. No. 828,219

10 Claims. (Cl. 222—110)

The present invention is related to displacement pumps actuated entirely by fluid pressures. More specifically, the invention is related to the use of fluid pressures to actuate displacement pumps and to simultaneously move the pumped liquid to the pump, prevent foreign matter from entering the system, conserving the liquid pumped and preserve the volumetric efficiency of the pump.

Displacement pumps are particularly useful in injecting chemical, at a predetermined rate, into a stream of oil well emulsion which is to be broken into its separate components. Chemical pumps must operate dependably under the harsh conditions of oil fields where dirt is an ever-present problem and maintenance is often unavailable for long periods of time. A displacement pump for chemical injection which is simple to service, utilizes a minimum of working parts and is efficient in operation is badly needed in the oil fields.

The displacement pumps with which the present invention is associated are considered as having a chamber in which a piston is reciprocated in at least a portion of its total volume on a working stroke and a loading stroke. A loading check valve is connected to the piston chamber, and fluid drawn through this valve on the loading stroke of the piston. A working check valve is also connected to the piston chamber, and fluid is discharged through this valve on the working stroke of the piston. The power for these pumps may be a diaphragm operator, or a power piston, to move the pump piston in its chamber on the working stroke. It has been conventional to provide the loading stroke power through a spring.

Springs in displacement pumps are a source of trouble when exposed to corrosive conditions. Elimination of springs avoids the troubles attendant to their use.

Provision of separate sources of fluid pressure for providing the loading stroke of a pump and maintaining the reservoir of liquid to be pumped under positive pressure makes a complex system. If a separate source of fluid pressure is also required to move the liquid from the reservoir to the loading check valve, the system is further complicated and made more expensive.

A further problem in pumps is the danger of foreign matter being forced between the packing and the pump piston. A separate positive pressure system can be provided to isolate foreign matter from the packing. However, a separate system further complicates the system and increases its cost.

It is generally desirable to have a piston pump packing leak to some degree. When the packing of a pump leaks, and the reservoir of liquid pumped is maintained under pressure, conservation of the liquid leaked requires still another complicating pressure system to return the leaked liquid to the reservoir.

A final problem in positive displacement pumps is developed on the loading stroke of the piston in its chamber. A vapor space is developed by gases coming out of solution with the liquid pumped. If this gas is not reabsorbed by the liquid, the volumetric efficiency of the

2

pump is correspondingly reduced on the working stroke of the position.

An object of the present invention is to utilize a common source of fluid pressure supply to develop both the power for the loading stroke of a displacement pump and positive pressurization of the reservoir of liquid to be pumped.

Another object is to utilize a common source of fluid pressure to develop both the power for the loading stroke of the displacement pump and movement of the liquid to be pumped through the loading check valve of the pump.

Another object is to utilize a common source of fluid pressure to develop both the power for the loading stroke of the displacement pump and to pressurize the packing about the pump piston to exclude foreign abrasive substances from between the packing and piston.

Another object is to utilize a common source of fluid pressure to develop the power for the loading stroke of the displacement pump, pressurization of the reservoir of liquid to be pumped and pressurization of the packing about the pump piston.

Another object is to return the liquid to be pumped which leaks between the packing and pump piston to the liquid to be pumped in the reservoir.

Another object is to eliminate gaseous fluid in the piston cylinder developed following the loading stroke of the pump piston.

The present invention is embodied in a fluid pressure supply system for a positive displacement pump. The pump piston is reciprocated by a diaphragm operator, or power piston. A first fluid pressure is alternately applied to a first face of the diaphragm, or piston, to develop the power of the working stroke of the displacement piston and decayed toward atmospheric value. A second source of fluid pressure is applied to the second face of the diaphragm, or piston, to develop the power of the loading stroke of the displacement piston. The second source of fluid pressure is simultaneously applied to the gaseous space above the liquid in the reservoir of liquid to be pumped as a positive force to keep foreign matter out of the liquid which would contaminate the liquid.

The present invention is also embodied in a fluid pressure supply system for the displacement pump where the second source of fluid pressure is simultaneously applied to develop the power of the loading stroke of the displacement piston and to the surface of the liquid in the reservoir of liquid to be pumped so the liquid will be forced up a feed tube which conducts the liquid to the loading check valve of the pump.

The present invention is also embodied in a fluid pressure supply system for the displacement pump which utilizes the second source of fluid pressure to develop the power of the loading stroke of the displacement piston and the housing for the packing is attached to the housing for the diaphragm, or piston, to simultaneously expose the packing to the second source of fluid pressure.

The present invention is also embodied in a fluid pressure supply system for the displacement pump where the second source of fluid pressure simultaneously applied to develop the power of the loading stroke of the displacement piston, to the interior of the container of liquid to be pumped, and to the housing of the packing about the piston.

The present invention is also embodied in the arrangement of the piston packing in its housing mounted on the housing for the face of the diaphragm, or piston, in which the fluid pressure is developed for the power of the loading stroke so the leakage of the fluid in the piston cylinders past the packing can be returned to the reservoir of fluid pumped from piston cylinder by gravity flow.

The present invention is also embodied in a positive displacement pump powered by a piston, or diaphragm where

3

the piston, or diaphragm, has the power for its working stroke developed on one of its two faces from a fluid pressure which is alternately applied on the first face and exhausted to atmosphere. The fluid pressure alternately applied to, and removed from, the diaphragm, or piston, is conducted through a manually set valve to regulate the development and decay of fluid pressure and, therefore, the speed of the pump reciprocation. A substantially constant fluid pressure is applied on the second side of the diaphragm, or piston, to develop its loading stroke. The manual valve can be set to a position which provides a finite period between the exhaustion of the pressure on the first side and its development on the first side to a valve which will begin the working stroke after any gaseous space developed in the piston cylinder on the loading stroke has had time to be eliminated by reabsorption of the gaseous fluid by the liquid in the piston cylinder which is being pumped.

Other objects, advantages and features of this invention will become apparent to one skilled in the art upon consideration of the written specification, appended claims, and attached drawing wherein;

Fig. 1 is a sectioned elevation of a pump embodying the present invention in which the loading stroke has been completed;

Fig. 2 is similar to Fig. 1 but illustrates completion of the working stroke;

Fig. 3 is a sectioned elevation of a valve used as the check valves of the pump of Figs. 1 and 2;

Fig. 4 is a diagrammatic vertical elevation of a high pressure regulator used in the pumping system of Figs. 1 and 2; and

Fig. 5 is a diagrammatic sectioned elevation of a low pressure regulator used in the pumping system of Figs. 1 and 2.

General pump system

Figs. 1 and 2 will be referred to together. Fig. 1 illustrates the pump as having completed its loading stroke. Fig. 2 illustrates the pump as having delivered its working stroke. The pump piston moves in a vertical direction in Figs. 1 and 2, and, therefore, the piston of the pump is in its extreme upper position in Fig. 1 and in its extreme lower position in Fig. 2. Taken together, Figs. 1 and 2 illustrate the complete cycle of the pump operation.

The power source for the pump function is to be taken as the fluid pressure available from a source of which a well head, separator, or other processing equipment is an example. It is assumed that this fluid pressure in this disclosure is that of gas from a well, available in the order of 1,000 to 3,000 lbs. per square inch. This relatively high pressure is made available at the pump by pipe 1. Pipe 1 brings the high pressure to a regulator 2. A high pressure regulator 2 is selected to deliver a pressure in the order of 10 to 30 lbs. per square inch. This pressure is delivered to pipe 3.

Pipe 3 is provided with two branch pipes. Branch pipe 4 transmits the output pressure of regulator 2 to switch valve 5 as a source of supply for valve 5. Branch pipe 6 takes the output pressure of regulator 2 as an input to a second regulator 7.

Regulator 7 receives the 10 to 30 lbs. per square inch output pressure of regulator 2 and develops it into an output in the order of 5 lbs. per square inch. This relatively low gas pressure output is applied in such a way as to oppose the output pressure of regulator 2 across the movable element of a power operator for the pump piston.

Switch valve 5, supplied the output of regulator 2, is actuated to impose this fluid pressure on diaphragm operator 10. Diaphragm operator 10 is a well-known form, being composed of housing 11 in which is mounted a movable element in the form of a diaphragm 12. Pipe 13 takes the output of switch valve 5 and applies it to the upper chamber of housing 11 in order to develop force on the top of diaphragm 12.

4

Switch valve 5 is essentially a three-way valve, mechanically actuated between its two positions by abutments moved by the pump piston. A valve suitable for this purpose is disclosed in Swatsworth 2,860,660. The valve has three ports, the center one being connected to pipe 13 into which its output is delivered. The valve element is shifted to block the fluid pressure developed in branch pipe 4 and the port leading to the atmosphere. As the valve element is shuttled between these two positions the fluid pressure of pipe 4 is developed in pipe 13 or pipe 13 is vented to atmosphere. Pipe 13 contains speed control valve 14 which is manually adjustable to determine the rate at which fluid pressure builds up in pipe 13 or decays to an atmospheric value. Valve 14 is manually manipulated to establish this rate of pressure build up and decay in the upper chamber of housing 11 above diaphragm 12.

Mounted on the top of housing 11 of diaphragm operator 10 is a housing 15, designated as the switch rod abutment housing. Switch valve 5 is mounted on the side of housing 15 so that the actuating arm of switch 5 extends into the housing. On the diaphragm plates clamped at the center section of diaphragm 12 is mounted switch rod 16 in such manner that its upper end extends into housing 15. Abutments 17 are mounted within housing 15, on rod 16 in such manner as to engage the actuating arm of switch 5 as switch rod 16 is reciprocated vertically. Thus, as diaphragm 12 is moved up and down in housing 11, rod 16 switches valve 5. Another way of looking at the combination is that as switch valve 5 is actuated to alternately apply pressure to the top of diaphragm 12 and decrease the pressure to substantially that of atmosphere, diaphragm 12 is moved up and down, providing a force is available for the upstroke.

The force for the upstroke of diaphragm 12 could be the constant force of a spring. However, in the present invention, the output of regulator 7 is utilized for this purpose.

Regulator 7 establishes its output in pipe 20. Pipe 20 has a branch pipe 21 and a branch pipe 22. Branch pipe 21 applies the output of regulator 7 on the underside of diaphragm 12. As a constant force developed on the underside of diaphragm 12, the power of this fluid pressure is available to return the diaphragm to its extreme up position as the pressure on the upper side of diaphragm 12 decreases to substantially that of atmosphere by bleeding through speed control valve 14. The power for reciprocating the pump through its loading and working strokes is therefore disclosed. The control of the speed of reciprocation is exerted by the manual setting given valve 14.

The reciprocated pump unit

Pump housing 25 is mounted on the lower side of housing 11. Pump housing 25 is shown as formed of a solid block of metal, properly machined to form a piston chamber centrally within the block with a working chamber 27, essentially an extension of the piston chamber.

The housing 25 is mounted solidly beneath and to housing 11 so as to receive pump piston 28 in chamber 26. Pump piston 28 is essentially a rod fixed to the central plates of diaphragm 12 in the same manner as switch rod 16. Pump piston 28 depends from the diaphragm 12 into chamber 26 through a packing 29, held in place with a packing nut 30 fitting about piston 28 with a close tolerance.

A bore 31 is formed in housing 25 at right angles to the bore of chambers 26 and 27. In this way, bore 31 becomes a part of the working chamber of the pump. Working check valve 32 is communicated with bore 31 and loading check valve 33 is also communicated with the working chamber, however, depending from below housing 25.

5

The operation of a pump of this type is quite simple in theory. As piston 28 is reciprocated in piston chamber 26, the liquid to be pumped is drawn into working chamber 27 through check valve 33. As the pump piston is forced down into chamber 26 the liquid pumped is blocked from leaving through check valve 33 and, therefore, forced out check valve 32. Piston 28, of course, being attached to diaphragm 12, is reciprocated by the power developed on diaphragm 12 to pump fluid supplied check valve 33 through check valve 32 to a source supplied by pipe 34.

Reservoir

The pump, together with its diaphragm operator, is mounted on a reservoir, or tank, 40. Liquid 41 is introduced into tank 40 through a filling neck 42. Filling neck 42 is closed by a manually operated closure means 43.

Specifically, the pump housing 25 is mounted on a cover plate 44, bolted to tank 40. Branch pipe 22, from pipe 20, and regulator 7, communicates the output pressure of regulator 7 with the space above liquids 41 in tank 40. The low pressure of regulator 7 applied to the surface of liquid 41 forces the liquid up loading pipe 45, through foot valve 46. With loading pipe 45 maintained full of liquid, pumping action will immediately produce an output in pipe 34. A float 47 is buoyed by the liquid 41 and mechanically linked to a sight indicator 48 mounted on the cover 44.

Function and results of the pump system

The particular arrangement of the pumping mechanism, its power source and reservoir of liquid to be pumped, together with a source of pressure from regulator 7, has several unique features. To begin with, the output pressure of regulator 7 is a fortunate substitution for a spring with which to power the up, or return, stroke of diaphragm 12. The mechanical troubles of breakage, deterioration, and maladjustment are some of the problems eliminated by the substitution of fluid pressure for a spring.

With the fluid pressure simultaneously applied to the surface of the liquid 41, a means of fluid boosting the liquid to the loading check valve is readily applied. At the same time the fluid pressure of regulator 7 performs the function of diaphragm power return and fluid boosting, it maintains its positive pressure upon each side of packing 29 about pump piston 28. This positive pressure isolates packing 29 from foreign matter which would otherwise tend to enter pump housing 25 and lodge between packing 29 and pump piston 28. Thus, the scoring and abrasion of pump piston is avoided and the seal with housing 25 is maintained constant.

Still another advantage of this arrangement is the fact that leakage of pump fluid along pump piston 28 and into housing 11 will gravitate downwardly through branch pipes 21 and 22 back into tank 40, joining liquid 41. Conservation of pumped liquid is thereby effected with this unique arrangement.

Another advantage of the arrangement is formed in the function of valve 14 in controlling the speed of pump reciprocation. Further, the control of reciprocation provides a time lag between the completion of the loading stroke of piston 28 and beginning of the working stroke of piston 28, which can be adjusted to enable the vapors in any space developed above the pumped liquid of chamber 26 to be reabsorbed by the liquid. This elimination of vapor preserves the volumetric efficiency of the pump.

Check valves

Reference will now be made to Fig. 3 where there is illustrated, in section, one of the check valves essential to the operation of the pump. Specifically, check valve 32 is illustrated. Valve 32 is given the same orientation

6

it has in Figs. 1 and 2, joining with pump housing 25 on its left and conduit 34 on its right.

Liquid from housing 25 is flowed unidirectionally through valve 32. The flow is made unidirectional by the function of valve member 50 in being urged onto its seat by spring 51. On the working stroke of pump piston 28, pressure is built up in chamber 26 and bore 31 until a force is developed on valve member 50 which will move the valve member off its seat, against the force of spring 51. Fluid will then flow from housing 25 into conduit 34. As pump piston 28 completes its working stroke, and moves in its loading stroke, the pressure in chamber 26, and bore 31, falls. Spring 51 then forces member 50 onto its seat, preventing the fluid of conduit 34 from flowing into housing 25.

Closer examination of valve 32 shows its housing to be in two parts, threadedly engaged. Male section 52 is somewhat shorter than female section 53. When the two parts are coupled together, the larger bore of female section 53 defines the end of male section 52 as an internal, offset, seat for the valve member 50. Valve member 50 is primarily arranged within the bore of female section 53, along with the spring which urges the valve member upon the seat-end of male section 52.

Still closer examination shows valve member 50 to be formed in one piece. However, the shape of the valve member 50 is so complex that ready reference to its various parts, and their corresponding function, are specifically designated.

The central portion of valve member 50 is referred to as main section 54. Section 54 is the specific valve member which engages the seat-end of male section 52. An O-ring 55 is carried in an insert in the face of the seat-engaging surface of section 54, sealing the valve member and its seat against fluid passage between them.

Main section 54 has a protuberance 56 which extends into the bore of male section 52 from the face of the seat-engaging surface. Protuberance 56 is provided with a bore up to the seat-engaging surface of main section 54. A series of holes 57 are then formed through the walls of protuberance 56, transverse the longitudinal axis of this bore.

Holes 57 are spaced a finite distance from the seating surface of main section 54. The external diameter of protuberance 56 has a close fit with the bore of male section 52, so holes 57 become the communication for fluid from housing 25 as it passes from housing 25, up the bore, and between the seat-end of female section 53 and seat-engaging surface of main section 54.

On the other side of main section 54, protuberance 58 is centrally formed with a bore also along its longitudinal axis, which bore extends down to the main section 54. Holes 59 are formed in the walls of the protuberance, transverse to the longitudinal axis of this bore. As the external diameter of main section 54 is a finite amount less than the internal diameter of the bore of female section 53, fluid will flow across the valve seat, passing up to the holes 57 and into the bore of protuberance 58.

To the right of holes 59, an offset is formed on the external surface of protuberance 58 for engaging spring 51. Spring 51 is arranged about the remaining external surface of protuberance 58, the other end of spring 51 engaging an offset in the internal bore of female section 53. With this arrangement, spring 51 develops a force to urge valve member 50 to the left against its seat.

As the fluid pressure of housing 25, in chamber 26 and bore 31, develops its spring-opposing force on the left face of main section 54, the force of spring 51 is overcome. The valve 50 will be forced from its seat a finite distance before holes 57 will be uncovered by the walls of the bore in male section 52. O-ring 55 will actually leave the end-seat of section 52 before fluid jets through holes 57 parallel to the engaging surfaces of the valve. This directional jetting of the fluid across the seat and valve surface, after the seat and valve surface

have separated obviates wire drawing of the sealing surfaces. Past the engaging surfaces of the valve and seat, the fluid passes around main section 54, through holes 59, and into conduit 34. The end of protuberance 58 engages the internal offset of the bore of female section 53 as a positive stop for the valve member 50.

The end of the bore in protuberance 58, with the sides of holes 59 formed close to main section 54, provide a face on section 54 upon which the fluid pressure of conduit 34 develops a force, additive to the spring force. When the fluid pressure force of housing 25 decreases valve 50 is moved back upon its seat very quickly. The force developed from fluid pressure in conduit 34 in adding to the spring force makes this seating quick, positive and efficient in preventing reversal of fluid flow through the check valve.

High pressure regulator

Referring to Fig. 4, high pressure regulator 2 is illustrated in section. A regulator of this type is available from Modern Engineering Company, St. Louis, Missouri. Its principle of operation is readily understood from Fig. 4.

The fluid pressure of conduit 1 is a supply for nozzle 65. A closure for nozzle 65 is provided by a surface of a yoke member 66. Yoke 66 is attached to a diaphragm 67. A spring 68 develops a predetermined force on diaphragm 67 in opposition to the fluid pressure force developed on the underside of diaphragm 67.

The fluid pressure on the underside of diaphragm 67 is developed by the relative position of nozzle 65 and the engaging surface of yoke 66. As the force of spring 68 moves diaphragm 67 and yoke 66 downward, the fluid pressure of pipe 1 develops a force on the underside of diaphragm 67 which overcomes the force of spring 68 and moves diaphragm 67 and yoke 66 up to a position which will just open nozzle 65 enough to keep the spring-opposing fluid pressure force under diaphragm 67 built up to balance the force of the spring. The result is a fluid pressure output in pipe 3 whose value is determined by the force of adjustable spring 68.

Low pressure regulator

Fig. 5 illustrates the low pressure regulator 7. A regulator of this type is available from Fisher Governor Company, Marshalltown, Iowa. Its principle of operation is quite similar to that of the high pressure regulator 2.

A nozzle 70 has the flow of fluid from pipe 6 regulated through it by pivoted beam 71. Beam 71 is linked to diaphragm 72. Spring 73 develops a force at the top of diaphragm 72 while the fluid pressure of the 70-71 couple develops the regulated, opposing, fluid pressure force under the diaphragm 72 for output pipe 20.

From the foregoing it will be seen that this invention is one well adapted to attain all of the ends and objects hereinabove set forth, together with other advantages which are obvious and which are inherent to the apparatus.

It will be understood that certain features and sub-combinations are of utility and may be employed without reference to other features and sub-combinations. This is contemplated by and is within the scope of the claims.

As many possible embodiments may be made of the invention without departing from the scope thereof, it is to be understood that all matter herein set forth or shown in the accompanying drawings is to be interpreted, as illustrative and not in a limiting sense.

The invention having been described, what is claimed is:

1. In a constant volume displacement pump having a working piston and chamber with a loading check valve through which liquid is drawn into the working cham-

ber and a working check valve through which the liquid drawn into the working chamber is discharged, including,

A power operator attached to the working piston having two sides on which power is developed to reciprocate the piston,

Means developing power on the first side of the operator from a first fluid pressure source for the working stroke of the piston,

Means developing power on the second side of the operator from a second fluid pressure source for the loading stroke of the piston,

A reservoir of liquid supplied the loading check valve through which the working chamber is filled on the loading stroke of the piston,

And a conduit system providing a direct connection between the second side of the operator and the reservoir, whereby the second source of fluid pressure power is simultaneously applied to the second side of the operator and the gaseous space in the reservoir above the surface of the liquid to be pumped.

2. The pump of claim 1 in which,

The power operator is a diaphragm operator with a chamber on each side of the diaphragm,

The means developing power on the first side of the diaphragm includes a source of fluid pressure regulated to a predetermined value supplying fluid pressure to a three-way valve which is actuated by movement of the diaphragm operator to alternately apply the source of regulated fluid pressure to the first side of the diaphragm and vent the first side of the diaphragm to atmosphere.

3. The pump of claim 1 in which,

The power operator is a diaphragm operator with a chamber on each side of the diaphragm,

And the means developing power on the second side of the diaphragm operator includes a source of fluid pressure regulated to a constant predetermined value supplied the second side of the diaphragm in a volume sufficient that the working stroke of the diaphragm compresses the fluid pressure a degree which is small compared with the pressure of the first fluid pressure source.

4. The pump of claim 3 including,

A feed tube extending from the liquid in the reservoir up to the loading check valve, whereby the fluid pressure supplied the second side of the diaphragm and the gaseous surface in the reservoir above the surface of the liquid supplies the liquid through loading check valve to the working chamber on the loading strokes of the piston.

5. The pump of claim 4 including,

A packing about the working piston and arranged between the working chamber and the diaphragm operator chamber on the second side of the diaphragm,

And a housing for the packing and working chamber attached to the diaphragm operator chamber, whereby the pressure developing power on the second side is simultaneously applied to the packing to maintain the packing under continuous positive pressure and thereby exclude abrasive foreign matter from between the packing and the working piston.

6. The pump of claim 5 in which,

The housing for the packing is arranged lower than the diaphragm operator chamber on the second side of the diaphragm and the reservoir of liquid to be pumped is arranged lower than the housing, whereby any liquid leaking from the working chamber up into the diaphragm operator chamber on the second side of the diaphragm will gravitate downwardly into the reservoir through direct connection of the conduit system between the second side of the diaphragm and the reservoir.

7. The pump of claim 2 including,

A manually controlled restricting valve located in the conduit between the three-way valve and the first side of the diaphragm so the source of regulated fluid pressure applied to the first side of the diaphragm and the venting of

the first side of the diaphragm to atmosphere is regulated in rate to control the speed of the pump reciprocation and rate to control the speed of the pump reciprocation and provide a finite period of time between the exhaustion of the pressure on the first side of the diaphragm and the development of pressure on the first side to a value which will begin the working stroke after any gaseous space developed in the piston cylinder on the loading stroke has had time to be eliminated by reabsorption of the gaseous fluid by the liquid in piston cylinder which is being pumped.

8. A pump for liquid including,

A working chamber,

A working piston arranged to reciprocate at least partially into and out of the working chamber volume,

A loading check valve communicated with the working chamber through which liquid to be pumped is drawn into the working chamber as the working piston is withdrawn from within the working chamber,

A working check valve communicated with the working chamber through which liquid pumped is discharged,

A two-sided power operator attached to the working piston on which fluid pressure develops power to reciprocate the working piston into and out of the working chamber,

A first source of fluid pressure,

Means for applying the fluid pressure of the first source to the top side of the power operator to develop the power for the working stroke of the operator and attached piston,

A second source of fluid pressure,

Means for applying the fluid pressure of second source to the underside of the power operator to develop the power for the loading stroke of the operator and attached piston,

5

10

15

20

25

30

35

A reservoir of liquid to be pumped below the loading check valve and communicated with the valve to feed the liquid to the working chamber through the valve when the working piston is withdrawn from the chamber on its loading stroke,

And a direct communication between the underside of the power operator and the reservoir of liquid to be pumped, whereby the fluid pressure of the second source simultaneously develops the loading stroke power and keeps the reservoir under positive pressure to militate against foreign matter entering the liquid to be pumped in the reservoir.

9. The pump of claim 8 including,

A packing about the working piston and sealing the working chamber from the underside of the power operator, whereby the packing is maintained under the pressure of the fluid of the second source and any liquid to be pumped in the working chamber which leaks up into the power operator is returned through the direct communication to the reservoir.

10. The pump of claim 9 including,

A control valve between the first source of fluid pressure and the top side of the power operator to control both the rate at which the fluid pressure of the first source is applied to the operator and the rate at which the fluid pressure is removed from the operator to control the speed of reciprocation and provide a finite period of time between the exhaustion of the pressure on the top side of the operator and the development of the pressure on the top side to a value which will start the working stroke after absorption of any gas in the working cylinder liquid which is being pumped.

No references cited.