

[54] **FLUID PUMP**

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137/99, 137/625.69, 417/395

[51] Int. Cl. **F04b 17/00, F04b 35/00**

[58] Field of Search ... 417/395, 393, 401, 344, 345;
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624.14, 625.69 X

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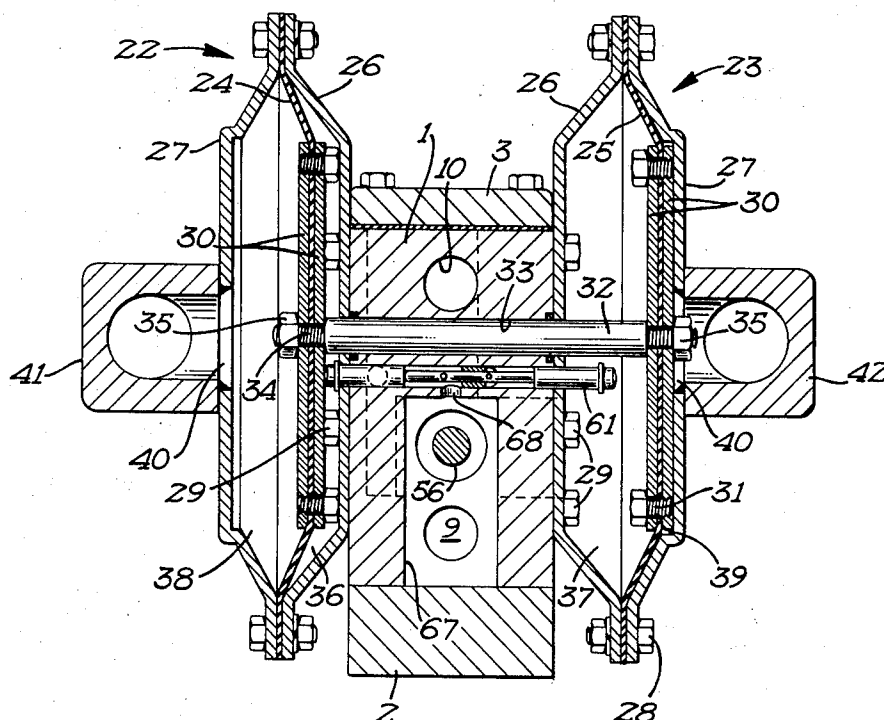
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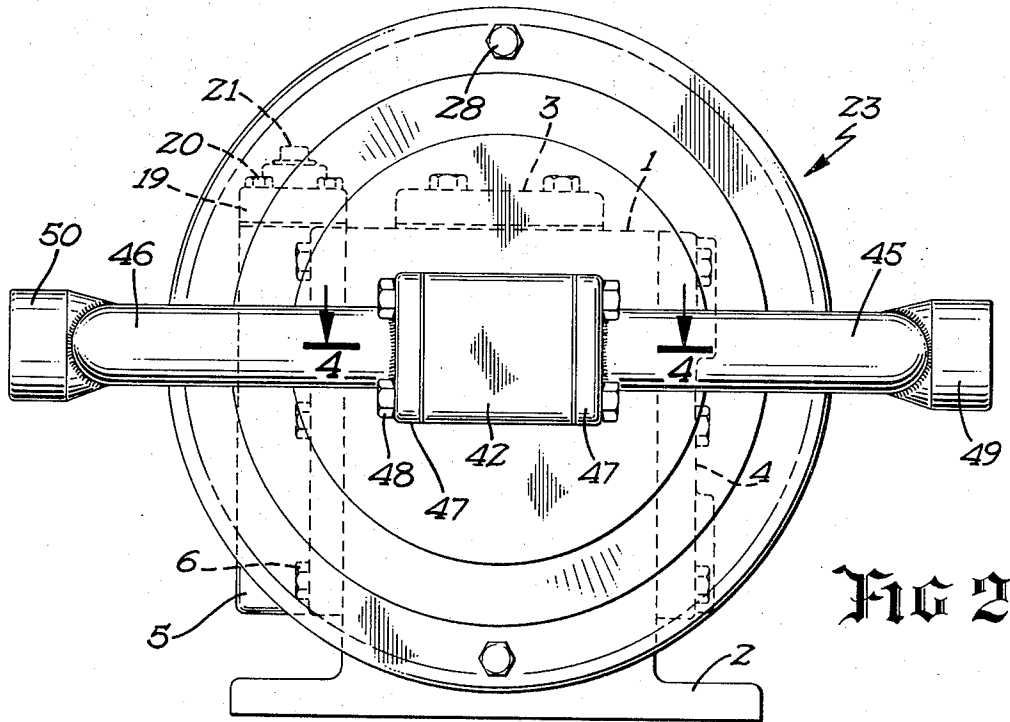
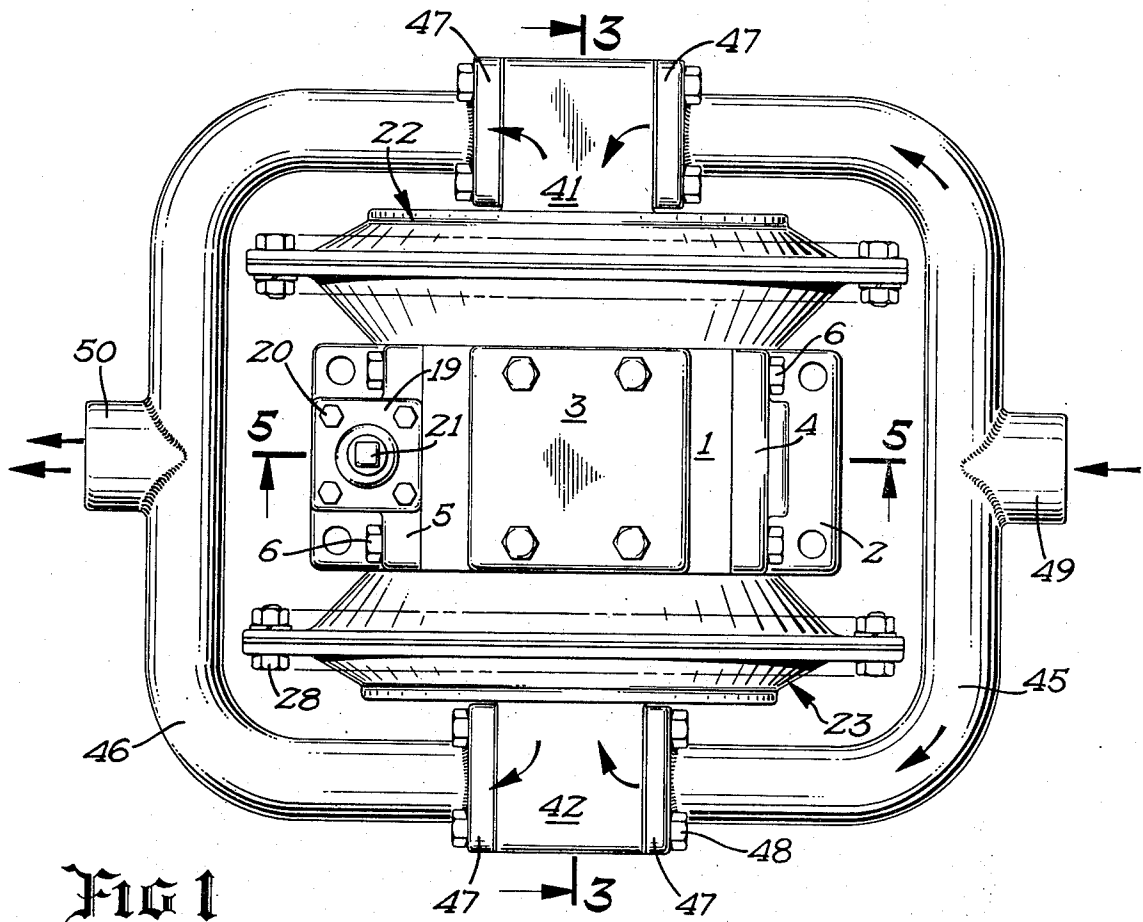
[57] **ABSTRACT**

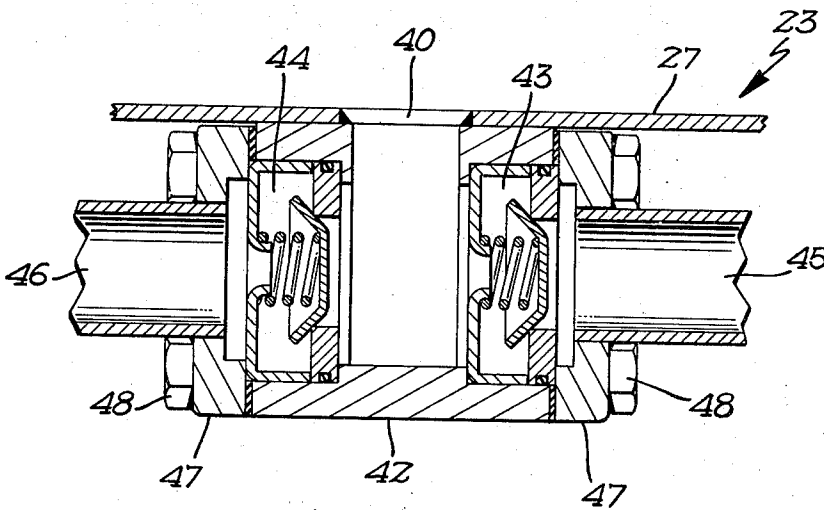
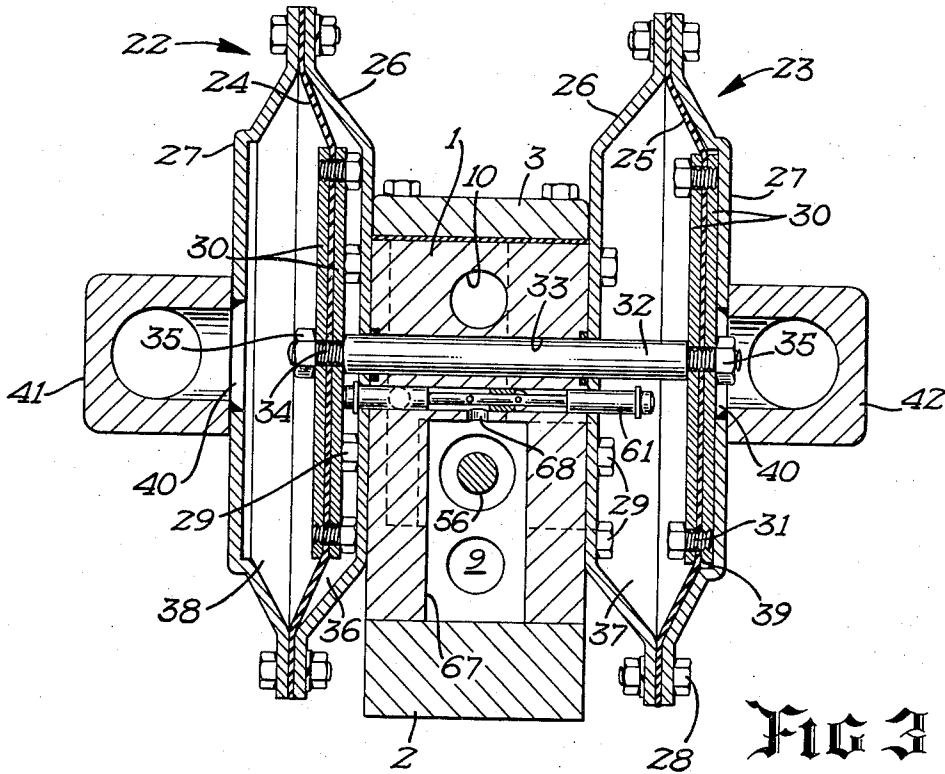
A pair of fluid pressure operated diaphragm pumps, the diaphragms of which are disposed in separate housings and connected together for common reciprocatory movements. A valve body provides support for the housings and for a connection between the diaphragms. The valve body contains a reversing valve, a pilot valve, and a pressure relief valve in a pump operating fluid circuit which includes primary pressure chambers in the housings at one side of the diaphragms. The housings define secondary chambers at the other side of the diaphragms for pumping fluids isolated from the pump operating fluids.

3 Claims, 6 Drawing Figures



SHEET 1 OF 3





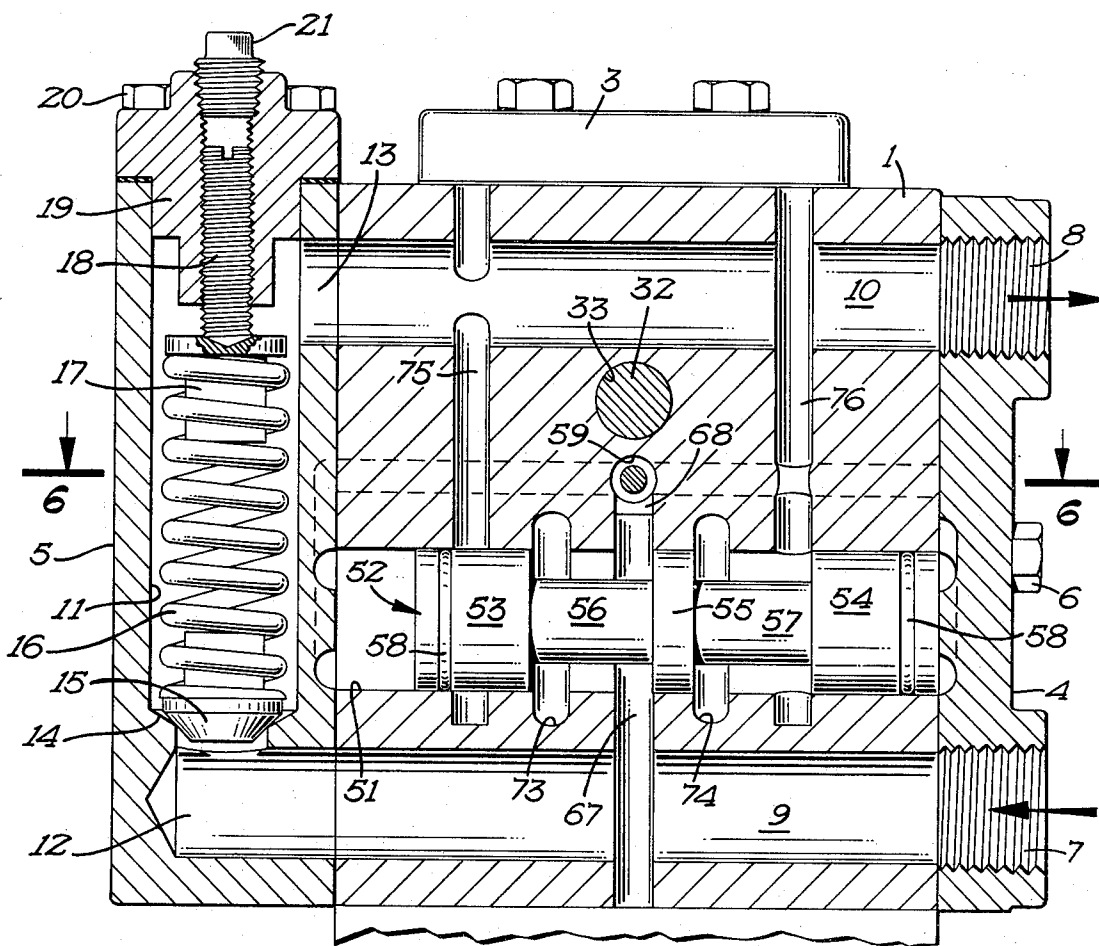


FIG 5

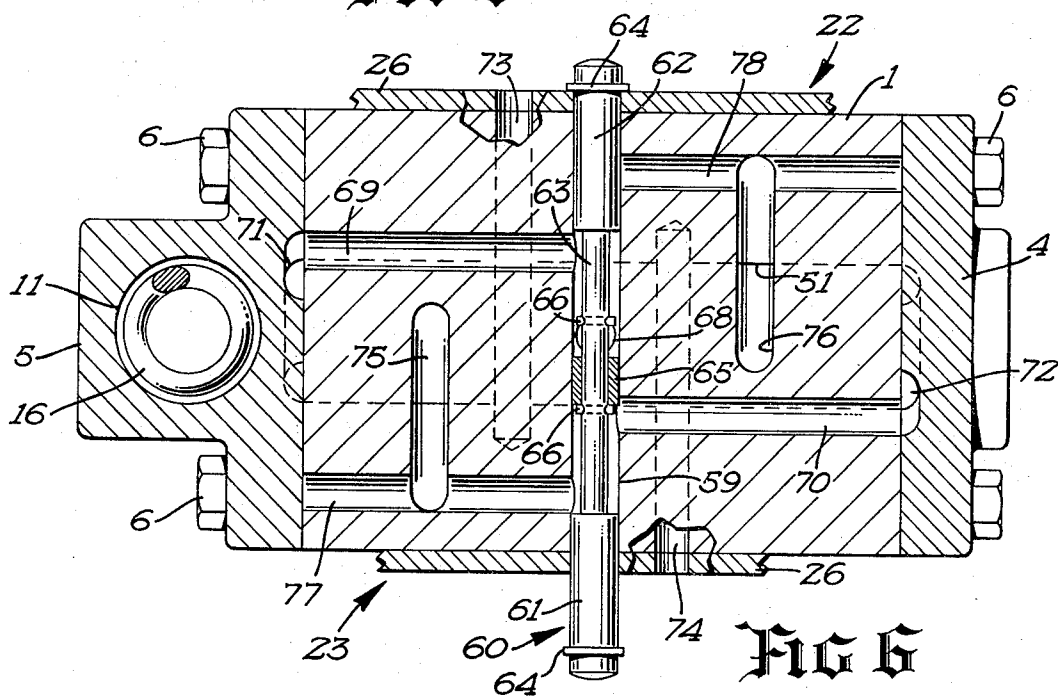


FIG 6

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FLUID PUMP

BACKGROUND OF THE INVENTION

Diaphragm pumps in and of themselves are well known, as are fluid pressure operated diaphragm pumps, the latter being often used as pulse dampening devices. Heretofore, in arrangements wherein a pair of diaphragm pumps are tied together for common reciprocation of the diaphragms, mechanical linkage connecting the diaphragms has required the use of spring loaded snap action mechanism to initiate reversal of reciprocatory movement, to avoid stalling of the pumps. Also, such systems have required the use of four-way valves mechanically linked to the mechanical connections between a pair of diaphragms.

SUMMARY OF THE INVENTION

An important object of this invention is the provision of an improved fluid pressure operated diaphragm pump which includes means for preventing stalling of the reciprocating action of the diaphragms.

Another object of this invention is a provision of a fluid pressure powered diaphragm pump in a compact self-contained unit including an integral pressure control.

Another object of this invention is a provision of a fluid pressure powered diaphragm pump in which the differential pressure across the diaphragm is always small regardless of the operating pressure of the system.

To the above ends, I provide a main body which defines primary inlet and outlet ports, a pilot valve chamber, a reversing valve chamber, and fluid pressure passages interconnecting the ports and valve members. A pair of pump housings are attached to opposite sides of the main body and have diaphragms therein which cooperate with the housings to define primary and secondary pressure chambers, the main body having fluid passages connecting the reversing valve chamber with the primary pressure chambers. The diaphragms are disposed on a common axis and are connected for common reciprocatory movement in their respective housings by a rigid connector element. A reversing valve is axially movable in the reversing valve chamber, and a pilot or shuttle valve is axially movable in the pilot valve chamber, the pilot valve being in the nature of a spool having an axis parallel to the axis of the diaphragms and opposite end portions each projecting to a different one of the primary chambers for abutting engagement with the diaphragm. A tubular member is axially slideable on a diametrically reduced portion of the spool within the pilot valve chamber, and a pair of stop elements limit axial movement of the tubular member relative to the spool. The spool is of a length relative to the distance between the diaphragms to provide a predetermined lost motion relationship between the spool and diaphragms. An adjustable pressure relief valve is disposed in the main body to provide a by-pass in the primary fluid pressure circuit. The secondary pressure chambers communicate with a manifold through check valves, the manifold having secondary fluid inlet and outlet ports.

DESCRIPTION OF THE DRAWINGS

FIG. 1 is a view in plan of a pump produced in accordance with this invention;

2

FIG. 2 is a view in side elevation;

FIG. 3 is a transverse section taken on the line 3—3 of FIG. 1;

FIG. 4 is an enlarged fragmentary section taken on the line 4—4 of FIG. 2;

FIG. 5 is an enlarged fragmentary section taken on the line 5—5 of FIG. 1; and

FIG. 6 is a fragmentary section taken on the line 6—6 of FIG. 5.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

A generally rectangular main body 1 is mounted on a base 2 and has bolted or otherwise rigidly secured to its top surface a top closure plate 3. The opposite ends of the main body 1 are covered by end members 4 and 5 secured to the main body 1 by machine screws or the like 6, the end member 4 having therein screw threaded inlet and outlet ports 7 and 8 respectively, see FIG. 5. The ports 7 and 8 are hereinafter designated as primary ports. The main body 1 is bored to provide inlet and outlet passages 9 and 10 respectively extending longitudinally therethrough, and registering at one end with the inlet and outlet ports 7 and 8 respectively. The end member 5 defines a valve passage 11 having an angularly displaced inlet end 12 in register with the inlet passage 9, the opposite end of the valve passage 11 having an angularly displaced outlet end 13 in register with the outlet passage 10. Adjacent the inlet end 12, the valve passage 11 is formed to provide a valve seat 14 for seating engagement with adjustable pressure relief valve element 15. A coil compression spring 16 is interposed between the valve element 15 and a spring seat member 17 that is engaged by an adjustment screw 18 screw threaded in a mounting cap 19 mounted on the upper end of the end member 5 and secured thereto by machine screws or the like 20. A conventional pipe plug 21 is screw threaded into the mounting cap 19 to protect the threaded opening for the adjustment screw 18 from foreign matter.

A pair of diaphragm pumps comprise pump housings 22 and 23 and respective diaphragms 24 and 25. Each of the housings 22 and 23 includes laterally inner and outer generally circular housing sections 26 and 27 rigidly secured together about their marginal edges by circumferentially spaced nut equipped screws 28, the marginal edges of the diaphragms 24 and 25 being clamped between said marginal edges by the screws 28, see particularly FIG. 3. Other machine screws 29 extend through suitable openings in the inner housing sections 26 and are screw threaded into opposite sides of the main body 1 to anchor the pump housings 22 and 23 to the main body 1 in axial alignment.

The diaphragms 24 and 25 may be made from any suitable sheet material, but are preferably made from flexible or plastic sheet material, such as rubber or other material that is inert to various liquids or fluids with which the pump may be used. The diaphragms 24 and 25 are each reinforced at their central portions by pairs of metallic plates 30 held in face to face relationship with opposite sides of their respective diaphragms 24 and 25 by machine screws 31. The diaphragms 24 and 25 are connected for common reciprocatory movement in their respective housings 22 and 23 by a rigid tie rod 32 extending axially of the diaphragms 24 and 25 and through an opening 33 extending through the body 1, see FIGS. 3 and 5. As shown in FIG. 3, the op-

posite ends of the tie rod 32 are formed with diametrically reduced screw threaded portions 34 that extend through aligned central openings in the diaphragms 24 and 25 and their respective plates 30, the opposite ends of the tie rods being anchored to their respective diaphragms 24 and 25 by anchoring nuts 35 screw threaded on the threaded portions 34. The diaphragms 24 and 25 cooperate with their respective pump housing sections 26 to define primary pressure chambers 36 and 37 respectively, and with their respective housing sections 27 to define secondary pressure chambers 38 and 39 respectively.

The housing sections 27 of the pump housings 22 and 23 are provided with axial openings 40 that communicate with the interiors of the respective check valve boxes 41 and 42 each of which contain an inlet check valve 43 and an outlet check valve 44, one of each being shown in FIG. 4. A pair of generally U-shaped inlet and outlet manifolds 45 and 46 respectively are provided at their opposite ends with mounting flanges 47 through which extend mounting screws 48 for securing the manifolds 45 and 46 to opposite sides of the check valve boxes 41 and 42. With reference to FIG. 4, it will be seen that the mounting flanges 47 are arranged to hold the check valves 43 and 44 within recesses formed in the check valve boxes 41 and 42. Intermediate their ends, the manifolds 45 and 46 are provided with respective inlet and outlet ports 49 and 50 respectively, hereinafter designated as secondary inlet and outlet ports. It will be noted that the secondary ports communicate with the secondary pressure chambers 38 and 39 through the manifolds 45 and 46, valve boxes 41 and 42 and housing openings 40.

Just above the inlet passage 9, the main body 1 is formed to provide a cylindrical reversing valve chamber 51 disposed on an axis in spaced parallel relation to the axes of the passages 9 and 10. A reversing valve 52 is in the nature of a spool having end lands 53 and 54, a central land 55 and diametrically reduced portions 56 and 57 between the central land 55 and end lands 53 and 54 respectively. The lands 53 - 55 are cylindrical for axial sliding movement in the chamber 51, the lands 53 and 54 preferably being provided with sealing rings 58, see FIG. 5.

Above the reversing valve chamber 51 and below the tie rod opening 33, the main body 1 is bored or otherwise formed to provide the transverse opening there-through which opening forms a pilot valve chamber 59. A pilot valve, in the nature of an elongated spool 60 includes a pair of diametrically enlarged end portions or lands 61 and 62, and a diametrically reduced intermediate portion or stem 63 connecting the end portions 61 and 62. With reference to FIGS. 3 and 6, it will be noted that the lands 61 and 62 extend through suitable openings in the housing sections 26 of the diaphragm pump housings 22 and 23, the extreme ends of the valve spool 60 be adapted to abuttingly engage adjacent ones of the plates 30 of the diaphragms 24 and 25 respectively. The lands 61 and 62 are provided adjacent their outer ends with stop collars or the like 64 which limit movement of the valve spool 60 in opposite directions relative to the main body 1. The pilot valve 60 includes a tubular member 65 that encompasses the shank portion 63 and is axially slideable thereon between a pair of axially spaced stop pins 66 projecting radially outwardly from the shank portion 63, all for a purpose which will hereinafter become apparent. The

pilot valve spool 60 is adapted to be moved axially with respect to the pilot valve chamber 59 by engagement of the opposite ends of the valve spool 60 with the plates 30 of the diaphragms 24 and 25. It will be noted, particularly with reference to FIG. 3, that the axial length of the pilot valve spool 60 is substantially less than the distance between the diaphragms 24 and 25, so that there is a fair amount of lost motion therebetween during reciprocation of the diaphragms 24 and 25 and the tie rod 32.

Generally centrally between the opposite ends of the main body 1, a fluid passage 67 extends upwardly from the inlet passage 9 through the central portion of the reversing valve chamber 51, and terminates in a reduced passage portion 68 that communicates with the longitudinally central portion of the pilot valve chamber 59, see FIGS. 3, 5 and 6. A pair of laterally spaced passages 69 and 70 extend longitudinally of the main body 1 in opposite directions from the pilot valve chamber 59, and at their outer ends, register with respective ones of a pair of passages 71 and 72 formed in the adjacent surfaces of the end members 5 and 4 respectively. As shown particularly in FIG. 5, the passages 71 and 72 communicate with adjacent ends of the reversing valve chamber 51. A pair of fluid passages 73 and 74 extend transversely of the main body 1 from the reversing valve chamber 51 and through the diaphragm pump housing sections 26 to the secondary pressure chambers 36 and 37 respectively. As shown in FIGS. 5 and 6, the fluid passages 73 and 74 are spaced apart in a direction axially of the reversing valve chamber 51 at opposite sides of the fluid passage 67. Another pair of fluid passages 75 and 76 extend upwardly from the reversing valve chamber 51 through the outlet passage 10, the passages 75 and 76 being disposed in outwardly spaced relation to respective passages 73 and 74, in a direction axially of the reversing valve chamber 51. The passages 75 and 76 communicate with axially spaced portions of the pilot valve chamber 59 through connecting passages 77 and 78 respectively, these passages extending longitudinally of the main body 1 in laterally outwardly spaced relation to adjacent ones of the fluid passages 69 and 70.

In the embodiment of the invention illustrated, it may be assumed that the main body 1 is of cast or moulded material, the passages 67 and 73 - 76 being formed therein by conventional cores. The lower end of the passage 67 is closed by the base 2, the upper ends of the cored fluid passages 75 and 76 being closed by the closure plate 3. In the embodiment illustrated, the connecting passages 77 and 78 are drilled in the main body 1, the outer ends thereof being closed by the end members 4 and 5.

Operation

Assuming that the secondary inlet port 49 is connected by conduit means, not shown, to a source of fluid, and that the secondary outlet port 50 is similarly connected to a point of delivery, pumping fluid under pressure is introduced to the inlet passage 9 through the primary inlet port 7. The pumping fluid flows upwardly through the passage 67 into the reversing valve chamber 51. With the reversing valve spool 52 disposed in its position illustrated in FIG. 5, fluid will flow between the lands 53 and 55 outwardly through the fluid passage 73 to the pressure chamber 36 to move the diaphragm 24 in a direction to the left with respect to FIG. 3. As the diaphragm 24 moves in this direction,

the tie rod 32 carries the diaphragm 25 in the same direction. During this time, the fluid passage portion 68, pilot valve chamber 59, passages 69 and 71, and the end portion of the reversing valve chamber 51 adjacent the land 53, are under fluid pressure to hold the reversing valve spool 52 in its position shown in FIG. 5. As the diaphragms 24 and 25 move to the left with respect to FIG. 3, fluid is pulled into the secondary chamber 39 from the secondary inlet 49, the fluid in the secondary pressure chamber 38 being forced outwardly under pressure through the manifold 46 and secondary outlet 50. At the same time, pumping fluid in the primary pressure chamber 73 flows outwardly therefrom through the passage 74 into the reversing valve chamber 51 between the lands 54 and 55, from whence fluid flows outwardly through the passage 76 to the outlet passage 10 and outlet port 8. It should here be noted that the passages 75 and 76 intersect the passages 77 and 78 respectively.

As the pump diaphragms 24 and 25 continue their movement toward the left with respect to FIG. 3, the inner plate 30 of the diaphragm 25 abuttingly engages the end of the adjacent pilot valve land 61 to move the pilot valve spool 60 toward the left with respect to FIG. 3. One of the stop pins 66 imparts movement to the tubular member 65 in common with the pilot valve spool 60 until the tubular member 65 moves over the passage portion 68 sufficiently to expose the upper end of the passage portion 68 to the space between the tubular member 65 and the land 61. As soon as the passage portion 68 is thus exposed, fluid under pressure moves into the space to impart movement to the tubular member 65 to the left with respect to FIG. 3 independently of the valve spool 60 until the tubular member 65 engages the opposite stop pin 66. At this time, the passage portion 68 becomes fully in register with the space between the tubular member 65 and land 61 before the pilot valve spool 60 and the diaphragms 24 and 25 have reached their limit of movement toward the left with respect to FIG. 3. With the passage portion 68 thus uncovered, fluid under pressure flows through the fluid passages 70 and 72 to the end of the reversing valve chamber 51 adjacent the reversing valve land 54 to move the reversing valve spool 52 to the left with respect to FIG. 5. During this movement, fluid in the left-hand end of the chamber 51 flows outwardly therefrom through the passages 71 and 69, to the pilot valve chamber 59 between the tubular member 65 and land 62 of the valve spool 60, and from thence through the passages 78 and 76 to the outlet passage 10 and primary outlet port 8. Movement of the reversing valve spool 52 to the opposite end of the valve chamber 51 exposes the passage 74 to fluid pressure from the passage 67, and exposes the passage 73 to the passage 75, so that fluid may be exhausted from the primary pressure chamber 36 the primary outlet port 8 while fluid under pressure is being introduced to the primary pressure chamber 37. As soon as the land 55 of the reversing valve spool 52 is moved beyond the passage 67, the pumping fluid reverses the direction of movement of the diaphragms 24 and 25. With reference to FIG. 3, it will be noted that the fluid passage 67 is of greater width than the diameter of the reversing valve chamber 51, so that fluid under pressure is supplied to the passage portion 68 at all times. Thus, movement of the reversing valve spool land 55 across the passage 67 does not shut off the supply of fluid under pressure to the

passage portion 68 and pilot valve chamber 59, so there is no chance for the reversing valve spool 52 to stall during its reversing movement. The shuttling movement of the tubular member 65 on the pilot valve spool 60, together with the lost motion arrangement between the pilot valve spool 60 and diaphragms 24 and 25 provides for efficient and non-stalling operation of the pilot valve.

The adjustable pressure relief valve element 15 opens to provide a by-pass for pumping fluid from the inlet passage 9 to the outlet passage 10 when pressure in the primary pressure chambers exceeds a given maximum, which maximum is determined by adjustment of the screw 18. Pressure in the primary chambers 36 and 37 is determined by the load pressure of material being pumped outwardly through the secondary outlet 50 by the diaphragms 24 and 25. Thus, fluid is pumped by the diaphragms 24 and 25 only on demand as indicated by a drop in pressure in the outlet manifold 46.

Most of the parts of the above described pump may be made from any suitable metal or plastic material, and the pump may be built in any desired size to meet various requirements. While I have shown and described a commercial embodiment of my improved diaphragm pump, it will be understood that the same is capable of modification without departure from the spirit and scope of the invention, as defined in the claims.

What is claimed is:

1. A fluid pump comprising:

- a. a main body;
- b. a pair of housings each disposed at an opposite side of said body;
- c. a pair of pumping diaphragms one in each of said housings and dividing the interior of each housing into primary and secondary pressure chambers;
- d. inlet and discharge manifolds disposed to communicate with said secondary pressure chambers and having one-way check valves therein and secondary inlet and outlet ports respectively;
- e. means connecting said diaphragms together for common reciprocatory movement in their respective housings;
- f. said main body defining primary inlet and outlet ports and passage means connecting said primary inlet and outlet ports to said primary chambers, said passage means including pilot and reversing valve chambers, said primary inlet port being adapted for connection to a source of fluid under pressure;
- g. and a pilot valve and a reversing valve movably mounted in respective ones of said pilot and reversing valve chambers;
- h. said pilot valve being movable alternately in opposite directions responsive to movement of said diaphragms to control flow of fluid to said reversing valve chamber; said pilot valve comprising a spool axially movable in said pilot valve chamber and having a diametrically reduced portion within said pilot valve chamber, a tubular member encompassing said reduced portion and axially movable relative to said main body and spool, and stop means in said pilot valve chamber limiting movements of said tubular member axially of said spool;
- i. said reversing valve being fluid pressure operated and operative responsive to movement of said pilot valve in opposite directions to direct flow of fluid from said primary inlet and alternately to said pri-

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mary pressure chambers and from alternating primary pressure chambers to said outlet port.

2. The fluid pump defined in claim 1 in which said passage means includes a valve passage intermediate said primary inlet and outlet ports, characterized by an adjustable pressure relief valve in said valve passage operative to by-pass flow of fluid around said pilot and reversing valves responsive to predetermined pressure

in said primary pressure chambers.

3. The fluid pump defined in claim 1, in which said stop means comprises a pair of axially spaced stop elements projecting radially outwardly of said diametrically reduced spool portion and each engageable with a different end of said tubular member.

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