

July 13, 1965

L. H. BROWNE
PUMPS

3,194,169

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3 Sheets-Sheet 1

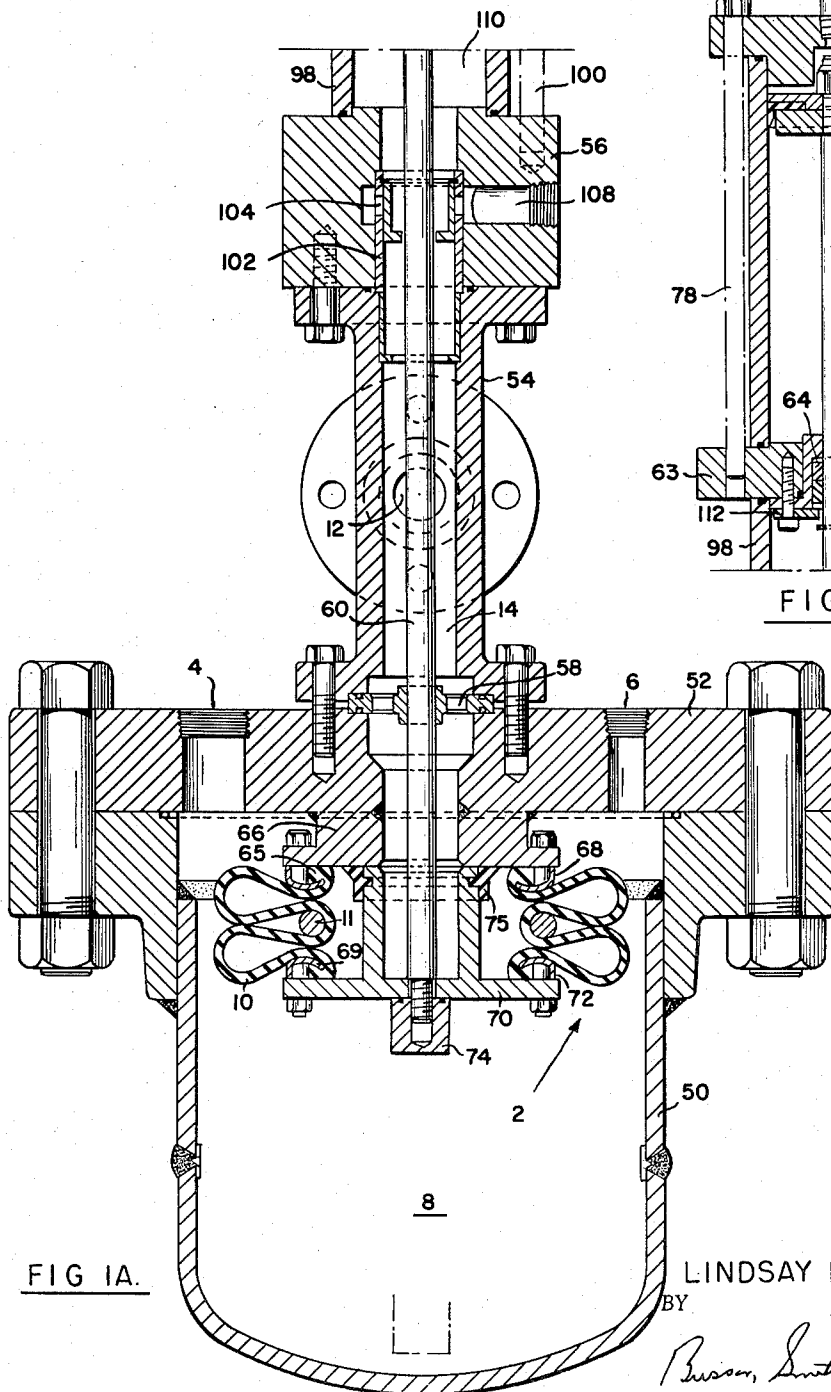


FIG. 1A.

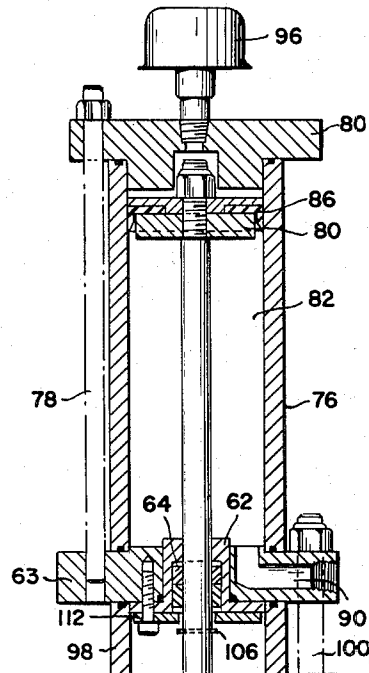


FIG. 1B.

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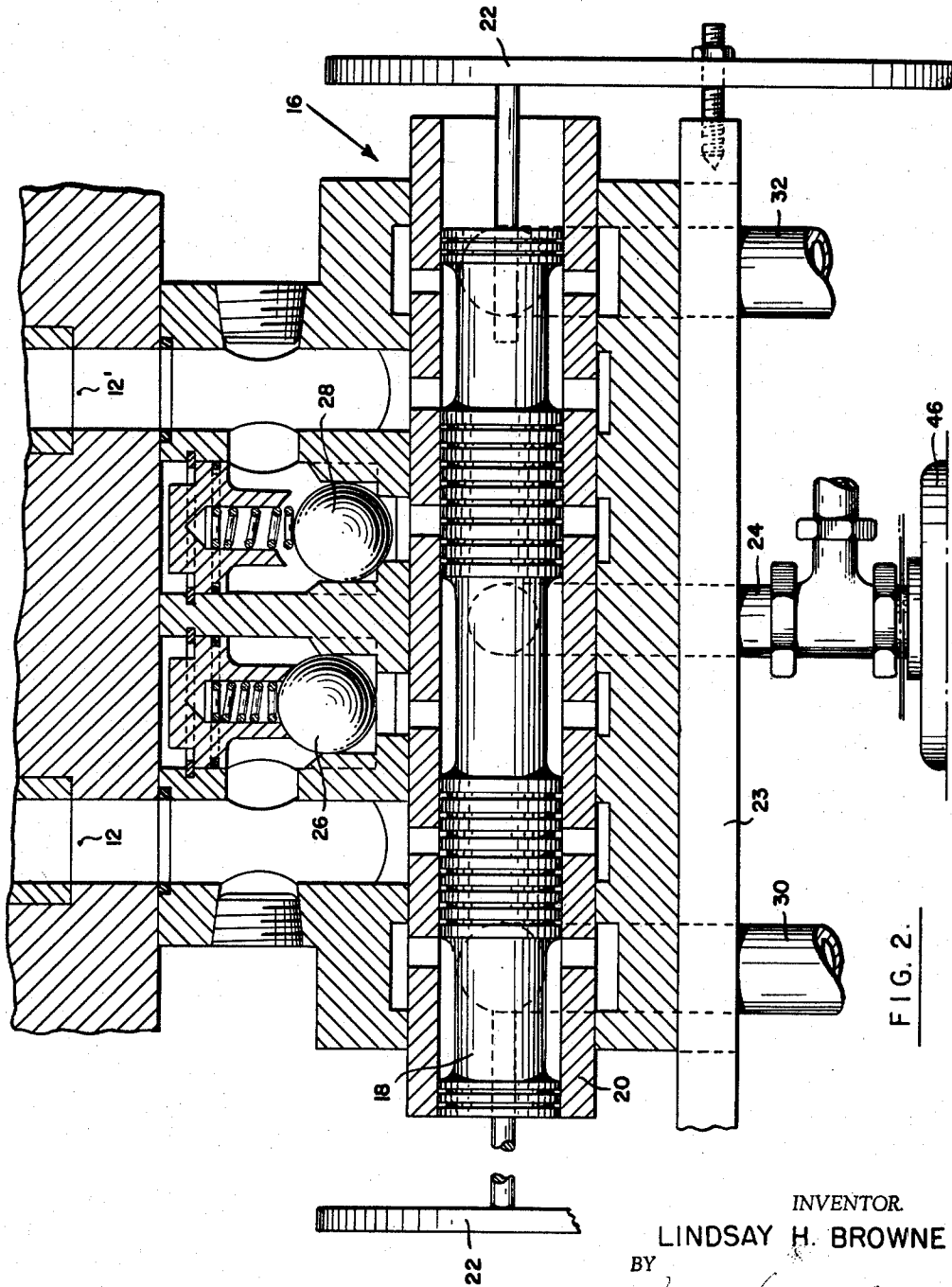


FIG. 2.

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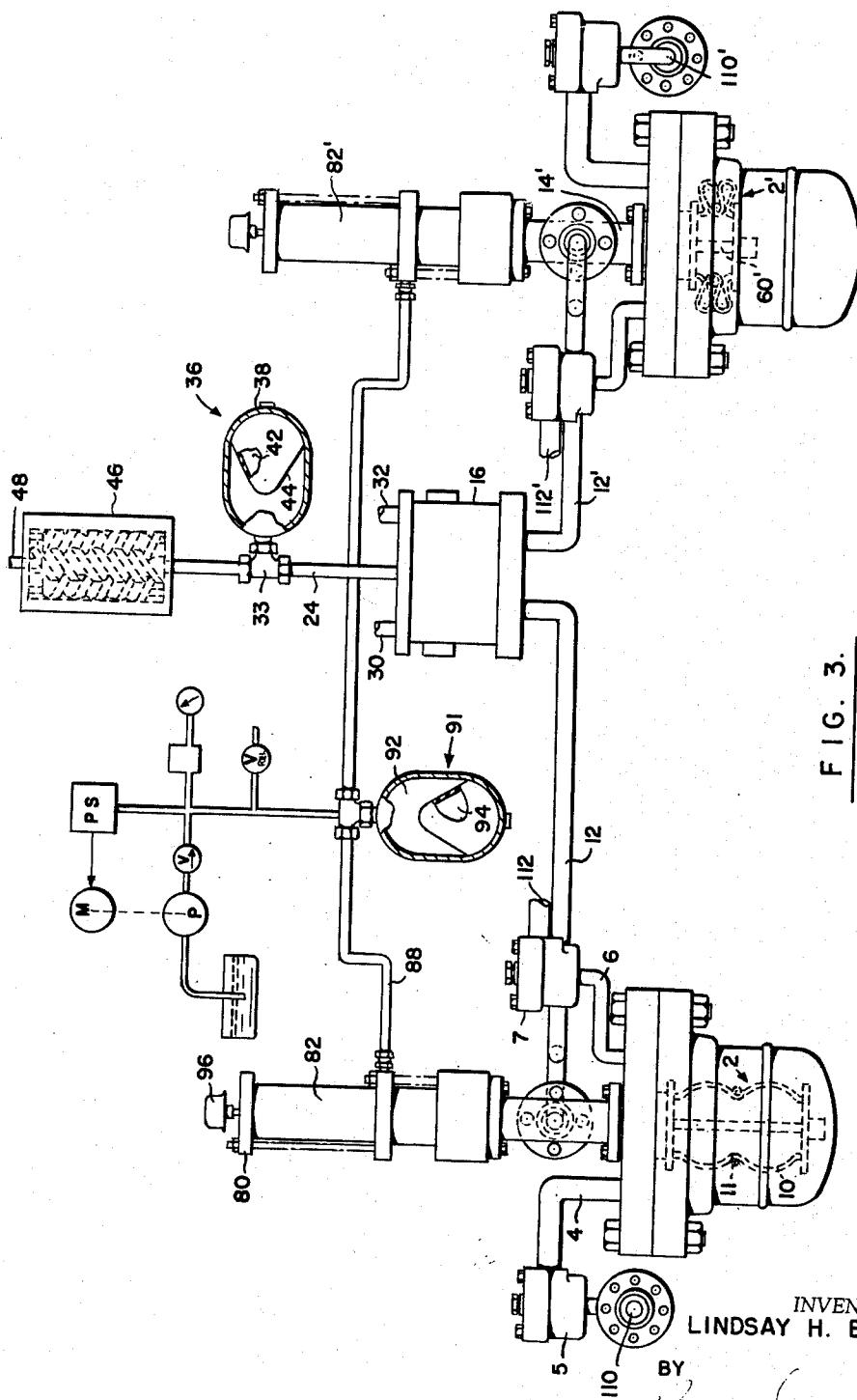


FIG. 3.

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3,194,169
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1 Claim. (Cl. 103—152)

This invention relates to pumps and has particular reference to pumps of the pulsating type in which an operating liquid is completely isolated from the liquid being pumped. Pumps of the type to which the present invention relates are disclosed in my U.S. Patents 2,836,121, issued May 27, 1958, 3,048,114, issued August 7, 1962 and 3,080,821, issued March 12, 1963.

As disclosed in said patents, a pair of pulsators may be so operated that, when supplied with a continuous flow of driving liquid, they will provide a substantially continuous flow of the liquid being pumped. The statement that the flow is "substantially" continuous here implies that there is not appreciable deviation percentage-wise from accurately continuous flow. Actually, the only deviation from precise continuity is involved in the occurrence of transient pulses of short duration which are more in the nature of sound waves than measurable deviations of flow rate. The first of the aforementioned patents is particularly concerned with the minimizing of such transient shock pulsations.

By the use of such pumps extremely high pressures may be developed in the pumped liquids. Furthermore, the liquids which are being pumped may contain solid materials, possibly being in the form of thick sludges, pumping being satisfactorily obtained without hindrance from the solid materials. The present invention is particularly directed to pumps of this type of large capacity and capable of handling sludges, corrosive materials, or the like which offer particular difficulties in pumping.

One of the objects of the present invention is to provide an improvement over the use of cylindrical elastic diaphragms shown as constituting pulsators in the first two patents cited above, and of the "tire" type pulsators shown in the third patent. The improvement provides means whereby the displacements of the pulsators may be increased, thus increasing the displacement of the pump during each operating cycle, and to provide means whereby the operation of a pulsator is not highly dependent upon the elastic properties of its material.

A further object of the present invention is to provide means for taking up volume changes occurring in the control fluid chambers of the apparatus due to large pressure variations.

These and other objects of the invention will become apparent from the following description, read in conjunction with the accompanying drawings, in which:

FIGURE 1A is a vertical section of the lower portion of one unit of a pump provided in accordance with the invention;

FIGURE 1B is a vertical section of the upper portion of the same pump unit;

FIGURE 2 is a cross-section of a distributing valve used in conjunction with the pump herein described; and

FIGURE 3 is a diagram, partly schematic, of a system including two pump units and additional apparatus elements pertinent to this invention.

Referring to FIGURES 1A and 3, pumping action of a pulsator 2 delivers liquid from inlet 4 through outlet 6, both of which are provided with one-way check valves 5 and 7 respectively, so that pumping is accomplished only in the direction from inlet to outlet. For purposes of this description the liquid being pumped will be referred to herein as the "product." Contraction of pulsator 2 draws the product through one-way check valve

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5 and through inlet passage 4 into the pumping chamber 8. Extension of pulsator 2 forces the product through outlet passage 6 and through check valve 7. Although only one inlet and one discharge valve are sufficient for each pulsator, it is desirable in the handling of products which may contain a large amount of solid material, to provide a pair of such check valves in parallel for each pulsator. The check valves 5 and 7 are desirably of the type claimed in my Patent 2,977,974, dated April 4, 1961.

The valve and seat elements are formed of rubber so as to operate consistently and reliably despite the presence of solid material, and are arranged for clearance from the valve and seat elements of such solid particles as may temporarily tend to accumulate. It will be understood, of course, that other types of valves may be here used, particularly where the product does not present difficulties by reason of abrasive or other solid constituents.

The pulsator 2 comprises a flexible folded annular casing 10 of a rubber, chosen to withstand the driving and pumped liquids, the shape of which is maintained by one or more metal rings 11. The maximum diameter of the flexible casing 10 decreases upon extension of the pulsator 2. With a greater number of folds the axial extension of pulsator 2 can be considerably increased without increasing the diameter of the pumping chamber 8. The metal reinforcing rings 11 may be replaced by molding the flexible casing 10 in a manner such that the inwardly convex folds are considerably thicker than the outwardly convex folds. Negligible friction is involved between the ring and the flexible casing since there is no rubbing of one against the other. When the pulsator is extended the casing 10 unfolds slightly in the region of contact with the ring or rings 11 exposing more of the surface of the reinforcing rings. The ring 11 moves downward with the part of the casing which it surrounds.

Stating the construction and operation in another way, the pulsator is in the form of a flexible bellows having a plurality of outwardly extending annular folds. If the pulsator consisted solely of the sufficiently flexible material of these folds, there would occur the possibility that during an expanding operation the trough portions between the folds might bulge outwardly and then, on contraction, more outwardly rather than inwardly, resulting in a complete and destructive change in configuration. Furthermore, such freedom of movement might occur as to result in engagement of the pulsator folds with the walls of the confining chamber producing damage or destruction by friction. Through the use of one or more confining rings 11, or by the use of equivalents thereof resulting from molding one or more heavy ring portions in the troughs of the pulsator, the circumference of each trough is maintained substantially constant so that the bulging of each trough is prevented and the pulsator returns always to its same retracted condition after expansion. Further, the rings restrain movements to prevent substantial lateral deflections of the pulsator as a whole to prevent contacts with the walls.

At the same time, the rings do not inhibit free axial expansion of the pulsator, moving with it axially without any relative sliding movement. As already indicated, expansion and contraction of the pulsator involve only variable embracing of the ring or rings by the folds of the pulsator and this action is not attended by relative sliding and therefore involves very little friction.

The extension of the pulsator 2 is effected by means of a driving liquid which is supplied under pressure through line 12 and into passage 14. Oil is desirably used as a driving liquid, the main reason being that it concomitantly serves as a lubricant for the pumping elements.

Referring to FIGURE 2, a valve 16 is shown which distributes the driving fluid in a manner such that two pulsators can be operated as a unit to provide continuous

flow of the product. For a detailed description of the valve reference may be had to my Patent 2,836,121. Briefly, however, the valve 16 comprises a valve spindle 18 reciprocating in a ported sleeve 20. Reciprocation of spindle 18 by a pair of members 22 carried by a reciprocating slide 23 causes the delivery of driving fluid from a line 24 alternately to lines 12 and 12', which line 12 has previously been described as supplying the pulsator 2 illustrated in FIGURE 1. Delivery of driving fluid to lines 12 and 12' is through ball check valves 26 and 28, respectively. When the valve spindle 18 is at the extreme limit of travel in either direction one of the lines 12 or 12' will receive driving fluid under pressure, while the other will be vented to an oil supply reservoir by one of a pair of discharge lines 30 and 32, provided respectively for lines 12 and 12', which lead to this main oil reservoir.

Referring now to FIGURES 2 and 3 there is shown an accumulator 36, which communicates with line 24 through a T-fitting 33. The accumulator 36 comprises a tank 38, separated internally into two spaces 40 and 42, by an elastic bag-like membrane 44. This membrane 44, preferably composed of synthetic rubber resistant to oil, seals chamber 42 inflated with air to a pressure such that through the working range of the pump the membrane will operate intermediate the ends of the accumulator housing 38. The primary function of the accumulator 36 is to provide means for absorption of shock produced in the system primarily by the sudden opening and closing of the ball check valves 26 and 28 and the movement of the spindle 18 and consequent exposure of chambers involved to sudden changes of pressures with consequent small but significant volumetric changes. The relatively low inertia of the membrane and air in space 42 in the accumulator 36 and consequent preferential absorption of shock minimizes expansion and contraction of the oil-containing chambers. Noise is thus suppressed.

The driving pump 46 is desirably of the positive screw type such as described in Patent 1,965,557, dated July 3, 1934, which supplies a continuous flow of driving fluid through passage 24 to the distributing valve 16. The driving pump 46 communicates with the oil supply reservoir through line 48. It may be remarked that the rate of reciprocation of spindle 18 through its cycle is such that, considering the maximum delivery of pump 46, if the delivery rate of this pump is adjustable, the pulsators will not be expanded during any cycle to an extent beyond that predetermined to be the desirable maximum. Variation in delivery rate of pump 46 then merely involves less expansion of the pulsators to provide corresponding displacement of the product being pumped.

Summing up the above matter of the distributing valve 16, it will be seen that reciprocation of spindle 18 results in a pulsating flow of oil from pump 46 to line 12, which leads to the interior of the pulsator 2, and to line 12', which supplies a second pulsator 2' (FIGURE 3) operating in conjunction with pulsator 2. The continuous supply of driving liquid from pump 46 involves total displacements of the pair of pulsators 2 and 2', first one, then both, and then the other, in such a fashion that the total of the displacements of the two pulsators remains constant as described in Patent 2,836,121. The result is that the flow of pumped liquid is also constant, assuming no leakage.

Returning to the description of the specific elements of the pump itself, referring to FIGURES 1A and 1B, the chamber 8 is defined by a housing comprising the drum 50, which is capped by a heavy platform 52 containing the inlet and outlet passages. Mounted atop the platform 52 is an upstanding tubular housing 54, on top of which is mounted valve block 56. Interposed in liquid-tight engagement between housing 54 and platform 52 is a spidered bearing 58 which provides lower support for a reciprocating rod 60, the function of which is to effect positive control over the collapse of the casing 10. The other end

of the shaft 60 finds support in a stuffing box 62 mounted in the upper plate 63 and having packing 64 therein.

The casing 10 may be formed of rubber, preferably of the synthetic type capable of withstanding lubricating oil in its interior and the liquid being pumped on its exterior. Due to the fact that a high pressure gradient does not normally exist across the pulsator membrane, the pulsator 10 need not be made of especially strong material capable of withstanding large pressure differences. The only strength required of the pulsator is that it be able to undergo continuous flexing without rupturing, which would cause leakage, and in this respect the characteristics of the pulsator should be similar to those of a tire casing. The upper bead 65 of the pulsator is clamped to a protruding portion 66 of platform 52 by means of a ring clamp 68. The lower bead 69 of the pulsator is similarly clamped to a rigid member 70 by means of a ring clamp 72. The member 70 is secured to reciprocating rod 60 by means of a threaded liquid-tight cap 74.

As will be apparent from the description thus far, reciprocation of rod 60 will be tied in with extension and contraction of pulsator 2. Thus a flow of driving liquid under pressure through line 12 and passage 14 to the interior of pulsator 2 will cause expansion thereof, and movement of the rod 60 upwardly (by means described hereafter) will collapse the pulsator. An important feature of the pump resides in a resilient sealing ring 75 provided in the upstanding annular portion of member 70. The sealing ring 75 is adapted to abut the portion 66 of platform 52 at the limit of movement in an upward direction to seal off the interior of the pulsator 2 from passage 14. If the one-way output valve 7 fails to close during the upward stroke of the pulsator, the pressure of the head being pumped against would ordinarily tend to force the pulsator upward and force the casing 10 to collapse radially with great and destructive violence. The sealing ring 75 is provided as a precaution against the occurrence of destruction of the pulsator due to valve failure. If the valve 7 fails to close, the pressure of the head being pumped against will force contraction of the pulsator, however driving liquid is trapped inside the pulsator 2. Its escape through passage 14 is prevented by the sealing ring 75. The pressure of this trapped liquid prevents further collapse of the pulsator casing.

In pulsator pumps of the type disclosed in said Patent 2,836,121, reliance is placed on the inherent elasticity of the pulsator to return it to collapsed position and to return driving fluid therein to a reservoir. In the pump according to the present invention means are provided to collapse the pulsator by positive action, and such means will now be described. At the top of the pump structure a cylinder 76 is clamped by means of a bolt 78 between an end plate 80 and the valve block 63, thereby defining a chamber 82. A piston 84 having a cylinder wall engaging and sealing shoe 86 is fixedly supported at the end of rod 60, and as such is adapted for reciprocatory movement within the cylinder 76. Referring to FIGURE 3, line 88 communicates with chamber 82 by means of a passage 90. An accumulator 91 is provided to produce positive return action of the pulsator to a collapsed position. Oil is maintained in space 92 at a pressure comparable to the air pressure in 94 by means of an oil pump P. A pressure switch PS responsive to pressure in the accumulator space 94, upon a predetermined drop in such pressure, initiates operation of a motor M for driving the pump P. Thereupon oil is pumped from a reservoir to the accumulator 91 via check valve V.

Again, referring to FIGURES 1A and 1B, a covered air vent 96 is mounted at the top of plate 80, providing a means for escape of air from the portion of chamber 82 above the piston 84 so that little resistance is offered by the air in chamber 82 to the expansion and collapse of the pulsator 2.

The safety valve block 56 is separated from valve block 63 by means of a cylinder 98 which is held in position

between the valve blocks by means of a bolt 100. A sleeve 102 is provided within valve block 56. Within the sleeve 102 there is provided a cylindrical valve element 104 which is capable of moving downward when engaged by collar 106 provided on rod 60, thus opening passage 14 to passage 108 so as to relieve pressure within the pulsator when the limit of downward extension, determined by the position of the collar 106, is exceeded. Passage 108 communicates with a driving liquid supply reservoir.

The chamber 110 defined by cylinder 93 and valve blocks 56 and 63 respectively provides a housing in which the vertical reciprocating motion of collar 106 takes place. Chamber 110 is normally filled with driving liquid which is capable of passing between rod 60 and valve element 104 with considerable freedom. Packing 64, supported in stuffing box 62 by means of a ring 112 bolted to valve block 63 prevents intercommunication of driving liquid in chamber 110 with pulsator return actuating fluid in chamber 82.

It will be understood that the single pump shown in FIGURES 1A and 1B is one of a pair of pumps which are adapted to function as a unit. The second pump is identical in all respects with the pump disclosed herein in detail, and certain of these identical parts have been identified by corresponding numbers primed. The operation of the system shown in FIGURE 3 will be outlined below.

The operation of pump 46 forces driving liquid from an oil reservoir through line 48 into line 24 and thus applying pressure to the air in space 42 of the accumulator 38. Both the pump 46 and the accumulator 38 communicate with the distributing valve 16 through line 24. The reciprocating motion of the spindle 18 (see FIGURE 2) causes flow of driving liquid to be directed alternately to line 12 and to line 12'. At one limit of travel of the spindle 18 (see FIGURE 2), driving liquid is directed through line 12 into passage 14, thus extending pulsator 2. At this time the pressure in the air space 94 of accumulator 91 forces oil into chamber 82' of the second pump, thus effecting collapse of pulsator 2'. At the other limit of travel of the spindle 18, driving liquid from line 24 is directed through line 12' into chamber 14' causing extension of pulsator 2'. The extension of pulsator 2' is tied in, by means of rod 60', with compression of the oil in chamber 82' which communicates with chamber 82 through line 88. Piston 84 (see FIGURE 1B) is thus forced upward, and, by virtue of its connection to pulsator 2, casing 10 is collapsed. It will be apparent that only a single pulsator return system including accumulator 91 and associated pressurizing system communicating with line 88 is necessary in a pumping system comprising two pulsators.

Inlet ports 110 and 110' are connected in parallel. Likewise, outlet ports 112 and 112' are connected in parallel. By virtue of the alternation in the contraction and extension of the two pulsators substantially continuous flow of fluid is achieved between parallel inlet and outlet ports.

The main advantage of the present invention is that the pulsators by virtue of the extensibility of their folded casings are capable of displacing a large amount of liquid in each stroke. The diameter of the drum 50, and thus the overall horizontal dimensions of the pumps may be minimized.

Another advantage of the present invention is that noise due to the sudden exposure of chambers containing driving liquid at greatly differing pressures is greatly reduced due to the incorporation of an accumulator in the line leading from the driving pump to the distributing valve. Damage to the distributing valve by reason of exposure of chambers containing driving liquid at greatly differing pressures is also eliminated to a large extent by this accumulator.

It will be understood that various departures from the specifically disclosed pump may be made without departing from the scope of the invention as defined by the following claim.

What is claimed is:

A pump comprising a chamber having at least one opening for the inflow and outflow of pumped fluid; a pulsator within said chamber provided by a flexible, expandible member comprising a plurality of alternately inwardly and outwardly extending rounded annular folds, said expandible member being mounted, at one end, to a boundary of said chamber and closed at its other end by a rigid member, said pulsator separating said chamber into an outer region surrounding the pulsator for the reception of pumped fluid and an inner region for the reception of driving fluid; means controlling the flow of driving fluid into and out of said inner region thereby effecting expansion and permitting contraction of said pulsator; and means engaging and preventing radial expansion of at least one of said inwardly extending folds, the last means comprising an inextensible toroidal member having an axial cross-section which is substantially circular in the region of engagement with said inwardly extending fold, the radius of curvature of the circular portion of said cross-section being substantially greater than the thickness of the wall of said expandible member, said toroidal member being supported between adjacent pairs of outwardly extending folds, whereby the pulsator variably embraces said toroidal member during its expansion and contraction without substantial frictional sliding relative thereto.

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