Oct. 25, 1966

M. B. SENNET ET AL

3,280,749

PUMPS

Filed Nov. 6, 1964

3 Sheets-Sheet 1

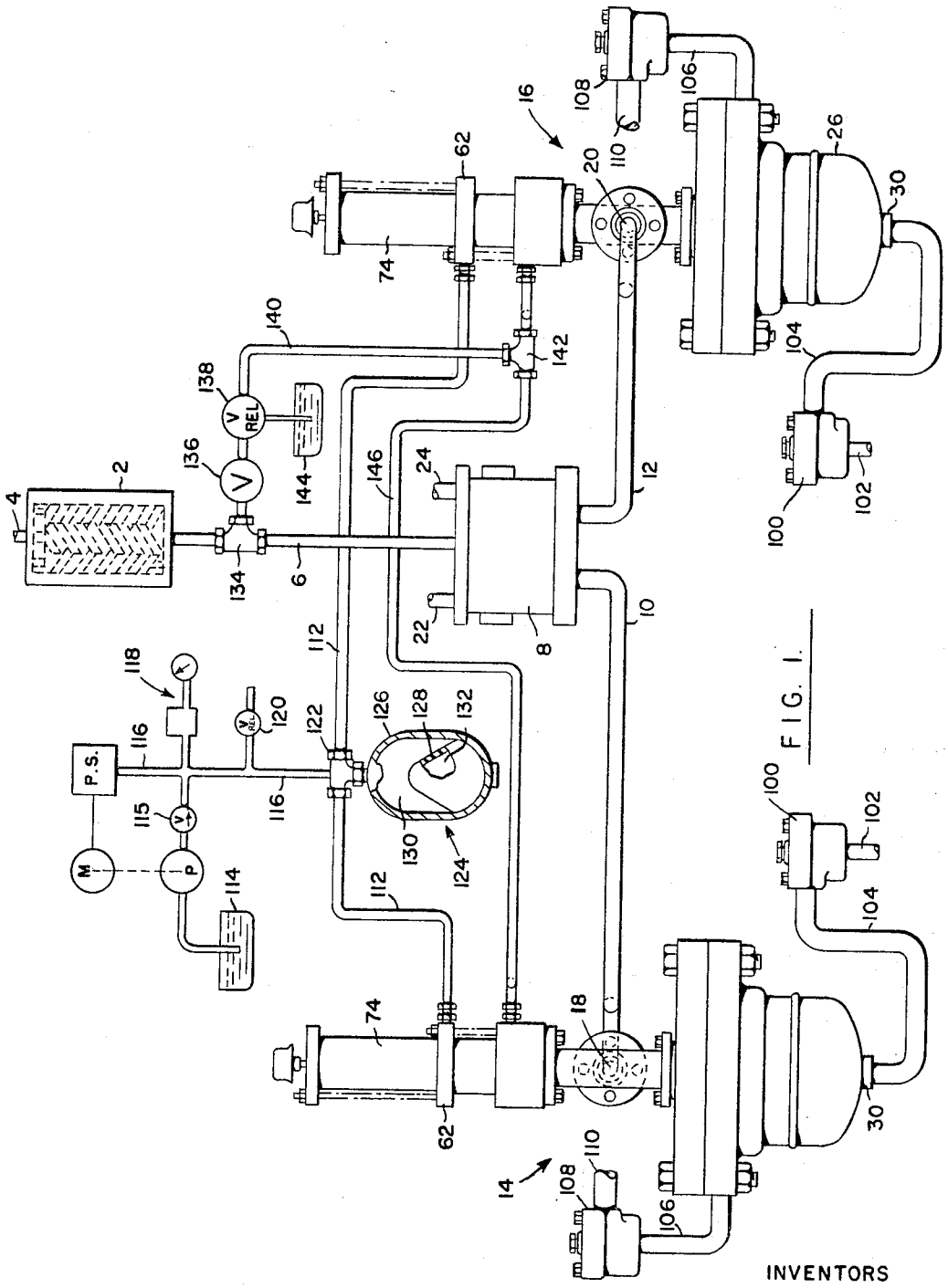


FIG. 1.

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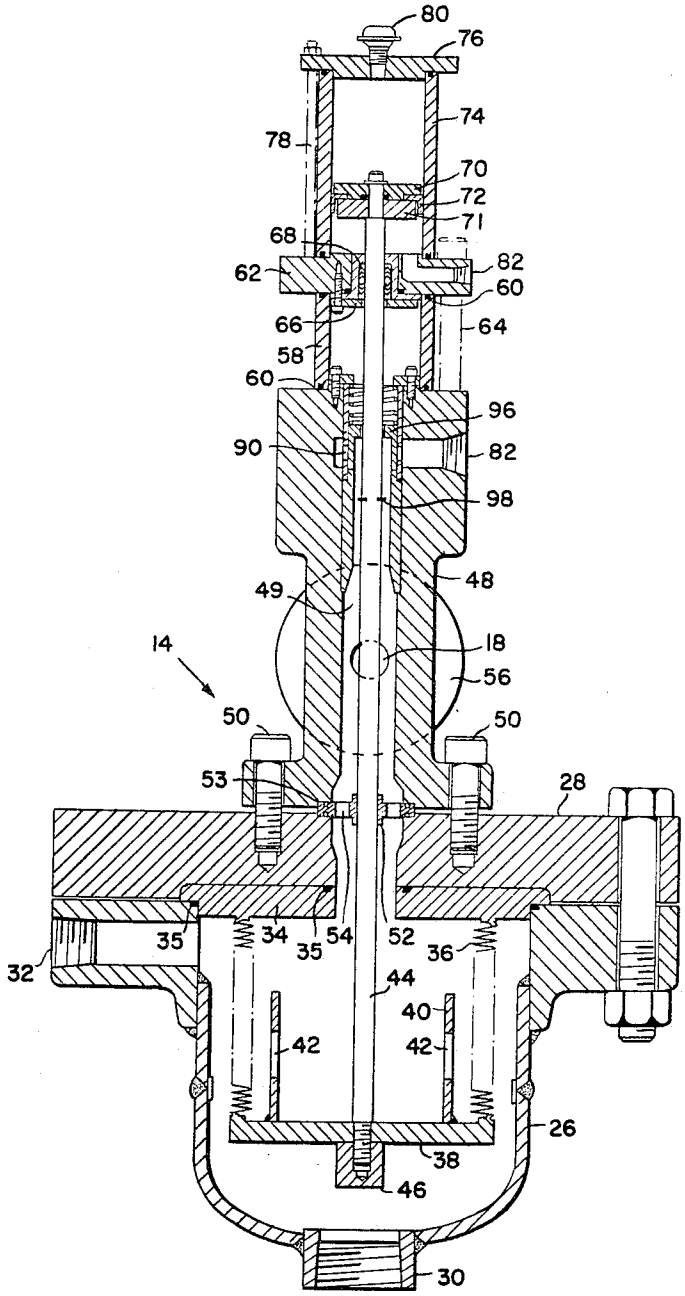


FIG. 2.

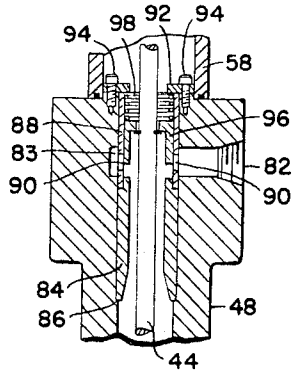


FIG. 3.

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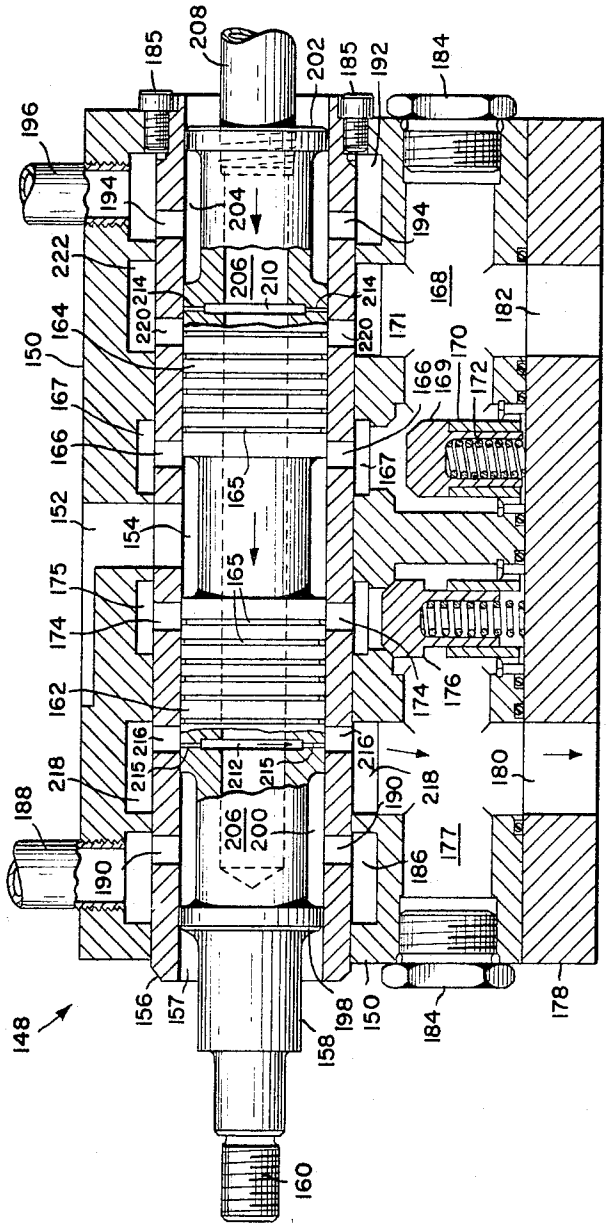


FIG. 4.

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PUMPS

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Filed Nov. 6, 1964, Ser. No. 409,368
5 Claims. (Cl. 103—49)

This invention relates to pumps, and particularly to pumps of the "pulsator" type, which have particular utility in the pumping of corrosive liquids and liquids containing suspended solid material at high pressures. A pulsator pump of this general type is disclosed in United States Patent 3,080,821, issued March 12, 1963.

A typical pulsator pumping system consists, basically of, a pair of pulsator pumps, a driving pump and a distributing valve. A pulsator pump operates on a hydraulic exchange principle wherein pressure energy is transferred from a driving medium such as oil to the hydraulic product by means of a pulsator membrane separating the driving medium and the product. In operation, the driving pump delivers oil from a reservoir in substantially continuous flow to the inlet of the phasing valve, which operates to deliver oil alternately to the interior of the first pulsator and to the interior of the second pulsator. With proper design, the flow of product can be made to be almost uniform and continuous.

A problem inherent in pumping systems of this type results from the natural compressibility of hydraulic oil, rubber and pumped fluids and from the expansion of piping and pressure vessels at high pumping pressures. During the "cross-over" period of the phasing valve, the pressure in the interior of the pulsator about to be expanded by driving oil from the phasing valve is decreased somewhat below the pressure of the head being pumped against due to the compression and expansion effects mentioned above. Consequently, a delay occurs during which the pressure within the pulsator is brought up to the discharge pressure of the system before any fluid can be displaced from the chamber. This delay is periodic and corresponds to the time required for the driving pump to pressurize the pulsator to equalize the pressure of the head. This delay causes a periodic momentary drop in displacement of the pulsator, and a corresponding periodic drop in the product system pressure occurs.

The present invention provides several alternative modifications to pumping systems of the pulsator type, each of which virtually eliminates this problem. In accordance with this invention a means is provided to "prepressurize" the interior of the contracted pulsator during the "dwell time" of the pulsator, that is, the period during which the pulsator is in its uppermost position. This prepressurization, then, occurs just before the cross-over of the phasing valve.

In accordance with the present invention, the pulsator is prepressurized either from the main source of driving liquid or from a supplementary source so that, when the phasing valve crosses over to deliver driving liquid to the pulsator, all of the oil delivered through the phasing valve is utilized in displacing product.

It is therefore an object of the present invention to provide a new and improved pumping system utilizing pulsators, which provides a substantially continuous product flow and a substantially constant product pressure.

Other objects will become apparent from the following description when read in conjunction with the accompanying drawings in which:

FIGURE 1 is a diagrammatic view of a pumping system in accordance with the present invention;

FIGURE 2 is a sectional view of a pulsator pump showing a modification in accordance with the present invention;

FIGURE 3 is a detailed section of the modification shown in FIGURE 2 which illustrates, along with FIGURE 2 the operation of the modification; and

FIGURE 4 is a sectional view of a modified phasing valve, showing a further embodiment of the present invention.

The invention will first be described with reference to FIGURE 1 and then to FIGURE 2 to illustrate the parts of the pulsator pumping system and the construction of the pulsator already known in the art, since these are operable without the modifications provided by the present invention. Reference will then be made to FIGURES 2 and 3 to illustrate the preferred embodiment of the invention, and reference will be made to FIGURE 4 to show a further embodiment.

Referring to FIGURE 1 a positive screw pump **2** is shown, this pump being of the type disclosed in United States Patent 1,965,557, issued July 3, 1934. Screw pump **2** receives oil from a reservoir through its inlet passage **4**, and delivers oil in substantially continuous flow through line **6** to the inlet of phasing valve **8**, which is designed to deliver oil or driving fluid from line **6** alternately to line **10** and to line **12**. A phasing valve of this type is disclosed in United States Patent 2,836,121, issued May 27, 1958. This phasing valve is driven by a motor (not shown) which operates at a speed such that, considering the maximum rate of delivery from screw pump **2**, it will operate the phasing valve at such a rate that neither of the pulsators will reach their maximum limit of expansion. Displacement of product by the pulsator pumps is varied by adjusting the delivery of screw pump **2** which is desirably operated by a variable speed motor.

A pair of pulsator pumps **14** and **16** are shown receiving driving liquid from the phasing valve **8** through lines **10** and **12**, respectively. Driving liquid enters the interior of the pulsators through ports **18** and **20** on the respective pulsator pumps.

On the phasing valve, as disclosed in Patent 2,836,121, passages **22** and **24** are outlet passages provided to return exhausted driving fluid from the interiors of the pulsators to the driving liquid reservoir communicating with passage **4**.

Referring to FIGURE 2, the details of pump **14** are shown. A bowl-shaped enclosure **26** is fastened by bolts to a top member **28** to define a chamber for the product to be pumped. A threaded opening **30** is provided at the bottom of an enclosure **26** as an inlet passage for the product, and a threaded outlet passage **32** is provided near the top of enclosure **26**. These passages communicate with the usual check valves.

A ring-like member **34** rests on the top of enclosure **26**, and sealing rings **35** are provided to prevent escape of driving liquid and product from the enclosure.

A cylindrical bellows **36** is fastened at its upper end to member **34**, and at its lower end to a plate **38**. Members **34**, **36** and **38** define the pulsator interior. A hollow cylinder **40** is welded to the top of plate **38** and is provided with a plurality of openings **42**. An elongated return rod **44** is threaded at its lower extremity and is fastened to plate **38** by means of a threaded cap **46**.

An enclosure **48** having an interior passage **49** is fastened above top member **28** by bolts **50** clamping a spidered bearing **52** between members **48** and **28**. This bearing is provided with sealing rings **53** to prevent the escape of driving liquid between members **48** and **28**, and openings **54** provide communication between passage **49** and the interior of the pulsator. A flange **56** is provided on the exterior of enclosure **48** for the connection of a driving liquid pipe to passage **18**.

Resting on the top of of enclosure **48** is a hollow cylindrical enclosure **58** provided with sealing rings **60** at its upper and lower ends. Block **62** is provided to rest

on enclosure 58 and enclosure 58 is clamped between block 62 and member 48 by a plurality of bolts 64.

The upper portion of rod 44 passes through a clamping ring 66 bolted to the underside of block 62 and through packing 68 held in position within block 62 and ring 66.

A piston comprising clamping members 70 and 71 and sealing member 72 clamped between them is fixed to the upper end of rod 44. The piston, which will, for simplicity, be referred to as piston 70 is arranged to reciprocate within a cylinder provided by member 74. Member 74 is clamped between a top closure 76 and block 62 by a plurality of bolts 78. An opening is provided in top closure 76 for the escape of air within the space above piston 70, and a dust cover 80 is provided above this opening.

Referring to FIGURES 2 and 3, the upper portion of enclosure 48 is provided with a partially threaded passage 82 leading to a circular groove 83 provided in the wall of the interior of enclosure 48. A cylindrical supporting member 84 rests on the bottom edge 86 of a larger circular groove in the inner wall of enclosure 48 of which groove 83 is a part. A cyclinder 88 provided with a plurality of transverse openings 90 is clamped within enclosure 48 between member 84 and a circular clamping ring 92. Clamping ring 92 is fastened to the top of enclosure 48 by bolts 94 and holds cylinder 88 in fixed relationship with respect to enclosure 48. Cylinder 88 tightly engages the wall of enclosure 48 so that passages 90 provide the only access from groove 83 to the interior of the enclosure.

A cylindrical valve member 96 is arranged to slide within cylinder 88 and is urged downwardly by coil spring 98 acting against the underside of ring 92.

A flange 98, fixed to the return rod 44 is arranged, as depicted in FIGURES 2 and 3 to engage the inside of valve member 96 and to raise this valve member when return rod 44 is raised under the action of piston 70. As shown in FIGURE 3, passages 90 are closed off by valve member 96 when it is in its lowermost position resting against the top of member 84. From FIGURES 2 and 3, it will be apparent that, when the pulsator approaches its uppermost position (when member 40 engages member 34), valve member 96 will be raised opening passage 82 to the interior of enclosure 48 and, consequently, to the interior of the pulsator.

Again referring to FIGURE 1, inlet valves 100 are shown. Valves of this type are disclosed in detail in United States Patent 2,977,974, issued April 4, 1961. For present purposes it will be sufficient to say that these valves are automatically operated one-way valves permitting flow of liquid from line 102 to line 104, but prohibiting flow in the opposite direction. A pair of valves 100 is provided in accordance with the present invention, the outlet lines 104 of each valve communicating with the inlet passages 30 to the respective pulsator pumps. Both inlet lines 102 lead to the source of liquid to be pumped. The outlet passage of each pulsator pump communicates through a line 106 to the inlet of a one-way check valve 108 similar to valves 100. The outlet lines 110 of both valves 108 are ordinarily connected to a single outlet line.

A return line 112 connects both passages 82 in blocks 62 together. A substantially constant pressure of oil in this line is maintained by a pump P receiving liquid from reservoir 114 and feeding it through a one-way check valve 115, and through line 116 to line 112. Pressure-responsive switch P.S. is arranged to sense pressure in line 116 and to operate motor M when the pressure in line 116 exceeds a certain predetermined value. Motor M, in turn, drives pump P to maintain pressure in line 112. An indicating mechanism 118 is provided to give a visual indication of the pressure in line 116 and a relef valve 120 is provided to open when the pressure in line 116 greatly exceeds that which would be normal. Such a condition might arise from failure of the pressure responsive switch to open.

A T-connection 122 is provided at a point along line 112, and an accumulator 124 communicates with line 112 through this T-connection. Accumulator 124 consists of a housing 126 within which is disposed an elastic membrane 128 of synthetic rubber or the like which separates the interior of housing 126 into two chambers 130 and 132. Chamber 130 communicates directly with line 112 through the T-connection 122. Chamber 132 is filled with compressed air to a pressure such that if chamber 130 were subjected only to atmospheric pressure, chamber 132 would substantially fill the entire housing 126.

Disposed along line 6 connecting the driving pump 2 with the inlet to the phasing valve 8 is a T-connection 134 permitting communication of the inlet to a valve 136 to communicate with line 6. Valve 136 is manually operable. The outlet of valve 136 communicates with the inlet to a relief valve 138. The outlet of relief valve 138 communicates through line 140 with T-connector 142. The relief exit of relief valve 138 leads to an oil sump 144. T-connection 142 is disposed along a line 146 which connects passages 82 of the respective pulsator pumps together.

The operation of the particular embodiment of the invention just described is characterized by the following steps.

Consider the pulsator of pump 14 to be in its uppermost position, while the pulsator of pump 16 is in its lowermost position. At this time, flange 98 is holding valve member 96 in its upper position so as to open passages 90 to permit driving liquid from line 146 to pass through passage 82 to the interior of the pulsator of pump 14 to pre-pressurize it by pressure from driving pump 2 delivered through valves 136 and 138 and line 140. At this time, passages 90 in pump 16 are closed.

The phasing valve 8 crosses over to deliver driving liquid from line 6 through line 10 to the interior of the pulsator of pump 14. The pulsator of pump 14 descends forcing product out through passage 32, through line 106, through valve 108 and through line 110. Since valve 100 (on pump 14) is a check valve, product cannot flow out through passage 30.

As the pulsator of pump 14 descends, piston 70 is pulled downwardly by rod 44 causing oil within chamber 74 below the piston to be forced out through passage 82 and through line 112 to the interior of chamber 74 of pump 16. Piston 70 of pump 16 is forced upward by the pressure in line 112 since there is no longer pressure in line 12 to force the pulsator of pump 16 downward.

Referring now to pump 16, the upward movement of piston 70 causes the pulsator to contract by virtue of its connection to piston 70 through line 44, and product is drawn through line 102, through one-way valve 100 and through line 104 to the interior of chamber 26. Again, since valve 108 is a one-way valve, no flow can take place in the direction from line 110 to line 106.

It will be apparent that the oil maintained in line 112 prevents both pulsators from being expanded simultaneously, and that an alternating operation of the pulsators results from the alternating direction of flow of oil in line 112.

As the pulsator of pump 16 approaches its uppermost position, its valve comprising valve member 96 and passages 90 opens to permit prepressurization of the pulsator. When the phasing valve 8 crosses over to deliver the driving liquid through line 12, the pulsator of pump 16 begins to descend and the pulsator of pump 14 begins its ascent.

It will be apparent that the passages 90 within each pump close under the action of spring 98 shortly after the pulsator begins its descent, and open only as the pulsator approaches its upper limit. Thus, prepressurization occurs only when the pulsator has returned to the uppermost position in the pressure chamber.

The pressure in the prepressurizing system is controlled by relief valve **138**. Valve **136** is manually operable and can be closed off when prepressurization is not desired.

An alternative means for accomplishing prepressurization in a pulsator pumping system is depicted in FIGURE 4.

Phasing valve **148** can be used in the system of FIGURE 1 in place of phasing valve **8**, and this replacement eliminates the necessity for line **146** and the valve assemblies within enclosure **48** on each pump. Phasing valve **148** operates in a manner similar to phasing valve **8** whose operation is disclosed in Patent 2,836,121. In addition, however, it includes provisions for prepressurizing the pulsator chambers to obtain the same effect as in the system described above.

Phasing valve **148** comprises a housing **150** provided with an inlet passage **152** communicating with an interior chamber defined by member **156** having a circular bore **157** in which is provided a spindle valve member **158**. Valve member **158** is provided at one end with a threaded connector **160** which, in ordinary installations is connected to a reciprocating driving motor which causes the spindle valve to slide back and forth within bore **157**. the spindle valve is provided with a pair of cylinder portions **162** and **164**, each of which has a plurality of circular grooves **165** disposed along its exterior. These cylinders, with member **156** define a chamber **154** communicating with passage **152**. A pair of passages **166** is provided in cylinder **156** each of which communicates with a circular groove **167** in the housing. The lower part of groove **167** is opened to passage **168** in the lower part of the housing, and is adapted to be closed off by a check valve comprising member **169**, which is arranged to slide within cylinder **170**, and which is urged by coil spring **172** against valve seat **171** to close off the opening in groove **167**. Valve member **169** acts as a check valve, only permitting flow of liquid in the direction from groove **167** to passage **168**.

A similar pair of passages **174** is provided in cylinder **156** to communicate with a groove **175** in the housing. A passage at the bottom of groove **175** is closed off by check valve member **176**, which prevents flow in the direction from passage **177** to grooves **174**.

A member **178** completes part of the closure of the housing and provides a seat for the coil springs operating the check valves. Aligned passages in housing **150** and in member **178** form openings **180** and **182**. A pair of threaded plugs **184** complete the closing of the housing.

A pair of bolts **185** are provided between housing **150** and cylinder **156** to prevent rotation of the cylinder with respect to the housing.

A circular groove **186** is provided in housing **150** about cylinder **156**, and an outlet passage **188** is provided to direct driving liquid within this groove to a sump. A pair of passages **190** in cylinder **156** provide connection between groove **186** and the interior of the cylinder. Housing **150** is provided with a similar groove **192** near its opposite end. Passages **194** provide connection between this groove and the interior of cylinder **156**, and an outlet to a sump is provided by passage **196**.

A ring portion **198** is provided on spindle valve **158** to provide an enclosure for space **200** between the spindle valve and cylinder **156**. Ring portion **202** at the other end of the spindle valve provides a similar space **204**.

The operation of the valve as a phasing valve alone will now be described with a view toward a better understanding of the subsequent simple modifications.

Passage **152** receives driving fluid under pressure from a positive displacement pump. Spindle valve **158** is now moving toward the left. With the spindle valve **158** in the position shown in the drawing, driving liquid is passing through chamber **154**, and through passages **166** into groove **167**. Valve member **169** is forced open by this liquid, which is directed through passage **158** and through opening **182** to a line leading to the interior of one of the pulsators. The pulsator associated with opening **182** is almost fully expanded when the valve is in this position.

The spindle valve then moves toward the left under the action of driving motor, closing off openings **166** and directing driving liquid from passage **152** through openings **174** into groove **175**. Check valve member **169** closes at this time, while member **176** opens. Driving liquid is then delivered to the interior of the other pulsator through passage **177** and opening **180**. A pair of passages **216** are provided in cylinder **156** and communicate with groove **218** in the housing. Groove **218** is continually opened to passage **177**. A pair of passages **220** is similarly provided in the cylinder **156** to communicate with groove **222** in the housing.

As the spindle valve moves further toward the left, passage **220** opens, and driving liquid from the interior of the now contracting pulsator associated with opening **182** is allowed to pass through openings **220**, through space **204**, and through openings **194** to the sump by way of passage **196**. When the other pulsator is collapsing, driving liquid is directed to the sump through passage **188** by a similar provision comprising passage **216**, space **200**, passage **190** and groove **186**.

As mentioned previously, the spindle valve reciprocates at a rate such that neither of the pulsators reaches the maximum limit of its expansion. During the cross-over of valve member **158**, passages **166** and **174** are momentarily opened to each other. Valves **169** and **176** prevent backflow of driving liquid from one pulsator to the other through passages **174** and **166**, when member **158** crosses over.

With regard to modification providing prepressurization, passage **206** is provided along the axis within spindle valve **158**, and is adapted to receive liquid through line **208**. A pair of annular grooves **210** and **212** are provided in this passage and restricted passages **214** and **215** lead from these grooves, respectively, to the exterior of members **164** and **162**. Groove **222** is continually opened to passage **168**. If line **208** is connected through either a flexible hose or a liquid-tight sliding connector to a source of driving liquid under high pressure such as line **140** in FIGURE 1, a prepressurizing operation essentially the same as that obtained with the previous arrangement will occur.

When the spindle valve **158** is in the position shown in the drawing, the pulsator associated with opening **182** is approaching its lowermost position, while the pulsator associated with opening **180** is in its uppermost position. The latter pulsator receives driving liquid from line **208** through passage **206**, through openings **215** and through passage **177**. The flow of prepressurizing liquid is designated by arrows.

As the spindle valve moves further to the left, passages **215** are closed off, driving liquid passes through passages **174** to expand the prepressurized pulsator, and the passages **214** associated with groove **210** are opened to passages **220** momentarily. As the spindle valve moves further to the left, driving liquid in the pulsator associated with opening **182** is forced through passages **220** and through space **204** and passages **194** to passage **196** leading to the sump. The last-mentioned pulsator is then permitted to contract, and is prepressurized upon reopening of passages **220** to passages **214** when the spindle valve moves toward the right.

As the spindle valve moves further toward the right, passages **166** are opened, causing the pulsator associated with passage **182** to expand again, and driving liquid from the other pulsators is forced out through passage **188** to the sump.

During each cycle, passages **215** are opened to passages **216** twice, and passages **214** are opened to passages **220** twice. Prepressurization is accomplished only during

one of these openings. The other opening occurs momentarily at the time when the pulsator is fully expanded, and since passages 214 and 215 are quite restricted, very little prepressurizing liquid is permitted to flow through them, and no substantial change in the operation of the pumping system occurs.

It will be apparent that the results obtained through the use of both embodiments of the present invention are substantially the same. By prepressurizing the pulsators just before their expansion, better continuity in product flow is obtained, and a substantially constant product pressure is achieved. It will be apparent that various other modifications can be made to the pumping system of the present invention, and, accordingly, it is not desired to be limited except by the following claims.

What is claimed is:

1. A pump comprising a pair of chambers having openings for the inflow and outflow of pumped liquid, pulsators within said chambers separating said chambers into outer regions for the reception of pumped liquid and inner regions for the reception of driving liquid, a source of driving liquid under pressure, means directing flow of driving liquid from said source alternately into each of said inner regions of said pulsators effecting alternate expansions thereof, and additional valve-controlled means directing an initial volume of driving liquid from said source to the inner region of each said pulsator when said pulsator is completely collapsed and prior to movement thereof, thereby to prepressurize said pulsator prior to its expansion by said driving liquid.

2. A pump comprising a pair of chambers having openings for the inflow and outflow of pumped liquid, pulsators within said chambers separating said chambers into outer regions for the reception of pumped liquid and inner regions for the reception of driving liquid, a source of driving liquid under pressure, means directing flow of driving liquid from said source alternately into each of said inner regions of said pulsators effecting alternate expansions thereof, and additional valve-controlled means directing an initial volume of driving liquid under pressure to the inner region of each said pulsator when said pulsator is completely collapsed and prior to movement thereof, thereby to prepressurize said pulsator prior to its expansion by said driving liquid.

3. A pump comprising a pair of chambers having openings for the inflow and outflow of pumped liquid, pulsators within said chambers separating said chambers into outer regions for the reception of pumped liquid and inner regions for the reception of driving liquid, a source of driving liquid under pressure, means directing flow of driving liquid from said source alternately into each of said inner regions of said pulsators effecting alternate expansions thereof, means effecting contraction of each said pulsator when driving liquid is directed into the said inner region of the other one of said pulsators, and valve means operable by said means effecting contraction of each said pulsator for admitting driving liquid into the inner region of each said pulsator when said pulsator is completely contracted.

4. A pump comprising a pair of chambers having openings for the inflow and outflow of pumped liquid, pulsators within said chambers separating said chambers into outer regions for the reception of pumped liquid and inner regions for the reception of driving liquid, a first source of driving liquid under pressure, means directing driving liquid from said first source alternately into each of said inner regions of said pulsators effecting alternate expansions of said pulsators, means for effecting contraction of said pulsators, and a second source of driving liquid under pressure, said means directing driving liquid from said first source including means for directing driving liquid from said second source to the inner region of each said pulsator when said pulsator is completely contracted.

5. A pumping system comprising a pair of pulsator pumps, a source of driving liquid under pressure, means directing driving liquid from said source alternately to each of said pulsator pumps to effect alternate expansions thereof, a rod means for effecting positive contraction of each said pulsator, an additional source of driving liquid, and valve means for admitting driving liquid from said additional source to prepressurize each said pulsator when said pulsator is in its contracted condition, said valve means being operable by said rod means.

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