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Kelley

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[54] **PUMP HAVING SPRING-LOADED PISTON SHAFT ASSEMBLY**

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[52] **U.S. Cl.** **60/539;** 92/DIG. 4; 92/113; 417/385; 417/471

[51] **Int. Cl.**[2]..... **F15B 7/02;** F01B 3/00; F04B 9/08; F04B 19/00

[58] **Field of Search** 417/385, 471; 92/84, 113, 92/DIG. 4; 74/18.2; 60/539

[56] **References Cited**

UNITED STATES PATENTS

3,109,282	11/1963	Price	92/DIG. 4
3,353,606	11/1967	Dyer	74/18.2
3,392,674	7/1968	Schlosser	417/385
3,669,575	6/1972	Beckerer	74/18.2
3,831,999	8/1974	Sonneborn	92/DIG. 4

FOREIGN PATENTS OR APPLICATIONS

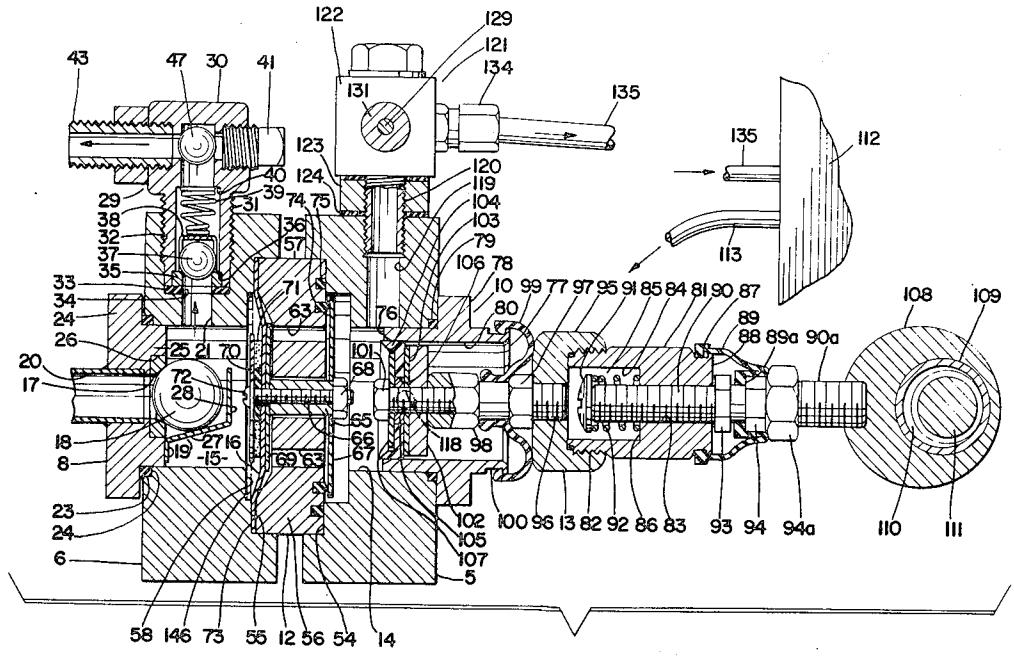
186,075	9/1955	Austria	92/113

Primary Examiner—William L. Freeh
Assistant Examiner—G. P. La Pointe
Attorney, Agent, or Firm—Isler and Ornstein

[57] **ABSTRACT**

A pump is disclosed of the type utilizing a diaphragm and a spring-loaded piston shaft assembly. The assembly is characterized by the use of a piston having a delayed movement on the suction stroke of the assembly, whereby cavitation effects usually occuring in piston-operated pumps are eliminated.

4 Claims, 4 Drawing Figures



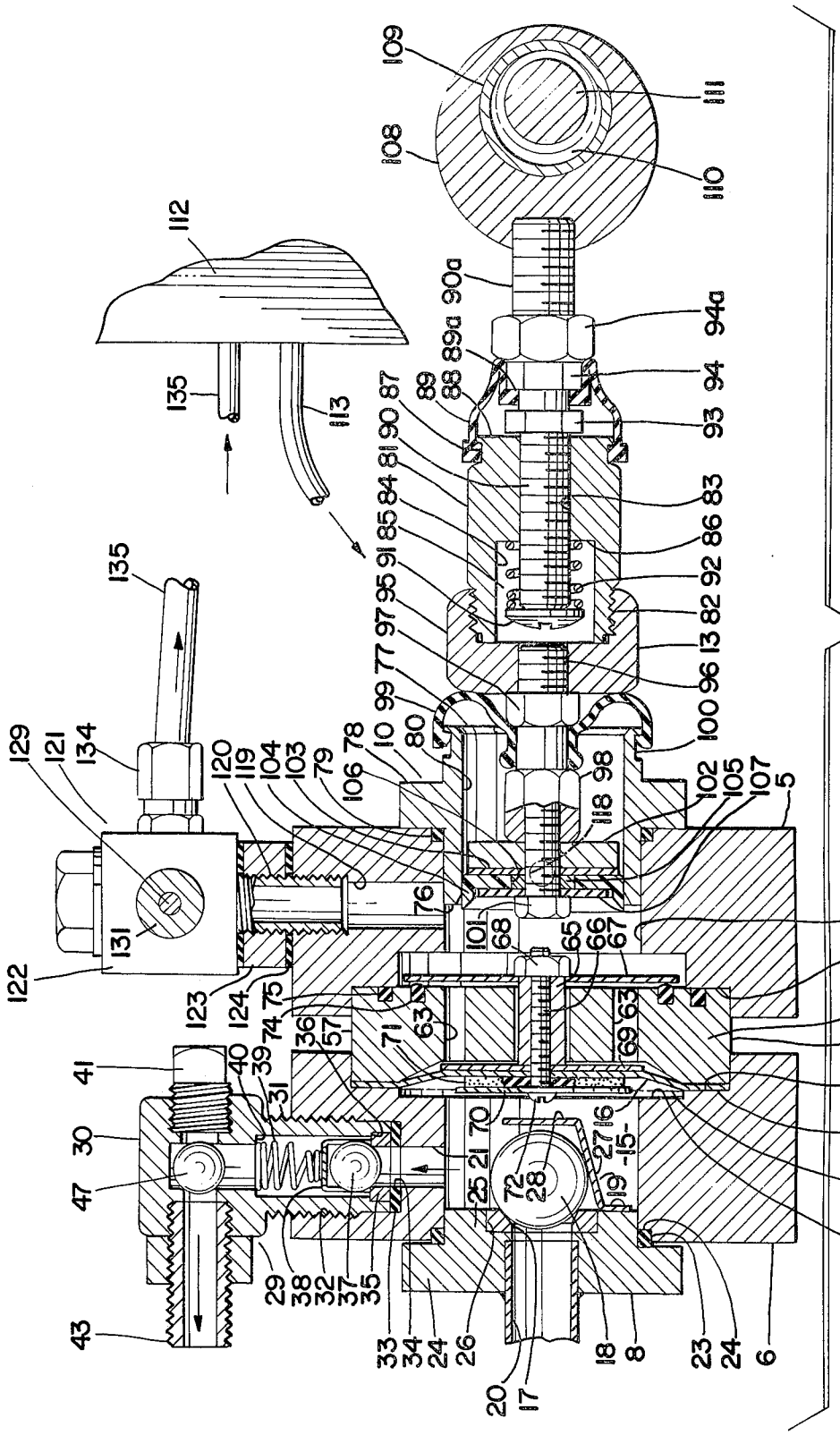

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Fig. 1

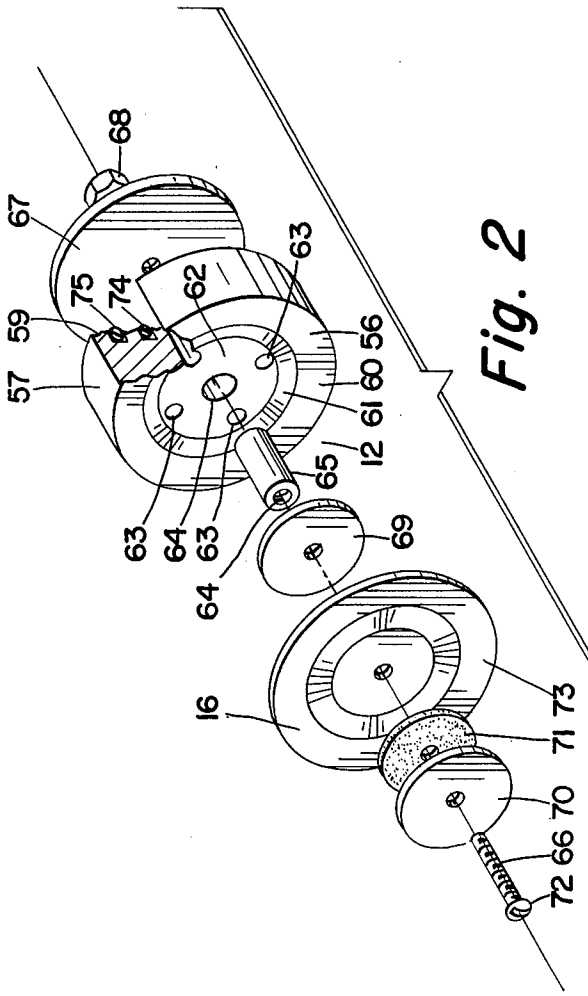

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Fig. 2

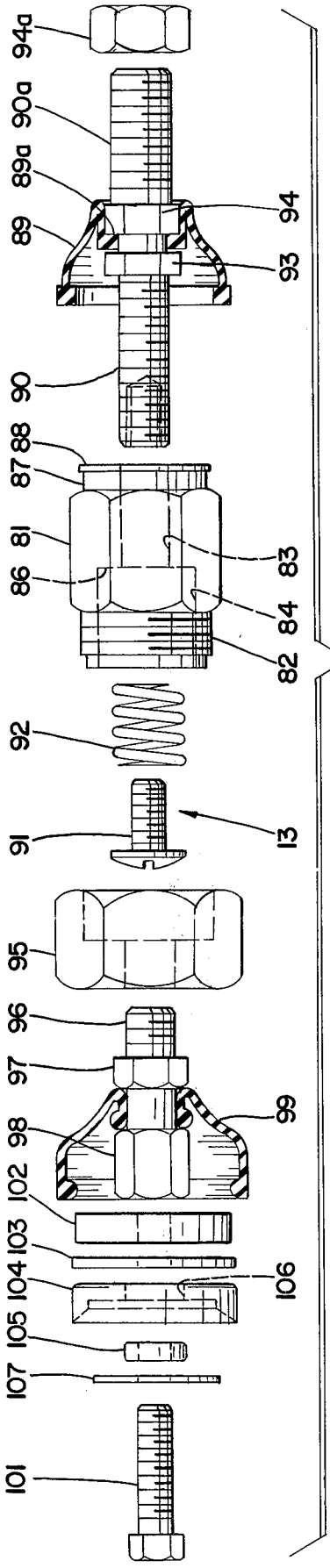

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Fig. 3

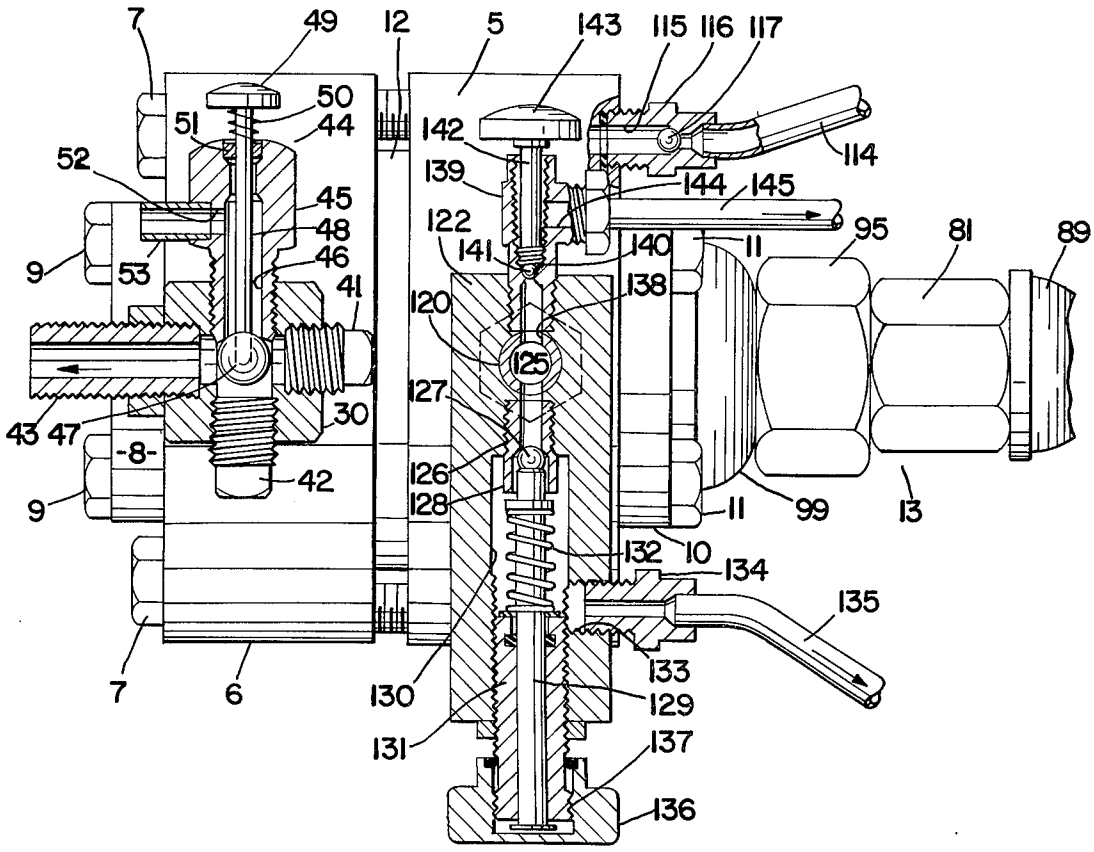

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Fig. 4

PUMP HAVING SPRING-LOADED PISTON SHAFT ASSEMBLY

This invention relates, as indicated, to pumps, but has reference more particularly to pumps of the type used for airless spraying, and which have incorporated therein a novel spring-loaded piston shaft assembly designed to eliminate cavitation effects in such pumps.

In Schlosser U.S. Pat. No. 3,392,674, a pump is disclosed having a pair of compartments sealingly separated by a flexible diaphragm, a hydraulic fluid being pumped in and out of the first compartment through inlet and outlet valves by a piston reciprocating in a cylinder sealed from the atmosphere, and the diaphragm being actuated by the hydraulic fluid to pump a second liquid in and out of the second compartment through inlet and outlet valves.

The hydraulic fluid is pumped from a reservoir into the first compartment through an inlet check valve by the suction stroke of the piston, but only a relatively small volume of driving fluid is thus introduced compared to the volume displaced by the suction movement of the piston. This results in cavitation within the first compartment, or piston cylinder, that is to say, the formation of a partial vacuum in the compartment or cylinder.

The difference between the piston-displaced volume and the volume of driving fluid entering through the inlet valve is stated in the aforesaid patent to be made up by the closing movement of the aforesaid flexible diaphragm, but, in actual practice, this movement is insufficient to completely obviate the cavitation effect, with the result that the pump is not as efficient in operation as would be desired.

The present invention has as its primary object the incorporation in a pump of the aforesaid character or type of a spring-loaded piston shaft assembly which is effective not only to completely obviate the cavitation effect, but to enable the pump to operate in a more highly efficient manner than has previously been possible.

Another object of the invention is to provide an assembly of the character described, which consists of a minimum number of easily manufactured and assembled parts, which can be incorporated in such a pump without appreciable increase in the overall cost of the pump, and without the aid of special tools or assembly technique.

Other objects and advantages of my invention will be apparent during the course of the following description.

In the accompanying drawings forming a part of this specification, and in which like numerals are employed to designate like parts throughout the same,

FIG. 1 is a side elevational view, partly in section, showing an embodiment of a pump constructed in accordance with the invention, and having incorporated therein the spring-loaded piston shaft assembly, which is the principle feature of the invention;

FIG. 2 is an exploded perspective view of an assembly which forms a part of the pump of FIG. 1, with a portion broken away to show a constructional detail;

FIG. 3 is an exploded view of the spring-loaded piston shaft assembly, and

FIG. 4 is a plan view, partially in section and partially cut away, of the pump of FIG. 1.

Referring more particularly to the drawings, the pumps, in this instance, comprises first and second

housing portions designated generally by reference numerals 5 and 6, which are secured together by bolts 7 (FIG. 4).

Each housing portion has a first or inner open end in mutually facing disposition and a second or outer open end opposite the first open end. The outer open end of the housing portion 6 is closed by an end member generally designated by reference numeral 8 and secured to housing portion 6 by bolts 9 (FIG. 4). Secured within the outer open end of housing portion 5 is a hollow cylinder, generally designated by reference numeral 10, and attached thereto by bolts 11 (FIG. 4).

Disposed between housing portions 5 and 6, at the mutually facing inner open ends thereof, is a separator assembly, generally indicated by reference numeral 12. This separator assembly is free floating in the sense that it is not secured by fasteners to either of the housing portions 5 and 6, but is clamped therebetween. Located within cylinder 10 is the piston end of a spring-loaded piston shaft assembly, generally designated by reference numeral 13, and which will presently be described in detail.

The first housing portion 5, separator assembly 12, cylinder 10 and piston end of the piston shaft assembly 13, define a driving fluid chamber 14. The second housing portion 6, separator assembly 12, and end member 8, define a driven fluid chamber 15.

In operation, the piston end of the piston shaft assembly 13 reciprocates in inward and outward directions within cylinder 10 (to the left and right respectively, as viewed in FIG. 1). When the piston end of the piston shaft assembly 13 moves inwardly, driving fluid within the chamber 14 is urged against separator assembly 12, causing a flexible, fluid impermeable diaphragm 16, constituting a part of the separator assembly 12, to flex to the left, as viewed in FIG. 1. When the piston end of the piston shaft assembly 13 moves outwardly, the pressure within driving fluid chamber 14 is decreased and flexible diaphragm 16 is urged to the right, as viewed in FIG. 1.

When diaphragm 16 is urged to the right, pressure within driven fluid chamber 15 is decreased, an inlet valve 17, 18 and 19 is opened, and driven fluid is drawn into chamber 15 through an inlet conduit 20. When diaphragm 16 is urged to the left, driven fluid within chamber 15 is expelled therefrom through an outlet channel 21 in housing portion 6. Separator assembly 12 prevents mixing of the respective fluids in compartments 14 and 15.

The components which define driven fluid chamber 15 will now be described in more detail.

End member 8 includes an outer portion 22 which bears against an O-ring seal 23 received within a circular indentation 24 located around the outer open end of housing portion 6. End member 8 also includes an inner portion 25 extending within housing portion 6 and including an inner recess 26 holding a valve seat 12 composed of a hard, wear-resistant material, such as tungsten carbide, and constituting part of the inlet valve. The inlet valve also includes a ball 18 normally maintained in a seated position, closing inlet conduit 20, by a retainer indicated generally at 19.

Retainer 19 is constructed of a spring material and includes an inclined portion 27 and an upright portion 28 extending upwardly from inclined portion 27. Inclined portion 27 normally urges ball 18 in a downward direction to maintain the ball in a seated position against seat 17, thereby closing inlet conduit 20.

When diaphragm 16 is urged to the right, as viewed in FIG. 1, the pressure within driven fluid chamber 15 to the right of ball 18, becomes less than the pressure within inlet conduit 20, and this urges ball 18 to the right upwardly along inclined retainer portion 27 against the urging of gravity. The movement of ball 18 up inclined portion 27 is restrained by upright portion 28 of retainer 19. The distance between upright portion 28 and the inlet defined by valve seat 17 is less than the diameter of the ball. The movement of the ball 18 off the seat 17 permits fluid to enter the chamber 15 from the conduit 20.

When flexible diaphragm 16 stops flexing to the right, ball 18 rolls downwardly along inclined retainer portion 27 to the closed portion shown in FIG. 1. When diaphragm 16 flexes to the left, driven fluid is expelled out of driven fluid compartment 15 through outlet channel 21 and opens an outlet valve assembly designated generally by reference numeral 29 in FIG. 1.

Valve assembly 29 includes an upper portion 30 from which depends an externally threaded, cylindrical portion 31 threadedly engaged within a threaded opening 32 communicating with outlet channel 21 in housing portion 6. The innermost end of cylindrical portion 31 presses against a gasket 33 resting atop a shoulder 34 at the innermost end of threaded opening 32 in housing portion 6. Located atop gasket 33 is an annular valve seat 35 held in place by an interior shoulder 36 on valve housing portion 31. A ball 37 normally rests on seat 35.

When fluid is expelled from compartment 15, ball 37 is raised upwardly by the expelled fluid to permit the fluid to flow therearound and upwardly through the interior of the housing portion 31. Upward movement of the ball 37 is limited by a retainer 38 held in place by the lower end of a spring 39, the upper end of which engages an interior shoulder 40 in valve upper portion 30.

Valve upper portion 30 has four internally threaded channels therein, spaced 90° apart. In the illustrated embodiment, two of these channels, as best seen in FIG. 4, are closed by externally threaded plugs 41, 42, these channels normally performing no function, but being available for connection of externally threaded outlets such as 43, shown received in one of the other threaded channels in valve portion 30.

The fourth channel on valve portion 30 receives an air relief valve for driven fluid compartment 15. This valve is indicated generally at 44 in FIG. 4 and includes housing 45 having an elongated, hollow, cylindrical portion 46 terminating in an inner open end normally closed by a ball 47 attached to one end of a rod 48 having another end extending outwardly from housing 45 and terminating at a button 49 normally urged in an outward direction by one end of a spring 50, the other end of which seats against an annular member 51 located in a recess at the outermost portion of housing 45. Housing 45 also includes a port 52 communicating with a conduit 53 through which air is expelled in a manner now to be described.

Assuming there is air within driven fluid compartment 15, the air can be released while the pump is operating merely by depressing button 49. This pushes ball 47 inwardly, thus opening the innermost end of housing 45 to communication with compartment 15 and permitting air from compartment 15 to pass through hollow cylindrical portion 46, through port 52 and through outlet conduit 53. Button 49 is held depressed until driven fluid is expelled through outlet 53, and this indicates that compartment 15 has been purged of air. Button 49 is then released, and spring 50 returns button 49, rod 48 and ball 47 outwardly to their normal closed positions in which ball 47 blocks entry to fluid into valve housing 45. After ball 47 returns to its closed position, continuing operation of the pump builds up the fluid pressure, around the exterior of ball 47, urging the ball outwardly and preventing it from being moved inwardly from its normally closed position. This prevents button 49 from being depressed while the pump is in operation at a time after air has been expelled from driven fluid compartment 15.

Gasket 33, to which reference has been made, is sufficiently compressible to permit threaded cylindrical portion 31 of valve assembly 29 to be turned through an angle sufficient to permit adjustment of driven outlet 43 or of air relief valve 44 to a particular angular orientation.

Referring again to FIG. 1 and to the first and second housing portions 5 and 6, respectively, at their mutually facing inner open ends, each housing portion 5, 6 has a recess or shoulder 54, 55, respectively, for clamping therebetween the outer peripheral portion 56 of the main body element 57 (FIG. 2) of separator assembly 12. Second housing portion 6 also includes another recess 58 located concentrically within outer shoulder 55. Recess 58 provides a clearance for flexing of diaphragm 16 during operation of the pump.

Referring to FIGS. 1 and 2, separator assembly 12 comprises main body element 57 having opposed first and second surfaces 59, 60 facing toward driving and driven fluid compartments 14, 15, respectively. Second surface 60 of element 57 includes a tapered portion 61 extending inwardly from peripheral portion 56 to a recess 62. Extending through main body element 57 are a plurality of fluid passages 63 arranged around a central opening 64 in which is slidably received a plug 65 having a threaded interior for engagement by a bolt 66 upon which are mounted a number of elements.

Mounted on bolt 66 adjacent the first surface 59 of main body element 57, is a disk 67 sandwiched between an adjacent end of plug 65 and a nut 68. Mounted on bolt 66, next to the end of plug 65 adjacent driven fluid compartment 15, and adjacent the second surface 60 of main body element 57, is a relatively rigid metal washer 69; and mounted next to metal washer 69 is flexible diaphragm 16. Mounted adjacent the surface of diaphragm 16 facing the interior of driven fluid compartment 15 is a relatively hard, rigid second metal washer 70 and sandwiched between the latter and diaphragm 16 is a relatively soft, pliable, plastic washer 71. First metal washer 69, diaphragm 16, plastic washer 71 and second metal washer 70 are all held in place between a head 72 of the bolt 66 and the adjacent end of plug 65.

The washers 69, 70 provide rigidity to the central portion of diaphragm 16, and are of a substantially smaller diameter than the diaphragm to permit flexibility of intermediate portions of the diaphragm. The outermost peripheral portion 73 of diaphragm 16 is clamped between shoulder 55 of the second housing portion 6 and outer peripheral portion 56 of main body element 57.

Located on first surface 59 of main body element 57, facing toward driving fluid chamber 14, is a circular recess containing a first O-ring 74 positioned to be contacted by the outer peripheral portion of disk 67; and located concentrically outwardly of O-ring 74 is a second O-ring 75, also received within a circular recess in

surface 59. Second O-ring 75 forms a seal between outer peripheral portion 56 of main body element 57 and shoulder 54 on first housing portion 5. This prevents leakage of driving fluid from driving fluid compartment 14 outwardly between main body element 57 and first housing portion 5.

An important feature of the invention resides in the provision of a spring-loaded piston shaft assembly, which will now be described, with particular reference to FIGS. 1, 3 and 4.

The cylinder 10 has opposed inner and outer open ends 76 and 77 and includes a peripheral or flange portion 78 which bears against an O-ring 79 mounted in a circular indentation at the outer open end of first housing portion 5. O-ring 79 is held between first housing portion 5 and cylinder 10 and defines a seal to prevent leakage of fluid from within driving fluid compartment 14 outwardly between first housing portion 5 and cylinder 10. The cylinder has an inner surface 80 which is hardened to resist wear and abrasion from the components of the spring-loaded piston shaft assembly.

The spring-loaded piston shaft assembly comprises a body 81 having a reduced externally threaded portion 82 at one end, and an axial bore 83 in its other end, which is counterbored, as at 84, to provide a recess or chamber 85, for a purpose to be presently described. The junction of the bore 83 and counterbore 84 provide a shoulder or abutment 86.

The body 81 is also provided with an extension 87 of reduced diameter and having a flange 88, for retaining a boot 89 on the extension 87, which boot is composed of a flexible rubber or plastic material, and serves a purpose to be presently described.

Mounted in the bore 83, for sliding reciprocal movement in said bore, is a piston shaft or stem 90, to the forward end of which a screwbolt 91 is secured, and between the head of which and the shoulder or abutment 86 a compression coil spring 92 is interposed.

The piston shaft 90 is provided with a rearward threaded extension 90a of enlarged diameter, on which spaced nuts 93 and 94 are mounted, the space therebetween receiving a flange 89*a* of the boot 89. The boot 89 thus serves as a grease retainer for grease enclosed in the space between the boot and the flange 88 and nut 93. This grease serves as a lubricant for facilitating sliding of the piston shaft in the bore 83. The boot 89 is retained in position by a nut 94*a* which is secured to the extension 90*a* of the shaft 90.

The piston shaft assembly further comprises a nut 95 which is threadedly secured to the portion 82 of the body 81.

Secured to the nut 95 is a threaded stem 96 provided with spaced hex portions 97 and 98, between which is received one end of a boot 99, composed of a flexible rubber or plastic material. The other end of the boot 99 is sealingly received in an annular recess 100 in the outer end of cylinder 10.

Secured to the portion 98 of the stem 96, as by a screwbolt 101, are a collar 102, a backing washer 103, an annular, elastically deformable cup seal 104 of rubber or the like, which is of slightly larger external diameter than the collar 102 and washer 103, an arbor 105 disposed within an opening 106 in the seal 104, and a retainer washer 107.

The boot 99 prevents air outside the pump from entering cylinder 10.

The extension 90a of the piston shaft 90 is adapted to be connected to a bearing retainer 108 having a drive bearing 109 mounted eccentrically therein, and in which is received a crank portion 110 of a crank shaft 111, rotation of which by an electric motor (not shown) causes reciprocal movement of the piston shaft assembly.

Driving fluid for the chamber 14 of the pump is supplied from a reservoir 112 through a conduit 113 having an end 114 communicating with a hollow interior 115 of an externally threaded inlet valve having a body 116 threadedly secured to pump housing portion 5. Interior 115 may be closed to the entry of driving fluid by a ball 117 when the latter is seated, as shown in FIG. 4. On a suction stroke of the piston shaft assembly (movement to the right, as viewed in FIG. 1), ball 117 is urged to the left, as viewed in FIG. 4, and unseated, thus opening the valve's hollow interior 115 for the entry of fluid from the conduit 113. Driving fluid passes from valve 116 to chamber 14 through an opening 118 extending through the housing portion 5 and cylinder 10.

Ball 117 has a slightly smaller diameter than interior 115 to provide a slight clearance between the ball and said interior when the ball is unseated. The size of this clearance, being relatively small, permits the introduction of only a relatively small volume of driving fluid on a suction stroke of the piston assembly, compared to the volume displaced by movement of the piston assembly to the right. In the pump of the aforesaid Schlosser patent, utilizing the piston assembly shown therein, the difference between the displaced volume and the volume of driving fluid entering through the inlet valve is made up by the movement of the diaphragm 19, since the smaller the volume of fluid entering through the inlet valve, the greater the movement of the diaphragm and the greater the movement of the diaphragm, the more driven fluid it draws into the driven fluid compartment for a given stroke of the piston.

However, this results in cavitation within the driving fluid compartment, or piston cylinder, that is to say, the formation of a partial vacuum in the compartment or cylinder.

This cavitation or cavitation effect is completely obviated in the present pump, through the use of the novel springloaded piston shaft assembly, which has been described above, and in a manner to be presently described.

Driving fluid is expelled from the compartment 14 through a passage 119 in pump housing portion 5, which communicates at one end with the compartment 14 and at the other end with the interior of a hollow bolt 120 which secures a valve assembly, designated generally by reference numeral 121, to the housing portion 5. Valve assembly 121 includes a housing 122 which rests on a spacer 123, which, in turn, rests on a seal 124.

Referring to FIG. 4, hollow bolt 120 includes a radially extending port 125 communicating with externally threaded tubular valve seat 126 threadedly secured in valve housing 122. A ball 127 normally closes seat 126 and is surrounded by a tubular retainer 128 and held in place by one end of a retaining rod 129 extending longitudinally through a hollow interior portion 130 of valve housing 122 and through an externally threaded hollow member 131 threadedly secured in housing 122. Rod 129 is urged against ball 127 to hold the ball in closed position on seat 126 by a compression coil spring 132.

When the pressure of fluid expelled from driving fluid compartment **14** exceeds the pressure of spring **132** against ball **127**, the ball and rod **129** are pushed outwardly against the urging of spring **132**, to provide an opening for the passage of driving fluid which now may pass upwardly through hollow bolt **120**, through port **125** in the bolt, through tubular valve seat **126** into the hollow interior portion **130** of housing **122**, through a port **133** in the housing, a fitting **134** and conduit **135**, to the reservoir **112**.

The pressure which spring **132** exerts against ball **127** may be adjusted by unscrewing an internally threaded cap **136** threadedly secured to an outer end portion **137** of hollow member **131**, and turning member **137**, the pressure on spring **132** being increased or decreased depending upon the direction in which the member **137** is turned.

Means are provided for bleeding air from compartment **14**, in situations wherein air may be present therein, such situations being, for example, when the pump is brand new or when it has recently been repaired. Such means, as shown in FIG. **4**, includes a second port **138** communicating with the hollow interior of an externally threaded fitting **139** threadedly secured in housing **122** and having a valve seat **140** closed by a ball **141** held in place by one end of a bolt **142** having its other end attached to a knob **143**. Fitting **139** also includes a port **144** communicating with a transparent conduit **145**.

When knob **143** is loosened sufficiently, ball **141** will be displaced from its seat on an inward movement of the piston shaft assembly and will return to its seat upon an outward movement of the piston shaft assembly, so that the net result will be to expel fluid through fitting **139** into conduit **145**.

By observing transparent conduit **145**, it can be determined whether driving fluid compartment **14** still contains air. As long as there are bubbles in the fluid being expelled through conduit **145**, there is air within compartment **14**. When the fluid within conduit **145** contains no observable bubbles, there is no longer any air within compartment **14**; and knob **145** may be tightened to hold the ball **141** in closed position on its seat **140**; and the pump can then be operated in a normal manner.

The operation of the pump may be described as follows:

When the piston drive shaft assembly moves inwardly (to the left, as viewed in FIG. **1**), the nut **93** of the assembly comes into engagement with the extension **87** of the body **81**, thereby forcing the cup seal **104**, which, in effect, is the piston of the assembly, to the left. This forces driving fluid from the compartment **14** through the fluid passages **63** in main body element **57** into the space between diaphragm **16** and the surface **60** of the element **57**; and the driving fluid pushes against washer **69** and the surface of diaphragm **16** facing the element **57**, thereby causing flexing of the diaphragm to the left, as viewed in FIG. **1**. As diaphragm **16** flexes to the left, all of the components of the separator assembly connected to the diaphragm for movement therewith (namely, metal washers **69**, **70**, plastic washer **71**, plug **65**, bolt **66**, and disk **67**) move to the left. Such movement continues until the outer peripheral portion of disk **67** engages O-ring **74**.

Engagement of disk **67** with O-ring **74** prevents further entry of driving fluid into fluid passages **63**, thus stopping flexing movement of diaphragm **16** to the left. The spacing of disk **67**, relative to diaphragm **16** and the other movable components of the separator assembly, is such that when disk **67** engages O-ring **74**, diaphragm **16** is in a vertical planar position, with the diaphragm surface facing driven fluid compartment **15** corresponding to the dotted line **146** in FIG. **1**. Because it is not flexed beyond a vertical planar position, when flexed to the left, the wear on the diaphragm is much less than would be the case if it were flexed beyond such a position, and accordingly the life of the diaphragm is increased.

When the piston drive shaft assembly moves outwardly in cylinder **10** (to the right, as viewed in FIG. **1**), a substantial volume, communicating with the driving fluid compartment **14**, is displaced. This lowers the pressure within driving fluid compartment **14** and urges all of the movable components of separator assembly **12** to the right. As a result, the seal between disk **67** and O-ring **74** is broken, and driving fluid passes from left to right through fluid passages **63**, with the diaphragm **16** being flexed to the right. Movement of the movable components of the separator assembly **12** to the right continues until metal washer **69** contacts the surface of recess **62**, thereby closing fluid passages **63** and preventing further passage of fluid therethrough from the left to the right.

With the piston arrangement of the aforesaid Schlosser patent, the valve **116** (corresponding to valve **122** of the Schlosser patent) is so small that the intake of oil into the cylinder **14** is so restricted that on the suction stroke of the piston, the piston cannot completely fill the cylinder with sufficient rapidity to avoid cavitation in said cylinder.

With the use of the present spring-loaded piston shaft assembly, no significant cavitation or phase reversal can occur.

On the suction stroke, the piston shaft or stem **90** is first retracted through the bore **83**, so that the spring **92** is compressed, while the piston (**104**) remains in its forward position relatively to the moving shaft **90**. The pressure of the spring **92** is less than atmospheric pressure, so that when the spring expands to its initial condition, the piston (**104**) is drawn back, thereby eliminating what would otherwise have been a vacuum in the cylinder **14**, and thus, in effect, eliminating the possibility of cavitation.

Although the piston shaft assembly which has been described utilizes a compression coil spring, it will be understood that other means may be used as a means of delaying the retraction of the piston proper, as, for example, a compressible rubber bushing or collar interposed between the head of the bolt **91** and the shoulder or abutment **86**.

Moreover, while the invention has been described more particularly with reference to a pump of the character described in the aforesaid Schlosser patent, it may be used in pumps or various other types and constructions, wherein cavitation may occur.

It is to be understood that the form of my invention, herewith shown and described, is to be taken as a preferred example of the same, and that various changes may be made in the shape, size and arrangement of parts thereof, without departing from the spirit of the invention or the scope of the subjoined claims.

Having thus described my invention, I claim:

1. In a pump, means including a first housing portion defining a fluid driving compartment, means including a second housing portion defining a driven fluid com-

partment, valve-controlled means for introducing fluid into said fluid driving compartment, piston means in said fluid driving compartment having a suction stroke in response to which said valve-controlled means is opened to cause said fluid to pass into said fluid driving compartment, said valve being of a size such that intake of said fluid into said fluid driving compartment is so restricted that on the suction stroke of said piston means, said piston means cannot completely fill said fluid driving compartment with sufficient rapidity to avoid cavitation in said fluid driving compartment, and means for preventing significant cavitation in said fluid driving compartment, said last-named means comprising a stem extending axially from said piston means, a body removably secured to the outer end of said stem, said body comprising a portion having an axial bore which is counterbored to provide a hollow chamber in said body, the junction of said bore and chamber forming a shoulder, a piston shaft slidably mounted in said axial bore and having a portion extending into said chamber and provided at one end with an abutment, a compression coil spring interposed between said abutment and said shoulder for resiliently biasing said piston shaft toward said stem, and means for causing reciprocal movement of said piston shaft, whereby on the suction stroke of said piston means, said piston shaft is first retracted through said axial bore, so that said compression coil spring is compressed while said piston means remains in a forward position relatively to said piston shaft, the pressure of said compression coil spring being less than atmospheric pressure, so that when said compression coil spring expands to its initial condition, said piston means is drawn back, thereby substantially eliminating what would otherwise have been a vacuum in said fluid driving compartment, and, in effect, substantially eliminating the possibility of cavitation in said fluid driving compartment.

2. A pump, as defined in claim **1,** wherein said stem has secured to its rear end a nut which is threadedly secured to said body to close the forward end of said chamber.

3. A spring-loaded piston shaft assembly for a pump having a piston actuating a driving fluid actuating a flexible diaphragm pumping a driven fluid, said assembly comprising a piston means, a piston driving element secured to and extending axially from said piston means, a body secured to said piston driving element and having a chamber in its forward portion and an axial bore in its rearward portion extending rearwardly from said chamber, said axial bore being counterbored to provide said chamber with the junction of said bore and chamber forming a shoulder, a piston shaft slidably mounted in said bore and provided at its forward end with an abutment disposed in said chamber, and a compression coil spring interposed between said abutment and said shoulder for resiliently biasing said piston shaft in an axial direction toward but in spaced relation to said piston driving element.

4. An assembly, as defined in claim **3,** wherein said piston driving element comprises a threaded stem having secured to its rear end a nut which is threadedly secured to said body to close the forward end of said chamber.

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