United States Patent [19]

Bickford

[11] **3,811,798**

[45] **May 21, 1974**

[54] **PISTON PUMP WITH SELF-LUBRICATING PISTONS**

[75] Inventor: **John C. Bickford,** Novato, Calif.

[73] Assignee: **Hydraulic Systems, Inc.,** San Rafael, Calif.

[22] Filed: **July 19, 1972**

[21] Appl. No.: **273,154**

[52] **U.S. Cl.** **417/269,** 92/156

[51] **Int. Cl.** **F04b 1/12,** F01b 31/10

[58] **Field of Search** 417/269, 270, 437; 92/80, 92/82, 153, 156, 168; 277/188

[56] **References Cited**

UNITED STATES PATENTS

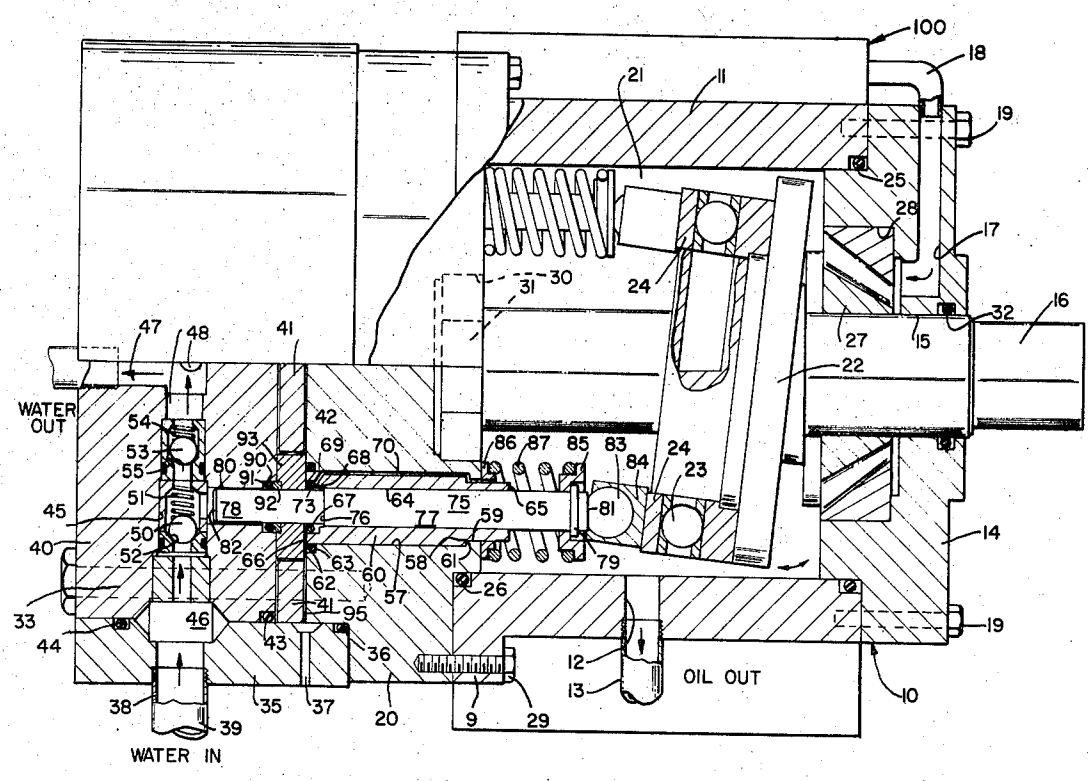
2,996,320	8/1951	Mason	277/188
3,362,720	1/1968	Henry et al.	277/188
2,963,304	12/1960	Comlossy	277/188
2,405,938	8/1946	Beeh	417/269
1,546,596	7/1925	Mader	92/156
2,669,185	2/1954	Tallis	417/269
3,310,230	3/1967	Wirth	92/168
2,392,543	1/1946	Mercier	417/269
3,085,514	4/1963	Budzich	417/203
2,433,222	12/1947	Huber	417/270
3,663,122	5/1972	Kitchen	417/269
2,376,856	5/1945	Hatch	417/269
3,297,106	1/1967	Hanson et al.	184/55 A
3,361,077	1/1968	Freeman	417/269
3,584,541	6/1971	Cunningham	92/168
3,292,554	12/1966	Hessler	417/269
2,842,068	7/1958	Sundin	417/269
3,191,542	6/1965	Hughes	417/269

Primary Examiner—William L. Freeh
Assistant Examiner—G. P. LaPointe
Attorney, Agent, or Firm—Owen, Wickersham & Erickson

[57] **ABSTRACT**

A pump having pistons that actuate a pumping device by suction and compression and having novel means for sealing the fluid being pumped from the lubricating fluid and for ensuring lubrication between the pistons and their cylinders. The reciprocation of the pistons is made to pump the lubricating fluid between them and the cylinder and to return the fluid to an internal lubricant reservoir. A swash plate acts also as a circulating pump for sending the lubricating fluid through an external cooling reservoir.

21 Claims, 6 Drawing Figures



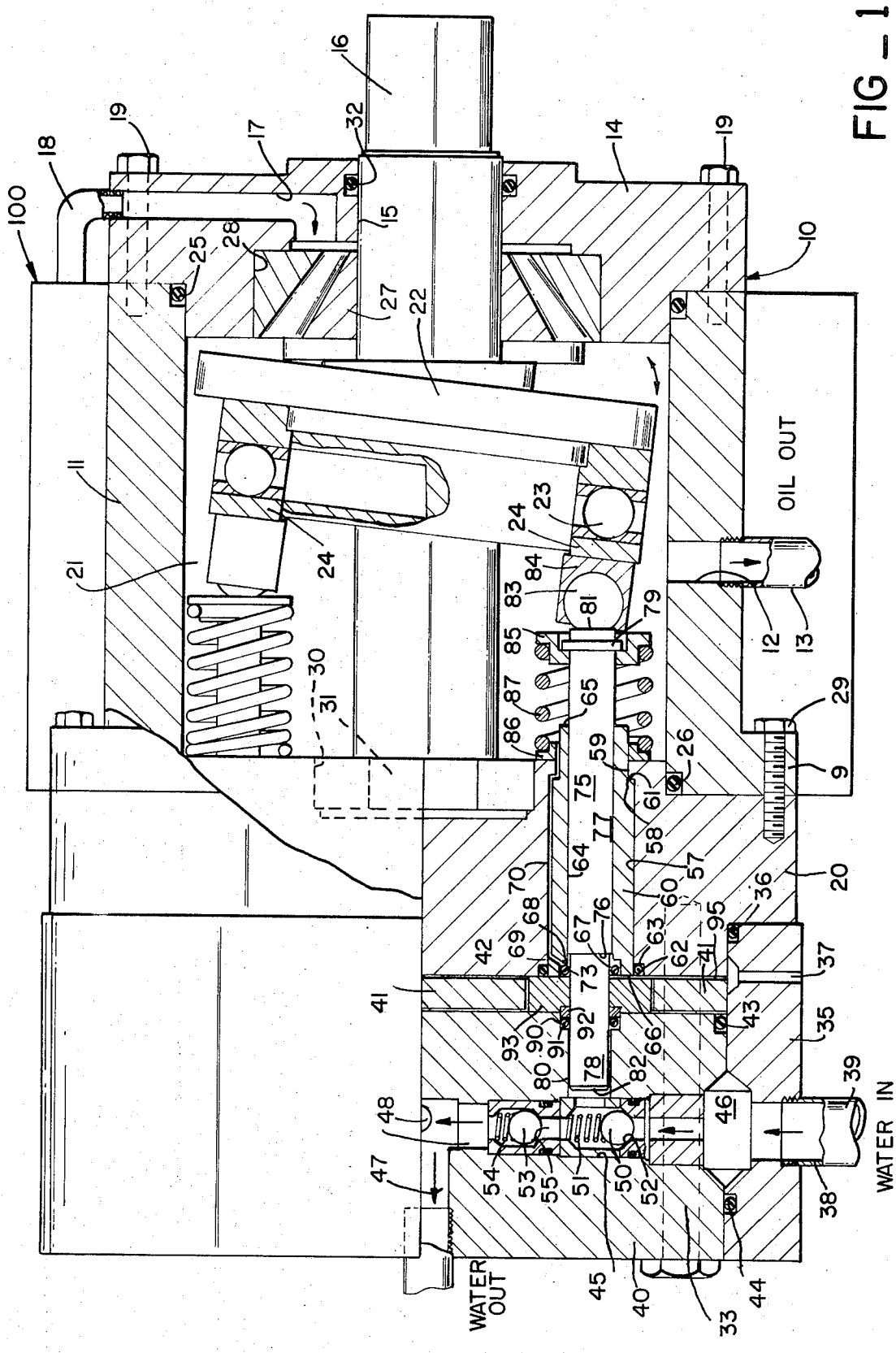


FIG - 1

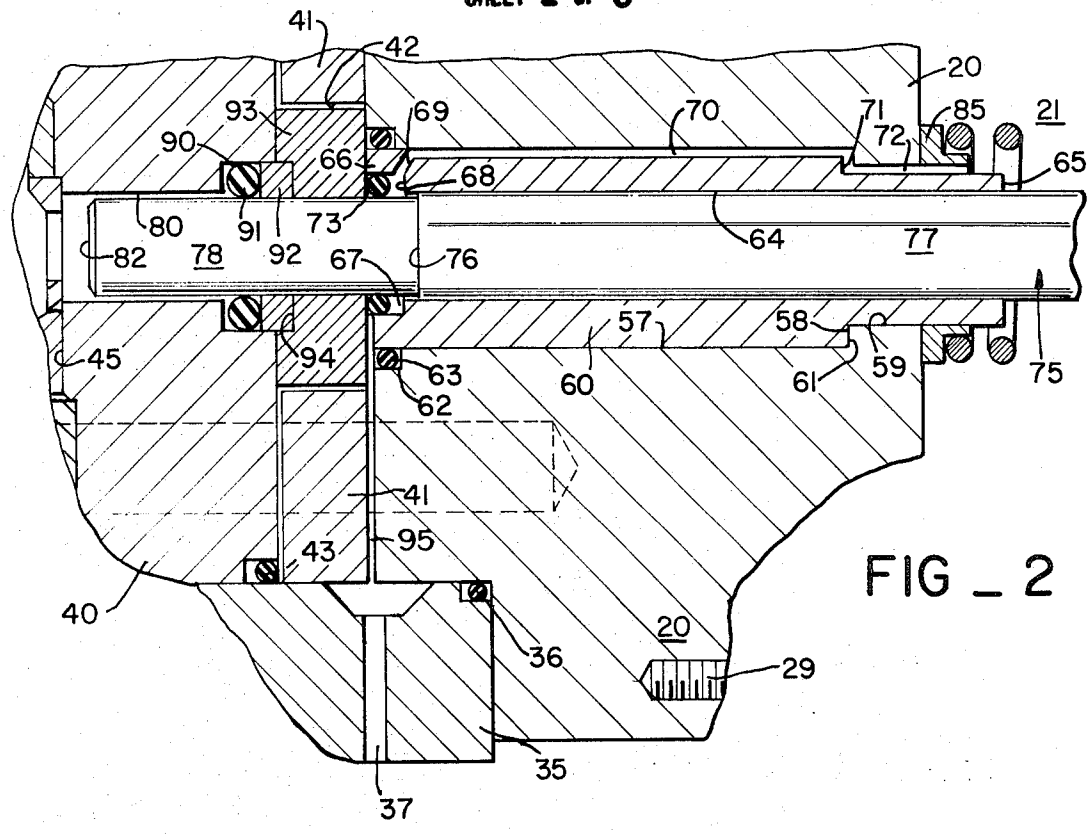

41
42
20
93
69
70
71
85
21
90
66
72
65
68
80
91
73
64
77
82
78
92
67
76
45
94
57
58
63
60
59
75
62
61
41
95
43
40
36
20
29
35
37

FIG _ 2

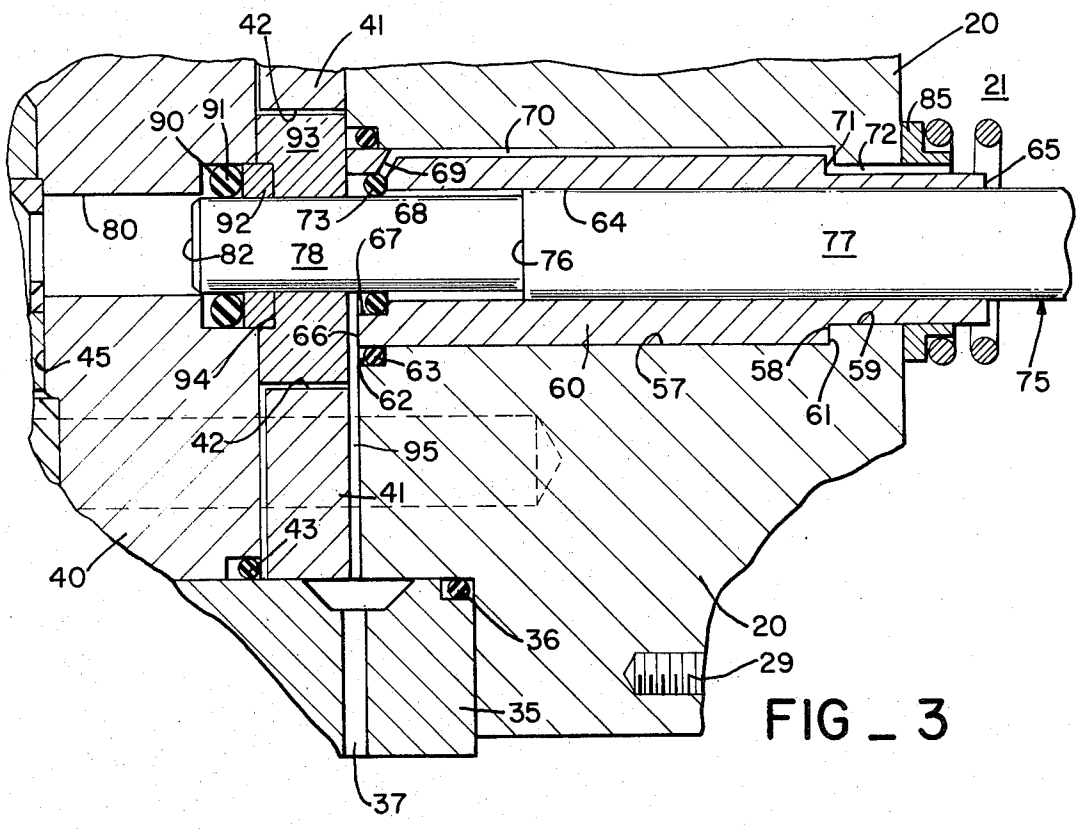

42
41
20
90
91
93
70
71
72
85
21
65
69
80
92
73
68
64
82
78
67
76
77
66
45
94
63
60
57
58
59
75
62
61
42
95
41
43
40
36
20
29
35
37

FIG _ 3

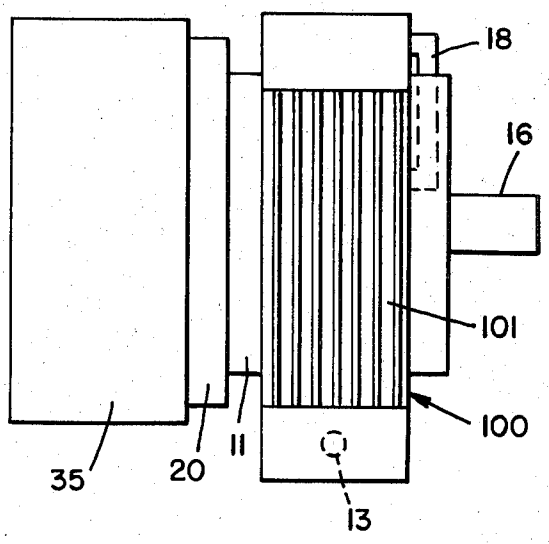


FIG_4

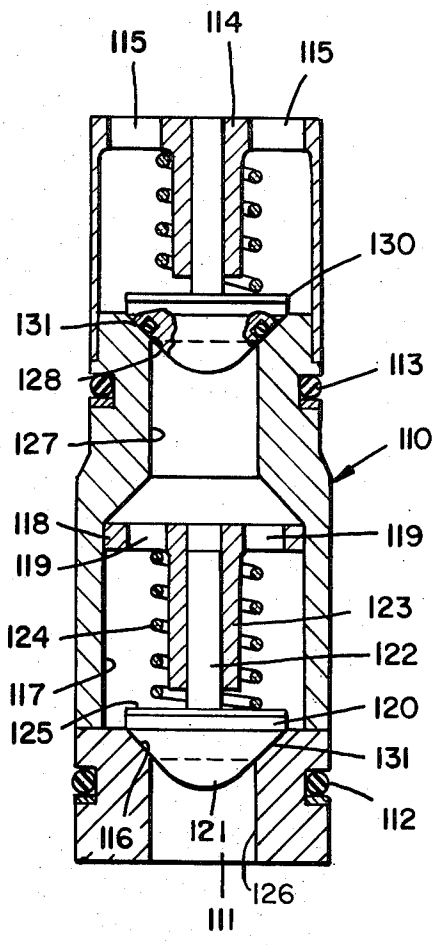


FIG_6

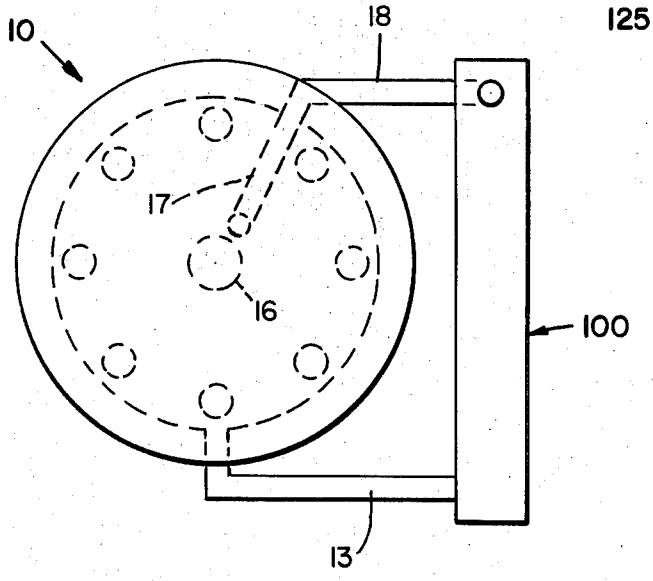


FIG_5

PISTON PUMP WITH SELF-LUBRICATING PISTONS

BACKGROUND OF THE INVENTION

This invention relates to an improved pump of the piston type having a novel lubrication system and a sealing system.

In previous pumps the lubrication between the pistons and their cylinders was typicaally accomplished by grease fittings, or by pressure lubrication requiring a separate oil pump or splash oiling. In all these cases the lubricant seals were in the cylinder, and the lubrication was marginal. Foreign particles were liable to get in past the seals and, if they got in, they caused scoring of the piston or the cylinder, leading to binding and galling of the mating surfaces. The present invention overcomes these lubrication and sealing problems.

In pumps where the lubricant seal between the piston and cylinder is in the working area, the clearance between the cylinder and the piston has to be so small that adequate lubrication is very difficult to achieve. Moreover, in high-pressure pumps where the sealing is effected between the piston and the cylinder, the cylinder tends to be stretched by the pressure exerted on it and therefore to induce a small bypass of fluid, the amount of bypass increasing as the pressure of the pump increases. This mixes the fluid being pumped with the lubricant, to the disadvantage of both. In the present invention, the seals are located outside this working area, and the clearance between the piston and cylinder can therefore be large enough to insure adequate lubrication. In the pump of this invention, the sealing is done in the valve head, outside the piston-cylinder working area. Sealing is much more effective, partly because the valve head is much stronger and less likely to permit bypassing.

The structure of this invention also reduces the head space on the end of the piston, and this, in turn, reduces the shock wave that tends to produce the water hammer effect found in many high-pressure pumps.

The same structure of the present invention makes it possible for the pump to be more compact, for the cylinder and its sleeve need not accommodate lubricant seals and can be utilized solely as bearing areas.

Another problem with the prior art was the difficulty of replacing the lubricant seals, and the present invention makes seal replacement simple and quick.

Another feature of the present invention is the use of the drive shaft and the swash plate mounted on it as substantially a centrifugal pump for circulating the lubricant through the internal reservoir and through an external reservoir and cooling system.

SUMMARY OF THE INVENTION

The invention provides a pump having a series of pistons that are reciprocated inside respective cylindrical sleeves which are themselves supported in parallel relationship in a body member inside the housing. One end of each piston and cylindrical sleeve is open to an oil reservoir inside the housing, in which the reciprocating drive mechanism for the pistons is also located. Preferably this is a swash plate mounted on a drive shaft. Each cylindrical sleeve fits snugly in the bore of the body member and provides the cylindrical bore for the piston, and each sleeve also provides at the end remote from the oil reservoir an annular chamber. A passage

leads from this annular chamber to a longitudinally extending groove on the exterior surface of each sleeve, which leads to the lubricant reservoir and affords a means for returning the lubricant to the reservoir.

The piston has a larger diameter portion which reciprocates in the cylindrical sleeve and a somewhat smaller diameter portion that extends through a cylindrical bore in a second body member that is spaced away from the first-named body member, with the fit there being a typical piston-cylinder fit. The shoulder at which the two piston portions meet lies inside the cylindrical bore in all of almost all positions of the piston relative to the cylinder.

The second body member has an annular recess, and a plate between the two body members closes both the outer end of that recess and the end of the annular chamber of the sleeve. An O-ring is provided around the narrower-diameter portion of the piston, inside the annular chamber, and it moves back and forth with the reciprocation of the piston to open the lubricant return passageway between the cylindrical bore and the groove, or to close it, depending upon the direction of movement of the piston. A second O-ring is held in the annular chamber of the second body member, with a back-up ring in contact with the plate between the two body members; this second O-ring serves to provide a tight seal there for the narrower-diameter portion of the piston, enabling suction to develop for actuating one of a pair of valves in the pumping chamber so that one valve is opened upon suction, while the second one is closed, and then the second one is opened by pressure while the first one is closed.

It will be explained below how the combination of the groove, the annular chamber, its O-ring, and a carefully developed tolerance in the cylindrical bore enable lubrication of the piston.

The invention also makes it possible to provide for superior circulation of lubricant in the reservoir by employing the drive shaft and its swash plate as a centrifugal pump therein, and this same structure also circulates the lubricant externally through a cooling reservoir and brings it back into the internal reservoir. This circulating structure is better than a conventional lubricant supply pump for it does not increase the internal pressure in the pump, with consequent effect on the sealing rings.

Also, the structure makes it much simpler to replace parts, assembly and disassembly being very simple, with sealing O-rings at strategic places.

Other objects and advantages of the invention will appear from the following description of a preferred embodiment.

BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings:

FIG. 1 is a view in elevation and partly in section of a pump embodying the principles of the invention.

FIG. 2 is a fragmentary enlarged view in section of one of the pistons and its associated members, the piston being shown in one extreme position.

FIG. 3 is a view similar to FIG. 2 with the piston in its other extreme position.

FIG. 4 is a view in side elevation of the pump of FIG. 1, showing the external lubricant cooling reservoir, all on a smaller scale than in FIG. 1.

FIG. 5 is a view in end elevation of the assembly of FIG. 4.

FIG. 6 is a view in side elevation and partly in section of a cone-valve system which may be substituted for the ball valve system shown in FIG. 1.

DESCRIPTION OF A PREFERRED EMBODIMENT

The pump of this invention comprises a housing **10**, preferably made up of several members in order to make disassembly easy. Thus, there may be a first cylindrical housing member **11** having a radially extending oil outlet passage **12** therethrough to which an oil conduit **13** may be connected. One end of the cylindrical housing member **11** is closed by an annular end plate **14** having a bore **15** to accommodate a rotary drive shaft **16** which extends through it and also having an oil inlet passage **17** connected to an oil conduit **18.** Bolts **19** hold the members **11** and **14** together.

The other end of the cylindrical housing member **11** is closed by a first cylindrical body **20,** held to a flange **9** of the housing member by bolts **29.** The members **11, 14,** and **20** enclose an internal oil reservoir **21,** in which the drive shaft **16** rotates a swash plate **22,** which is provided with a series of thrust ball bearings **23** and thrust face bearings **24.** O-ring seals **25** and **26** are provided between the cylindrical member **11** and, respectively, the end plate **14** and the body **20,** so that these members can readily be disassembled and are sealed when put together. The drive shaft **16** has a bearing **27** in a recess **28** in the end plate **14** and continues into a recess **30** where bearings **31** are provided in the body member **20.** An O-ring seal **32** in the end plate **14** prevents leakage around the shaft **16.**

A second cylindrical housing member **35** is bolted to the first body **20** by bolts **33** and sealed to it by an O-ring **36,** and is provided at its lower end with a drain opening **37** to drain out any excess lubricant or bypassed pump fluid. The housing member **35** also has an inlet passage **38** for the fluid being pumped, which may be water or some other liquid coming from a conduit **39.** Inside the member **35** is mounted a second body or valve head **40.** The second body or valve head **40** is spaced from the first body **20** by an annular spacing disk **41** having a series of round openings **42,** and O-rings **43** and **44** are provided to seal between the members **35** and **40.** The second body **40** provides a series of stepped receptacles **45,** each receiving fluid from a manifold **46** that lies between the members **35** and **40,** and the second body **40** provides a water-outlet passage **47** collecting fluid from a series of outlets **48** leading from the receptacles **45.**

In each receptacle **45** are inserts providing cages for a double valve pump valve mechanism. Ball valves are shown in FIG. **1** and cone valves are shown in FIG. **6;** the basic structure is the use of two check valves, one opening on suction, the other opening on pressure. In FIG. **1,** a first ball **50** is urged by a spring **51** to close an inlet opening **52** and opens when suction pulls the ball **50** up against the pressure of the spring **51.** A second ball **53** is urged by a spring **54** against an opening **55** and opens when the fluid between the balls **50** and **53** is placed under pressure. The fluid pumped may be water, hot or cold, or other liquids, including refrigerants.

The first body **20** is provided with a series of cylindrical bores **57,** which may be stepped at a shoulder **58** to provide a smaller-diameter bore portion **59,** and in these bores **57** is inserted a cylindrical sleeve **60,** which acts as the cylinder of the device. There are a series of sleeves **60** around the device — for instance, there may be eight cylinders (see FIG. **5**) or four cylinders. Preferably, all of them are identical, and a description of one will be sufficient.

Each sleeve **60** has a shoulder **61** which abuts the shoulder **58** of the bore **57** to position the cylindrical sleeve **60** in its proper position, and the body **20** has a groove **62** for an O-ring **63** that seals between the body **20** and the cylindrical sleeve **60.** The sleeve **60** has a cylindrical bore **64** extending from a first end **65,** lying inside the reservoir **21** to a second end **66** where there is an annular chamber **67** having a shoulder **68.** A passage **69** leads to an axially extending groove **70** in the exterior wall of the sleeve **60** and extends longitudinally from the outer end of the passage **69** to the shoulder **61,** where a short radial groove **71** opposite the shoulder **58** leads to an axially extending groove **72** that empties into the reservoir **21.** In the annular chamber **67** is a very important O-ring **73** that will be discussed later.

Each cylinder **60** has a corresponding piston **75,** and each piston **75** has two different diameter portions meeting at a shoulder **76**: a wider-diameter portion **77** reciprocates inside the cylindrical bore **64** and a narrower-diameter portion **78** reciprocates inside a bore **80** in the second body **40.** Each piston **75** has a first end **81** in the reservoir **21,** with a shoulder **79** thereon, and a second end **82** adjacent the ball valve mechanism. The end **81** adjoins a ball **83** for swiveling a thrust bearing **84** which faces the face bearings **24** of the swash plate **22.** A pair of spring retainers **85** and **86** are provided for a spring **87;** one of the retainers **85** is mounted against the shoulder **79** of the piston **75,** and the other retainer **86** is supported around the sleeve **60** and against the face of the first body **20.** The spring **87** holds the thrust bearing **84** at all times in firm engagement with the swash plate thrust bearings **24.**

While a swash plate construction has been shown, the invention is operable with other means for driving the pistons, and any number of pistons may be spaced radially around the actuating shaft for axial movement parallel to the axis of the drive shaft.

The second body **40** has an annular recess **90** in which there is a sealing ring **91** which seals between the second body member **40** and the smaller-diameter portion **78** of the piston **75,** and there is a back-up ring **92** for the sealing ring **91.** The back-up ring **92** abuts an annular member **93** and may fit either in a groove **94** therein or against the face. Each member **93** is supported by the spacing disk **41** in one of the openings **42,** in which it fits loosely. The members **93** are thicker than the disk **41,** to provide pressure and to prevent extrusion of the rings **91, 92** and **73,** the members **93** being held in compression between the members **20** and **40.** A drain passage **95** may be provided as a recess in the member **20.** The member **93** serves both to close the end of the annular recess **90** and to close the end of the annular recess **67.**

The clearance between the narrower-diameter piston portion **78** and the bearing member **93** is minimal to prevent any extrusion of the back-up ring **92.** The back-up ring **92** is made of material that is not subject to cold flow and can provide a zero clearance, so that the sealing ring **91** can make a substantially perfect seal with the reciprocating shaft portion **78.** This back-up ring **92** is preferably made of a combination of fiber-

glass, bronze, and Teflon (tetrafluoroethylene). For example, one suitable ring **92** is made up of 17 percent fiberglass, 40 percent bronze, and 43 percent Teflon. Composition may vary, depending on the material being pumped and on the temperature, but the back-up ring **92** should have good resistance to wear and to the lubricant and to the fluid being pumped. The sealing ring **91** is preferably a high-pressure seal quad ring, but it may be an O-ring or packing depending upon the type needed for the fluid and pressure being pumped. The portion of the sealing ring **91** that is exposed to pressure is kept minimal, and this helps to reduce the gripping pressure or squeeze, so that the life of the sealing ring **91** is extended. The features just described are adaptable to other types of pumps or motors, including various configurations and are not limited to axial piston pumps. The sealing ring seal **91** isolates the high-pressure area from the atmosphere and from the drive end and the sealing rings **63, 73,** and **91** cooperate to seal the lubrication area from the pumping area.

The piston portion **78** is preferably about 0.010 inch smaller in diameter than the piston portion **77.** The difference can be somewhat greater or somewhat smaller if desired, but this is a preferable figure. The piston portion **77** fits in the bore **64** with a clearance of about 0.0015 inch to 0.0025 inch, so that lubricant can readily flow in between them.

The O-ring **73** has minimal squeeze in the annular chamber **67** of the sleeve **60,** but fits in a normal way on the piston portion **78,** so that the O-ring **73** can move in the annular chamber **67** and function as a valve, opening and closing the port of the passage **69.** On the outward portion of the cycle, that is, as the piston **75** moves to the right in FIGS. **1–3** (in other words, when the piston is moving away from the valve pumping mechanism and toward the swash plate **22**) the piston **75** draws the O-ring **73** against the shoulder **68** and thereby closes the passageway **69,** so that there is no movement of oil through the cylindrical bore **64** or through the groove **70** during this time. This movement also means that the smaller-diameter portion **78** of the piston **75** enters deeper within the cylindrical bore **64,** and as a result increases the total volume of the space between the cylindrical bore **64** and the piston **75.** Thus, this space is much larger in FIG. **3** than in FIG. **2,** and with the increase in capacity, the pressure is reduced and oil is drawn in along the piston portion **77,** moving oppositely to the direction in which the piston **75** is moving, and passes into the clearance between the larger-diameter piston portion **77** and the bore **64** and there flows to the clearance between the smaller diameter piston portion **78** and the bore **64.**

When the piston **75** moves in the opposite direction (to the left in FIGS. **1–3,** in other words, towards the ball valves and away from the reservoir **21**) the total clearance volume between the piston **75** and the bore **64** is, of course, reduced in size, and therefore pressure builds up. This pressure, together with the movement of the piston **75,** moves the O-ring **73** away from the shoulder **68,** exposing the passage or port **69** so that oil then is urged by this buildup of pressure to flow from the annular chamber **67** and from the cylindrical bore **64** into the groove **70.** It moves then through the grooves **70, 71,** and **72** to the reservoir **21,** completing the cycle of oil movement in the circulating pattern. Thus there is an intermittent but regular flow of oil between the piston **75** and the cylinder bore **64,** moving in one direction inwardly and then moving by the groove **70** back to the reservoir **21,** so that lubrication is always assured. The reservoir **21** is of course flood lubricated and is always kept full of oil.

It should be noted that the close fitting surfaces **78** and **93** are short in length, and sufficient oil is carried on the piston surface **78** to keep this mating surface lubricated, the seal here being provided by the sealing ring **91** and its back-up ring **92.**

The O-rings **25, 26, 36, 43,** and **44** provide a sealing structure enabling one to take the pump apart and reassemble it readily, when the bolts **19, 29** and **33** are removed. Thus, once the bolts **33** are removed, the valve head or body **40** and the member **35** can be removed from the body **20** and the disk **41** then removed; when the bolts **19** are removed, the end plate **14** comes off readily; and when the bolts **29** are removed, then the cylindrical portion **11** can be removed from the first body **20.** When the first body **20** and the second annular housing member **35** along with the valve head **40,** are detached from each other, this gives adequate access for replacing the piston seals **73** and **91,** for example, without disassembling the piston sleeves **60** from their body **20,** and this can be done without separating the body **20** from the member **11,** letting the piston-swash plate assembly remain in place.

In this pump, the oil reservoir **21** should be kept on about the same level as the drive case. By feeding the oil to the case via the inlet **17** at about the center of the housing **10** and by draining or discharging it via the outlet **12** on the outer periphery of the housing **10,** the rotation of the drive shaft **16** helps to circulate the lubricant, acting substantially as a centrifugal pump. An air bleed valve **96** frees the lubricant from air.

The oil circulation system is best understood with reference to FIGS. **4** and **5** as well as FIG. **1.** An external oil reservoir **100** is connected to the housing **10** by the conduits **13** and **18.** The reservoir **100** has fins **101** for cooling. The oil from the reservoir **100** flows via the conduit **13** to the inlet conduit **17** where it approaches the center of the housing **10,** near the drive shaft **16.** It flows through the bearings **27,** lubricating them, into the reservoir **21.** There, the rotation of the shaft **16** and the rotation of the eccentric swash plate **22** move the oil radially outwardly toward the pistons **75,** which, as already described in detail use it for self-lubrication. The outlet **12** conducts the oil to the conduit **13** and thence to the cooler-reservoir **100,** the circulation being achieved by the shaft **16** and swash plate **22** without any external pump. This is far preferable, because an external pump creates internal pressures that tend to hold the O-ring **73** in its open position at all times.

The clearances provided by this invention make it possible, in connection with the cooler-reservoir **100,** to pump fluid over a wide variety of temperatures, depending on the mechanical strength and corrosion-resistance of the pump elements and to do this without the complicated temperature controls necessitated by other high-pressure pumps. The cooler **100** prevents the lubricant from becoming overheated and thereby the lubricant keeps the piston temperatures in the desired range.

It has been stated that the suction-pressure actuation need not rely on ball valves, as shown in FIG. **1.** One alternative structure for the suction-pressure check-valve assembly is shown in FIG. **6.** Here a tubular valve

housing **110** has an inlet **111** at its lower end and has O-rings **112** and **113** for sealing the housing **110** in a drilled passage **45** in the body or valve head **40.** The upper end has a spider **114** providing outlets **115.**

The inlet **111** leads to a conical seat **116** and an enlarged passage **117.** A spider **118** with passages **119** supports a valve member **120.** The valve member **120** has a conical head **121** and a stem **122.** A tubular sleeve **123** integral with the spider **118** guides the sleeve **122,** and a spring **124** seated at one end against the spider **118** bears against the flat upper end **125** of the valve member **120** to urge the head **121** towards its seat **116.** An opening **126** provides communication between the passage **117** and the base **80** in the member **40,** for alternate application of suction and pressure to the fluid being pumped.

The passage **117** leads to a narrower passage **127** and thence to a seat **128** for a second valve **130** like the valve **120.** Both valves **120** and **130** may have an O-ring **131** in their conical heads for better seating. It is apparent that the valve **120** is seated by pressure and opened by suction, according to the direction of movement of the piston **75.** Similarly, the valve **130** is closed by suction and seated by pressure. This operation is as previously described.

To those skilled in the art to which this invention relates, many changes in construction and widely differing embodiments and applications of the invention will suggest themselves without departing from the spirit and scope of the invention. The disclosures and the description herein are purely illustrative and are not intended to be in any sense limiting.

I claim:

1. In a pumping mechanism having a housing, an internal oil reservoir therein filled with lubricant, at least one reciprocating piston in a stationary cylindrical bore, and means in said reservoir for reciprocating said piston, the combination comprising:

said cylindrical bore having a first end in said reservoir, a first portion extending to an annular chamber meeting said cylindrical bore at a shoulder, with a longitudinally extending passage extending outside said bore adjacent to said shoulder to said first end, and a second smaller-diameter portion beyond said annular chamber terminating at a second end,

said piston having a first end in said reservoir and a first portion having a diameter just enough smaller than said first portion of said cylindrical bore to enable passage of oil therebetween during reciprocation, said piston having a second end beyond said annular chamber and within said second bore portion at all times and a second portion smaller in diameter than said first piston portion extending from said second piston end and meeting said first piston portion at a rim always lying within said first portion of said cylindrical bore,

an O-ring in said annular chamber and movable against and away from said shoulder and in sealing relation with said second portion of said piston, thereby having a position closing said passage and a position opening said passage,

sealing means sealing between said second bore portion and said second portion of said piston, and,

pumping mechanism in said housing beyond said second end of said piston and actuated by the suction of said second portion of said piston in said second bore portion,

said sealing means sealing off the fluid being pumped from said lubricant, while said O-ring acts as a valve opening and closing the passage between said groove and said cylindrical bore as the piston reciprocates, thereby lubricating said cylindrical bore and said piston.

2. The combination of claim **1** wherein said second piston portion is about 0.010 inch smaller in diameter than said first piston portion.

3. The combination of claim **2** wherein said diameter of said first piston portion is about 0.0015 to 0.0025 inch less than that of said cylindrical bore.

4. The combination of claim **1** wherein there is an enlarged annular recess in said second bore portion and said sealing means comprises

an elastomeric sealing ring in said annular recess and

a back-up ring in said annular recess between said sealing ring and said bearing member.

5. In a pumping mechanism having a housing, an oil reservoir therein filled with lubricant, at least one reciprocating piston in a stationary cylindrical bore, means in said reservoir for reciprocating said piston, the combination comprising:

an enlarged annular recess in said bore,

an elastomeric sealing ring of circular cross-section in said annular recess sealing between said bore and said piston and having a cross-sectional diameter slightly larger than the radial width of said recess,

a non-elastomeric back-up ring in said annular recess next to said sealing ring having substantially the same crosssection radial width as said recess, said recess being longer in its axial extent than the combined axial extent of said backup ring and said cross-sectional diameter of said sealing ring, said two rings being the only members in said recess, said back-up ring being a combination of glass fibers, bronze, and tetrafluoroethylene, each ingredient being present in an amount of at least 15 percent of the total, and

pumping mechanism in said housing beyond said piston and communicating with said bore and actuated by the alternating suction and pressure provided by reciprocation of said piston,

said sealing ring sealing off the fluid being pumped from said lubricant.

6. In a pumping mechanism having a housing, an internal oil reservoir therein filled with lubricant, a plurality of reciprocating pistons each in a stationary cylindrical bore, and means in said reservoir for reciprocating said piston, the combination comprising:

a first body in said housing with one end forming a wall of said reservoir and having a bore for each cylinder,

a sleeve member fitting snugly in each said bore and providing said cylindrical bore, said sleeve having a first end in said reservoir and a second end distant therefrom having an annular chamber meeting said cylindrical bore at a shoulder, said sleeve having an exterior longitudinally extending groove extending from near said shoulder to said first end and having a bored passage connecting said groove to said annular chamber adjacent said shoulder,

each said piston having a first end in said reservoir and a first portion having a diameter just enough smaller than said cylindrical bore to enable passage of oil therebetween during reciprocation, said piston having a second end beyond said second end of said sleeve member at all times and a second portion smaller in diameter than said first portion extending from said second end and meeting said first portion at a rim always lying within said cylindrical bore,

a second body spaced from said first body having a bore in which said second piston portion reciprocates,

an annular bearing member between said first and second bodies and closing said annular chamber,

an O-ring in said annular chamber and movable between said shoulder and said bearing member and sealing between said second portion of said piston and said sleeve and having a position closing the passage between said chamber and said groove and a position opening that passage,

sealing means sealing between said second body and said second portion of said piston, and,

pumping mechanism in said second body and actuated by the alternate suction and pressure provided by said second portion of said piston in said second body,

said sealing means sealing off the fluid being pumped from said lubricant, while said O-ring acts as a valve opening and closing the passage between said groove and said cylindrical bore as the piston reciprocates, thereby lubricating said cylindrical bore and said piston.

7. The combination of claim **6** wherein said second piston portion is about 0.010 inch smaller in diameter than said first piston portion.

8. The combination of claim **7** wherein said diameter of said first piston portion is about 0.0015 to 0.0025 inch less than that of said cylindrical bore.

9. The combination of claim **6** wherein said second body has an enlarged annular recess facing said annular bearing member and said sealing means comprises

an elastomeric sealing ring in said annular recess and

a back-up ring in said annular recess between said sealing ring and said bearing member.

10. The combination of claim **9** wherein said annular recess extends into a recessed portion of said bearing member.

11. The combination of claim **6** having an annular disk between said first and second body members slightly thinner than said bearing member and having a through opening for loosely receiving said bearing member.

12. The combination of claim **6** wherein

said pumping mechanism comprises a drive shaft having a swash plate theron in said internal reservoir engaging said pistons for reciprocation thereof,

an external oil-cooling reservoir,

inlet means for said oil into said internal reservoir near the axial center thereof adjacent to said drive shaft and connected to said external reservoir by an inlet conduit, and

outlet means for said oil from said reservoir adjacent the periphery thereof and connected to said external reservoir by an outlet conduit,

the rotation of said drive shaft and its swash plate in said internal reservoir circulating oil from said inlet means to said outlet means and through said external reservoir to said inlet means.

13. The combination of claim **6** wherein said housing comprises a cylindrical reservoir-containing portion closed at one end and bolted at its other end to said first body for ready disassembly and reassembly.

14. The combination of claim **13** wherein said closed end of said reservoir portion is bolted thereon for easy removal.

15. The combination of claim **13** wherein said first and second body members are bolted together for easy disassembly and reassembly.

16. In a pumping mechanism having a housing, an oil reservoir therein filled with lubricant, a plurality of reciprocating pistons each in a stationary cylindrical bore, means in said reservoir for reciprocating said piston, the combination comprising:

a first body in said housing with one end forming a wall of said reservoir and having a first bore for each cylinder, each said first bore having a first end facing said reservoir and a second end distant therefrom,

each said piston having a first end in said reservoir and a first portion having a diameter just enough smaller than said cylindrical bore to enable passage of oil therebetween during reciprocation, said piston having a second end beyond said second end of said first bore at all times and a second portion smaller in diameter than said first portion extending from said second end and meeting said first portion at a rim always lying within said cylindrical bore,

a second body spaced from said first body having a second bore in which said second piston portion reciprocates and having an enlarged annular recess,

an annular bearing member between said first and second bodies and closing said annular recess,

a sealing ring of circular cross-section in said annular recess sealing between said second body and said second portion of said piston, and having a cross-sectional diameter slightly larger than the radial width of said recess,

a back-up ring in said annular recess between said sealing ring and said bearing member, said back-up ring having substantially the same cross-sectional radial width as said recess, said recess being longer in its axial extent than the combined axial extent of said back-up ring and said crosssectional diameter of said sealing ring, said two rings being the only members in said recess, and

pumping mechanism in said second body and actuated by the suction of said second portion of said piston in said second body,

said sealing ring sealing off the fluid being pumped from said lubricant.

17. The combination of claim **16** wherein said sealing ring is elastomeric and said back-up ring is non-elastomeric.

18. The combination of claim **17** wherein said back-up ring is a combination of glass fibers, bronze, and tetrafluoroethylene.

19. The combination of claim **16** having an annular disk thinner than said bearing means between said first

and second body members and having openings therein for holding each said bearing means loosely.

20. The combination of claim **16** having a plurality of sleeve members each fitting snugly in one said first bore and providing a said cylindrical bore, said sleeve having a first end in said reservoir and a second end distant therefrom having an annular chamber meeting said cylindrical bore at a shoulder, said sleeve having an exterior longitudinally extending groove extending from near said shoulder to said first end and having a bored passage connecting said groove to said annular chamber adjacent said shoulder, and means for closing said bored passage when said piston moves in one direction and opening it when said piston moves in the opposite direction.

21. In a pumping mechanism having a housing, an oil reservoir therein filled with lubricant, a plurality of reciprocating pistons each in a stationary cylindrical bore, means in said reservoir for reciprocating said piston, the combination comprising:

a first body in said housing with one end forming a wall of said reservoir and having a first bore for each cylinder, each said first bore having a first end facing said reservoir and a second end distant therefrom,

each said piston having a first end in said reservoir and a first portion having a diameter just enough smaller than said cylindrical bore to enable passage of oil therebetween during reciprocation, said piston having a second end beyond said second end of said first bore at all times and a second portion smaller in diameter than said first portion extending from said second end and meeting said first portion at a rim always lying within said cylindrical bore,

a second body spaced from said first body having a second bore in which said second piston portion reciprocates and having an enlarged annular recess,

an annular bearing member between said first and second bodies and closing said annular recess,

a sealing ring in said annular recess sealing between said second body and said second portion of said piston,

a back-up ring in said annular recess between said sealing ring and said bearing member,

pumping mechanism in said second body and actuated by the suction of said second portion of said piston in said second body,

said sealing ring sealing off the fluid being pumped from said lubricant,

a plurality of sleeve members each fitting snugly in one said first bore providing a said cylindrical bore, said sleeve having a first end in said reservoir and a second end distant therefrom having an annular chamber meeting said cylindrical bore at a shoulder, said sleeve having an exterior longitudinally extending groove extending from near said shoulder to said first end and having a bored passage connecting said groove to said annular chamber adjacent said shoulder,

means for closing said bored passage when said piston moves in one direction and opening it when said piston moves in the opposite direction,

an O-ring in said annular chamber movable between said shoulder and said spacing member and sealing between said second portion of said piston and said sleeve and having a position closing the passage between said chamber and said groove and a position opening that passage,

said O-ring acting as a valve opening and closing the passage between said groove and said cylindrical bore as the piston reciprocates, thereby lubricating said cylindrical bore and said piston.

* * * * *