April 21, 1970 R. W. ROBBINS, JR 3,507,584

AXIAL PISTON PUMP FOR NONLUBRICATING FLUIDS

Filed March 27, 1968 3 Sheets-Sheet 1

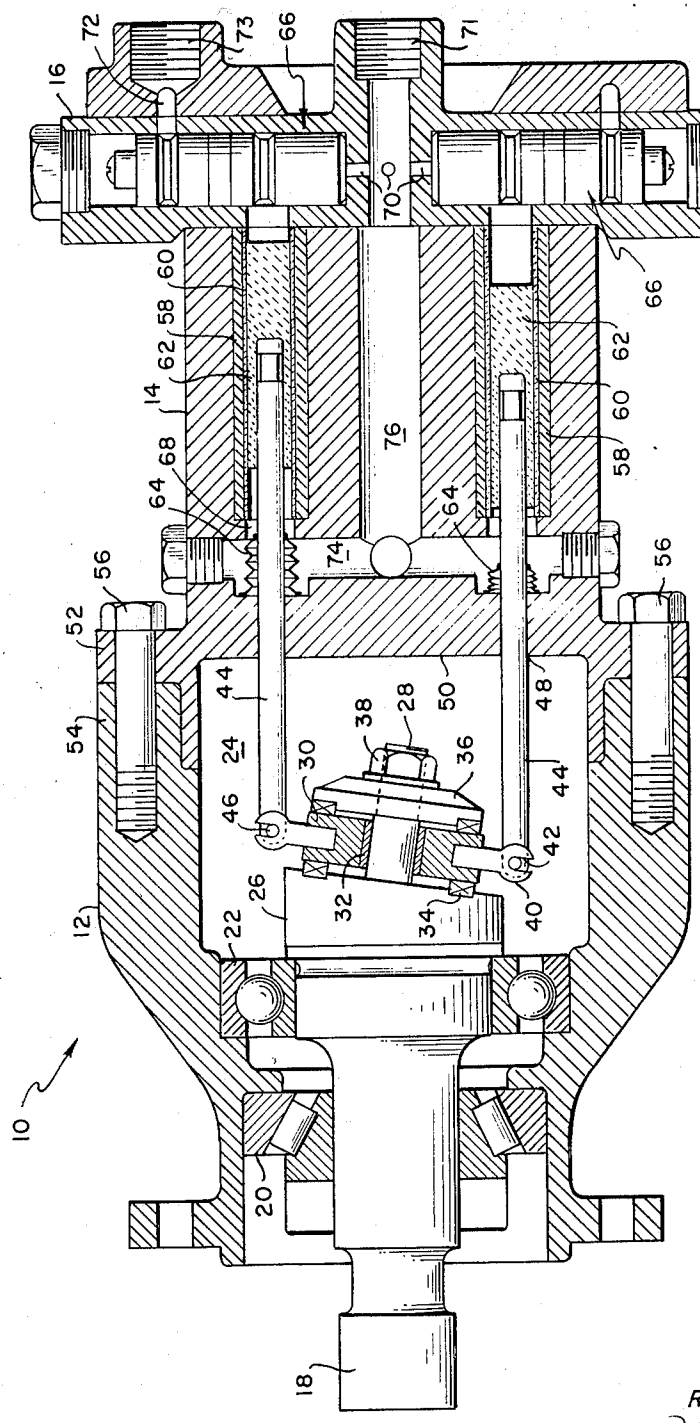


FIG. 1.

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AXIAL PISTON PUMP FOR NONLUBRICATING FLUIDS

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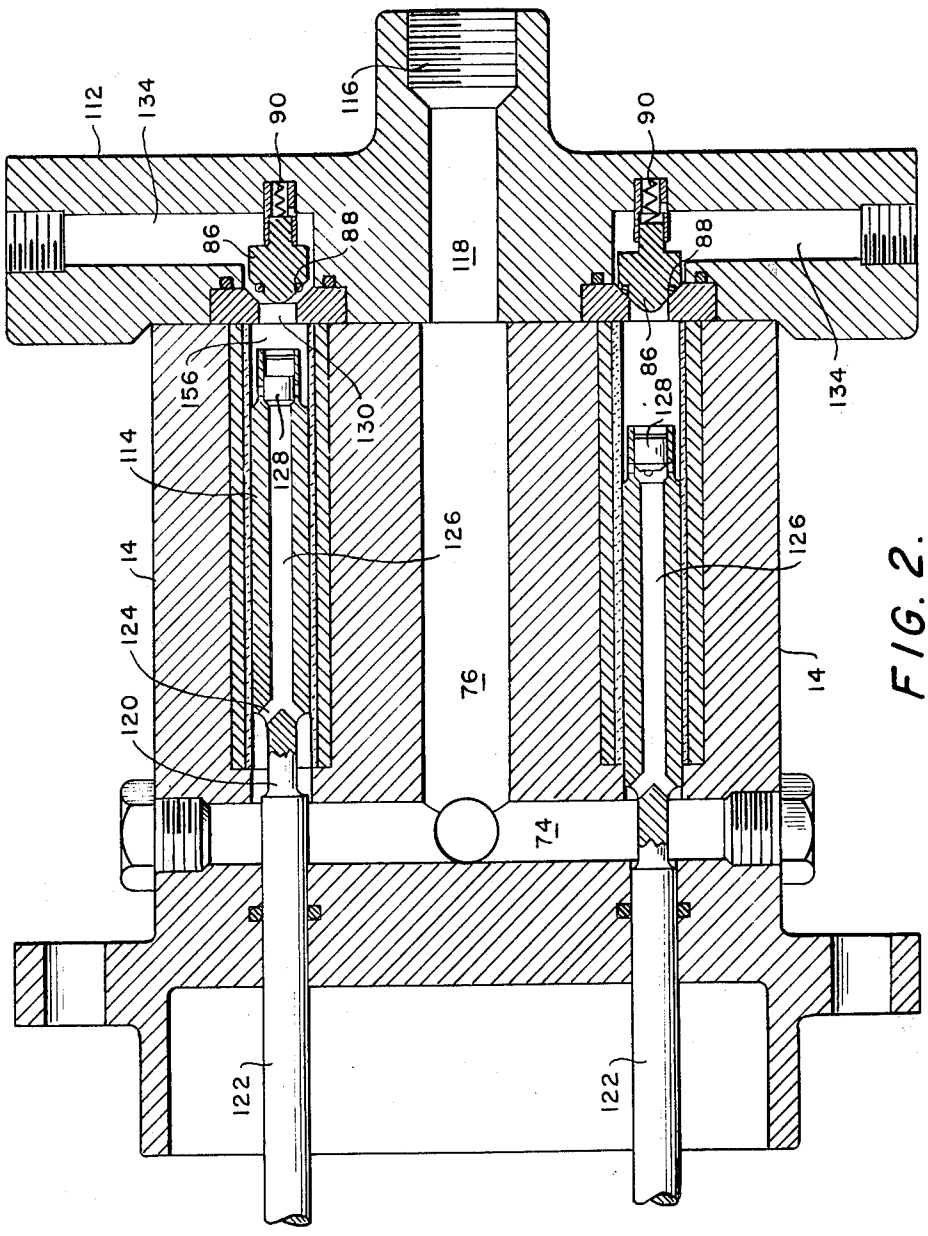


FIG. 2.

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AXIAL PISTON PUMP FOR NONLUBRICATING FLUIDS

Filed March 27, 1968 3 Sheets-Sheet 3

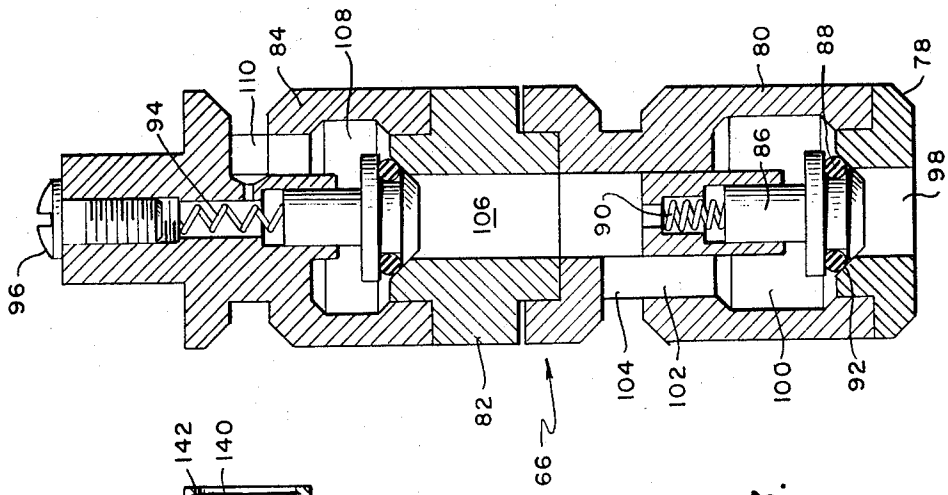


FIG. 3.

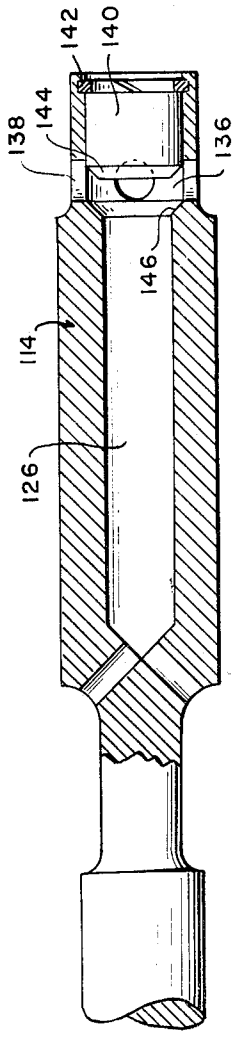


FIG. 4.

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3,507,584

AXIAL PISTON PUMP FOR NONLUBRICATING FLUIDS

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Int. Cl. F04b 1/14; F16j 15/50
U.S. Cl. 417—439 3 Claims

ABSTRACT OF THE DISCLOSURE

A high speed axial piston pump for nonlubricating fluids having separate sealed compartments for the lubricating fluid for the piston drive mechanism and for the fluid to be pumped. In addition, the pump provides a positive piston drive means and inlet valves incorporated in the delivery end of the pistons.

The invention described herein may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

BACKGROUND OF THE INVENTION

This invention relates to high speed axial piston pumps in which a plurality of pistons are driven by a cam or a swash plate mechanism and in particular for pumps of the type described for operating at high speeds under high ambient pressures. Further, the invention relates to devices for pumping fluids having poor lubricating characteristics or are corrosive in nature.

While pumps of the swash plate type are well known for pumping lubricating fluids they have not been found satisfactory for fluids which have poor lubricating qualities or which tend to cause corrosion within the pump. The problem with corrosive fluid pumping occurs due to leakage of fluid past the pistons and into the piston driving mechanism and consequently breaking down lubricating fluids required by this mechanism. Further the prior art pumps have utilized spring activated check valves at the inlet and outlets openings of the pump and also provided for spring return of the pistons through the intake stroke. Spring actuation of these components while satisfactory at low operating speeds are not suitable for high speed operation since at high speeds the valves may get out of synchronism with the piston stroke and cause the pump to become inoperative.

The present invention overcomes these disadvantages by first providing separate sealed compartments for the lubricating fluid for the swash plate mechanism, and for the fluid to be pumped. These compartments are so arranged that any leakage of the pumped fluid past the piston in the cylinder is prevented from entering the swash plate compartment and is returned to the intake of the pump. High speed capability is provided by first incorporating in the swash plate mechanism provision for positively actuating the pistons in both directions rather than relying upon a spring return. Further by incorporating the inlet valves in the working end of the piston the problem of lack of synchronization is resolved.

Protection of the working portions of the pump against the corrosive effects of the pumped fluid is provided by utilizing ceramic cylinder liners and pistons which are generally impervious to most corrosive fluids. Of course, the materials selected to be used for the components in the liquid handling portions will ultimately depend on the liquid to be pumped.

It is therefore an object of this invention to provide an axial piston pump having separate sealed compartments for the lubricating fluid and the fluid to be pumped.

It is another object of this invention to provide means for positive piston actuation in both directions.

It is still another object of this invention to provide inlet valves incorporated in the piston working head to insure high speed valve synchronization.

An additional object of this invention is to provide ceramic cylinder liners and pistons to prevent corrosion in the pumping portion of the pump.

Other objects and advantages of this invention will become readily apparent in the following detailed description taken in connection with the accompanying drawings in which:

FIG. 1 is a view along a longitudinal section of the assembled pump.

FIG. 2 is a longitudinal view of the pump of FIG. 1 with a modified portion showing inlet valves in the pistons along with their associated outlet valves.

FIG. 3 is a detailed sectional view of the double check valve of the embodiment of FIG. 1.

FIG. 4 is a detail of the piston of the assembly of FIG. 2.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to the drawings, there is shown in FIG. 1 an axial piston pump designated generally **10**. The housing for the pump **10** comprises three sections designated **12**, **14**, and **16**. Section **12** is the section of the housing which contains the piston drive mechanism, section **14**, attached to one end of section **12**, contains the pistons of the pump, and the head section **16** contains inlet and outlet valves and the inlet and outlet openings to the pump. Referring now to the piston drive mechanism contained in section **12** of the housing, there is shown an input shaft **18** which is supported for rotation in the housing section **12** by bearings **20** and **22**. Bearing **20** is a thrust bearing and bearing **22** is a radial bearing for supporting shaft **18**. The outboard end of shaft **18** may be provided with gear teeth, splines or other conventional means for driving the shaft.

At the opposite end of shaft **18** within chamber **24** in section **12** of the housing is the cam plate **26** to which the piston drive mechanism is attached. Extending from cam plate **26** and at an angle to the shaft axis there is provided a spindle **28**. Rotatably mounted on spindle **28** is the spider **30** which is supported radially by sleeve bearing **32** and axially by roller bearings **34**. The spider **30** is assembled on the spindle **28** by means of retaining ring **36** which is secured on spindle **28** by nut **38**. Attached to spider **30** are a plurality of piston drive forks **40** corresponding in number to the number of pistons in the pump; in the illustration of FIG. 1, four pistons are included in the pump. The drive forks are slideably mounted and spring biased in the spider so as to provide rotational freedom about their long axis and bias them against pin **46**. The forks **40** terminate at their outer ends in a slot for connection to the piston rods. The forks **40** are attached to the piston rods **44** by means of pin **46**. The piston rods **44** extend through openings **48** in wall **50** of the piston housing portion.

Proceeding now to the center section **14** of the housing there is provided on this section a flange **52** which mates with shoulder **54** on housing section **12**. The two sections are fastened by means of bolts **56** and the joint between the housing sections is made fluid tight by any conventional means. The piston housing section is provided with a plurality of cylindrical piston chambers **68** into which are inserted respective outer and inner cylinder liners **58** and **60**. In the preferred embodiment outer cylinder liner

58 is of stainless steel and inner cylinder liner 60 is of ceramic material. The resistance to corrosion of these materials allows the pump to be used to transport corrosive liquids. Slidably mounted in cylinder liner 60 is a ceramic piston 62 which is attached to the other end of piston rods 44. At the point where the piston rod passes through wall 50 of housing section 14 there is provided a seal member 64 in the form of a bellows through which the piston rod passes. The bellows is fluid tightly sealed at its attachment point to wall 50 and the point of attachment to the piston rod to provide a fluid tight joint between the housing sections 12 and 14.

Attached to the end of housing section 14 is a head section 16 which contains the inlet and outlet openings 71 and 73, respectively and double check valve shown generally at 66. The inlet opening communicates with the inlet valve and the piston chamber by means of holes 70 and the outlet opening communicates with the outlet valve through annular chamber 72.

The pump operates in a conventional manner in which rotation from shaft 18 rotates cam plate 26 which causes the spider 30 to oscillate back and forth to impart reciprocating motion to pistons 62. In conventional axial piston pumps the piston driving force on the intake stroke is usually provided by spring means and only the pumping stroke is positively driven by the cam plate mechanism. In the drive mechanism of the pump described herein, positive drive motion is applied to the piston during both the intake and pumping strokes of the piston. This feature is particularly advantageous when the pump is to be operated at high speed or at very high inlet pressures either of which conditions can cause the piston stroke to be shortened to less than the optimum design length. While this disadvantage can be theoretically overcome by the use of stronger springs than are normally required, considerable additional power is used to compress these springs on the pumping stroke. By providing positive piston drive force in both directions the optimum length of piston stroke is insured.

Another disadvantage of conventional pumps of this type is the inherent possibility of the pumped fluid leaking into the drive mechanism chamber contaminating the lubricants therein thus shortening the like of the pump. This disadvantage is overcome by the use of the seals 64 between the piston rod and the drive mechanism chamber. As can be seen from FIG. 1 should any of the pumped fluid leak past piston 62 it is effectively sealed from entering compartment 24 and is returned to the inlet opening 70 through openings 74 and 76 provided in the piston housing. Additionally, the use of separate sealed compartments allows the drive mechanism compartment to be maintained at a higher pressure than the adjacent section thus further reducing the possibility of lubricant contamination.

An additional novel feature of the pump as shown in FIG. 1 is provided by a double check valve assembly 66 shown in detail in FIG. 3. This assembly provides both the inlet and outlet check valves in a single assembly which may be quickly and easily replaced without disassembly of the pump housing. The check valve assembly as shown in FIG. 3 is comprised of four housing sections 78, 80, 82, and 84. The inlet check valve is contained in valve housing section 80 and comprises valve piston 86 which is provided with an annular sealing member 88 contained in a groove at the end of the piston. The sealing member which may be an O-ring or similar elastic seal member is forced in sealing engagement with shoulder 92 of housing member 78 by means of spring 90. The outlet valve piston is identical in construction to the inlet valve piston and its annular sealing member seats against a similar shoulder in housing section 82. The outlet valve is actuated by spring 94 which bear against screw 96 by which the force of spring 94 may be adjusted.

In operation liquid is drawn into opening 98 on the intake stroke of the pistons in the pump; flows past the valve piston seal through chamber 100 and channel 102 and is discharged into the pump cylinder through opening 104. On the working stroke of the pump piston the liquid is forced through opening 104 and to chamber 106, forcing the outlet valve piston into the raised position against spring 94 and the fluid then passes through chamber 108 and out opening 110 which discharges into the outlet opening in the head portion of the housing. Thus there is provided a simple and inexpensive valve assembly which is easily repaired and can be removed from the pump housing without disassembly of other portions of the pump.

A second embodiment of the pump is shown in FIG. 2. This embodiment differs from the embodiment previously described in that the inlet valve is assembled in the working end of the piston rather than in the head portion of the housing. A common problem in axial piston pumps which are to be operated at high speeds is that the operation of the inlet valve may get out of synchronization with the piston motion. That is, because of valve inertia, the opening and closing of the inlet channels may lag behind the piston motion. While this problem may be partially cured by increasing the inlet valve spring force, this solution causes a second, more serious problem. The stronger spring causes an increased drop across the inlet valve which may cause the fluid to cavitate and actually form vapor in the cylinder and disrupt pump operation. Incorporation. of the inlet valve into the piston assembly insures synchronous operation of the valves and pistons. This embodiment utilizes the same piston housing section as that shown in FIG. 1 but incorporates alternate designs of pistons, housing head and outlet valves.

In this embodiment the fluid to be pumped is drawn into the cylinder 156 through the rear of the piston 114. As in the previous embodiment there is provided in the head portion 112 an inlet opening 116 which communicates with channel 118. Fluid taken in through the inlet opening passes through channel 76 in the piston housing then through channel 74 and enters the cylinder through the reduced diameter portion 120 of the piston rod 122. The liquid then passes through the cross-holes 124 in the piston; through channel 126 provided in the center of the piston; through inlet valve 128 into the cylinder chamber 156. On the pumping stroke of the piston, inlet valve 128 is closed and the fluid is forced out through opening 130 in the head past the outlet valve 86 and exits through opening 134 in the head which communicates with the outlet opening. Details of the inlet valve in the piston are shown in FIG. 4. Referring now to FIG. 4 there is shown in the end of the piston 114 an enlarged opening 136 having additional openings 138 which communicate with the cylinder chamber. Within opening 136 there is provided a shuttle 140 which is slidably mounted in the opening 136. The shuttle is retained in the opening through the means of snap ring 142 positioned in a groove in opening 136.

In operation, on the intake stroke of the piston the shuttle 140 is moved to the end of the opening nearest the snap ring and liquid is drawn through the central opening of the piston and through holes 138 into the cylinder chamber. When the piston begins its pumping stroke the shuttle 140 is positioned at the opposite end of opening 136 and closes opening 126 in the piston by seating of the beveled face 144 with a mating face 146 at the end of opening 136 in the piston. The outlet valve piston 86 is the same as that described in connection with the double check valve shown in FIG. 3 and operates in the same manner.

Thus it can be seen that there is herein provided an axial piston pump which is suitable for pumping non-lubricating or corrosive liquids which may be operated at high speeds and under high ambient pressures without impairment of its operation because of internal corrosion, contamination of drive mechanism lubricant, or loss of valve synchronization.

What is claimed is:

1. A piston pump for liquids comprising:

a housing having first and second sections therein, said sections being separated in a liquid-tight fashion by transverse wall means;

piston means including at least one piston mounted in said first section for accepting liquids at low pressure and discharging such at high pressure;

cylinder means including at least one cylinder for enclosing said piston means and for confining the movemet thereof to two directions of movement in a slidable fashion within the cylinder means;

piston connection means including at least one connecting rod with two ends and having one end attached to said piston means and having the other end extended through said wall means for coupling said piston means to a driving means;

driving means in said second section attached to said other end of said piston connection means;

liquid-tight sealing means, including at least one flexible extensible seal, one for each of said at least one connecting rod, attached at one end to said wall means and attached at the other end to each of said at least one connecting rod, said sealing means preventing liquid in said first section from entering said second section through said wall means;

a head member attached to said housing and having at least one liquid inlet opening and at least one liquid outlet opennig, each of which communicating with said cylinder means; and

inlet and outlet check valve means for isolating said liquid inlet and liquid outlet openings;

whereby liquid being pumped through said first section is sealed from said second section by said liquid-tight sealing means and said transverse wall means thereby preventing elements contained in said second section from undue wear and corrosion.

2. A pump as set forth in claim 1 wherein said second section contains a fluid channel means between said cylinder means and said liquid inlet opening for returning liquid leaking past said piston means to said liquid inlet opening.

3. A pump as set forth in claim 1 wherein said at least one cylinder and said at least one piston contain noncorrosive materials, whereby said second section is made more corrosion resistant.

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74—18.2; 92—71, 86, 168, 171, 248; 417—552, 568