June 23, 1970 E. J. SCROGGINS 3,516,761

FLUID ACTUATED HYDRAULIC PUMP

Filed Oct. 10, 1968 2 Sheets-Sheet 1

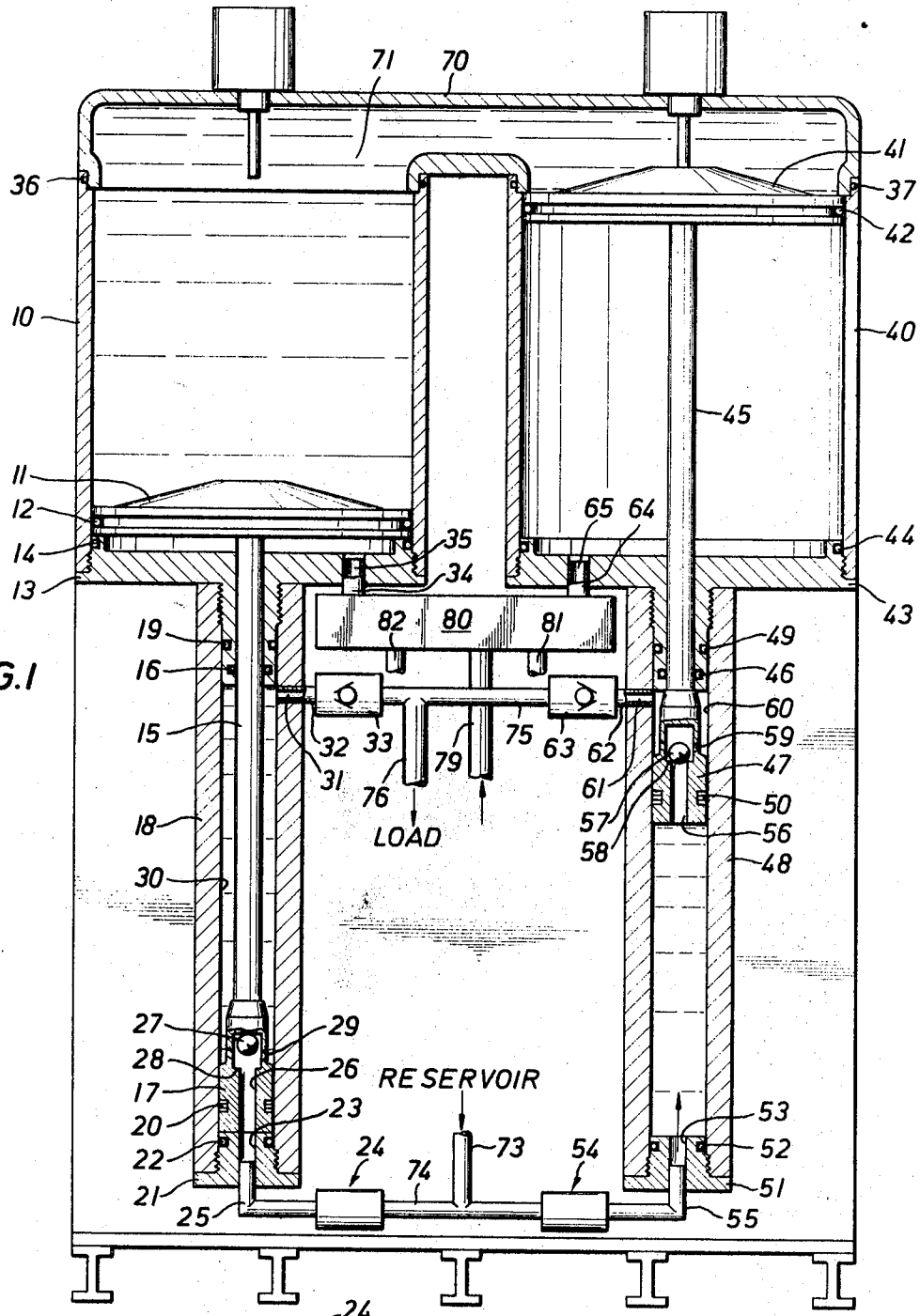


FIG. 1

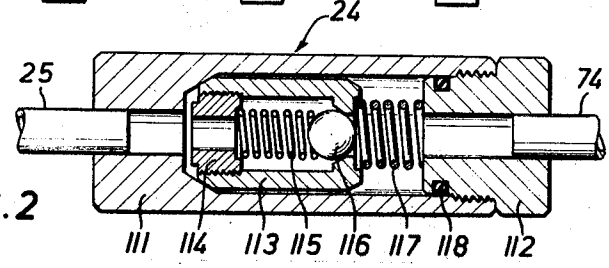


FIG. 2

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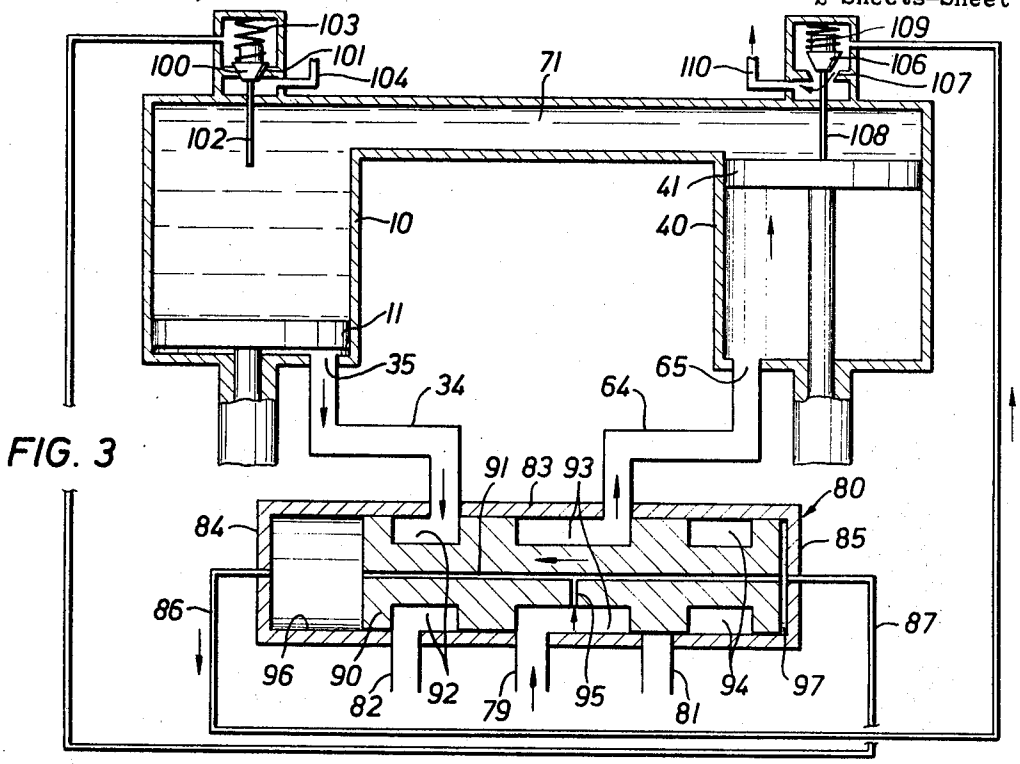


FIG. 3

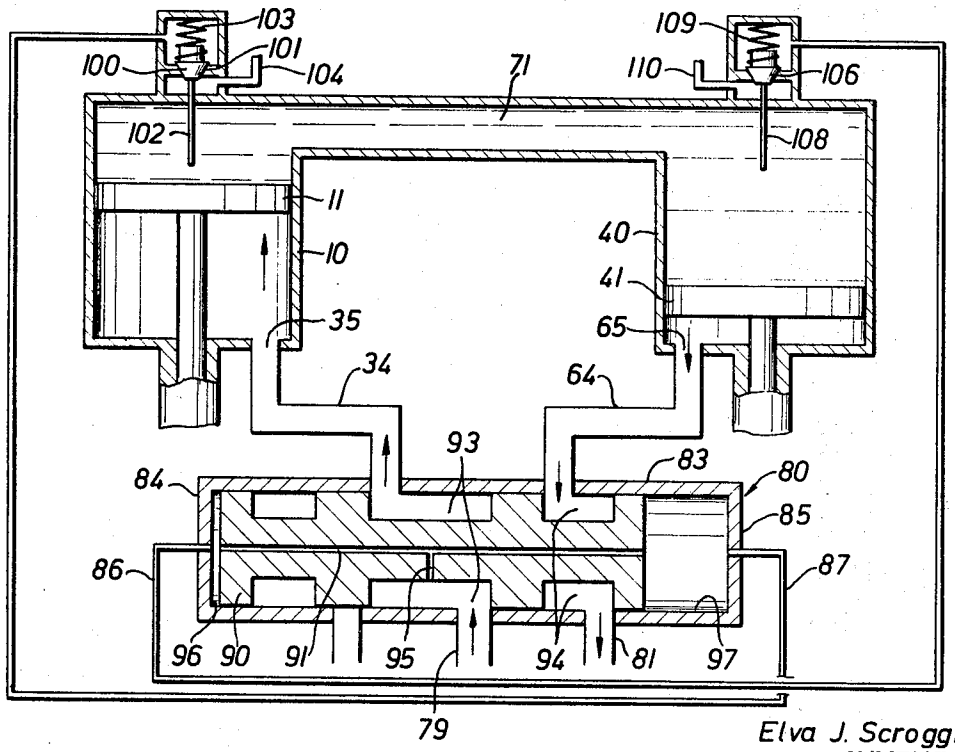


FIG. 4

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FLUID ACTUATED HYDRAULIC PUMP

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ABSTRACT OF THE DISCLOSURE

An improved fluid actuated reciprocating piston pump having pistons that are driven through power strokes by the selective application of a pressurized fluid thereto. The pump includes means for confining a coupling fluid between the opposite ends of the pistons whereby alternate application of the pressurized fluid to the pistons causes alternate reciprocation thereof such that during the powered stroke of one piston the coupling fluid drives the other piston through the return stroke.

This invention relates to an improved fluid actuated reciprocating piston engine capable of motivating high pressure fluid pumps. More particularly, in this invention the engine pistons are driven through their power stroke by the selective application of a pressurized fluid behind the pistons. A coupling fluid ahead of the pistons transmits the force from a powered piston to a previously powered piston, driving the previously powered piston through a return stroke. One embodiment of this invention may be used to actuate lift plunger type pumps, for example, and is particularly suited for motivating hydraulic pressure pumps used for high pressure testing.

Devices heretofore employed in this field lack the simplicity of construction and operation provided by this invention. This invention does not require use of mechanical linking means between the pistons to create or augment a return stroke for a previously powered piston, nor does it require application of the pressurized drive fluid against the engine pistons to create or augment the return stroke.

It is therefore an object of this invention to provide an improved fluid actuated pump which overcomes the shortcomings of the prior art noted above and provides the advantages herein specified.

Briefly stated, this invention concerns an improved fluid actuated reciprocating piston engine having a plurality of reciprocating pistons. It includes in combination therewith means for selectively applying a first fluid to one face of one piston to move said piston through a powered stroke. It also includes means confining a second fluid between the other face of said one piston and a face of another piston for moving said other piston through a return stroke in response to the power generating stroke of said one position.

In one preferred embodiment of the invention, the pressurized fluid is a gas and the coupling fluid is a hydraulic fluid.

A preferred embodiment is also comprised of a pair of pistons and an automatic reciprocating valve means for selectively applying the pressurized drive fluid to the pistons.

Reference to the drawings will further explain the invention wherein:

FIG. 1 is a generally central vertical sectional view of one embodiment of the invention showing a pair of pistons and including attached pump means.

FIG. 2 is an enlarged sectional view of the check valve indicated by the numeral 24 in FIG. 1.

FIG. 3 is a view similar to FIG. 1, but partially schematic, and showing in greater detail a cross-sectional view of the automatic reciprocating valve, and showing the drive fluid being directed to one piston.

FIG. 4 is a view similar to FIG. 3 showing the alternating reciprocating valve directing drive fluid to the other piston.

Referring to the drawings, and in particular to FIG. 1, cylinders 10 and 40 contain pistons 11 and 41 respectively, slidably mounted for reciprocal movement therein, with O-rings 12 and 42 providing a pressure tight seal between the respective pistons and cylinders. Cylinders 10 and 40 are enclosed at one end by cylinder heads 13 and 43 respectively, which are threadably attached thereto with O-rings 14 and 44 respectively providing a pressure tight seal between the respective cylinders and cylinder heads. The other end of cylinders 10 and 40 are enclosed by coupling manifold 70, with O-rings 36 and 37 respectively providing a pressure tight seal between the coupling manifold and the cylinders. A substantially incompressible fluid 71 fills coupling manifold 70 and the space above pistons 11 and 41, directly contacting the upper ends of the pistons.

Piston rods 15 and 45 are attached to and coaxially depend from pistons 11 and 41 respectively and extend through cylinder heads 13 and 43 respectively, with O-rings 16 and 46 providing a pressure tight seal between the respective piston heads and piston rods. Ball check valves 17 and 47 are attached to and coaxially depend from piston rods 15 and 45 respectively. Pump cylinders 18 and 48 are threadably attached to cylinder heads 13 and 43 respectively, and depend therefrom enclosing piston rods 15 and 45 respectively and ball check valves 17 and 47 respectively. O-rings 19 and 49 provide a pressure tight seal between the respective pump cylinders and piston heads, and seals 20 and 50 provide a pressure tight interface between the respective pump cylinders and ball check valves.

Pump cylinders 18 and 48 are closed at their lower ends by threadably attached cylinder end plugs 21 and 51 respectively, containing pump inlet ports 23 and 53 respectively, and the attachment is sealed against pressure loss by O-rings 22 and 52 respectively.

Partial check valves 24 and 54 are positioned in pipes 25 and 55 respectively, and permit a limited flow of fluid in two directions. Referring now to FIG. 2, the body of partial check valve 24 comprises a housing 111 and end plug 112. Tapered plug 113 is contained in housing 111 and is biased against movement to the right by spring 117. Ball 116 is seated in plug 113 and is biased against leftward movement by spring 115. Springs 115 and 117 are suitably selected so that a smaller fluid pressure is needed for leftward than rightward fluid flow. Partial check valve 54 is identical to valve 24 and is installed in reverse direction so that a smaller fluid pressure is needed for rightward than leftward fluid flow therethrough.

The fluid to be pumped (hereinafter work fluid) is contained in a reservoir (not shown). In operation of the pump and during the power stroke of piston 41, ball check valve 47 is drawn upwardly through cylinder 48 by piston rod 45 in the closed position. The resulting partial vacuum beneath ball check valve 47 draws the work fluid into the area enclosed by ball check valve 47, cylinder end plug 51, and cylinder 48, through pump inlet port 53 in cylinder end plug 51. The work fluid is drawn from the reservoir through pipe 73, interconnecting pipe 74, partial check valve 54 and pipe 55. Partial check valve 54 restricts reverse flow of the work fluid during the downward return stroke of ball check valve 47, forcing the work fluid therebeneath to flow through ball check valve 47 and into annulus 60.

Similarly, during the upward powered stroke of piston

11, piston rod 15 raises ball check valve 17 creating a partial vacuum in the area enclosed by check valve 17, cylinder end plug 21, and cylinder 18. The partial vacuum draws work fluid from the reservoir through pipe 73, interconnecting pipe 74, partial check valve 24, pipe 25 and pump inlet port 23 through cylinder end plug 21. Partial check valve 24 restricts reverse flow of the work fluid during the downward return stroke of ball check valve 17, forcing the work fluid therebeneath to flow through ball check valve 17 and into annulus 30.

The downward return stroke of piston 11, piston rod 15, and ball check valve 17 forces the work fluid entrapped beneath ball check valve 17 through check valve inlet port 26, past ball 27 and valve seat 28, and through check valve outlet port 29 into annulus 30 in cylinder 18. Due to the volume displacement of piston rod 15 during downward movement thereof, annulus 30 is not capable of containing all of the work fluid which was previously drawn into cylinder 18 during the upward stroke. Hence, during the downward stroke of piston rod 15 and ball check valve 17, a portion of the liquid contained beneath ball check valve 17 flows out of cylinder 18 through end plug 21, pipe 25, and partial check valve 24.

Similarly, during the downward return stroke of piston 41, piston rod 45, and ball check valve 47, a portion of the work fluid entrapped beneath ball check valve 47 flows out of cylinder 48 through end plug 51, pipe 55, and partial check valve 54.

On the upward powered stroke of piston 11, the fluid contained in annulus 30 is forced upwardly by ball check valve 17 through outlet port 31, pipe 32, check valve 33, interconnecting pipe 75 and pipe 76 into the load. The pressure of the work fluid contained in annulus 30 forces ball 27 downward against valve seat 28, preventing a reverse flow of the work fluid contained in annulus 30 through ball check valve 17. During this pumping stroke, check valve 63 prevents the work fluid contained in annulus 30 from moving into annulus 60.

Similarly, on the power stroke of piston 41, the work fluid contained in annulus 60 is forced through outlet port 61, pipe 62, check valve 63, interconnecting pipe 75, and pipe 76 to the load. Ball 57 seating on valve seat 58 prevents reverse flow of the work fluid entrapped in annulus 60 through ball check valve 47. Check valve 33 prevents the work fluid contained in annulus 60 from moving into annulus 30.

In operation, a pressurized fluid, such as gas, is introduced into automatic reciprocating valve 80 (described in detail below) through line 79. The automatic reciprocating valve alternately directs the pressurized gas through lines 34 and 64 and through gas ports 35 and 65 respectively, beneath pistons 11 and 41 respectively. When the automatic reciprocating valve 80 is switched to one position, the pressurized gas is directed beneath piston 11, forcing it upward. As piston 11 moves upward, it displaces coupling fluid 71 contained in cylinder 10 above piston 11. This displacement is transmitted through coupling manifold 70 and against the top of piston 41, thereby forcing piston 41 downward through its return stroke. As piston 41 moves downward through its return stroke, the gas contained in the area enclosed by cylinder 40 beneath piston 41 is forced out through gas port 65, line 64, automatic reciprocating valve 80, and line 81.

Similarly, when automatic reciprocating valve 80 is switched to its second position, pressurized gas is applied beneath piston 41 through port 65. The power stroke of piston 41 displaces the coupling fluid contained in cylinder 40 above piston 41 and this displacement, transmitted through manifold 70, forces piston 11 to its return position. The downward movement of piston 11 through its return stroke forces the gas contained in the area beneath piston 11 and enclosed by cylinder 10 to be exhausted through gas port 35, line 34, automatic reciprocating valve 80, and line 82.

Referring now to FIG. 3, automatic reciprocating valve 80, illustrated by a cross-sectional view, is comprised of a cylindrical body 83 enclosed at each end by suitable end plates 84 and 85, the end plates being disc shaped and suitably attached to the cylindrical body to form a pressure tight seal at each end. Through said end plates are mounted pressure relief lines 86 and 87, respectively, these lines being suitably joined to the end plates to provide a pressure tight seal between the respective end plates and pressure relief lines. The cylindrical body 83 of said valve contains reciprocating spool shaped piston 90 therein, suitably mounted for limited slidable movement coaxial with cylindrical body 83. Piston 90 is provided with gas port 91 through the longitudinal axis thereof and contains circumferential recessed grooves thereabout which create annuli 92, 93, and 94. Piston 90 is also provided with transverse gas port 95 which interconnects gas port 91 and annulus 93. Cylindrical body 83 has attached thereto gas outlet lines 81 and 82, and gas inlet line 79, which lines provide means to allow the pressurized drive gas to flow through automatic reciprocating valve 80 as hereinafter described. Gas ports 35 and 65 and lines 34 and 64 respectively allow flow of the pressurized drive gas to and from cylinders 10 and 40 respectively.

In operation the pressurized gas is introduced through line 79 into annulus 93. When reciprocating piston 90 is in its right hand position, as shown in FIG. 3, the pressurized drive gas flows into annulus 93, through line 64 and gas port 65, and into cylinder 40 beneath piston 41, forcing the same upward. Simultaneously, coupling fluid 71 forces piston 11 downward to its return position. The gas beneath piston 11 evacuates through gas port 35, line 34, annulus 92, and line 82. At the same time, the pressurized drive gas in annulus 93 flows through gas ports 95 and 91, and into annuli 96 and 97, providing an equal pressure on both ends of reciprocating piston 90.

Switch means for causing shifting of piston 90 will now be described. Return springs 103 and 109 are appropriately selected to maintain valves 100 and 106 respectively against valve seats 101 and 107 respectively, when valve stems 102 and 108 are not engaged by pistons 11 and 41 respectively. While valves 100 and 106 remain in the closed position, the pressurized drive gas contained in annuli 96 and 97 is prevented from venting through pressure release lines 86 and 87, respectively. As piston 41 approaches the top of its drive stroke, as shown in FIG. 3, it engages valve stem 108, unseating valve 106 and depressing return spring 109. When valve 106 opens, the pressurized drive gas contained in annulus 96 is relieved through pressure release line 86, past valve 106 and valve seat 107, and is vented to atmosphere through line 110. The gas pressure in annulus 96 is now less than the gas pressure in annulus 97 and the difference in gas pressure moves reciprocating piston 90 laterally to its left hand stop position.

With reciprocating valve 90 in its left hand position, as shown in FIG. 4, the pressurized gas is introduced beneath piston 11 through gas inlet line 79, annulus 93, line 34, and gas port 35. As piston 11 moves through its upward power stroke, coupling fluid 71 forces piston 41 downward through its return stroke and the gas beneath piston 41 is evacuated through gas port 65, line 64, annulus 94, and gas outlet line 81. Meanwhile, pressurized drive gas is introduced into annuli 96 and 97 through gas ports 95 and 91. Return springs 103 and 109 maintain valves 100 and 106 respectively in the closed position when pistons 11 and 41 are disengaged from valve stems 102 and 108. Since said gas release valves are closed, the pressurized drive gas contained in annuli 96 and 97 is prevented from escaping through pressure release lines 86 and 87 respectively, and while the pressures in annuli 96 and 97 are equal, the reciprocating valve remains in its left hand stop position. As piston 11 approaches the top

of its drive stroke, it engages valve stem **102** which forces valve **100** upward, compressing return spring **103**, and allowing the pressurized gas contained in annulus **97** to flow through pressure release line **87**, past valve **100** and valve seat **101**, venting through line **104**. The difference in pressure thus created between annuli **96** and **97** forces reciprocating piston **90** to move laterally to its right hand stop position. With piston **11** at its uppermost position, piston **41** at its downward return position and reciprocating valve **90** at its right hand stop position, the pressurized drive gas from line **79** is again applied through annulus **93**, line **64** and port **65**, repeating the previously described cycle.

While the accompanying drawings and foregoing description illustrate one embodiment of this improvement in a fluid actuated reciprocating piston engine, it is understood that this invention may be practiced in other configurations as long as means are used to selectively apply a drive fluid to one face of reciprocating pistons and means are provided to confine a coupling fluid between the opposite faces of the pistons so that the force of the drive fluid applied to one piston is transmitted through the coupling fluid to a previously powered piston, forcing the previously powered piston to its return position.

What is claimed is:

1. In a fluid actuated pump having a pair of first cylinders having pistons mounted for reciprocation therein and including means for confining a substantially incompressible fluid between first faces of said pistons and automatic reciprocating valve means for alternately applying pressurized gas to the second faces of said pistons to alternately force one of said pistons through a powered stroke and the other of said pistons through a return stroke, the improvement comprising:

a piston rod connected to each of said pistons and extending axially away from the second face thereof;

a second pair of cylinders mounted axially adjacent to and generally coaxially aligned with said first cylinders, with each of said second cylinders being arranged to receive therein one of said piston rods, and each of said second cylinders having a fluid inlet port towards the axially outward end thereof, and a fluid outlet port toward the axially inward end thereof, with said inlet ports being connected to a reservoir having a fluid supply therein and said outlet ports being connected to a load;

and, means connected to the axially outward ends of each of said piston rods for forcing fluid in said second cylinders out said outlet ports and drawing fluid in said inlet ports during the powered stroke thereof, whereby said piston rods are placed under tension forces during said powered strokes.

2. The invention as claimed in claim **1** wherein: said means for forcing fluid out said outlet ports includes one-way valves attached to the ends of said piston rods.

3. The invention as claimed in claim **2** wherein each of said one-way valves includes:

a generally cylindrical valve body arranged for axially slidable sealing engagement with the inner circumferential surface of said second cylinder, and said valve body having an axial passageway therethrough;

and, means for closing said passageway during the power stroke of said piston rod and opening said passageway during the return stroke of said piston rod.

4. The invention as claimed in claim **3** including:

conduits connecting each of said inlet ports to said reservoir of fluid to be pumped;

and, double acting check valves operably mounted in each of said conduits and arranged to allow flow of said fluid from said reservoir into said inlet ports when said double acting check valves are subjected to a first fluid pressure and arranged to allow said fluid to flow from said inlet ports to said reservoir when subjected to a higher second fluid pressure.

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U.S. Cl. X.R.

91—306; 417—296, 342, 345