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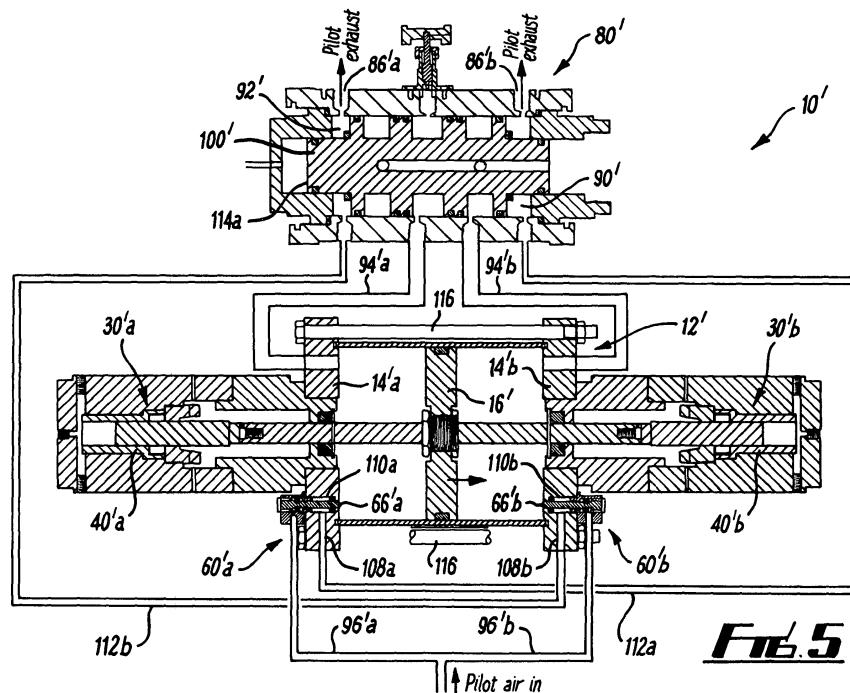
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(30) Priority: **14.10.2005 GB 0520879**(71) Applicant: **Stamper, Eric Swan****Aberdeen****Aberdeen City AB21 0DP (GB)**(72) Inventor: **Stamper, Eric Swan****Aberdeen****Aberdeen City AB21 0DP (GB)**(74) Representative: **Orr, Robert et al****Kennedys Patent Agency Limited****185 St Vincent Street****GB-Glasgow G2 5QD (GB)**(54) **A valve assembly**

(57) There is disclosed a valve assembly for a pump such as a dual-piston reciprocating pump, and to such a pump incorporating a valve assembly.

In one embodiment, a valve assembly (10) is disclosed which includes a valve main body (98); a valve member (100) mounted for movement within the valve main body, to control the supply of an actuating fluid to a pump (10); a main valve inlet (81) formed in the valve

main body, through which actuating fluid is supplied to the valve main body; and an inlet valve (83) for controlling the flow of actuating fluid through the main valve inlet into the valve main body. Providing a valve assembly with such an inlet valve facilitates accurate control of the flow of actuating fluid into the valve assembly. This in turn facilitates control of the flow of actuating fluid to a pump, thereby permitting one or more operating characteristics of the pump to be varied.

**FIG. 5****EP 1 775 468 A2**

Description

[0001] The present invention relates to a valve assembly for a pump, and to a pump including a valve assembly. In particular, but not exclusively, the present invention relates to a valve assembly for a reciprocating pump such as a dual-piston reciprocating pump, and to such a pump incorporating a valve assembly.

[0002] Pumps are commonly used in hydraulic systems for the supply of fluid under pressure. There exist a range of different types of pump. For example, single piston reciprocating pumps are known, which, in operation, draw fluid in during part of a cycle of the pump, and discharge fluid during another part of the cycle.

[0003] Dual-piston reciprocating pumps are also known, which provide a substantially constant fluid output. Such pumps include opposed pistons, which are successively actuated, such that during discharge of one of the pistons, the other piston is being charged, and vice versa. Joining the two outlets of the pistons into a common fluid line facilitates constant fluid flow into the line (during the cycle of the pump), giving a constant flow output.

[0004] These reciprocating dual-piston pumps can be mechanically driven, for example, using a rotating cam arrangement. However, in other arrangements, the pumps may be fluid operated, with an actuating fluid supplied to the pump to drive the pistons in a reciprocating fashion. One such type of pump is pneumatically actuated and includes a main actuating piston. The actuating piston is mounted between and coupled to the discharge pistons and is pneumatically controlled for reciprocating motion, to drive and thus alternately charge and discharge the discharge pistons.

[0005] Control of the actuating piston is achieved using a valve assembly, which is built into and configured for the pump. By providing the valve assemblies built-in to the pump, access to and thus maintenance of the valve assembly is inhibited. For example, in existing pumps, the valve assemblies may be built into a main body of the pump, requiring the pump itself to be dismantled in order to conduct maintenance on the valve assembly.

[0006] A number of other problems exist in relation to existing pumps, such as single and dual-piston reciprocating pumps. For example, it is not possible to vary the flow characteristics of the pumps, or to customise the flow output for different applications.

[0007] These and other problems and disadvantages also occur in other types of fluid pumps.

[0008] It is amongst the objects of embodiments of the present invention to obviate or mitigate at least one of the foregoing disadvantages.

[0009] According to a first aspect of the present invention, there is provided a valve assembly for a pump, the valve assembly comprising:

- a valve main body;
- a valve member mounted for movement within the

valve main body, to control the supply of an actuating fluid to a pump;

a main valve inlet formed in the valve main body, through which actuating fluid is supplied to the valve main body; and

an inlet valve for controlling the flow of actuating fluid through the main valve inlet into the valve main body.

[0010] Preferably, the inlet valve is adjustable to thereby permit the flow of actuating fluid into the valve main body to be varied.

[0011] Providing a valve assembly with an inlet valve facilitates accurate control of the flow of actuating fluid into the valve assembly. This in turn facilitates control of the flow of actuating fluid to a pump, thereby permitting one or more operating characteristics of the pump to be varied. For example, by adjusting the inlet valve to vary the pressure, velocity and/or rate of flow of actuating fluid into the valve main body, the pressure, velocity and/or flow rate of actuating fluid supplied from the valve assembly to the pump may be correspondingly varied, thereby affecting one or more operating characteristic of the pump.

[0012] The flow of actuating fluid to the pump to operate the pump may be dependent upon a position of the valve member within the valve main body. The valve assembly may comprise two or more primary pump flow ports, for fluid communication between the valve assembly and a pump. The primary pump flow ports may serve for flow of actuating fluid to and from a pump, for actuating the pump. Fluid may be adapted to be supplied to the pump through one of the primary pump flow ports and to be returned from the pump to the valve assembly through the other one of said ports, depending upon the position of the valve member within or relative to the valve main housing.

[0013] For example, in a first position of the valve member, fluid may flow from the valve assembly to the pump through a first one of said primary pump flow ports, and may return to the valve assembly from the pump through the second one of said primary pump flow ports. In a second position of the valve member, fluid may flow from the valve assembly to the pump through the second primary pump flow port, and may return to the valve assembly from the pump through the first primary pump flow port. Thus by controlling the position of the valve member, the flow of actuating fluid to and from the pump may be controlled.

[0014] Preferably, the valve assembly comprises a control system for controlling the position of the valve member, and thus for controlling flow of fluid to and from the pump. The control system may be fluid operated, and may be adapted to selectively generate or provide a pressure differential across the valve member, for moving the valve member between the first and second positions.

[0015] Preferably also, the control system comprises at least two control valves, such as pilot valves, which control valves may be adapted to be operated by or as-

sociated with a pump. The control valves may be adapted to control the position of the valve member within the valve main body by selectively permitting bleed of a control fluid from the valve assembly. For example, the control valves may be adapted to selectively permit fluid supply and/or bleed to and/or from a first end of the valve main housing to generate a pressure differential across the valve member and thereby facilitate movement of the valve member in a first direction; and to selectively permit fluid supply and/or bleed to and/or from a second, opposite end of the valve main housing to generate a pressure differential across the valve member and thereby facilitate movement of the valve member in a second, opposite direction. The control fluid is preferably the same fluid as is used to actuate the pump, such that the pump actuating fluid and the valve control fluid may be supplied from a common source.

[0016] The control valves may be mechanically operated and may be biased towards a closed position. Thus in the absence of an operating or actuating force, the control valves may be closed. In the closed positions of the control valves, the valve member may be restrained against movement by fluid pressure, and may thus be hydraulically locked. The control valves may be adapted to be opened by the pump and, in particular, may be adapted to be opened by an actuating piston of the pump during movement thereof in a cycle of the pump. In this fashion, the pump itself may ultimately control the supply of actuating fluid thereto, according to a position of the actuating piston.

[0017] In a particular embodiment, a first control valve may be coupled to a first end of the valve housing, and a second control valve to a second, opposite end of the valve housing, by corresponding fluid lines. The control valves may each be coupled to a fluid pressure source. Actuation of the first control valve may supply fluid to the first end of the valve housing, to move the shuttle valve in a first direction. Actuation of the second control valve may supply fluid to the second end of the valve housing, to move the shuttle in a second, opposite direction.

[0018] The primary pump flow ports may be in selective fluid communication with the inlet, for the supply of actuating fluid from the valve assembly to the pump; and with an exhaust, for the discharge of used or spent actuating fluid from the valve assembly. The valve member may control the flow of actuating fluid from the inlet to one of the primary pump flow ports, and from the other one of the primary pump flow ports to the exhaust, depending upon whether the valve member is in the first or second position.

[0019] The valve member may be a shuttle valve or the like, mounted for translation relative to the valve main body, and may comprise a plurality of flanges or the like which define a number of annular chambers with the valve housing. The valve member and in particular the flanges may carry a plurality of seals, for defining the chambers within the valve main housing. The valve member may define first and second end chambers, each one

associated with a respective pilot valve, and a main chamber associated with the primary pump flow ports.

[0020] Preferably, the valve assembly is adapted to be provided separately from/externally of the pump and to be coupled to the pump via suitable flow lines or pipes. For example, the valve assembly and in particular the valve main body may be mounted to an external surface of the pump. This may facilitate access to the valve assembly for maintenance and the like. Alternatively, the valve assembly may be provided integrally with the pump.

[0021] The actuating fluid may be a gas and in preferred embodiments, may be air. Alternatively, the actuating fluid may be a liquid and may be a hydraulic liquid.

[0022] According to a second aspect of the present invention, there is provided a pump assembly comprising:

a pump; and

a valve assembly according to the first aspect of the invention.

[0023] Preferably, the pump is a reciprocating pump, and may be a dual-piston reciprocating pump.

[0024] Further features of the valve assembly are defined in relation to the first aspect of the invention.

[0025] According to a third aspect of the present invention, there is provided a valve assembly for a pump, the valve assembly comprising:

a valve main body; and

a valve member mounted for movement within the valve main body, to control the supply of an actuating fluid to a pump;

wherein the valve main body is adapted to be provided separately from the pump.

[0026] Preferably, the valve assembly is adapted to be coupled to the pump via suitable flow lines or pipes. This may facilitate access to the valve assembly for maintenance and the like. The valve assembly may be provided externally of the pump, and may be adapted to be mounted to an external surface of the pump. Preferably, the valve main body is adapted to be mounted to an external surface of the pump.

[0027] Further features of the valve assembly in common with the valve assembly of the first aspect of the present invention are defined above.

[0028] According to a fourth aspect of the present invention, there is provided a valve assembly for a pump, the valve assembly comprising:

a valve main body; and

a valve member mounted for movement within the valve main body;

wherein the valve member is movable between a first position in which actuating fluid is supplied to a first end

of an actuating cylinder of the pump and exhausted from a second, opposite end of the actuating cylinder, and a second position in which actuating fluid is supplied to the second end of the actuating cylinder and exhausted from the first end of the actuating cylinder, to thereby reciprocate an actuating piston of the pump back and forth within the actuating cylinder.

[0029] Further features of the valve assembly in common with the valve assembly of the first aspect of the present invention are defined above.

[0030] In a further aspect of the present invention, there is provided a pump comprising:

an actuating cylinder;
 an actuating piston mounted for reciprocating movement within the actuating cylinder;
 a discharge cylinder;
 a discharge piston coupled to the actuating piston and mounted for reciprocating movement within the discharge cylinder to successively draw fluid into and discharge fluid from the discharge cylinder; and
 a valve assembly according to any one of the first, third or fourth aspects defined above.

[0031] In a yet further aspect of the present invention, there is provided a pump comprising:

an actuating cylinder;
 an actuating piston mounted for reciprocating movement within the actuating cylinder;
 a discharge cylinder;
 a sleeve releasably mounted within the discharge cylinder, to thereby define an operating diameter of the discharge cylinder;
 a discharge piston coupled to the actuating piston and mounted for reciprocating movement within the sleeve to successively draw fluid into and discharge fluid from the discharge cylinder; and
 a valve assembly according to any one of the first, third or fourth aspects defined above.

[0032] An embodiment of the present invention will now be described, by way of example only, with reference to the accompanying drawings, in which:

Figure 1 is a longitudinal, cross-sectional view of a reciprocating pump, in accordance with an embodiment of the invention, with a valve assembly of the pump removed, for illustration purposes;

Figure 2 is a view of the pump of Figure 1, also showing a valve assembly of the pump, in accordance with an embodiment of the invention, illustrating the pump at a stage in a cycle of operation of the pump;

Figure 3 is a view of the pump of Figure 2 shown at a further stage in the cycle of operation of the pump;

Figure 4 (presented on same sheet as Figure 1), is an enlarged view of an inlet valve forming part of the valve assembly shown in Figure 2;

Figure 5 is a longitudinal, cross-sectional view of a reciprocating pump in accordance with a preferred embodiment of the present invention.

Figure 6 is a longitudinal, cross-sectional view of a main valve assembly forming part of a reciprocating pump in accordance with a further alternative embodiment of the present invention;

Figures 7 and 8 are longitudinal, cross-sectional views of a main valve assembly forming part of a reciprocating pump in accordance with a preferred embodiment of the present invention, with a shuttle of the valve assembly shown at opposite extents of movement; and

Figures 9 and 10 are views similar to those of Figs 7 and 8 of a main valve assembly of a reciprocating pump in accordance with a further alternative embodiment of the present invention.

[0033] Turning firstly to Figure 1, there is shown a longitudinal, cross-sectional view of a pump in accordance with the present invention, the pump indicated generally by reference numeral 10. The pump 10 is illustrated in more detail in Figures 2 and 3, which also show a main valve assembly 80 coupled to the pump 10, the valve assembly 80 also in accordance with the invention, and which show the pump 10 at various stages in a cycle of operation.

[0034] The pump 10 comprises an actuating cylinder 12 and an actuating piston in the form of an air drive flange 16, which is mounted for reciprocating movement within the actuating cylinder 12. The pump also comprises a discharge cylinder 52a which is provided in a hydraulic end housing 38a, and a sleeve 40a which is optionally releasably mounted within the discharge cylinder 52a, to thereby define an operating diameter 42a of the cylinder. Additionally, a discharge piston 30a is coupled to the flange 16 and mounted for reciprocating movement within the sleeve 40a, to discharge fluid from the discharge cylinder 52a.

[0035] In use, the pump 10 is operated to pump a fluid by controlling reciprocating movement of the flange 16 within the actuating cylinder 12. This is achieved by controlling the supply of actuating fluid (in this case, compressed air) to the actuating cylinder 12. The discharge piston 30a, by virtue of its connection to the flange 16, is reciprocated back and forth within the sleeve 40a during movement of the flange 16, and thus repeatedly charges the discharge cylinder 52a (drawing fluid in through an inlet 56a, having a check valve) and discharges the cylinder 52a (expelling the fluid through an outlet 58a, also having a check valve).

[0036] As noted above, the sleeve 40a is optionally releasably mounted within the discharge cylinder 52a, which facilitates maintenance and/or replacement. Indeed, the sleeve 40a may be replaced with a sleeve of a different internal diameter, which enables the flow characteristics of the pump to be adjusted. For example, by replacing the sleeve 40a with a sleeve of a smaller internal diameter, a smaller volume of fluid is drawn into the discharge cylinder 52a on each cycle of the discharge piston 30a. However, as the diameter of the replacement sleeve 40a is smaller, the resultant pressure of the discharged fluid is higher; this is due to the corresponding smaller piston area defined by the replacement sleeve, which will be described below.

[0037] The valve assembly 80 includes an inlet valve in the form of an adjustable needle valve 83, which controls the entry of air into the valve assembly 80 through an inlet 81, for driving the pump 10. Providing a valve assembly 80 with such an inlet valve 83 facilitates accurate control of the flow of actuating fluid to the valve assembly 80. This in turn facilitates control of the flow of actuating fluid to the pump 10, which permits one or more operating characteristics of the pump to be varied, as will be described in more detail below.

[0038] The valve assembly 80 is provided separately from the pump 10 in that it is mounted externally of the pump, either on a part of the pump such as the air cylinder 12, or to a support frame or structure (not shown). In either case, the valve assembly 80 is connected to the pump 10 through appropriate control lines and pipes, as will also be described below.

[0039] The structure and method of operation of the pump 10, and of the valve assembly 80, will now be described in more detail. The pump 10 is a dual-piston reciprocating pump, for supplying a substantially constant fluid output, and includes two discharge pistons 52a, 52b at opposite ends 32 and 34 of the pump. Like components of the pump components at the end 32 with those at the end 34 share the same reference numerals, but with the suffix 'a' generally replaced with the suffix 'b'.

[0040] The air cylinder 12 includes end caps 14a,b and a drive shaft 18 is provided which extends along a longitudinal axis of the cylinder 10 and through apertures 20a,b in the end caps 14a,b. The air drive flange 16 is connected to the portion 22 of the shaft 18 within the cylinder 12, and seals 24 are provided around the outer circumference of the flange 16. The discharge pistons 30a,b are connected to the drive shaft 18 via threaded connections 36a,b thereby allowing the pistons to be readily changed out. The hydraulic end housings 38a,b are threadably connected to the respective end caps 14a, b so that they can be removed easily for access to components of the pump.

[0041] The hydraulic end housings 38a,b define the discharge cylinders 52a,b and are aligned with the longitudinal axis of the pump, such that the drive shaft 18 with pistons 30a,b are able to slideably move relative to the discharge cylinders. The housings 38a,b include re-

spective end portions or caps 50a,b.

[0042] The hydraulic end housings 38a,b receive the sleeves or cartridges 40a,b, which have hydraulic seals 44a,b which seal between the cartridges 40a,b and the outer surface of the pistons 30a,b. The diameter 42a,b defined by the cartridges 40a,b and seals 44a,b are matched to that of the pistons 30a,b such that the pistons fit snugly and slideably within the cartridges.

[0043] The seals 44a,b and cartridge 40a,b are secured in position in the hydraulic end housings 38a,b by packing nuts 46a,b which are threadably connected to the housings. In this way, the cartridges are removable from the end housings and the pump.

[0044] In use, a maximum, operating volume of the discharge cylinders 52a,b are defined by front surfaces 54a,b of the pistons 30a,b, the inner surfaces of the cartridges 40a,b, and end portions 50a,b of the hydraulic end housings and depend upon the extent of movement of the pistons relative to the cartridges.

[0045] Inlets 56a,b are provided for drawing in hydraulic fluid from an external reservoir, whilst the discharge pistons 30a,b move in a direction away from the respective first and second ends 32,34 of the pump. Also provided in the end housings are outlets 58a,b through which high-pressure fluid is discharged from the cylinders 52a, b under the force of the pistons 30a,b.

[0046] By this arrangement, the pump 10 is modular and the detachable hydraulic end housings 38a,b allow easy access to the pistons 30a,b and hydraulic seals 44a,b. This facilitates cleaning/maintenance and replacement without having to fully dismantle the pump 10.

[0047] The provision of removable pistons, cartridges and seals also allows pistons of different sizes to be selected and installed with ease, in situ, and without requirement to change other pump components. To achieve this, different cartridges 40a,b provided with different size internal bores are inserted into the end housings 38a,b with internal diameters corresponding to the outer diameters of the desired pistons 30a,b.

[0048] Thus, a piston may be changed out and replaced with a different piston as required by a user for a particular application. For example, a smaller piston may be required to provide high-pressure, low-flow-rate output. The provision of different cartridge or insert sizes removes the need to provide pumps with different specifications for different jobs or purposes.

[0049] The air cylinder is additionally provided with ports 57a,b extending through the cylinder end caps 14a, b. As will be described, the ports 57a,b provide a fluid connection to ends 26 and 28 of the air cylinder 12 for driving the pump 10.

[0050] In Figure 2, the pump 10 is shown in an operational configuration, connected to the main valve assembly 80. In use, air is supplied to the air cylinder 12 under the control of the valve assembly 80, which comprises a valve main body in the form of a housing 98 and a valve member in the form of a shuttle valve 100. The shuttle valve 100 is mounted for reciprocating movement

within the housing 98, and is provided with a number of flanges 102 having outer surfaces 104 which carry seals 106. The flanges 102 of the shuttle body thereby define a series of annular chambers 82, 84, 90 and 92 between the shuttle valve 100 and the valve housing 98, which serve for controlling air flow, as will be described below.

[0051] The valve assembly 80 also includes an inlet 81 and an inlet valve in the form of an adjustable needle valve 83, through which air enters the valve assembly for driving the pump 10. Air enters the valve assembly 80 via the port 81, and flows into the chamber 82. In the portion of the pump cycle depicted in Figure 2, the shuttle valve is in a first position. Air provided to the chamber 82 exits through a first, primary pump flow port 85 and flows into the air cylinder 12 via a pipe 94a and the port 57a. This air enters the end 26 of the cylinder 12 under pressure, and exerts a pressure force on the drive flange 16. Simultaneously, the end 28 of the air cylinder 12 is open to atmosphere, via the port 57b, a pipe 94b, a second primary pump flow port 87 (in the valve housing 98) and an exhaust port 89 (which opens on to the annular chamber 84). A pressure differential is created across the flange 16, which then moves towards the second end 34 of the pump, to a second position. The piston 30b connected to the drive shaft 18 acts against the fluid in the chamber 52b, providing a high-pressure output from outlet 58b. The pressure of the air provided to the air cylinder 12 is typically between 2 and 12 bar (approximately 30 to 175 psi), whilst the output pressure is in the region of 60,000 psi.

[0052] The needle valve 83 is shown in more detail in the enlarged view of Figure 4, and comprises a base body 144 and a threaded shaft 146, with a handle 140 attached to a top end of the shaft, for turning the shaft in the base body 144. A passageway 150 is provided through the handle and opens into an area 151, for entry of air into the valve 83. The handle 140, and thus the shaft 146 can be rotated to lift the needle pin 145 away from a valve seat 147 in the base body 144. This facilitates air flow through the valve into the region 149 and thus into the valve chamber 82. Adjustment of the handle 140 position provides different rates of air flow through the valve 83. This may be set by manually turning the handle or by an automatic control arrangement (not shown). The needle valve 83 has a connecting portion 148 on the base body 144 which engages with the valve housing 98.

[0053] Use of the needle valve 83 to control delivery of air for driving the pump 10 allows the operational characteristics of the pump 10 to be adjusted. Specifically, provision of the needle valve 83 allows control of the rate of flow of actuating fluid into the pump 10 independently of the air within the pipes 96a,b.

[0054] In addition to providing improved control, the valve assembly 80 is a self-contained unit that may be utilised with a range of different pumps, and may also be utilised to control operational characteristics of the pumps. Specifically the needle valve 83 allows the flow

to be adjusted according to desired operational characteristics of the pump.

[0055] As an independent or a detachably integratable unit, the valve assembly 80 may be easily maintained as it is not necessary to dismantle the pump to replace parts of the valve assembly. The valve assembly 80 can thus be maintained and repaired independently, which saves costs and reduces downtime.

[0056] The pump 10 also comprises two pilot valves 60a,b which are biased closed, and which are opened via mechanical activation of valve pins 66a,b from inside the air cylinder 12. The length of the pins 66a,b is adjustable and the pins 66a,b protrude inwardly into the cylinder ends 26 and 28.

[0057] At the end of the phase of the drive cycle shown in Figure 2, the flange 16 strikes a valve pin 66b of the pilot valve 60b, and when the pin is depressed, the valve is opened. As shown in Figure 2, the pilot valves 60a,b are connected via pipes 96a,b to control fluid flow to the ports 88a,b of the valve assembly 80. Air is supplied to the pipes from a common pressure source (not shown) through ports 86a,b of the valve assembly 80 and annular end chambers 90 and 92 respectively. Air pressure in these pipes 96a,b and the chambers 90 and 92 determine the position of the shuttle valve 100 within the valve housing 98. In the position of Figure 2, the pressure in the chamber 90 is held at a higher level than that in the chamber 92 by the closed pilot valve 60b, creating a pressure differential across the shuttle valve 100 holding it in the Figure 2 position.

[0058] When the valve 60b is opened through contact between the flange 16 and the valve pin 66b, the air in the pipe 96b is vented to atmosphere through a pilot hole (not shown) which is opened by this movement of the valve pin 66b. The pressure in pipe 96b and chamber 90 thus reduces to near atmospheric pressure, urging the shuttle 100 towards the now-low pressure chamber 90, driven by the higher pressure of air in chamber 92, moving the shuttle valve 100 to the position shown in Figure 3.

[0059] Thus referring now to Figure 3, the pump is shown following movement of the shuttle 100 to the opposite end of the valve housing 98. In this position, the chamber 82 of the valve assembly 80 opens onto the port 87, such that air is now provided to the end 28 of the air cylinder 12 through port 57b. In a similar manner to the cycle described above with reference to Figure 2, air is supplied to the cylinder end 28 and forces the flange 16 and piston 30 to move toward the first end 32 of the pump 10. In this case, air exits the cylinder end 26 via port 57a and pipe 96a and back to the valve assembly 80. The return air enters port 85 and exhausts to the atmosphere through a port 126. After the flange 16 commences movement towards the pump end 32, the pilot valve 62b is released and closes, locking the shuttle 100 in the position of Figure 3.

[0060] This part of the cycle ends when the flange 16 comes into contact with the pilot valve pin 66a, exhausting air from chamber 92 to atmosphere (through the line

94a and valve 62a), such that the pressure of the air in chamber 90 returns the shuttle 100 to the left to the position of Figure 2. A continuous reciprocating two-way pump cycle is thus produced by providing a constant air flow to the valve assembly 80, and a common pressure source to ports 86a,b.

[0061] In use of the pump 10, the different internal diameters 42a,b of the sleeves 40a,b result in different flow characteristics of the discharged fluid. For example, a larger volume of fluid is discharged from the cylinder 52a on each cycle of the piston 30a than on each cycle of the piston 30b. However, the smaller piston area of the piston 30b results in higher pressure output from the discharge cylinder 52b. By combining the outputs from the cylinders 52a and 52b, a balance of a good flow rate and pressure can be achieved.

[0062] The pump 10 provides a number of other advantages. The pins 66a,b for triggering the switching of the stroke direction of the pump are adjustable in length. This allows the stroke length of the pump in either direction to be adjusted, i.e. arranging the pins to protrude further into the air cylinder 12 will shorten the stroke length. The valves containing these pins may be unscrewed to insert appropriate length pins 66a,b or the lengths of the pins could be adjusted externally without needing to unscrew the valve. In either case, the pins and stroke length can be adjusted easily without dismantling the pump or providing a different size cylinder, which would otherwise be necessary.

[0063] Turning now to Figure 5, there is shown a longitudinal, cross-sectional view of a reciprocating pump in accordance with an alternative embodiment of the present invention, the pump indicated generally by reference numeral 10'. Like components of the pump 10' with the pump 10 of Figs 1 to 4 share the same reference numerals, with the addition of the suffix '. Only significant differences between the pump 10' and the pump 10 will be described in detail herein.

[0064] The pump 10' includes pilot valves 60'a and 60'b which govern the position of a shuttle valve 100', in a similar fashion to the valves 60a, 60b of the pump 10. However, end caps 14'a and 14'b of an actuating cylinder 12' include bleed vents 108a, 108b which open on to bores 110a, 110b in which the respective valves 60'a, 60'b are mounted. The bleed vent 108a is coupled to a fluid outlet line 112a which is in fluid communication with a chamber 90' of the valve assembly 80'. In a similar fashion, the bleed vent 108b is coupled by a fluid outlet line 112b to a chamber 92' at an opposite end of the valve 80'. The valves 60'a and 60'b are coupled via fluid supply lines 96'a and 96'b to a common pilot pressure source (not shown). Ports 86'a and 86'b of the shuttle valve 80' carry one-way valves (not shown), and permit exhaust of air from the chambers 92' and 90', respectively.

[0065] The pump 10 operates as follows. In use and during movement of a flange 16' of the pump 10' to the right, as shown in Figure 5, the flange 16' comes into contact with a pin 66'b of the pilot valve 60'b. This causes

the valve 60'b to open, thereby permitting fluid communication between the pilot pressure source and the chamber 92', through the supply line 96'b and the outlet line 112b. The valve 60'a is closed, and the fluid supplied to chamber 92' causes the shuttle valve 100' to move to the right, exhausting the air in chamber 90' through the port 86'b. In a similar fashion to the valve assembly 80 of the pump 10, this switches flow into the actuating cylinder 12', and reverses the flange 16'.

[0066] When the flange 16' strikes a pin 66'a of the pilot valve 60'a, fluid communication between the pilot pressure source and the chamber 90 through the inlet line 96'a and outlet line 112a is opened. This permits fluid communication between the pilot pressure source and the chamber 90', through the supply line 96'a and the outlet line 112a. The shuttle valve 100' is thus urged back to the left, exhausting the air in chamber 92' through the port 86'a. This reverses flow into the actuating cylinder 12' once again.

[0067] It should be noted in Figure 5 that the pump 10' includes sleeves 40'a and 40'b which are of similar internal diameters, and thus illustrates a situation where it is desired to have similar discharge from each discharge piston 30'a and 30'b. Additionally, Figure 5 illustrates clamping bolts 116 which secure the cylinder flanges 14'a, 14'b together.

[0068] Turning now to Figure 6, there is shown a longitudinal, cross-sectional view of a main valve assembly forming part of a reciprocating pump in accordance with a further alternative embodiment of the present invention, the main valve assembly indicated generally by reference numeral 80''. The valve assembly 80'' typically forms part of a pump similar to the pump 10' shown in Figure 5, and thus may replace the valve assembly 80'. For ease of illustration, only the valve assembly 80'' is shown in Figure 6 and described, the remaining components of the pump being as shown in Figure 5. Only the differences between the assemblies 80'' and 80' will be described herein in detail, and like components of the valve assembly 80'' with the valve assemblies of Figs 1 to 4 and Fig 5 share the same reference numerals, with the addition of the suffix ''.

[0069] The valve assembly 80'' includes a shuttle 100'' of slightly different shape to the shuttle 100' of the valve assembly 80'. Specifically, the shuttle 100'' includes shoulders 118, 120 which abut end caps 122, 124 respectively at each extreme extent of travel of the shuttle 100''. These end caps 122, 124 are threadably coupled to a housing 98'' of the valve assembly 80'', in a similar fashion to the valve assemblies shown in Figures 1 to 5. This permits removal of the shuttle 100'' for maintenance/replacement. The shoulders 118, 120 define maximum extents of movement of the shuttle 100'', and thus the position of the shuttle 100'' in relation to the various ports 85''; 86''a,b; 87''; and 88''a,b. Additionally, the end cap 124 defines an outlet 126 from an end chamber 128 which is of larger diameter than similar vent or bleed ports from the valve assemblies shown in Figures 1 to 5. This pro-

vides improved exhaust of air from the chamber 128 in use of the valve assembly 80". Operation of the valve assembly 80" is otherwise as described in relation to the valve assembly 80' of Figure 5.

[0070] Turning now to Figures 7 and 8, there are shown longitudinal, cross-sectional views of a main valve assembly forming part of a reciprocating pump in accordance with a preferred embodiment of the present invention, the valve assembly indicated generally by reference numeral 80''' and shown in the Figures at respective opposite extents of travel of a shuttle 100''' of the valve assembly.

[0071] As with the valve assembly 80" of Figure 6, the valve assembly 80''' is provided as part of a reciprocating pump similar to that shown in Figure 5, save that the valve assembly 80' has been replaced with the valve assembly 80'''. The remaining components of the pump have been omitted, for ease of illustration. Furthermore, only the differences between the valve assembly 80''' and the previously described valve assemblies will be described herein in detail. Like components of the valve assembly 80''' with the valve assemblies of Figs 1 to 4, Fig 5 or Fig 6 share the same reference numerals, with the addition of the suffix '''.

[0072] A housing 98''' of the valve assembly 80''' includes a number of flow ports 130a and 130b (two of each shown) spaced around a circumference of the housing 98'''. Outer seal rings 132a, 132b are mounted on the housing 98 in abutment with a central flange 134, and are secured by bolts (not shown) which extend through passages 136a,b and engage in the flange 134. The seal rings 132a,b define main flow ports (not shown) similar to the ports 85" and 87" of the valve assembly 80". These main flow ports open onto annular chambers 138a,b between the seal rings 132a,b and the housing 98''', as do the flow ports 130a, 130b. This provides fluid communication between the valve assembly 80''' and the cylinder of the pump (such as the cylinder 12' of the pump 10' shown in Figure 5). This arrangement of the flow ports 130a,b spaced around the circumference of the housing 98''', and of the main flow ports opening onto the annular chambers 138a,b provides enhanced flow of air to and from the cylinder in use of the valve assembly 80'''.

[0073] Additionally, end caps 122''' and 124''' of the valve assembly 80''' have enlarged outlets 126'''a, 126'''b, to provide enhanced flow of exhaust air. The shuttle 100''' also includes a number of exhaust ports 140 and 142 (five of each shown) spaced around a circumference of the shuttle valve, to enhance flow of exhaust air. Finally, the shuttle 100''' includes a throughbore 144 which provides for fluid communication between the exhaust ports 140, 142 and the respective outlets 126'''a, b. The shuttle 100''' is shown following movement to the opposite extent of its travel in Figure 8.

[0074] Turning now to Figures 9 and 10, there are shown views similar to those of Figures 7 and 8 of a main valve assembly 80^{iv} of a reciprocating pump in accordance with a further alternative embodiment of the present

invention, the valve assembly indicated generally by reference numeral 80^{iv} and illustrated at opposite extents of movement in Figures 9 and 10. As with the valve assembly 80" of Figure 6, the valve assembly 80^{iv} is provided as part of a reciprocating pump similar to that shown in Figure 5, save that the valve assembly 80' has been replaced with the valve assembly 80^{iv}. The remaining components of the pump have been omitted, for ease of illustration. Furthermore, only the differences between the valve assembly 80^{iv} and the previously described valve assemblies will be described herein in detail. Like components of the valve assembly 80^{iv} with the assemblies of Figs 1 to 4, Fig 5, Fig 6 or Figs 7 and 8 share the same reference numerals, with the addition of the suffix ^{iv}.

[0075] The valve assembly 80^{iv} is essentially the same as the valve assembly 80''', save that the internal diameter of the shuttle 100''' throughbore 144 is $\frac{3}{4}$ ", whereas a throughbore 144^{iv} of the shuttle 100^{iv} is 1" to provide enhanced air flow. Additionally, internal diameters of end caps 122^{iv} and 124^{iv} have been enlarged to account for the larger diameter shuttle 100^{iv}. Operation of the valve assemblies 80''' and 80^{iv} is otherwise as described in relation to the valve assembly 80' of Figure 5.

[0076] Other characteristics of the pumps described above may also be customised for different applications by the provision of detachable end housings. The end housings may be detached, allowing the piston to be unscrewed and replaced with a different diameter piston to suit needs. Cartridges provided in the housing that compliment the piston and house the hydraulic seals can similarly be unscrewed, removed and replaced. Such replacement can be carried out with ease and can be carried out with the pump in situ as part of a larger system. Hydraulic seals can be easily accessed, maintained and replaced.

[0077] The present pump 10 mitigates the need to dismantle the pump or to change out the entire pump with a new pump when different pump characteristics are required. This saves costs relating to the purchase of parts and operational downtime for repair and maintenance.

[0078] Various modifications and improvements may be made to the foregoing without departing from the spirit and scope of the present invention.

[0079] For example, the discharge pistons may be directly threadably coupled to the actuating piston, such that the entire piston is released from the actuating piston when it is desired to changeover for a discharge piston of a different diameter.

Claims

1. A valve assembly for a pump, the valve assembly comprising:

a valve main body;
a valve member mounted for movement within

- the valve main body, to control the supply of an actuating fluid to a pump;
a main valve inlet formed in the valve main body, through which actuating fluid is supplied to the valve main body; and
an inlet valve for controlling the flow of actuating fluid through the main valve inlet into the valve main body.
2. A valve assembly as claimed in claim 1, wherein the inlet valve is adjustable to permit at least one characteristic of the actuating fluid flowing into the valve main body to be varied.
 3. A valve assembly as claimed in either of claims 1 or 2, wherein the flow of actuating fluid to a pump to operate the pump is dependent upon a position of the valve member within the valve main body.
 4. A valve assembly as claimed in any preceding claim, comprising at least a first and a second primary pump flow port, for fluid communication between the valve assembly and a pump.
 5. A valve assembly as claimed in claim 4, wherein the primary pump flow ports serve for flow of actuating fluid to and from the pump, for actuating the pump.
 6. A valve assembly as claimed in either of claims 4 or 5, wherein the valve assembly is adapted to supply fluid to the pump through one of the primary pump flow ports and to return fluid from the pump to the valve assembly through the other one of said flow ports, depending upon the position of the valve member within the valve main housing.
 7. A valve assembly as claimed in any one of claims 4 to 6, wherein in a first position of the valve member, fluid flows from the valve assembly to the pump through the first primary pump flow port, and returns to the valve assembly from the pump through the second primary pump flow port.
 8. A valve assembly as claimed in claim 7, wherein in a second position of the valve member, fluid flows from the valve assembly to the pump through the second primary pump flow port, and returns to the valve assembly from the pump through the first primary pump flow port.
 9. A valve assembly as claimed in any preceding claim, comprising a control system for controlling the position of the valve member, and thus for controlling flow of fluid to and from the pump.
 10. A valve assembly as claimed in claim 9, wherein the control system is fluid operated, and is adapted to selectively generate a pressure differential across
- the valve member, for moving the valve member between the first and second positions.
11. A valve assembly as claimed in either of claims 9 or 10, wherein the control system comprises at least two control valves, and wherein the control valves are adapted to be operated by the pump.
 12. A valve assembly as claimed in claim 11, wherein the control valves are adapted to control the position of the valve member within the valve main body by selectively permitting bleed of a control fluid from the valve assembly.
 13. A valve assembly as claimed in either of claims 11 or 12, wherein the control valves are adapted to selectively permit fluid supply to a first end of the valve main housing and fluid bleed from a second, opposite end of the valve main housing, to generate a pressure differential across the valve member to move the valve member in a first direction.
 14. A valve assembly as claimed in claim 13, wherein the control valves are also adapted to selectively permit fluid supply to the second end of the valve main housing and fluid bleed from the first end, to generate a pressure differential across the valve member to move the valve member in a second, opposite direction.
 15. A valve assembly as claimed in any one of claims 9 to 14, wherein the control fluid is the same fluid as is used to actuate the pump.
 16. A valve assembly as claimed in claim 11, or any one of claims 12 to 15 when dependent on claim 11, wherein the control valves are mechanically operated and biased towards a closed position.
 17. A valve assembly as claimed in claim 16, wherein, in the closed positions of the control valves, the valve member is restrained against movement by fluid pressure.
 18. A valve assembly as claimed in either of claims 16 or 17, wherein the control valves are adapted to be opened by an actuating piston of the pump during movement thereof in a cycle of the pump.
 19. A valve assembly as claimed in either of claims 11 or 12, comprising a first control valve coupled to a first end of the valve housing, and a second control valve to a second, opposite end of the valve housing, by corresponding fluid lines.
 20. A valve assembly as claimed in claim 19, wherein the control valves are each coupled to a fluid pressure source, and wherein actuation of the first control

valve supplies fluid to the first end of the valve housing, to move the valve member in a first direction, and further wherein actuation of the second control valve supplies fluid to the second end of the valve housing, to move the valve member in a second, opposite direction.

21. A valve assembly as claimed in claim 4, or any one of claims 5 to 20 when dependent on claim 4, wherein the primary pump flow ports are in selective fluid communication with the inlet, for the supply of actuating fluid from the valve assembly to the pump; and with an exhaust, for the discharge of spent actuating fluid from the valve assembly.

22. A valve assembly as claimed in claim 8, or any one of claims 9 to 21 when dependent on claim 8, wherein the valve member controls the flow of actuating fluid from the inlet to one of the primary pump flow ports, and from the other one of the primary pump flow ports to the exhaust, according to the position of the valve member.

23. A valve assembly as claimed in any preceding claim, wherein the valve member is a shuttle valve mounted for translation relative to the valve main body, the shuttle valve comprising a plurality of flanges defining annular chambers within the valve housing.

24. A valve assembly as claimed in any preceding claim, wherein the valve assembly is adapted to be provided separately from the pump and to be coupled to the pump via flow lines.

25. A valve assembly as claimed in any preceding claim, wherein the valve assembly is adapted to be provided externally of the pump and to be coupled to the pump via flow lines.

26. A pump assembly comprising:

a pump; and
a valve assembly according to any one of claims 1 to 25.

27. A valve assembly for a pump, the valve assembly comprising:

a valve main body; and
a valve member mounted for movement within the valve main body, to control the supply of an actuating fluid to a pump;

wherein the valve main body is adapted to be provided separately from the pump.

28. A valve assembly for a pump, the valve assembly comprising:

a valve main body; and
a valve member mounted for movement within the valve main body;

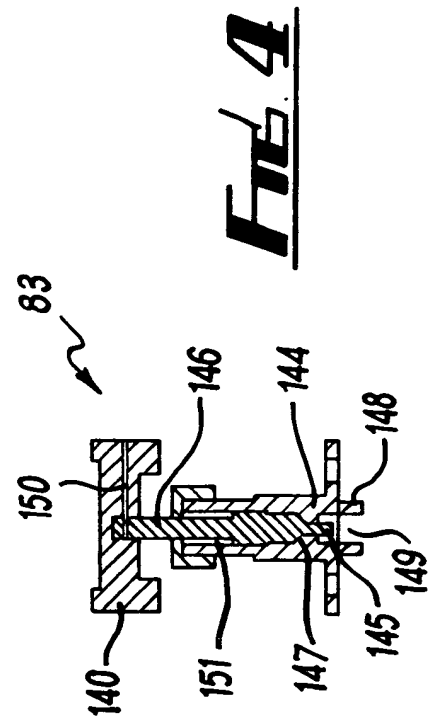
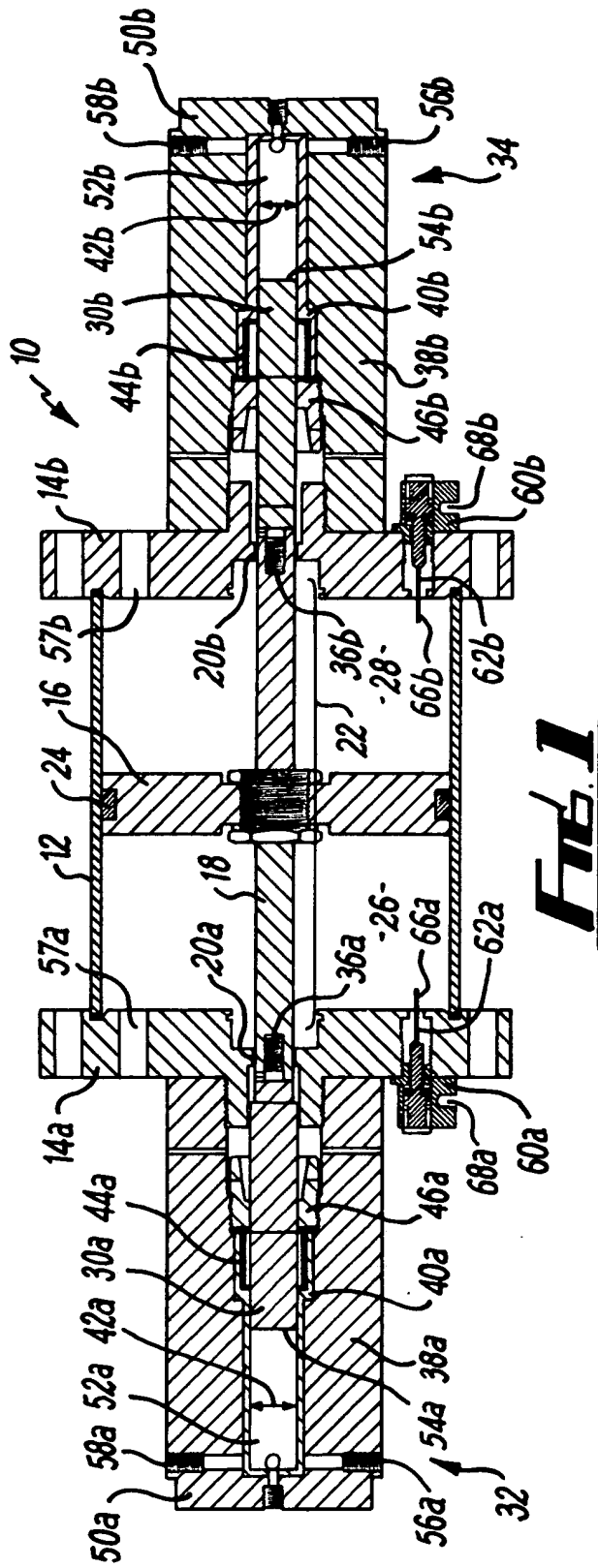
wherein the valve member is movable between a first position in which actuating fluid is supplied to a first end of an actuating cylinder of the pump and exhausted from a second, opposite end of the actuating cylinder, and a second position in which actuating fluid is supplied to the second end of the actuating cylinder and exhausted from the first end of the actuating cylinder, to thereby reciprocate an actuating piston of the pump back and forth within the actuating cylinder.

29. A pump comprising:

an actuating cylinder;
an actuating piston mounted for reciprocating movement within the actuating cylinder;
a discharge cylinder;
a discharge piston coupled to the actuating piston and mounted for reciprocating movement within the discharge cylinder to successively draw fluid into and discharge fluid from the discharge cylinder; and
a valve assembly according to any one of claims 1 to 28.

30. A pump comprising:

an actuating cylinder;
an actuating piston mounted for reciprocating movement within the actuating cylinder;
a discharge cylinder;
a sleeve releasably mounted within the discharge cylinder, to thereby define an operating diameter of the discharge cylinder;
a discharge piston coupled to the actuating piston and mounted for reciprocating movement within the sleeve to successively draw fluid into and discharge fluid from the discharge cylinder; and
a valve assembly according to any one of claims 1 to 28.



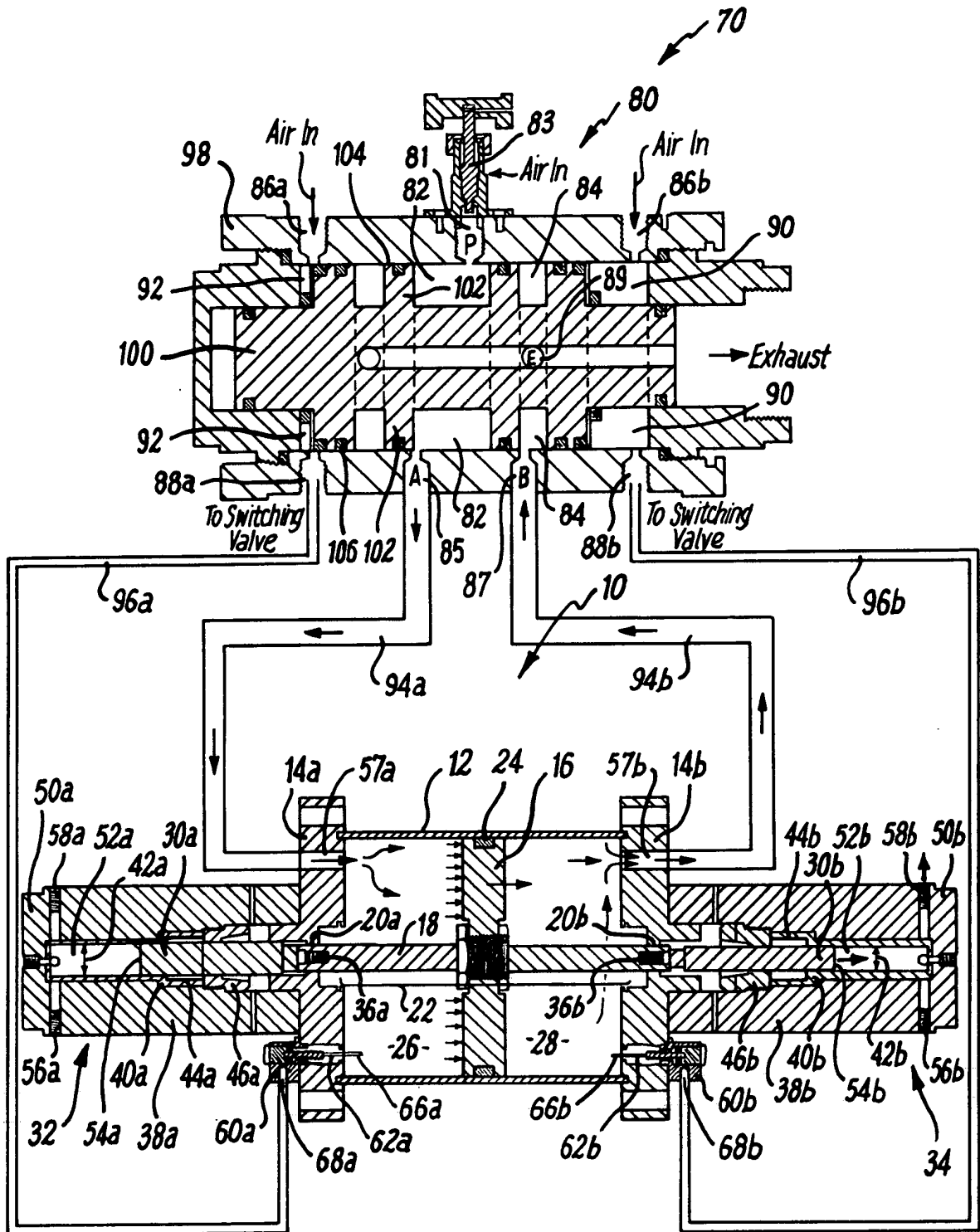


FIG. 2

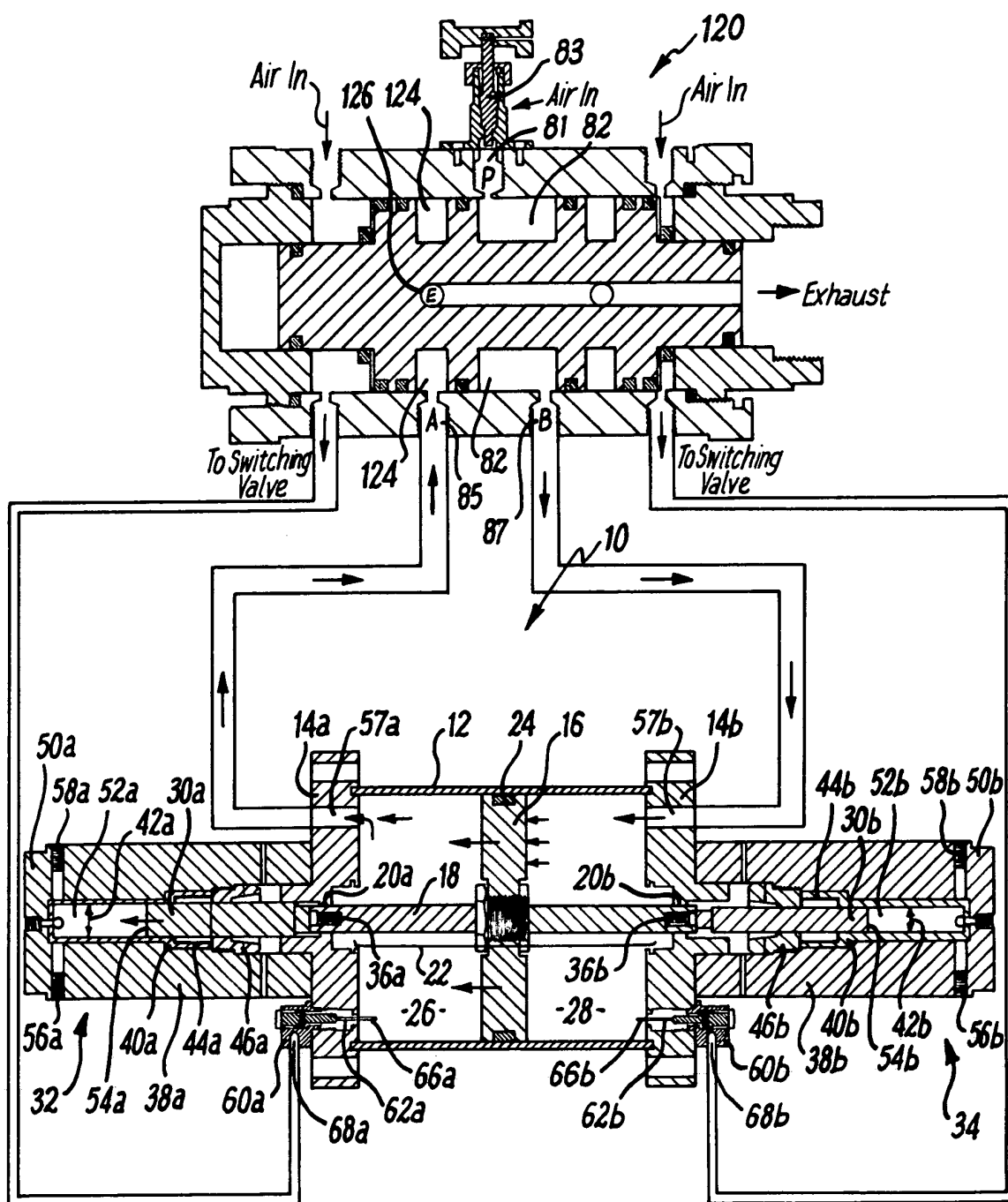
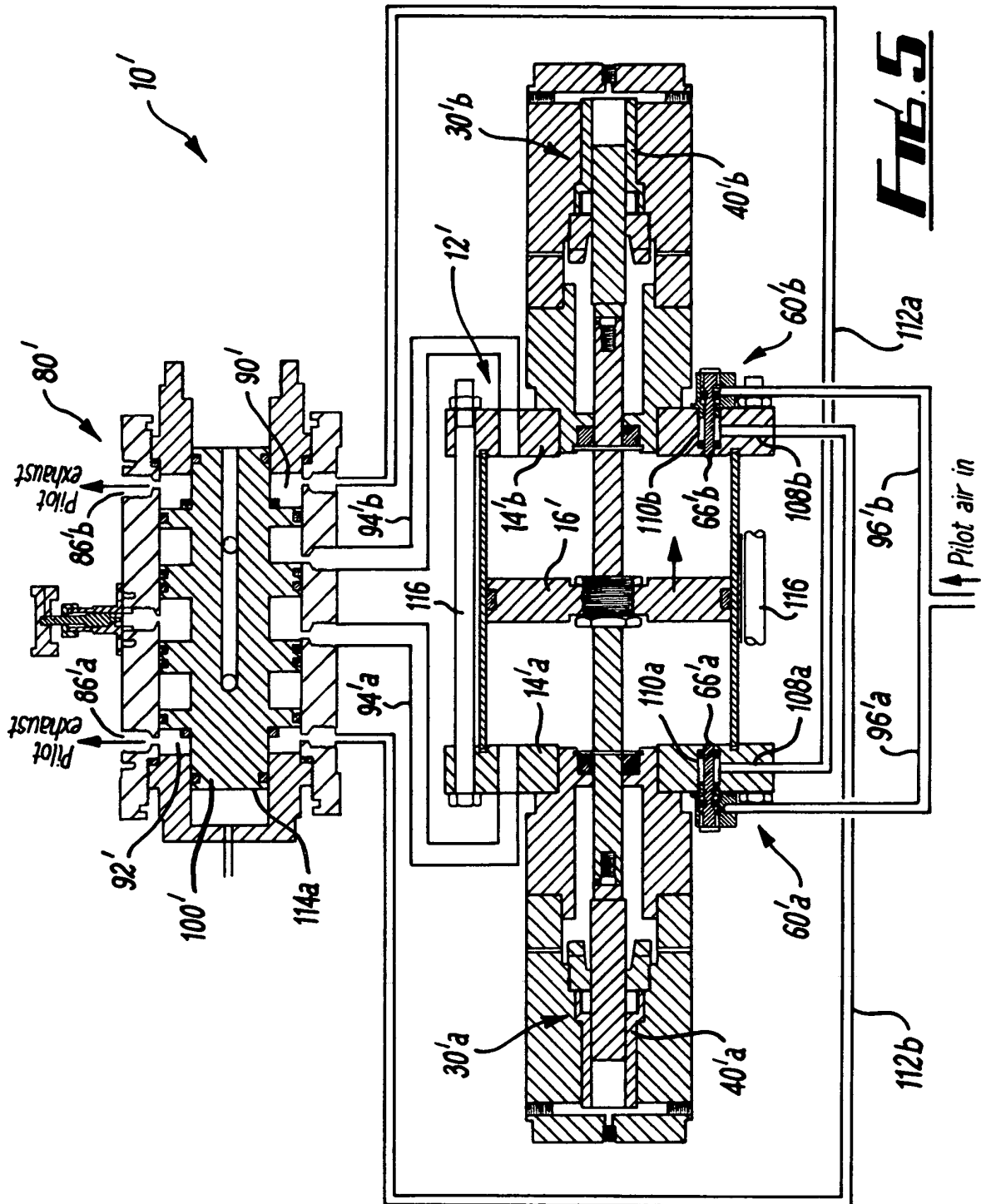


FIG. 3



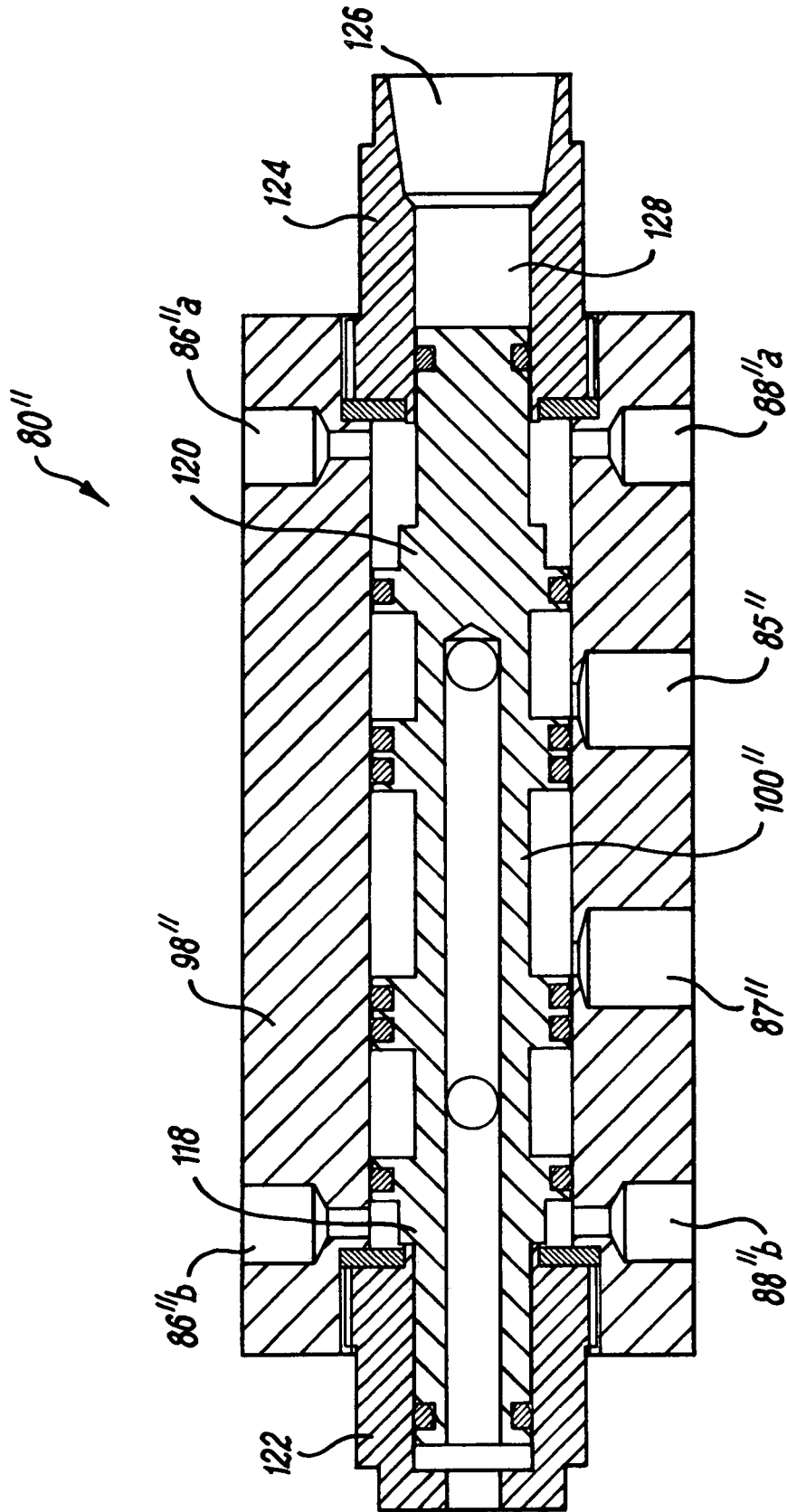


FIG. 6

