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(71) Applicant *(for all designated States except US)*: **AFRICAN EXPLOSIVES LIMITED** [ZA/ZA]; c/o AECI Place, The Woodlands, Woodlands Drive, Woodmead, 2196 Sandton (ZA).

(72) Inventors; and

(75) Inventors/Applicants *(for US only)*: **BÜHRMANN, Rudolph, Teodor** [ZA/ZA]; c/o AECI Place, The Woodlands, Woodlands Drive, Woodmead, 2196 Sandton (ZA). **BÜHRMANN, Rudolph** [ZA/ZA]; c/o AECI Place, The Woodlands, Woodlands Drive, Woodmead, 2196 Sandton (ZA). **NIEMANN, Frank** [ZA/ZA]; c/o AECI Place, The Woodlands, Woodlands Drive, Woodmead, 2196 Sandton (ZA).

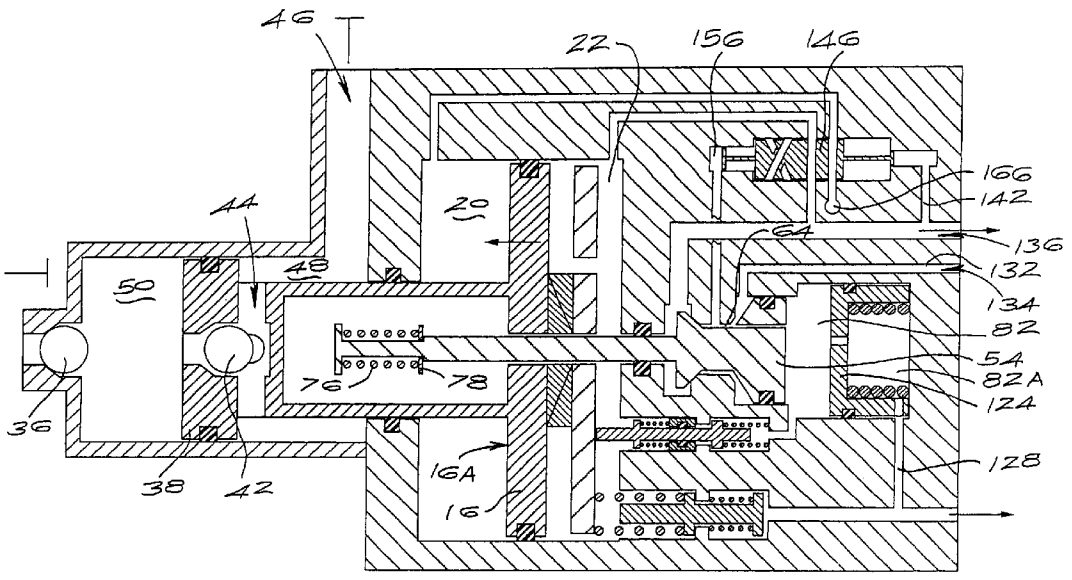
(74) Agents: **McCALLUM, RADEMEYER & FREIMOND** et al.; PO Box 1130, Maclyn House, 7 June Avenue, 2125 Bordeaux (ZA).

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(54) Title: PUMPING ARRANGEMENT



(57) Abstract: A pump arrangement which has a piston which is reciprocably movable in response to a directional control valve, a pilot valve which, in response to the piston, operates the directional control valve and an index valve operable to inhibit or allow the pilot valve to function.

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PUMPING ARRANGEMENT

BACKGROUND OF THE INVENTION

[0001] This invention relates to a pumping arrangement which is driven by a pressurised fluid such as compressed air to pump a second fluid.

[0002] In certain applications such as in the pumping of an emulsion for use in the mixing of a liquid explosive, there is a strong requirement for a pump which can deliver a predetermined volume of the emulsion at a controlled rate. It is desirable to start delivery of the pumped emulsion by means of a simple operation and, moreover, if the starting operation is repeated before a particular pump cycle is completed, the pump cycle should not be interrupted nor should it be recommenced. This feature allows the pump, once started, to deliver a predetermined quantity of the emulsion and, only thereafter, can the pump be restarted to repeat a succeeding pump cycle.

[0003] An object of the present invention is to provide a pumping arrangement which, at least partially, addresses the aforementioned requirements.

SUMMARY OF INVENTION

[0004] The invention provides a pumping arrangement which includes a body, a bore inside the body, a directional control valve, a piston which is sealingly engaged with the bore and which is mounted for reciprocating movement inside the bore, in response to the directional control valve, between first and second limiting positions, a pilot valve which is operable when the piston is moved towards each limiting

position to cause the directional control valve to operate and thereupon reverse movement of the piston, and an index valve which is movable between a first position at which it inhibits operation of the pilot valve and a second position at which it does not inhibit operation of the pilot valve.

[0005] The pumping arrangement may include a starting component which takes up a static position when operation of the pilot valve is inhibited and a control device which is actuable to cause the starting component to move from the static position to a start-up position at which the operation of the pilot valve is initiated.

[0006] The pumping arrangement may include a restart control valve which, unless the index valve is in the second position, assists in inhibiting the effect of the starting component upon actuation of the control device.

[0007] The piston may be of any appropriate kind and may include a tubular component into which at least part of the pilot valve extends. The piston may operate on a volume which interacts with two non-return valves in order to pump a fluid from an inlet to the volume to an outlet from the volume.

[0008] The directional control valve may comprise a multi-port device. The directional control valve may be switched by the application of a pressurised fluid such as compressed air which is also used to cause movement of the piston.

[0009] The pilot valve may include a stem which projects into the tubular component of the piston and first and second valve members which are engageable with first and second seats respectively preferably formed in the body. The stem may engage with the piston preferably indirectly through the medium of a biasing element to

cause one of the valve members to disengage from its seat when it is sealingly engaged with such seat.

[0010] The first and second valve members may be located on a body in which is formed a passage through which compressed air is passed to displace the starting component to a static position.

[0011] The starting component may be in the form of a piston which is located in a chamber which is bounded at least partly by a face of the body of the pilot valve.

[0012] The index valve preferably includes a projection which is extended into the bore by a biasing member when the piston is moved away from the projection. The projection may abut the piston or an element which is movable by or with the piston and be moved in a reverse direction against the action of the biasing member when the piston is moved towards the index valve. The index valve may include a sealing component which is movable relatively to the projection and which allows pressure in the chamber to be reduced when the projection is moved in the reverse direction.

[0013] The restart control valve may be biased to a position at which it prevents compressed air from flowing from the chamber when the piston reaches one of its limiting positions.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014] The invention is further described by way of example with reference to the accompanying drawings in which:

Figure 1 schematically illustrates components in a pumping arrangement according to the invention in a static configuration;

Figure 1A is a view on an enlarged scale of part of a pumping arrangement shown in Figure 1;

Figure 2 is similar to Figure 1 illustrating the components of the pumping arrangement when pumping is started;

Figure 3 shows the pumping arrangement with a piston at one limiting position;

Figure 4 shows the pumping arrangement on a return stroke with the piston at an intermediate position; and

Figure 5, which in a number of aspects is similar to Figure 1, shows the pumping arrangement with the piston at a second limiting position but starting a repeat pumping cycle.

DESCRIPTION OF PREFERRED EMBODIMENT

[0015] Figure 1 of the accompanying drawings illustrates components, partly schematically and to some extent simplified for ease of illustration, of a pumping arrangement 10 according to the invention in a static configuration.

[0016] The pumping arrangement includes a main body 12 in which is formed a bore 14. A piston 16 is located inside the bore. The piston has a seal 18 and divides the bore into a first volume 20 and a second volume 22 located respectively on opposing sides of the piston.

[0017] The piston has a tubular component 24 which projects from one side of the piston through the first volume 20 and through an aperture 26 in a wall of the body. An interface between the surrounding surface of the body, at the aperture 26, and an opposing surface of the tubular component is sealed by means of an appropriate seal 28. To the left of the main body the tubular component projects into a housing

30. The housing includes an inlet 32 which is connected to a source of an emulsion 34 which is to be pumped. A first one-way valve 36 is positioned in the inlet 32. At an outer end the tubular component carries a second piston or plunger 38 through which is formed a passage 40. A second one-way valve 42 is positioned inside the passage 40. The plunger 38 includes a second passage 44 from a receiving side of the second one-way valve which is in communication with an exit port 46 leading from a chamber 48 on the right hand side of the piston. The left side of the piston faces a chamber 50.

[0018] A pilot valve 52 is positioned inside the body 12. The pilot valve includes a body 54 and a stem 55 which projects from the body. The body has formations which define a first valve member 56 and a second valve member 58. The valve member 56 opposes a first seat 60 while the valve member opposes a second seat 62.

[0019] A small passage 64 extends through the second valve member to a right side of the body 54.

[0020] The stem 55 passes through a seal 66 and through an opening 68, in the piston 16, into an interior 70 of the tubular component 24. The stem has a slender section 72 which terminates in a head 74 and a coil spring 76 which surrounds the section 72 is located between opposing surfaces of the head 74 and a washer 78 which is movably located on the section 72.

[0021] The body 54 of the pilot valve has an external seal 80 which is engaged with a wall of a chamber 82 in which that portion of the body which defines the second

valve member is slidingly located. The small passage 64 has one end in communication with the chamber.

[0022] A passage 84 extends from the chamber 82 to a volume 86 inside the body which is occupied by an index valve 88. The index valve is in the form of an elongate rod 90 with a projection 92 at one end and two spaced shoulders 94 and 96 respectively. A spring 98 acts at a right end of the rod between opposing surfaces of the shoulder 96 and of the volume 86 respectively and biases the shoulder into sealing engagement with a first side of an annular formation 99. A second spring 100 acts between opposing surfaces of the shoulder 94 and a valve member 102 which is slidingly and sealingly engaged with the rod and which is located between the shoulders 94 and 96. The spring 100 biases the valve member 102 into engagement with a second side of the annular formation.

[0023] The projection 92 can extend slightly into the second volume 22.

[0024] A restart control valve 104 is located inside a volume 106 which faces into the second volume 22. A first spring 108 acts between a shoulder 109 on the restart valve and a reaction formation 110 on the body. A second spring 112 acts on a second shoulder 114 on the control valve. The second shoulder is engageable with a sealing action with the reaction formation 110. A free end of the spring which is retained on the restart control valve by any appropriate device extends partly into the second volume 22.

[0025] The chamber 82 is stepped and a starting component 116 is positioned inside an enlarged portion 82A of the chamber. The starting component includes a cup-shaped piston 118 which has an external seal 120 in sealing engagement with a

wall of the enlarged chamber portion 82A. A small orifice 122 is formed through a circular portion 124 of the piston 118. A spring 126 biases the piston to the left in the drawing.

[0026] A passage 128 extends from a right side of the chamber portion 82A to the volume 106. The passage branches to a normally closed start up control valve 130.

[0027] A passage 132 is formed in the body from a left side of the second valve member 58 to an exit port 134. An inlet port 136 is connected to a source of compressed air, not shown. The inlet port is in communication with a passage 138 which extends to a left end of the body 54 of the pilot valve and two passages 140 and 142 respectively which go to a four way directional control valve 144. This control valve has a body 146 which is formed with two direct passages 148 and 150 respectively and two cross over passages 152 and 154 respectively. A passage 156 at a left end of a cavity 160 in which the body 146 is located goes to an intermediate portion of a reduced size part of the chamber 82. Two passages 162 and 164 respectively go from exit ports of the cavity 160 to the first volume 20 and the second volume 22 respectively. Another port, designated 166, is an exhaust port.

[0028] Figure 1 shows the components of the pumping arrangement in a static configuration. The starting component 116 which comprises the cup-shaped piston 118 is at a left limiting position inside the chamber portion 82A. The pressure on opposing sides of the circular portion 124 is the same due to the pressure-equalising effect of the small orifice 122. The valve seating surfaces 58 and 62 are engaged to seal off compressed air that flows through the opening between the surfaces 56 and 60 and into the passage 156. The body 146 is biased to the right and compressed air passes through the passage 162 to hold the piston to the right.

[0029] If the control valve 130 is briefly opened then air on the right side of the circular portion 124 inside the chamber portion 82A can escape to atmosphere. This abruptly reduces the pressure on the right side of the piston 118. The pressure on the left side of the piston is, however, relatively high for the orifice 122 is small and air cannot flow through the orifice quickly enough to equalise the pressures on opposing sides of the piston. The piston is therefore moved to the right in the drawing. The pressure on the left side of the piston inside the chamber 82A drops and, as a result, the pilot valve is displaced to the right. The first valve member 56 then comes into sealing contact with the seat 60 and the pressure on the projected area between the location of the seal between the member 56 and the seat 60 and the base of the seal 66 locks the pilot body in that position.

[0030] Compressed air at the inlet port 136 flows through the passage 142 and displaces the body 146 of the directional control valve to the left. The pumping arrangement then takes up the configuration shown in Figure 2. Air from the compressed air source flows through the directional control valve and thereafter via the passage 164 into the second volume 22. Pressure in the second volume builds up and the piston 16 is displaced to the left. The plunger 38 is simultaneously moved along the housing 30. The pressure of fluid in the chamber 50 is increased and the first one-way valve 36 is closed. The second one-way valve 42 opens and fluid flows through the passage 40 to the second passage 44, into the chamber 48 and then flows from the exit port 46.

[0031] As the piston 16 advances to the left a limiting position is reached at which an inner surface 16A of the piston strikes the washer 78. The spring 76 is then compressed and force is exerted on the body 54 of the pilot valve causing the pilot valve to move to the left. The seal between the first valve member 56 and its seat 60

is broken. The seal is then established between the second valve member 58 and its seat 62.

[0032] Compressed air from the port 136 flows through the passage 156 and displaces the directional control valve to the right. The air flow, via the passage 162, then enters the first volume 20 and the piston movement is reversed. A flow of air bleeds through the small passage 64 into the chamber 82. This air flow is greater than what passes through the orifice 122 and the start-up piston 118 thus remains in the Figure 3 position. Air on the right side of the start-up piston can flow through the passage 128 and pass via the restart valve 104, which is in an open configuration, into the low pressure second volume 22 on the right side of the piston. Via the passage 164 air in the second volume can pass to the exhaust port 166. During this phase if the control valve 130 is actuated the only effect is to bleed air from the right side of the start-up piston and there is otherwise no effect on the pumping operation.

[0033] Interposed between the right hand side of the piston 16 and an opposing surface of the body 12 are an indexing and stroke adjustment device 170 and a rotatable member 172. The device 170 controls aspects of the working of the pumping arrangement in a manner which is not important in an understanding of the present invention. With each stroke of the piston the device causes the member 172 to rotate through a predetermined angle. The member 172 is in the nature of a wheel which has one or more holes 174 at strategic positions. The device 170 and the member 172 are moved together with the reciprocating piston. The stem 55 of the pilot valve passes through centrally positioned holes in the device 170 in the member 172.

[0034] The device 170 and the member 172 are referred to merely by way of example as providing a mechanism for controlling an aspect of the operation of the pumping arrangement. Any equivalent mechanism could be used in place of the device and the member. For example, instead of being moved automatically by the device 170, the member 172 could be rotated, when required, to move a hole 174 into alignment with the rod 90 of the index valve, or out of alignment therewith.

[0035] On the return stroke of the piston the member 172 initially contacts a projecting end of the spring 112 and the force which is thereby exerted causes the restart control valve to be urged to the right to enhance sealing engagement of the shoulder 114 with the reaction formation 110. This stops air flow through the volume 106.

[0036] Secondly, the piston, moving to the right, causes the member 172 to impact the projection 92 of the index valve. As is shown in Figure 5 the rod 90 of the index valve is then moved to the right. The shoulder 96 is displaced from one side of the annular formation 99 and pressure in the chamber 82, if sufficiently high, causes the valve member 102 to be displaced to the left away from an opposing side of the annular formation 99. Air can then escape into the second volume 22 and is exhausted to atmosphere via the passage 164 and the exhaust port 166.

[0037] During the piston's reverse stroke the one-way valve 42 on the plunger 38 is closed and fluid is thus expelled by the plunger 38 from the chamber 48 through the exit port 46. Pumping action therefore takes place on the forward stroke and on the reverse stroke of the piston and continues without interruption, even if the control valve 130 is left open or is opened intermittently or repeatedly.

[0038] When the piston reaches a limiting position in the reverse direction the pumping arrangement has the configuration shown in Figure 5. The directional control valve 144 is switched and high air pressure is again introduced into the volume 22 to drive the piston in the forward direction.

[0039] As noted on each reverse stroke of the piston the device 170 causes the member 172 to be rotated about the stem 55 through a defined angle. If the result of such rotation is to align a hole 174 in the member with the projection 92 of the index valve then at the limiting position of the return stroke of the piston the projection enters the hole 174 in the manner shown in Figure 1. When this occurs the index valve is not displaced to the right and so is not operated to depressurise the chamber 82. The pilot valve is however switched to its left position and air from the source 136 flows through the gap between the displaced first valve member 56 and the seat 60. Air flows through the passage 64 into the chamber 82 and then through the orifice 122. Pressure on the right side of the start-up piston increases and is ultimately equal to the pressure on the left side of the piston. Due to the action of the spring 126 the piston is then moved to the left to take up the position shown in Figure 1. It is only at this stage that it is possible, again, to restart the pumping operation by opening the control valve 130.

[0040] In the pumping arrangement the piston, which is air actuated, thus provides pumping action with each stroke in each direction. The seal 28 prevents air from entering the emulsion which is being pumped, and vice versa. The pilot valve is caused to switch by the index valve which vents the chamber 82. The index valve is in turn responsive to movement of the member 172. The pumping operation thus continues until the index valve is not capable of venting the chamber 82. This means that pumping, once started, will continue for a predetermined number of cycles

determined only by the movement of the member 172. Any attempt to retrigger the pumping arrangement during the predetermined number of cycles will have no effect on the operation of the pump.

[0041] The manner in which the member 172 is rotated thus determines the duration of a pumping cycle. The member 172 can be rotated through a defined angle automatically by the reciprocating action of the piston but, if necessary, can be rotated in any other way e.g. electrically, pneumatically or manually.

CLAIMS

1. A pumping arrangement which includes a body, a bore inside the body, a directional control valve, a piston which is sealingly engaged with the bore and which is mounted for reciprocating movement inside the bore, in response to the directional control valve, between first and second limiting positions, a pilot valve which is operable when the piston is moved towards each limiting position to cause the directional control valve to operate and thereupon reverse movement of the piston, and an index valve which is movable between a first position at which it inhibits operation of the pilot valve and a second position at which it does not inhibit operation of the pilot valve.

2. A pumping arrangement according to claim 1 which includes a starting component which takes up a static position when operation of the pilot valve is inhibited and a control device which is actuable to cause the starting component to move from the static position to a start-up position at which the operation of the pilot valve is initiated.

3. A pumping arrangement according to claim 2 which includes a restart control valve which, unless the index valve is in the second position, assists in inhibiting the effect of the starting component upon actuation of the control device.

4. A pumping arrangement according to any one of claims 1 to 3 wherein the piston includes a tubular component into which at least part of the pilot valve extends and wherein the piston operates on a volume which interacts with

two non-return valves in order to pump a fluid from an inlet to the volume to an outlet from the volume.

5. A pumping arrangement according to claim 4 wherein the pilot valve includes a stem which projects into the tubular component of the piston and first and second valve members which are engageable with first and second seats respectively, formed in the body.

6. A pumping arrangement according to claim 5 wherein the stem engages with the piston through the medium of a biasing element to cause one of the valve members to disengage from its seat when it is sealingly engaged with such seat.

7. A pumping arrangement according to claim 5 or 6 wherein the first and second valve members are located on a body in which is formed a passage through which compressed air is passed to displace the starting component to a static position.

8. A pumping arrangement according to any one of claims 1 to 7 wherein the directional control valve comprises a multi-port device which is switched by the application of a pressurised fluid which is also used to cause movement of the piston.

9. A pumping arrangement according to any one of claims 1 to 8 wherein the starting component is in the form of a piston which is located in a chamber which is bounded at least partly by a face of the body of the pilot valve.

10. A pumping arrangement according to any one of claims 1 to 9 wherein the index valve includes a projection which is extended into the bore by a biasing member when the piston is moved away from the projection and which abuts the piston or an element which is movable by or with the piston and which is thereby moved in a reverse direction against the action of the biasing member when the piston is moved towards the index valve.

11. A pumping arrangement according to claim 10 wherein the index valve includes a sealing component which is movable relatively to the projection and which allows pressure in the chamber to be reduced when the projection is moved in the reverse direction.

12. A pumping arrangement according to claim 3 wherein the restart control valve is biased to a position at which it prevents compressed air from flowing from a chamber in which the piston is located, when the piston reaches one of its limiting positions.

13. A pump arrangement which has a piston which is reciprocably movable in response to a directional control valve, a pilot valve which, in response to the piston, operates the directional control valve and an index valve operable to inhibit or allow the pilot valve to function.

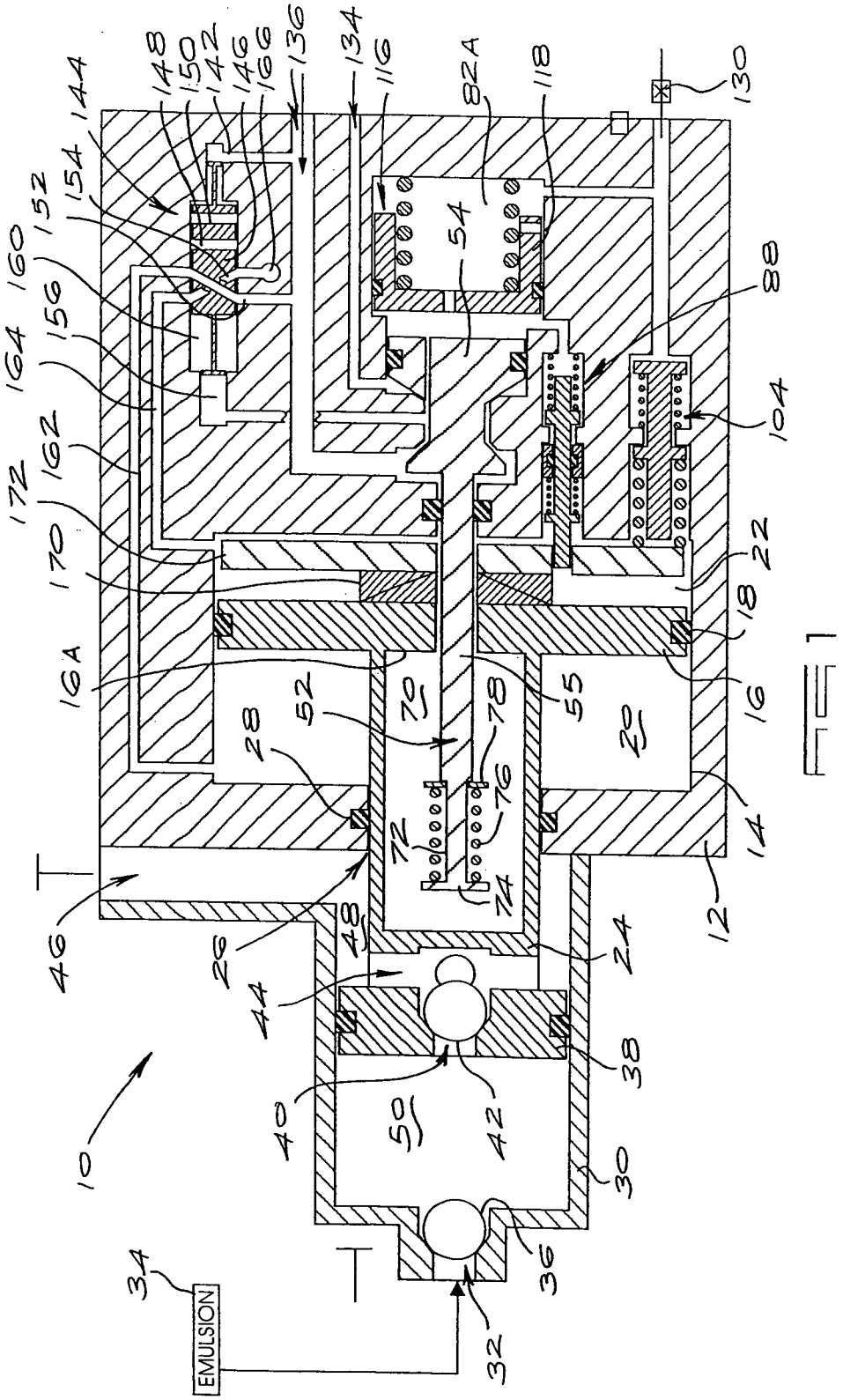


FIG 1

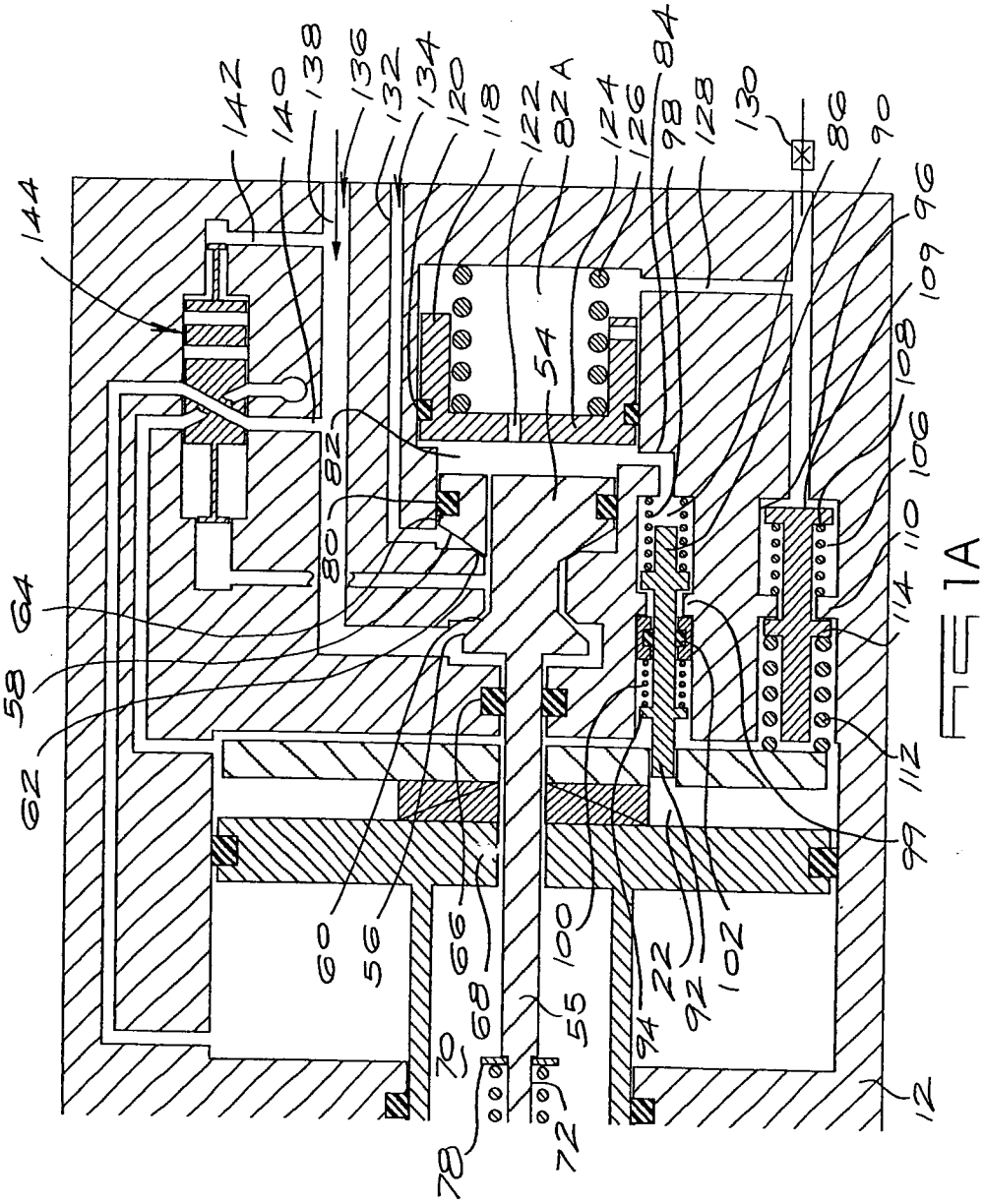

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FIG 1A

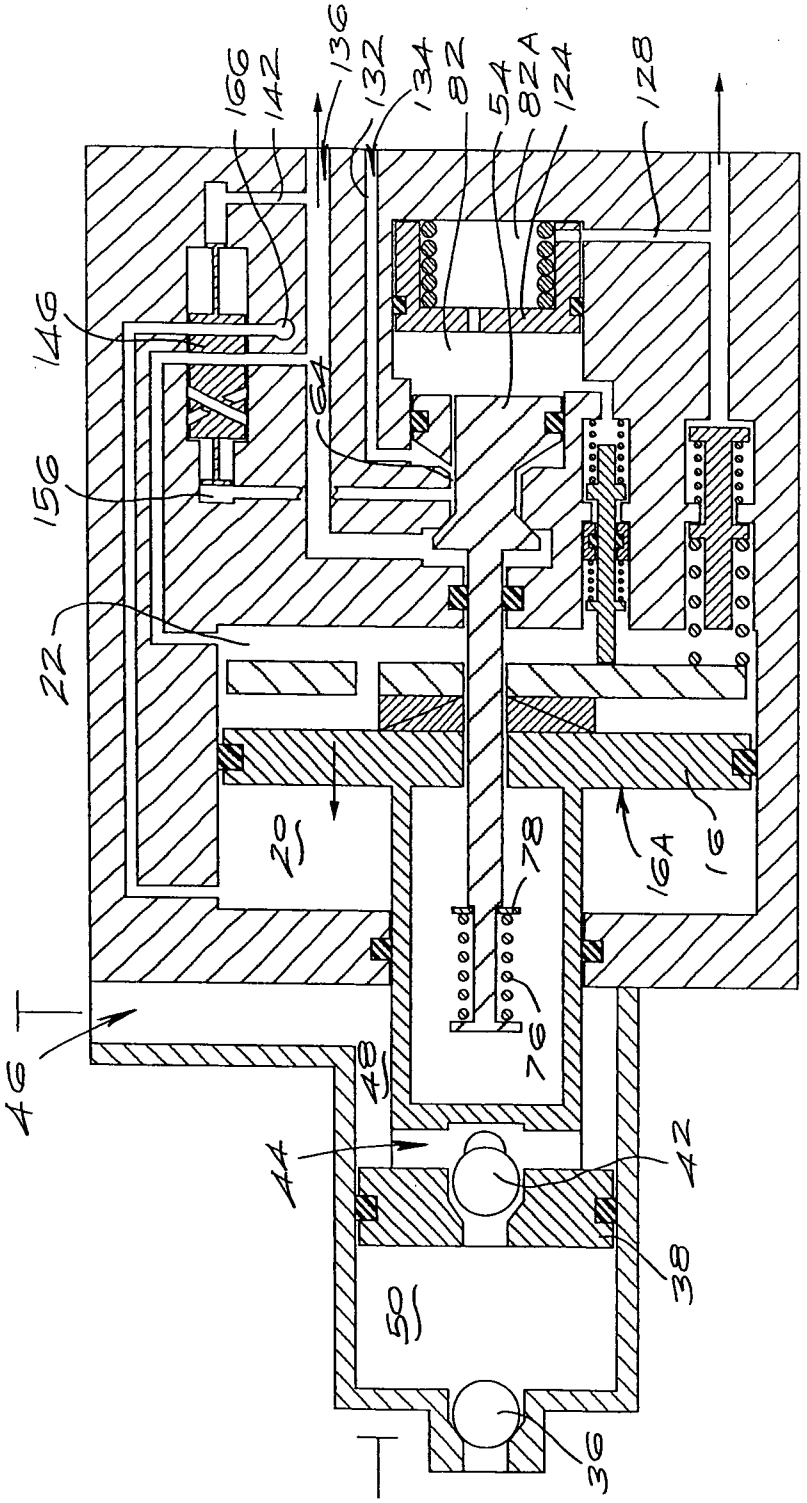

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FIG 2

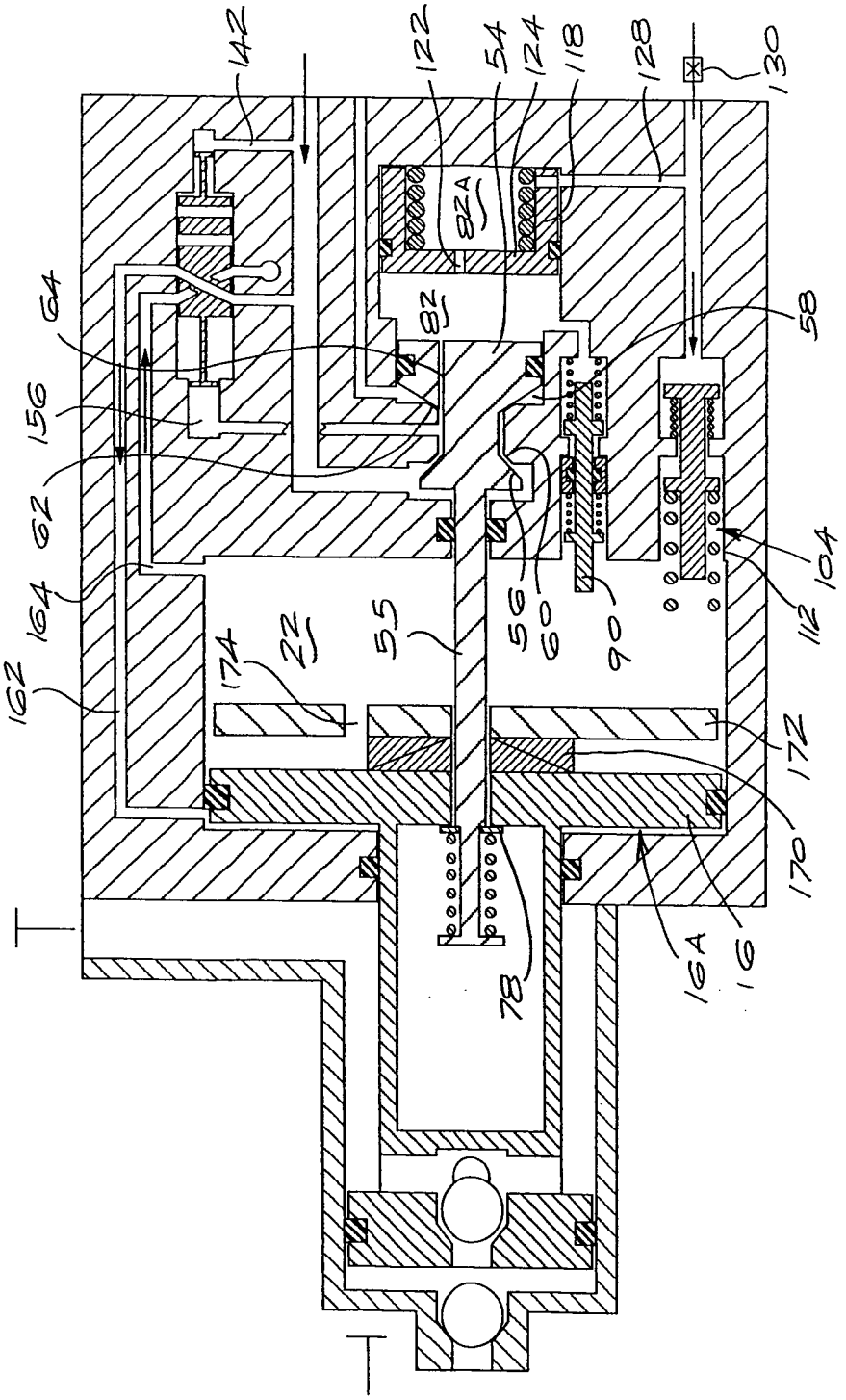

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FIG 3

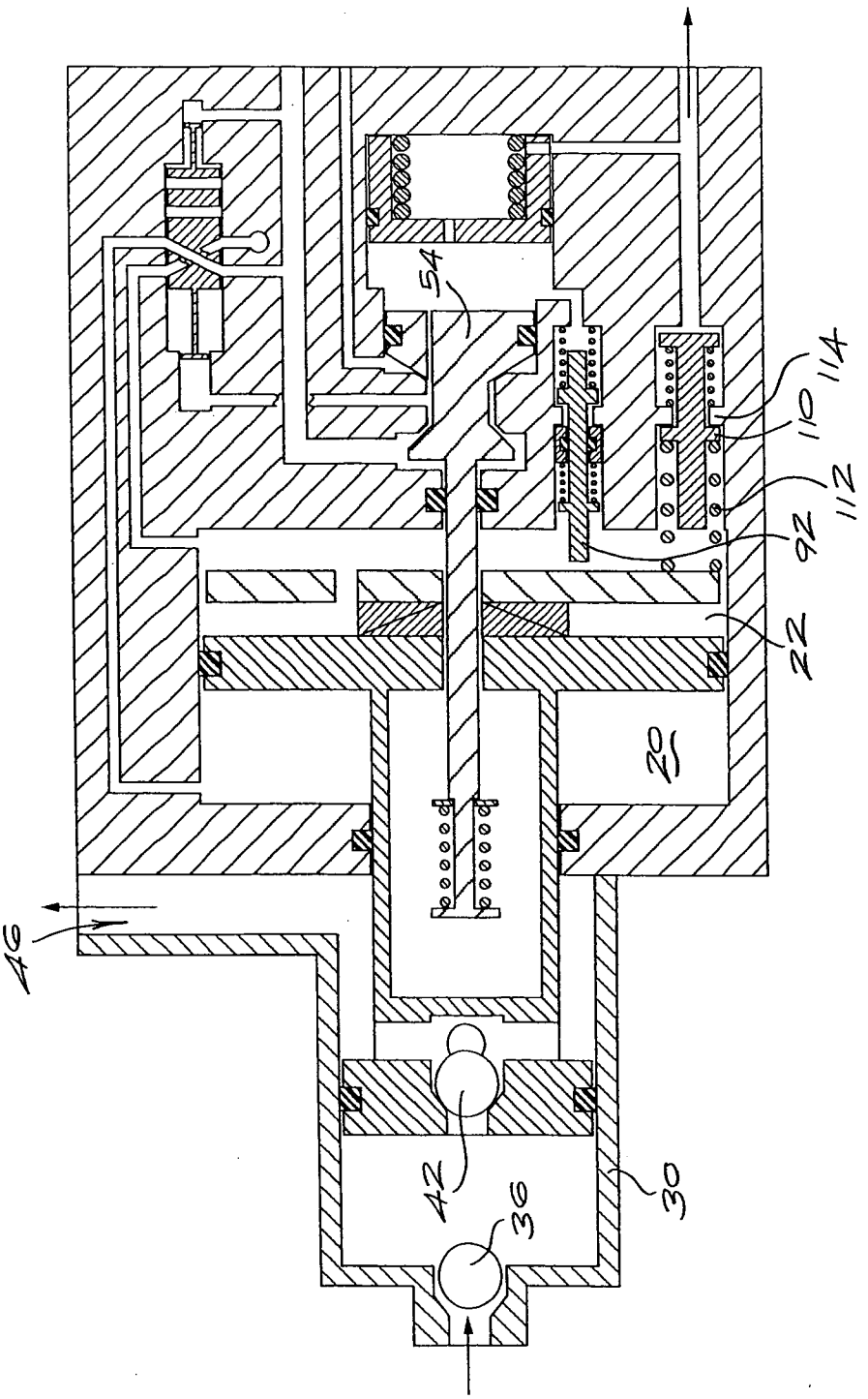


FIG 4

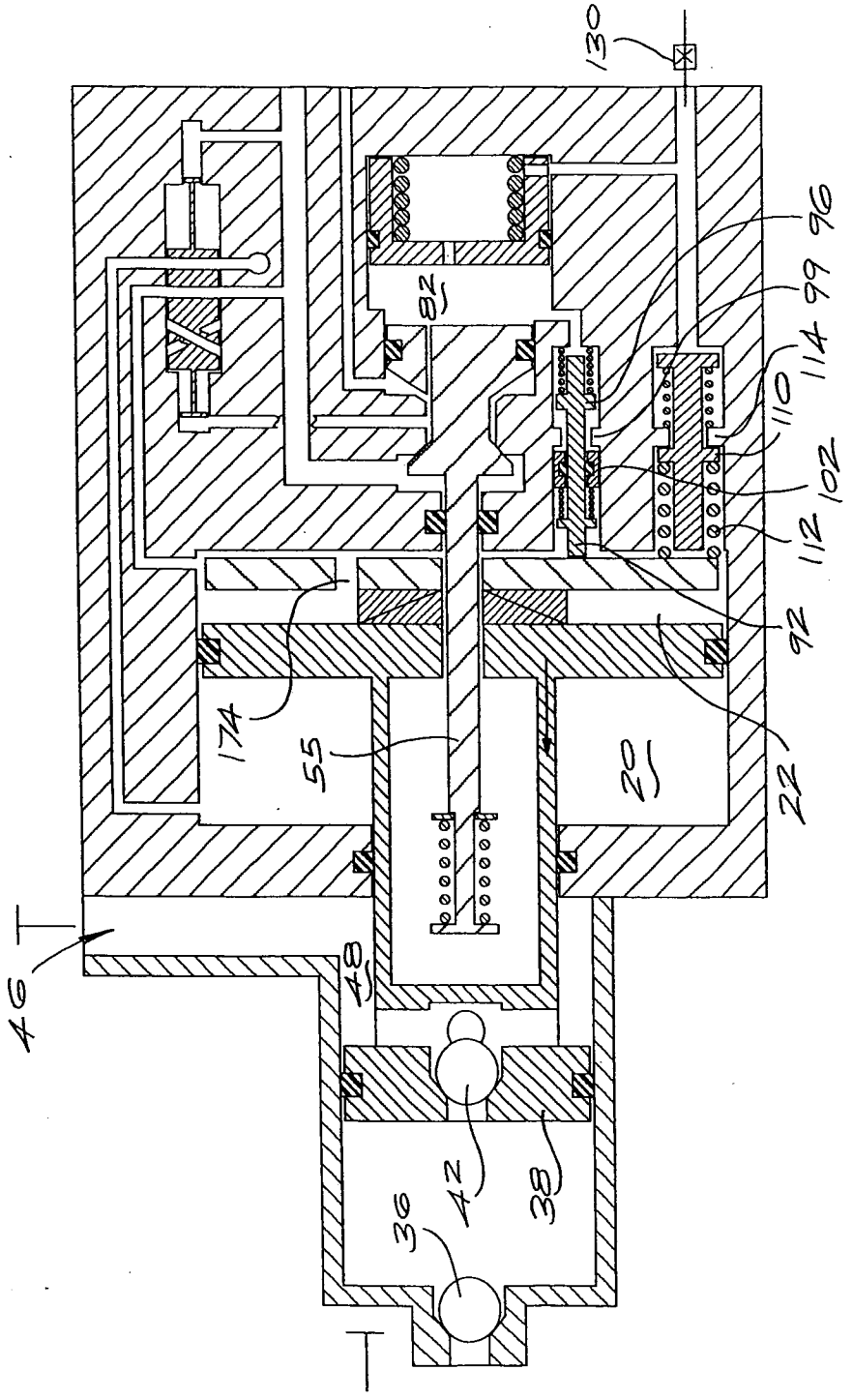


FIG 5