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under INID code 62.

(54) **Pump with selectable outlet pressure**

(57) A fixed capacity pump (120) has a pressure relief
valve piston (136) with two control surfaces (176,180)
forming chambers (152,168) with the pump housing

(184), such that the pump can be operated at either of
at least two selected equilibrium pressures.

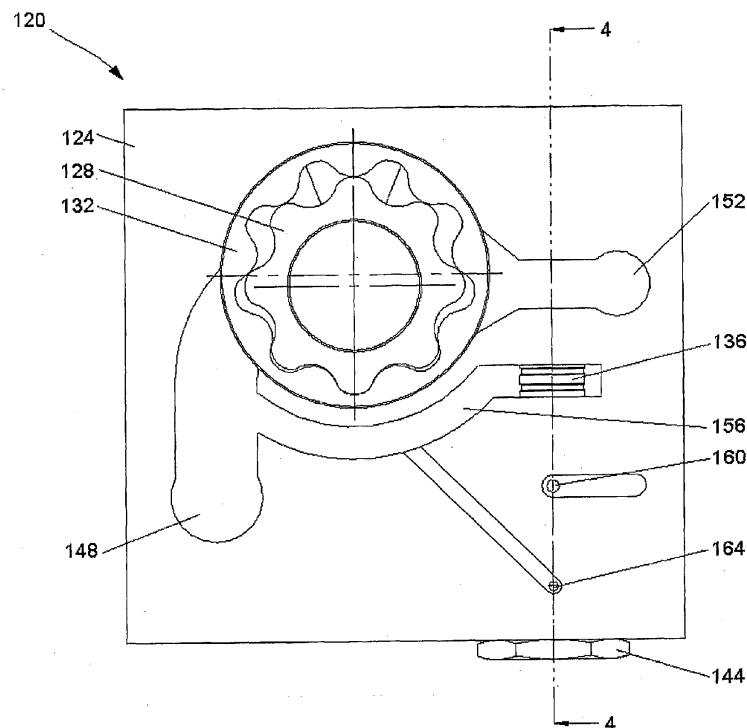


Fig. 6

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Description

FIELD OF THE INVENTION

[0001] The present invention relates to a variable capacity vane pump or to a fixed capacity pump. More specifically, the present invention relates to a pump of either type in which at least two different equilibrium pressures can be selected between.

BACKGROUND OF THE INVENTION

[0002] Variable capacity vane pumps are well known and feature a capacity adjusting element, in the form of a ring known as a slide ring, that can be moved to alter the eccentricity of the pump and hence alter the volumetric capacity of the pump. If the pump is supplying a system with a substantially constant hydraulic resistance, such as an automobile engine lubrication system, changing the output volume of the pump is equivalent to changing the pressure produced by the pump.

[0003] Having the ability to alter the capacity of the pump is important in environments such as automotive lubrication pumps, wherein the pump will be operated over a range of operating speeds. In such environments, it is known to employ a feedback supply of the working fluid (e.g. lubricating oil) from the output of the pump to a control piston acting against the slide ring, or directly to a portion of the exterior of the slide ring, to move the slide ring to decrease capacity, typically against a bias from a return spring.

[0004] With control piston configurations, when the pressure at the output of the pump increases, such as when the operating speed of the pump increases, the increased pressure is applied to the control piston to overcome the bias of the return spring and move the slide ring to reduce the capacity of the pump, thus reducing the output volume and hence pressure at the output of the pump.

[0005] Conversely, as the pressure at the output of the pump drops, such as when the operating speed of the pump decreases, the decreased pressure applied to the control piston decreases the force exerted by the control piston, and the return spring can move the slide ring to increase the capacity of the pump, raising the output volume and hence pressure of the pump. In this manner, an equilibrium pressure is obtained at the output of the pump.

[0006] Fixed capacity pumps are typically controlled by a pressure relief valve, which limits the pressure at the pump outlet by diverting the unwanted portion of the flow to a low pressure space such as the pump inlet. The pressure relief valve system often features a simple piston located in a close fitting bore. The position of the piston in the bore determines whether a passage leading from the pump outlet to a low pressure space such as the pump inlet is open or blocked off. A surface on the piston is exposed directly or indirectly to pressurized

working fluid from the pump outlet, tending to move the piston in the direction that opens the passageway. The piston is biased in the opposite direction by a spring, such that the balance of forces between the spring and the pressurized fluid acting on the piston determines the equilibrium position of the piston in the bore. Thus the passageway will begin to open and flow will begin to be diverted at one particular value of pressure.

[0007] In both types of pump described above, the equilibrium pressure is determined by the area of the control piston against which the working fluid acts, the pressure of the working fluid at the output of the pump and the force generated by the return spring.

[0008] Conventionally, the equilibrium pressure is selected to be a pressure which is acceptable for the expected operating range of the engine and is thus somewhat of a compromise as, for example, the engine may be able to operate acceptably at lower operating speeds with a lower working fluid pressure than is required at higher engine operating speeds. In order to prevent undue wear or other damage to the engine, the engine designers will select an equilibrium pressure for the pump which meets the worst case (high operating speed) conditions. Thus, at lower speeds, the pump will be operating at a higher pressure than necessary for those speeds, wasting energy.

[0009] It is desired to have a variable capacity vane pump or a fixed capacity pump which can provide at least two equilibrium pressures in a reasonably compact pump housing.

SUMMARY OF THE INVENTION

[0010] It is an object of the present invention to provide a novel variable capacity vane pump or fixed capacity pump which obviates or mitigates at least one disadvantage of the prior art.

[0011] According to a first aspect of the present invention, there is provided a variable capacity vane pump having a slide ring which is moveable to alter the capacity of the pump, the pump being operable at at least two selected equilibrium pressures, comprising: a pump casing having a pump chamber therein; a vane pump rotor rotatably mounted in the pump chamber; a slide ring enclosing the vane pump rotor within said pump chamber, the slide ring being moveable within the pump chamber to alter the capacity of the pump; a control housing in the pump casing; a control piston having an actuator end and two control surfaces, the control piston being received within the control housing such that the actuator end engages the slide ring and such that each control surface forms a respective chamber within the control housing, each chamber being connected to a respective gallery through which pressurized fluid can be provided to or removed from the respective chamber to move the control piston within the control housing; and a return spring acting between slide ring and the casing to bias the slide ring towards a given position, wherein a supply of pres-

surized fluid to one of the two chambers can be applied or removed to change the equilibrium pressure of the pump.

[0012] According to a second aspect of the present invention, there is provided a fixed capacity pump having a bore in the pump casing with a passageway that connects the pump outlet to a low pressure space; a piston that opens or closes the passageway according to its position in the bore, the piston having two surfaces, such that each surface forms a respective chamber within the bore, each chamber being connected to a respective gallery through which pressurized fluid can be provided to or removed from the respective chamber to move the piston within the bore; and a return spring acting between the piston and the casing to bias the piston against opening the passageway, wherein a supply of pressurized fluid to one or both of the two chambers can be applied or removed to change the equilibrium pressure of the pump.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013] Preferred embodiments of the present invention will now be described, by way of example only, with reference to the attached Figures, wherein:

Figure 1 is a front view of a variable capacity vane pump in accordance with a first embodiment of the present invention;

Figure 2 is a side view of the pump of Figure 1;

Figure 3 is a section of the pump of Figure 1 taken along line 3-3 of Figure 2;

Figure 4 is a dual chamber control piston used in the pump of Figure 1;

Figure 5 is a perspective view of a slide ring of the pump of Figure 1;

Figure 6 is a view of a fixed capacity pump with control piston in accordance with a second embodiment of the present invention; and

Figure 7 is a section taken along line 4-4 of Figure 6.

DETAILED DESCRIPTION OF THE INVENTION

[0014] A variable capacity vane pump in accordance with a first embodiment of the present invention is indicated generally at 20 in Figures 1 and 2. In this embodiment, pump 20 includes a casing 22 with a front face 24 which is sealed with a pump cover (not shown) and a suitable gasket, to an engine (not shown) for which pump 20 is to supply pressurized working fluid.

[0015] In a substantially conventional manner, pump 20 includes a drive shaft 28 which is driven by any suitable means, such as the engine to which the pump is to supply lubricating oil, to operate pump 20. As drive shaft 28 is rotated, a pump rotor 32 located with a pump chamber 36 is turned with drive shaft 28. A series of slidable pump vanes 40 rotate with rotor 32, the outer end of each vane 40 engaging the inner surface of a slide ring 44 to define a series of working fluid chambers 48, best seen in Figure

3.

[0016] As the center of slide ring 44 is located eccentrically with respect to the center of pump rotor 32, each of slide ring 44 and pump rotor 32 being circular in shape, the volume of working fluid chambers 48 changes as the chambers rotate around pump chamber 36, with their volume increasing at the low pressure side of pump 20 and decreasing at the high pressure side of pump 20. This change in volume of working fluid chambers 48 generates the pumping action of pump 20.

[0017] By moving the center of slide ring 44 relative to the center of pump rotor 32, (in the vertical direction with respect to the orientation of pump 20 shown in the Figures) the amount of rotor eccentricity can be changed to vary the rate at which the volume of working fluid chambers 48 changes on the low pressure side of pump 20 and on the high pressure side of pump 20, thus changing the volumetric capacity of the pump.

[0018] As mentioned above, it is conventional to provide a control piston and return spring to move the slide ring of a variable capacity vane pump to establish an equilibrium output volume, and its related equilibrium pressure. However, as best seen in Figures 3 and 4 and in accordance with the present invention, pump 20 includes a dual control surface control piston 52 and a return spring 56 to control slide ring 44.

[0019] Pump 20 includes a control piston housing 60 in which control piston 52 and return spring 56 are received. Control piston housing 60 includes an inner central bore 64 through which the actuator end 68 of control piston 52 extends and housing 60 has an inner step such that housing 60 has two different diameters along its length. Control piston 52 includes first and second control surfaces 72 and 76 respectively which engage a respective one of each of the two diameters of housing 60 to form first and second chambers 80 and 84 respectively within housing 60. Each of chambers 80 and 84 is connected to a respective gallery 88 and 92, best seen in Figure 1, through which pressurized working fluid can be supplied to chambers 80 and 84.

[0020] To make efficient use of available space, control piston 52 includes a center bore in which return spring 56 is received and the assembly of control piston 52 and return spring 56 is maintained in control piston housing 60 by a plug 100, which can be press fit or otherwise installed in housing 60. Return spring 56 acts between plug 100 and control piston 52 to bias actuator end 68 of control piston 52 out of pump chamber 36.

[0021] The connection of actuator end 68 of control piston 52 to slide ring 44 employed in the illustrated embodiment is believed to be particularly advantageous. It is well known that a good connection between control piston 52 and slide ring 44 is required to ensure that backlash between these elements is substantially avoided, otherwise pump 20 can suffer from undesirable "hunting" about its equilibrium pressure point. Further, the connection between slide ring 44 and control piston 52 must be accomplished in a manner which does not require space

that is either not available, or is needed for other engine components. However, providing such a good connection can incur significant machining and/or assembly labour costs.

[0022] In pump 20, slide ring 44 is formed by the known process of sintering and sizing, without requiring machining, and such a process can typically be performed to tolerances no smaller than $\pm 0.025\text{mm}$. As best seen on Figure 5, slide ring 44 is formed with a slot 104, the height of which can be controlled within the above-mentioned $\pm 0.025\text{mm}$ tolerance.

[0023] Control piston 52 is machined in a conventional manner to provide the necessary fit with the interior of housing 60 and actuator end 68 is formed on piston 52 as a disc-shaped button at the end of a narrow stem, as illustrated, which is machined to fit within the height of slot 104 with minimal, if any, backlash. The diameters of the disc shaped button and the narrow stem are, however, intentionally formed to be somewhat smaller than the corresponding widths of slot 104 to accommodate lateral misalignment of control piston 52 and slide ring 44 which, unlike the above-mentioned backlash, can be tolerated and may occur during assembly, etc.

[0024] The combination of slot 104 and button-shaped actuator end 68 of control piston 52 allows cost effective manufacturing of this aspect of pump 20 and does away with the typical requirement for pins, circlips or other joining hardware to connect control piston 52 to slide ring 44, thus reducing part cost and assembly cost.

[0025] As should now be apparent, pump 20 can operate in a conventional manner to achieve an equilibrium pressure by providing a feedback supply of pressurized working fluid from the output of pump 20 to one of chambers 80 or 84. For example, pressurized working fluid can be provided to chamber 84 via gallery 92 and the force created by the pressure of the supplied working fluid over the relevant area of chamber 84 can overcome the force of return spring 52 to retract actuator 68 outwardly from pump chamber 36 to move slide ring 44 to decrease capacity. Or, conversely, the force of return spring 52 can overcome the force created by the pressure of the supplied working fluid over the relevant area of chamber 84 to extend actuator 68 of control piston 52 into pump cavity 36, moving slide ring 44 to increase capacity of pump 20.

[0026] However, by selectively supplying pressurized working fluid to the other of chambers 80 or 84, a second equilibrium pressure can be selected. For example, a solenoid-operated valve controlled by an engine control system, can supply pressurized working fluid to chamber 80, via gallery 88, such that the force created by the pressurized working fluid on the relevant area of chamber 80 is added to the force created by the pressurized working fluid in chamber 84, thus moving slide ring 44 further than would otherwise be the case, to establish a new, lower, equilibrium pressure for pump 20.

[0027] As an example, at high operating speeds of pump 20, pressurized working fluid can be provided to

only chamber 84 and slide ring 44 will be moved to a position wherein the capacity of the pump produces a first equilibrium pressure which is acceptable at high operating speeds.

[0028] When pump 20 is driven at lower speeds, the control mechanism can operate to also supply pressurized working fluid to chamber 80, thus moving slide ring 44 to establish a second equilibrium pressure for pump 20, which second equilibrium pressure is lower than the first equilibrium pressure.

[0029] A fixed capacity pump with control piston in accordance with a second embodiment of the present invention is generally indicated at 120 in Figure 6. In this embodiment, pump 120 includes a housing 124 which is sealed with a pump cover (not shown) and a suitable gasket, to an engine (not shown) for which pump 120 is to supply pressurized working fluid.

[0030] Pump 120 includes an inner rotor 128 and an outer rotor 132 of conventional design. Inner rotor 128 is engaged and rotated by a suitable driving shaft from the engine, causing outer rotor 132 to rotate also. The pumping operation of such rotors is well known and is described in UK patent 596379. Working fluid is drawn into the chambers formed by the rotor teeth from pump inlet space 148 and expelled at high pressure into pump outlet space 152.

[0031] As mentioned above, it is conventional to provide a simple pressure relief valve including piston and return spring to divert the unwanted portion of the pump discharge flow to a low pressure space such as the pump inlet, such valves having one equilibrium pressure according to the balance of forces between the return spring and the effective pressurized area of the piston. However, as best seen in Figure 7 and in accordance with the present invention, pump 120 includes a dual control surface piston 136.

[0032] Pump 120 includes a bore in housing 124 in which piston 136 and return spring 140 are received. Piston 136 has two different diameters along its length which closely engage with two corresponding diameters in the piston bore of housing 124, whereby chamber 168 is formed. End surface 176 of piston 136 is exposed to the pressurized working fluid in pump outlet chamber 152 and control surface 180 of piston 136 is exposed to chamber 168 which may or may not be supplied with pressurized working fluid.

[0033] To make efficient use of available space, piston 136 includes a center bore in which return spring 140 is received and the assembly of piston 136 and return spring 140 is maintained in the piston bore of housing 124 by a plug 144. Return spring 140 acts between plug 144 and piston 136 to bias piston 136 against forces exerted on at least one of surfaces 176 and 180 by pressurized working fluid.

[0034] A chamber 172 is formed between piston 136 and plug 144 within the piston bore of housing 124. A hole 164 is provided to link chamber 172 with pump inlet space 148 to allow low pressure working fluid to enter

and exit chamber 172 as required to accommodate movement of piston 136.

[0035] Housing 124 includes a passageway 156 which allows working fluid to escape from pump outlet space 152 to pump inlet space 148 when piston 136 moves far enough against the biasing force of spring 140 such that passageway 156 is not blocked by piston 136.

[0036] A hole 160 is provided to link chamber 168 to an external control system (not shown) which can supply chamber 168 with either pressurized working fluid directly or indirectly from the pump outlet or with low pressure working fluid from the pump inlet or elsewhere in the engine.

[0037] Pump 120 is thus capable of operating in two modes. In the first mode, chamber 168 is supplied with low pressure working fluid and no force is exerted on surface 180 of piston 136. In order for piston 136 to move far enough to unblock passageway 156, the pump outlet pressure, which acts only against surface 176 of piston 136, must rise to a relatively high value to overcome the return spring force. In the second mode, chamber 168 is supplied with pressurized working fluid, thus exerting a force on surface 180 of piston 136, in addition to the force already acting at surface 176, both forces acting in the same direction against return spring 140. In this mode, the pressure of the working fluid need only rise to a relatively low value to overcome the return spring force and thus unblock passageway 156, because said pressure acts against a larger total surface area.

[0038] As should now be apparent, pump 120 can operate at either of two equilibrium pressures according to the state of the external control system. An advantage of such a pump system is that the external control system can be made to select the low equilibrium pressure when the engine is operating at lower speeds, at which time high pressure is not required for effective lubrication of the engine, thus saving energy. At higher speeds, at which time the engine requires higher pressure for effective lubrication, the control system can be made to select the high equilibrium pressure. A further advantage of such a pump system is that in the event of a failure in the external control system such that pressurized working fluid cannot be supplied to chamber 168, the pump will revert to the higher of the two equilibrium pressures, thus maintaining effective lubrication of the engine at all speeds.

[0039] While in the illustrated embodiments chambers 80 and 84 (or chambers 152 and 168) are designed such that the forces created by a supply of pressurized fluid therein add together to act against the force of return spring 56 (or 140), it will be apparent to those of skill in the art that it is a simple matter, if desired, to alter the design of control piston 52 (or 136) and housing 60 (or 124) such that the force generated by pressurized working fluid in one chamber acts against the force generated by pressurized working fluid in the other chamber and against the force of return spring 56 (or 140). Such alternatives are also intended to be within the scope of the

present invention.

[0040] If the relevant areas of chambers 80 and 84 (or 152 and 168) differ, three different equilibrium pressure points can be selected between. For example, if the relevant area of chamber 84 is larger than the relevant area of chamber 80, then: to select a first equilibrium pressure, pressurized working fluid can be supplied to only chamber 80; to select a second equilibrium pressure, pressurized working fluid can be supplied to only chamber 84; and to select a third equilibrium pressure pressurized working fluid can be provided to both of chambers 80 and 84.

[0041] As will also be apparent to those of skill in the art, should additional equilibrium pressures be desired, control piston 52 (or 136) and control housing 60 (or 124) can be fabricated to form one or more additional chambers, as necessary.

[0042] Further embodiments of the present invention are as follows:

1. A variable capacity vane pump having a slide ring which is moveable to alter the capacity of the pump, the pump being operable at at least two selected equilibrium pressures, comprising: a pump casing having a pump chamber therein; a vane pump rotor rotatably mounted in the pump chamber; a slide ring enclosing the vane pump rotor within said pump chamber, the slide ring being moveable within the pump chamber to alter the capacity of the pump; a control housing in the pump casing; a control piston having an actuator end and two control surfaces, the control piston being received within the control housing such that the actuator end engages the slide ring and such that each control surface forms a respective chamber within the control housing, each chamber being connected to a respective gallery through which pressurized fluid can be provided to or removed from the respective chamber to move the control piston within the control housing; and a return spring acting between slide ring and the casing to bias the slide ring towards a given position, wherein a supply of pressurized fluid to one of the two chambers can be applied or removed to change the equilibrium pressure of the pump.

2. The variable capacity pump of embodiment 1 wherein the return spring is mounted with the control housing and acts between the control housing and the control piston to bias the slide ring.

3. The variable capacity pump of embodiment 1 wherein, when supplied with pressurized fluid, each chamber creates a force which adds to the force created by the other chamber to act against the bias force of the return spring.

4. The variable capacity pump of embodiment 1 wherein pressurized fluid is supplied to a first chamber of the two chambers when the pump is operating and pressurized fluid is supplied to a second of the two chambers only in response to a signal from a

control system.

5. The variable capacity pump of embodiment 1 wherein to engage the slide ring, the actuator end of the control piston is in the form of a disc which is received in a slot the slide ring, the height of the disc being closely toleranced to engage the slot to inhibit backlash between the slide ring and the control piston, the diameter of the disc being less than the width of the slot to provide an allowance for lateral misalignment of the control piston and the slide ring.

6. The variable capacity pump of embodiment 1 wherein each chamber has a different sized area against which the pressurized fluid can act.

7. The variable capacity pump of embodiment 6 wherein a supply of pressurized fluid can be applied to either or both of the two chambers to select from three equilibrium pressures for the pump.

8. The variable capacity pump of embodiment 1 wherein the control piston has at least three control surfaces, the control piston being received within the control housing such that at least three chambers are formed, each chamber being connectable to a respective gallery wherein a supply of pressurized fluid can be applied to or removed from one or more of the chambers to change the equilibrium pressure of the pump.

[0043] The above-described embodiments of the invention are intended to be examples of the present invention and alterations and modifications may be effected thereto, by those of skill in the art, without departing from the scope of the invention which is defined solely by the claims appended hereto.

Claims

1. A fixed capacity pump having a dual surface control piston, the pump being operable at at least two selected equilibrium pressures, comprising: a fixed capacity pump mechanism having a pump inlet and a pump outlet; a piston having two control surfaces, the piston being received within a pump housing such that each control surface forms a respective chamber within the housing, each chamber being connected to a respective gallery through which pressurized fluid can be provided to or removed from the respective chamber to move the piston within the housing, the piston being disposed in the housing such that its position determines whether a passageway is blocked or unblocked, the passageway when unblocked allowing working fluid to escape from the pump outlet to a low pressure space; and a return spring acting between piston and the casing to bias the piston towards a given position, wherein a supply of pressurized fluid to one of the two chambers can be applied or removed to change the equilibrium pressure of the pump.

2. The fixed capacity pump of claim 1 wherein, when supplied with pressurized fluid, each chamber creates a force which adds to the force created by the other chamber to act against the bias force of the return spring.

3. The fixed capacity pump of claim 1 wherein pressurized fluid is supplied to a first chamber of the two chambers when the pump is operating and pressurized fluid is supplied to a second of the two chambers only in response to a signal from a control system.

4. The fixed capacity pump of claim 1 wherein each chamber has a different sized area against which the pressurized fluid can act.

5. The fixed capacity pump of claim 4 wherein a supply of pressurized fluid can be applied to either or both of the two chambers to select from three equilibrium pressures for the pump.

6. The fixed capacity pump of claim 1 wherein the piston has at least three control surfaces, the piston being received in the housing such that at least three chambers are formed, each chamber being connectable to a respective gallery wherein a supply of pressurized fluid can be applied to or removed from one or more of the chambers to change the equilibrium pressure of the pump.

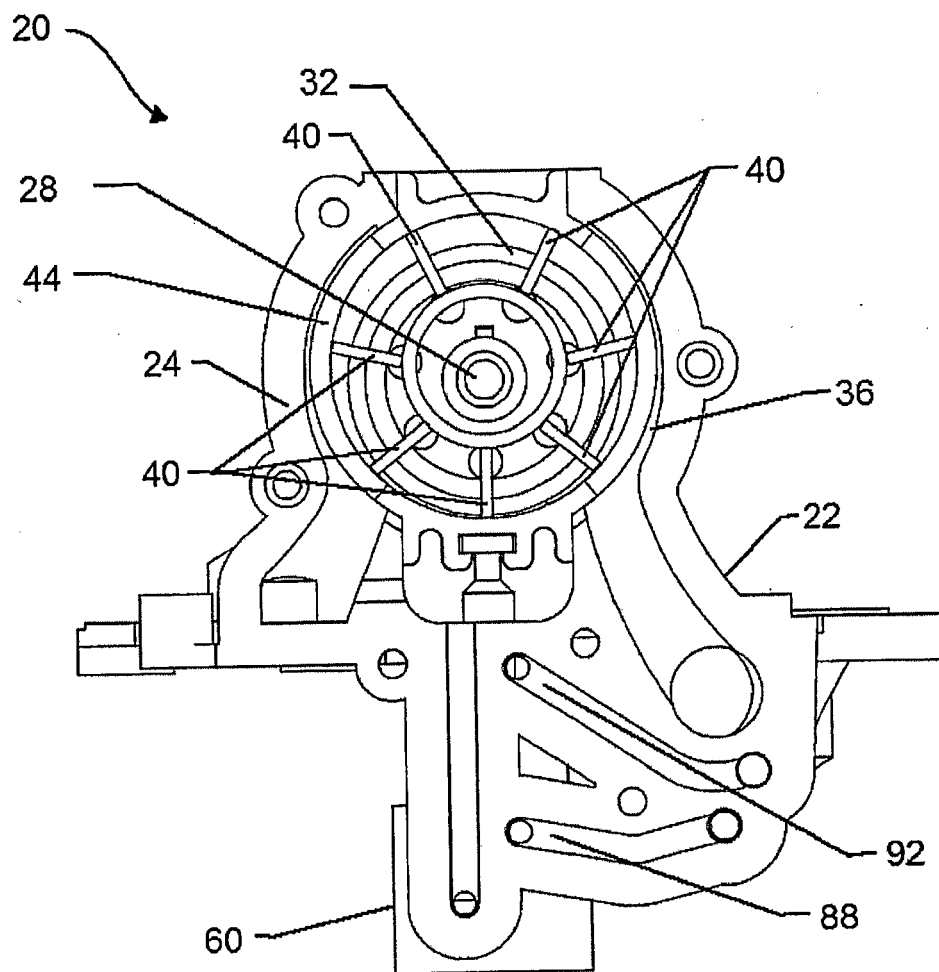


Fig. 1

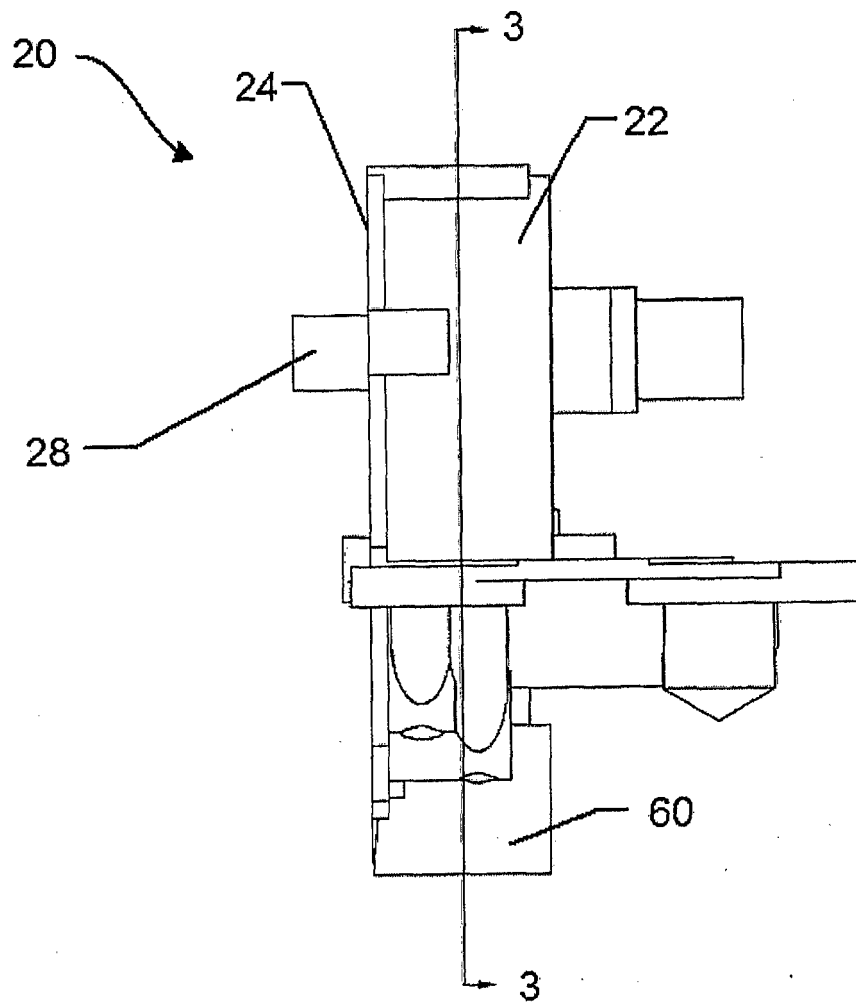


Fig. 2

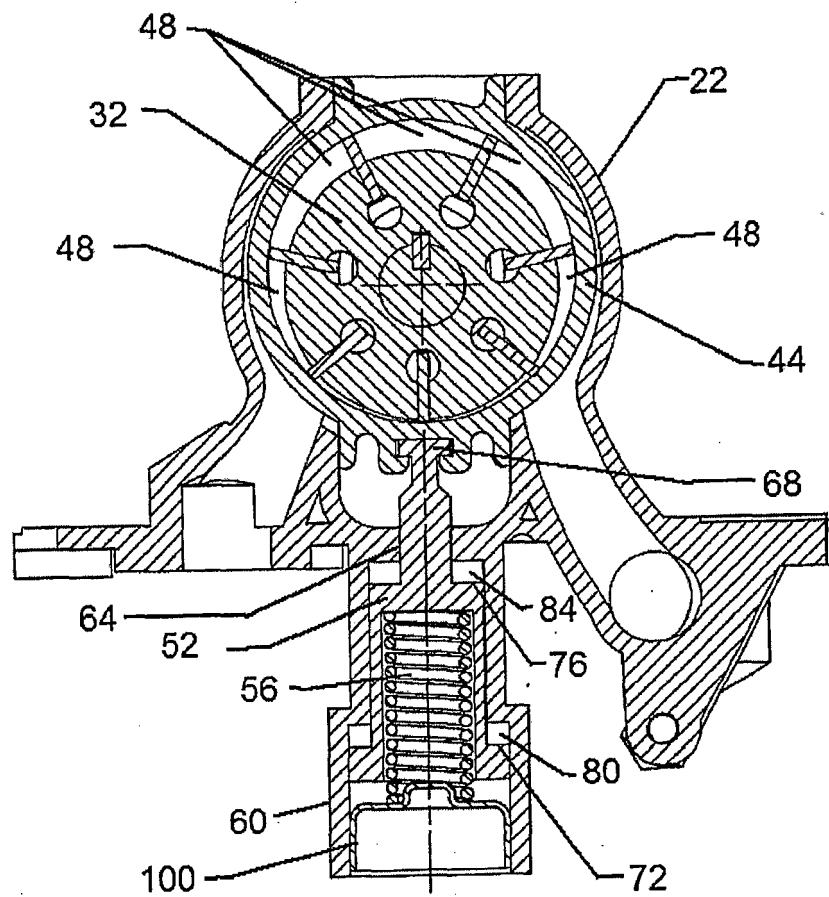


Fig. 3

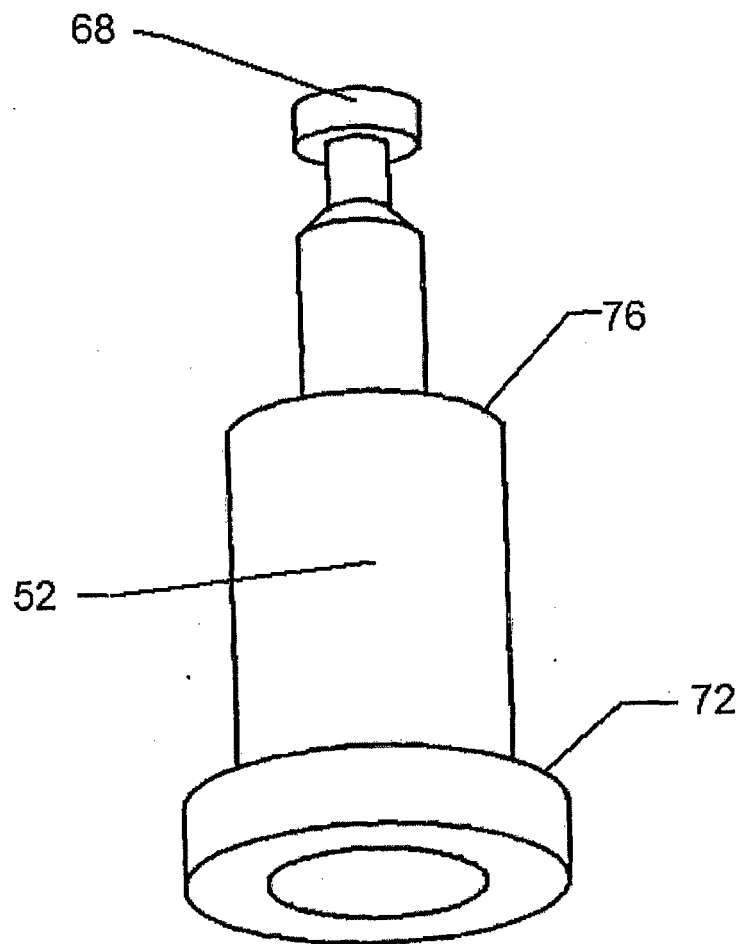


Fig. 4

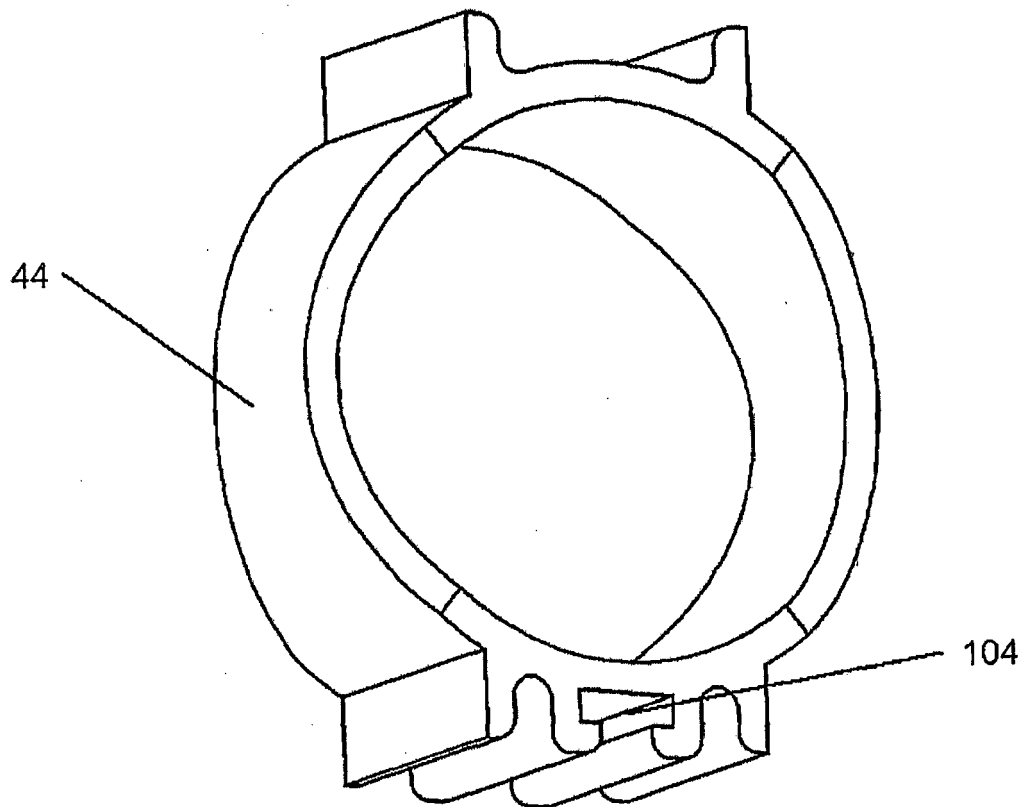


Fig. 5

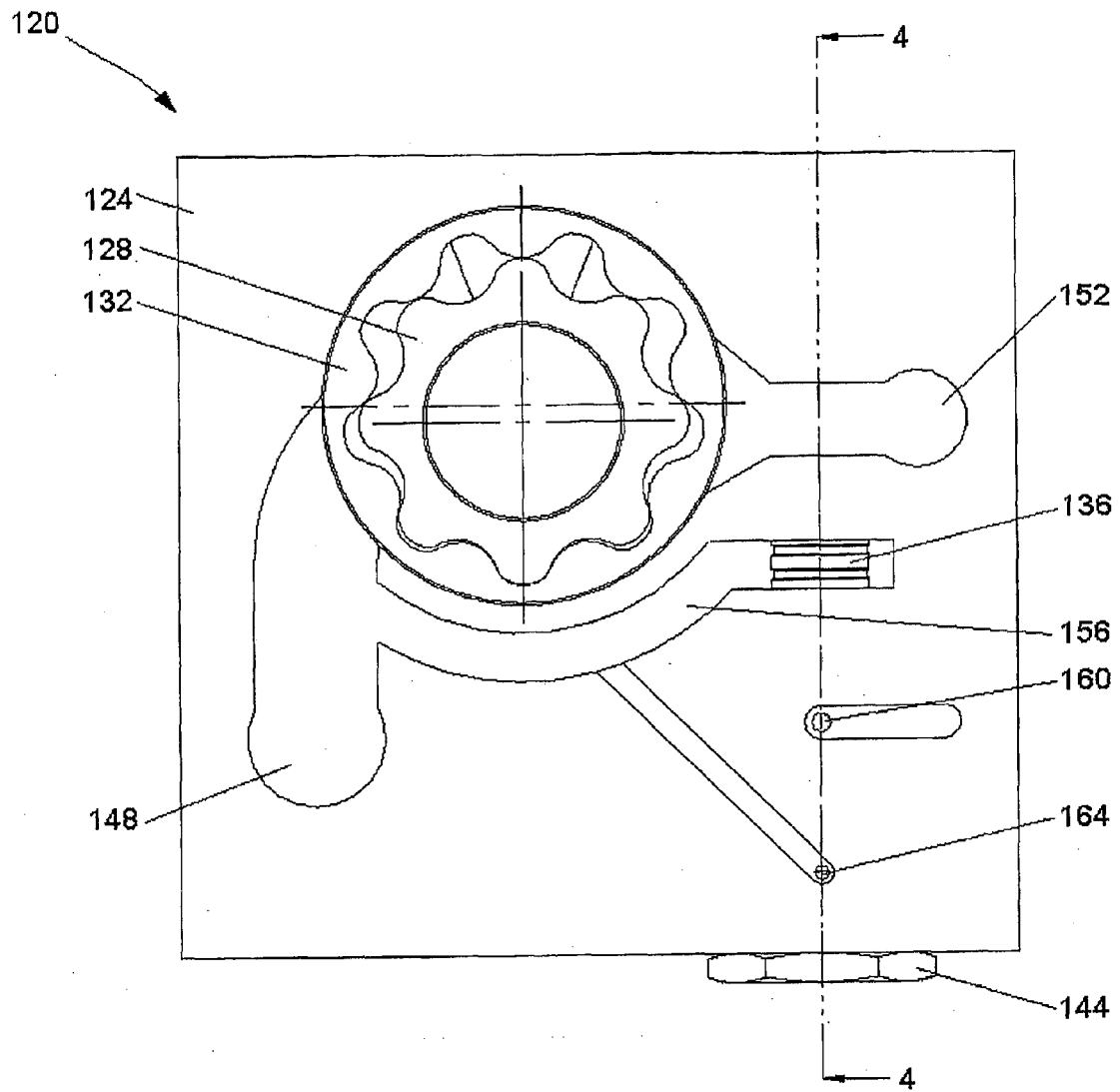


Fig. 6

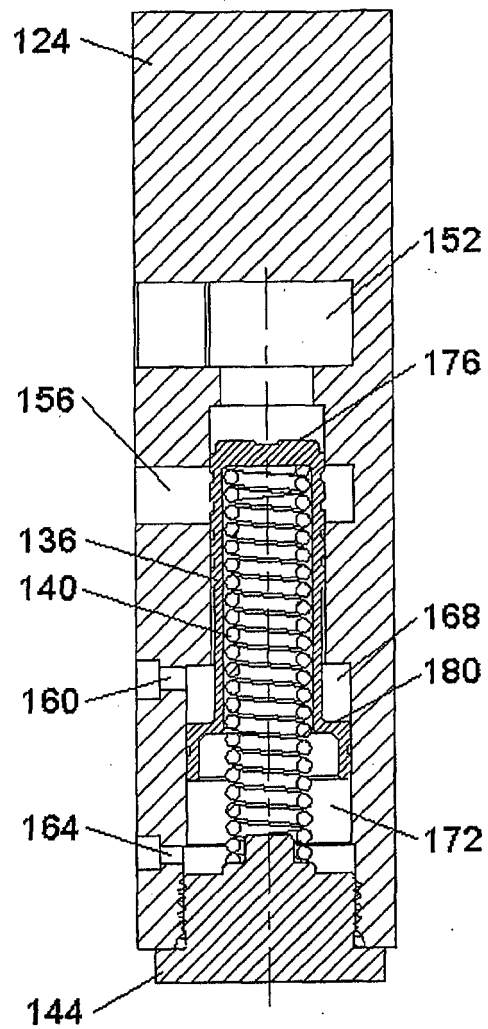


Fig. 7



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Application Number
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Place of search Munich		Date of completion of the search 23 April 2014	Examiner Lange, Christian
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