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(54) **VARIABLE DISPLACEMENT PUMP WITH AXIAL DISPLACEMENT OF THE VANES**

(57) The present disclosure relates to a variable displacement vane pump, in particular for oil, comprising a body having a cavity wherein a movable ring slides in the longitudinal direction over the rotor which rotates around an axis and which is provided with vanes which are radially supported on the inner surface of the fixed ring of fixed eccentricity relative to the rotation axis of the rotor, and with movement means in the longitudinal direction of the movable ring according to a pilot pressure between a position corresponding to the maximum volume of the plurality of chambers, the return elastic spring being in this position at its maximum length, and a predetermined end position corresponding to the minimum volume of the plurality of chambers, the return elastic spring being in this position at its minimum length by action of the displacement in the longitudinal direction of the movable wall which occurs simultaneously to the longitudinal displacement of the plurality of vanes and of the movable ring.

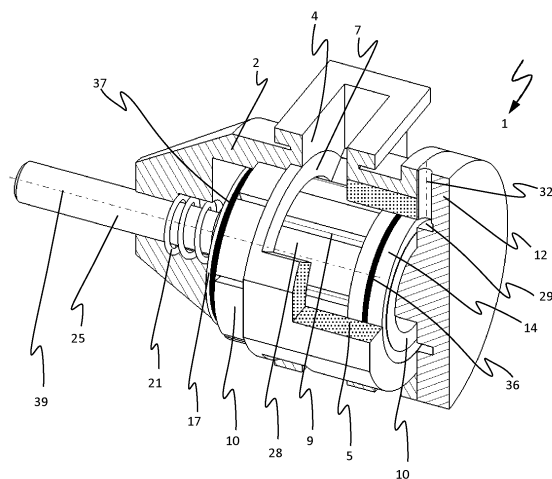


Fig. 7

Description

Technical domain

[0001] The present disclosure relates to a variable displacement vane pump, in particular for oil, comprising a body having a cavity where a movable ring slides in the longitudinal direction over the rotor which rotates around an axis and which is provided with vanes which are radially supported on the inner surface of the fixed ring of fixed eccentricity relative to the rotation axis of the rotor, and with movement means in the longitudinal direction of the movable ring according to a pilot pressure between a position corresponding to the maximum volume of the plurality of chambers, the return elastic spring being in this position at its maximum length, and a predetermined end position corresponding to the minimum volume of the plurality of chambers, the return elastic spring being in this position at its minimum length by action of the displacement in the longitudinal direction of the movable wall which occurs simultaneously to the longitudinal displacement of the plurality of vanes and of the movable ring.

Background

[0002] Vane pumps are commonly used to move different fluids, namely water, oil and air into suction pumps. These pumps mainly consist of a closed body and a cap forming the stator and of a rotor provided with radial slots in which the vanes can slide radially. Two successive vanes with the inner wall of the body and the outer wall of the rotor, and also the side walls of the body and the cap, form a chamber. The suctioning and discharging of the fluid are carried out by lower and upper ports in the walls of the body or cap. Near the suction port, the chambers are still small. As the rotor rotates, the chambers increase in volume by action of the eccentricity of the rotor relative to the body and they are filled with fluid. As soon as the chambers reach their maximum size, they separate themselves from the suction port and come into contact with the discharging port. The volume of the chamber begins to decrease to reach its minimum value thus discharging the fluid contained therein.

[0003] The flow rate or pressure variation in the discharging port can be obtained in different ways. In a first option, the cavity that is embodied in the pump body has an inner section eccentric with respect to the rotation axis of the rotor. With this embodiment, it is not possible to modify the discharged volume, wherein at a given rotational speed of the rotor the same pressure or the same flow rate are obtained.

[0004] There are vane pumps designed in such a way that it is possible to regulate their cylinder capacity to allow the adjustment of the volume of the chambers and therefore a variation of the flow rate and pressure.

[0005] These variable cylinder capacity pumps operate according to the same principle, but a movable ring

is interposed between the cavity and the rotor. The movable ring can move in the cavity between a position where it is concentric to the rotation axis of the rotor (neutral point) and an eccentric end position. The more the axis move away, the bigger the volume of the chambers becomes. The ring is held in eccentric position by a return spring, whose tension is adjustable. A plunger is placed in opposition to the spring and tends to push the ring into the neutral position. The plunger is fed by fluid exiting the pump, so that as pressure increases the more plunger pushes the ring towards the neutral position. As soon as pressure drops, the return spring tends to push the ring into the eccentric position. Such pumps are known as the example in EP 0398377 A. These pumps then allow a self-regulation of the flow rate depending on the pressure.

[0006] Variable cylinder capacity vane pumps also allow the flow rate to be adjusted according to a pilot pressure on the plunger which pushes the movable ring against the return spring, this pilot pressure being controllable by auxiliary means which can be mechanical or electronic, and may or may not be integrated in the pump body.

[0007] The operating principle for flow rate variation in this type of vane pumps is based on the change in the eccentricity of the rotor relative to the movable ring interposed between the cavity of the pump body and the rotor. What distinguishes the different types of these vane pumps is the manner in which the eccentricity of the movable ring relative to the rotor occurs. This change in eccentricity is usually associated with both the displacement of the movable ring, which may have different configurations, and the actuation mode of said displacement. Thus, there are variable displacement vane pumps in which the displacement of the movable ring occurs angularly by the limited rotation thereof around a pin fixed to the pump body, the plunger or actuating chamber being on the side opposite to the pin such as the example of patents WO2006/054159A1, US2012/0045355A1, WO2012/021992A1 and WO2003/069127A1. Another configuration is based on altering the eccentricity of the movable ring relative to the rotor through linear displacement of the movable ring guided by the walls of the pump body and cap as exemplified in patents WO 2003/

[0008] These facts illustrate the technical problem to be solved by the present solution.

General description

[0009] The present disclosure relates to a variable cylinder capacity vane pump, wherein the cylinder capacity variation and therefore of the flow carried by the plurality of chambers between the suction port and the discharge port for a given rotation of the rotor is carried out by changing the longitudinal length of the chambers, and not by changing the eccentricity between the ring and the rotor, the eccentricity being fixed, this being the main differentiating element with respect to the variable displacement

vane pumps currently available.

[0010] In an embodiment, the pump comprises a body having a suction port which may be connected to the fluid reservoir and a discharging port which may be connected to a circuit for distributing the fluid itself. A fixed ring secured to the body on which inner circular surface a plurality of vanes slide, wherein each is adapted for radially and longitudinally sliding in the corresponding slot of the rotor which rotates around a longitudinal axis, this axis being eccentrically positioned and fixed relative to the longitudinal axis defined by the inner circular surface of the fixed ring.

[0011] In an embodiment, the rotor is limited in its longitudinal movement by the surfaces of the body and a cap fixed to the body. The rotor is eccentrically positioned relative to the inner surface of a ring fixed to the pump body. The rotor has a plurality of slots which maintain angular positioning and allows sliding in the radial and longitudinal direction of the plurality of vanes. The rotor has a side surface perpendicular to its longitudinal axis which delimits the volume of the plurality of chambers in the longitudinal direction, in the opposite direction the delimitation of the volume of the chambers being ensured by the side surface of the movable ring. In the radial direction the volume of the plurality of chambers is delimited by the inner surface of the fixed ring and by the outer surface of the rotor, with two consecutive vanes the volume of each of the plurality of chambers being formed, carrying the fluid from the suction port to the discharging port by action of rotor rotation movement. Near the suction port, the chambers are still small. As the rotor rotates, the chambers increase in volume by action of the eccentricity of the rotor relative to the inner surface of the ring fixed to the body and they fill with fluid. As soon as the chambers reach their maximum size, they separate from the suction port and come into contact with the discharging port. The volume of the chamber begins to decrease to reach its minimum value thus discharging the fluid contained therein. The rotor is joined to the shaft which receives the rotational movement external to the pump.

[0012] In an embodiment, the movable ring in radial contact with the inner surface of the ring fixed to the body and with the outer radial surface of the rotor can only slide in the longitudinal direction, as a result of the eccentricity between the inner surface of the ring fixed to the body and the outer surface of the rotor. The displacement in the longitudinal direction of the movable ring pushes, through its side surface, the vanes to move in the longitudinal direction relative to the rotor. The plurality of vanes is in contact with a movable wall which is supported on a return elastic spring. This return elastic spring is supported on one end thereof on the pump body.

[0013] In an embodiment, it has a movement means in the longitudinal direction of the movable ring according to a pilot pressure, between an end position corresponding to the maximum volume of the plurality of chambers, the return elastic spring being in this position (Fig. 1, Fig. 7) at its maximum length, and another predetermined

end position corresponding to the minimum volume of the plurality of chambers, the elastic spring being in this position at its minimum length by action of the longitudinal displacement of the movable wall (Fig. 6, Fig. 8).

[0014] In an embodiment of the disclosure the movement means comprises a pilot chamber delimited by the inner surfaces of the cap, by the side surface of the movable ring, by the inner circular surface of the fixed ring and the outer surface of the rotor, the movable ring being adapted for longitudinally sliding in said pilot chamber due to the pilot pressure present in this pilot chamber. The pilot pressure comes from an external source to the pilot chamber through a channel in the cap.

[0015] In an embodiment, the variation of flow carried by the plurality of chambers between the suction port and discharging port at a given rotor rotation occurs by changing the pilot pressure in the pilot chamber, which acts on the side surface of the movable ring, thus causing a longitudinal force thereon. If the force generated on the side surface of the movable ring is greater or inferior to that exerted by the return elastic spring in contact with the movable wall, the longitudinal and simultaneous sliding in the movable ring of the plurality of vanes and the movable wall occurs. Sliding towards increasing the length of the return elastic spring increases the distance between the side surface of the movable ring and the side surface of the rotor up to a maximum and consequently increases the volume of the plurality of chambers. Sliding towards reducing the length of the return elastic spring decreases the distance between the side surface of the movable ring and the side surface of the rotor and consequently decreases the volume of the plurality of chambers. Changing the distance between the side surfaces of the movable ring and the rotor, that is, the longitudinal length of the plurality of chambers, changes the flow carried by the suction port to the discharging port per each rotor rotation.

[0016] In an embodiment, increasing the pilot pressure in the pilot chamber increases the force exerted on the side surface of the movable ring by causing it to move in the compression direction of the return elastic spring, thereby reducing pump flow for a given speed of rotation up to a predetermined minimum.

[0017] In an embodiment, the absence of or decreased pilot pressure in the pilot chamber decreases the force exerted on the side wall of the movable ring by causing it to move in the direction of return elastic spring strain thereby increasing the pump displacement for a given speed of rotation up to a predetermined maximum.

[0018] In an embodiment, the pilot chamber may communicate with the discharging port of the pump, that is the pressure zone at the pump outlet. Thus, the pressure in the pilot chamber may be the same as that at the pump outlet. It is also possible that the pilot pressure applied in the pilot chamber is dependent on the pressure in the zone of use of the fluid pumped by the vane pump. This solution allows accounting for load losses between the discharging zone of the pump and the engine zone where

the pumped fluid is actually used. Pilot pressure in the pilot chamber can be regulated by means of an auxiliary device of mechanical or electronic programmable origin which may or not be integrated into the pump body itself.

[0019] In an embodiment, in order to ensure the longitudinal return of the movable ring to the position of maximum volume of the plurality of chambers, it is provided that the displacement means comprise a return elastic spring tending to move the movable ring into the corresponding end position. This elastic spring is preferably placed on the side opposite the movable ring.

[0020] In an embodiment, it is provided that the pump can be provided with a fixed ring rigidly connected to the pump body so that a more wear resistant material in the fixed ring, where the plurality of vanes radially slide, and a lighter and less resistant material in the pump body can be used.

[0021] In an embodiment, the movable ring is provided with means adapted for reducing friction effects and improving the tightness between the pilot chamber and the plurality of chambers.

[0022] In an embodiment, it is provided that the movable wall in simultaneous contact with the plurality of vanes and the return elastic spring has means adapted for reducing friction effects.

[0023] In an embodiment of the disclosure, means are provided to be provided so as to insulate the suction region from the discharging region.

[0024] The present disclosure thus relates to a vane rotary pump (1) with a displacement variation, in particular for oil, comprising a support body (2), with a suction port (3), which may be connected to the fluid reservoir; a discharging port (4), which may be connected to a circuit for dispensing the fluid itself; a fixed ring (5) secured to the support body (2) with suction (6) and discharging ports (7) wherein on the inner circular surface (8) thereof a plurality of vanes (9) slide wherein each is adapted for radially and longitudinally sliding in the corresponding slot in the rotor (10) which rotates around the longitudinal axis (39), this axis being positioned eccentrically and fixed with respect to the longitudinal axis (40) of the inner circular surface (8) of the fixed ring (5); the rotor (10) is limited in its longitudinal movement by the support body (2) through the side surface (11) and by the cap (12) through the side surface (13); the cap (11) is fixed to the support body (2); the movable ring (14) is in radial contact with the inner circular surface (8) of the fixed ring (5) and with the outer surface (15) of the rotor (10); the plurality of vanes (9) are simultaneously in longitudinal contact with the side surface (16) of the movable ring (14) and with the side surface (18) of the movable wall (17); the plurality of vanes maintains the radial positioning by action of the radial contact with the washers (19, 20) and the inner circular surface (8) of the fixed ring (5); the movable wall (17) is in contact with the return elastic spring (21) through the side surface (22); the fixed end spring is supported on the side surface (23) of the pump body (2); the movable wall (17) is in radial contact with the

pump body (2) through the surface (24) and with the shaft (25) through the surface (26); the outer (15) and side (27) surfaces of the rotor (10) together with the inner circular surface (8) of the fixed ring (5) of two successive vanes (9) and the side surface (16) of the movable ring (14) form the volume of each of the plurality of chambers (28) carrying the fluid from the suction port (3) to the discharging port (4) by action of rotor rotation movement (10) fixed to the shaft (25) receiving the rotational movement external to the pump (1); characterized by movement means in the longitudinal direction (29) of the movable ring (14) according to a pilot pressure between a position corresponding to the maximum volume of the plurality of chambers (28), the return elastic spring (21) being in this position at the maximum of its length, and a predetermined end position corresponding to the minimum volume of the plurality of chambers (28), the return elastic spring (21) being in this position at the minimum of its length by action of the displacement in the longitudinal direction of the movable wall (17) occurring simultaneously to the longitudinal displacement of the plurality of vanes (9) and of the movable ring (14).

[0025] In an embodiment, the rotary pump (1) with a displacement variation, in particular for oil, is characterized in that the movement means (29) comprises a pilot chamber (29) delimited by the surfaces (31) of the cap (11), the side surface (30) of the movable ring (10), the inner circular surface (8) of the fixed ring (5) and the outer surface (15) of the rotor (10), the movable ring (14) being adapted for sliding in the longitudinal direction in said pilot chamber (29) due to the pilot pressure present in said pilot chamber (29); the pilot pressure comes from a source external to the pilot chamber (29) through the channel (32); guiding means (8, 15) for longitudinal displacement of the movable ring (14) comprise the inner circular surface (8) of the fixed ring (5) and outer surface (15) of the rotor (10); guiding means (33, 34) for longitudinal and radial displacement of the plurality of vanes (9) comprise the surfaces (33, 34) of the plurality of rotor slots (10); longitudinal guiding means (24, 26) of the movable wall (17) comprise the surface (24) of the pump body (2) and the surface (26) of the shaft (25).

[0026] In an embodiment, the rotary pump (1) with a displacement variation, in particular for oil, is characterized in that it allows the variation of flow carried by the plurality of chambers (28) between the suction port (3) and the discharging port (4) at a given rotation of the rotor (10) by varying the pilot pressure in the pilot chamber (29) acting on the side surface (30) of the movable ring (15), causing a force in the longitudinal direction thereon, which being greater or less than the force exerted by the return elastic spring (21) in contact with the movable wall (17) causes sliding in the longitudinal direction and simultaneously in the movable ring (14) of the plurality of vanes (9) and the side wall (17), the sliding towards the cap (12) increasing the distance between the side surface (16) of the movable ring and the side surface (27) of the rotor (10) up to its maximum, and consequently

increasing the volume of the plurality of chambers (28), the sliding towards the elastic spring (21) decreasing the distance between the side surface (16) of the movable ring and the side surface (27) of the rotor (10) and consequent volume decrease of the plurality of chambers (28) thereby changing the flow carried from the suction port (3) to the discharging port (4) per each rotation of the rotor (10).

[0027] In an embodiment, the rotary pump (1) with a displacement variation, in particular for oil, is characterized by having in the movable ring (14) means (35, 36) adapted for reducing friction effects and improving tightness between the pilot chamber (29) and the plurality of chambers (28) and has in the movable wall (17) means (37, 38) adapted for reducing friction effects.

[0028] In an embodiment, the rotary pump (1) with a displacement variation, in particular for oil, is characterized in that the pilot pressure in the pilot chamber (29) may or may not derive from the available pressure near the discharging port (4) of the pump (1), being regulated by means of an auxiliary device of mechanical or electronic programmable origin and which may or may not be integrated in the pump body (2) itself.

[0029] In an embodiment, the rotary pump (1) with a displacement variation, in particular for oil, is characterized in that the return elastic spring (21) tends to move the movable wall (17), plurality of vanes (9) and movable ring (14) into the position next to the cap (12) maximizing the volumes of the chambers (28) and hence the flow of the pump (1) in the event of absence or low pilot pressure.

[0030] In an embodiment, the rotary pump (1) with a displacement variation, in particular for oil, is characterized by the means being provided in order to isolate the suction region (6) from the discharging region (7).

[0031] A variable displacement vane pump is described comprising a body with a ring fixed to said body, with a rotor provided with a plurality of radial vanes wherein each is adapted for radially and longitudinally sliding in a corresponding slot in said rotor, the pump further comprising:

a ring adapted for longitudinally sliding along the rotor, referred to as movable ring,
a body that is not longitudinally slidable over the rotor, referred to as fixed body,
wherein each of the vanes crosses and seals in openings of the side surface of the fixed body in one of the longitudinal tops of the vane, and sealing with a side surface of the movable ring in the other of the longitudinal tops of the vane,
defining chambers of variable longitudinal length.

[0032] A variable displacement vane pump is described comprising a body with a ring fixed to said body, with a rotor provided with a plurality of radial vanes wherein each is adapted for radially and longitudinally sliding in a corresponding slot in said rotor, the pump further comprising:

a ring adapted for longitudinally sliding along the rotor, referred to as movable ring,
a body that is not longitudinally slidable over the rotor, referred to as fixed body,
wherein each of the vanes in one of the longitudinal ends of the vane passes through and seals in opening of the side surface of the fixed body and in the other of the longitudinal ends of the vane, seals against a side surface of the movable ring,
defining chambers of variable longitudinal length.

[0033] A variable displacement vane pump is further described comprising a body with a ring fixed to said body, with a rotor provided with a plurality of radial vanes wherein each is adapted for radially sliding in a corresponding slot in said rotor, wherein the vanes slide along the circular inner surface of said fixed ring, and wherein the rotation axis of the rotor is eccentric relative to the axis defined by the circular inner surface of the fixed ring, the pump further comprising:

a ring adapted for longitudinally sliding along the rotor, referred to as movable ring,
a body that is not longitudinally slidable over the rotor, referred to as fixed body,
wherein each of the vanes is adapted for longitudinally sliding along the rotor in the corresponding slot in said rotor, passing through and sealing in openings of the side surface of the fixed body in one of the longitudinal tops of the vane, and sealing with a side surface of the movable ring in the other of the longitudinal tops of the vane,
defining chambers between vanes of variable longitudinal length arranged among the side surface of the movable ring, side surface of the fixed body, outer surface of the rotor and circular inner surface of the fixed ring.

[0034] In an embodiment, the fixed body is fixed to the rotor and jointly rotates with the rotor.

[0035] The fixed body and the rotor may be formed by the same part, and may be referred to simply as rotor.

[0036] In an embodiment, each of the vanes passes through the fixed body.

[0037] In an embodiment, the movable ring has the cross-section of a surface delimited by two non-concentric circumferences wherein one of the circumferences is completely contained by the other circumference.

[0038] An embodiment comprises force means for longitudinally moving the movable ring and the vanes.

[0039] In an embodiment, the force means comprise a return elastic spring for longitudinally moving the movable ring and the vanes up to their initial position.

[0040] An embodiment comprises force means for applying longitudinal force on the movable ring for longitudinally moving the movable ring and the vanes in order to increase the volume of said chambers.

[0041] In an embodiment, the force means comprise

a pilot chamber delimited by the side surface of the movable ring opposite the side surface of the movable ring which seals with longitudinal tops of the vanes, wherein the pilot chamber comprises a channel for receiving pressure from an external pressure source.

[0042] In an embodiment, the pilot chamber is connected to the pump outlet.

[0043] In an embodiment, the force means are mechanically or electronically controlled.

[0044] An embodiment comprises a wall which leans laterally against the longitudinal top of the vanes passing through the fixed body, for applying longitudinal force to said vanes.

[0045] An embodiment comprises force means for applying longitudinal force on said wall for longitudinally moving the movable ring and the vanes in order to decreasing the volume of said chambers.

[0046] In an embodiment, the fixed ring is of a more wear resistant material than the material of the pump body.

[0047] A variable displacement vane pump is further described according to any of the described embodiments for pumping a fluid wherein the fluid is oil. There is further described a variable displacement vane pump according to any of the previous embodiments for a vehicle. There is further described a vehicle engine or a vehicle comprising a variable displacement vane pump according to any of the described embodiments.

[0048] Longitudinal ends and longitudinal tops of the vanes are used interchangeably, as is also apparent from the figures. Longitudinal refers generally to the axial rotation orientation of the pump. Throughout the specification and claims the word "comprising" and variations thereof, are not intended to exclude other technical features, such as other components, or steps. Additional objects, advantages and features of the disclosure will become apparent to those skilled in the art upon examination of the specification, or may be learned upon practice of the disclosure. The following examples and drawings are provided by way of illustration and are not intended to be limiting of the present disclosure. Furthermore, the present disclosure covers all possible combinations of particular or preferred embodiments herein described.

Brief Description of the Figures

[0049] For an easier understanding of the present disclosure, drawings are herein attached, which represent preferred embodiments which, however, are not intended to limit the scope of the present disclosure.

Figure 1: Schematic representation of the longitudinal section of the variable displacement vane pump in an embodiment of the disclosure in the maximum volume position of the plurality of chambers.

Figure 2: Schematic representation of the cross-

section of the variable displacement vane pump along line I-I in figure 1.

Figure 3: Schematic representation of the cross-section of the variable displacement vane pump along line II-II in figure 1.

Figure 4: Schematic representation of the cross-section of the variable displacement vane pump along line III-III in figure 1.

Figure 5: Schematic representation of the cross-section of the variable displacement vane pump along line IV-IV in figure 1.

Figure 6: Schematic representation of the longitudinal section of the variable displacement vane pump in an embodiment of the disclosure in the minimum volume position of the plurality of chambers.

Figure 7: Schematic perspective representation of the partial longitudinal section of the variable displacement vane pump in an embodiment of the disclosure in the maximum volume position of the plurality of chambers.

Figure 8: Schematic perspective representation of the partial longitudinal section of the variable displacement vane pump in an embodiment of the disclosure in the minimum volume position of the plurality of chambers.

Figure 9: Schematic representation of a variable displacement pump wherein (A) represents a minimum volume position of the plurality of chambers and (B) represents a maximum volume position of the plurality of chambers in which the vanes pass through the fixed body.

Figure 10: Schematic representation of a variable displacement pump wherein (A) represents a minimum volume position of the plurality of chambers and (B) represents a maximum volume position of the plurality of chambers in which the vanes pass through the side surface of the fixed body.

Detailed Description

[0050] Figure 1 schematically shows the longitudinal section of the vane pump wherein 1 represents a vane rotary pump or of variable displacement; 2 represents a support body, 3 represents a suction port in the support body, 4 represents a discharge port in the support body, 5 a fixed ring, 6 represents a suction port in the fixed ring, 7 represents a discharging port in the fixed ring; 8 represents an inner circular surface of the fixed ring, 9 represents a vane, 10 represents a rotor; 11 represents a side surface of the body; 12 represents a cap; 13 repre-

sents a side surface of the cap; 14 represents a movable ring; 15 represents an outer surface of the rotor; 16 represents a side surface of the movable ring; 17 represents a movable wall; 18 a side surface of the movable wall; 19 and 20 represent washers; 21 represents an elastic spring; 22 represents a side of the movable wall, 23 represents a side surface of the body, 24 represents an inner surface of the body, 25 represents a shaft, 26 represents an outer surface of the shaft, 27 represents a side surface of the rotor, 28 represents chambers, 29 represents a pilot chamber, 30 represents a side surface of the movable ring, 31 represents a side surface of the cap, 32 represents a channel, 33 and 34 represent surfaces of the slot in the rotor; 35 and 36 represent a means for reducing friction in the movable ring, 37 and 38 represent a means for reducing friction in the movable wall, 39 represents an axis around which the rotor rotates; 40 represents an axis defined by the inner circular surface of the fixed ring.

[0051] The present disclosure relates to a variable displacement vane pump (1) comprising a body (2) having a cavity wherein a movable ring (14) slides in the longitudinal direction over the rotor (10) which rotates around an axis (39) and which is provided with vanes (9) which are radially supported on the inner circular surface (8) of the fixed ring (5) of fixed eccentricity relative to the rotation axis of the rotor (10), and with movement means in the longitudinal direction of the movable ring (29) according to a pilot pressure between a position corresponding to the maximum volume of the plurality of chambers (28), the return elastic spring (21) being in this position at its maximum length, and a predetermined end position corresponding to the minimum volume of the plurality of chambers (28), the return elastic spring (21) being in this position at its minimum length by action of the displacement in the longitudinal direction of the movable wall (17) which occurs simultaneously with the longitudinal displacement of the plurality of vanes (9) and of the movable ring (14).

[0052] In an embodiment, the present vane rotary pump (1) with a displacement variation, in particular for oil, comprises a support body (2) with a suction port (3) which may be connected to the fluid reservoir and a discharging port (4) which may be connected to a circuit for dispensing the fluid itself.

[0053] A fixed ring (5) secured to the support body (2) with suction (6) and discharging ports (7) wherein on the inner circular surface (8) a plurality of vanes (9) slides, wherein each is adapted for radially and longitudinally sliding in the corresponding slot of the rotor (10) which rotates around the longitudinal shaft (39), this shaft being positioned eccentrically and fixed relative to the longitudinal axis (40) of the inner circular surface (8) of the fixed ring (5).

[0054] The rotor (10) is limited in its longitudinal movement by the support body (2) through the contact surface (11) and by the cap (12) through the surface (13), the cap (12) being fixed to the support body (2).

[0055] The movable ring (14) is in radial contact with the inner circular surface (8) of the fixed ring (5) and with the outer surface (15) of the rotor (10). The plurality of vanes (9) are in simultaneous contact in the longitudinal direction with the side surface (16) of the movable ring (14) and with the side surface (18) of the movable wall (17).

[0056] The plurality of vanes maintains the radial positioning by action of the radial contact with the washers (19, 20) and the inner circular surface (8) of the fixed ring (5).

[0057] The movable wall (17) is in contact with the return elastic spring (21) through the side surface (22), the fixed end of the elastic spring (21) being supported on the side surface (23) of the pump body (2). The movable wall (17) is in radial contact with the pump body (2) through the surface (24) and with the shaft (25) through the surface (26).

[0058] The outer (15) and side (27) surfaces of the rotor (10) together with the inner circular surface (8) of the fixed ring (5) of two successive vanes (9) and the side surface (16) of the movable ring (14) form the volume of each of the plurality of chambers (28) carrying the fluid from the suction port (3) to the discharging port (4) by action of the rotor rotation movement (10) fixed to the shaft (25) receiving the rotational movement external to the pump (1).

[0059] The longitudinal movement means (29) of the movable ring (14) according to a pilot pressure between a position corresponding to the maximum volume of the plurality of chambers (28), the return elastic spring (21) being in this position at its maximum length, and a predetermined end position corresponding to the minimum volume of the plurality of chambers (28), the return elastic spring (21) being in this position at its minimum length by action of the longitudinal displacement of the movable wall (17) occurring simultaneously to the longitudinal displacement of the plurality of vanes (9) by action of the surface (16) of the movable ring (14).

[0060] The movement means (29) comprising a pilot chamber (29) delimited by the surfaces (31) of the cap (11), by the side surface (30) of the movable ring (10), by the inner circular surface (8) of the fixed ring (5) and by the outer surface (15) of the rotor (10), the movable ring (14) being adapted for longitudinally sliding in said pilot chamber (29) due to the pilot pressure present in this pilot chamber (29). The pilot pressure comes from a source external to the pilot chamber (29) through the channel (32).

[0061] The guiding means (8, 15) for the longitudinal displacement of the movable ring (14) comprise the inner circular surface (8) of the fixed ring (5) and the outer surface (15) of the rotor (10). The guiding means (33, 34) for longitudinal and radial displacement of the plurality of vanes (9) comprise the surfaces (33, 34) of the plurality of rotor slots (10). The longitudinal guiding means (24, 26) of the movable wall (17) comprise the surface (24) of the pump body (2) and the surface (26) of the shaft (25).

[0062] The variation of flow carried by the plurality of chambers (28) between the suction port (3) and discharging port (4) at a given rotation of the rotor (10) is carried out by varying the pilot pressure in the pilot chamber (29) acting on the side surface (30) of the movable ring (14), causing a longitudinal force thereon, which being greater or less than the force exerted by the return elastic spring (21) in contact with the movable wall (17) causes longitudinal and simultaneous sliding in the movable ring (14) of the plurality of vanes (9) and of the side wall (17), the sliding towards the cap (12) increases the distance between the side surface (16) of the movable ring and the side surface (27) of the rotor (10) up to a maximum, and consequent increase of the volume of the plurality of chambers (28). The sliding towards the elastic spring (21) decreasing the distance between the side surface (16) of the movable ring (14) and the side surface (27) of the rotor (10) and consequent volume decrease of the plurality of chambers (28) thereby changing the flow carried from the suction port (3) to the discharging port (4) per each rotation of the rotor (10).

[0063] The movable ring (14) is provided with means (35, 36) adapted for reducing friction effects and improving the tightness between the pilot chamber (29) and the plurality of chambers (28). The movable wall (17) is provided with means (37, 38) adapted for reducing friction effects.

[0064] The pilot pressure in the pilot chamber (29) may or may not derive from the available pressure next to the discharging port (4) of the pump (1), it being controllable by means of an auxiliary device of mechanical or electronic programmable origin and which may or may not be integrated in the pump body (2) itself.

[0065] The return elastic spring (21) tends to move the movable wall (17), plurality of vanes (9) and movable ring (14) into the end position of the movable ring (14) next to the cap (12) maximizing the volume of the chambers (28) and hence the flow of the pump (1) in the event of absence or low pilot pressure.

[0066] Although the present disclosure has only shown and described particular embodiments of the solution, one skilled in the art shall know how to introduce modifications and replace some technical features for equivalents, depending on the requirements of each situation, without departing from the scope of protection defined by the appended claims. The embodiments are combinable. The following claims further define preferred embodiments.

Claims

1. Variable displacement vane pump comprising a body with a ring fixed to said body, with a rotor provided with a plurality of radial vanes wherein each is adapted to slide radially in a corresponding slot in said rotor, wherein the vanes slide along the circular inner surface of said fixed ring, and wherein the ro-

tation axis of the rotor is eccentric relative to the axis defined by the circular inner surface of the fixed ring, **characterised by** comprising:

a ring adapted for sliding longitudinally along the rotor, referred to as movable ring,
a body that is not longitudinally slidable over the rotor, referred to as fixed body,
wherein each of the vanes is adapted for sliding longitudinally along the rotor in the corresponding slot in said rotor, passing through and sealing in openings of the side surface of the fixed body in one of the longitudinal tops of the vane, and sealing with a side surface of the movable ring in the other of the longitudinal tops of the vane, defining chambers between vanes of variable longitudinal length arranged among the side surface of the movable ring, side surface of the fixed body, outer surface of the rotor and circular inner surface of the fixed ring.

2. Variable displacement vane pump according to the previous claim wherein the fixed body is fixed to the rotor and rotates jointly with the rotor.
3. Variable displacement vane pump according to the previous claim wherein the fixed body and the rotor are formed by the same part.
4. Variable displacement vane pump according to any previous claim wherein the movable ring has the cross-section of a surface delimited by two non-concentric circumferences wherein one of the circumferences is completely contained by the other circumference.
5. Variable displacement vane pump according to any previous claim comprising force means for longitudinally moving the movable ring and the vanes.
6. Variable displacement vane pump according to the previous claim wherein the force means comprise a return elastic spring for longitudinally moving the movable ring and the vanes up to their initial position.
7. Variable displacement vane pump according to any claim 5-6 comprising force means for applying longitudinal force on the movable ring for longitudinally moving the movable ring and the vanes in order to increasing the volume of said chambers.
8. Variable displacement vane pump according to any claim 5-7 wherein the force means comprise a pilot chamber delimited by the side surface of the movable ring opposite to the side surface of the movable ring which seals with longitudinal tops of the vanes, wherein the pilot chamber comprises a channel for receiving pressure from an external pressure

source.

9. Variable displacement vane pump according to the previous claim wherein the pilot chamber is connected to the pump outlet. 5
10. Variable displacement vane pump according to any claim 5-9 wherein the force means are mechanically or electronically controlled. 10
11. Variable displacement vane pump according to any previous claim comprising a wall which leans laterally against to the longitudinal top of the vanes passing through the fixed body, for applying longitudinal force to said vanes. 15
12. Variable displacement vane pump according to the previous claim comprising force means for applying longitudinal force on said wall for longitudinally moving the movable ring and the vanes in order to decrease the volume of said chambers. 20
13. Variable displacement vane pump according to any previous claim wherein the fixed ring is of a more wear resistant material than the material of the pump body. 25
14. Variable displacement vane pump according to any previous claim for pumping a fluid wherein the fluid is oil. 30
15. Variable displacement vane pump according to any previous claim for a vehicle.
16. Vehicle engine or vehicle comprising a variable displacement vane pump described in any previous claim. 35

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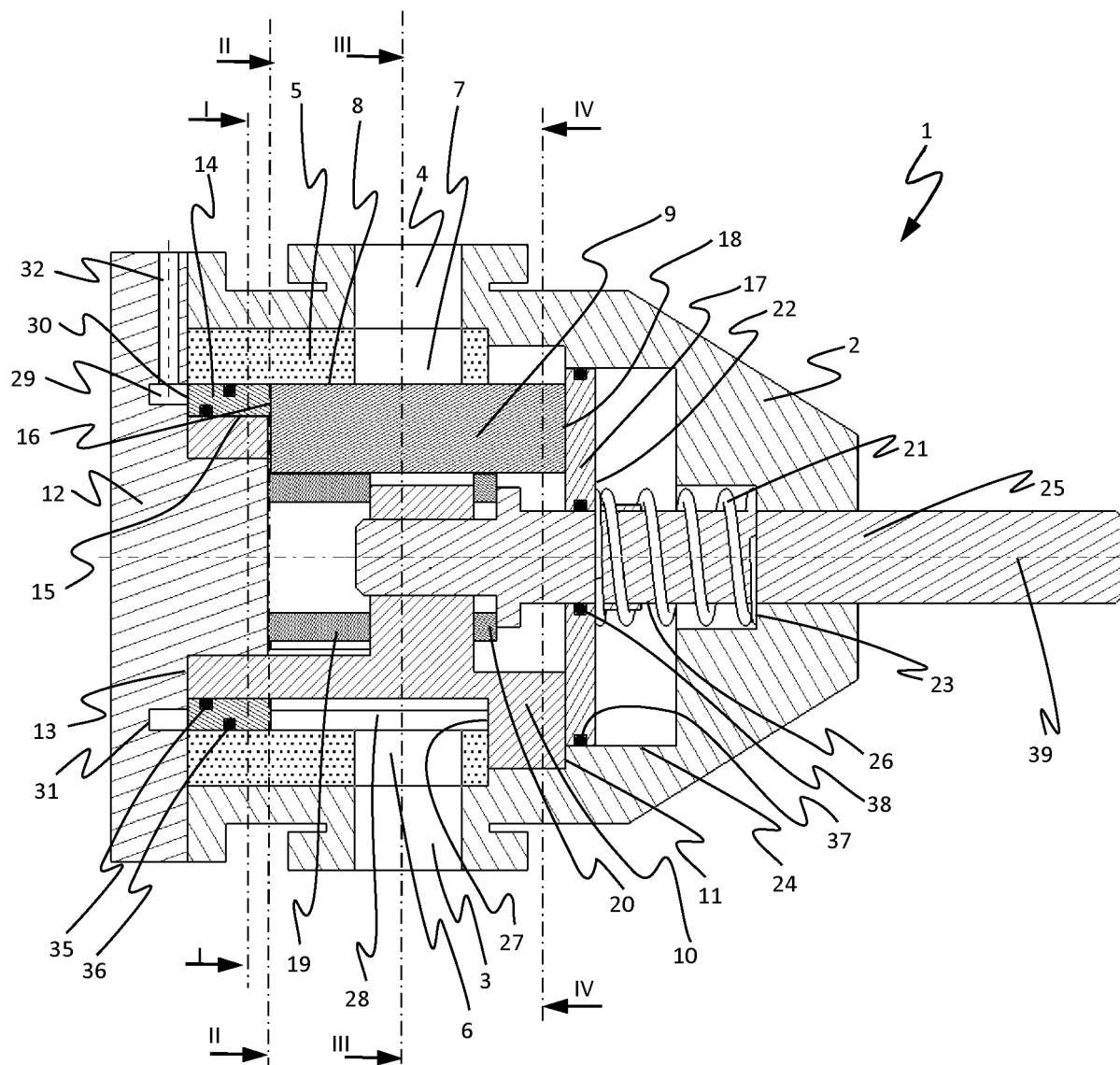


Fig. 1

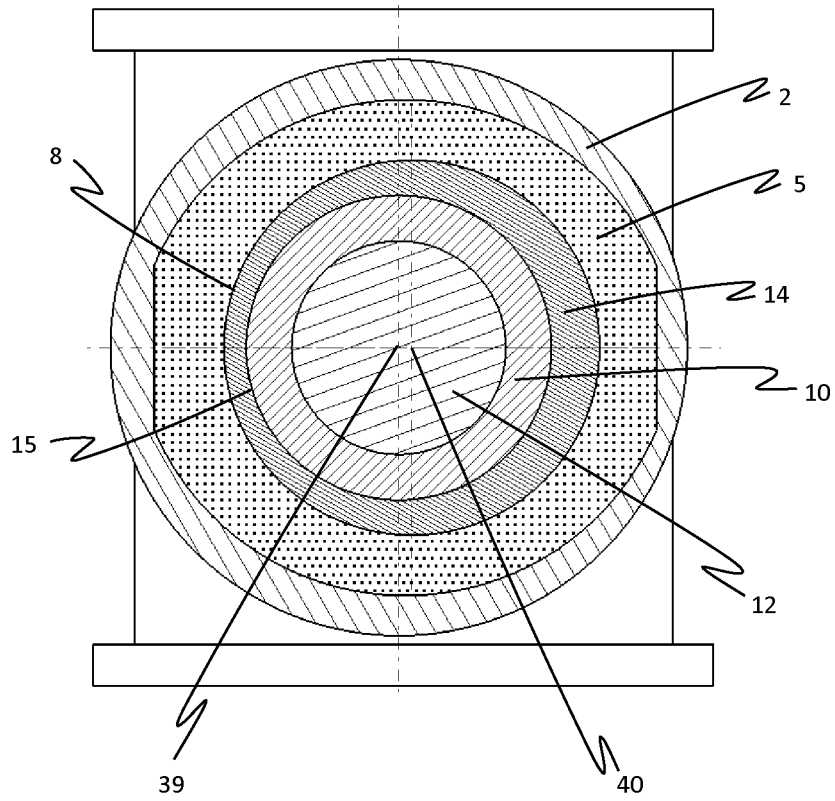


Fig. 2

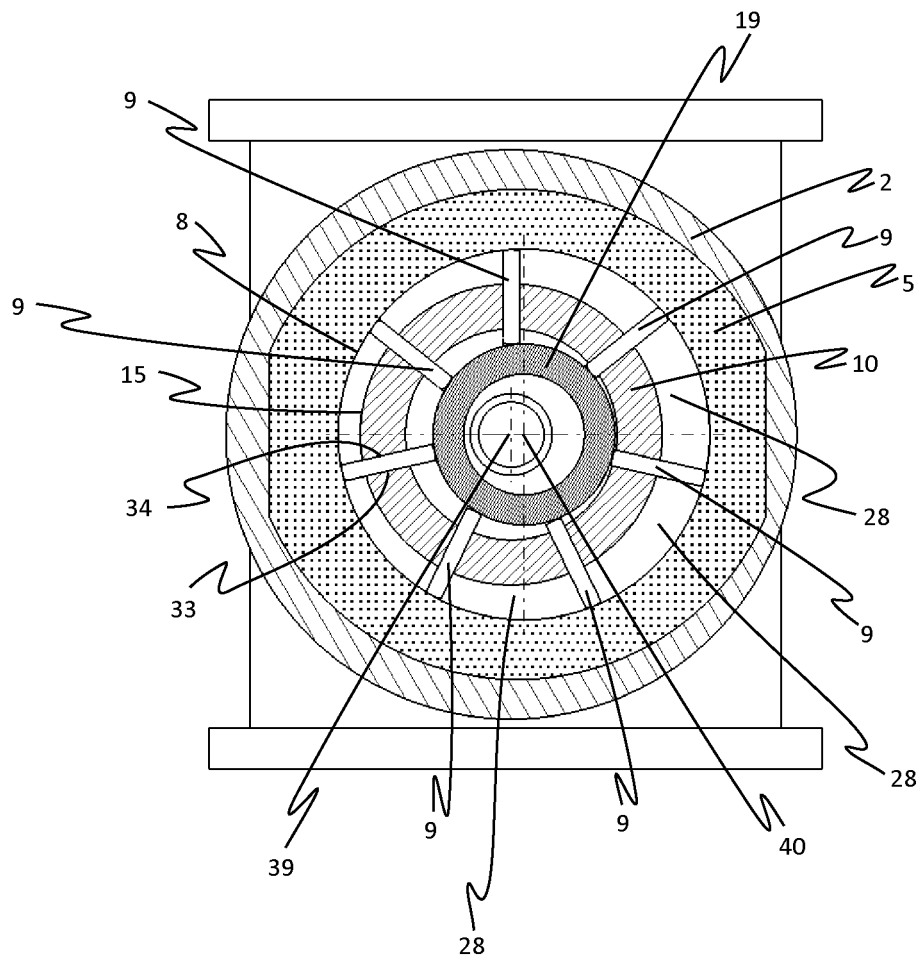


Fig. 3

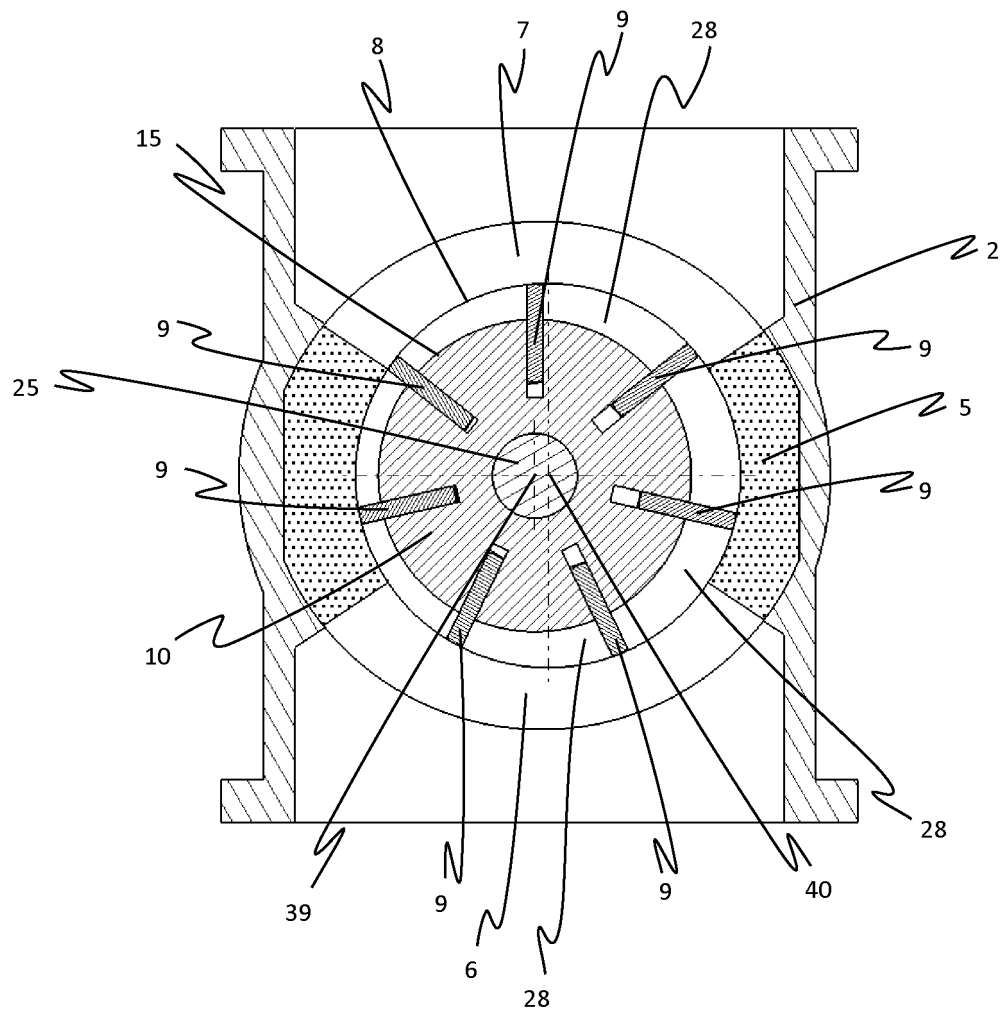


Fig. 4

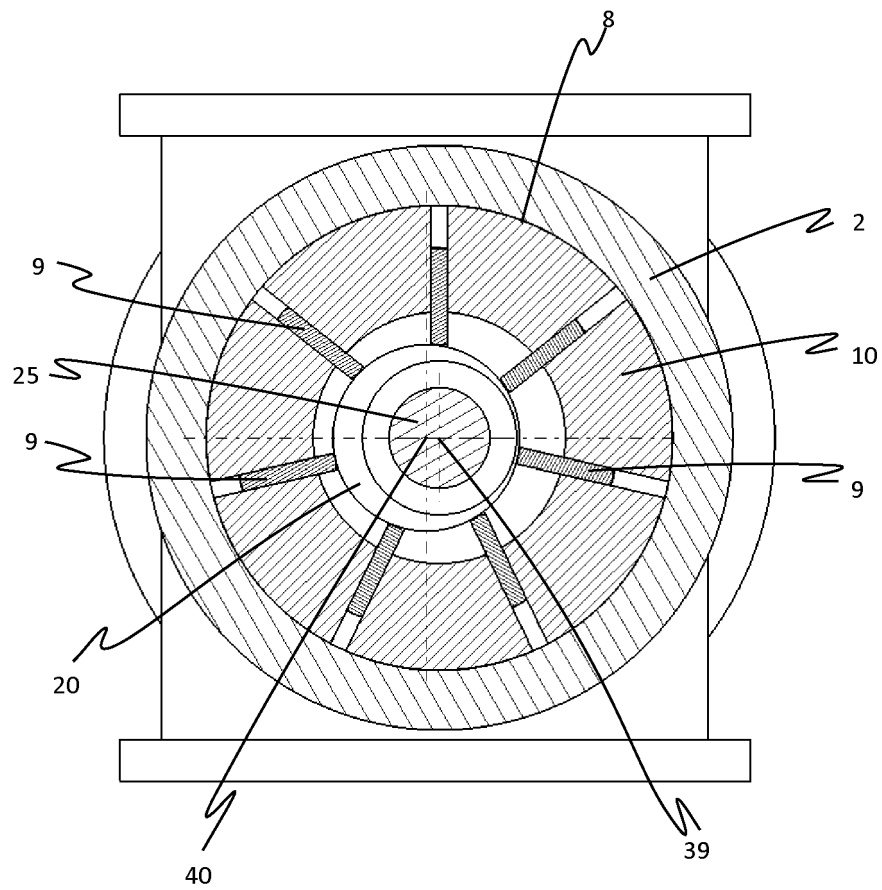


Fig. 5

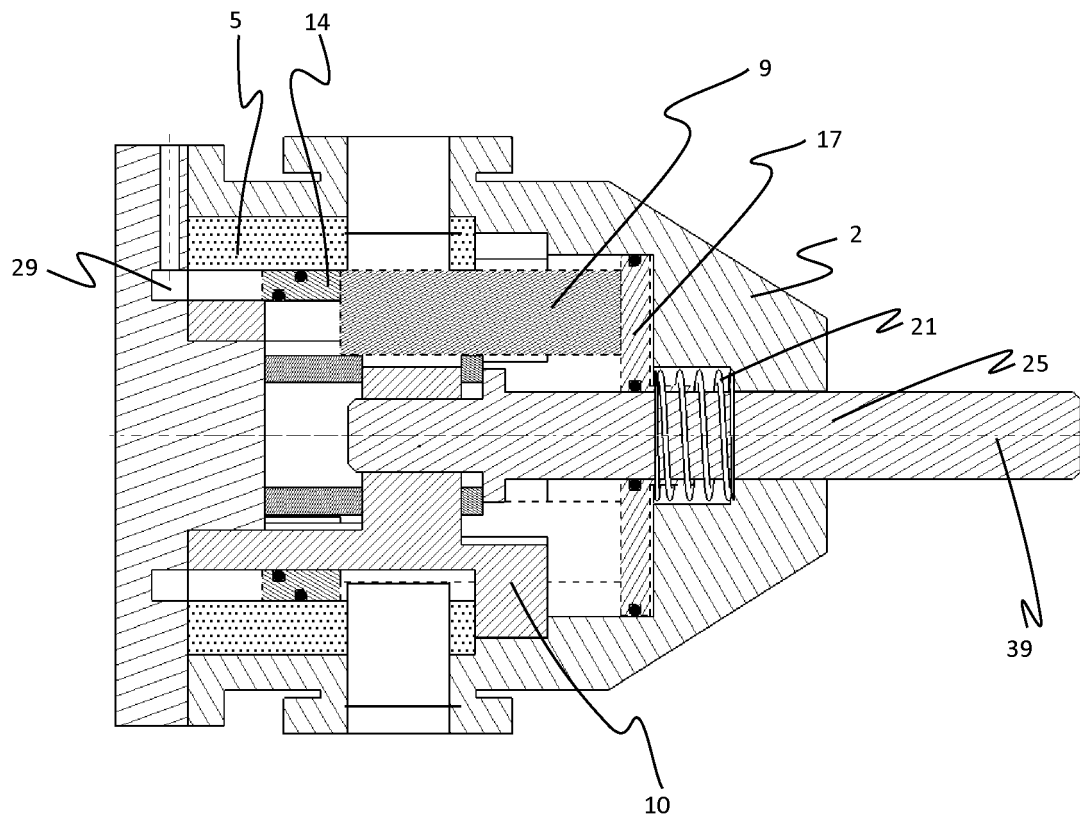


Fig. 6

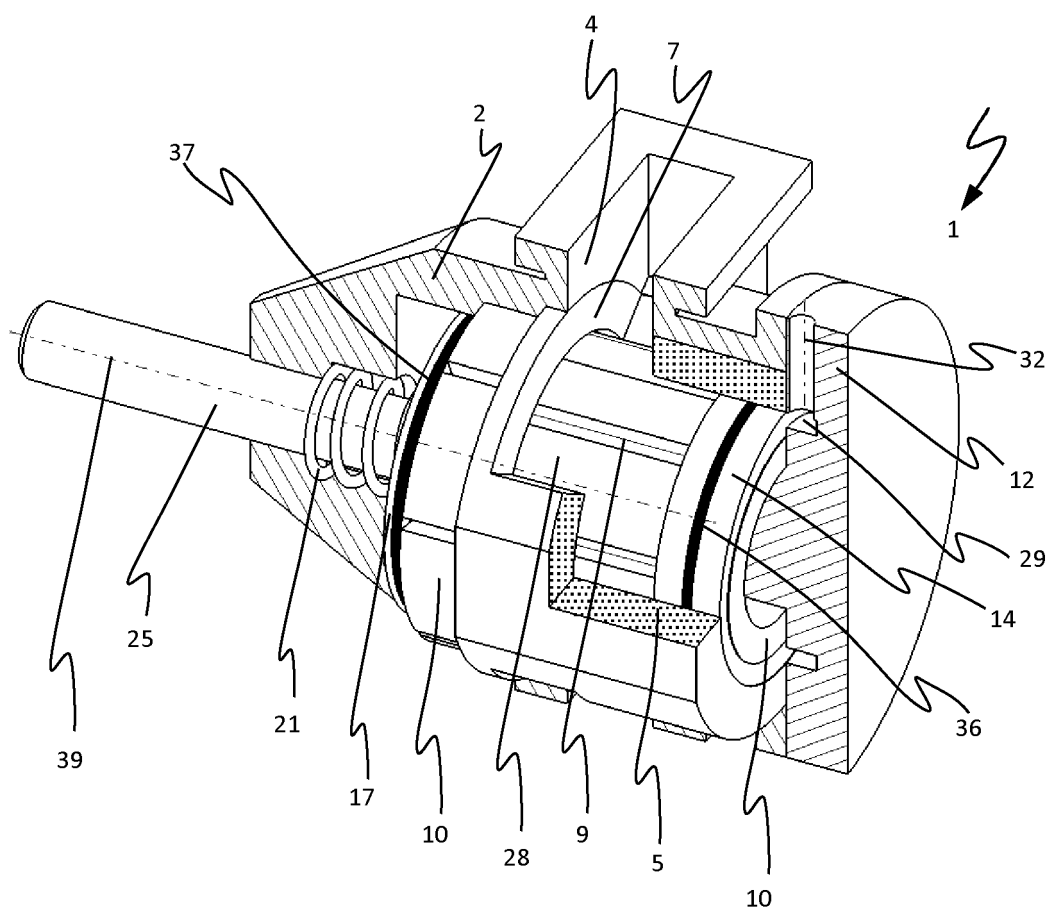


Fig. 7

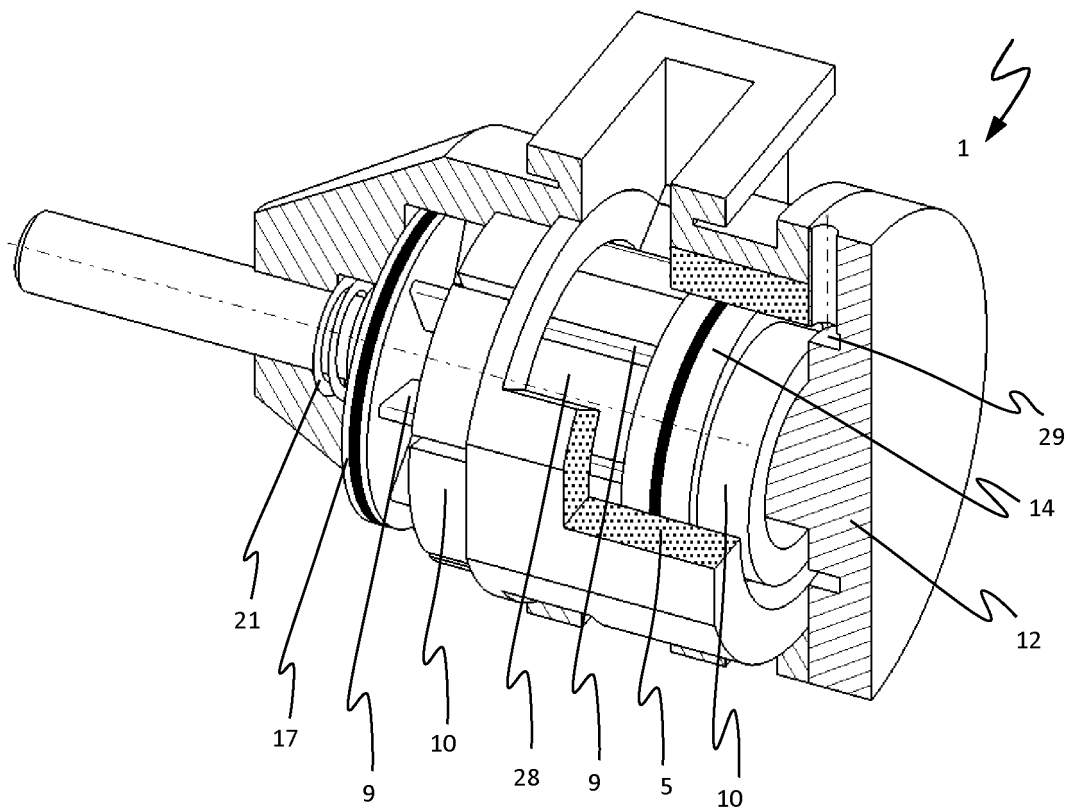


Fig. 8

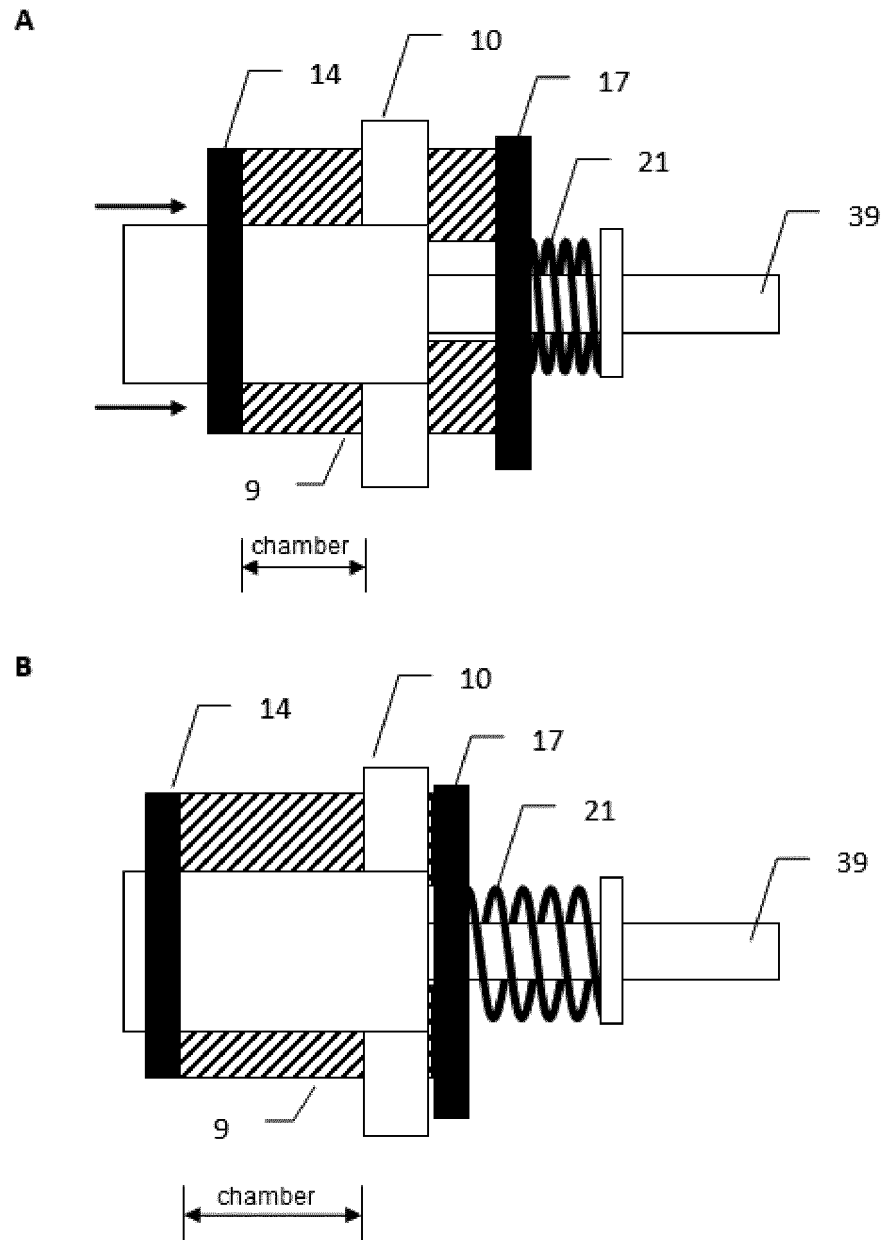


Fig. 9

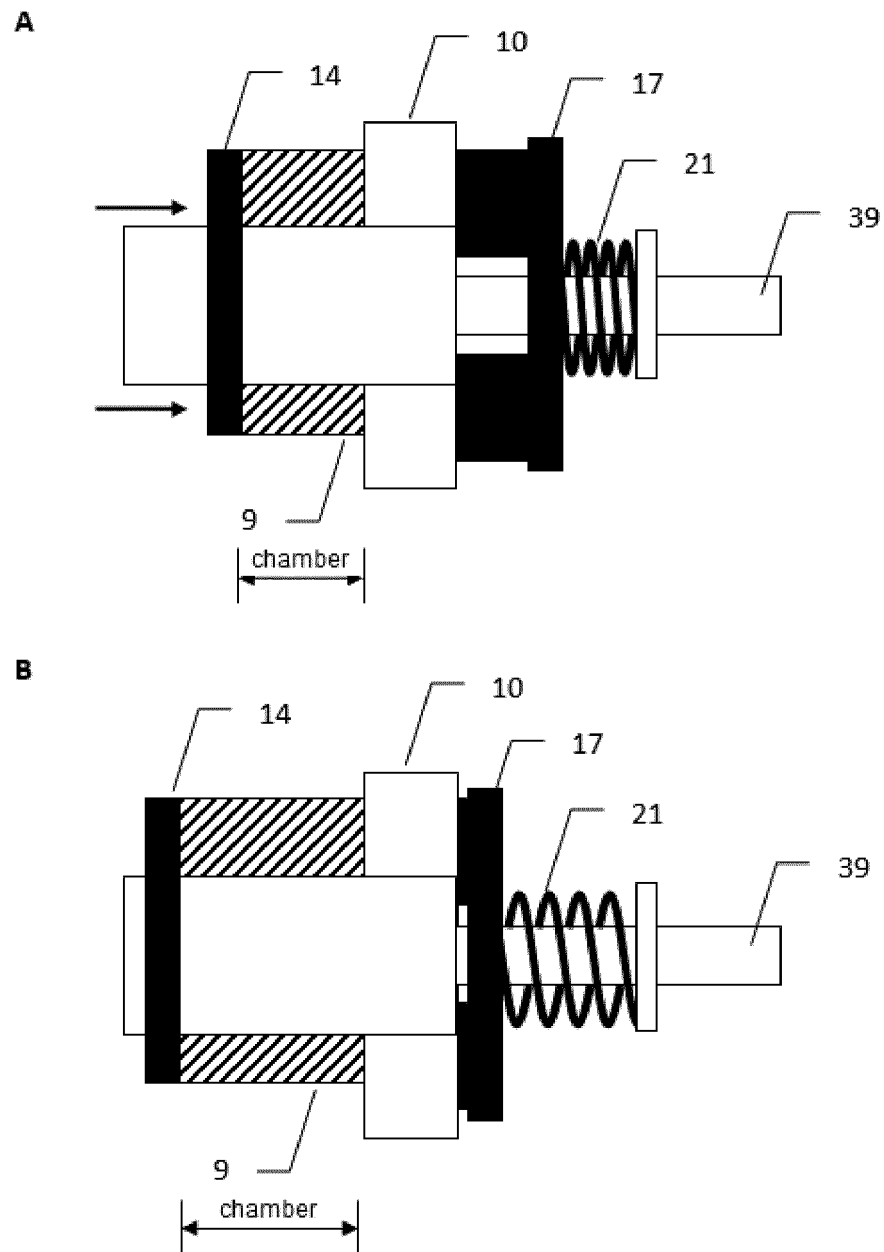


Fig. 10

INTERNATIONAL SEARCH REPORT

International application No

PCT/IB2016/057678

A. CLASSIFICATION OF SUBJECT MATTER

INV. F04C2/344 F04C14/18
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

F04C F01C

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	DE 20 61 385 A1 (HESS, PAUL [DE]) 15 June 1972 (1972-06-15) the whole document figure 3 page 1, paragraph 2 page 4, paragraph 2 page 7, paragraph 2 - page 8, paragraph 2 -----	1-16
X	DE 43 04 208 C1 (DAIMLER BENZ AG [DE]) 7 April 1994 (1994-04-07) the whole document figure 1 column 3, line 32 - line 53 -----	1-16

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents :

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"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

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Date of the actual completion of the international search

7 March 2017

Date of mailing of the international search report

17/03/2017

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Authorized officer

Sbresny, Heiko

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/IB2016/057678

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Form PCT/ISA/210 (patent family annex) (April 2005)

REFERENCES CITED IN THE DESCRIPTION

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