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(54) VARIABLE DISPLACEMENT PUMP AND METHOD FOR REGULATING THE DISPLACEMENT OF THE PUMP

VERSTELLPUMPE UND VERFAHREN ZUR REGELUNG DER VERDRÄNGUNG DER PUMPE

POMPE À CYLINDRÉE VARIABLE ET PROCÉDÉ POUR RÉGULER LA CYLINDRÉE DE LA POMPE

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EP 3 087 276 B1

Description

Technical field

[0001] The present invention relates to variable displacement pumps, and more particularly it concerns a pump with improved means for opposing the displacement regulation, and a method of regulating the displacement of such a pump.

[0002] Preferably, but not exclusively, the invention is applied in a pump for the lubrication oil of the engine and/or the drive system of a motor vehicle, and particular reference will be made to such a preferred application in the description below.

Prior art

[0003] It is known that, in pumps for making lubricating oil under pressure circulate in engines and/or drive systems in motor vehicles, the capacity, and hence the oil delivery rate, depends on the rotation speed of the engine. Hence, the pumps are designed so as to provide a sufficient delivery rate at low speeds, in order to ensure lubrication also under such conditions. If the pump has fixed geometry, at high rotation speed the delivery rate exceeds the necessary rate, whereby high power absorption, with a consequently higher fuel consumption, and a higher stress of the components occur due to the high pressures generated in the circuit.

[0004] In order to obviate this drawback, it is known to provide the pumps with systems allowing a delivery rate regulation at the different operating conditions of the vehicle, in particular through a displacement regulation.

[0005] The solutions for displacement regulation are specific for the particular type of pumping elements (vanes, external or internal gears, pistons...), but an element common to all solutions is the provision of movable regulation members driven by the pressure of the pumped fluid and of members, generally springs, opposing the movement of the regulation members and having the function of:

- ensuring that the pump is kept in the maximum displacement condition when starting and under low speed conditions;
- enabling a quick return of the pump to the maximum displacement during vehicle deceleration and/or when the operating conditions of the engine change.

[0006] Considering by way of example only a rotary pump with vanes, a very frequent solution is based on the variation of the relative position between an external regulation ring, also referred to as "stator ring", within which the rotor eccentrically rotates, and the rotor itself.

[0007] In particular, the rotor rotates about an axis internal to the ring itself and parallel to the axis of rotation of the ring.

[0008] As known, in such pumps the amount of rotation is a function of the eccentricity between the centre of rotation of the ring and the centre of the pressure chamber, and the force applied by the spring is inversely proportional to the overall amplitude of the rotation angle. This relation usually demands a low rigidity of the spring with a relatively important stroke and hence it entails the need to guide the spring. An example is disclosed in WO 2013/140304, which shows a spring guided on a tappet coupled with the ring by means of a spherical joint. This creates problems of frictions on both the joints and the guide tappets, which frictions result in a discrete variation of the stroke/force characteristic between the spring compression and decompression phases, and consequently of the characteristic of the displacement/pressure regulation for which the spring is designed, since the variation of the spring characteristic gives rise to a non-linear variation of the torque applied to the stator.

[0009] Similar considerations can be made for variable displacement pumps of other kinds, where regulation is obtained through an oscillatory movement of the movable member. The term "oscillatory movement" is used herein to denote a rotation by a given angle about an axis with can be internal or external to the movable member.

Description of the invention

[0010] It is an object of the present invention to provide a variable displacement pump as defined by appended claim 1, obviating the drawbacks of the prior art.

[0011] Springs without a guide are often used in motor vehicle suspensions, as disclosed for instance in EP 2062754 or EP 2466167. The springs employed in suspensions perform a limited oscillatory movement about an axis and, moreover, in the average, they have proportions and/or size about 10 times greater than the springs used in a pump for the lubricating oil and have to bear much heavier loads. Therefore, in such springs, the above mentioned problems do not occur and hence the teaching of those documents does not provide hints useful for attaining the invention.

[0012] The invention also concerns a method of regulating the displacement of a variable displacement pump for fluids, as defined by appended claim 7.

Brief description of the Figures

[0013] The above and other features and advantages of the invention will become apparent from the following description of preferred embodiments, made by way of non limiting example with reference to the accompanying drawings, in which:

- Fig. 1 is a plan view of a pump according to the invention, without the closing cover and in the maximum displacement condition;
- Fig. 2 is a view similar to Fig. 1, showing the pump in the minimum displacement condition;
- Fig. 3 shows the opposing spring in the maximum

and minimum displacement conditions; and

- Figs. 4 and 5 are simplified diagrams showing the opposing force and its arm in the maximum and minimum displacement conditions.

Description of preferred embodiments

[0014] The Figures show, by way of example only, a variable displacement rotary pump with vanes, the general structure of which is as disclosed in WO 2013/140304. Thus, that structure will be described here only to the extent necessary for the understanding of the invention and, for further details, reference is to be made to that document.

[0015] Referring to Figs. 1 and 2, a pump 1 of the above kind comprises a body (schematised by dotted-and-dashed line 10), having a cavity within which regulation ring 11 (hereinafter also referred to simply as stator) is mounted so as to be freely rotatable along an arc of circumference about an axis 18 internal to the stator itself. Stator 11 has a chamber 12 accommodating rotor 13, keyed on a shaft 14 parallel to the rotation axis of stator 11. In the Figures, it is assumed that the rotor rotates in counterclockwise direction. As known to the skilled in the art, the rotation of stator 11 causes a variation of the relative eccentricity between stator 11 and rotor 13, and hence a variation of the displacement, between a condition of maximum eccentricity and displacement (Fig. 1), which is taken also in rest conditions of the pump, and a condition of minimum eccentricity and displacement (Fig. 2). Between stator 11 and body 10 there is formed a chamber 15 balancing the radial thrusts exerted on stator 11 because of the hydraulic pressure acting on the arc of the wall of chamber 12 corresponding to the balancing chamber. Balancing chamber 15 is defined by gaskets 16, 17 and it communicates with the devices utilising the pumped fluid, in particular with the lubrication circuit of the engine or the drive system of a motor vehicle.

[0016] Stator 11 is configured as a multistage rotary piston for displacement regulation, directly driven by pressurised fluid coming for instance from the devices utilising the pumped fluid (for instance, from a point of the lubrication circuit located downstream the oil filter). In the illustrated embodiment, the rotary piston has a pair of actuation stages (or surfaces) formed by portions 19, 20 of the external surface of stator 11. Said stages are exposed to the action of the pressurised fluid introduced into chambers 21, 22, where portions of the stator surface adjacent to actuation surfaces 19, 20 move in fluid-tight manner. Reference numerals 33, 34 denote ducts through which the regulation pressures act on stages 19, 20. Possible further stages can be formed in lightening chambers formed in stator 11, as disclosed in WO 2013/140304.

[0017] In the illustrated example, stages 19, 20 are formed so that the pressure applied to stage 19 generates a force F1 in turn arranged to generate a torque causing stator rotation towards the minimum displacement position against the action of an opposing member 23 (in particular a helical spring), and so that the pressure applied to stage 20 generates a force F2 generating an antagonistic torque concordant with the torque generated by a force F3 due to the reaction of spring 23. For the sake of easiness of description, the torques generated by F1, F2, F3 will also be referred to hereinafter as torque 1, torque 2 and torque 3.

[0018] Spring 23 is preloaded so as to prevent the rotation of stator 11 - and hence to keep it in the position shown in Fig. 1 - as long as the resultant of the pressures applied to stages 19, 20 is lower than a predetermined threshold, and to subsequently keep the pump displacement at the value corresponding to the pressure threshold. Such a condition is attained when an equilibrium is established between torques 1, 2 and 3.

[0019] Spring 23 has a longitudinal axis 28 (Fig. 3) which does not cross rotation axis 18 of stator 11, and is located in a seat 24 formed in body 10. Its end loops 23A, 23B, suitably arranged close to one another and preferably tapered, abut against flat end surface 24A of seat 24 and on a flat portion 25 of the external surface of stator 11, respectively.

[0020] Planes 24A, 25 have formed thereon centring projections 26, 27 engaging end loops 23A, 23B of spring 23. Such projections are aimed at maintaining end loops 23A, 23B univocally positioned and at preventing the spring from "sliding" over planes 24A, 25 because of the radial and/or axial components of the applied forces, should the friction coefficients of the materials of spring 23, body 10 and stator 11 allow such a sliding. In place of the projections, also recesses surrounding loops 23A, 23B might be provided, or a projection might be provided on one side and a recess on the other side. The projections or the recesses may even have non-circular shape.

[0021] In the configuration shown by way of example, planes 24A, 25 are formed so that they are mutually parallel when the displacement is minimum, and so that they define a certain angle under all other conditions, said angle being maximum in the maximum displacement condition. Spring 23 will have therefore a minimum (substantially zero) deformation and a substantially rectilinear axis in the minimum displacement condition, and will attain the maximum deformation in the maximum displacement condition. Advantageously, in the deformed condition, the behaviour of the spring axis can be defined by a polynomial of third degree.

[0022] The conditions of maximum and minimum deformation of spring 23 are also shown in Fig. 3.

[0023] It will be appreciated that centring elements 26, 27 are the only elements retaining spring 23 and that, since they cooperate only with the end loops, they have no guiding function. The remaining portion of the spring therefore can freely deform itself during the rotation of stator 11. In this way, force vector F3 applied to plane 25 at the centre of element 27 creates a non-linear countermotive torque since, as clearly shown in Figs. 4 and 5, the force and its application arm b3 (distance from rota-

tion axis 18 of stator 11) change as stator 11 is rotates. In particular, in the maximum displacement condition (Fig. 4), force F3 is the resultant of the components of the whole of the radial and tangential forces acting on plane 25 and has smaller intensity and arm than in the minimum displacement condition (Fig. 5), where the vector is perpendicular to plane 25.

[0024] Such conditions are gradually attained, without any friction due to the spring.

[0025] The counter-reaction to the forces generated by spring 23 in turn is discharged at the centre of centring element 26 (Figs. 1, 2), orthogonally to plane 24A.

[0026] It is to be taken into account that, in order spring 23 correctly operates, it is necessary to prevent unwanted side "drifts" making the spring strike against the axial sides of seat 24. In other words, the deformation must be such that, in the deformed condition, the curve described by the axis remains in a plane transversal to axis 28. The tests carried out have shown that the angle between the planes must be in the range from about 10° to about 30°, and preferably of the order of 20°. Also the diameter of the wire cooperates to the definition of such a ratio.

[0027] Provided that such general indications are to be met, for a given application the characteristics of spring 23 will depend on the pump displacement, on the difference between the maximum and the minimum displacement, on the regulating pressure, and, in case of a rotary pump, on the driving geometry of rotor 13.

[0028] It is clear that the above description is given only by way of non-limiting example and that changes and modifications are possible without departing from the scope of the invention.

[0029] For instance, even if a configuration has been shown in which axis 28 of spring 23 is linear in the minimum displacement condition of pump 1 and attains the maximum deformation in the maximum displacement condition, both the reverse arrangement and configurations in which axis 28 always has a certain deformation are also possible.

[0030] Moreover, even if there has been disclosed in detail a pump where displacement regulation is performed through a rotation of the stator about an axis internal to the stator itself and said rotation is directly driven by the pressure of the pumped fluid, the invention can be applied also to pumps where the rotation of the stator is indirectly driven by said pressure, or to pumps where the displacement regulation movement is different from the rotation illustrated here (so-called "pendulum" pumps, pumps with a rocking or oscillating stator, and so on). Moreover, even if a vane pump has been illustrated, the invention can be applied also to pumps with a rotor of different kind, e.g. a gear rotor (for instance G-rotor or split G-rotor) as well as to non-rotary pumps, for instance pumps with pistons actuated by a rotating plate with variable inclination.

Claims

1. A variable displacement pump for fluids, comprising:

- a movable regulation ring (11) arranged to perform, as operating conditions of the pump (1) vary, a rotational movement about a rotation axis (18) between two extreme positions corresponding to a maximum displacement and a minimum displacement of the pump (1), respectively;
- a helical spring (23) opposing the movement of the regulation ring (11), wherein
- the rotation axis (18) is internal to the movable regulation ring (11), **characterised in that**
- the helical spring (23) has opposite end loops (23A, 23B) arranged to cooperate with centring and transversally retaining projections or recesses (26, 27) associated with said movable regulation ring (11) and with a body (10) of the pump (1), respectively, said opposite end loops (23A, 23B) resting on planes (24A, 25) forming an angle of about 10° to about 30° in a condition of maximum deformation of the helical spring (23), **in that**
- the helical spring (23) has an intermediate portion freely deformable during said movement, and **in that**
- the helical spring (23) is built and mounted so that:

  - a longitudinal axis thereof (28) does not cross said rotation axis (18) and, in a deformed condition of said helical spring (23), forms a curve lying on a plane perpendicular to the rotation axis (18).

2. The pump as claimed in claim 1, **characterised in that** said curve lying on a plane perpendicular to the rotation axis (18) can be expressed as a polynomial of third degree.

3. The pump as claimed in any one of preceding claims, **characterised in that** the opposite end loops (23A, 23B) of the helical spring (23) rest on planes (24A, 25) forming an angle of about 20°, in a condition of maximum deformation of the helical springs (23).

4. The pump as claimed in any one of preceding claims, **characterised in that** said planes (24A, 25) are parallel in one extreme position and form the angle corresponding to the maximum deformation in the other extreme position.

5. The pump as claimed in any one of preceding claims, **characterised in that** the centring projections (26, 27) engage the end loops (23A, 23B) of the ring (23), or the centring recesses receive said end loops (23A,

23B), or a projection engages one end loop and a recess receives the other end loop.

6. The pump as claimed in any one of preceding claims, **characterised in that** the pump (1) is a pump for a lubrication circuit of an engine and/or a drive system of a motor vehicle.

7. A method of regulating the displacement of a variable displacement pump for fluids, comprising the steps of:

- making a movable regulation ring (11) move, as operating conditions of the pump (1) vary, according to a rotational movement about an axis internal to the movable regulation ring (11), between two extreme positions corresponding to a maximum displacement and a minimum displacement of the pump (1), respectively;
- opposing the movement of the regulation ring (11) by means of a helical spring (23) having opposite end loops (23A, 23B) resting on the movable regulation ring (11) and a pump body (10), respectively;

wherein the step of opposing the movement of the movable regulation ring (11) by means of the helical spring (23) comprises the steps of:

- mounting the helical spring (23) so that it is transversally retained only at its end loops (23A, 23B) which rest on planes (24A, 25) forming an angle of about 10° to about 30° in a condition of maximum deformation of the helical spring (23), and so that a longitudinal axis thereof (28) does not cross said rotation axis (18); and
- during the movement of the movable regulation ring (11), making an intermediate portion of the helical spring (23) deform so that, in deformed condition, the longitudinal axis (28) forms a curve lying on a plane perpendicular to the rotation axis (18).

8. The method as claimed in claim 7, **characterised in that** the step of mounting the helical spring (23) comprises making its opposite end loops (23A, 23B) rest on planes (24A, 25) forming an angle of about 20°, in a condition of maximum deformation of the opposing members (23).

9. The method as claimed in claim 7 or 8, **characterised in that** said planes (24A, 25) are parallel in one extreme position and form the angle corresponding to the maximum deformation in the other extreme position.

Patentansprüche

1. Verstellpumpe für Fluide, umfassend:

- einen bewegbaren Regelungsring (11), der so angeordnet ist, dass er, während sich Betriebszustände der Pumpe (1) ändern, eine Drehbewegung um eine Drehachse (18) zwischen zwei Endlagen durchführt, die einer maximalen Verdrängung beziehungsweise einer minimalen Verdrängung der Pumpe (1) entsprechen,
- eine Schraubenfeder (23), die der Bewegung des Regelungsrings (11) entgegenwirkt, wobei
- die Drehachse (18) innerhalb des bewegbaren Regelungsrings (11) liegt, **dadurch gekennzeichnet, dass**
- die Schraubenfeder (23) sich gegenüberliegende Endwindungen (23A, 23B) aufweist, die so angeordnet sind, dass sie mit zentrierenden und quer haltenden Vorsprüngen oder Ausnehmungen (26, 27) zusammenwirken, die mit dem bewegbaren Regelungsring (11) beziehungsweise mit einem Körper (10) der Pumpe (1) verbunden sind, wobei die sich gegenüberliegenden Endwindungen (23A, 23B) auf Ebenen (24A, 25) ruhen, die in einem Zustand der maximalen Verformung der Schraubenfeder (23) einen Winkel von ca. 10° bis ca. 30° bilden, dass
- die Schraubenfeder (23) einen Zwischenabschnitt aufweist, der während der Bewegung frei verformbar ist, und dass
- die Schraubenfeder (23) so gebaut und befestigt ist, dass:

  - eine Längsachse (28) derselben die Drehachse (18) nicht kreuzt und in einem verformten Zustand der Schraubenfeder (23) eine Kurve bildet, die auf einer rechtwinklig zu der Drehachse (18) verlaufenden Ebene liegt.

2. Pumpe nach Anspruch 1, **dadurch gekennzeichnet, dass** die Kurve, die auf einer rechtwinklig zu der Drehachse (18) verlaufenden Ebene liegt, als ein Polynom dritten Grades ausgedrückt werden kann.

3. Pumpe nach einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass** die sich gegenüberliegenden Endwindungen (23A, 23B) der Schraubenfeder (23) auf Ebenen (24A, 25) ruhen, die in einem Zustand der maximalen Verformung der Schraubenfedern (23) einen Winkel von ca. 20° bilden.

4. Pumpe nach einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass** die Ebenen (24A, 25) in einer Endlage parallel verlaufen und in der

anderen Endlage den der maximalen Verformung entsprechenden Winkel bilden.

5. Pumpe nach einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass** die zentrierenden Vorsprünge (26, 27) mit den Endwindungen (23A, 23B) des Rings (23) eingreifen oder die zentrierenden Ausnehmungen die Endwindungen (23A, 23B) aufnehmen oder ein Vorsprung mit einer Endwindung eingreift und eine Ausnehmung die andere Endwindung aufnimmt.

6. Pumpe nach einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass** die Pumpe (1) eine Pumpe für einen Schmierkreis eines Motors und/oder ein Antriebssystem eines Kraftfahrzeugs ist.

7. Verfahren zur Regelung der Verdrängung einer Verstellpumpe für Fluide, umfassend die folgenden Schritte:

- Bewirken, dass sich ein bewegbarer Regelungsring (11), während sich Betriebszustände der Pumpe (1) ändern, gemäß einer Drehbewegung um eine innerhalb des bewegbaren Regelungsrings (11) liegende Achse zwischen zwei Endlagen bewegt, die einer maximalen Verdrängung beziehungsweise einer minimalen Verdrängung der Pumpe (1) entsprechen,
- Entgegenwirken gegen die Bewegung des Regelungsrings (11) mit Hilfe einer Schraubenfeder (23), die sich gegenüberliegende Endwindungen (23A, 23B) aufweist, die auf dem bewegbaren Regelungsring (11) beziehungsweise einem Pumpenkörper (10) ruhen,

wobei der Schritt des Entgegenwirkens gegen die Bewegung des bewegbaren Regelungsrings (11) mit Hilfe der Schraubenfeder (23) die folgenden Schritte umfasst:

- Befestigen der Schraubenfeder (23) so, dass sie nur an ihren Endwindungen (23A, 23B), die auf Ebenen (24A, 25) ruhen, die in einem Zustand der maximalen Verformung der Schraubenfeder (23) einen Winkel von ca. 10° bis ca. 30° bilden, quer gehalten wird, und so, dass eine Längsachse (28) derselben die Drehachse (18) nicht kreuzt, und
- während der Bewegung des bewegbaren Regelungsrings (11) Bewirken, dass sich ein Zwischenabschnitt der Schraubenfeder (23) so verformt, dass in einem verformten Zustand die Längsachse (28) eine Kurve bildet, die auf einer Ebene liegt, die rechtwinklig zu der Drehachse (18) verläuft.

8. Verfahren nach Anspruch 7, **dadurch gekennzeichnet, dass** der Schritt des Befestigens der Schraubenfeder (23) das Bewirken umfasst, dass ihre sich gegenüberliegenden Endwindungen (23A, 23B) auf Ebenen ruhen (24A, 25), die in einem Zustand der maximalen Verformung der sich gegenüberliegenden Elemente (23) einen Winkel von ca. 20° bilden.

9. Verfahren nach Anspruch 7 oder 8, **dadurch gekennzeichnet, dass** die Ebenen (24A, 25) in einer Endlage parallel verlaufen und in der anderen Endlage den der maximalen Verformung entsprechenden Winkel bilden.

Revendications

1. Pompe à cylindrée variable pour fluides, comprenant

- une couronne de régulation mobile (11) agencée pour effectuer, lorsque les états de fonctionnement de la pompe (1) varient, un mouvement rotatif autour d'un axe de rotation (18) entre deux positions extrêmes correspondant à une cylindrée maximale et une cylindrée minimale de la pompe (1), respectivement ;
- un ressort hélicoïdal (23) s'opposant au mouvement de la couronne de régulation (11), dans laquelle
- l'axe de rotation (18) est interne à la couronne de régulation mobile (11), **caractérisée en ce que**
- le ressort hélicoïdal (23) comporte des spires d'extrémité opposées (23A, 23B) agencées pour coopérer avec des saillies ou évidements (26, 27) de centrage et de retenue transversale associés à ladite couronne de régulation mobile (11) et à un corps (10) de la pompe (1), respectivement, lesdites spires d'extrémité opposées (23A, 23B) reposant sur des plans (24A, 25) formant un angle d'environ 10° à environ 30° dans un état de déformation maximale du ressort hélicoïdal (23), **en ce que**
- le ressort hélicoïdal (23) comporte une partie intermédiaire déformable librement pendant ledit mouvement, et **en ce que**
- le ressort hélicoïdal (23) est construit et monté de telle sorte que :

- son axe longitudinal (28) ne croise pas ledit axe de rotation (18) et, dans un état déformé dudit ressort hélicoïdal (23), forme une courbe située sur un plan perpendiculaire à l'axe de rotation (18).

2. Pompe selon la revendication 1, **caractérisée en ce que** ladite courbe située sur un plan perpendiculaire

à l'axe de rotation (18) peut être exprimée comme un polynôme de troisième degré.

3. Pompe selon l'une quelconque des revendications précédentes, **caractérisée en ce que** les spires d'extrémité opposées (23A, 23B) du ressort hélicoïdal (23) reposent sur des plans (24A, 25) formant un angle d'environ 20°, dans un état de déformation maximale du ressort hélicoïdal (23).

4. Pompe selon l'une quelconque des revendications précédentes, **caractérisée en ce que** lesdits plans (24A, 25) sont parallèles dans une position extrême et forment l'angle correspondant à la déformation maximale dans l'autre position extrême.

5. Pompe selon l'une quelconque des revendications précédentes, **caractérisée en ce que** les saillies de centrage (26, 27) viennent en prise avec les spires d'extrémité (23A, 23B) de la couronne (23), ou les évidements de centrage reçoivent lesdites spires d'extrémité (23A, 23B), ou une saillie vient en prise avec une spire d'extrémité et un évidement reçoit l'autre spire d'extrémité.

6. Pompe selon l'une quelconque des revendications précédentes, **caractérisée en ce que** la pompe (1) est une pompe pour un circuit de lubrification d'un moteur et/ou d'un système d'entraînement d'un véhicule à moteur.

7. Procédé de régulation de la cylindrée d'une pompe à cylindrée variable pour fluides, comprenant les étapes :

- d'amenée d'une couronne de régulation mobile (11) à se déplacer, lorsque les états de fonctionnement de la pompe (1) varient, suivant un mouvement rotatif autour d'un axe interne à la couronne de régulation mobile (11), entre deux positions extrêmes correspondant à une cylindrée maximale et une cylindrée minimale de la pompe (1), respectivement ;
- d'opposition au mouvement de la couronne de régulation (11) au moyen d'un ressort hélicoïdal (23) comportant des spires d'extrémité opposées (23A, 23B) reposant sur la couronne de régulation mobile (11) et un corps de pompe (10), respectivement ;

dans lequel l'étape d'opposition au mouvement de la couronne de régulation mobile (11) au moyen du ressort hélicoïdal (23) comprend les étapes :

- de montage du ressort hélicoïdal (23) de telle sorte qu'il est retenu transversalement seulement au niveau de ses spires d'extrémité opposées (23A, 23B) qui reposent sur des plans (24A, 25) formant un angle d'environ 10° à environ 30° dans un état de déformation maximale du ressort hélicoïdal (23), et de telle sorte que son axe longitudinal (28) ne croise pas ledit axe de rotation (18) ; et
- pendant le mouvement de la couronne de régulation mobile (11), d'amenée d'une partie intermédiaire du ressort hélicoïdal (23) à se déformer de telle sorte que, dans l'état déformé, l'axe longitudinal (28) forme une courbe située sur un plan perpendiculaire à l'axe de rotation (18).

8. Procédé selon la revendication 7, **caractérisé en ce que** l'étape de montage du ressort hélicoïdal (23) comprend l'amenée de ses spires d'extrémité opposées (23A, 23B) à reposer sur des plans (24A, 25) formant un angle d'environ 20°, dans un état de déformation maximale des organes opposés (23).

9. Procédé selon la revendication 7 ou 8, **caractérisé en ce que** lesdits plans (24A, 25) sont parallèles dans une position extrême et forment l'angle correspondant à la déformation maximale dans l'autre position extrême.

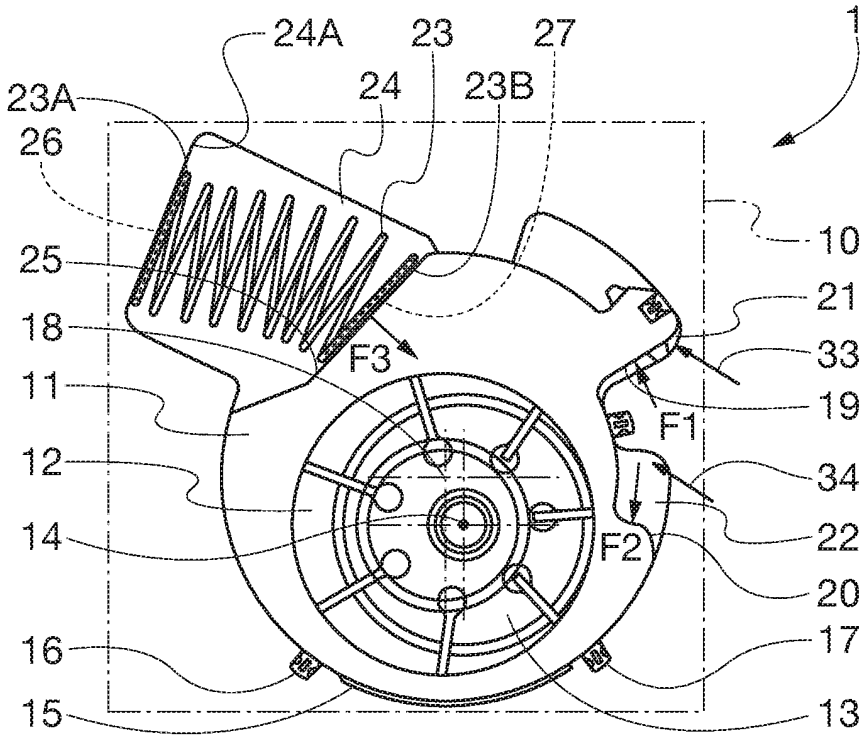

1
24A
23
27
24
23B
23A
26
10
25
21
18
F3
33
11
19
F1
12
34
F2
14
22
20
16
17
15
13

Fig. 1

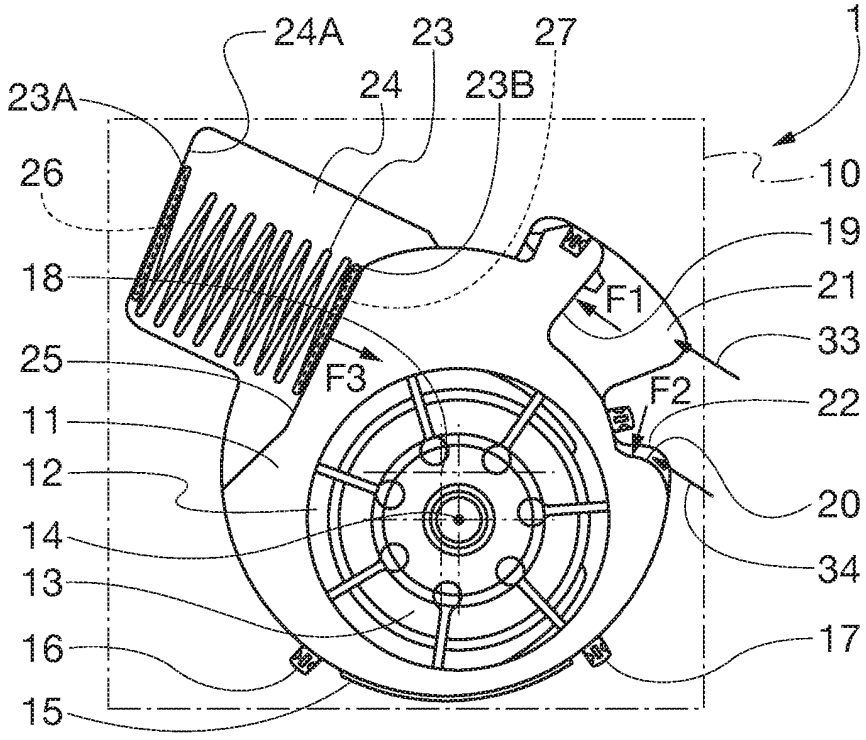

1
24A
23
27
24
23B
23A
26
10
19
18
F1
21
33
25
F3
F2
22
11
12
20
14
34
13
16
17
15

Fig. 2

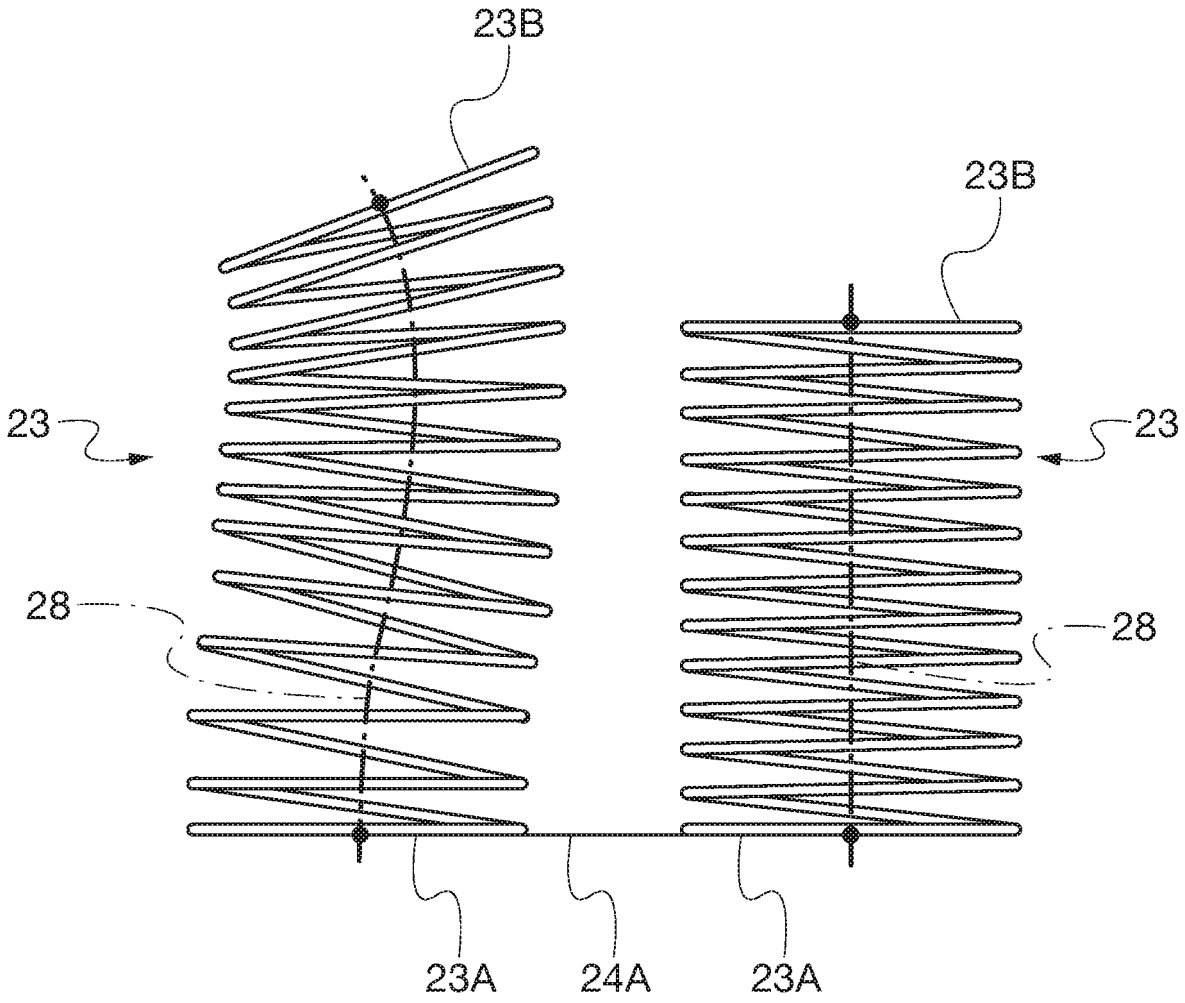


Fig. 3

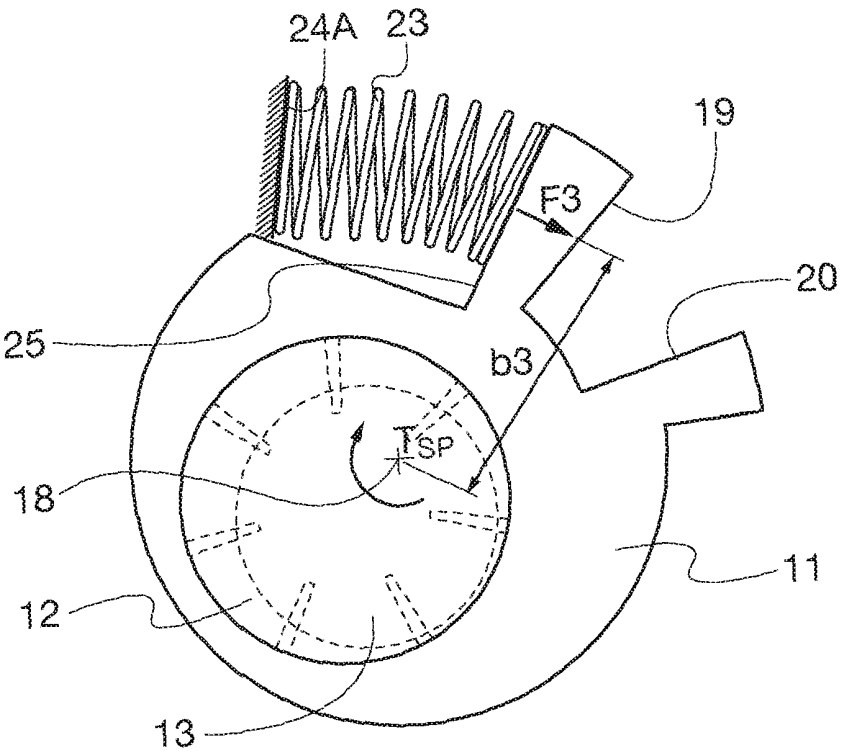

24A
23
19
F3
20
25
b3
T_{SP}
18
11
12
13

Fig. 4

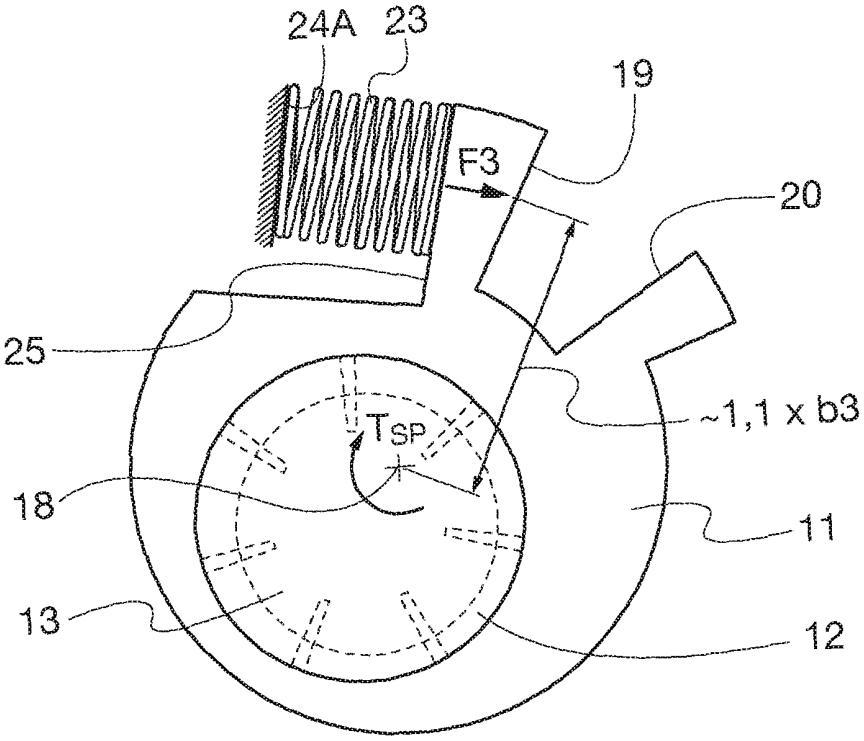

24A
23
19
F3
20
25
~1,1 x b3
T_{SP}
18
11
13
12

Fig. 5

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

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