(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 3 279 477 A1

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
07.02.2018 Bulletin 2018/06

(51) Int Cl.:
F04C 2/344 (2006.01) ***F04C 14/22*** (2006.01)

(21) Application number: **17184197.6**

(22) Date of filing: **01.08.2017**

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
MA MD

(30) Priority: **04.08.2016 IT 201600082659**

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(54) A POSITIVE DISPLACEMENT PUMP WITH A BLADE ROTOR

(57) A positive displacement pump with variable displacement comprising:
- a blade rotor (2);
- a stator (3) comprising a collar (30) internally of which the rotor (2) can rotate.

The collar (30) defines at least a first channel (4) which contributes to an introduction of fluid between the rotor (2) and the stator (3). The first channel (4) reduces an axial thickness of the collar (30) in a zone in which it is fashioned.

The first channel (4) directs the fluid so as to reduce a misalignment with a second flow of fluid which is short-circuited by the rotor (2). When displacing from a radially more external position (991) towards a radially more internal position (992), the first channel (4) defines a ramp (99). The ramp (99) reduces the depth of the first channel (4), the depth being measured parallel to the rotation axis (20).

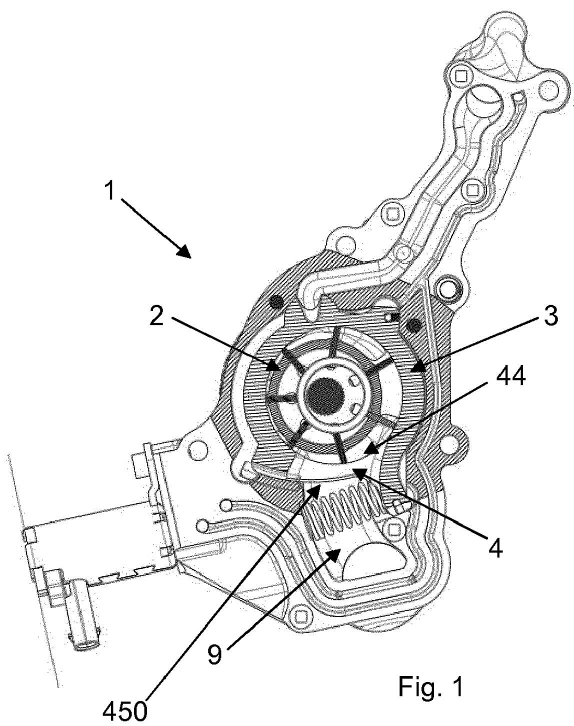

Fig. 1

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Description

[0001] The present invention relates to a positive displacement pump with a blade rotor. The pump is preferably but not necessarily used for lubricating motors.

[0002] Positive displacement pumps with blade rotors comprise a rotor provided with radial slots in which the blades are positioned.

[0003] The pump further comprises an aspirating conduit, a fluid delivery conduit and a stator internally of which the rotor rotates. The rotor is arranged eccentrically with respect to the stator. During use the blades are pushed against the stator.

[0004] In the technical sector, the space interposed between two blades is usually defined the "compartment". The compartment rotates together with the rotor. When the compartment is placed in communication with the aspirating conduit it increases its own volume; when the compartment is placed in communication with the delivery conduit the compartment reduces its own volume, forcing the fluid to exit from the stator.

[0005] In a first known, design version, the stator comprises an annular collar which identifies a chamber housing the rotor. This chamber is delimited not only by the external collar but also by two opposite walls in which an inlet mouth and an outlet mouth of the liquid are fashioned.

[0006] With the aim of increasing the processed fluid flow rate, the collar can comprise, in proximity of the inlet mouth, a channel which facilitates introduction of the fluid. This channel, where present, reduces the axial thickness of the collar of the stator.

[0007] The interaction between the aspirated fluid in the stator after having passed through said channel and the short-circuited fluid already present in the stator generates turbulence, undesired vortices, disturbances in the local distribution of the pressure. All of the above also causes cavitation problems at high speed.

[0008] US2011/189043 and EP2351934 disclose known vane pumps.

[0009] In this context, the technical task on which the present invention is based is to provide a positive displacement pump with a blade rotor which enables increasing the quantity of fluid that can be introduced internally of the stator while at the same time optimising the fluid-dynamics. A further object of the present invention, strictly related to the preceding object, is to improve the cavitation behaviour of the pump and the fluid-dynamic performance thereof.

[0010] A further object of the present invention is to reduce noise levels.

[0011] The stated technical task and specified objects are substantially achieved by a positive displacement pump with a blade rotor comprising the technical features disclosed in one or more of the appended claims. Further characteristics and advantages of the present invention will become more apparent from the following indicative, and hence nonlimiting, description of a preferred, but not exclusive, embodiment of a positive displacement pump with a blade rotor as illustrated in the appended drawings, in which:

- figures 1 and 2 are views with some parts in section of a pump according to the present invention;
- figure 3 is an enlargement of figure 1;
- figures 4-6 illustrate a component of the pump of figure 3 from various angles;
- figure 7 illustrates the operation of a pump according to the preceding figures;
- figures 8-10 illustrate a component of the pump of figures 4-6 from various angles;
- figures 11 and 12 illustrate two views in section of a pump according to the present invention;
- figure 13 is a plan view of a component of the pump according to the present invention;
- figure 14 or 15 illustrates the pathway of the fluid internally of a part of the pump.

[0012] In the accompanying figures, reference numeral 1 denotes a variable-volume positive displacement pump which interacts with a fluid (a liquid), for example lubricating oil.

[0013] It comprises a blade rotor 2. The rotor 2 can rotate about a rotation axis 20. The rotor 2 comprises a plurality of slots 33 each housing one of said blades 32. Typically the slots 33 extend radially.

[0014] The pump 1 further comprises a stator 3. The stator 3 comprises a collar 30 internally of which the rotor 2 can rotate. The collar 30 is also known in the technical sector as the external ring. The collar 30 surrounds the rotor 2, in particular surrounds the rotation axis 20.

[0015] The stator 3 defines a housing chamber 34 of the rotor 2. The chamber 34 is advantageously cylindrical. The pump 1 comprises a first and a second plane 311, 312 (see for example figure 11) which are transversal to the rotation axis 20 and which occlude the chamber 34, together with the collar 30.

[0016] The rotor 2 and the stator 3 are eccentric.

[0017] The stator 3 and a rotation axis 20 of the rotor 2 are mobile with respect to one another so as to vary the volume of the pump 1. In other words the position of an axis of cylindrical symmetry of the chamber 34 can be varied relative to the position of the rotation axis 20 of the rotor 2. The rotation axis 20 preferably remains fixed and the position of the stator 3 is modified. In order to modify the volume, the stator 3 can advantageously rotate about a hinged zone or can translate.

[0018] The stator 3 (collar 30) defines at least a first channel 4 which contributes to an introduction of fluid between the rotor 2 and the stator 3. The first channel 4 is a dip or a groove.

[0019] The first channel 4, in a zone in which it is fashioned, reduces an axial thickness of the collar 30 (the axial thickness of the collar is assessed axially, i.e. parallel to the rotation axis 20). The pump 1 appropriately comprises a supply conduit 9 of the fluid which opens into the chamber 34. The supply conduit 9 opens into the chamber 34 at least through an aspirating opening 90 afforded in the first plane 311. The first channel 4 faces and is located at said aspirating opening 90.

[0020] The supply conduit 9 comprises a deflector 900 which generates a first and a second lane 901, 902 for the fluid current. The first and second lane 901, 902 diverge from one another. Along the outflow direction, the first and/or the second lane 901, 902 have a reduction of the transversal crossing section.

[0021] In this matter, observe not only figures 11-13 but also figures 14 and 15, which however illustrate the compartment 905 that the fluid can occupy during the displacement thereof along the conduit 9 and not the outside of the conduit 9. This deflector 900 is a narrowing member of the conduit 9, which functions as a distributor of the fluid along the first and the second lane 901, 902, facilitating the entrance of the fluid to the chamber 34.

[0022] The aspirating opening 90 extends between a first and a second end 903, 904 (see for example figure 13); the first and the second end 903, 904 determine the phasing of the pump 1.

[0023] The first end 903 faces a circumferential portion of the rotor 2 which is more downstream than the circumferential portion faced by the second end 904 (in this case upstream and downstream are calculated with respect to the rotation direction of the rotor 2). The first lane 901 terminates at the first end 903 of the aspirating opening 90; the second lane 902 terminates at the second end 904 of the aspirating opening 90. The first lane 901 has a larger passage section with respect to the second lane 902 (see for example figure 13). In fact the first lane 901 reduces the misalignment of the fluid with the fluid present in the chamber 34. In other words, the first lane 901 increases a component of the fluid motion which is orientated towards the rotation direction of the rotor 2. In particular the component of motion of the fluid perpendicular to a radial direction (or in equivalent terms tangential to an internal circumference of the chamber 34 and coaxial to the rotation axis 20) increases.

[0024] The second lane 902 enables not altering the phasing of the pump 1 and directing the smallest possible quantity of fluid into the volume.

[0025] The supply conduit 9 is profiled so as to eliminate or in any case minimise the presence of live edges. This is so as to most effectively guide the fluid, reducing fluid-dynamic losses and therefore the possibility of incurring cavitation phenomena.

[0026] The first channel 4 advantageously directs the fluid so as to reduce a misalignment between a first flow of the fluid which comes from said first channel 4 and a second flow of fluid which intercepts the first flow and transits, drawn by the rotor 2, between the first channel 4 and the rotor 2. The second flow is the short-circuited fluid already present in the stator 3. For example in figure 7 the first flow of fluid is denoted by reference letter "a" and the second flow of fluid is denoted by reference letter "b".

[0027] In other words the first channel 4 increases the fluid component orientated in the rotation direction of the rotor 2 (in particular the tangential component perpendicular to the radial direction).

[0028] The first channel 4 comprises a first and a second wall 41, 42 which are reciprocally facing. There is advantageously at least a straight segment which connects the first and the second wall 41, 42 without intercepting the rotor 2. The fact that the first and the second wall 41, 42 are facing one another is important as it means that the distance between the first and the second wall 41, 42 is limited; this enables appropriately guiding and directing the fluid (if the distance between the first and the second wall 41, 42 were excessive the first channel 4 would not succeed in effectively channelling the fluid in the desired direction).

[0029] The first channel 4 comprises a base surface 43 for connecting the first and the second wall 41, 42. In the version illustrated in figures 4-7, the first and the second wall 41, 42 are connected without live edges to the base surface 43. In the version illustrated in figures 8-10, on the other hand, a live edge is present between the base surface 43 and the first wall 41; likewise a live edge is present between the base surface 43 and the second wall 42.

[0030] The collar 30 comprises an annular surface 31 which faces and surrounds the rotor 2. The minimum distance between the first and the second wall 41, 42 measured along the annular surface 31 is less than 1/3 of the minimum length of a line which, lying entirely on the annular surface 31, surrounds the rotor 2. In particular, the minimum distance between the first and the second wall 41, 42 measured along a circumference defined by the annular surface 31 is less than 1/3 of the circumference.

[0031] The blades 32 are advantageously radially interposed between a centring ring 5 and the annular surface 31. The centring ring 5 limits the maximum insertion of the blades 32 in the slots 33. The centring ring 5 advantageously remains coaxial to the annular surface 31 as it is in contact with the radially more internal part of the blades 32.

[0032] As shown by way of example in figures 1-7 the second wall 42 can be connected to the annular surface 31. The second wall 42 and the annular surface 31 are advantageously tangential at a common join zone 91 (indicated for example in figure 3).

[0033] The version given by way of example in figures 8-10 is the fruit of fluid-dynamic simulations made using dedicated software.

[0034] In general the annular surface 31 extends along a circle. The first channel 4 defines an outlet mouth 44 of the fluid in a zone interposed between the rotor 2 and the stator 3. The mouth 44 is preferably subtended by two planes 93, 94 which between them form an angle of less than 100 ° (see for example figures 5 and 9). The intersection between the two planes 93, 94 lies along a straight line that:

- is parallel to the rotation axis 20;
- passes through a centre of said circle.

[0035] The fact that the outlet mouth 44 involves a limited portion of a circumferential extension of the collar 30 enables directing the operating fluid into a predetermined zone.

[0036] When displacing from a radially more external position 991 towards a radially more internal position 992, the first channel 4 advantageously comprises a ramp 99. The ramp 99 reduces the depth of the first channel 4 (the depth is measured parallel to the rotation axis 20).

[0037] The depth of the first channel 4, measured parallel to the rotation axis 20 is on average smaller at the outlet mouth 44 than at the radially more external opening 450. The above-described specifications enable guiding the fluid and causing it to converge into the desired position.

[0038] In particular, with reference to the version given by way of example in figures 8-10, the depth of the first channel 4 (measured parallel to the rotation axis 20 of the rotor 2) is nil or in any case tends to 0 at the annular surface 31. In this case the extension of the annular surface 31 able to face the end of the blades 32 is increased, thus increasing the volumetric performance, the fluid-dynamic performance and the pump 1 performance. As it moves from a radially more external point to a radially more internal point, the depth of the first channel 4 is progressively reduced. In particular, in this version the base surface 43, when displacing from a radially more external position towards a radially more internal position, progressively reduces the depth of the first channel 4. This advantageously occurs over the whole radial extension of the first channel 4. Further, in figure 10 line 95 indicates a change of slope.

[0039] With reference to the various illustrated versions, the axial thickness of the collar 30 progressively increases as it passes from the first to the second wall 41, 42. In particular, the axial thickness of the collar 30 at the base surface 43 progressively increases as it passes from the first to the second wall 41, 42. This also enables better guiding of the fluid, directing it as schematically indicated in figure 7.

[0040] As shown in the appended drawings the first channel 4 crosses the collar 30 between a radially more external opening 450 and the radially more internal outlet mouth 44. The radially more external opening 450 comprises a guide entry 451 for inlet of the fluid. It is advantageously fashioned along a perimeter edge of the opening 450. This guide entry 451 further facilitates the inlet of the fluid. In the version given by way of example in figures 1-7, the guide entry 451 comprises a convexity. In particular the guide entry 451 comprises an arched bevel.

[0041] The collar 30 develops in thickness in a radial direction. The thickness of the collar 30 is not constant along the first channel 4. As for example illustrated by way of example in figure 5, the thickness is smaller in a predetermined section interposed between the first and the second wall 41, 42. The thickness progressively increases as it displaces towards the first and the second wall 41, 42.

[0042] The collar 30 comprises a first and a second face 301, 302 which are at least in part parallel to one another and between which the annular surface 31 facing and surrounding the rotor 2 extends. The first and second wall 301, 302 are preferably flat.

[0043] The first channel 4 crosses the collar 30 radially. In the version of figures 1-7 the outlet mouth 44 is defined by an opening afforded on the annular surface 31. In the version of figures 8-10, the depth of the first channel 4 tends to nil at the annular surface 31.

[0044] In general however the first channel 4, starting from the first face 301, projects towards the inside of the collar 30, reducing the axial thickness thereof in that portion (note that as mentioned in the foregoing the axial thickness of the collar, as indicated in the foregoing, should be measured axially i.e. parallel to the rotation axis 20).

[0045] Advantageously the first and the second wall 41, 42 are reciprocally asymmetric. In the version of figures 8-10, a terminal portion, radially more internal, of the first and the second wall 41, 42, are reciprocally convergent.

[0046] In the following reference is made to the embodiment of figures 1-7. In this case the first wall 41, between the radially more external opening 450 and the outlet mouth 44, extends along a first straight direction 410. The second wall 42, between the radially more external opening 450 and the outlet mouth 44, extends along an arched line.

[0047] Moving from the radially more external opening 450 towards the outlet mouth 44, the first wall 41 and a terminal portion of the second wall 42 diverge.

[0048] Let us define an imaginary intersecting line between:

- a prolongation 460 of the first wall 41 along the first straight direction 410;
- a plane 461 tangential to the intersection between the second wall 42 and the annular surface 31. The imaginary intersecting line is external of the stator 3 (in figure 5 the prolongation 460 and the plane 461 are illustrated and it can be observed that they are destined to intercept one another reciprocally externally of the stator 3).

[0049] A particular application of the present pump 1 is linked to the lubrication of internal combustion engines of vehicles.

[0050] The collar 30 advantageously comprises a second channel 6 which contributes to an introduction of fluid between the rotor 2 and the stator 3. The first and second channel 4, 6 are advantageously reciprocally symmetrical. This symmetry is observed with respect to an intermediate plane perpendicular to the rotation axis 20 of the rotor 2. The second channel 6 involves only a part of the collar 30 and, where present, reduces the axial thickness of the collar 30 (as previously explained the axial thickness of the collar 30 should be measured parallel to the direction of the rotation axis 20).

[0051] The second channel 6 directs the fluid so as to reduce a misalignment between the first flow of the fluid and the second flow of fluid, already defined in the foregoing, (i.e. a flow that transits in the stator 3 in front of the first channel 4 and is drawn by the rotor 2).

[0052] The second channel 6 advantageously comprises two lateral walls 96, 97 and a connecting surface 98 of the two lateral walls 96, 97. While radially displacing from a more external position to a more internal position, the base surface 43 of the first channel 4 and the connecting surface 98 of the second channel 6 are reciprocally divergent.

[0053] One or more of the characteristics described in the foregoing with reference to the first channel 4 can be repeated with reference to the second channel 6 The collar 30 advantageously externally defines a leading edge which separates the fluid flow and guides it towards the first and second channel 4, 6. In the maximum volume condition almost all the fluid aspirated by the pump 1 transits through the first and second channel 4, 6. Moving away from the optimal condition of maximum volume increases the quantity of fluid that might also by-pass the first and second channel 4, 6.This specification enables further reducing fluid-dynamic losses by better guiding the fluid; this is also reflected in better pump behaviour with regard to cavitation.

[0054] The stator 3 illustrated in the version of figures 1-7 is advantageously typically made of a metal material. The stator of figures 8-10 has a shape such that it might also be made of a plastic material.

[0055] The object of the present invention is therefore a system comprising:

- an internal combustion engine for vehicles;
- a lubricating system of the motor comprising a positive displacement pump having one or more of the characteristics described in the foregoing. During use the non-compressible fluid is introduced via the supply conduit 9 between the rotor 2 and the stator 3. The fluid flows into the chamber 34, transiting via the first channel 4 (and via the second channel 6, if present). The first and the second channel 4, 6 direct the fluid so as to reduce a misalignment with a fluid current already present in the stator 3.

[0056] The invention thus conceived makes it possible to achieve multiple advantages.

[0057] It consists in optimising the shape of the stator, enabling obtaining a better volumetric performance and a lower risk of cavitation (i.e. it enables greater rotation velocities of the rotor before encountering cavitation phenomena). This is obtained by studying the profiles of the stator in order to minimise the "dead zones" in which the fluid re-circulates.

[0058] Tests carried out by the Applicant have evidenced a 4% improvement in fluid-dynamic performance of the pump and a reduction in the noise levels if compared to pumps having conventional design and lacking in the claimed specifications.

[0059] In the particular sector of the automobile industry the pump of the present invention can be used for lubricating internal combustion engines, enabling a reduction in emissions and preventing power losses. The ever-greater attention to this area of problems (especially, but not only, in the automotive sector) in recent years has led to analysing and optimising all pump components.

[0060] The invention as it is conceived is susceptible to numerous modifications, all falling within the scope of the inventive concept characterising it. Further, all the details can be replaced with other technically-equivalent elements. In practice, all the materials used, as well as the dimensions, can be any according to requirements.

Claims

1. A positive displacement pump with variable displacement comprising:

   - a blade rotor (2);
   - a stator (3) comprising a collar (30) internally of which the rotor (2) can rotate; the stator (3) and a rotation axis (20) of the rotor (2) being movable with respect to one another so as to vary the volume of the pump (1);

   the collar (30) defining at least a first channel (4) for enabling or contributing to an introduction of fluid between the rotor (2) and the stator (3); the first channel (4) reducing an axial thickness of the collar (30) in a zone in which it is fashioned;
   characterised in that
   when displacing from a radially more external position (991) towards a radially more internal position (992), the first channel (4) defines a ramp (99) which reduces the depth of the first channel (4), said depth being measured parallel to the rotation axis (20).

2. The pump according to claim 1, **characterised in that** the first channel (4) radially crosses the collar (30) between a radially more external opening (450) and a radially more internal outlet mouth (44).

3. The pump according to claim 2, **characterised in that** the depth of the first channel (4), measured parallel to the rotation axis (20) is on average smaller at the outlet mouth (44) than at the radially more external opening (450).

4. The pump according to claim 2 or 3, **characterised**

in that said radially more external opening (450) comprises a guide entry (451) for inlet of the fluid.

5. The pump according to claim 4, **characterised in that** the guide entry (451) comprises a connection which defines a convexity that develops along a perimeter edge of the radially more external opening (450).

6. The pump according to any one of the preceding claims, **characterised in that** the first channel (4) comprises a first and a second wall (41, 42) which are reciprocally facing.

7. The pump according to claim 6, **characterised in that** the collar (30) comprises an annular surface (31) which faces and surrounds the rotor (2); the minimum distance between the first and the second wall (41, 42) measured along the annular surface (31) is less than 1/3 of the minimum length of a line which, lying entirely on the annular surface (31), surrounds the rotor (2).

8. The pump according to claim 7, **characterised in that** the second wall (42) is arched and tangentially connected to said annular surface (31).

9. The pump according to claim 7 or 8, **characterised in that** the depth of the first channel (4), measured parallel to the rotation axis (20) is nil at the annular surface (31).

10. The pump according to any one of claims from 6 to 9, **characterised in that** the first and the second wall (41, 42) are reciprocally asymmetric.

11. The pump according to any one of claims from 6 to 10, **characterised in that** it comprises a base surface (43) which connects the first and the second surface (41, 42); the axial thickness of the collar (30) at the base surface (43) progressively increasing as it passes from the first to the second wall (41, 42).

12. The pump according to any one of claims from 5 to 10, **characterised in that** the first channel (4) comprises a base surface (43) for connecting the first and the second wall (41, 42); said pump (1) comprising a second channel (6) in turn comprising two lateral walls (96, 97) and a connecting surface (98) of the two lateral walls (96, 97); radially displacing from a more external position to a more internal position, the base surface (43) of the first channel (4) and the connecting surface (98) of the second channel (6) being reciprocally divergent and enacting a directing of the fluid.

13. The pump according to any one of the preceding claims, **characterised in that** the stator (3) defines a housing chamber (34) of the rotor (2); the stator (3) comprising a first and a second plane (311, 312) which are transversal to the rotation axis (20) and which occlude the chamber (34), together with the collar (30), the pump (1) comprising a supply conduit (9) of the fluid which opens into the chamber (34); the supply conduit (9) opening into the chamber (34) through an aspirating opening (90) afforded in the first plane (311); the first channel (4) facing and being located at said aspirating opening (90).

14. The pump according to claim 13, **characterised in that** the supply conduit (9) comprises a deflector (900) which generates at sides thereof a first and a second lane (901, 902) for the fluid current, the first and the second lane (901, 902) being divergent from one another; the aspirating opening (90) extending between a first and a second end (903, 904); the first end (903) facing a circumferential portion of the rotor (2) which is more downstream, with respect to the rotation direction of the rotor (2), than the circumferential portion faced by the second end (904); the first lane (901) terminating at the first end (903) of the aspirating opening (90); the second lane (902) terminating at the second end (904) of the aspirating opening (90); the first lane (901) having a larger passage section with respect to the second lane (902); the first lane (901) increasing a component of the fluid motion transiting through the conduit (9) which is orientated towards the rotation direction of the rotor (2).

15. The pump according to any of the preceding claims, **characterised in that** the first channel (4) directs the fluid for increasing the fluid component orientated in the rotation direction of the rotor (2) so as to reduce a misalignment between the first flow of the fluid which comes from said first channel (4) and a second flow of fluid which: intercepts the first flow, transits in front of the first channel (4) and is drawn by the rotor (2).

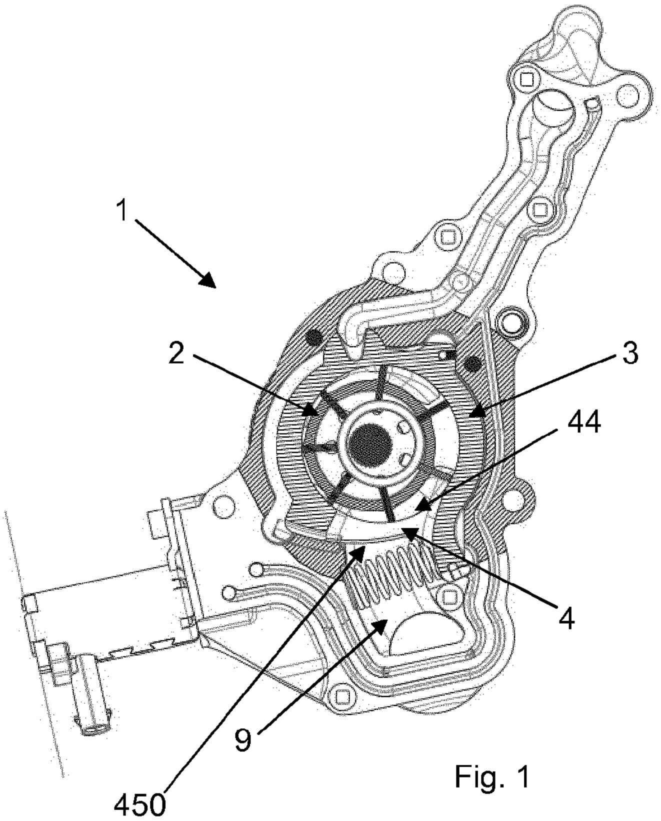


Fig. 1

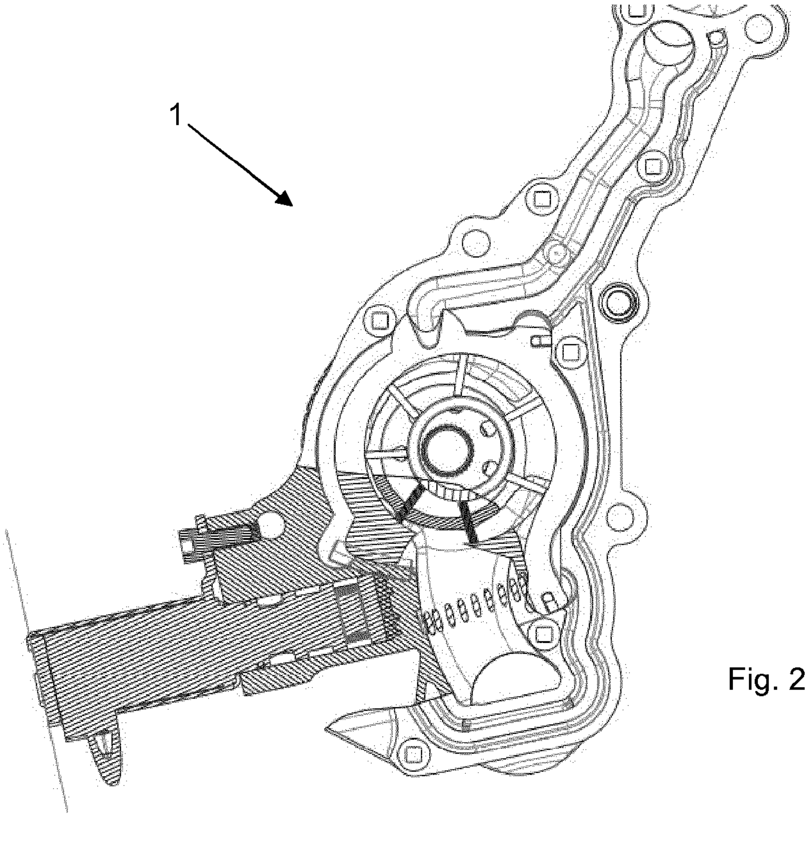
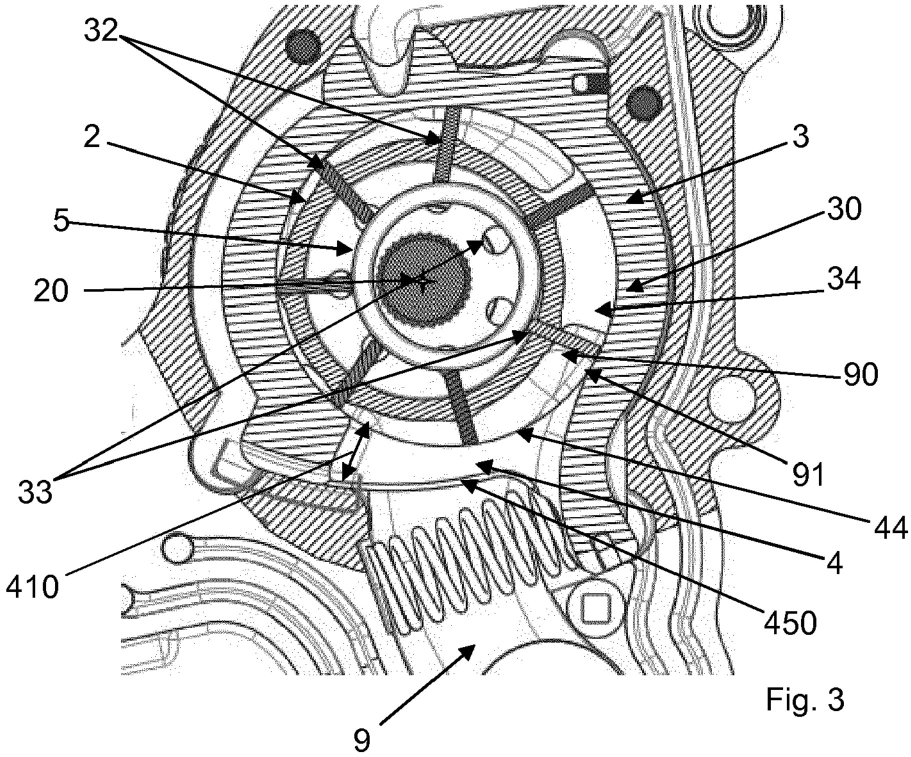


Fig. 2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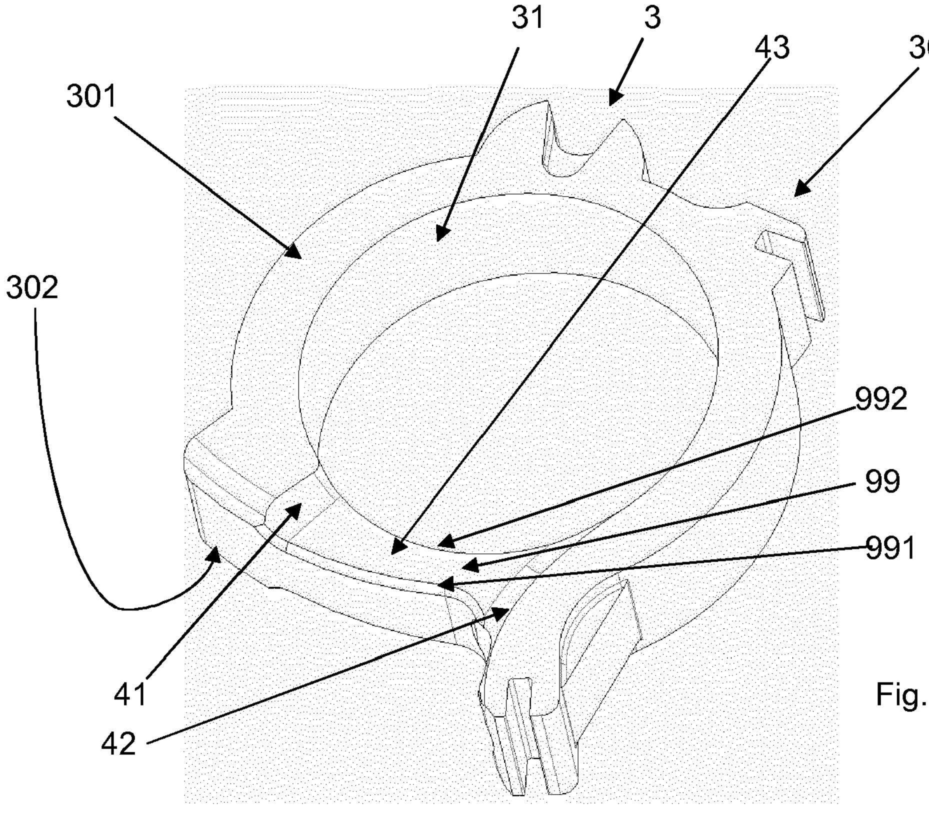
2
5
20
33
410
3
30
34
90
91
44
4
450
9

Fig. 3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43
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302
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42

Fig. 4

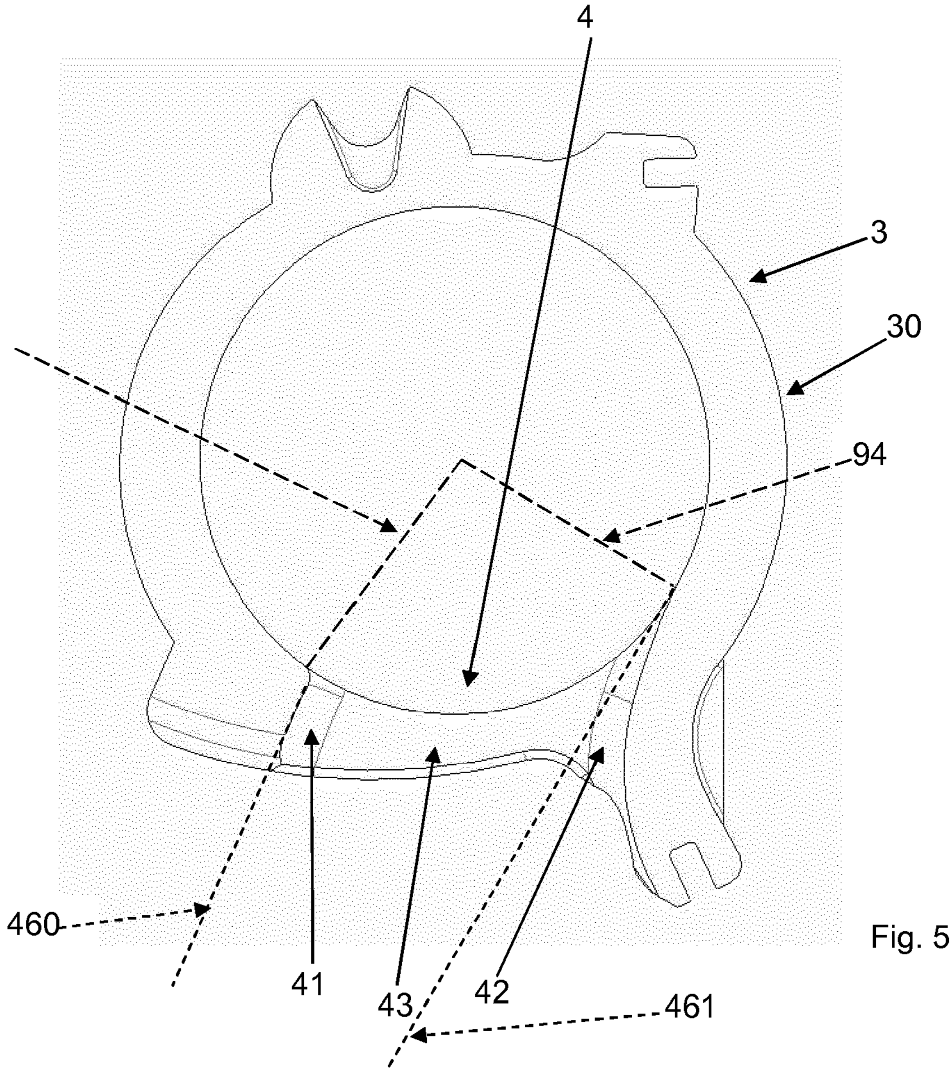

Fig. 5

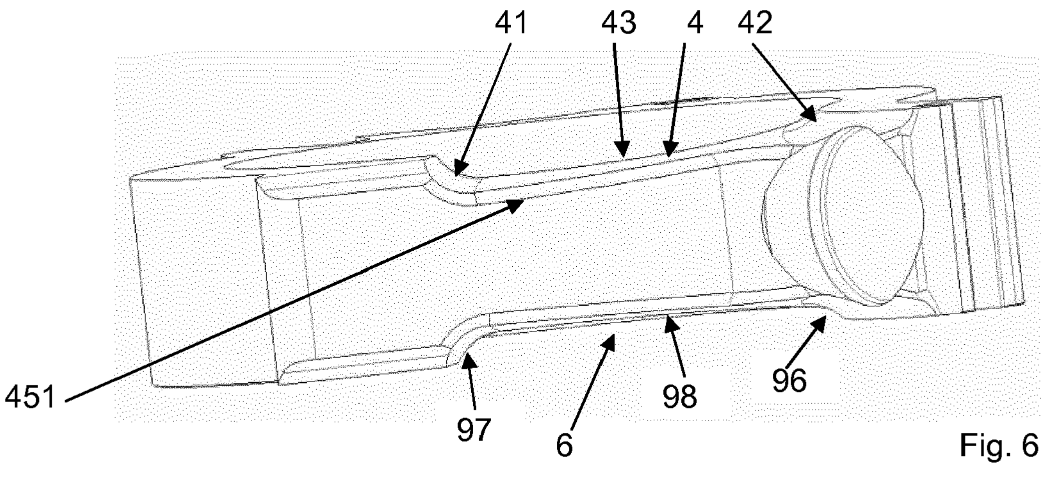

Fig. 6

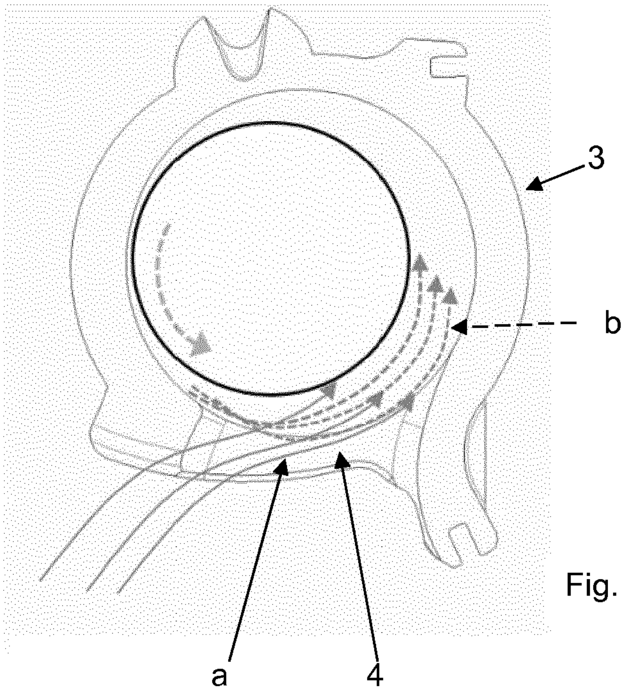

Fig. 7

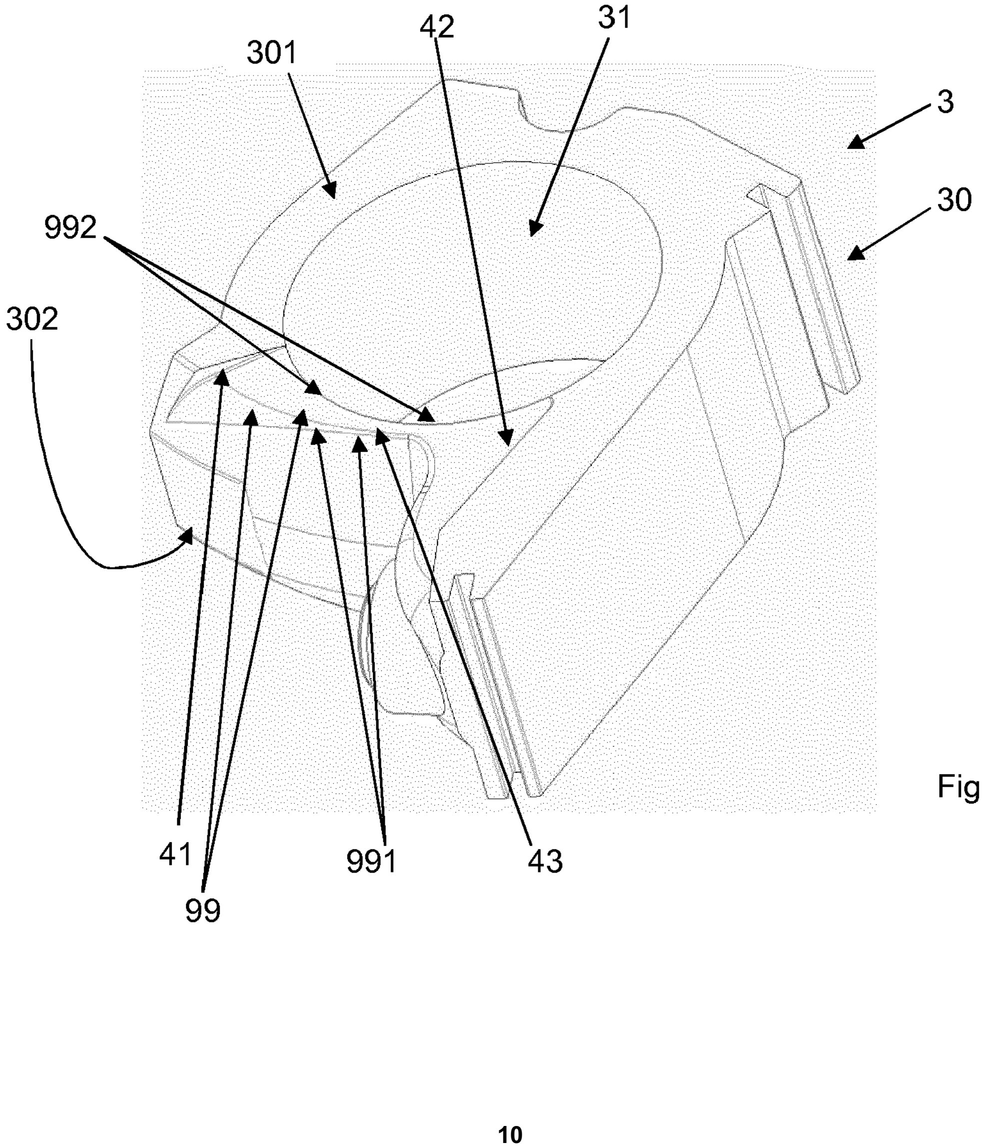

Fig. 8

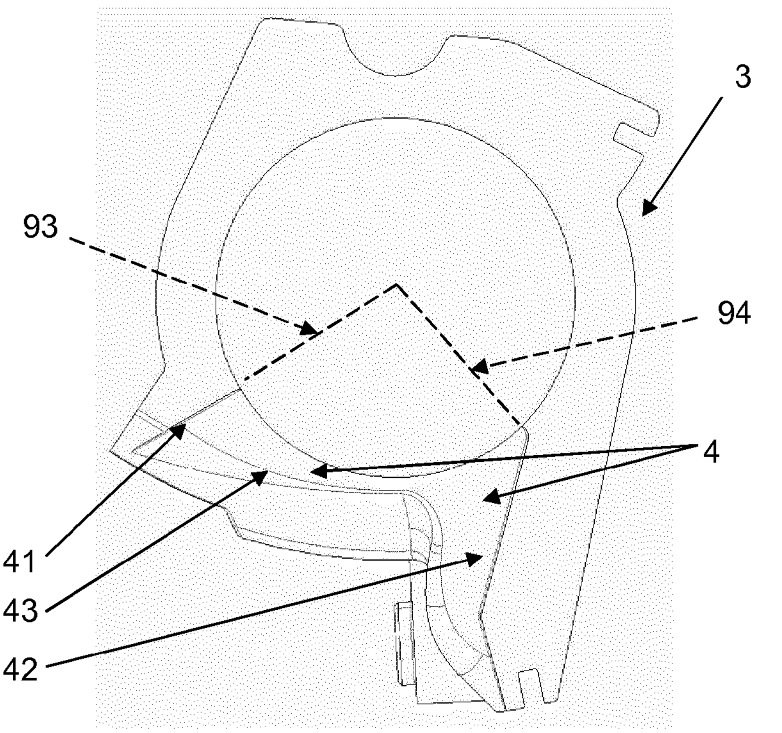

Fig. 9

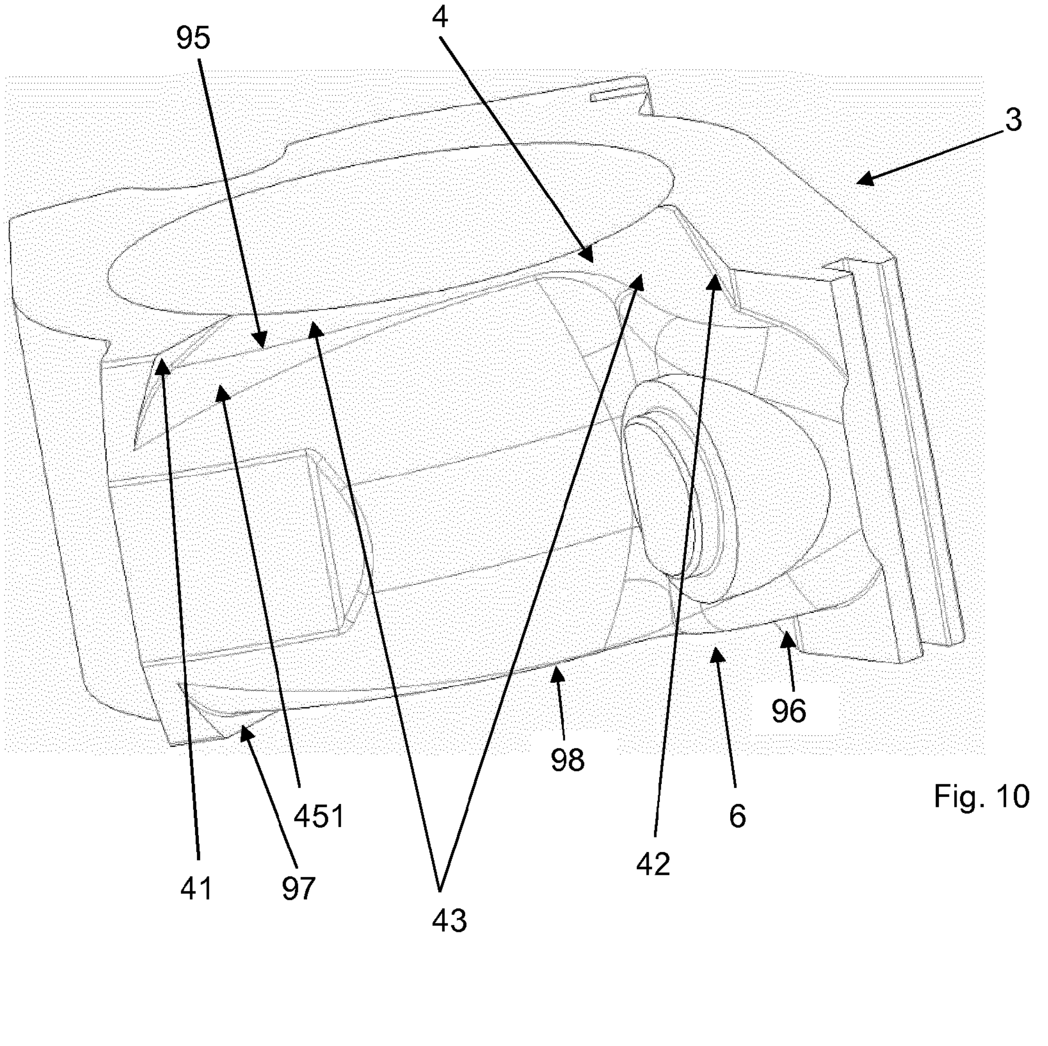

Fig. 10

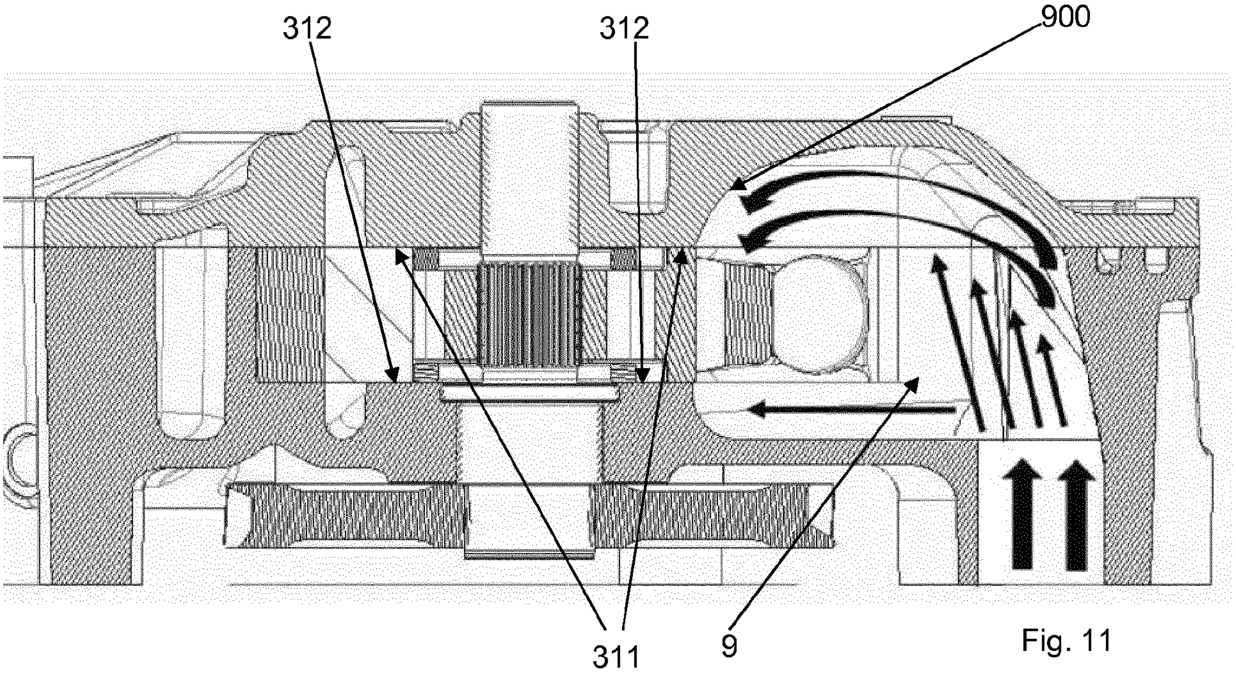

Fig. 11

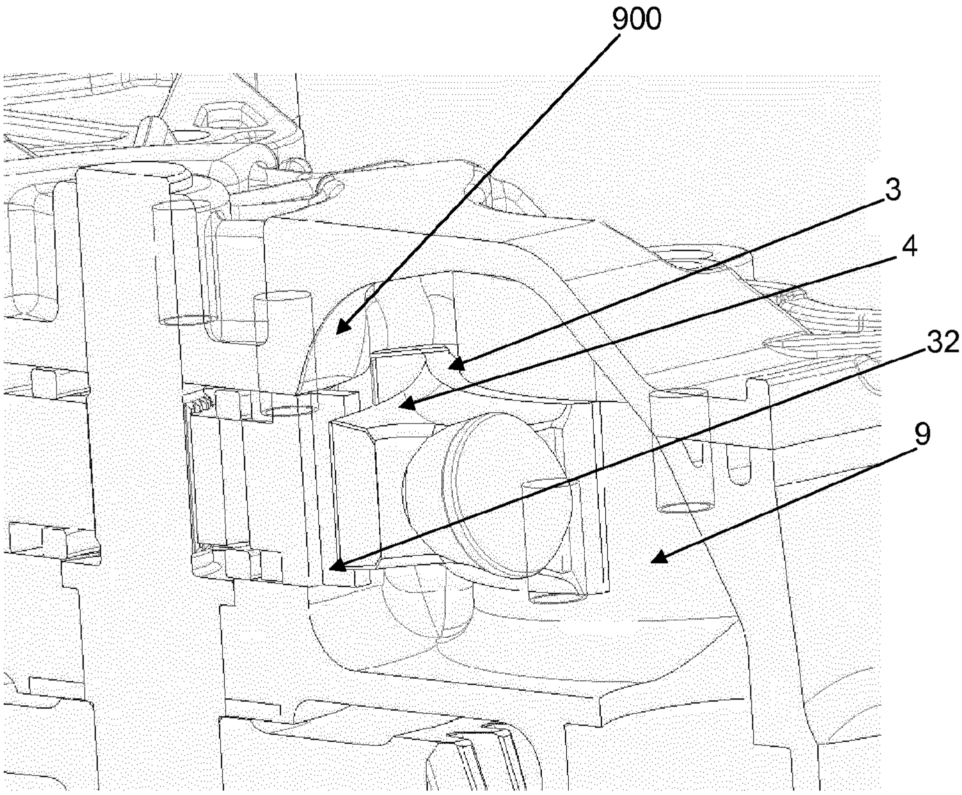

Fig. 12

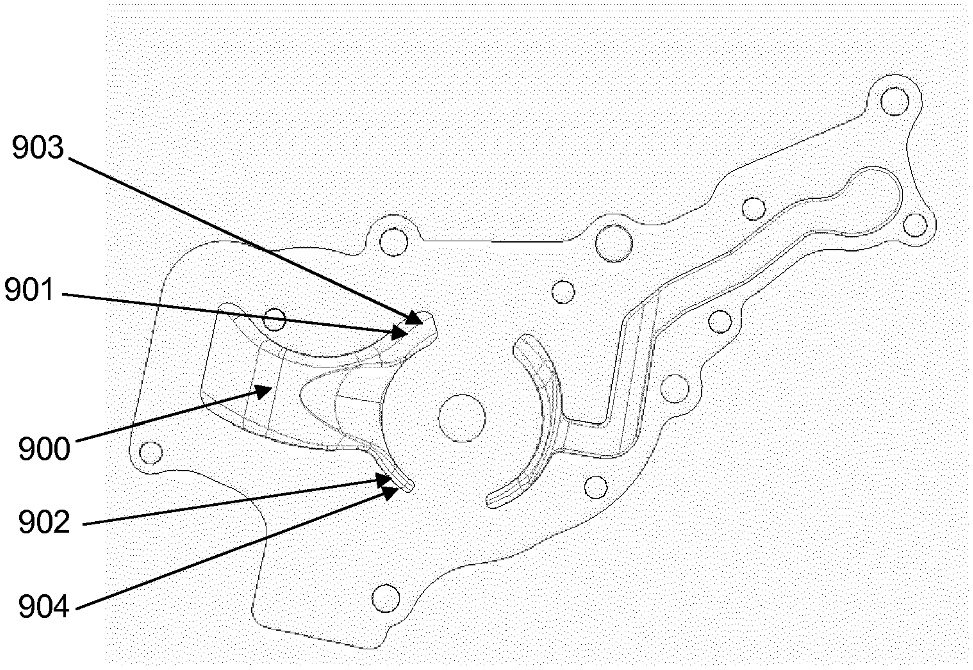

Fig. 13

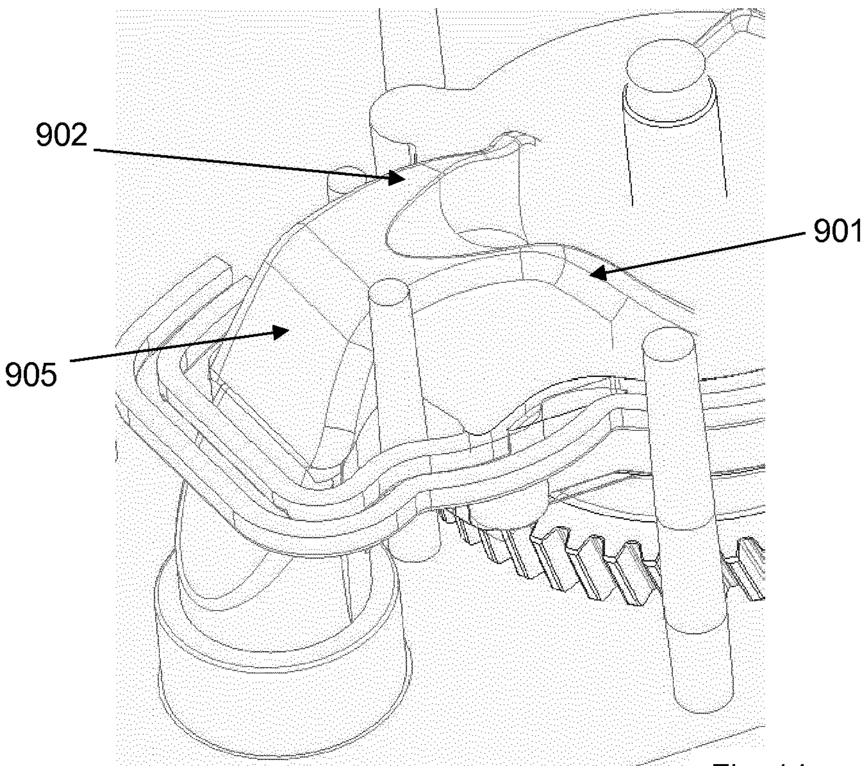

Fig. 14

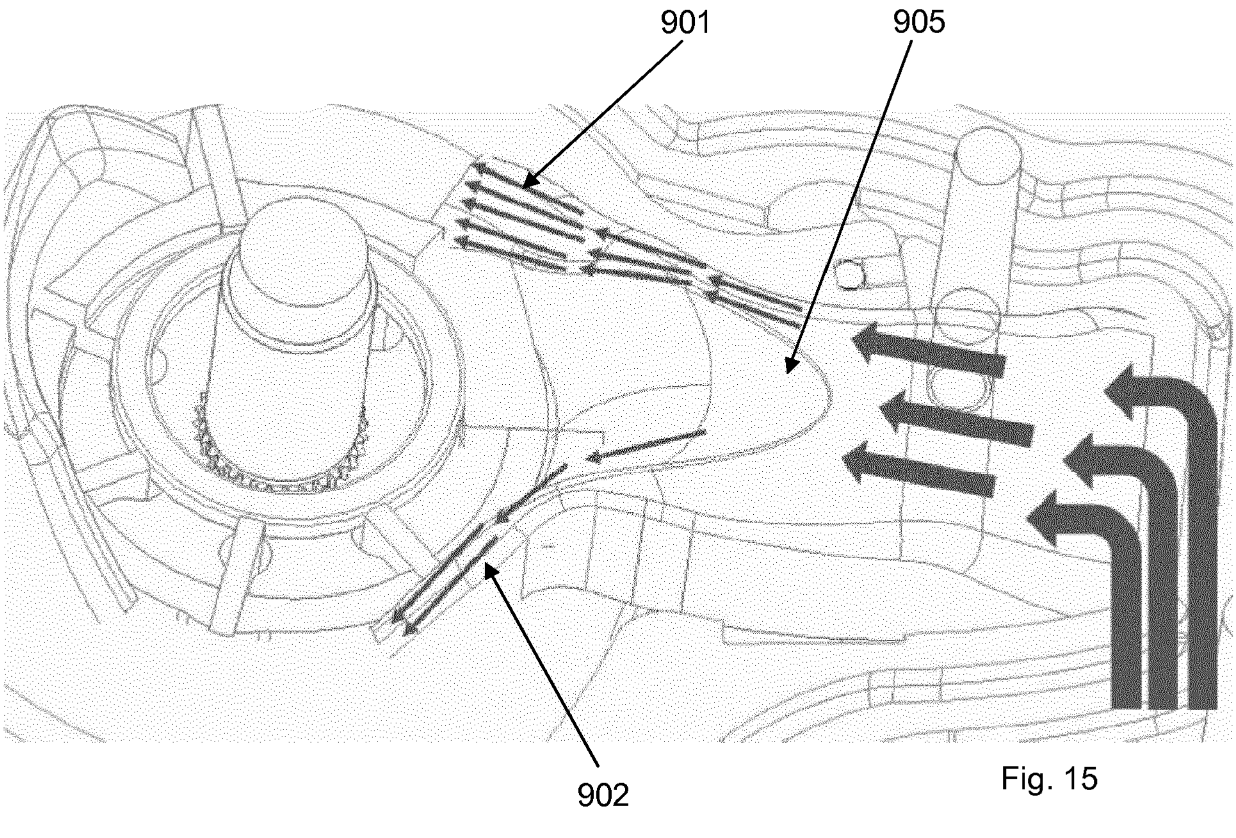

Fig. 15

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EUROPEAN SEARCH REPORT

Application Number
EP 17 18 4197

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Place of search	Date of completion of the search	Examiner
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