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(54) **VARIABLE COOLANT PUMPS**

(57) A variable coolant pump is provided. The pump comprising: a housing comprising an impeller area and a driving area, wherein the housing has a locking plate to define the impeller area; a shaft connected to a driving element arranged in the driving area; a main impeller to drive coolant in the impeller area; a shutter to cover an outflow region of the main impeller such that an amount

of the coolant delivered by the pump is variable; a control pressure pump to increase hydraulic pressure to displace the shutter; a first fluid path to feed the control pressure pump with coolant from the impeller area; a collector to collect driven coolant in a region between the main impeller and the locking plate, wherein the collector is in fluid communication with the first fluid path.

EP 4 067 665 A1

Description

BACKGROUND

[0001] Coolant pumps for combustion engine vehicles may have a mechanical sealing of a main drive shaft to prevent the fluid from leaking to a driving pulley or the like. The mechanical sealing requires a proper refrigeration to avoid premature failing. Fluid near the mechanical sealing of the main drive shaft may be fully or partially trapped and isolated because flow on that area may be restricted. A restricted flow does not allow the proper refrigeration of the mechanical sealing so a premature failure can be expected.

[0002] Some coolant pumps developed for reducing global fuel consumption and/or exhaust emissions in combustion engine vehicles are based on adjusting or regulating elements that fully or partially cover the outlet area of an impeller. This way, suitable operating temperatures of the engine may be achieved in a shorter period of time, e.g. a cold start. A variety of solutions have been proposed to activate that adjusting element, for instance those mentioned in the background of the application DE102008026218B4.

[0003] The adjusting or regulating elements may be driven in several ways. For instance, those elements may be driven based on pressurizing coolant drawn from the cooling system of the engine. The coolant may be pressurized by an auxiliary pump. If the amount of coolant obtained from the cooling system is below a threshold value, the regulating element cannot be operated properly.

[0004] Moreover, if an auxiliary pump is mounted to the shaft, between the mechanical sealing and the impeller, it may be even more difficult for the fluid to reach the mechanical sealing and so the proper refrigeration thereof. The auxiliary pump may hinder the renewal of the coolant to the seal.

[0005] It is an object of the present disclosure to provide examples of variable coolant pumps that avoid or at least reduce the afore-mentioned drawbacks.

SUMMARY

[0006] In a first aspect, a variable coolant pump is provided. The variable coolant pump comprises: a housing comprising an impeller area and a driving area, wherein the housing has a locking plate to define the impeller area at least partially; a shaft to rotate around an axis of rotation of the housing, wherein the shaft is operatively connected to a driving element arranged in the driving area; a main impeller to drive coolant in the impeller area, the main impeller being assembled in the shaft; a shutter displaceable in axial direction along the shaft to cover, at least partially, an outflow region of the main impeller such that an amount of the coolant delivered by the pump is variable; a control pressure pump to increase hydraulic pressure to displace the shutter, wherein the control pres-

sure pump is assembled in the shaft; a first fluid path to feed the control pressure pump with coolant from the impeller area; a collector to collect driven coolant in a region between the main impeller and the locking plate, wherein the collector is in fluid communication with the first fluid path.

[0007] The coolant may be driven by rotation of the main impeller. The coolant may flow through the impeller area, for example through an intermediate region arranged between the main impeller and the locking plate, with respect to the length of the shaft. The coolant flowing in that intermediate region may flow following an angular direction or path with respect to the length of the shaft. The path of the driven coolant may be substantially parallel to the locking plate, or at least a component thereof.

[0008] The collector may capture and conduct or lead a portion of the driven coolant circulating in the impeller area. Thanks to the collector, the kinetic energy carried by the driven coolant in the intermediate region may be used to enhance the flow rate through the first fluid path. This way, a suitable coolant flow rate to feed the control pressure pump may be achieved more easily and simply than a fluid path without a collector.

[0009] In a case where a pump is void of a collector as defined in the first aspect, an orifice in the locking plate may be provided such that the direction followed by the circulating fluid in the intermediate region is substantially perpendicular to a first fluid path. Thus, it may be complex to absorb through an orifice in the locking plate the coolant circulating in the intermediate region as it is in motion. A resistance may be generated to absorb coolant through the first fluid path. To overcome that resistance, the pressure control pump has to generate a sufficient level of suction to obtain desired or predefined flow working requirements to actuate the shutter, e.g. a predefined volume of coolant.

[0010] This may mean oversizing the pressure control pump.

[0011] Since the collector as herein disclosed may allow for easy collection of the moving coolant, the control pressure pump does not have to be oversized to ensure the proper amount of pressurized coolant to drive the shutter. If the control pressure pump is not to be oversized, the size of the control pressure pump may be kept significantly reduced. A control pressure pump of reduced size may require less energy for activation. Therefore, a more efficient coolant pump may be achieved. Furthermore, a control pressure pump of reduced size may occupy less room. Therefore, a space-saving coolant pump may be achieved.

[0012] A separation of coolant streams may be obtained through the pump of the first aspect. A separation of the coolant that is driven by the main impeller and the coolant that may be sucked by the control pressure pump, so that the coolant from the main impeller (which may have a higher speed) does not drag/disturb the coolant to be sucked by the control pressure pump (which may have a lower speed to enter the first fluid path).

[0013] The collector may also act as a stagnation point. The collector may slow down or even stop the collected coolant relative to the rest of the coolant. This way, the collected coolant may avoid escaping, i.e. the collector may be a closed cavity that may create a backwater in which the collected coolant has proper or suitable conditions to be sucked in such as speed.

[0014] The collector may guide the collected coolant. The collector may have a shape that favors the entry and channeling of the coolant to the first fluid path.

[0015] A collector's intake may be configured, for example oriented or faced, so as to draw or capture the coolant moving through the intermediate region. A portion of the coolant flowing in the intermediate region may pass through the collector intake. The collector intake may be configured as a gate to capture the driven coolant.

[0016] The collector may be arranged over the locking plate or on the locking plate, for example the collector may lead at least a part of the coolant in a substantially parallel direction to the locking plate.

[0017] The locking plate may be substantially perpendicular to the length of the shaft.

[0018] In some examples, the first fluid path may be in fluid communication with the collector intake through a duct. A duct may mean a channel, passage, or conduit.

[0019] The collector and the first fluid path may be arranged with respect to each other such that an angle may be defined in the path of the coolant passing from the collector to the first fluid path, viewed in a longitudinal section of the pump. In some examples, the angle may be substantially about 90 degrees. However, this angle may vary. In examples, the collector and the first fluid path may be arranged to form an L-shaped junction therebetween.

[0020] The coolant may flow through the collector in a direction substantially parallel to the locking plate and may subsequently flow through a portion of the first fluid path substantially parallel to the shaft of the pump.

[0021] The collector may be arranged in such a way that a coolant flowing inside the collector may run substantially aligned with the driven coolant in the intermediate region, when seen in longitudinal cross section.

[0022] In examples, the variable coolant pump may comprise: a shaft seal to prevent the coolant of the impeller area from reaching the driving area of the housing, wherein the shaft seal may be disposed in a seal chamber of the housing; wherein the seal chamber may be in fluid communication with the first fluid path, such that the coolant for feeding the secondary impeller passes at least partially through the seal chamber. This way, the shaft seal may receive a coolant flow. A coolant flow may cool or keep the shaft seal's temperature within a suitable value range, i.e. a proper refrigeration of the shaft seal may be obtained. Therefore, a premature failure of the coolant pump may be avoided. The seal's life may be extended.

[0023] The seal may be cooled by the collected coolant before reaching the control pressure pump. Coolant ex-

iting from the control pressure pump, i.e. through the second fluid path, may be at a higher pressure than the coolant in the first fluid path. If the seal was cooled with coolant from the outlet of the control pressure pump, the seal could be subjected to more pressure than it may withstand and could fail or collapse. Owing to the present example, the seal is not cooled by coolant from the outlet of the control pressure pump.

[0024] According to some examples, the control pressure pump may have a pump element slidably connected in axial direction to the shaft, the housing may comprise a cavity to receive the pump element, wherein the cavity may be configured to allow a relative displacement between the pump element and the shaft in axial direction. The pump element may be connected to the shaft and may be displaceable along axial direction, i.e. length of the shaft. As no axial attachment between the pump element and the shaft may be defined, a mechanical transmission of the shaft rotation to the pump element may be done in a way that torque may be transmitted substantially without axial stress.

[0025] In some examples, the variable coolant pump may comprise: a second fluid path to discharge coolant from the control pressure pump into the impeller area; wherein the second fluid path may comprise a discharge bore arranged in the locking plate in such a way that a discharged coolant flows parallel to the shaft, at least partially.

[0026] In this way the coolant circulating in the intermediate region may help to expel the coolant from the second fluid path, due to the Venturi effect. Thanks to this, the coolant may avoid getting stuck in the second fluid path. If the pressurized coolant remains in the second flow path, this could lead to accidental activation of the plug.

[0027] Throughout the present disclosure, expressions such as above, below, beneath, under, upper, top, bottom, lower, side, etc are to be understood taking into account the arrangement of a variable coolant pump or the like in an operating condition as a reference.

[0028] Throughout the present disclosure, expressions such as axis of rotation, shaft length or longitudinal axis are interchangeably used.

BRIEF DESCRIPTION OF THE DRAWINGS

[0029] Non-limiting examples of the present disclosure will be described in the following, with reference to the appended drawings, in which:

Figure 1 schematically illustrates a partial longitudinal cross section view of a variable coolant pump with a collector according to an example when a regulation function is deactivated;

Figure 2 schematically illustrates a cross section view of the variable coolant pump of Figure 1 along line A-A';

Figure 3 schematically illustrates a longitudinal cross section view of the variable coolant pump of the Figure 1 with a direction of the collected coolant through a first fluid path according to an example;

Figure 4 schematically illustrates a longitudinal cross section view of the variable coolant pump of the Figure 1 with a direction of the coolant through a second fluid path according to an example when a regulation function is deactivated;

Figure 5 schematically illustrates a longitudinal cross section view of the variable coolant pump of the Figure 1 with a direction of the coolant through a second fluid path according to an example when a regulation function is activated;

Figure 6 schematically illustrates a longitudinal cross section view of the variable coolant pump of the Figure 1 with a direction of the coolant through a second fluid path to a control valve according to an example when a control valve is open;

Figure 7 schematically illustrates a longitudinal cross section view of the variable coolant pump of the Figure 1 with a direction of the coolant through a second fluid path from the control valve to a discharge bore according to an example; and

Figure 8 schematically illustrates a longitudinal cross section view of the variable coolant pump of the Figure 7 from a different point of view according to an example.

DETAILED DESCRIPTION OF EXAMPLES

[0030] In these figures, the same reference signs have been used to designate matching elements. Some parts have not been illustrated for the sake of clarity.

[0031] In the present description a first and second fluid path has been respectively depicted with arrows in the accompanying drawings for the sake of clarity. These arrows may schematically indicate the path that the coolant may travel before and after passing through a pressure control pump.

[0032] In the following some examples of a variable coolant pump 1 will be described.

[0033] Although those examples may be related to an internal combustion engine, the variable coolant pump 1 could be related to any kind of engine or the like. The variable coolant pump 1 may be used for conveying and circulating a coolant or coolants.

[0034] Figure 1 schematically illustrates a partial longitudinal cross section view of a variable coolant pump 1 with a collector 12 according to an example when a regulation function is deactivated.

[0035] The variable coolant pump 1 of Figure 1 comprises:

a housing 100 that comprises an impeller area 101 and a driving area 102 wherein the housing 100 has a locking plate 10 to define the impeller area 101 at least partially. The impeller area 101 may be a region of the housing 100 where the parts for impelling coolant of the engine are located. The driving area 102 may be a region of the housing 100 where the parts for driving the pump 1 are located. The housing 100 may be directly or indirectly attached to an engine or the like and may be made from metallic material; a shaft 2 to rotate around an axis of rotation AR of the housing 100, wherein the shaft 2 is operatively connected to a driving element 3 arranged in the driving area 102. The shaft 2 may be driven by the driving element 3 and according to some examples the driving element 3 may be a pulley, a chain, a belt, a gear, or even an electric motor. In some examples, the driving element 3 may be driven by a crankshaft (not illustrated) of an engine through a belt (not illustrated). However, alternative power sources to drive the shaft 2 may be envisaged. This shaft 2 may be positioned, at least partially, in the housing 100. The axis of rotation AR may match the longitudinal axis of the housing 12 in some examples;

a main impeller 4 to drive coolant in the impeller area 101, and the main impeller 101 is assembled in the shaft 2. The main impeller 4 is located in the impeller area 101 of the housing 100. The main impeller 4 may be assembled in the shaft 2 through different ways: the impeller 4 may be attached or fixed to the shaft 2 or even the main impeller 4 may be integrally formed with the shaft 2. The main impeller 4 may be placed in the shaft 2 at the end opposite to the driving area 102 as can be seen in figures 1, 3 - 6. The construction of the impeller 4 may be similar to that one of impellers available in the market, so no further explanation will be provided;

a shutter 7 displaceable in axial direction along the shaft 2 to cover, at least partially, an outflow region OR of the main impeller 4 such that an amount of the coolant delivered by the pump 1 is variable. The shutter 7 or adjustment element may be displaced by hydraulic pressure as will be explained later. An example of the pump 1 with the shutter 7 displaced can be seen in Figure 5 which schematically illustrates a longitudinal cross section view of the variable coolant pump of the Figure 1 with a direction of the coolant through a second fluid path according to an example when a regulation function is activated. The shutter 7 may comprise a tube-like or cup-like construction or any other shape which allows covering, at least partially, the outflow region OR of the main impeller 4. An outflow region OR may comprise a portion of the impeller area 101 where the outgoing coolant may leave the main impeller 4. The impeller area 101 may be associated, for instance, with a coolant circuit of an engine;

a control pressure pump 8 to increase hydraulic pres-

sure to displace the shutter 7, wherein the control pressure pump 8 is assembled in the shaft 2. The control pressure pump 8 or secondary pump may be to generate hydraulic pressure. The control pressure pump 8 may be a flow pump such as an impeller or a positive displacement type pump such as a rotary positive displacement pump or a G rotor. Further details about the secondary pump 8 will be provided later;

a first fluid path 17 to feed the control pressure pump 8 with coolant from the impeller area 101. An inlet 18 of the control pressure pump 8 may be related to the impeller area 101 by virtue of the first fluid path 17. A description of the first fluid path 17 followed by the coolant will be set forth later;

a collector 12 to collect driven coolant in a region between the main impeller 4 and the locking plate 10, wherein the collector 12 is in fluid communication with the first fluid path 17. The region IR may be an intermediate region IR between the main impeller 4 and the locking plate 10.

[0036] The coolant driven by the main impeller 4 may describe a generally annular path in the intermediate region IR in the direction of the length of the shaft 2. In Figure 2, the direction that the driven coolant may follow around the axis of rotation AR has been depicted as the arrow DC. In the example of Figures 1 - 2, the collector 12 protrudes, at least partially, from the locking plate 10 toward the main impeller 4. This way, a step may be formed between the collector 12 and the locking plate 10. The collector 12 may have a collector intake 15 located in the step. By arranging the collector intake 15 on the step, the collection of driven coolant may be optimized.

[0037] An intake bore 13 may be arranged between the collector 12 and the first fluid path 17. The intake bore 13 may be located in the locking plate 10. The intake bore 13 may be funnel-shaped. The intake bore 13 may act as the first fluid path's intake, so as to feed the first fluid path 17.

[0038] In some examples, the first fluid path 17 may be in fluid communication with the collector intake 15 through a duct 105. The duct 105 may adopt any suitable shape to lead the coolant driven by the main impeller 4. In the example of Figure 2, the duct 105 is nozzle shaped or bell-shaped. In this way, the inlet of the moving coolant between the main impeller 4 and the locking plate 10 may be facilitated.

[0039] The duct 105 may be defined between the locking plate 10 and a collector cover 14. The collector cover 14 may be generally flat and attached to the locking plate. The collector cover 14 may protrude with respect to the locking plate 10 towards the main impeller 4.

[0040] In some examples, the locking plate 10 and/or the collector cover 14 may have a recess to form the duct 105. In the attached drawings, the collector cover 14 is the one with a recess defining the path of the first fluid

path 17. The latter can be seen for instance in Figures 1 and 2. The collector cover 14 may have a notch to define the track of the duct 105.

[0041] The collector cover 14 may separate the coolant captured by the collector 12 from the remaining coolant driven by the main impeller 4. Thus, the characteristics of the captured coolant such as speed and/or pressure may be suitably adjusted before entering the first fluid path 17.

[0042] In some examples, the duct 105 may be arranged such that a section of its length is perpendicular to the shaft 2. The path that the collected coolant follows through the interior of the collector may change direction when it enters the first fluid path 17 of the pump 1.

[0043] In some examples, the duct 105 may be arranged such that a section of its length is substantially parallel to the locking plate 10.

[0044] According to some examples, the duct 105 may be arranged such that a portion of its length is rounded about the shaft 2 or tangential to the shaft 2. In this way, the coolant collected by the collector 12 may be smoothly conveyed to the first fluid path 17. The intake bore 13 may be generally rounded and/or elongate to follow, at least partially, the rounded portion of the duct 105.

[0045] In examples, the collector intake 15 may be directly connected to the first fluid path 17.

[0046] In these examples, the pump 1 does not comprise a duct.

[0047] In some examples, the collector 12 may be arranged, at least partially, on the locking plate 10.

[0048] The duct 105 may present a generally curved layout when viewed in plan, as seen in figure 2. This curved layout may be adapted to the circular path that the coolant may follow in the intermediate region. This curved shape may facilitate the collection of driven coolant.

[0049] In some examples, the collector intake 15 may comprise at least one rounded wall. This rounded wall may be a side wall of the curved layout. The rounded wall may provide a significantly smooth entry of the collected coolant.

[0050] According to some examples, the variable coolant pump 1 may comprise:

a shaft seal 5 to prevent the coolant of the impeller area 101 from reaching the driving area 102 of the housing 100, wherein the shaft seal 5 may be disposed in a seal chamber 16 of the housing 100; wherein the seal chamber 16 may be in fluid communication with the first fluid path 17, such that the coolant for feeding the control pressure pump 8 may pass at least partially through the seal chamber 16. The shaft seal 5 may be disposed for instance around the shaft 2 and inside the seal chamber 16; the shaft seal 5 may be fitted in a fix manner into the seal chamber 16. The seal chamber 16 may be located in a position between the impeller area 101 and the driving area 102. The shaft 2 may pass through the

seal chamber 16.

[0051] The first fluid path 17 followed by the coolant from the impeller area 101 to the inlet 18 may comprise the seal chamber 16 where the shaft seal 5 is placed. Therefore, the coolant suctioned by the secondary pump 8 may keep the shaft seal 5 at a proper temperature to avoid a premature failure.

[0052] In some examples, the control pressure pump 8 may have a pump element 81 slidably connected in axial direction to the shaft 2, the housing 100 may comprise a cavity 103 to receive the pump element 81. The cavity 103 may be configured to allow a relative displacement between the pump element 81 and the shaft 2 in axial direction as depicted by arrows 82. This may facilitate installation tasks or smooth operation of the pump as clearances between parts may be compensated or absorbed by axial displacement of pump element 81 relative to shaft 2. The pump element 81 may be made of a material with flexible features.

[0053] In some examples, the control pressure pump 8 may comprise a secondary impeller as the pump element 81 which may be arranged coaxially with the shaft 2, the secondary impeller may be driven by the shaft 2.

[0054] According to some examples, the variable coolant pump 1 may comprise:

a second fluid path 19 to discharge coolant from the control pressure pump 8 into the impeller area 101; wherein the second fluid path 19 may comprise a discharge bore 110 arranged in the locking plate 10 in such a way that a discharged coolant may flow through the second fluid path parallel to the shaft 2, at least partially. An outlet 20 of the control pressure pump 8 may be in fluid communication with the impeller area 101. The outlet 20 may be related to the pressure side of the control pressure pump 8. The discharge bore 110 may allow a leakage of coolant from the outlet 20 to the impeller area 101.

[0055] In some other examples, the locking plate 10 may be arranged between the impeller area 101 and the cavity 103. In the example of figure 1, the locking plate 10 is provided between the impeller area 101 and the control pressure pump 8. In this example the locking plate 10 extends beyond the cavity 103 in plan view but the locking plate 10 may be limited to the extension of the cavity 103 in plan view. The locking plate 10 may be attached in a fixed manner to the housing 100, for instance, by several fixation elements 11.

[0056] A lid 83 may define along with the cavity 103 a room to receive the control pressure pump 8 as can be seen in Figure 1. The lid 83 may be arranged between the cavity 103 and the locking plate 10 in axial direction. The lid 83 may comprise an annular body.

[0057] According to some examples, a return spring 36 may be placed between the shutter 7 and the housing 100 as seen in Figure 4. The return spring 36 may push

the shutter 7 back to its deactivated position. This may occur when the control valve 27 is deactivated after having been activated.

[0058] In some examples, the variable coolant pump 1 may further comprise a control valve 27 to control the flow rate or pressure of the coolant from the outlet 20 of the control pressure pump 8 to the impeller area 101. The control valve 27 may control the flow rate and/or pressure of the second fluid path 19. An example of control valve 27 can be seen in Figures 3 - 6. The control valve 27 may be any type of valve which may allow controlling the flow of coolant such as a solenoid valve.

[0059] If a pressure value equal to or above a pressure threshold builds up in the second fluid path 19, it is possible to overcome the resistance offered by the return spring 36 to actuate the plug 7. If the control valve 27 is deactivated, i.e., at least partially open, coolant is allowed to flow from the outlet 20 to the impeller area 101, see Figure 6. As the pressurized coolant by the control pressure pump 8 is evacuated through the discharge bore 110, no pressurized coolant accumulates in the second fluid path 19 and therefore does not build up sufficient pressure to overcome the resistance offered by the return spring 36.

[0060] If the control valve 27 is actuated, i.e., at least partially closed, pressurized refrigerant begins to accumulate driven by the control pressure pump 8, see Figure 4. A pressure is generated in the second fluid path 19 that may reach the pressure threshold. Once the pressure threshold is reached, the return spring 36 may be compressed, so that the plug 7 may gradually limit the outflow of refrigerant from the output region OR. See for instance, Figure 5. If the control valve 27 is subsequently opened, the coolant may follow the second fluid path 19 until the discharge bore 110.

[0061] The discharge bore 110 may be positioned in the locking plate so that there is substantially no fluid interference between the collector intake and the discharge bore 110. For example, the collector intake and the discharge bore may be arranged diametrically opposite each other.

[0062] The following describes the operation of the pump 1 according to an example.

[0063] The pump shaft 1 may rotate thanks to the impulse received through the driving element 3, for example, from the crankshaft of the combustion engine. The main impeller 4 may also rotate due to the rotation transmitted by the shaft 2. The coolant present in the impeller area 101 may in turn be driven due to the rotation of the main impeller 4. Part of that driven coolant flows in the intermediate region IR between the main impeller 4 and the locking plate 10. In that region, part of the driven coolant may follow a substantially annular path around the shaft 2 due to the impulse that may be applied by the main impeller 4. The collector 12 may receive part of the coolant flowing through the intermediate region IR. The coolant collected by the collector 12 may continue through the duct 105 in case the pump 1 has one. In the

duct 105, the properties of the coolant such as pressure and/or speed may be modified with respect to those of the coolant flowing through the intermediate region IR. If the duct 105 has a rounded or curved portion around the shaft 2, the collected coolant may follow a path or way similar to that carried by the coolant that runs through the intermediate region IR.

[0064] The collected coolant may pass through the intake bore 13 and enter the first fluid path 17. The collected coolant may retain at least a part of the kinetic energy obtained due to the rotation of the main impeller 4. The collected coolant may continue along the first fluid path 17. In the example of the attached figures, the coolant passes through the seal chamber 16 and from there goes to the inlet 18 of the pressure control pump 8. In the case of not passing through the seal chamber, the coolant would go to the inlet 18. When the coolant flows through the seal chamber 16 it may cool the shaft seal 5. The path of the first fluid path 17 may be implemented thanks to the kinetic energy carried by the coolant as explained above and to the suction exerted by the control pressure pump 8.

[0065] Coolant may exit the control pressure pump through the outlet 20. Passage through the control pressure pump 8 may cause the pressure of the coolant to increase. The coolant pressurized by the control pressure pump 8 may continue through the second flow path 19 as shown in Figure 4. If the control valve 27 is open or inactive, the shutter 7 remains in its retracted position as shown in Figure 6. The coolant may continue through the second flow path 19 as shown in Figures 7 and 8 until it reaches the discharge bore 110.

[0066] If the control valve 27 is activated or closed, at least partially, it does not allow at least a portion of the coolant pressurized by the pressure control pump 8 to reach the discharge bore 110. A pressure may build up in the section of the second fluid path 19 from the outlet 20 to the control valve 27 as seen in Figure 4. If a pressure threshold is reached, the resistance of the return spring 36 can be overcome and the plug 7 may be extended to at least partially shut off the outflow region OR as shown in Figure 5. A motor control unit (not shown) may send a command to actuate the control valve 27. When the control valve 27 is opened, pressure inside the second fluid path 19 may be reduced because coolant may be allowed to flow through the control valve 27 as seen in Figure 6.

[0067] The first fluid path 17 and the second fluid path 19 may have several sections or regions as set forth in the following:

In a first section FF of the first fluid path 17, the coolant may flow towards the driving area 102 and substantially parallel to the shaft 2. This first section FS may start at the intake bore 13. In a second section SF of the first fluid path 17, the coolant may flow substantially perpendicular and towards the shaft 2, so that it may enter the seal chamber 16 if the pump

1 is provided with one. After leaving the seal chamber 16 the coolant flows in a third section TF of the first fluid path 17 in a substantially perpendicular direction and from the shaft 2. In a fourth section OF of the first fluid path 17 the coolant may circulate substantially parallel to the shaft 2 and towards the impeller area 101. The fourth section OF of the first fluid path 17 may terminate at the inlet 18 of the control pressure pump 8.

In a first section FS of the second fluid path 19, the coolant may circulate towards the driving area 102 and substantially parallel to the shaft 2. This first section FS may start at the outlet 20 of the pressure control pump 8. In a second section SS of the second fluid path 19, the coolant may circulate through a control valve channel 24 towards the control valve 27, see Figure 6. If the control valve 27 is at least partially open, the coolant may pass into a third section TS comprising an outlet valve channel 28 disposed between the control valve 27 and a fourth section OS comprising a discharge channel 29, see Figures 7 - 8. In the fourth section OS the coolant circulates substantially parallel to the shaft 2 and towards the driving area 102. The fourth section OS may terminate in the discharge bore 110.

[0068] The housing 100 may have a piston chamber 75 to receive at least one end portion of the shutter 7, the end portion being arranged at an opposite side to the main impeller 4, see Figure 5. The piston chamber 75 may be annular shaped around the axis of rotation AR.

[0069] The shutter 7 may have a pressure ring 71 around the axis of rotation AR, see Figure 5. The pressure ring 71 may be configured to move within the piston chamber 75 in a direction of the length of the shaft 2. The pressuring ring 71 may move within the piston chamber 75 when the shutter moves to or from the main impeller 4. The pressure ring 71 may be in fluid communication with the second section SS of the second fluid path 19 through a shutter feeding channel 74. This way, if the control valve 27 is at least partially closed, the pressure inside at least the second section SS may rise as above described and the built-in pressure coolant may apply a force and so a pressure to the pressure ring 71. The applied pressure to the ring 71 above the pressure threshold may compress the spring 36.

[0070] The pressure ring 71 may have a cross section having an indentation 73 in the side of the coolant which may create a ring channel 72 about the axis of rotation AR. The pressurized coolant may flow through the ring channel 72 around the axis of rotation AR. In this way the pressure within the ring channel 72 may be distributed substantially homogeneously. This may mean that the activation of the shutter 7 may be uniform around the axis of rotation AR, i.e., the outflow region OR may be shut off uniformly around the axis of rotation AR.

[0071] The shutter feeding channel 74 may be oriented

towards the ring channel 72 to further improve the filling of the ring channel 72 and so a homogeneous distribution of the pressurized coolant between the piston chamber 75 and the pressure ring 71 may be achieved.

[0072] The indentation 73 may be generally U- or V-shaped. 5

[0073] The pressure ring 71 may have a planar surface in the side of the spring 36.

[0074] For reasons of completeness, various aspects of the present disclosure are set out in the following numbered clauses: 10

Clause 1. A variable coolant pump comprising:

a housing comprising an impeller area and a driving area, wherein the housing has a locking plate to define the impeller area at least partially; a shaft to rotate around an axis of rotation of the housing, wherein the shaft is operatively connected to a driving element arranged in the driving area; 20
a main impeller to drive coolant in the impeller area, the main impeller being assembled in the shaft;
a shutter displaceable in axial direction along the shaft to cover, at least partially, an outflow region of the main impeller such that an amount of the coolant delivered by the pump is variable; a control pressure pump to increase hydraulic pressure to displace the shutter, wherein the control pressure pump is assembled in the shaft; 30
a first fluid path to feed the control pressure pump with coolant from the impeller area;
a collector to collect driven coolant in a region between the main impeller and the locking plate, wherein the collector is in fluid communication with the first fluid path. 35

Clause 2. The variable coolant pump according to clause 1, wherein the first fluid path is in fluid communication with a collector intake through a duct. 40

Clause 3. The variable coolant pump according to clause 2, wherein the duct is nozzle shaped. 45

Clause 4. The variable coolant pump according to any of clauses 2 to 3, wherein the duct is defined between the locking plate and a collector cover.

Clause 5. The variable coolant pump according to clause 4, wherein the locking plate and/or the collector cover has a recess to form the duct. 50

Clause 6. The variable coolant pump according to any of clause 2 to 5, wherein the duct is arranged such that a section of its length is perpendicular to the shaft. 55

Clause 7. The variable coolant pump according to any of clauses 2 to 6, wherein the duct is arranged such that a section of its length is parallel to the locking plate.

Clause 8. The variable coolant pump according to any of clauses 2 to 7, wherein the duct is arranged such that a portion of its length is rounded about the shaft or tangential to the shaft.

Clause 9. The variable coolant pump according to any of clauses 1 to 8, wherein the collector is arranged, at least partially, on the locking plate.

Clause 10. The variable coolant pump according to any of clauses 1 to 9, wherein the collector protrudes, at least partially, from the locking plate toward the main impeller.

Clause 11. The variable coolant pump according to any of clauses 2 to 10, wherein the collector intake comprises at least one rounded wall.

Clause 12. The variable coolant pump according to any of clauses 1 to 11, comprising:

a shaft seal to prevent the coolant of the impeller area from reaching the driving area of the housing, wherein the shaft seal is disposed in a seal chamber of the housing;
wherein the seal chamber is in fluid communication with the first fluid path, such that the coolant for feeding the control pressure pump passes at least partially through the seal chamber.

Clause 13. The variable coolant pump according to any of clauses 1 to 12, wherein the control pressure pump has a pump element slidably connected in axial direction to the shaft, the housing comprising a cavity to receive the pump element, wherein the cavity is configured to allow a relative displacement between the pump element and the shaft in axial direction.

Clause 14. The variable coolant pump according to any of clauses 1 to 13, wherein the control pressure pump has a pump element made of a material with flexible features.

Clause 15. The variable coolant pump according to any of clauses 1 to 14, comprising:

a second fluid path to discharge coolant from the control pressure pump into the impeller area; wherein the second fluid path comprises a discharge bore arranged in the locking plate in such a way that a discharged coolant flows through the second fluid path parallel to the shaft, at least

partially.

Clause 16. The variable coolant pump according to any of clauses 1 to 15, wherein the locking plate comprises an intake bore to feed the first fluid path with coolant.

Clause 17. The variable coolant pump according to clauses 2 and 15, wherein the discharge bore is positioned in the locking plate so that there is no fluid interference between the collector intake and the discharge bore.

Clause 18. The variable coolant pump according to clause 2, wherein the duct presents a generally curved layout when viewed in plan.

[0075] Although only a number of examples have been disclosed herein, other alternatives, modifications, uses and/or equivalents thereof are possible. Furthermore, all possible combinations of the described examples are also covered. Thus, the scope of the present disclosure should not be limited by particular examples, but should be determined only by a fair reading of the claims that follow. If reference signs related to drawings are placed in parentheses in a claim, they are solely for attempting to increase the intelligibility of the claim, and shall not be construed as limiting the scope of the claim.

Claims

1. A variable coolant pump comprising:

a housing comprising an impeller area and a driving area, wherein the housing has a locking plate to define the impeller area at least partially;
a shaft to rotate around an axis of rotation of the housing, wherein the shaft is operatively connected to a driving element arranged in the driving area;
a main impeller to drive coolant in the impeller area, the main impeller being assembled in the shaft;
a shutter displaceable in axial direction along the shaft to cover, at least partially, an outflow region of the main impeller such that an amount of the coolant delivered by the pump is variable;
a control pressure pump to increase hydraulic pressure to displace the shutter, wherein the control pressure pump is assembled in the shaft;
a first fluid path to feed the control pressure pump with coolant from the impeller area;
a collector to collect driven coolant in a region between the main impeller and the locking plate, wherein the collector is in fluid communication with the first fluid path.

2. The variable coolant pump according to claim 1, wherein the first fluid path is in fluid communication with a collector intake through a duct.
3. The variable coolant pump according to claim 2, wherein the duct is nozzle shaped.
4. The variable coolant pump according to any of claims 2 to 3, wherein the duct is defined between the locking plate and a collector cover.
5. The variable coolant pump according to claim 4, wherein the locking plate and/or the collector cover has a recess to form the duct.
6. The variable coolant pump according to any of claims 2 to 5, wherein the duct is arranged such that a section of its length is perpendicular to the shaft.
7. The variable coolant pump according to any of claims 2 to 6, wherein the duct is arranged such that a section of its length is parallel to the locking plate.
8. The variable coolant pump according to any of claims 2 to 7, wherein the duct is arranged such that a portion of its length is rounded about the shaft or tangential to the shaft.
9. The variable coolant pump according to any of claims 1 to 8, wherein the collector is arranged, at least partially, on the locking plate.
10. The variable coolant pump according to any of claims 1 to 9, wherein the collector protrudes, at least partially, from the locking plate towards the main impeller.
11. The variable coolant pump according to any of claims 2 to 10, wherein the collector intake comprises at least one rounded wall.
12. The variable coolant pump according to any of claims 1 to 11, comprising:
 - a shaft seal to prevent the coolant of the impeller area from reaching the driving area of the housing, wherein the shaft seal is disposed in a seal chamber of the housing;
 - wherein the seal chamber is in fluid communication with the first fluid path, such that the coolant for feeding the control pressure pump passes at least partially through the seal chamber.
13. The variable coolant pump according to any of claims 1 to 12, wherein the control pressure pump has a pump element slidably connected in axial direction to the shaft, the housing comprising a cavity to receive the pump element, wherein the cavity is con-

figured to allow a relative displacement between the pump element and the shaft in axial direction.

14. The variable coolant pump according to any of claims 1 to 13, wherein the control pressure pump has a pump element made of a material with flexible features. 5

15. The variable coolant pump according to any of claims 1 to 14, comprising: 10

a second fluid path to discharge coolant from the control pressure pump into the impeller area; wherein the second fluid path comprises a discharge bore arranged in the locking plate in such a way that a discharged coolant flows parallel to the shaft, at least partially. 15

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Fig. 1

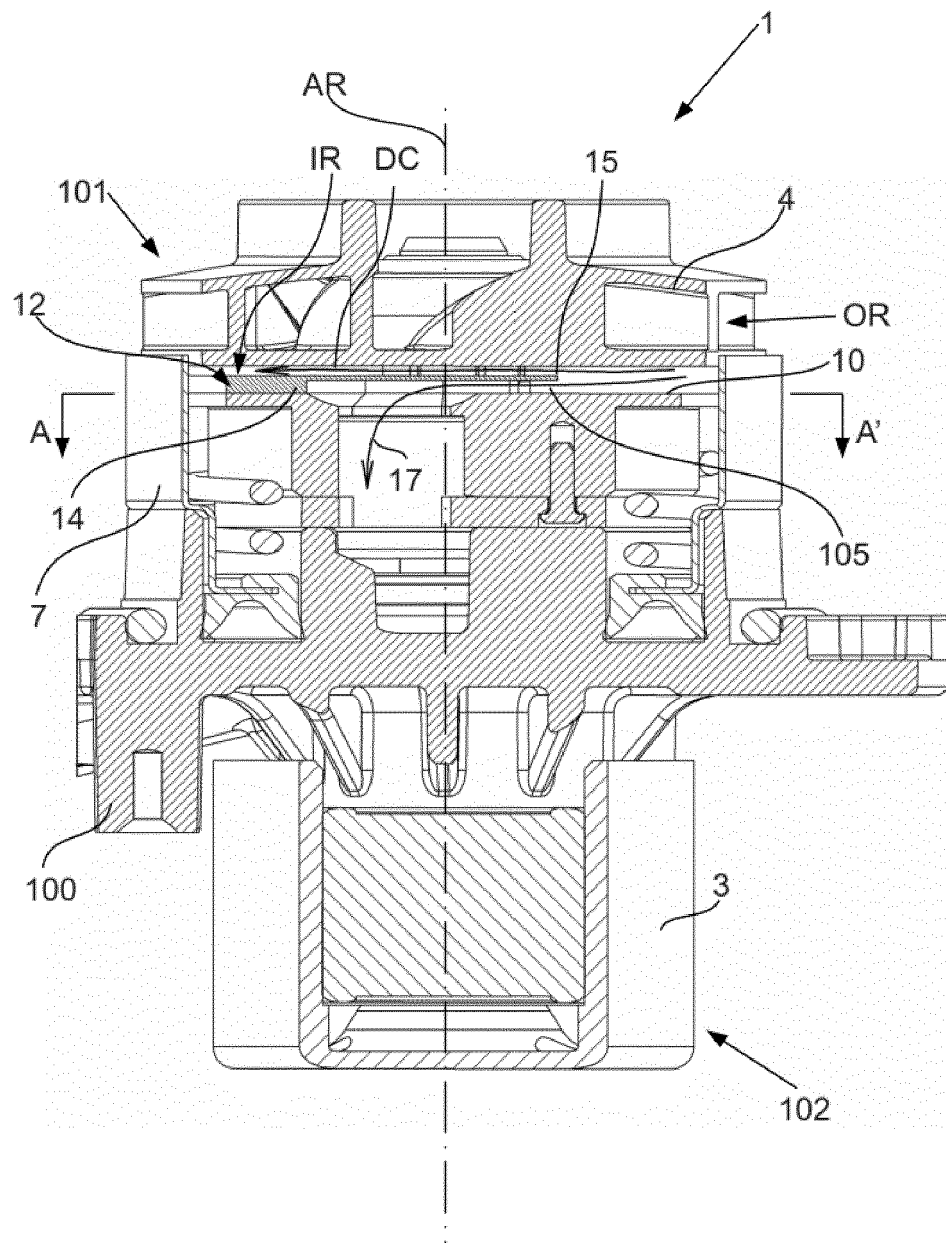


Fig. 2
SECTION A-A'

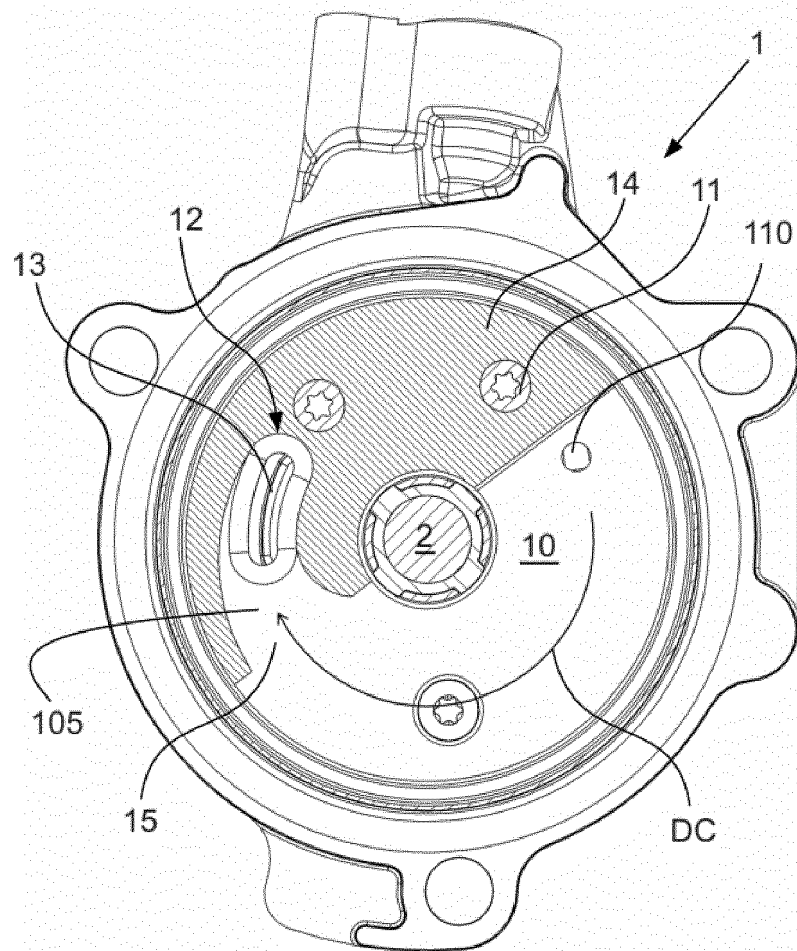


Fig. 3

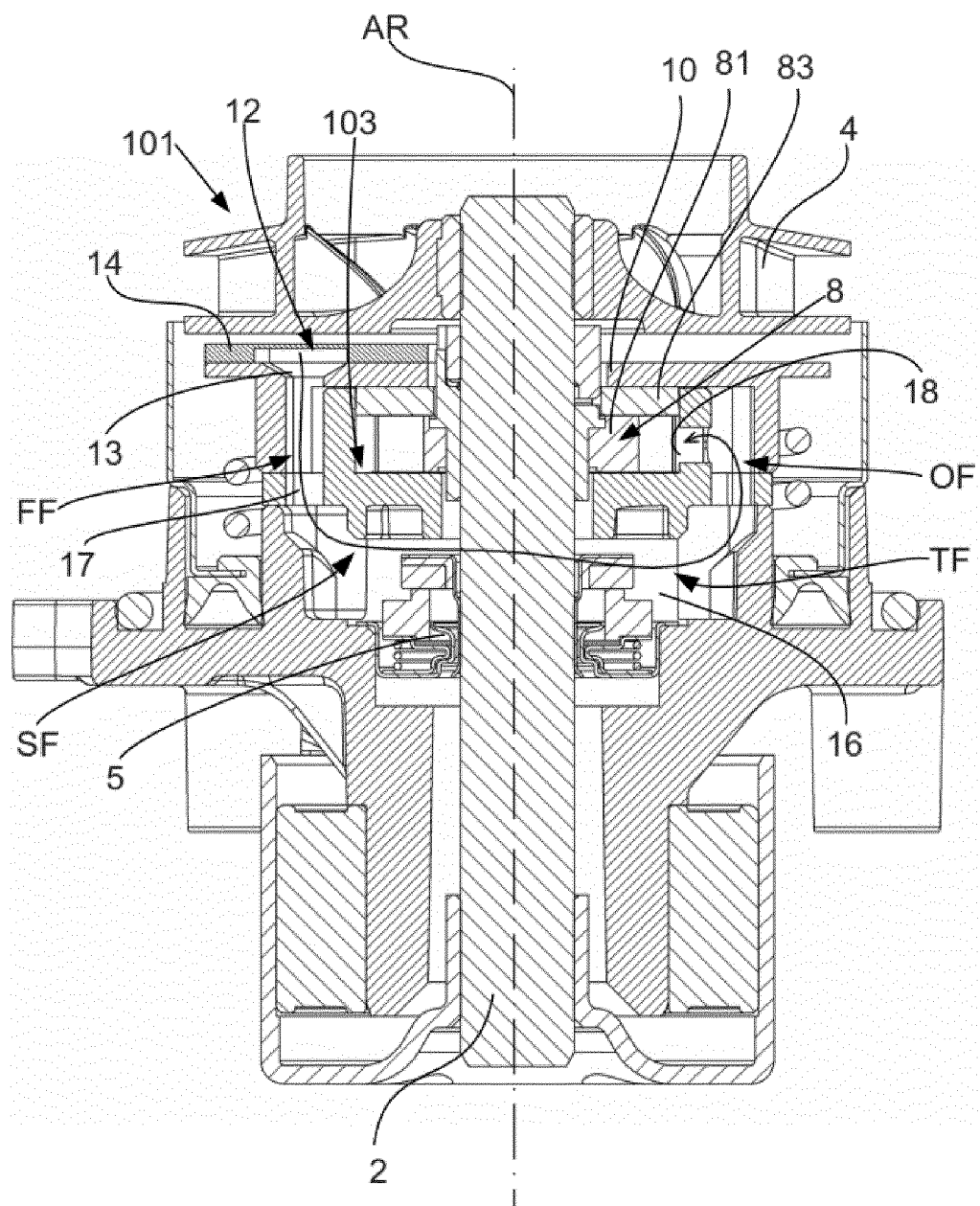


Fig. 4

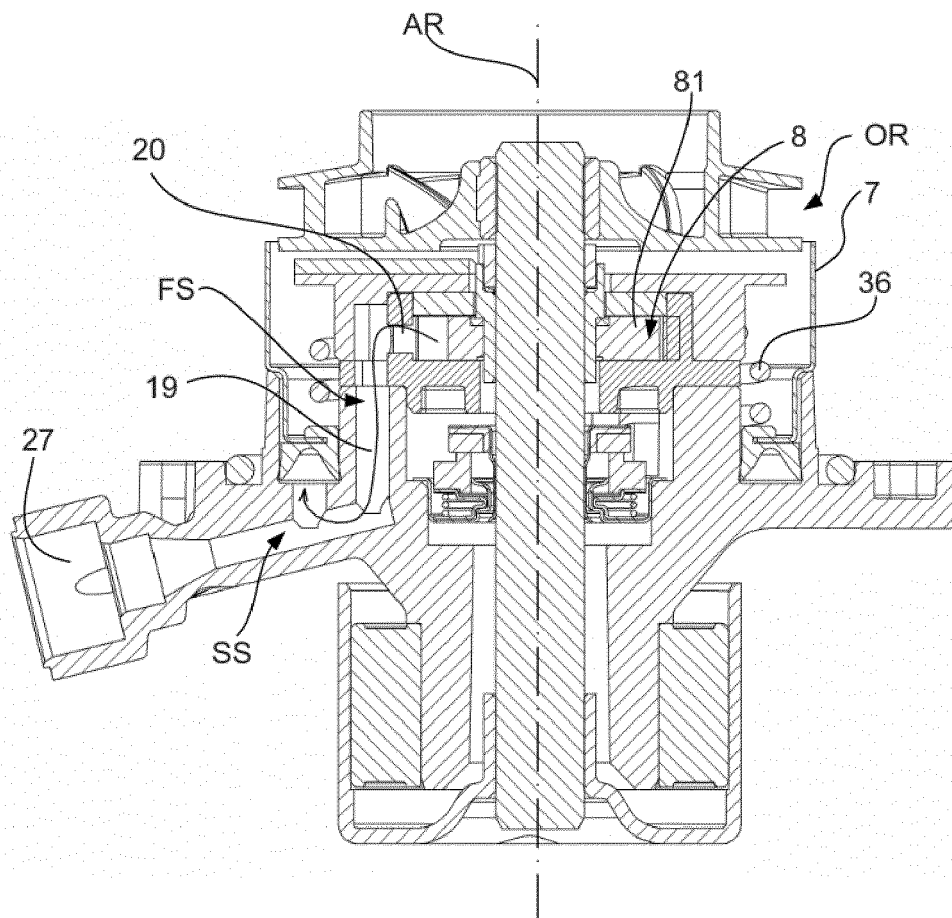


Fig. 5

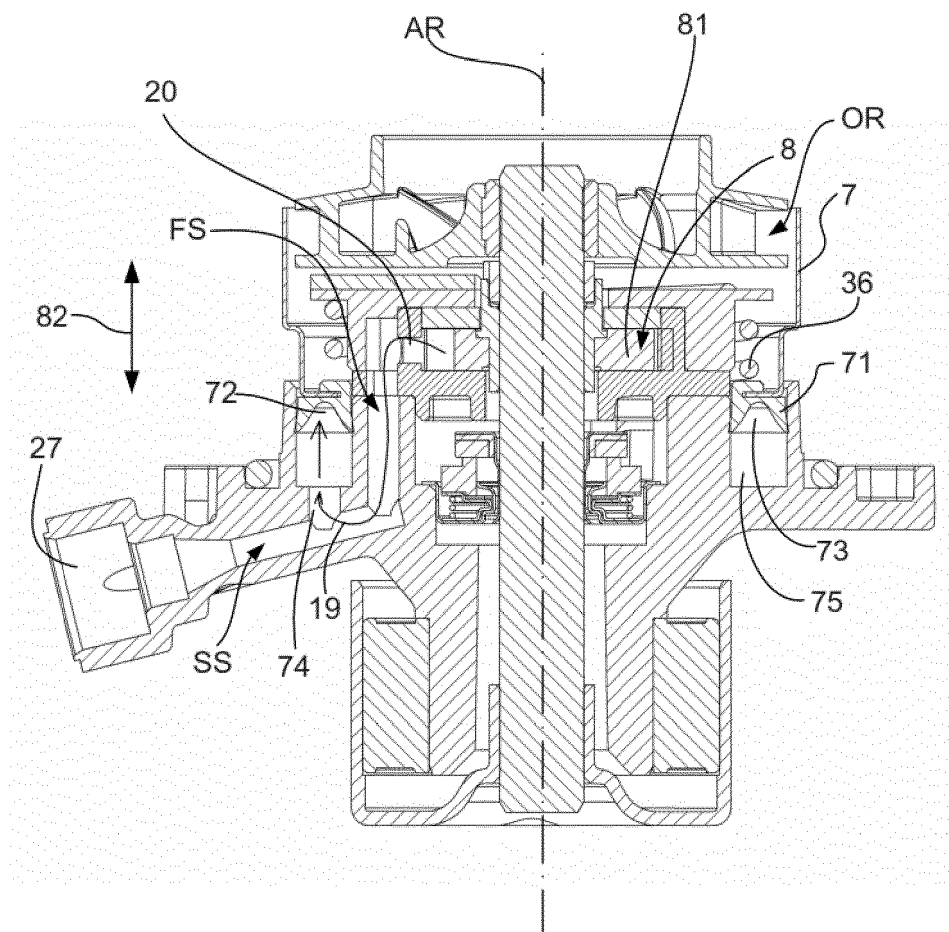


Fig. 6

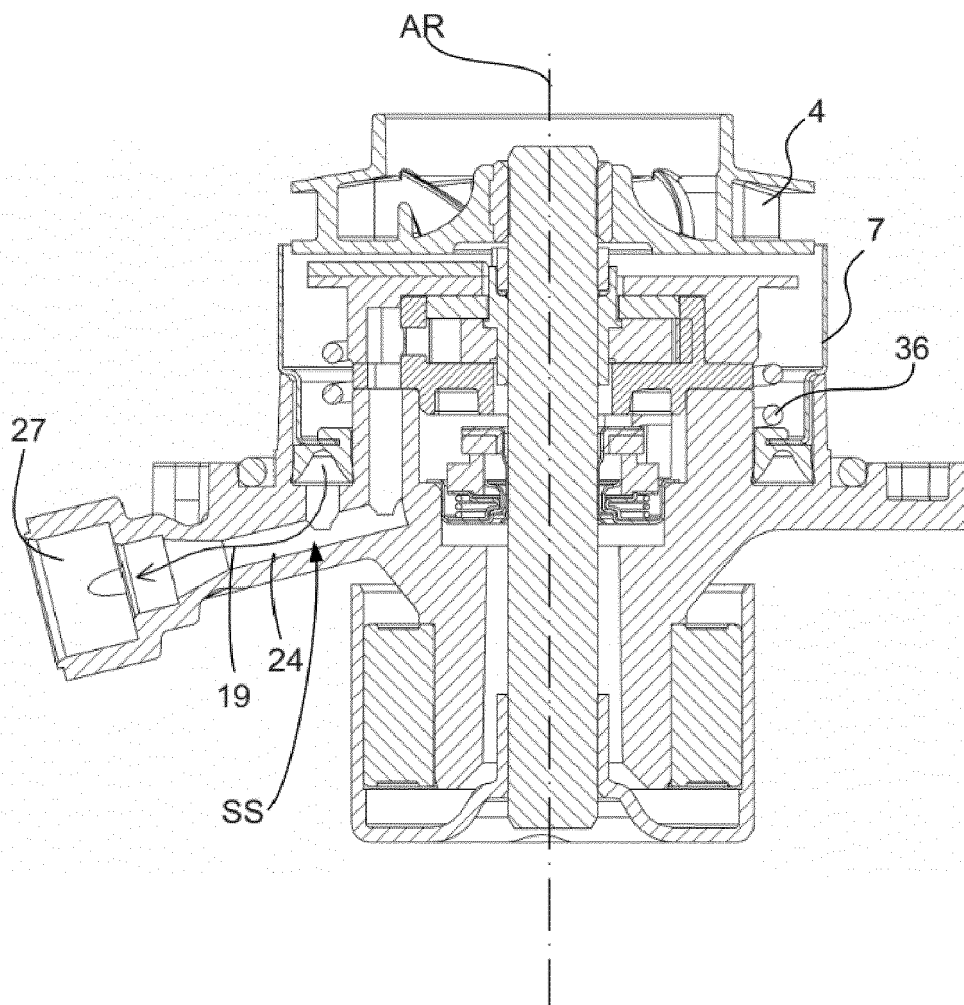


Fig. 7

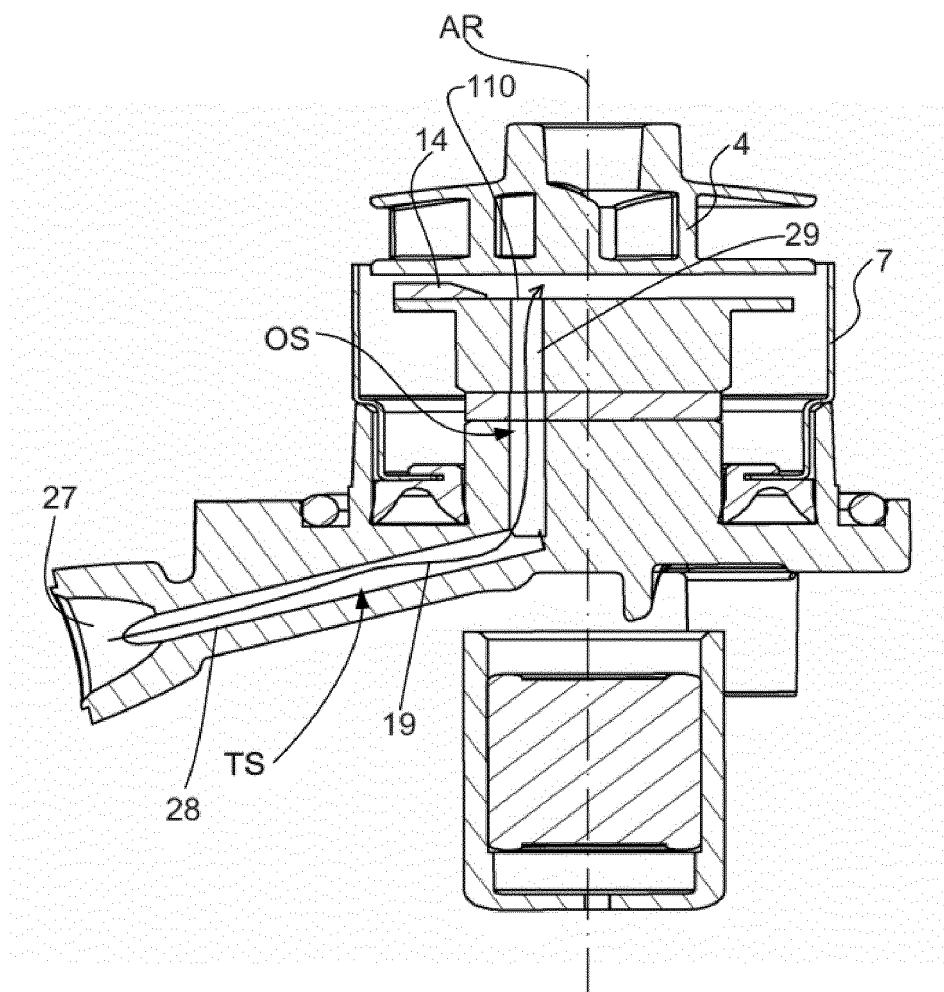
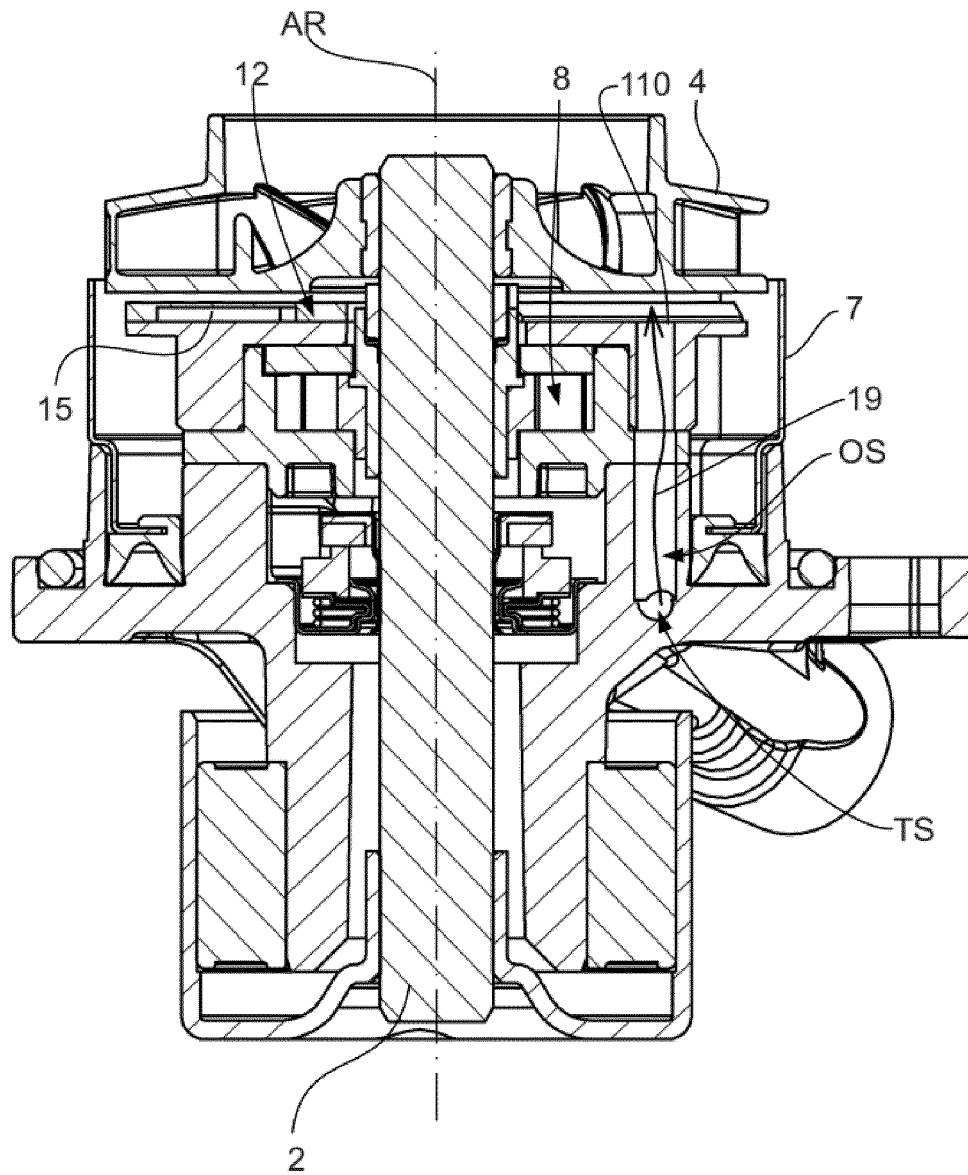


Fig. 8





EUROPEAN SEARCH REPORT

 Application Number
 EP 21 38 2270

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A	* paragraphs [0029] - [0034], [0041] - [0045], [0048] * * figures 1-5 *	12-14	
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A	* paragraphs [0029] - [0035], [0038] - [0041] * * figures 1-3 *	4-6, 12-14	
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A	* paragraphs [0026] - [0029] * * figures 1-4 *	4,5,9, 10,12,15	TECHNICAL FIELDS SEARCHED (IPC) F04D F01P
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Place of search The Hague		Date of completion of the search 10 September 2021	Examiner Gombert, Ralf
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EPO FORM 1503 03.82 (P04C01)

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