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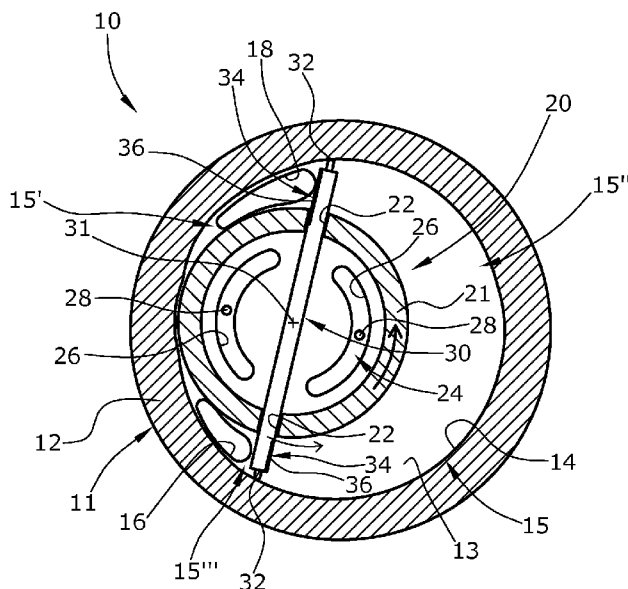


Fig.1

(57) Abstract: An automotive volumetric vacuum pump (10) is being oil-lubricated and is used for providing an actuation vacuum of less than 100 mbar. The pump comprises: A rotor (20) with a circular rotor body (21) being provided with an oil receiving cavity (24) and rotating inside a pump room (15) which is surrounded by a circumferential pump room wall (12). The rotor body (20) is arranged adjacent to the pump room wall (12). A vane (30) with a longitudinal vane body (31) being arranged radially shiftable in a radial guiding slot (22) of the rotor body (20), whereby the rotor body (20), the vane (30) and the pump room wall (12) define at least two rotating pump chambers (15', 15'', 15'''). A radial oil discharge channel (34; 40; 50) at the radial end portion (33) of the vane (30) and/or at the guiding slot (22), whereby the oil discharge channel (34) is provided with a flow opening (37; 47; 57) in a radial plane. The flow opening (37; 47; 57) is arranged to be open to thereby allow an oil to flow from the pump chamber (15') through the discharge channel (34; 40; 50) to the oil receiving cavity (24) only in the retracted position of the vane end portion (33) during the final compression phase of the respective rotating pump chamber (15').

## Automotive volumetric vacuum pump

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The invention refers to an automotive volumetric vacuum pump which is oil-lubricated, for providing an actuation vacuum of less than 100 mbar. In particular, the invention is directed to a vane pump.

Automotive vacuum pumps are used to provide a vacuum of an absolute  
10 pressure between 100 mbar and 1 mbar as an actuation vacuum for switches, servo brake actuators etc. In contrast to a volumetric vacuum pump without oil-lubrication, an oil-lubricated vacuum pump has reduced frictional losses, reduced wear and, due to a better pneumatic isolation of the rotating pump chambers, a better pump efficiency.

15 However, the discharge of the air and the oil at the end of the discharge phase can be critical if a substantial volume of oil is still present in the rotating pump chamber. If the oil is not completely discharged in the discharge phase and therefore is compressed, a high pressure load at the vane head and an increase of the power consumption can be caused.

20 It is an object of the invention to provide an automotive volumetric vacuum pump with oil lubrication with reduced power consumption.

This object is, according to the invention, solved with an automotive volumetric vacuum pump with the features of claim 1.

According to the invention, the vacuum pump is provided with a circular  
25 rotor body which is provided with an oil receiving cavity in the middle. The oil collected in the receiving cavity can be discharged from the receiving cavity. The rotor body is rotating inside a pump room which is surrounded and defined by a circumferential pump room wall. The rotor body is arranged adjacent to one sector of the pump room wall. This arrangement  
30 is typical for a vane pump.

The pump is provided with at least one vane with a longitudinal vane body which is arranged radially shiftable in a radial guiding slot of the rotor body. The rotor body, the vane and the circumferential pump room wall define at least two, and typically three rotating pump chambers. The  
5 typical arrangement of the vacuum pump is a single-vane pump whereby the vane is provided with two vane heads so that, together with the pump rotor being arranged adjacent to the circumferential pump room wall, three rotating pump chambers are defined. The vane head can be an integral part together with the vane body or can be a separate part made  
10 of the same or another material as the vane body.

A radial oil discharge channel is provided at a radial end portion of the vane, i.e. at the vane head, or is provided at the guiding slot. The oil discharge channel is not necessarily exactly radial but is provided with a radial component so that oil can flow radially inwardly through the  
15 discharge channel. The oil discharge channel is provided with a flow opening in a radial plane, whereby the flow opening is arranged in that way that the oil can flow from the pump chamber through the discharge channel to the oil cavity only in the retracted position of the vane end portion and during the final compression phase of the respective rotating  
20 pump chamber. When the end portion of the vane is moving into its retracted position, the rotating pump chamber at the bow side of the vane is in the final compression phase so that the pneumatic outlet opening of the pump room is very small or can be even completely closed already. In this final compression phase the flow opening lying in a radial plane is  
25 open so that the oil remaining in the pump chamber can be discharged into the oil receiving cavity until the final compression phase is completely finished and the chamber volume of the respective rotating pump chamber is zero.

The radial oil discharge channel being open in the final compression phase  
30 guarantees that no substantial overload pressure can occur so that the

vane is not stressed and bended in tangential direction and no unnecessary power consumption occurs.

According to a preferred embodiment of the invention, the flow opening is arranged in that way that the flow opening is covered and thereby closed  
5 by the vane body or by the rotor body in a non-retracted position of the vane end portion. If the discharge channel is provided in the vane end portion, the flow opening is covered by a surface defining the guiding slot of the rotor body in the non-retracted position of the vane end portion. If the discharge channel is provided in the rotor body and is arranged close  
10 or directly adjacent to the guiding slot of the rotor body, then the flow opening is covered by the vane body in the non-retracted position of the vane end portion. By closing the flow opening in the non-retracted position of the vane end portion it is guaranteed that the air of the respective pump chamber is completely discharged through the pneumatic outlet  
15 opening, and not through the discharge channel.

Preferably, the discharge channel is provided as a radial groove in the rotor body, whereby the groove is covered by the vane body. The radial groove has a groove opening preferably in a radial plane, whereby the groove opening is covered by the vane body to define a closed discharge  
20 channel. The radial groove in the rotor body is a simple construction and allows a relatively easy manufacturing.

Alternatively or additionally, the discharge channel is provided as a radial groove in the vane body, whereby the groove opening is covered by a surface of the guiding slot of the rotor body. The radial groove in the vane  
25 body is also a simple construction and allows a relatively easy manufacturing.

Alternatively or additionally, the discharge channel is provided as a radial conduit in the vane body and/or in the rotor body. The radial conduit defines a closed discharge channel which is provided with a flow opening  
30 at the inlet or at the outlet of the radial conduit.

Three embodiments of the invention are described with reference to the enclosed drawings, wherein

figure 1 shows a cross section of an automotive vacuum pump with oil-lubrication,

figure 2 shows in detail a first embodiment of an oil discharge arrangement of the vacuum pump of figure 1,

figure 3 shows in detail a second embodiment of an oil discharge arrangement of the vacuum pump of figure 1, and

figure 4 shows in detail a third embodiment of an oil discharge arrangement of the vacuum pump of figure 1.

In figure 1, an automotive volumetric vacuum pump 10 is shown which is provided as a so-called single vane pump. The vacuum pump 10 is oil-lubricated to improve the pneumatic effectivity of the pump 10. The vacuum pump 10 is able to provide a total pressure of less than 10 mbar for providing an actuation vacuum for automotive actuators driving flaps, switches, servo brakes etc. The vacuum pump 10 can be driven mechanically by an internal combustion engine, or can directly be driven by its own electric motor.

The vacuum pump 10 is provided with a pump housing 11 including a circumferential pump room wall 12 enclosing and defining a pump room 15. The inner surface 14 of the circumferential pump room wall 12 is not necessarily circular. Inside of the pump room 15 a rotor 20 is provided which is defined by a circular rotor body 21 and a vane 30. The rotor body 21 is provided as a rotor body ring and is arranged directly adjacent to one section of the pump room wall 12. Inside the rotor body 21 an oil receiving cavity 24 is defined. The rotor body 21 is provided with two radial guiding slots 22 in which a longitudinal vane body 31 of the vane 30 is inserted. The vane body 31 is supported radially shiftable in the guiding

slots 22 between two guiding slot surfaces lying in a radial plane. The vane body 31 has two axial end portions 33 which are both provided with a separate vane head 32 which is supported radially shiftable at the vane body 31.

5 The rotor body 21, the vane body 31 and the pump room wall 12 define three rotating pump chambers 15', 15'', 15'''.

In a side wall 13 of the pump housing 11 a pneumatic inlet opening 16 and a separate pneumatic outlet opening 18 of the pump room 15 are provided. When the rotor 20 rotates, which is, in this embodiment, in  
10 counter-clockwise direction, one rotating pump chamber 15''' is in a suction phase, the following rotating pump chamber 15'' is in a transition phase and the third rotating pump chamber 15' is in a compression phase.

In the oil receiving cavity 24 a circular rotor basis plate can be provided with two circular discharge openings 26 corresponding to two discharge  
15 openings 28 at the pump housing side wall 13.

Referring to the first embodiment shown in figures 1 and 2, both vane end portions 33 are provided with an oil discharge channel 34 which is provided as a radial groove 36 with a groove opening orientated in a circumferential direction and lying in a radial plane. As can be seen in  
20 figure 2, the vane end portion 33 is in a retracted position in the final compression phase of the respective rotating pump chamber 15'. In this vane position, the groove opening of the channel groove 36 is substantially but not totally covered by a side wall surface 23 of the guiding slot 22, whereby the side wall surface 23 is lying in a radial plane.

25 A proximal section of the groove opening is not covered by the guiding slot wall surface 23, but is open to the oil receiving cavity 24. This section of the groove opening defines a flow opening 37 which allows the oil in the rotating pump chamber 15' in the final compression phase to radially flow into the discharge channel 34 and from the discharge channel 34 through  
30 the flow opening 37 into the oil receiving cavity 24.

In a less-retracted position of the end portion 33 of the vane 30, the flow opening 37 is completely covered by the side wall 23 of the guiding slot 22 so that no fluid can be discharged from the respective rotating pump chamber 15'. When the respective vane end portion 33 is projecting with  
5 the complete discharge channel 34 out of the rotor 20, no fluid at all can flow from the respective rotating pump chamber 15' to the oil receiving cavity 24.

Referring to the embodiment shown in figure 4, two groove-like discharge channels 50, 51 are provided at the guiding slot 22 as well as at the vane  
10 30. The guiding slot discharge channel 50 is provided as a radial groove 54 in the side wall surface 23' of the guiding slot 22 and the vane discharge channel 51 is provided as a radial groove 52 in the vane end portion 33, whereby the groove opening is, in part, covered by a side wall 25 of the vane end portion 33. The radial length of both discharge  
15 channels 50, 51 is less than the radial thickness of the circular rotor body ring 21. The flow opening 57 is defined by the proximal section of the groove opening of the vane discharge channel 51.

Referring to the embodiment shown in figure 3, the discharge channel 40 is defined as a conduit 42 in the circular rotor body 21. The flow opening  
20 47 is defined by an inlet opening of the conduit 42, whereby the flow opening 47 is lying in a radial plane and is not covered by a side wall 25 of the vane end portion 33 in the retracted position of the vane end portion 33.

**CLAIMS**

- 5 1. An automotive volumetric vacuum pump (10) being oil-lubricated, for providing an actuation vacuum of less than 100 mbar, with
- a rotor (20) with a circular rotor body (21) being provided with an oil receiving cavity (24) and rotating inside a pump room (15) which is surrounded by a circumferential pump room wall (12), whereby
- 10 the rotor body (21) is arranged adjacent to the pump room wall (12),
- a vane (30) with a longitudinal vane body (31) being arranged radially shiftable in a radial guiding slot (22) of the rotor body (21), whereby the rotor body (21), the vane (30) and the pump room wall
- 15 (12) define at least two rotating pump chambers (15',15'',15'''),
- a radial oil discharge channel (34;40;50,51) at the radial end portion (33) of the vane (30) and/or at the guiding slot (22), whereby the oil discharge channel (34) is provided with a flow opening
- (37;47;57) in a radial plane, the flow opening (37;47;57) being
- 20 arranged to be open to thereby allow the oil to flow from the pump chamber (15') through the discharge channel (34;40;50,51) to the oil receiving cavity (24) only in the retracted position of the vane end portion (33) during the final compression phase of the respective rotating pump chamber (15').
- 25
2. The automotive volumetric vacuum pump (10) of claim 1, whereby the flow opening (37;47;57) is arranged in that way that the flow opening (37;47;57) is covered and thereby closed by the vane body (31) or by the rotor body (21) in a non-retracted position of the
- 30 vane end portion (33).

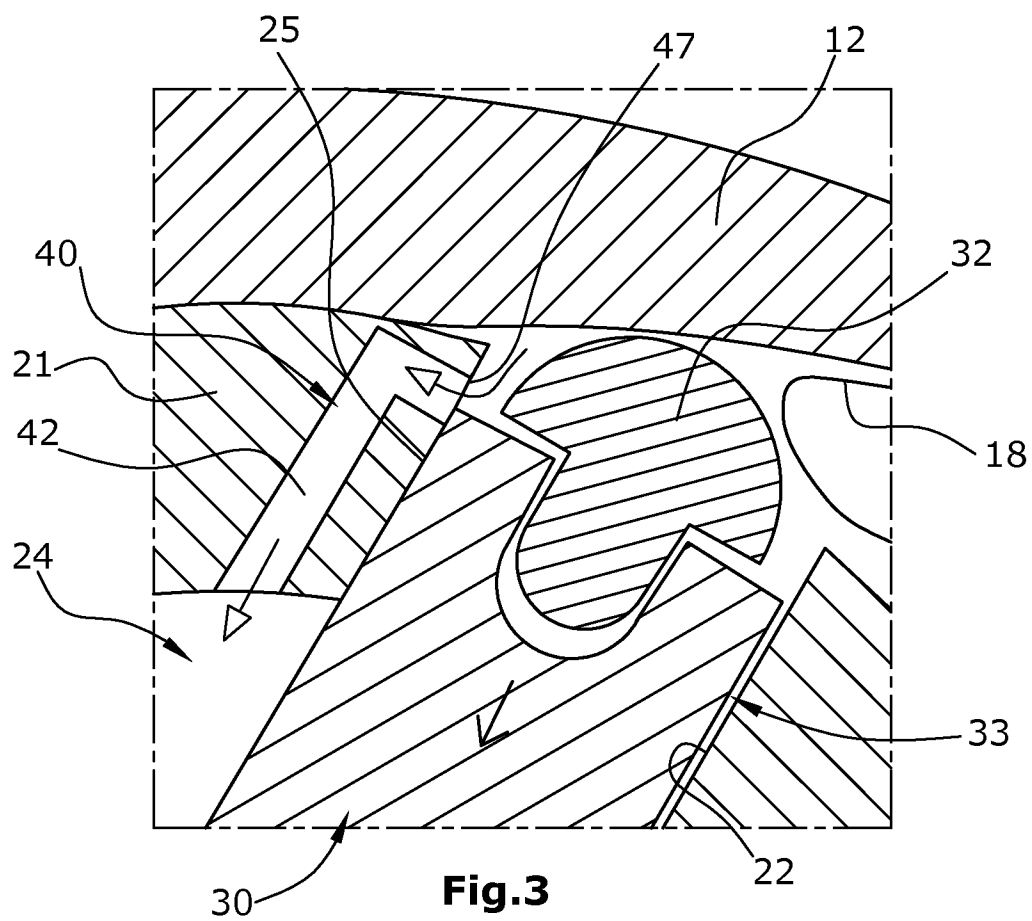
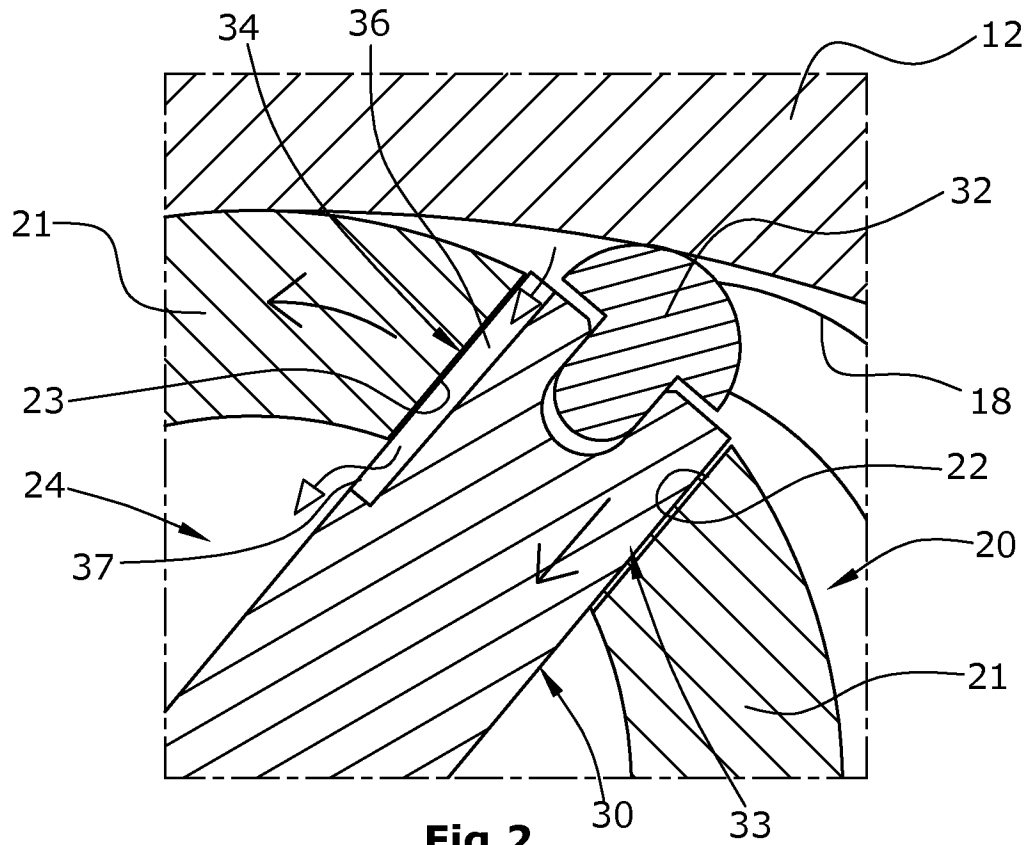
3. The automotive volumetric vacuum pump (10) of one of the preceding claims, whereby the discharge channel (34) is provided as a radial groove (36) in the rotor body (20), whereby the groove (36) is covered by the vane body (31).

4. The automotive volumetric vacuum pump (10) of one of the preceding claims, whereby the discharge channel (50) is provided as a radial groove (52) in the vane body (31), whereby the groove opening is covered by a surface of the guiding slot (22).

5. The automotive volumetric vacuum pump (10) of one of the preceding claims, whereby the discharge channel (40) is provided as a radial conduit (42) in the vane body or in the rotor body (21).



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