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(54) **Vacuum pump**

(57) A sliding vane vacuum pump includes a casing (10) having a cover which together define a cavity (12), a rotor and a vane slidably mounted to said rotor. The pump further includes an inlet passage (24) extending from the exterior of the pump to the cavity (12) and an outlet passage (20) extending from the cavity (12) to the exterior of the pump. The pump further includes an oil relief arrangement operable to vent lubricating oil to the exterior of the pump in the event of reverse rotation of the rotor and vane.

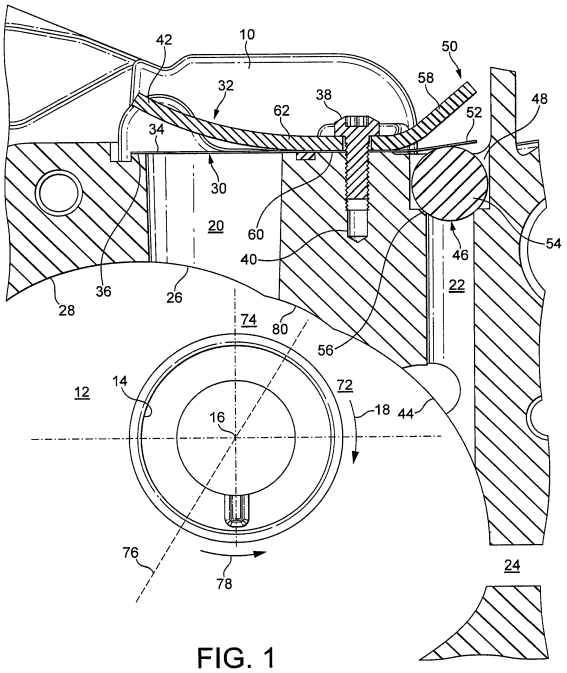

FIG. 1

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Description

[0001] The present invention relates to a sliding vane vacuum pump having an oil relief valve having the configuration described herein.

[0002] Sliding vane vacuum pumps may be used in conjunction with vehicles having internal combustion engines to provide braking assistance via a brake booster. The engine may operate on, for example, a compression ignition cycle, or a spark ignition cycle with gasoline direct injection. Typically the pump is driven directly by the engine. The pump comprises a casing having a cavity, a rotor and a sliding vane. The casing is typically provided with a cover which may be removed to gain admittance to the cavity, rotor and vane. The casing and/or cover are provided with an inlet and an outlet which communicate with the cavity. The rotor is provided within the cavity at a position offset from the centre of the cavity. The vane is slidably mounted within a slot of the rotor. The length of the vane, the shape of the cavity and the position of rotor within the cavity are such that the opposing ends of the vane remain substantially in contact with the wall of the casing defining the cavity at all rotational positions of the rotor. It will be appreciated however that a slight gap is provided between the tips of the vane and the cavity wall so as to ensure that the vane does not seize or jam against the cavity wall. In use, lubricating oil is introduced into the cavity to seal the gap between the vane tips and the cavity wall

[0003] In use, the rotor and vane are rotated to draw air into the cavity through the inlet and out of the cavity through the outlet.

[0004] It is possible that the engine to which the pump is fitted may turn in reverse, with the result that the rotor and vane rotate in the direction opposite to their normal rotational direction. This can potentially result in lubrication oil becoming trapped between the rotor, vane and/or cover and the wall of the casing causing a hydraulic lock which can damage the pump. Sliding vane vacuum pumps are thus typically provided with an oil relief valve which permits oil entrained by the reverse rotation of the rotor and vane to be vented from the cavity through a relief port or aperture before a hydraulic lock can occur. The valve may include a flexible a reed element which is urged against a seat which surrounds the port or aperture extending through the casing from the cavity. Problems can exist in achieving effective sealing of such oil relief valves during assembly as any contamination in the form of, for example, particulate matter can hold the reed element away from it's seat.

[0005] According to the present invention there is provided a sliding vane vacuum pump including a casing having a cover which together define a cavity, a rotor and a vane slidably mounted to said rotor, said pump further including an inlet passage extending from the exterior of the pump to the cavity and an outlet passage extending from the exterior of the pump to the cavity, wherein the pump further includes an oil relief arrangement operable to vent lubricating oil from the cavity to the exterior of the pump in the event of reverse rotation of the rotor and vane, the oil relief arrangement including an oil relief passage extending from the cavity to the exterior of the pump, said oil relief passage extending between respective apertures in the cavity and casing or cover, a valve member received in a seat provided around the aperture in the casing, and a resilient member positioned so as to urge the valve member into said seat.

[0006] In the event that reverse rotation of the rotor and vane occurs, then lubricating oil swept before the vane is directed into the oil relief passage through the aperture in the cavity. Once the pressure of the oil in the oil relief passage exceeds the force applied to the valve member by the resilient member, then the valve member lifts from the seat and permits the oil and any air mixed therewith in the form of oil foam or bubbles to exit from the passage. The resilient member urges the valve member back into the seat when the pressure within the oil relief passage drops below the force applied to the valve member by the resilient member.

[0007] The valve member may be at least part spherical. The valve member is preferably spherical. It will be appreciated that a spherical or part spherical valve member, together with an appropriately configured seat, defines a minimal valve member to seat contact area. This minimal contact area is resistant to the degradation of sealing efficiency between the valve member and seat which may be caused by particulate contamination during assembly. The spherical or part spherical valve member is in point contact with the resilient member. Such point contact is resistant to the build up of contaminants such as, for example, grease and dirt, between the valve and resilient members which could adversely affect the energisation of the valve member by the resilient member. The valve member may be constructed from a material that is resiliently deformable. In such an embodiment, the valve member may be constructed from a material which is resiliently deformed by the action of the resilient member. In an alternative embodiment the valve member may not be deformable. For example, the valve member may be made from steel.

[0008] The valve member may be received in a recess of the casing. In such an embodiment the casing aperture of the oil relief passage may be provided in the base of said recess. The recess may be provided with a drain channel which, in use, permits oil to drain from the recess. The base of the channel may be aligned with the base of the recess. The channel may extend in a direction orthogonal to the direction of the oil relief passage. The recess may be provided with a plurality of drain channels

[0009] The resilient member may comprise a flexible planar member. In such an embodiment the flexible planar member may be connected to the casing at one edge in the manner of a reed valve. In an alternative embodiment the flexible planar member may be connected to the casing at a position intermediate opposing edges thereof. In such an embodiment a first portion of the pla-

nar member extending from the connection position to an edge thereof may form the resilient member of the present invention, and a second portion of the planar member extending from the connection position to the opposing edge thereof may form a further resilient member. In such an embodiment the further resilient member may define an outlet valve of the pump.

[0010] An embodiment of the present invention will now be described with reference to the accompanying drawings in which:

Figure 1 shows a partial cross-sectional view of a vacuum pump casing and cavity having an oil relief valve according to the present invention;

Figure 2 shows a perspective view of the exterior of a vacuum pump casing having an oil relief valve according to the present invention; and

Figure 3 shows a plan view of the exterior of a vacuum pump casing having an oil relief valve according to the present invention.

[0011] Referring to the figures there is shown the casing 10 of a sliding vane vacuum pump. The casing 10 includes a cavity 12 within which, in use, a rotor (not shown) and a sliding vane (not shown) are provided. The cavity 12 is provided with a circular aperture 14 within which the rotor is situated, in use. The central axis 16 of the aperture corresponds to the axis of rotation of the rotor and vane, in use. The normal direction of rotation of the rotor and vane is indicated by arrow 18. The rotor has a larger diameter portion which, in use projects into the cavity 12 and a smaller diameter portion which, in use, is received in the circular aperture 14. The cavity 12 is provided with a cut out 80 which corresponds to the shape of the larger diameter portion of the rotor and within which the rotor is received, in use.

[0012] The casing 10 is further provided with an outlet passage 20 which extends from the cavity 12 to the exterior of the casing 10, and an oil relief passage 22 which extends from the cavity 12 to the exterior of the casing 10. The casing 10 is further provided with an inlet passage 24 which extends from the cavity 12 to the exterior of the casing 10.

[0013] The outlet passage 20 extends between an aperture 26 in a peripheral wall 28 of the cavity 12 and an aperture 30 to the exterior of the casing 10. The outlet passage 20 is provided with a valve arrangement generally designated 32. The valve arrangement 32 includes a resilient reed member 34 which is biased against a raised seat 36 which surrounds the aperture 30. The reed member 34 is connected to the casing 10 by a threaded fastener 38 which is received in a complementarily formed blind recess 40 of the casing 10. The reed member 34 is surmounted by a curved plate 42 which, in use, limits the deflection of the reed member 34 from the seat 36. The curved plate 42 is connected to the casing 10 by the same fastener 38 as the reed member 34.

[0014] The oil relief passage 22 extends between an aperture 44 in a peripheral wall 28 of the cavity 12 and an aperture 46 to the exterior of the casing 10. The aperture 46 is recessed into the casing 10 and is provided at the base of a recess 48 in the casing 10. The oil relief passage 22 is provided with a valve arrangement generally designated 50. The valve arrangement 50 includes a resilient reed member 52, a spherical valve member 54 and a valve seat 56 surrounding the aperture 46. The combination of the spherical valve member 54 and circular seat 56 defines a minimal valve member to seat contact area. This minimal contact area is resistant to the degradation of sealing efficiency between the valve member and seat which may be caused by particulate contamination during, for example assembly or use over time. The spherical valve member 54 is provided in the recess 48 of the casing 10 over the aperture 46. The spherical valve member 54 is energised and thus biased against the valve seat 56 by the reed member 52. As can be seen from figure 1, the reed member 52 is deflected by the spherical valve member 54. The spherical valve member 54 may be comprised of a material which resiliently deforms slightly under the load applied by the reed member 52 and hence ensures that an airtight seal is provided between the spherical valve member 54 and the valve seat 56. The reed member 52 is surmounted by a curved plate 58 which, in use, limits the deflection of the reed member 52 from the recess 48. The spherical shape of the valve member 54 and the substantially flat configuration of the reed member 52 results in point contact between the valve and reed members 54,52. Such point contact is resistant to the build up of contaminants such as, for example, grease and dirt, between the valve and reed members 54,52 which could adversely affect the energisation of the valve member 54 by the reed member 52.

[0015] In an alternative embodiment the valve member 54 may be part spherical. In such an embodiment the spherical portions of the valve member 54 are alingned with both the reed member 52 and circular seat 56 to maintain the aforementioned advantages of minimal valve member to seat contact area and point contact between the valve and reed members 54,52.

[0016] In the embodiment shown the outlet and oil relief passage reed members 34,52 are defined by opposing ends of a common component 60. Similarly, the outlet and oil relief passage curved plates 42, 58 are defined by opposing ends of a common component 62. Both components 60,62 are retained to the casing 10 by a common fastener 38. It will be appreciated that, in an alternative embodiment, the outlet and oil relief passage reed members 34,52 and the outlet and oil relief passage curved plates 42, 58 may comprise separate components which are retained to the casing 10 by separate fasteners.

[0017] The recess 48 within which the spherical valve member 54 is situated is provided with opposed channels 64,66 which extend through portions of the casing which define the recess. The base 68,70 of each channel 64,66 is provided substantially at the level of the valve seat 56.

In the embodiment shown the channels 64,66 are provided in a direction substantially orthogonal to the axis of the oil relief passage 22. The channels 64,66 may extend in other directions.

[0018] In use, the vacuum pump is operated to draw air into the cavity 12 through the inlet passage 24 and to eject said air from the cavity 12 through the outlet passage 20. This is achieved by rotating the rotor and vane in the direction indicated by arrow 18. The cavity 12 may be considered to have an inlet side 72 and an outlet side 74. Broken line 76 indicates this division. On the inlet side 72 of the cavity 12, movement of the vane by the rotor results in the provision of a volume defined by the rotor, vane and cavity 12 which expands as the rotor rotates. This expansion of the defined volume draws air into the cavity 12 through the inlet passage 24. The location of the spherical valve member 54 to the oil relief passage valve seat 56 prevents air from being drawn into the cavity 12 through the oil relief passage 22.

[0019] On the outlet side 72 of the cavity 12, movement of the vane by the rotor in the direction indicated by arrow 18 causes the volume defined by the rotor, van and cavity 12 to contract. This contraction of the defined volume raises the pressure of the air contained therein with the result that the outlet passage reed member 34 is lifted from the seat 36. Continued rotation of the rotor and vane results in the air contained in the contracting volume being ejected from the cavity 12 through the outlet passage 20. Any lubricating oil which is swept in the direction of the outlet passage 20 by the vane is ejected through the outlet passage 20 by the vane.

[0020] In the event that the rotor and vane are moved in the opposite direction, as indicated by arrow 78, lubricating oil may be swept in the direction of the inlet and oil relief passages 24,22. While a portion of any such lubricating oil may be conducted into the inlet passage 24, the remainder is driven towards and into the oil relief passage 22. In the event that the volume of lubrication oil is greater than the volume of the oil relief passage 22, then the substantially incompressible nature of the oil and the pressure applied there to by the rotation of the vane results in the spherical valve member 54 being lifted from the valve seat 56. The movement of the valve member 54 away from the seat 56 is guided by the walls of the recess 48. The clearance between the valve member 54 and the walls of the recess 48 may be insufficient to allow the oil to move freely past the valve member 54. In such an event the oil within the passage 22 is thus able to pass into the channels 64,66 in order to reach the exterior of the casing 10.

Claims

1. A sliding vane vacuum pump including a casing (10) having a cover which together define a cavity (12), a rotor and a vane slidably mounted to said rotor, said pump further including an inlet passage extending from the exterior of the pump to the cavity (12) and an outlet passage (20) extending from the cavity (12) to the exterior of the pump, wherein the pump further includes an oil relief arrangement operable to vent lubricating oil to the exterior of the pump in the event of reverse rotation of the rotor and vane, the oil relief arrangement including an oil relief passage (22) extending from the cavity (12) to the exterior of the casing (10) or cover, said oil relief passage (22) extending between respective apertures (26,30) in the cavity (12) and casing (10) or cover, a spherical valve member (54) received in a seat (56) provided around the aperture (50) in the casing (10), and a resilient member (52) positioned so as to urge the spherical valve member (54) into said seat (56), wherein the resilient member (52) is in point contact with the spherical valve member (54); and
wherein location of the spherical valve member (54) to the seat (56) by the resilient member (52) prevents air from being drawn into the cavity (12) through the oil relief passage (22).

2. A sliding vane vacuum pump as claimed in any of claim 1 wherein the valve member (54) is constructed from a material that is resiliently deformable by the force applied thereto by the resilient member (52).

3. A sliding vane vacuum pump as claimed in claim 1 wherein the valve member (54) is constructed from a material which is not deformable by the force applied thereto by the resilient member (52).

4. A sliding vane vacuum pump as claimed in any preceding claim wherein the valve member (54) is received in a recess (48) of the casing (10).

5. A sliding vane vacuum pump as claimed in claim 4 wherein the casing aperture (30) of the oil relief passage (72) is provided in the base of said recess (48).

6. A sliding vane vacuum pump as claimed in claim 4 or claim 5 wherein the recess (48) is provided with a drain channel (64,66) which, in use, permits oil to drain from the recess (48).

7. A sliding vane vacuum pump as claimed in claim 6 wherein the base of the drain channel (64,66) is aligned with the base of the recess (48).

8. A sliding vane vacuum pump as claimed in claim 6 or claim 7 wherein the drain channel (64,66) extends in a direction orthogonal to the direction of the oil relief passage (22).

9. A sliding vane vacuum pump as claimed in any of claims 6 to 8 wherein the recess (48) is provided with a plurality of drain channels (64,66).

10. A sliding vane vacuum pump as claimed in any preceding claim wherein the resilient member (52) comprises a flexible planar member.

11. A sliding vane vacuum pump as claimed in claim 10 wherein the flexible planar member is connected to the casing (12) at one edge in the manner of a reed valve.

12. A sliding vane vacuum pump as claimed in claim 10 wherein the flexible planar member is connected to the casing at a position intermediate opposing edges thereof.

13. A sliding vane vacuum pump as claimed in claim 12 wherein a first portion of the planar member extending from the connection position to an edge thereof defines the resilient member (52) of the present invention, and a second portion of the planar member extending from the connection position to the opposing edge thereof defines a further resilient member (34).

14. A sliding vane vacuum pump as claimed in claim 13 wherein the further resilient member (34) defines an outlet valve of the pump.

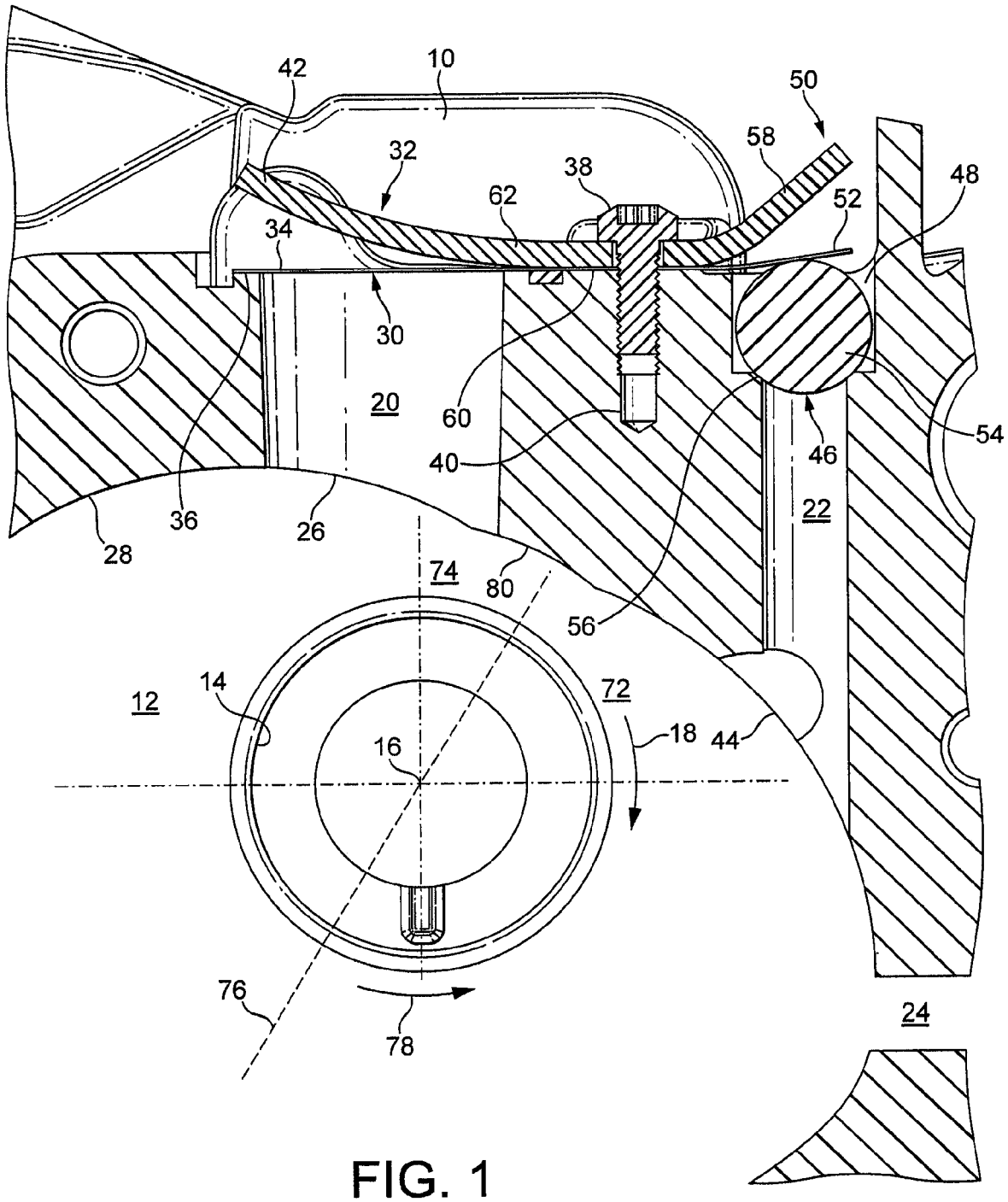
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FIG. 1

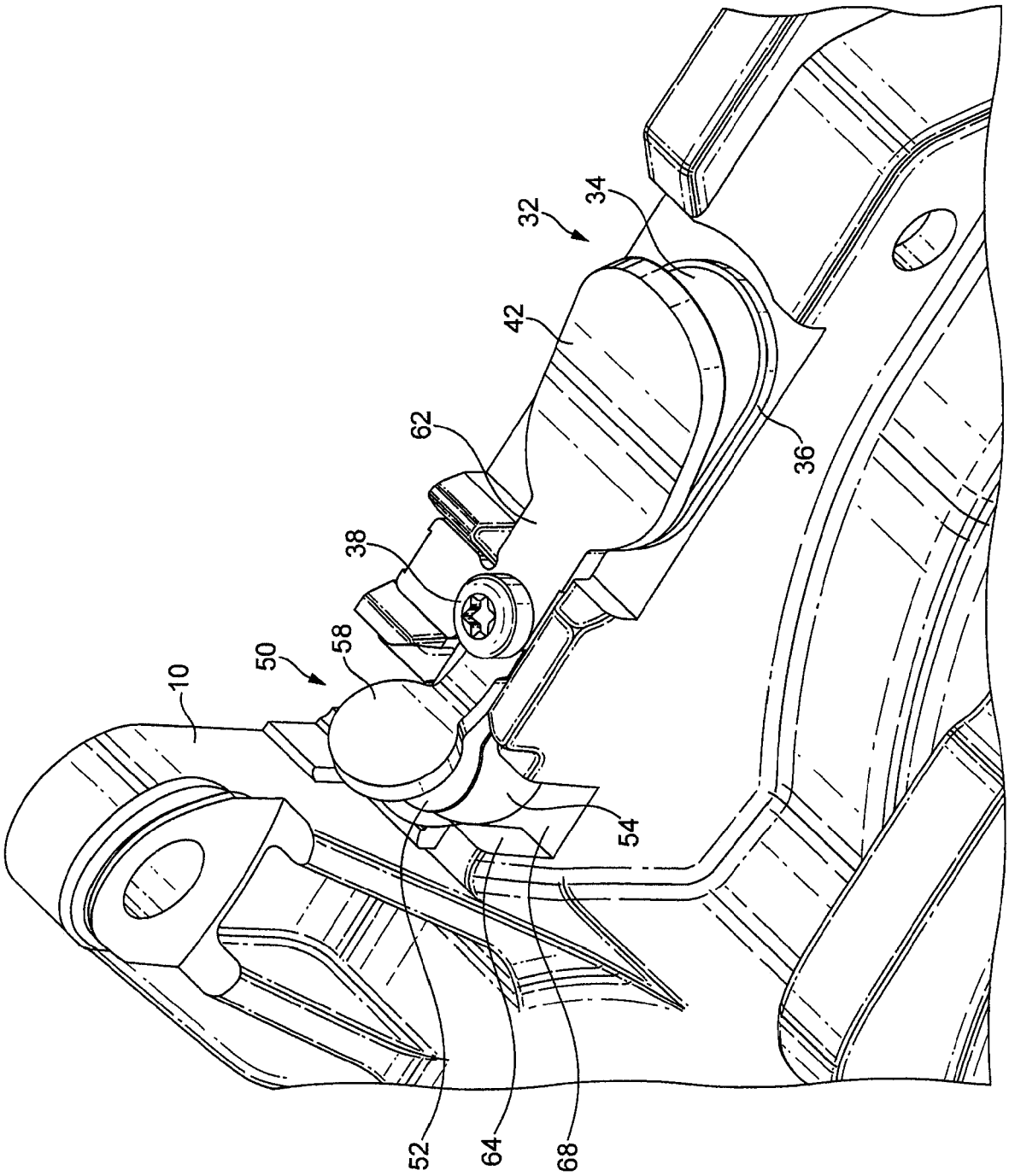

FIG. 2

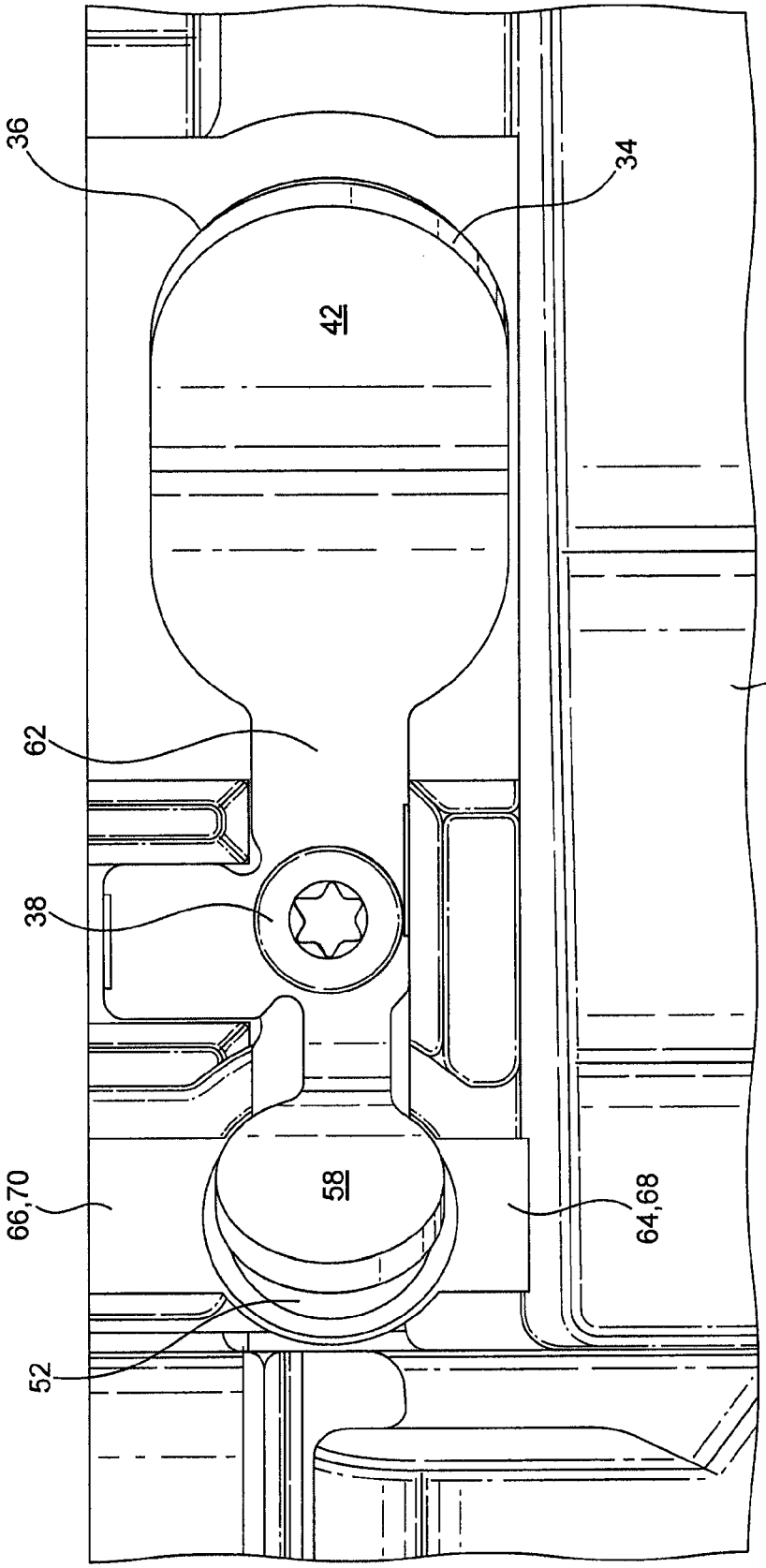

FIG. 3

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EUROPEAN SEARCH REPORT

Application Number
EP 14 19 1836

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	DE 100 00 755 A1 (HITACHI LTD [JP]; SANWA SEIKI LTD [JP]) 20 July 2000 (2000-07-20) * the whole document * * column 1, line 26 - line 41 * * column 3, line 24 - column 4, line 8 *	1-7,9	INV. F04C18/344 F04C28/28 F04C29/02 F04C28/06
X Y	EP 0 255 920 A2 (BARMAG BARMER MASCHF [DE]) 17 February 1988 (1988-02-17) * the whole document * * column 1, line 33 - line 39 * * column 2, line 7 - line 24 *	1-7,9 1,10,11	
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TECHNICAL FIELDS SEARCHED (IPC)

F04C
F01C
F16K

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	23 February 2015	Sbresny, Heiko

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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A : technological background
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D : document cited in the application
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EUROPEAN SEARCH REPORT

Application Number
EP 14 19 1836

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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			TECHNICAL FIELDS SEARCHED (IPC)

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	23 February 2015	Sbresny, Heiko

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Application Number
EP 14 19 1836

CLAIMS INCURRING FEES

The present European patent application comprised at the time of filing claims for which payment was due.

☐ Only part of the claims have been paid within the prescribed time limit. The present European search report has been drawn up for those claims for which no payment was due and for those claims for which claims fees have been paid, namely claim(s):

☐ No claims fees have been paid within the prescribed time limit. The present European search report has been drawn up for those claims for which no payment was due.

LACK OF UNITY OF INVENTION

The Search Division considers that the present European patent application does not comply with the requirements of unity of invention and relates to several inventions or groups of inventions, namely:

see sheet B

☐ All further search fees have been paid within the fixed time limit. The present European search report has been drawn up for all claims.

☒ As all searchable claims could be searched without effort justifying an additional fee, the Search Division did not invite payment of any additional fee.

☐ Only part of the further search fees have been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the inventions in respect of which search fees have been paid, namely claims:

☐ None of the further search fees have been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the invention first mentioned in the claims, namely claims:

☐ The present supplementary European search report has been drawn up for those parts of the European patent application which relate to the invention first mentioned in the claims (Rule 164 (1) EPC).

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LACK OF UNITY OF INVENTION
SHEET B

Application Number
EP 14 19 1836

The Search Division considers that the present European patent application does not comply with the requirements of unity of invention and relates to several inventions or groups of inventions, namely:

1. claims: 1-14

A sliding vane vacuum pump with an oil relief passage.

1.1. claims: 1-9

A sliding vane vacuum pump with an oil relief passage provided with a drain channel "orthogonal to the direction of the oil relief passage".

1.2. claims: 1, 10-14

A sliding vane vacuum pump with an oil relief passage having a valve provided with a "flexible planar member".

Please note that all inventions mentioned under item 1, although not necessarily linked by a common inventive concept, could be searched without effort justifying an additional fee.

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 14 19 1836

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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23-02-2015

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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82