

(19)



(11)

EP 3 303 843 B1

(12)

EUROPEAN PATENT SPECIFICATION

(45) Date of publication and mention
of the grant of the patent:
20.05.2020 Bulletin 2020/21

(51) Int Cl.:
F04C 25/02 ^(2006.01) **F04C 18/344** ^(2006.01)
F04C 29/02 ^(2006.01)

(21) Application number: **15727378.0**

(86) International application number:
PCT/EP2015/062285

(22) Date of filing: **02.06.2015**

(87) International publication number:
WO 2016/192782 (08.12.2016 Gazette 2016/49)

(54) **AUTOMOTIVE VACUUM PUMP**

KRAFTFAHRZEUGVAKUUMPUMPE

POMPE À VIDE POUR AUTOMOBILE

(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**

- **ROMBACH, Michael**
41470 Neuss (DE)
- **PACHETTI, Carlo**
I-56121 Cascina (Pisa) (IT)

(43) Date of publication of application:
11.04.2018 Bulletin 2018/15

(74) Representative: **terpatent Patentanwälte ter
Smitten**
Eberlein-Van Hoof Rütten Daubert
Partnerschaftsgesellschaft mbB
Burgunderstraße 29
40549 Düsseldorf (DE)

(73) Proprietor: **Pierburg Pump Technology GmbH**
41460 Neuss (DE)

(72) Inventors:

- **PERONI, Giorgio**
I-19038 Sarzana (IT)
- **SQUARCINI, Raffaele**
I-57127 Livorno (IT)

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Description

[0001] The invention is directed to an automotive vacuum pump which is lubricated with oil, and is preferably directed to a mechanical automotive vacuum pump which is mechanically driven by an internal combustion engine.

[0002] An automotive vacuum pump is provided with a housing arrangement which encloses a pumping chamber and rotatably supports a pump rotor with a pump rotor body. The pump rotor body can be separated in axial direction into two functional sections, namely a bearing section and a vane section. In the bearing section, the rotor body is radially supported rotatably at the pump housing arrangement. In the vane section, the rotor body is provided with at least one vane slit wherein at least one slidable pump vane is slidably supported. The pump vane or the pump vanes separate the pumping chamber into several rotating pumping compartments.

[0003] The housing arrangement is provided with a pumping chamber gas inlet opening through which gas flows into the pumping chamber and with a pumping chamber gas outlet opening through which compressed gas leaves the pumping chamber. The gas inlet opening and the gas outlet opening, in most cases, are provided in a pump chamber front end wall which lies in a radial plane perpendicular to the rotational axis of the pump rotor.

[0004] The vacuum pump is supplied with pressurized oil which is used to improve the pneumatic performance and, in case of a mechanical vacuum pump, is also used to lubricate the mechanical coupling of the vacuum pump. A particular amount of oil is supplied into the pumping chamber so that not only gas but also oil has to be discharged from the pumping chamber to avoid extensive vibrations and a deformation of the pump vane in the final discharge phase of the respective pumping compartment. In state-of-the-art vacuum pumps, the oil is discharged together with the gas through one single combined gas and oil outlet opening. It is also known, to provide a separate oil outlet opening in a front end wall of the housing arrangement. The separate oil outlet opening is arranged behind the gas outlet opening, seen in the direction of rotation. As a consequence, the oil outlet opening is relatively small so that the flow and pressure conditions during the oil discharge phase can be dramatic, in particular at high rotational speed.

[0005] EP 2 677 118 A1 discloses an automotive vacuum pump with an oil opening provided at the rotor body. The oil discharge path is opened dependent on the rotor position.

[0006] It is an object of the invention to provide an automotive vacuum pump with a smoother oil discharge characteristics.

[0007] This object is solved with an automotive vacuum pump with the features of claim 1.

[0008] The automotive vacuum pump according to the invention is provided with a rotor body which is provided with a separate oil outlet opening which is open to the

pumping chamber and through which the oil is discharged from the rotating pumping compartment in the final compression phase of the respective pumping compartment. The oil outlet opening is not provided in a static housing wall anymore, but is co-rotatably provided at the rotor body. The gas outlet opening is preferably arranged at a static side wall of the pump housing arrangement. Therefore, the gas outlet opening and the separate oil outlet opening are not in conflict anymore with respect to the available surface. Since the oil outlet opening is not provided at the housing, the opening angle of the oil outlet opening can be increased significantly. Since the opening angle of the oil outlet opening is increased, there is more time to discharge the oil from the rotating pumping compartment in the final compression phase of the pumping compartment. As a consequence, the oil discharge process is smoother, in particular at high rotational speed of the pump rotor. This leads to decreased noise, decreased vibration and decreased wearout of the mechanical components.

[0009] The gas openings are in fluidic connection with a pump gas inlet and with a pump gas outlet, respectively. It is not excluded that oil is flowing through a gas opening. The oil outlet opening has the main function to lead oil to a separate oil outlet, not to the pump gas outlet. But it can not be excluded that also gas is discharged through the oil outlet opening.

[0010] According to a preferred embodiment, the oil outlet opening is provided in the longitudinal cylindrical vane section of the rotor body. The oil outlet opening is not provided in the bearing section of the rotor body. More preferably, the complete oil outlet opening is provided in the cylindrical vane section of the rotor body.

[0011] Preferably, the pumping chamber is covered by two front end walls both lying in a radial plane so that the end walls are lying in a plane perpendicular to the rotational axis of the pump rotor. The oil outlet opening is provided adjacent to one end wall, and is in particular provided adjacent to the front end wall which is lying below the other end wall, with respect to the vector of gravitation, when the vacuum pump is mounted in an automobile. The oil outlet opening is preferably placed as close as possible to the bottom plane of the rotor to minimize the pressure drop all along the rotor's internal duct. More preferably, the oil outlet opening is arranged at the lowest point of the pumping chamber in the final phase of the compression interval of the respective pumping compartment. This arrangement of the oil outlet opening makes sure that the oil volume which is accumulated at the lowest gravitational location within the rotating pumping compartment can directly be discharged via the oil outlet opening when the rotating oil outlet opening arrives at the final compression phase of the respective pumping compartment.

[0012] The opening angle of the oil outlet opening is smaller than the angle of the gas-tight commutation sector between the gas outlet opening and the gas inlet opening so that the oil outlet opening can not define a fluidic

bypass with respect to the commutation sector. The opening angle of the outlet opening is an angle lying in a radial plane and with the sector center lying in the rotational axis of the pump rotor.

[0013] According to a preferred embodiment, the oil outlet opening is provided in the lagging third of the respective pumping compartment, and preferably in the lagging fourth of the respective pumping compartment. As a result, the oil outlet opening arrives at the final compression zone right before the vane head arrives at the commutation sector which is the liquid-tight sector between the gas outlet opening and the gas inlet opening, seen in the direction of rotation. In other words, the oil outlet opening is arranged in that sector of the respective pumping compartment which arrives at last at the gas-tight commutation sector.

[0014] According to a preferred embodiment, the pump rotor is provided with a coupling structure at one axial coupling end of the rotor body. Preferably, the coupling structure is provided at one axial coupling end which is defined by the bearing section of the rotor body. The rotor body is provided with an oil conduct which fluidically connects the oil outlet opening to the axial coupling end. As a result, the coupling structure is directly lubricated with the oil which is discharged via the oil outlet opening.

[0015] Preferably, the oil discharge opening is provided with a check-valve so that a backflow of the oil in direction from the axial coupling structure and back to the oil outlet opening is avoided.

[0016] According to a preferred embodiment, the vacuum pump is provided as a single-vane pump with one single pump vane which can have two vane parts which are slidable to each other. The single vane is supported by the single vane slit which radially penetrates the rotor body. At least two oil outlet openings are provided at the rotor body, one oil outlet opening in each pumping compartment.

[0017] One embodiment of the invention is described referring to the drawings, wherein

figure 1 shows a cross-section of a mechanical automotive vacuum pump including a pump rotor with two oil outlet openings,

figure 2 shows a longitudinal section of the vacuum pump of figure 1,

figure 3 shows a longitudinal section of the pump rotor of the vacuum pump of figures 1 and 2, and

figure 4 shows a plan view of the bearing section including a coupling structure of the pump rotor of the vacuum pump of figures 1 and 2.

[0018] The figures show a mechanical automotive vacuum pump 10 which provides an absolute pressure of below 100 mbar for supplying, for example, a pneumatic breaking force device with low pressure. The mechanical vacuum pump 10 is mechanically driven by an automotive engine, for example by an internal combustion engine.

[0019] The vacuum pump 10 comprises a static housing arrangement 12 which supports and substantially houses a rotatable pump rotor 14. The housing arrangement 12 comprises a complex and pot-shaped housing main body 11 for radially enclosing and rotatably supporting the pump rotor 14 and comprises a separate housing cover lid 13 for axially closing one axial end of the housing arrangement 12.

[0020] The pump rotor 14 comprises a plastic pump rotor body 30 with a substantially cylindrical and stepless outer surface over the entire axial length of the rotor body 30. The rotor body 30 is axially provided with two functional partitions, namely the vane section 16 with a vane slit 32 and the bearing section 18 where the rotor body 30 is rotatably supported at the housing body 11 by a frictional bearing. The vane slit 32 supports a radially shiftable pump vane 33 which is defined by one single vane body 34 which is co-rotating with the rotor body 30.

[0021] The housing arrangement 12 defined by the housing body 11 and the housing lid 13 encloses a pumping chamber 17 wherein the pump vane 33 is rotating. The housing lid 13 defines one axial front end wall 64 and a ring-like portion of the housing body 11 defines the other front end wall 62 of the pumping chamber 17. The pump vane 33 separates the pumping chamber 17 into two pumping compartments 171, 172 which rotate when the pump rotor 14 is rotating.

[0022] In the bearing section 18, the rotor body 30 is provided with a cylindrical bearing surface which defines together with a corresponding cylindrical bearing surface of the housing main body 11 a radial friction bearing. The rotor 14, in this embodiment, is supported only by one radial bearing so that the rotor body 14 is supported cantilevered. The bearing-sided axial coupling end 72 of the rotor 14 is provided with a bearing ring surface which is axially supported by a corresponding axial bearing ring surface defined by the housing main body 11. The two bearing ring surfaces together define an axial friction bearing. As shown in figure 4, the bearing-sided coupling end 72 of the rotor 14 is provided with a coupling structure 70 for coupling a corresponding coupling structure of a pump driving means. The other front end of the rotor body 30 is axially supported by the housing lid 13.

[0023] The bearing-sided front end wall 62 is provided with a sickle-shaped gas inlet opening 26 and with a sickle-shaped gas outlet opening 22. The gas inlet opening 26 is fluidically connected to a pump inlet 28 via a gas inlet channel 27. The gas outlet channel is fluidically connected to a pump outlet via a gas outlet channel 23. The gas inlet channel 27 and the gas outlet channel 23 are defined as bores in a ring body section 20 of the housing body 11.

[0024] Seen in circumferential direction, a commutation sector 60 is defined between the gas outlet opening 22 and the gas inlet opening 26, see Fig. 1. In the commutation sector 60, the rotor body 30 is arranged directly adjacent to the circumferential wall 80 of the housing body 11 so that the commutation sector 60 defines a gas-

tight section thereby avoiding a flow-back of compressed gas. The commutation width of the commutation sector 60, seen in circumferential direction, is equal or larger than the thickness of the vane body 34 or of the vane slit 32.

[0025] The rotor body 30 is provided with two separate oil outlet openings 40, 40' defined by outlet recesses 41, 41' which are both radially orientated and open to the respective pumping compartment 171, 172. The oil outlet openings 40, 40' both respectively lie in a cylindrical plane defined by the cylindrical outer surface of the rotor body 30. In the present embodiment, the pump rotor 14 rotates in clockwise direction so that the oil outlet openings 40, 40' both are arranged in the lagging fourth of the respective rotating pumping compartment 171, 172, so that the respective outlet opening 40, 40' arrives at the commutation sector 60 in the final part of the compression phase of the respective pumping compartment 171, 172. The opening angle 66 of the oil outlet openings is slightly smaller than the commutation sector angle of the commutation sector 60 where the cylindrical commutation slit is gas-tight. The oil outlet openings 40, 40' are both provided axially adjacent to the ring-like front end wall 62 which is provided with the gas outlet opening 22 and the gas inlet opening 26. Figure 2 shows the preferred orientation of the vacuum pump 10 when the vacuum pump 10 is mounted in an automobile. The ring-like front end wall 62 is preferably lying below the other front end wall 64 so that oil is collected at the ring-like front end wall 62 because of gravity.

[0026] The oil outlet openings 40, 40' are fluidically connected with corresponding oil discharge openings 44, 44' which are located at the axial coupling end 72 of the rotor body 30. The oil outlet opening 40, 40' and the corresponding oil discharge openings 44, 44' are connected by respective oil ducts 42, 42', 43, 43' which are a radial bore duct 42, 42' and an axial bore duct 43, 43'.

[0027] Both discharge openings 44, 44' are provided with a check valve 76, 76', respectively, which comprises a sheet-like valve body 45, 45' and a valve stop 46, 46' which limits the opening movement of the valve body 45, 45'. The valve body 45, 45' is defined by a sheet-like flexible tongue and opens the discharge openings 44, 44' when the pressure of the fluid in the respective oil outlet opening 40, 40' is above an opening pressure difference which is, for example, 100 mbar.

[0028] When the pump 10 is in use and the rotor 14 is rotating, gas, in particular air, is sucked through the pump inlet 28 and the gas inlet opening 26 into the rotating pumping compartment 172 at the suction side. The gas is transported in the rotating pumping compartment 172 to the compression side so that the compressed gas is pumped through the gas outlet opening 22 to the pump outlet 24. The pump outlet 24 can be provided with a check valve which avoids a flow back of gas into the pumping chamber 17.

[0029] During all pumping phases, a limited amount of oil is pumped into the interior of the pump 10 so that oil

is also accumulated within the pumping chamber 17. The oil in the pumping chamber 17 is in particular accumulated at the bottom front end wall 62 and is accumulated in the remaining volume of the compression-sided pumping compartment 171 in the final compression phase. As soon as the fluid pressure in the pumping compartment 172 is higher than the atmospheric counter pressure plus the opening pressure difference, the corresponding check valve 76 opens and the oil is discharged to the area of the coupling structure 70.

[0030] As soon as the oil outlet opening 40 is completely covered by the circumferential wall 80 in the commutation sector 60, the check valve 76 closes.

Claims

1. An automotive vacuum pump (10) with a housing arrangement (12) enclosing a pumping chamber (17) and rotatably supporting a pump rotor (14) with a rotor body (30) having a bearing section (18) and a vane section (16), wherein the vane section (16) of the rotor body (30) is provided with a vane slit (32) wherein a slidable pump vane (33) is supported which separates the pumping chamber (17) into several rotating pumping compartments (171, 172), the housing arrangement (12) is provided with a pumping chamber gas inlet opening (26) and with a pumping chamber gas outlet opening (22),
characterised in that
the rotor body (30) is provided with a separate oil outlet opening (40,40') which is lying in a cylindrical plane defined by the cylindrical outer surface of the rotor body (30) and which is open to the pumping chamber (17), and
the opening angle (66) of the oil outlet opening (40, 40') is smaller than the gas-tight commutation sector (60) defined between the gas outlet opening (22) and the gas inlet opening (26), whereas the opening angle (66) is an angle lying in a radial plane and with the sector center lying in the rotational axis of the pump rotor (14).
2. The automotive vacuum pump (10) of claim 1, wherein the oil outlet opening (40,40') is provided in the longitudinal cylindrical vane section (16) of the rotor body (30).
3. The vacuum pump (10) of one of the preceding claims, wherein the pumping chamber (17) is covered by two front end walls (62, 64) both lying in a radial plane, and wherein the oil outlet opening (40,40') is provided adjacent to one front end wall (62).
4. The automotive vacuum pump (10) of one of the preceding claims, wherein the oil outlet opening (40;40')

is provided in the lagging third, preferably in the lagging fourth of the respective rotating pumping compartment (171, 172).

5. The automotive vacuum pump (10) of one of the preceding claims, wherein the pump rotor (14) is provided with a coupling structure (70) at one axial coupling end (72) of the rotor body (30), and wherein the rotor body (30) is provided with an oil duct (42, 43) which fluidically connects the oil outlet opening (40, 40') to the axial coupling end (72). 5 10
6. The automotive vacuum pump (10) of one of the preceding claims, wherein the axial coupling end (72) is provided with an oil discharge opening (44, 44') which is fluidically connected to the oil outlet opening (40, 40'), and wherein every oil discharge opening (44, 44') is provided with a check-valve (76, 76'). 15
7. The automotive vacuum pump (10) of one of the preceding claims, wherein one single pump vane (33) with one single vane body (34) is supported in the single vane slit (32) which radially penetrates the rotor body (30), and wherein two oil outlet openings (40; 40') are provided at the rotor body (30), one in each pumping compartment (171, 172). 20 25

Patentansprüche

1. Kraftfahrzeugvakuumpumpe (10) mit einer Gehäuseanordnung (12), die eine Pumpkammer (17) umschließt und einen Pumpenrotor (14) mit einem Rotorkörper (30) drehbar stützt, der einen Lagerabschnitt (18) und einen Flügelabschnitt (16) aufweist, wobei der Flügelabschnitt (16) des Rotorkörpers (30) mit einem Flügelschlitz (32) versehen ist, in dem eine gleitend verschiebbare Pumpenschaufel (33) gelagert ist, welche die Pumpkammer (17) in mehrere rotierende Pumpräume (171, 172) trennt, die Gehäuseanordnung (12) mit einer Pumpkammer-Gaseinlassöffnung (26) und mit einer Pumpkammer-Gasauslassöffnung (22) versehen ist, **dadurch gekennzeichnet, dass** der Rotorkörper (30) mit einer separaten Ölauslassöffnung (40, 40') versehen ist, die in einer zylindrischen Ebene liegt, welche durch die zylindrischen Außenflächen des Rotorkörpers (30) definiert ist und welche zu der Pumpkammer (17) offen ist, und der Öffnungswinkel (66) der Ölauslassöffnung (40, 40') kleiner ist als der zwischen der Gasauslassöffnung (60) 22) und der Gaseinlassöffnung (26) gebildete gasdichte Kommutierungssektor (60), wobei der Öffnungswinkel (66) ein Winkel ist, der in einer radialen Ebene liegt, und wobei der Sektormittelpunkt in der Drehachse des Pumpenrotors (14) liegt. 30 35 40 45 50 55

2. Kraftfahrzeugvakuumpumpe (10) nach Anspruch 1, wobei die Ölauslassöffnung (40, 40') in dem längsverlaufenden zylindrischen Schaufelabschnitt (16) des Rotorkörpers (30) vorgesehen ist.
3. Kraftfahrzeugvakuumpumpe (10) nach einem der vorhergehenden Ansprüche, wobei die Pumpkammer (17) von zwei vorderen Endwänden (62, 64) bedeckt ist, die beide in einer radialen Ebene liegen, und wobei die Ölauslassöffnung (40, 40') neben einer vorderen Endwand (62) vorgesehen ist.
4. Kraftfahrzeugvakuumpumpe (10) nach einem der vorhergehenden Ansprüche, wobei die Ölauslassöffnung (40; 40') im nacheilenden Drittel, vorzugsweise im nacheilenden Viertel des jeweiligen rotierenden Pumpenraums (171, 172) vorgesehen ist.
5. Kraftfahrzeugvakuumpumpe (10) nach einem der vorhergehenden Ansprüche, wobei der Pumpenrotor (14) an einem axialen Kupplungsende (72) des Rotorkörpers (30) mit einer Kupplungsstruktur (70) versehen ist und wobei der Rotorkörper (30) mit einem Ölkanal (42, 43) versehen ist, der die Ölauslassöffnung (40, 40') fluidisch mit dem axialen Kupplungsende (72) verbindet.
6. Kraftfahrzeugvakuumpumpe (10) nach einem der vorhergehenden Ansprüche, wobei das axiale Kupplungsende (72) mit einer Ölaustrittsöffnung (44, 44') versehen ist, die fluidisch mit der Ölauslassöffnung (40, 40') verbunden ist und wobei jede Ölauslassöffnung (46, 46') mit einem Rückschlagventil (76, 76') versehen ist.
7. Kraftfahrzeugvakuumpumpe (10) nach einem der vorhergehenden Ansprüche, wobei eine einzelne Pumpenschaufel (33) mit einem einzelnen Schaufelkörper (34) in dem einzelnen Schaufelschlitz (32) gelagert ist, der den Rotorkörper (30) radial durchsetzt, und wobei zwei Ölauslassöffnungen (40; 40') am Rotorkörper (30), nämlich eine in jedem Pumpraum (171, 172), vorgesehen sind.

Revendications

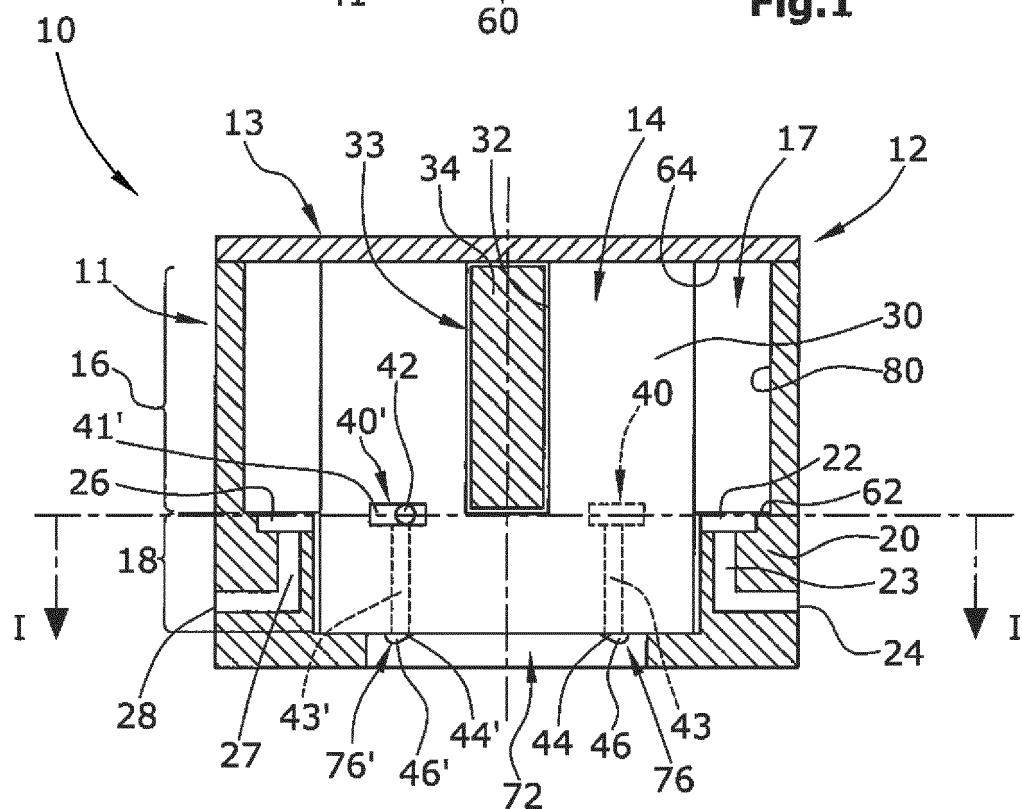
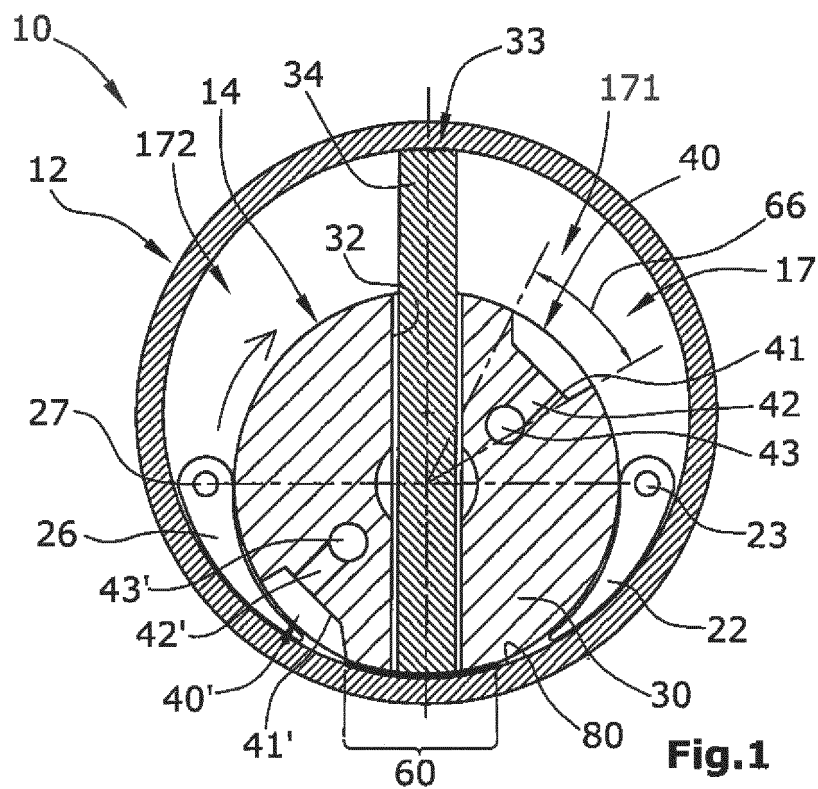
1. Pompe à vide pour automobile (10) avec un agencement de carter (12) renfermant une chambre de pompage (17) et supportant en rotation un rotor de pompe (14) avec un corps de rotor (30) ayant une section de palier (18) et une section d'aube (16), dans laquelle la section d'aube (16) du corps de rotor (30) est pourvue d'une fente d'aube (32) dans laquelle est supportée une aube de pompe (33) glissante qui sépare la chambre de pompage (17) en plusieurs compartiments de pompage rotatifs (171, 172),

le carter (12) est pourvu d'une ouverture d'entrée de gaz de la chambre de pompage (26) et d'une ouverture de sortie de gaz de la chambre de pompage (22), **caractérisée en ce que**

le corps de rotor (30) est pourvu d'une ouverture de sortie d'huile séparée (40, 40') qui est située dans un plan cylindrique défini par une surface extérieure cylindrique du corps de rotor (30) es qui est ouverte vers la chambre de pompage (17),
l'angle d'ouverture (66) de l'ouverture de sortie d'huile (40, 40') est inférieur au secteur de commutation étanche au gaz (60) défini entre l'ouverture de sortie de gaz (22) et l'ouverture d'entrée de gaz (26), tandis que l'angle d'ouverture (66) est un angle situé dans un plan radial et dont le centre du secteur est situé dans l'axe de rotation du rotor de pompe (14).

une seule aube de pompe (33) avec un seul corps d'aube (34) est supportée dans la fente à aube unique (32) qui pénètre radialement dans le corps du rotor (30), et dans laquelle deux ouvertures de sortie d'huile (40; 40') sont prévues sur le corps de rotor (30), une dans chaque compartiment de pompage (171, 172).

2. Pompe à vide pour automobile (10) selon la revendication 1, dans laquelle l'ouverture de sortie d'huile (40, 40') est prévue dans la section d'aube cylindrique longitudinale (16) du corps de rotor (30).
3. Pompe à vide pour automobile (10) selon l'une quelconque des revendications précédentes, dans laquelle la chambre de pompage (17) est couverte par deux parois d'extrémité avant (62, 64), les deux parois étant situées dans un plan radial, et dans laquelle l'ouverture de sortie d'huile (40, 40') est prévue à côté d'une paroi d'extrémité avant (62).
4. Pompe à vide pour automobile (10) selon l'une quelconque des revendications précédentes, dans laquelle l'ouverture de sortie d'huile (40; 40') est prévue dans le tiers en retard, de préférence dans le quart en retard du compartiment de pompage rotatif respectif (171, 172).
5. Pompe à vide pour automobile (10) selon l'une quelconque des revendications précédentes, dans laquelle le rotor de pompe (14) est pourvu d'une structure d'accouplement (70) à une extrémité d'accouplement axial (72) du corps de rotor (30), et dans lequel le rotor le corps (30) est pourvu d'un conduit d'huile (42, 43) qui relie fluidiquement l'ouverture de sortie d'huile (40, 40') à l'extrémité de couplage axial (72).
6. Pompe à vide pour automobile (10) selon l'une quelconque des revendications précédentes, dans laquelle l'extrémité d'accouplement axial (72) est pourvue d'une ouverture de décharge d'huile (44, 44') qui est connectée fluidiquement à l'ouverture de sortie d'huile (40, 40'), et dans laquelle chaque ouverture d'évacuation d'huile (46, 46') est pourvue d'un clapet anti-retour (76, 76').
7. Pompe à vide automobile (10) selon l'une quelconque des revendications précédentes, dans laquelle



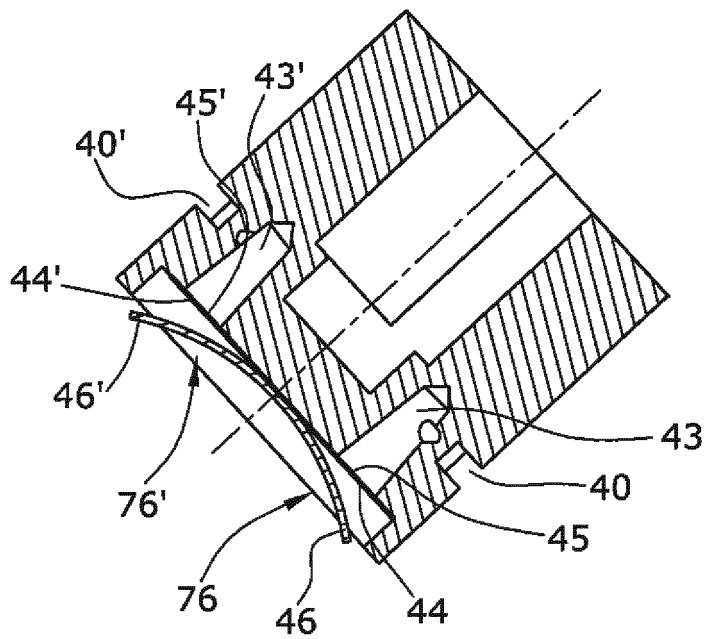


Fig.3

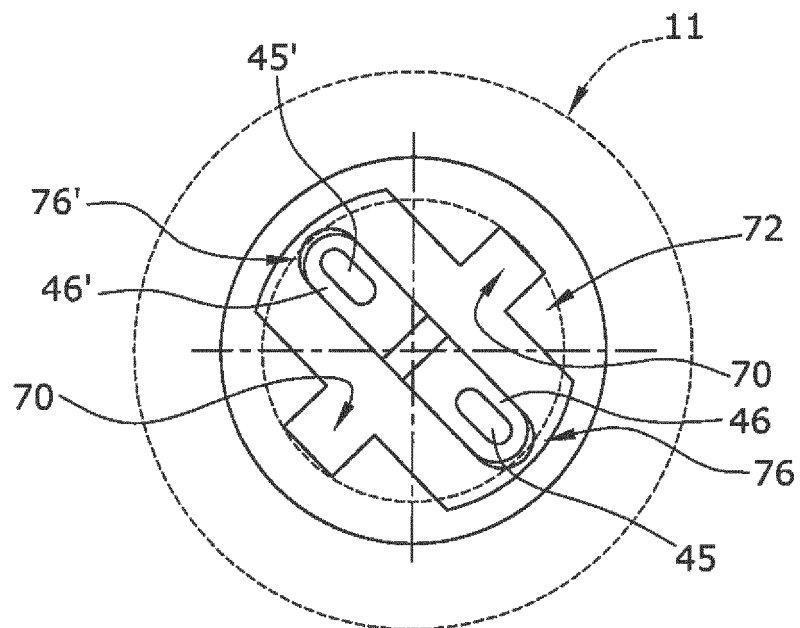


Fig.4

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

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