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(54) **Automotive vacuum vane pump**

Flügelzellen-Vakuumpumpe für Kraftfahrzeuge

Pompe à vide à ailettes pour automobile

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(56) References cited:
**EP-A2- 0 264 778 EP-A2- 1 134 417
WO-A1-00/73629 WO-A1-2007/140759
DE-B3-102004 034 921 US-A- 5 560 741**

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Description

[0001] The present invention refers to an automotive vacuum vane pump which comprises a housing with a radially moveable rotor vane.

[0002] Vacuum vane pumps of the state of the art comprise one or more vanes of a constant length, wherein the vane tips slide at a pump chamber wall. The vane separates the pump chamber in different rooms, for example in case of vacuum pump with a single vane assembly in an intake room and a pressure room. Vacuum vane pumps are used in automotive applications as a supply device for servo brake devices, valves etc.

[0003] The pump comprises a housing with a radially moveable rotor vane, wherein the one-piece metal vane has a constant length and wherein the vane tips slide at a pump chamber wall. A vacuum vane pump with a relatively heavy metal vane tends to vibrations due to high centrifugal forces, and therefore the pump is subject to high energy consumptions and mechanical wear. Another relevant problem is the abrasion of the vane ends or tips and the pump chamber wall.

[0004] DE 10 2005 058 129 A1 discloses a vacuum vane pump construction with a single thermosetting plastic vane, wherein the complete vane is made of a fiber reinforced material. The manufacturing of these vanes is complex and cost-intensive, and the vane ends are subject to abrasion so that the vane length decreases during the lifetime of the pump.

[0005] DE 10200434921 B3 discloses a vacuum pump with a vane consisting of a metal vane body and a plastic tip.

[0006] US 5560741 A refers to a fluid displacement machine used in an automotive air-conditioning environment. The machine is designed as a non-contacting displacement machine so that the vanes maintain always in adjacent but in non-contacting relationship with respect to the interior surface of the housing body.

[0007] EP 1134417 A2 refers to a fluid vane pump consisting of a vane body and a separate vane tip. The vane body is made out of metal and the vane tip is made out of plastic.

[0008] WO 0073629 A1 refers to a rotary vane pump for pumping air across the gyroscope instruments in piston powered aircrafts and does not refer to an automotive vacuum vane pump. The vanes are integral and therefore are only made out of one material which is carbon fiber reinforced PEEK.

[0009] It is an object of the present invention to provide a vane pump with improved long life properties.

[0010] This object is solved with an automotive vacuum vane pump with the features of claim 1.

[0011] The automotive vacuum vane pump according to claim 1 comprises a housing with a radially moveable rotor vane, wherein the vane consists of at least two components, i.e. a metal vane body and one or two separate plastic vane tips at one or both ends of the vane. Both, the metal vane body and the plastic vane tips can be

optimized with respect to their special function. The metal vane body material, for example, can have a high stability. The plastic tips can have a hardness which is less than the pump chamber wall hardness. Therefore, the abrasion of the metal pump chamber wall can be reduced significantly.

[0012] The vane body is made out of an aluminum alloy which is produced via a continuous casting process. Aluminum alloy is a lightweight material and comprises the benefit of an enhanced stability whereby the weight remains unchanged in comparison with pure aluminum. The continuously cast material provides an inexpensive production due to the inherently lower cost of continuous, standardized production of the product.

[0013] The vane tips are made out of a thermosetting plastic which is fiber reinforced. The vane tips are more elastic and stronger in comparison to pure thermosetting plastic.

[0014] According to a preferred embodiment of the invention, the metal vane body comprises axial recesses arranged in series in longitudinal direction of the vane, i.e. in radial direction of the rotor. This causes a weight reduction whereby the rigidity and the stability of the vane remains unchanged. Therefore, the automotive vacuum vane pump ensures long life properties and functionality, respectively.

[0015] Alternatively, the metal vane body comprises radial, i.e. longitudinal recesses arranged in series in axial direction of the vane. This causes a weight reduction whereby the rigidity and the stability of the vane remains unchanged. Moreover, the radial recesses which are arranged in axial direction cause a more stiff vane body in the direction of the main bending load.

[0016] According to a preferred embodiment of the invention, the vane tip is provided moveable in longitudinal direction at the vane body, i.e. moveable in radial direction of the rotor. The movability of the vane tip ensures air-tightness in case of abrasion.

[0017] According to a preferred embodiment of the invention, the combination of movable plastic tips and an aluminum alloy vane body leads to a lower impact of the centrifugal forces, which are primarily responsible for abrasion in view of maximum rotating speeds between 5000 and 10000 rpm. This assembly causes at one hand a reduced abrasion of said plastic vane tips and on the other hand ensures air-tightness.

[0018] Preferably, the vane tip is form-fitted hold at the vane body. The section of the vane tips has a mushroom form. The vane tips provide a semicircle head and a flat shaft. The flat shaft is arranged in a form-fitted recess of the vane body. This embodiment provides a torque-proof support of the vane tip at the vane body. The longitudinal movability of the tip provides an air-tight pump chamber separation during the life time of the pump.

[0019] The following is a detailed description of an embodiment of the invention with reference to the drawings, in which:

Figure 1 shows an automotive vacuum vane pump without a cover plate from the plan view,

Figure 2 shows a vane body with two moveable tips at the end of the vane, and

Figure 3 shows a vane body with radial recesses arranged in line in axial direction.

[0020] In figure 1, a vacuum vane pump 10 is shown in a plan view. The automotive vacuum vane pump 10 comprises a metal housing 40 with an inlet opening 47 and an outlet opening 48. The housing 40 surrounds the pump chamber 44. The pump chamber 44 is surrounded by a non-cylindrical pump chamber wall 42.

[0021] The pump chamber 44 comprises a circular pump rotor 30. The pump rotor 30 is with its circumferential rotor wall 32 arranged adjacent to the side wall 43 of the pump chamber 44, whereby a protrusion (not shown) of the pump rotor 30 protrudes axially to the outside of the side wall 43. The protrusion of the pump rotor 30 can be rotated by a pump motor (not shown).

[0022] The pump rotor 30 has a radial continuous vane guiding opening 26, wherein a radially moveable vane 20 is mounted. The vane 20 comprises a metal vane body 22 with two with respect to the rotor 30 radially moveable plastic vane tips 24 at the ends of the metal vane body 22, whereby the plastic vane tips 24 slide at the pump chamber wall 42. The vane tips 24 are arranged torque-proof with respect to the longitudinal axis of the vane 20.

[0023] The vane 20 separates the pump chamber 44 into an intake room 45 and a pressure room 46, because the rotor wall 32 slides permanently at the pump chamber wall 42, and thereby separates the intake room 45 and the pressure room 46 air-tight.

[0024] As figure 2 shows, the vane 20 comprises a metal vane body 22 and two radially, i.e. in the longitudinal direction of the metal vane body 22, moveable plastic vane tips 24 at the end of the vane 20. The metal vane body 22 comprises rectangular and/or elongated axial recesses 25 arranged in series in radial direction of the vane 20 in order to reduce the weight of the vane 20.

[0025] Figure 3 shows the metal vane body 22. The metal vane body 22 comprises rectangular and/or elongated radial recesses 27 arranged in series in axial direction of the vane 20 in order to reduce the weight of the vane 20.

Claims

1. Automotive vacuum vane pump (10) with a metal housing (40) with a pump chamber (44) being surrounded by a non-cylindrical pump chamber wall (42), a radially moveable rotor vane (20), the vane (20) comprising:

a metal vane body (22), and
a separate vane tip (24) at one end of the vane (20), wherein the vane tip (24) is made out of plastic and slides at the pump chamber wall (42),
characterized in that
the metal vane body (22) is made out of an aluminum alloy, and the vane tip (24) is made out of a thermosetting plastic reinforced with carbon fibers.

2. Automotive vacuum vane pump (10) of claim 1, wherein the vane body (22) comprises axial recesses (25) arranged in series in radial direction of the vane (20).
3. Automotive vacuum vane pump (10) of claim 1, wherein the vane body (22) comprises radial recesses (27) arranged in series in axial direction of the vane (20).
4. Automotive vacuum vane pump (10) of one of the preceding claims, wherein the vane tip (24) is provided radially moveable at the vane body (22).
5. Automotive vacuum vane pump (10) of one of the preceding claims, wherein the vane tip (24) is form-fitted hold at the vane body (22).

Patentansprüche

1. Flügelzellen-Vakuumpumpe (10) für Kraftfahrzeuge mit einem Metallgehäuse (40) mit einer Pumpenkammer (44), welche von einer nicht zylindrischen Pumpenkammerwand (42) umgeben ist, einem radial bewegbaren Rotorflügel (20), wobei der Flügel (20) aufweist:

einen metallischen Flügelkörper (22) und eine separate Flügelspitze (24) an einem Ende des Flügels (20), wobei die Flügelspitze (24) aus Kunststoff hergestellt ist und auf der Pumpenkammerwand (42) gleitet,
dadurch gekennzeichnet, dass
der metallische Flügelkörper (22) aus einer Aluminiumlegierung hergestellt ist, und die Flügelspitze (24) aus einem mit Kohlenstoffasern verstärkten duroplastischen Kunststoff hergestellt ist.

2. Flügelzellen-Vakuumpumpe (10) für Kraftfahrzeuge nach Anspruch 1, bei welcher der Flügelkörper (22) axiale Ausnehmungen (25) aufweist, die in radialer Richtung des Flügels (20) hintereinander angeordnet sind.
3. Flügelzellen-Vakuumpumpe (10) für Kraftfahrzeuge

nach Anspruch 1, bei welcher der Flügelkörper (22) radiale Ausnehmungen (27) aufweist, die in axialer Richtung des Flügels (20) hintereinander angeordnet sind.

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4. Flügelzellen-Vakuumpumpe (10) für Kraftfahrzeuge nach einem der vorhergehenden Ansprüche, bei welcher die Flügelspitze (24) radial bewegbar an dem Flügelkörper (22) vorgesehen ist.

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5. Flügelzellen-Vakuumpumpe (10) für Kraftfahrzeuge nach einem der vorhergehenden Ansprüche, bei welcher die Flügelspitze (24) formschlüssig an dem Flügelkörper (22) gehalten ist.

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Revendications

1. Pompe à vide à ailettes (10) pour automobile comprenant
un boîtier métallique (40) avec une chambre de pompage (44) entourée par une paroi non-cylindrique (42) de chambre de pompage,
une ailette de rotor (20) radialement déplaçable, ladite ailette (20) comprenant: 20

un corps d'ailette (22) métallique, et
une pointe d'ailette (24) distincte à une extrémité de ladite ailette (20), ladite pointe (24) étant fabriquée de matière plastique et glissant sur ladite paroi (42) de chambre de pompage, 30
caractérisée en ce que
le corps d'ailette (22) métallique est fabriqué d'un alliage d'aluminium et la pointe d'ailette (24) est fabriquée d'une matière plastique therm durcissable renforcée fibres de carbone. 35
2. Pompe à vide à ailettes (10) pour automobile selon la revendication 1, dans laquelle le corps d'ailette (22) comprend des évidements axiaux (25) rangés en série dans la direction radiale de l'ailette (20). 40
3. Pompe à vide à ailettes (10) pour automobile selon la revendication 1, dans laquelle le corps d'ailette (22) comprend des évidements radiaux (27) rangés en série dans la direction axiale de l'ailette (20). 45
4. Pompe à vide à ailettes (10) pour automobile selon l'une quelconque des revendications précédentes, dans laquelle la pointe d'ailette (24) est prévue au corps d'ailette (22) de manière déplaçable dans la direction radiale. 50
5. Pompe à vide à ailettes (10) pour automobile selon l'une quelconque des revendications précédentes, dans laquelle la pointe d'ailette (24) est retenue au corps d'ailette (22) par engagement positif. 55

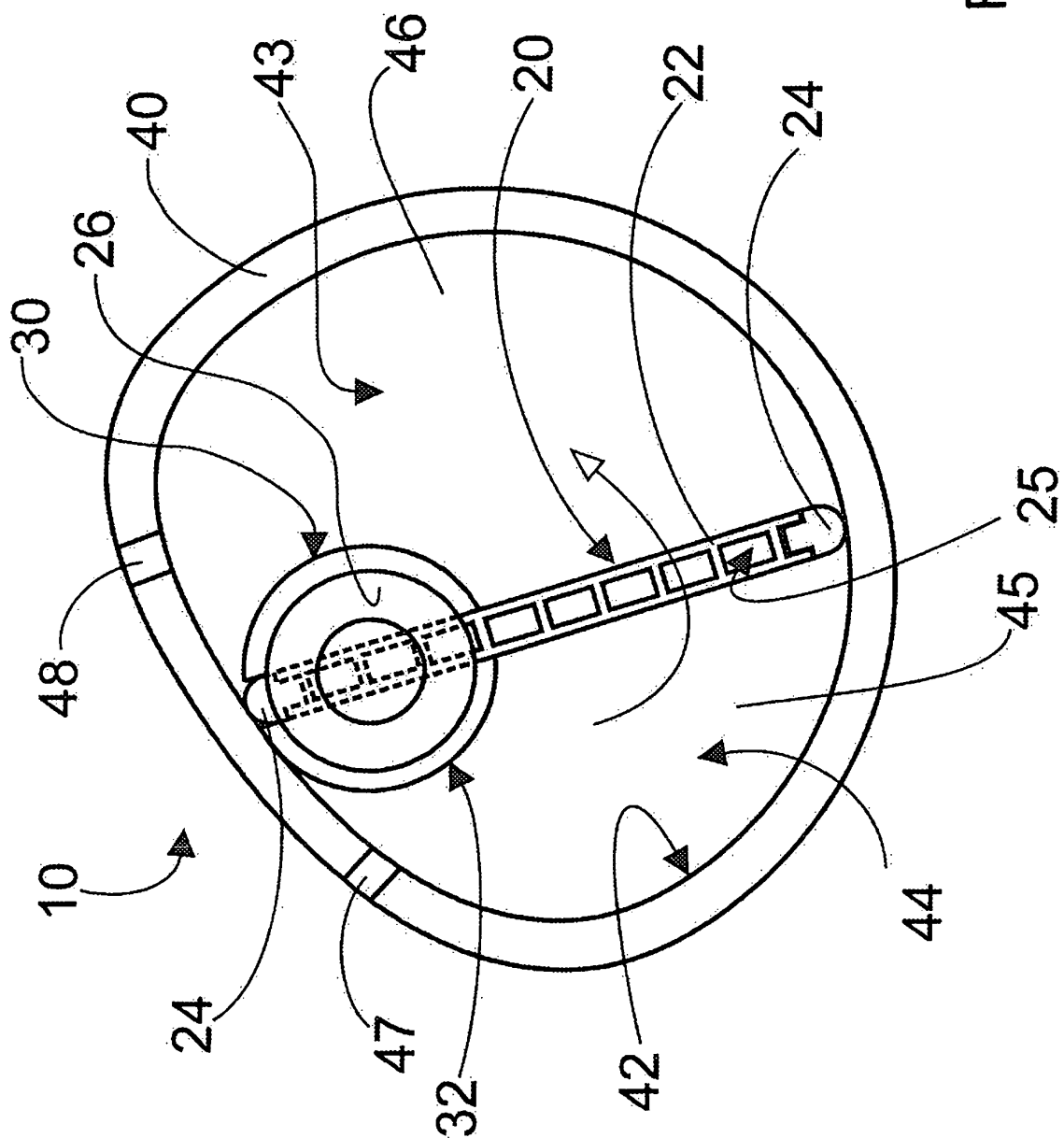


Fig. 1

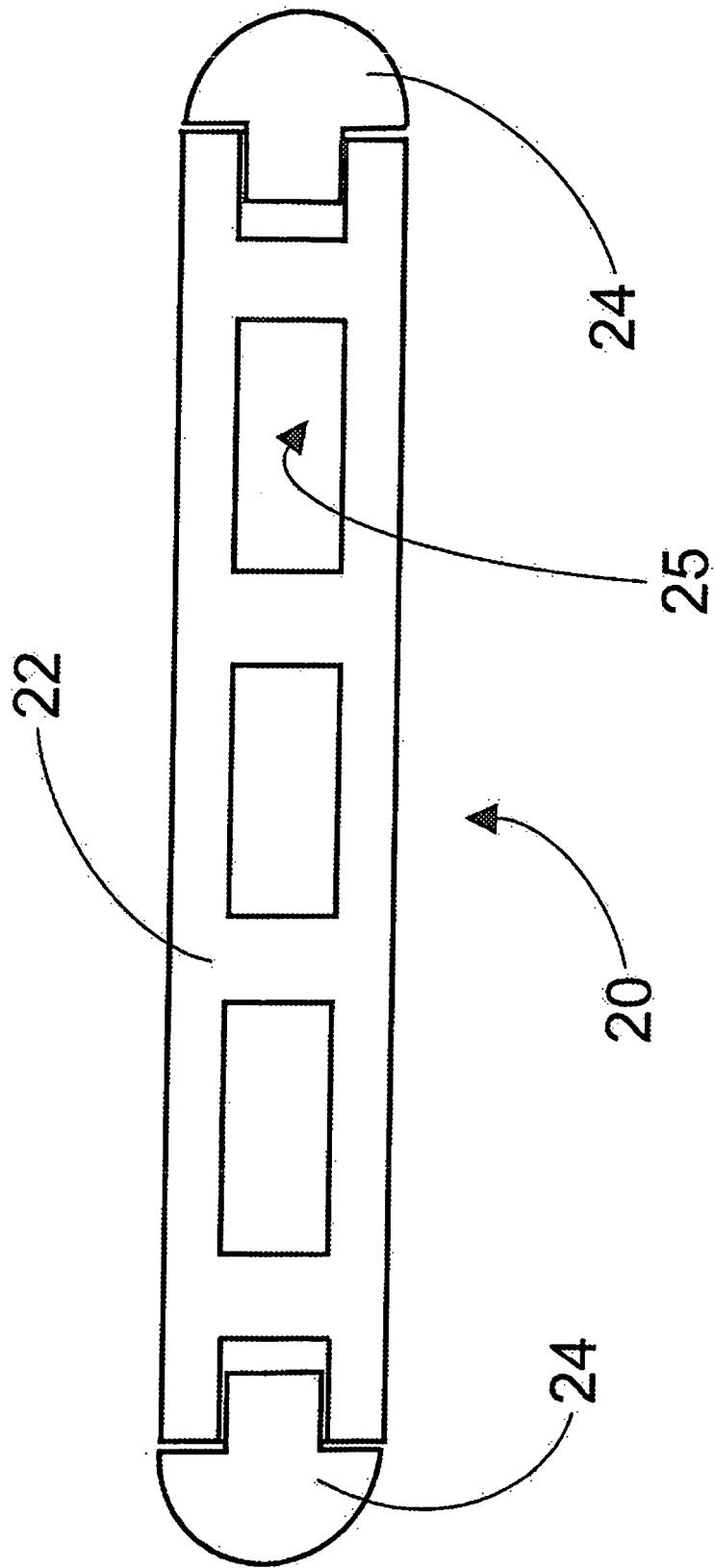


Fig. 2

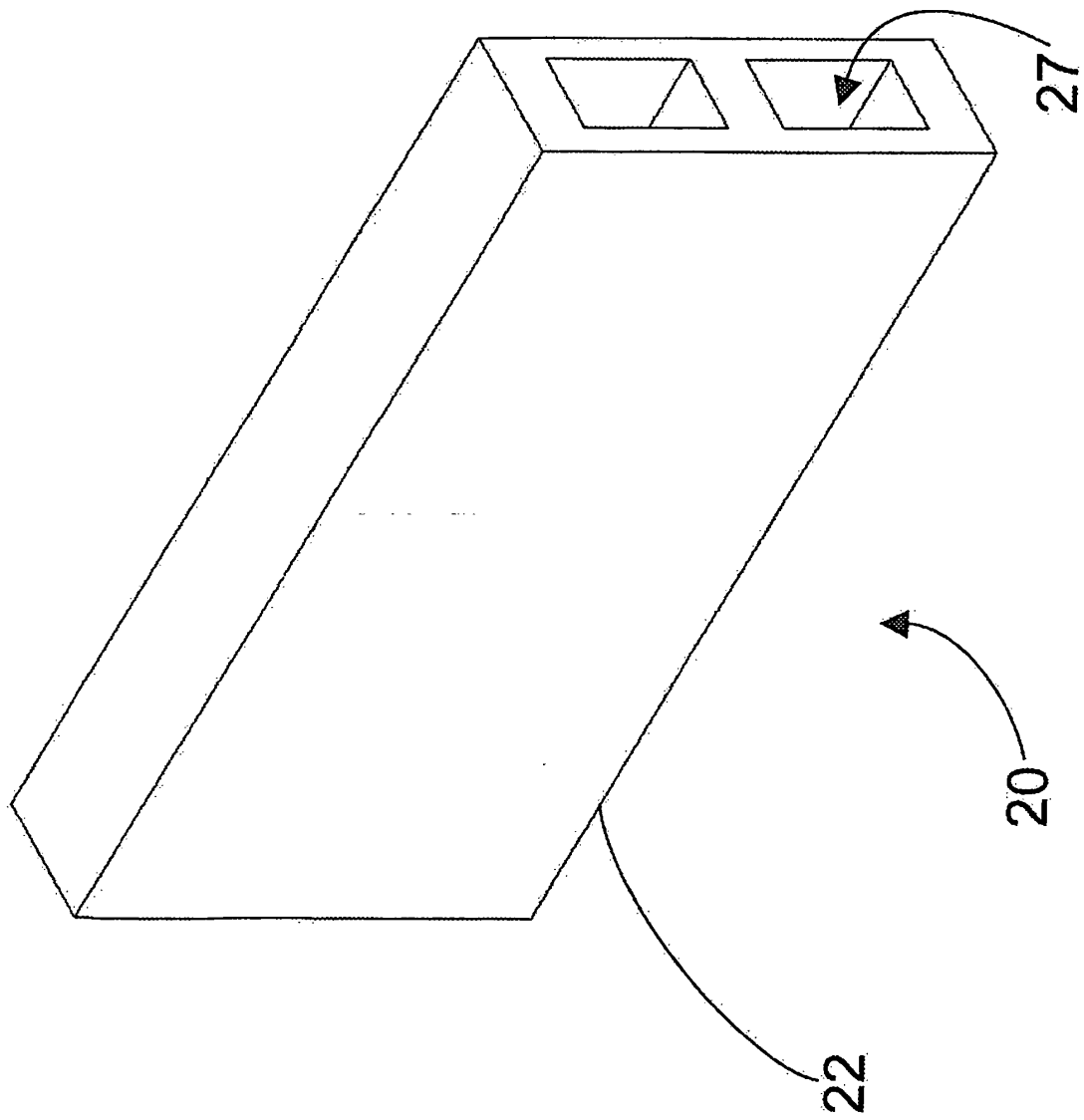


Fig. 3

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- DE 102005058129 A1 **[0004]**
- DE 10200434921 B3 **[0005]**
- US 5560741 A **[0006]**
- EP 1134417 A2 **[0007]**
- WO 0073629 A1 **[0008]**