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(54) Title: AUTOMOTIVE ELECTRIC EVAPORATION PUMP

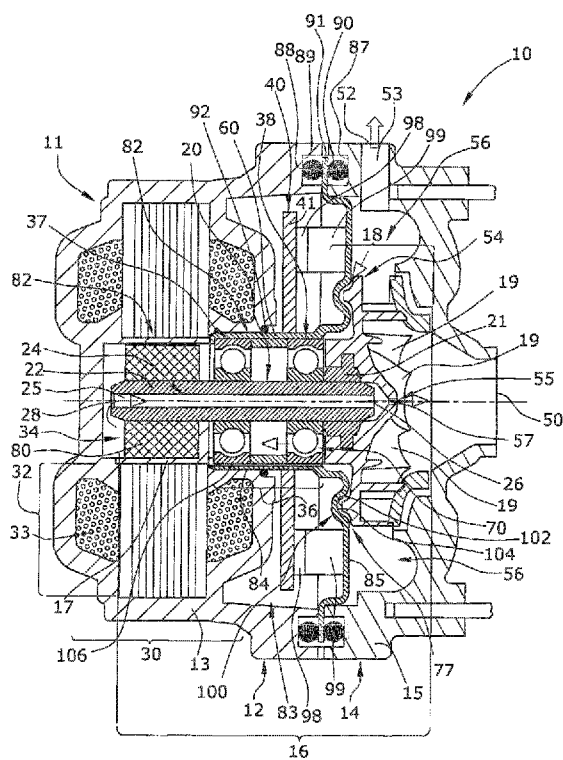


FIGURE 1

(57) Abstract: The invention is directed to an electric automotive evaporation pump (10) with a gas suction port (50) and a gas exhaust port (52). The pump comprises an electric canned motor (30) with a motor stator (32) comprising electromagnetic stator coils (33) and with a rotor assembly (16) comprising a pump wheel (18) with pump wheel blades (19), a rotatable rotor shaft (20) and a motor rotor (34). A separation can arrangement (82) is provided which fluidically separates the motor stator (32) in a gas-free section from the motor rotor (34) in a gas section. The separation can arrangement (82) comprises a can body (60) with a cylinder portion (84). The cylinder portion (84) directly supports the bearing means (36). The can body (60) separates an electronics chamber (83) comprising an electronic motor control (40) from the gas section.

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Automotive electric evaporation pump

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The invention refers to an automotive electric evaporation pump with a gas suction port and a gas exhaust port.

Electric evaporation pumps are used in automobiles with a fuel tank for pumping fuel vapor from a fuel vapor source to a fuel vapor target. The fuel vapor source can be the fuel tank itself or can be a vapor absorbent unit, which is, for example, filled with active carbon as the absorbent media. Since the absorbent unit has a limited total absorbance capacity, the fuel vapor gas absorbed by the absorbent must be discharged from time to time. The discharge action is provided by the electric evaporation pump which can be arranged fluidically between the vapor absorbent unit and the fuel vapor target which can be, for example, the gas inlet manifold of an internal combustion engine. Alternatively, the evaporation pump is used to degas the cylinder cover or the crank case of the engine.

In gas pumps, the typical axial arrangement of the pump components electric motor, pump wheel and motor electronics is with the electric motor axially in the middle and the electronics chamber comprising the motor control electronics at one axial end and the pump wheel at the other axial end.

It is an object of the invention to provide an electric automotive evaporation pump with a compact design which is easily to assemble.

This object is solved with an electric automotive evaporation pump with the features of claim 1.

The electric evaporation pump according to the invention is provided with a gas suction port and a gas exhaust port. The gas suction port can be fluidically connected to a fuel vapor source, for example to a fuel tank or

to a fuel vapor absorbent unit. The gas exhaust port can be fluidically connected to a fuel vapor target, for example to a condensation unit or to a gas inlet manifold of an internal combustion engine.

The evaporation pump comprises a canned electric motor with a motor
5 stator comprising at least two electromagnetic stator coils and with a rotor assembly comprising a pump wheel with pump wheel blades, a rotatable rotor shaft and a motor rotor. The motor rotor is preferably provided as a permanently magnetized rotor body. The evaporation pump is provided with a separation can arrangement which separates the motor stator
10 provided in a gas-free section from the motor rotor provided in a gas section. In the gas section, the pumped gas is present. The gas-free section is fluidically separated by the separation can arrangement from the gas section so that no pumped gas is present in the gas-free section. The gas-free section can be filled with air but is fluidically isolated from the gas
15 section where the pumped gas is present.

The gas pump is provided with a bearing means which is arranged in the gas section and which rotatably supports the motor rotor. The bearing means can be a roller bearing, can be a friction bearing, or can be a combination of both bearing types. Preferably, the bearing means is
20 provided with roller bearings because of the high rotational speed and the lack of bearing lubrication possibilities for a friction bearing.

The separation can arrangement comprises a can body with a cylinder portion. The cylinder portion of the can body directly supports the bearing means. The can body also separates a control electronics chamber
25 comprising an electronic motor control from the gas section. In other words, the separation can has two functions, namely to directly support the bearing means and to fluidically isolate the electronics chamber from the gas section of the pump. Preferably, the can body is a metal sheet can body.

30 The bearing means including the rotor assembly can be preassembled at the cylinder portion of the can body, and the can body can subsequently

be assembled together with the motor stator so that a simple assembly of the pump is realized.

According to a preferred embodiment of the invention, the electronics chamber is arranged axially between the motor stator and the pump wheel. Since the evaporation pump only pumps gas which has a relatively low thermal capacity, the cooling of the motor control electronics is somehow problematic. By arranging the electronics chamber including the motor control electronics adjacent to the pump wheel section, the cooling of the electronics chamber and of the control electronics therein can be improved significantly, compared to an arrangement of the motor control electronics at the axial end of the evaporation pump and remote of the relatively high gas flow in the neighborhood of the pump wheel.

Preferably, the electronics chamber is ring-like and surrounds the bearing means. This leads, seen in axial direction, to a compact design of the evaporation pump.

According to a preferred embodiment of the invention, the electronic motor control is provided with at least one power semiconductor for electrically supplying the stator coils. The power semiconductor is thermally connected to the can body by a separate thermal connection element. The thermal connection element consists of a material which conducts thermal energy at least two times better than air.

According to a preferred embodiment, the electronic motor control comprises a printed circuit board which is substantially arranged in a radial plane. The can body is provided with a substantially radial ring disk portion, so that the printed circuit board and the radial disk portion of the can body can be arranged in parallel and close to each other.

Preferably, the printed circuit board can have the shape of a ring disk. This design allows a very effective and compact arrangement of the electronic motor control, seen in axial direction of the evaporation pump.

Preferably, the thermal connection element is substantially arranged in axial direction and axially connects the power semiconductor with the radial ring disk portion of the can body.

Preferably, the stator coils are housed in a massive plastic housing body
5 which supports the axial end of a cylinder portion of the can body. The separation can arrangement comprises at least two elements, namely the massive plastic housing body separating the stator coils from the motor rotor and the separation can arrangement additionally separating the gas section from the gas-free section of the pump.

10 The bearing means can be provided with an axial gas passage. The axial bearing means gas passage can be realized by spaces and gaps between the neighboring roller elements of a roller bearing. Alternatively or additionally, the axial bearing means gas passage can also be provided as an axial groove or channel in a fixed part of the bearing means or in the
15 static frame structure supporting of the bearing means.

The rotor shaft can also be provided with an axial gas passage and the pump wheel is provided with an axial gas outlet passage upstream of the pump wheel blades so that a drying gas path through the bearing means, the shaft gas passage and the pump wheel gas outlet passage is realized.

20 The pumped gas is flowing axially through the bearing means gas passage to the distal end of the gas section and then axially flows back in the direction of the pump wheel through the rotor shaft gas passage and finally through the pump wheel outlet passage.

The gas pressure at the center of the pump wheel where the gas outlet
25 passage is located is relatively low compared to the gas pressure radially outwardly of the pump wheel blades, when the rotor assembly is rotating. As a consequence, a drying path gas current is caused flowing from the area radially outwardly of the pump wheel blades to the pump wheel gas outlet passage in the center.

The pump wheel is preferably provided as an impeller with an axial pump wheel inlet and a radial pump wheel outlet.

As long as the rotor assembly is rotating, a continuous gas current is caused in the drying gas path so that the gas section is continuously
5 vented. As a consequence, no condensate or fuel or water can appear or remain in the gas section, in particular not in the hidden areas of the gas section. Since moisture and condensate is continuously avoided, corrosion in the gas section is significantly reduced and the mechanical rotation resistance is significantly reduced, as well.

10 Generally, the rotor shaft gas passage can be realized by one or more axial groove in the rotor shaft. According to a preferred embodiment, the shaft gas passage is defined by an axial shaft bore extending through the complete axial length of the rotor shaft.

Preferably, the pump wheel gas outlet passage is defined by an axial
15 center opening in the pump wheel body. In the central area of the pump wheel, the gas pressure is relatively low so that an outlet opening in this area defining the fluidic end of the drying gas path is suitable to be used for generating a continuous drying gas path current.

According to a preferred embodiment of the invention, an inlet gas
20 passage of the drying gas path is defined by a circular gap between the rotatable pump wheel and a non-rotating part of the pump frame, of the pump housing or another static part of the pump. The pump wheel is preferably provided with a base disk from which the pump wheel blades axially project. The inlet gas passage of the drying path is preferably
25 defined by a circular gap between the pump wheel base disk and another circular static part of the pump.

According to a preferred embodiment of the invention, the gas inlet passage defined by the pump wheel and a nonrotating part of the pump frame or pump housing can be provided with a circular labyrinth sealing so
30 that the total radial inlet flow is restricted and moderated to a maximum

drying gas path rate which is sufficient to avoid condensation and moisture in the gas section.

Preferably, a motor rotor gas passage is defined by a circular gap between the motor rotor and the separation can arrangement. As an alternative or
5 in addition to the circular gap, an axial groove provided in the separation can arrangement and/or in the motor rotor body can serve as a motor rotor gas passage.

Preferably, an electronic motor control is provided which is arranged axially between the motor stator and the pump wheel and which
10 preferably surrounds the bearing means. The electronic motor control provides the electromagnetic stator coils with electric energy based on a commutation schema. The arrangement of the motor control electronics axially between the motor stator and the pump wheel allows a good mechanical protection of the electronics against environmental impact.

15 An embodiment of the invention is described with reference to the enclosed drawing, wherein the figure shows a longitudinal cross section of an electric evaporation pump.

The figure shows an electric evaporation pump 10 for pumping fuel vapor from a fuel vapor source to a fuel vapor target, for example from a fuel
20 vapor absorbent unit to an intake manifold of an internal combustion engine. The gas pump 10 is suitable for pumping gas but is not suitable for pumping a liquid. The gas pump 10 is provided with a pump housing 11 comprising an axial gas suction port 50 and a radial gas exhaust port 52. The gas pump 10 is provided with a pump section including an
25 impeller pump wheel 18 and the ports 50,52, and with a motor section including an electric canned motor 30 and a motor control 40. The motor control 40 including a printed circuit board 41 is arranged in a ring-like electronics chamber 83 axially between the pump section and the electric motor 30.

The pump housing 11 substantially comprises two separate parts, namely the motor section housing 12 and the pump section housing 14. Both section housings 12,14 are defined by massive plastic housing bodies 13, 15. The motor section housing 12 comprises and encloses numerous stator coils 33 of a motor stator 32. The stator coils 33 are embedded in the plastic motor housing body 13. The motor housing body 13 also defines the ring-like motor control electronics chamber 83 which houses the electronic motor control 40. The motor control 40 is defined by numerous electronic elements on the printed circuit board 41. The printed circuit board 41 has the shape of a ring disk and is provided with numerous power semiconductors 98 at the pump-wheel-side of the printed circuit board 41.

The gas pump 10 is provided with a rotatable rotor assembly 16 comprising a plastic pump wheel 18, an elastic coupling element 21, a metal rotor shaft 20 and a motor rotor 34 which is provided with a motor rotor body 80 with permanent magnets defining numerous magnetic rotor poles. The rotor shaft 20 co-rotatably supports the elastic coupling element 21 which directly supports the pump wheel 18. The elastic coupling element 21 allows the pump wheel 18 to tilt in a limited range so that blocking and jamming of the pump wheel 18 caused by solid particles can be avoided.

The plastic pump wheel 18 is provided with numerous pump wheel blades 19 which axially project from a pump wheel base disk body 54 substantially arranged in a radial plane. The pump wheel base disk body 54 is provided with an axial center opening 57 in the axial center thereof which defines a drying gas outlet passage 55.

The rotor shaft 20 is defined by a metal rotor shaft body 22 which is provided with an axial shaft bore 25 which defines an axial drying gas passage 24. The distal end of the shaft bore 25 defines a drying gas inlet opening 28 and the proximal end of the shaft bore 25 defines a drying gas outlet opening 26.

The rotor assembly 16 is rotatably supported by a bearing means 36 which comprises two roller bearings 37,38. The bearing means 36 is axially arranged between the motor rotor 34 and the pump wheel 18. The bearing means 36 is provided with an axial gas passage 70 which allows
5 the pumped drying gas to flow axially through the bearing means 36. In case of the present roller bearings 37, 38 the axial gas passage is defined by the interspaces between the roller elements of the roller bearing 37, 38. Additionally, the bearing means 36 is provided with a second axial gas passage defined by three axial grooves 106 which are provided in the
10 cylindrical cylinder portion 84 of the can body 60. Even if the axial grooves 106 are not part of the roller bearings 37, 38, they also define axial bearing means gas passages in the sense of the patent claims. The axial gas passage grooves 106 transport 50% to 80% of the gas flowing through the drying gas path. This is to avoid a washing of the lubrication
15 grease of the roller bearings 37,38.

The pump housing body 15 defines a pump volute 56 which radially surrounds the pump wheel 18 and fluidically leads into a radial pump outlet channel 53 which fluidically ends at the pump's gas exhaust port 52.

The gas pump 10 is provided with a separation can arrangement 82 which
20 fluidically separates the motor stator 32 which is located in a gas-free section from the motor rotor assembly 16 which is located in a gas section. In the gas section, the pumped gas is present, whereas in the gas-free section no pumped gas is present. However, another gas, as for example air, can be present in the gas-free section. In particular, the
25 electronics chamber 83 is filled with air, but is not filled with pumped gas. The separation can arrangement 82 comprises the cylindrical inner surface of the motor section housing body 13 and a separate metal sheet can body 60.

The sheet can body 60 has a substantially cylindrical cylinder portion 84
30 and a ring disk portion 85 substantially lying in a radial plane. The circular edge 91 of the ring disk portion 85 of the can body 60 is clamped between

corresponding flanges of the pump housing body 15 and the motor housing body 13. Both flanges are provided with a circular groove 87,89, respectively. In both circular grooves 87, 89 a sealing ring 88,90 is seated, respectively. The circular groove 87, 89, the circular sealing rings 88, 90
5 and the circular edge 91 of the ring disk portion 85 are axially aligned with each other so that a reliable sealing arrangement is realized.

The outer cylindrical surfaces of the roller bearings 37, 38 are fixed to the inner cylindrical surface of the separation can cylinder portion 84 by clamping. The outer surface of the separation can cylinder portion 84 is, in
10 part, fixed to a cylindrical portion of the motor housing body 13 by clamping, as well. The fluidic sealing is realized by a sealing ring 92 which is located between the outer surface of the separation can cylinder portion 84 and the inner cylindrical surface of the motor housing body 13.

The circular gap between the base disk 54 of the pump wheel 18 and the
15 ring disk portion 85 of the can body 60 defines an circular inlet drying gas passage 77 of a drying gas path from the inlet drying gas passage 77 to the outlet drying gas passage 55. The circular gap is provided with a labyrinth sealing 100 which is defined by a circular axial sealing land ring 102 at the back side of the disk portion 85 of the can body 60 and by a
20 corresponding circular axial groove at the front side of the ring disk portion 85 of the can body 60. The labyrinth sealing 100 defines the maximum flow through the drying gas path so that the pneumatic shortcut defined by the drying gas path does not significantly affect the pneumatic efficiency of the gas pump 10.

25 The motor housing body 13 is, at its cylindrical inner surface surrounding the motor rotor body 80, provided with one or more axial gas passage grooves 17 which allow an axial drying gas flow to pass the motor rotor 34 in axial direction.

The power semiconductors 98 are thermally connected to the ring portion
30 85 of the sheet can body 60 by separate thermal connection elements 99, respectively. The connection elements 99 axially connect the respective

power semiconductors 98 with the ring disk portion 85 of the sheet can body 60. Since this ring-like portion of the sheet can body 60 is cooled by the gas flowing by and pumped by the pump wheel 18 with a relatively high gas velocity, a considerable cooling capacity is realized so that the heat can reliably be dissipated from the power semiconductors 98.

When the gas pump 10 is active, the electric canned motor 30 rotates so that the pump wheel 18 is rotating, as well. The pump wheel pumps the gas which is fuel vapor axially through the axial gas suction port 50 and radially outwardly into the pump volute 56. From the pump volute 56 the gas flows through the outlet channel 53 to the gas exhaust port 52.

The gas pressure in front of the pump wheel 18 is below the gas pressure in the pump volute 56. As a consequence, a drying gas flow is caused from the drying gas inlet passage 77 along the drying gas path to the drying gas outlet passage 55. The drying gas path comprises the circular drying gas inlet passage 77, the axial gas passages 70, 106 of the bearing means 36, the axial gas passage grooves 17 at the motor housing body 13, the axial gas passage 24 of the rotor shaft 20 and the drying gas outlet passage 55 of the pump wheel 18.

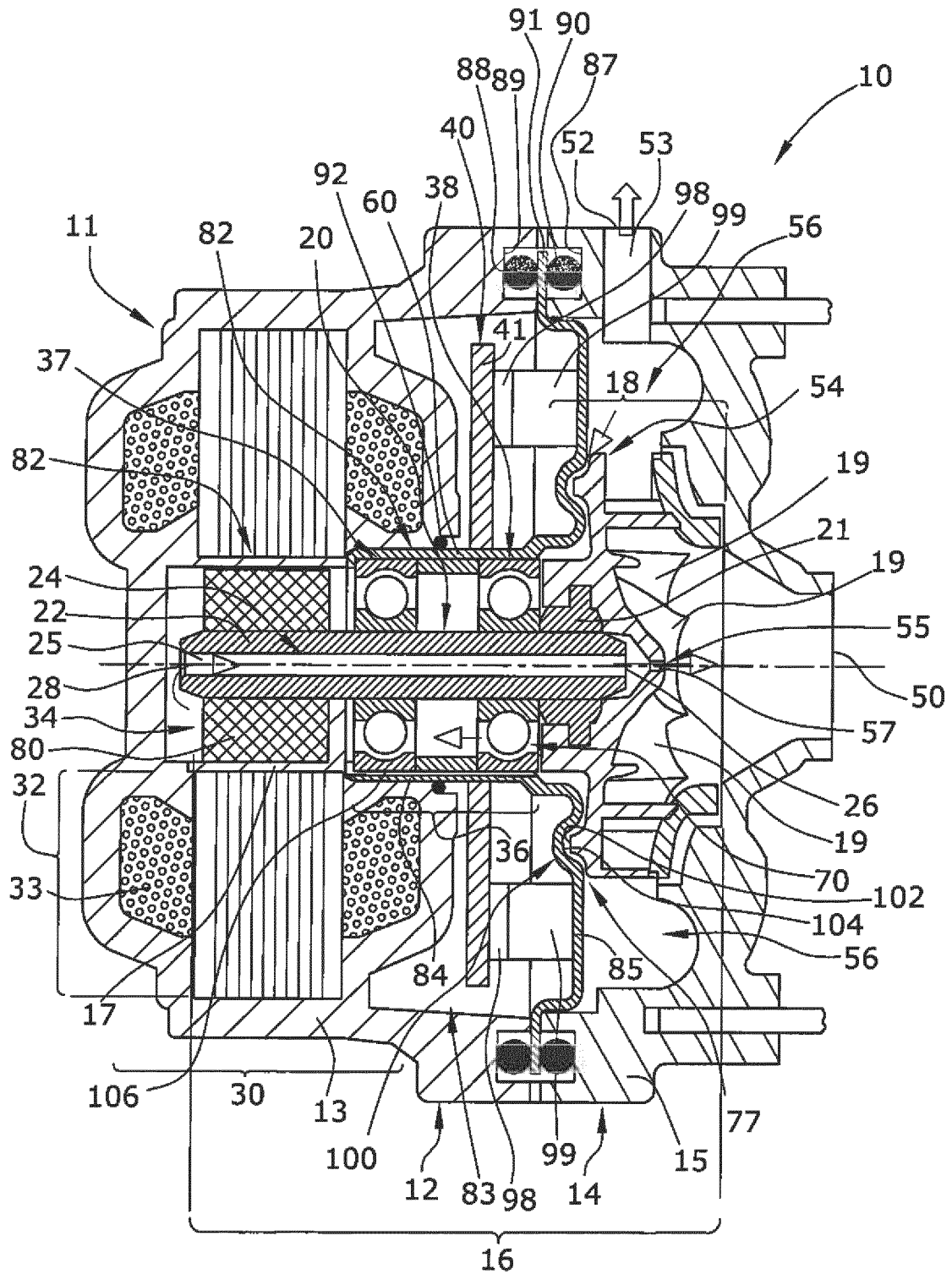
As long as the pump wheel 18 is rotating, the pressure difference between the gas suction port 50 and the gas exhaust port 52 causes a drying gas flow through the drying gas path so that no relevant condensate of the pumped gas remains in the gas section of the gas pump 10.

CLAIMS

- 5 1. An electric automotive evaporation pump (10) with a gas suction port (50) and a gas exhaust port (52), comprising:
- an electric canned motor (30) with a motor stator (32) comprising electromagnetic stator coils (33) and with a rotor assembly (16) comprising a pump wheel (18) with pump wheel blades (19), a
- 10 rotatable rotor shaft (20) and a motor rotor (34),
- a separation can arrangement (82) fluidically separating the motor stator (32) in a gas-free section from the motor rotor (34) in a gas section, and
- a bearing means (36) arranged in the gas section axially between
- 15 the motor (30) and the pump wheel (18) and rotatably supporting the motor rotor (34), wherein
- the separation can arrangement (82) comprises a can body (60) with a cylinder portion (84), the cylinder portion (84) directly supporting the bearing means (36), and
- 20 the can body (60) separates an electronics chamber (83) comprising an electronic motor control (40) from the gas section.
2. The electric automotive evaporation pump (10) of claim 1, wherein
- 25 the electronics chamber (83) is arranged axially between the motor stator (32) and the pump wheel (18).

3. The electric automotive evaporation pump (10) claim 2, wherein the electronics chamber (83) is ring-like and surrounds the bearing means (36).
- 5 4. The electric automotive evaporation pump (10) of one of the preceding claims, wherein electronic motor control (40) is provided with a power semiconductor (98) for electrically supplying the stator coils (33), wherein the power semiconductor (98) is thermally
10 connected to the can body (60) by a thermal connection element (99).
5. The electric automotive evaporation pump (10) of one of the preceding claims, wherein the electronic motor control (40) comprises a printed circuit board (41) which is substantially lying in
15 a radial plane and wherein the can body (60) is provided with a substantially radial ring disk portion (85).
6. The electric automotive evaporation pump (10) of claim 4 or 5,
20 wherein the thermal connection element (99) substantially axially connect the power semiconductor (98) with the can body (60).
7. The electric automotive evaporation pump (10) of one of the preceding claims, wherein the stator coils (33) are housed in a massive plastic housing body (13) which supports the axial end of a
25 cylinder portion (84) of the can body (60).
8. The electric automotive evaporation pump (10) of one of the preceding claims, wherein the can body (60) is a metal sheet can body (60).

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Figur

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2015/058891

A. CLASSIFICATION OF SUBJECT MATTER INV. F02M25/08 F04B35/04 F04D13/06 F04D25/06 ADD.		
According to International Patent Classification (IPC) or to both national classification and IPC		
B. FIELDS SEARCHED Minimum documentation searched (classification system followed by classification symbols) F02M F04B F04D		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched		
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) EPO-Internal, WPI Data		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP 2 407 670 A2 (AISIN SEIKI [JP]) 18 January 2012 (2012-01-18) abstract column 3, paragraph 23 - column 6, paragraph 38; figure 1 -----	1,7,8
A	US 2014/017073 A1 (MUIZELAAR RICHARD [CA] ET AL) 16 January 2014 (2014-01-16) abstract page 4, paragraph 44 - paragraph 47; figure 11 -----	1,3-5,8
A	EP 1 635 069 A1 (DANA AUTOMOTIVE LTD [GB]) 15 March 2006 (2006-03-15) the whole document -----	1-5
☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.		
* Special categories of cited documents : "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier application or patent but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art "&" document member of the same patent family		
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INTERNATIONAL SEARCH REPORT

Information on patent family members

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