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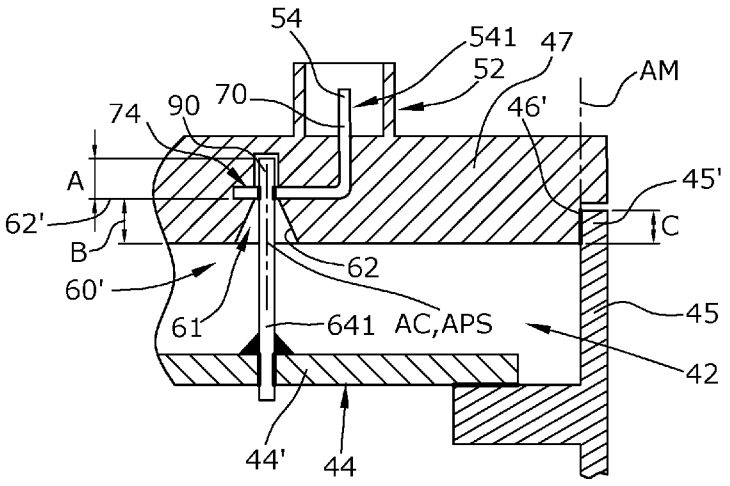

Fig.2

(57) **Abstract:** The invention is directed to an automotive electric fluid pump (10) with a pump part (20) with a pump rotor (22), an electric motor part (32) with motor coils (36) and a motor rotor (34) mechanically driving the pump rotor (22), an electronics part (40) with an electronics chamber (42) comprising an electronic motor driving circuit (44) for commutating and driving the motor coils (36) and an electronics chamber cover lid (46) fluidically closing an electronics chamber opening (46') of the electronics chamber (42), and an electric terminal pump connector (52;152) defining the electric interface between the electric fluid pump (10) and a complementary automotive-sided counter-connector, wherein the terminal pump connector (52;152) is provided with electric terminal connector elements (541,542,551,552) which are electrically connected to the electronic motor driving circuit (44) by electric connection lines penetrating the plastic cover lid body (47) of the electronics chamber cover lid (46), wherein the electric terminal connector elements (541,542,551,552) are electrically connected to the electronic motor driving circuit (44) by a multiple push-fit connection arrangement (60;160) of several connection pairings (60';160'), each connection pairing (60';160'), comprising a male pin element (90;190) and a female socket element (74;174) and defining a linear pin-socket axis (APS), wherein every socket element (74) is provided with a separate concave guiding cone (61) defined by a plastic body, whereas the guiding cone axis (AC) is identical with the linear pin-

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Published:

— *with international search report (Art. 21(3))*

Automotive electric fluid pump

The invention refers to an automotive electric fluid pump for pumping a fluid, preferably a gas or more preferably air for providing vacuum for a pneumatic actuator such as a pneumatic brake booster.

Automotive electric fluid pumps are generally driven by the direct current energy network of the automotive product and are preferably electronically commutated. The automotive electric fluid pump is provided with a pump part, an enclosed electric motor part driving the pump rotor and being provided with one or more motor coils for driving the motor rotor, and with an electronics part comprising an electronic motor driving circuit for electrically driving the motor coils.

DE 11 2014 001 518 T5 discloses a typical structure of an automotive electric fluid pump with an electronics part which is defined by an electronics chamber comprising an electronic motor driving circuit. The axial electronics chamber opening is closed by a separate cover lid. The cover lid is provided with an integral electric terminal pump connector for electrically connecting a corresponding electric counter-connector of the electric and electronic circuit of the automotive product. The terminal pump connector is provided with electric terminal connector elements which are defined by connector pins. The connector pins are defined by several electric pin bodies which are directly electrically connected to a printed circuit board of the electronic motor driving circuit. When the electronics chamber cover lid is assembled with the pump housing, the distal end tips of the electric pin bodies first need to be carefully aligned with the corresponding openings in the cover lid before the cover lid can be axially mounted and fixed at the electronics chamber opening edge.

Since every automotive product manufacturer has different electric counter-connectors with different pin sizes, different lateral pin distances et cetera, not only the electronics chamber cover lid but also the printed circuit board must be adapted individually to every automotive product manufacturer.

It is an object of the invention to facilitate and to improve the adaptability of the electric terminal pump connector of an automotive electric fluid pump for different car manufacturers.

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

The automotive electric fluid pump according to the invention is provided with a pump part, an electric motor part and an electronics part. The pump part comprises a pump rotor which can be a flow-type pump rotor or can be a positive-displacement-type pump rotor. The electric motor part comprises preferably static motor coils and a motor rotor, whereas the motor rotor is preferably permanently magnetized. The electronics part comprises an electronic motor driving circuit for commutating and for driving the electromagnetic motor coils. The electronic motor driving circuit is preferably substantially defined by a printed circuit board lying in a cross plane of the pump perpendicular to the rotational rotor axis of the electric fluid pump. The electronic motor driving circuit is arranged within an electronics chamber which is closed by a separate electronics chamber cover lid thereby closing an electronics chamber opening which is preferably provided at the distal pump end and is preferably lying in a cross plane of the electric fluid pump.

The electric fluid pump is provided with a terminal pump connector defining the electric and electronic interface between the electric fluid

pump and a complementary automotive-sided counter-connector being not a part of the electric fluid pump. The terminal pump connector is provided with several stiff electric terminal connector elements which are electrically connected to the electronic motor driving circuit by electric connection lines penetrating the plastic cover lid body of the electronics chamber cover lid.

According to the invention, an additional internal electro-mechanical interface is provided between the electronics chamber cover lid and the electronic motor driving circuit. The additional electro-mechanical interface is defined by a multiple push-fit connection arrangement of several connection pairings, whereas each connection pairing comprises a male pin element and a corresponding female socket element. The additional electro-mechanical interface between the electronic motor driving circuit and the electronics chamber cover lid allows to completely adapt the terminal pump connector individually to the corresponding counter-connector without any re-arrangement of the electronic motor driving circuit because the physical design of the multiple push-fit connection arrangement is standardized and therefore can always remain the same.

An automotive electric device is generally working under extreme environmental conditions with generally high temperature ranges, hard mechanical shocks and continuous vibrations so that special measures must be provided to ensure a good electric quality of the electric interface. The multiple electric push-fit connection arrangement between the electronics chamber cover lid and the electronic motor driving circuit provides such a reliable electronic interface. According to the present invention, no substance-bound connection technique such as soldering or welding is provided for the internal interface. The press-fit connection technique implies that the male pin elements and the corresponding female socket elements need to be perfectly aligned during the assembly

procedure which includes mounting the electronics chamber cover lid at the electronics chamber opening of the pump housing.

According to the invention, every socket element is provided with a separate concave guiding cone defined by a plastic body, whereas the guiding cone axis is identical with the linear pin-socket axis of the male pin element and the corresponding female socket element. During the assembly process, the male pin elements and the female socket elements of the pairing elements need initially only be roughly aligned with each other. During the axial assembly movement of the electronics chamber cover lid with respect to the electronics chamber opening, the concave guiding cones direct the male pin elements into the female socket elements so that no sophisticated and precise active alignment equipment is needed for precisely actively aligning the connection pairings of the multiple connection arrangement.

The concave guiding cone is not necessarily precisely conical in the geometrical sense but is suitable to guide of the male pin element perfectly into the female socket element. The central guiding cone axis is identical with the linear pin-socket axis.

According to a preferred embodiment of the invention, the female socket elements are permanently fixed and embedded within the plastic cover lid body. The guiding cone is defined by the plastic cover lid body, whereas the male pin elements are permanently fixed at a printed circuit board of the electronic motor driving circuit. Since the plastic cover lid body defines the guiding cones, no separate additional component is necessary to define the guiding cones.

Alternatively, the female socket elements are permanently fixed at a printed circuit board of the electronic motor driving circuit, and the guiding cones are defined by a separate plastic guiding body being

permanently fixed to the printed circuit board. The guiding cones are axially aligned with the female socket elements.

Preferably, the electric terminal connector elements and the cover lid-sided female socket elements or the cover lid-sided male pin elements each are defined by one single metal conductor body. The metal conductor body defines the electric terminal connector element as well as the cover lid-sided pairing element which can be the male pin element or the female socket element.

In an alternative embodiment of the invention, a flexible electric cable is fixed at the electronics chamber cover lid and is substantially provided outside of the pump housing. The terminal pump connector is provided at the distal end of the flexible electric cable whereas the proximal end of the flexible electric cable is electrically connected to the multiple push-fit connection arrangement. This embodiment allows to use a standardized electronics chamber cover lid whereas only the electric terminal pump connector at the distal end of the flexible electric cable needs to be adapted to different types of corresponding counter-connectors. The flexible connection cable provides a high flexibility for the mounting location and spatial orientation of the pump in the automotive product.

Preferably, the proximal wire ends of the flexible electric cable are electrically permanently directly connected by soldering or welding to the corresponding lid-sided metal element of the connection pairing which can be the male pin element or the female socket element. The mechanical and electrical soldering or welding connection between the proximal wire end and the corresponding metal element is preferably completely embedded within the plastic electronics chamber cover lid body.

More preferably, the outside surface of a plastic cable insulation body of the flexible electric cable is adhesively bonded to the plastic cover lid body

so that a fluid-tight connection is realized and no liquid or humidity can pass through the boundary line between the cable insulation body and the corresponding opening edge of the electronics chamber cover lid.

According to a preferred embodiment, the female socket elements are provided with a circular connection eye into which the male pin element is pressed-in so that the connection pairings of the multiple push-fit connection arrangement are press-fit connections. The outside cross-sectional contour of the unconnected male pin element is partly larger than the circular connection eye contour of the female socket element so that the electrical connection between the socket element and the pin element is realized by a ductile deformation of the socket element and the corresponding pin element. This kind of electrical connection provides a high electrical reliability but, in turn, requires a very high accuracy of the aligning process right before the male pin element arrives at the circular connection eye of the socket element. Preferably, the connection section of the male pin element could be provided with a slit-like opening to provide a more elastic and more deformable contact section of the male pin element.

According to a preferred embodiment, the electronics chamber cover lid is axially mounted at a pump housing wall along a cover lid assembly axis being parallel to the guiding cone axis and the pin-socket axis. In other words, the assembling direction of the electronics chamber cover lid with respect to the pump housing is identical with the assembling direction of the multiple push-fit connection arrangement. As a result the aligning characteristics of the guiding cones can be used for aligning the female socket element with the male pin element of the connection pairings as well as for aligning the electronics chamber cover lid with the electronics chamber opening. It is not necessary to provide a sophisticated and complex active guiding means for guiding the cover lid into the corresponding opening of the pump housing.

Preferably, the axial cover lid assembly guidance length is not larger than the pin element tip length distal of the cone bottom plane. The cover lid assembly guidance length is the axial extension between the initial contact position of the cover lid in the electronics chamber opening and the final rest position of the cover lid in the electronics chamber opening. The pin element tip length distal of the cone bottom plane is the length of the pin tip which is "downstream" of the cone bottom plane. The cone bottom plane is the cone plane right beneath the female socket element. With these claimed geometric relations it is guaranteed that, during the assembling process, the connection pairings of the connection arrangement are already perfectly aligned with each other before the electronics chamber cover lid gets in physical contact with the edge of the electronics chamber opening.

During the assembling process, the electronics chamber cover lid is actively moved axially and is radially passively movable so that the cover lid is aligned with respect to the pump housing by the guiding cones into which the male pin elements dive into before the cover lid arrives at the electronics chamber opening edge. No sophisticated assembling device is needed to perfectly and precisely actively align the connection pairings and the cover lid with the pump housing.

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

figure 1 shows schematically a longitudinal cross-section of an automotive electric fluid pump with a multiple push-fit connection arrangement at an electronics chamber cover lid,

figure 2 shows one connection pairing detail II of the multiple push-fit connection arrangement of figure 1,

figures 3a to 3c show in detail a male pin element and a female socket element of the connection pairing of figure 2,

figure 4 show a second embodiment of an electronics chamber cover lid with a flexible electric cable and a terminal pump connector at the distal cable end,

figure 5 shows another embodiment of the multiple push-fit connection arrangement provided at a printed circuit board of the electronic motor driving circuit, and

figure 6 shows a separate plastic guiding body of the multiple push-fit connection arrangement of figure 5.

Figure 1 shows the general structure of an automotive electric fluid pump 10 which is supplied with DC voltage from an automotive electric circuit and which is controlled by an electronic control means of an automotive product. The fluid pump 10 is provided with a pump part 20 comprising a pump rotor 22, an electric motor part 32 and an electronics part 40 with an electronics chamber 42 comprising an electronic motor driving circuit 44. The electric motor part 32 and the electronics part 40 together define an electronically commutated motor 30. The pump part 20 is provided with a fluidic pump inlet 11 and a fluidic pump outlet 12. The pump rotor 22 is defined by a rotating rotor body 24 holding several shiftable rotor blades 26 so that the pump part 20 is of the positive displacement pump type.

The electric motor part 32 is provided with several static electromagnetic motor coils 36 and a rotatable motor rotor 34 mechanically driving the co-rotatable pump rotor 22. The motor rotor 34 is permanently magnetized.

The motor rotor 34 and the pump rotor 22 coaxially rotate around a longitudinal pump rotor axis A.

The electronics part 40 comprises an electronics chamber 42 which houses an electronic motor driving circuit 44 for commutating and electrically driving the motor coils 36 via electric motor coils supply lines 37. The electronic motor driving circuit 44 is substantially defined by a populated printed circuit board 44' lying in a cross plane perpendicular to the pump rotor axis A. The printed circuit board 44' comprises several power semiconductors for driving the motor coils 36.

The fluid pump 10 is substantially provided with a cylindrical pump housing 10'. The pump housing 10' defines the cylindrical housing side-wall 45 of the electronics chamber 42, whereas the cylindrical housing side-wall 45 defines a basically circular axial pump chamber opening 46' which is mechanically and fluidically closed by an assembled electronics chamber cover lid 46. The electronics chamber cover lid 46 is defined by a complex plastic cover lid body 47.

In the first embodiment shown in figures 1 and 2, the cover lid body 47 also integrates a terminal pump connector 52 with several electric terminal connector elements 541, 542, 551, 552 which are electrically connected to the electronic motor driving circuit 44 by electric connection lines penetrating the plastic cover lid body 47. The cover lid 46 also comprises a multiple push-fit connection arrangement 60 of several connection pairings 60'. Each connection pairing 60' comprises a male pin element 90 and a corresponding female socket element 74 together defining a linear pin-socket axis APS. The electric terminal connector elements 541,542,551,552 and the corresponding cover lid-sided female socket elements 74 are each defined by one single metal conductor body 70 which is shown in figures 3a and 3c. The distal end portion 54 of the metal conductor body 70 defines the corresponding electrical terminal

connector element 541,542,551,552, whereas the proximal conductor body end defines the corresponding female socket element 74.

Generally, the female socket element 74;174 is provided with a circular connection eye 76 into which the male pin element 90;190 is pressed-in so that the connection pairings 60';160' of the multiple push-fit arrangement 60;160 are press-fit connections. The male pin element 90 is defined by an end portion of a metal pin element body 641. The end portion defining the male pin element 90 is provided with a longitudinal opening 92 so that this portion is an extended portion with an extended cross-sectional contour. As a consequence, the electrical and mechanical connection between the two elements of the connection pairing 60' is based on a ductile deformation of the male pin element 90 and the corresponding female socket element 74, and thereby defines a connection of high mechanical and electrical quality. The other end portion of the metal pin element body 641 is electrically connected to the printed circuit board 44', for example by soldering.

Figure 2 shows the first embodiment of an aligning arrangement defined by several separate concave guiding cones 61 defined by the plastic cover lid body 47. The guiding cone 61 is defined by the cone surface 62 which is not necessarily exactly conical. The central symmetric longitudinal axis of the guiding cone 61 is defined as the guiding cone axis AC which is, in the assembled state as shown in figures 1 and 2, identical with the linear pin-pocket axis APS.

As shown in figures 2 and 4, the electronics chamber cover lid 46 is axially mounted at the pump housing wall 45 along a cover lid assembly axis AM being parallel to the guiding cone axis AC and the pin-socket axis APS. The assembly axis AM represents the final assembly movement axis of the cover lid body 47 when the axial guiding surface 48 of the cover lid body

47 gets into contact with the corresponding axial guiding surface 49 of the housing wall 45.

As shown in figure 2, the axial cover lid assembly guidance length C is shorter than the pin element tip length A distal of the cone bottom plane 62'. The cone bottom plane 62' is the plane with the lowest cone diameter of the cone surface 62. These length relations cause that during the axial assembly movement of the cover lid 46 the male pin elements 90 arrive at the cone bottom plane 62' before the guiding surfaces 48,49 of the cover lid body 47 and the housing wall 45 get into contact with each other. As a result, the cover lid body 47 is already perfectly aligned with the housing wall 45 when the cover lid body 47 and the housing wall 45 get into contact during the assembly process movement.

Figure 4 shows another embodiment of the electric terminal pump connector 152 which is a part of an terminal pump connector arrangement 150 comprising the terminal pump connector 152 and a flexible electric cable 100 outside the pump housing 10'. The outside surface of a plastic cable insulation body 104 of the flexible electric cable 100 is adhesively bonded, for example by gluing, to the plastic cover lid body 47 to thereby create a reliable fluid-tight sealing of the cable lead-in. The proximal wire ends 102 of the flexible electric cable 100 each are permanently directly connected for example by welding, to a corresponding female socket element 74 defined by a single metal conductor body 170 which is enclosed by the cover lid body 47.

Figures 5 and 6 show another embodiment of a multiple push-fit connection arrangement 160. In this embodiment, the female socket elements 174 are defined by metal ring body's 174' which are permanently fixed at the printed circuit board 44' of the electronic motor driving circuit 44. The male pin elements 190 are embedded and hold by the cover lid 46 and define together with the female socket elements 174

four connection pairings 160'. The four guiding cones 61 are defined by a single separate plastic guiding body 260 which is directly fixed to the printed circuit board 44'.

The cone angle of the guiding cone 61 with respect to the cone axis AC is about 30° and can be up to 45°, but not larger. The cone length B is several millimeters, preferably 3 to 7 mm.

Pierburg Pump Technology GmbH, 41460 Neuss

CLAIMS

1. An automotive electric fluid pump (10) with
a pump part (20) with a pump rotor (22),
an electric motor part (32) with motor coils (36) and a motor rotor (34) mechanically driving the pump rotor (22),
an electronics part (40) with an electronics chamber (42) comprising an electronic motor driving circuit (44) for commutating and driving the motor coils (36) and an electronics chamber cover lid (46) fluidically closing an electronics chamber opening (46') of the electronics chamber (42), and
an electric terminal pump connector (52;152) defining the electric interface between the electric fluid pump (10) and a complementary automotive-sided counter-connector,
wherein the terminal pump connector (52;152) is provided with electric terminal connector elements (541,542,551,552) which are electrically connected to the electronic motor driving circuit (44) by electric connection lines penetrating the plastic cover lid body (47) of the electronics chamber cover lid (46),
wherein the electric terminal connector elements (541,542,551,552) are electrically connected to the electronic motor driving circuit (44) by a multiple push-fit connection arrangement (60;160) of several connection pairings (60';160'), each connection pairing (60';160'), comprising a male pin element (90;190) and a female socket element (74;174) and defining a linear pin-socket axis (APS),
wherein every socket element (74) is provided with a separate concave guiding cone (61) defined by a plastic body, whereas the

guiding cone axis (AC) is identical with the linear pin-socket axis (APS).

2. The automotive electric fluid pump (10) of claim 1, wherein the female socket elements (74) are permanently fixed within the cover lid body (47) and the guiding cone (61) is defined by the cover lid body (47), whereas the male pin elements (90) are permanently fixed at a printed circuit board (44') of the electronic motor driving circuit (44).

3. The automotive electric fluid pump (10) of claim 1, wherein the female socket elements (174) are permanently fixed in a printed circuit board (44') of the electronic motor driving circuit (44) and the guiding cones (61) are defined by a separate plastic guiding body (260) being directly fixed to the printed circuit board (44').

4. The automotive electric fluid pump (10) of one of the preceding claims 2 or 3, wherein the electric terminal connector elements (541,542,551,552) and the cover lid-sided female socket elements (74) or the cover lid-sided male pin elements (190) each are defined by one single metal conductor body (70).

5. The automotive electric fluid pump (10) of one of the preceding claims 2 or 3, wherein a flexible electric cable (100) is provided between the multiple push-fit connection arrangement (60) and the terminal pump connector (152).

6. The automotive electric fluid pump (10) of claim 5, wherein the cover lid-sided female socket elements (74) or the cover lid-sided male pin elements (190) each are defined by one single metal conductor body (170) which is electrically permanently directly

connected with a proximal wire end (102) of the flexible electric cable (100).

7. The automotive electric fluid pump (10) of claim 5 or 6, wherein the outside surface of a plastic cable insulation body (104) of the flexible electric cable (100) is adhesively bonded to the plastic cover lid body (47).

8. The automotive electric fluid pump (10) of one of the preceding claims, wherein the female socket elements (74;174) are provided with a circular connection eye (76) into which the male pin element (90;190) is pressed-in so that the connection pairings (60';160') of the multiple push-fit connection arrangement (60;160) are press-fit connections.

9. The automotive electric fluid pump (10) of one of the preceding claims, wherein the electronics chamber cover lid (46) is axially mounted in the electronics chamber opening (46') with a cover lid assembly axis (AM) being parallel to the guiding cone axis (AC) and the pin-socket axis (APS).

10. The automotive electric fluid pump (10) of one of the preceding claims, wherein the axial cover lid assembly guidance length (C) in the chamber opening (46') is not larger than the pin element tip length (A) distal of the cone bottom plane (62').

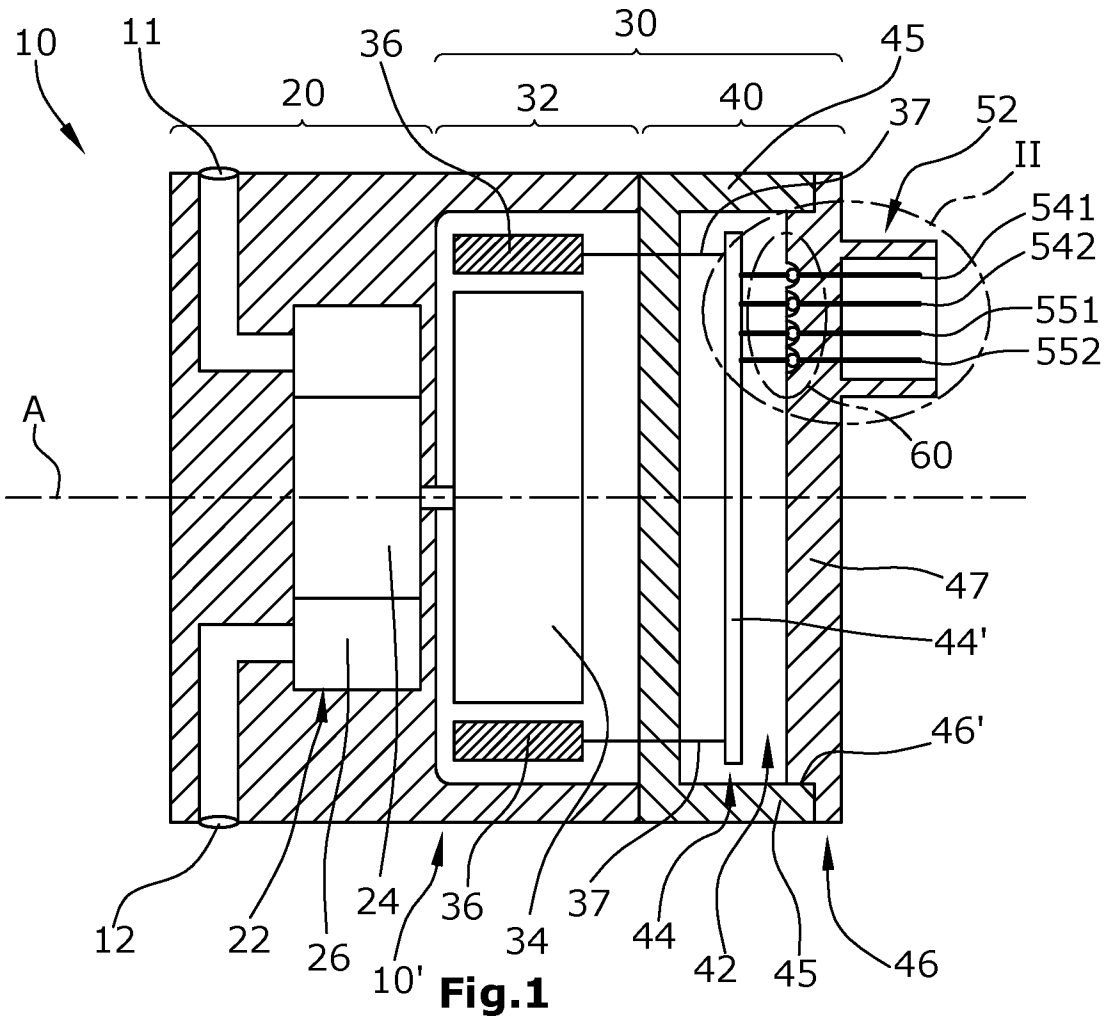
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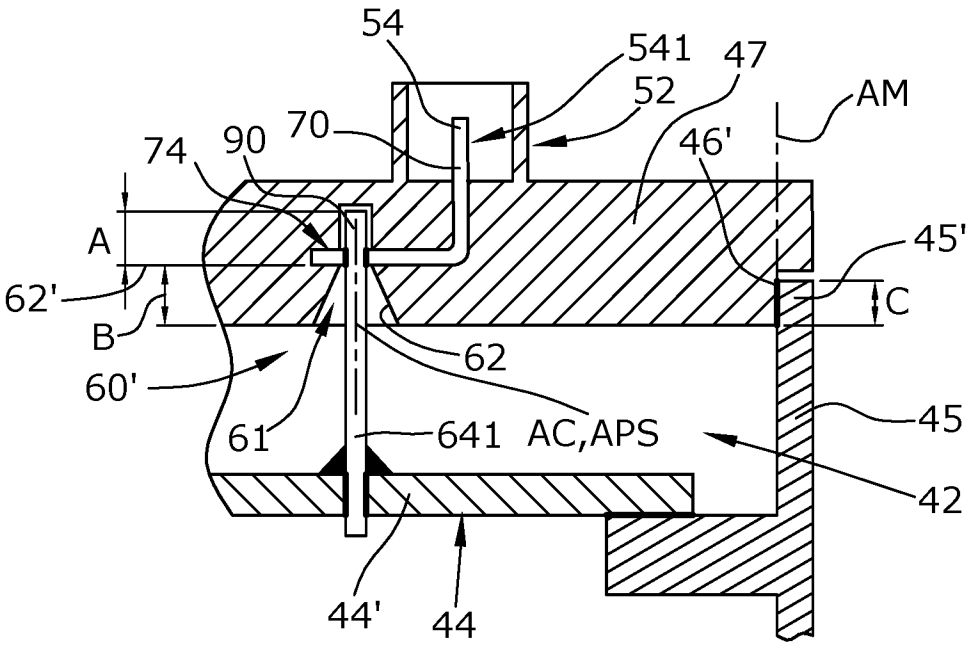
Fig.1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541
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AM
74
90
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46'
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62'
C
B
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AC,APS
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42
44'
44

Fig.2

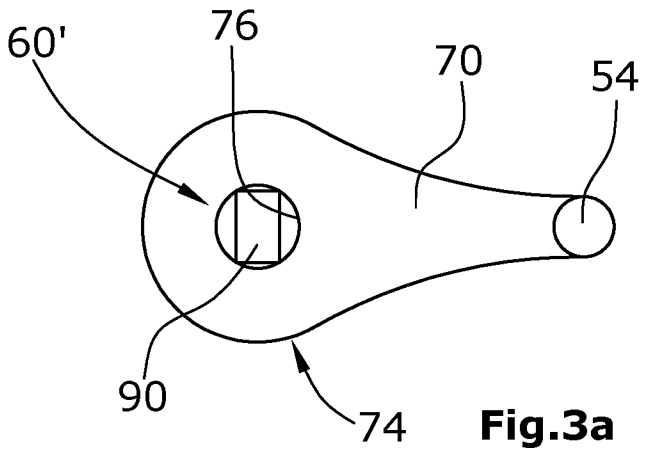


Fig.3a

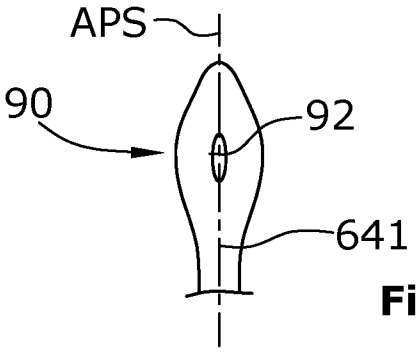


Fig.3b

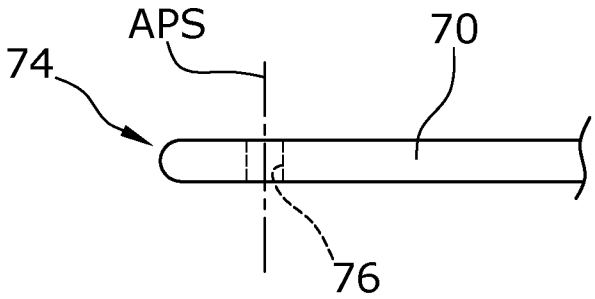
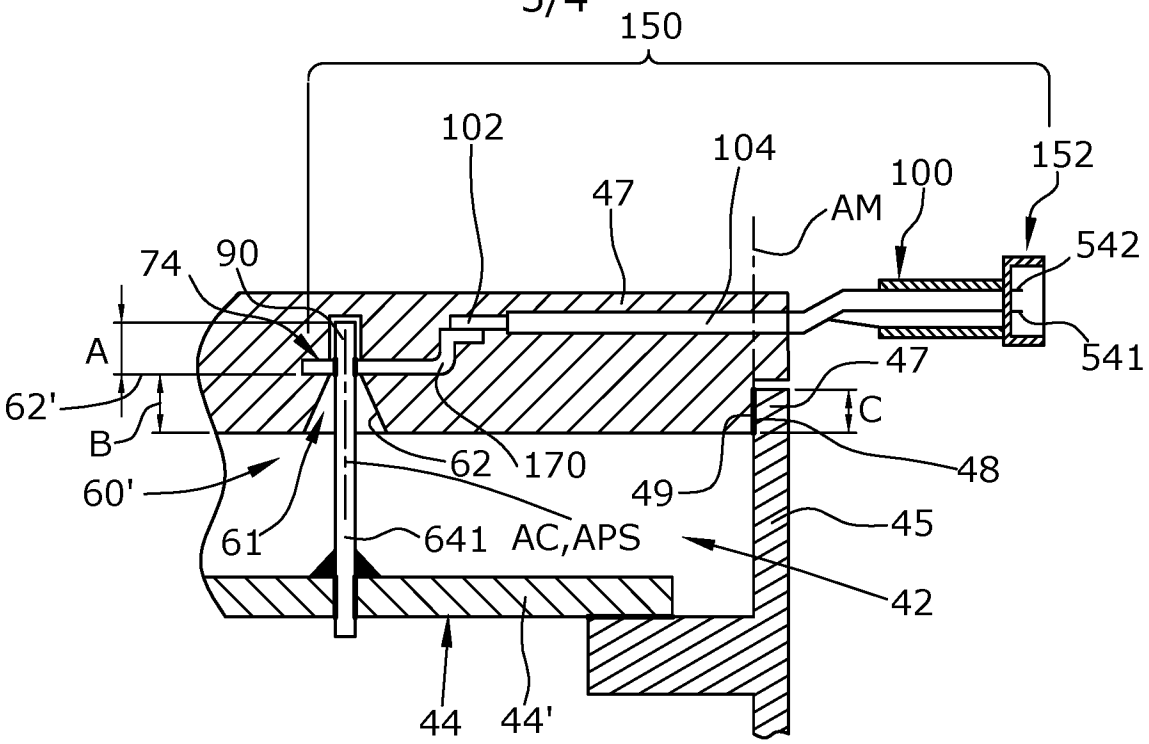


Fig.3c


150
102
104
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152
47
AM
542
74
90
541
A
47
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C
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AC,APS
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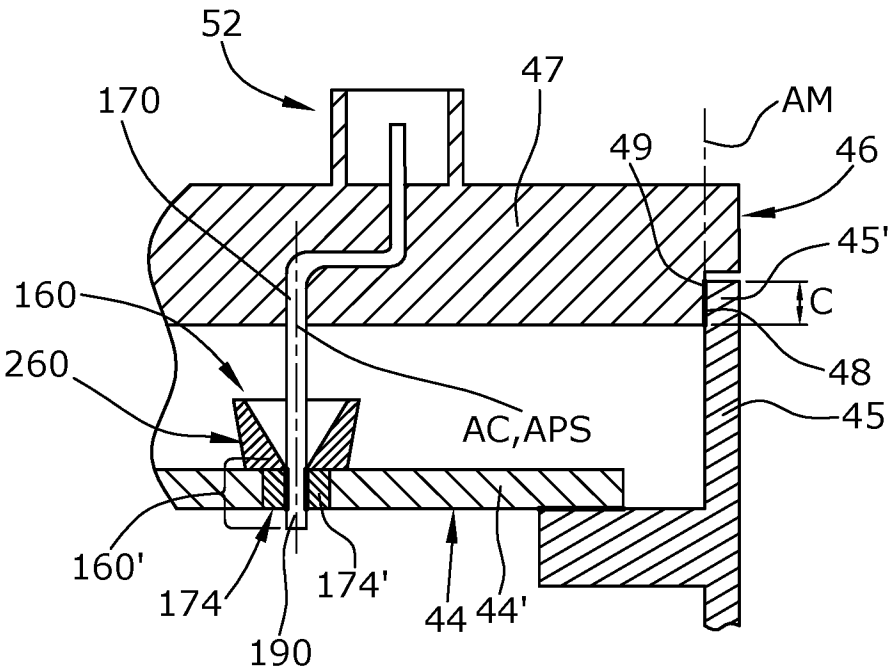
Fig.4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190

Fig.5

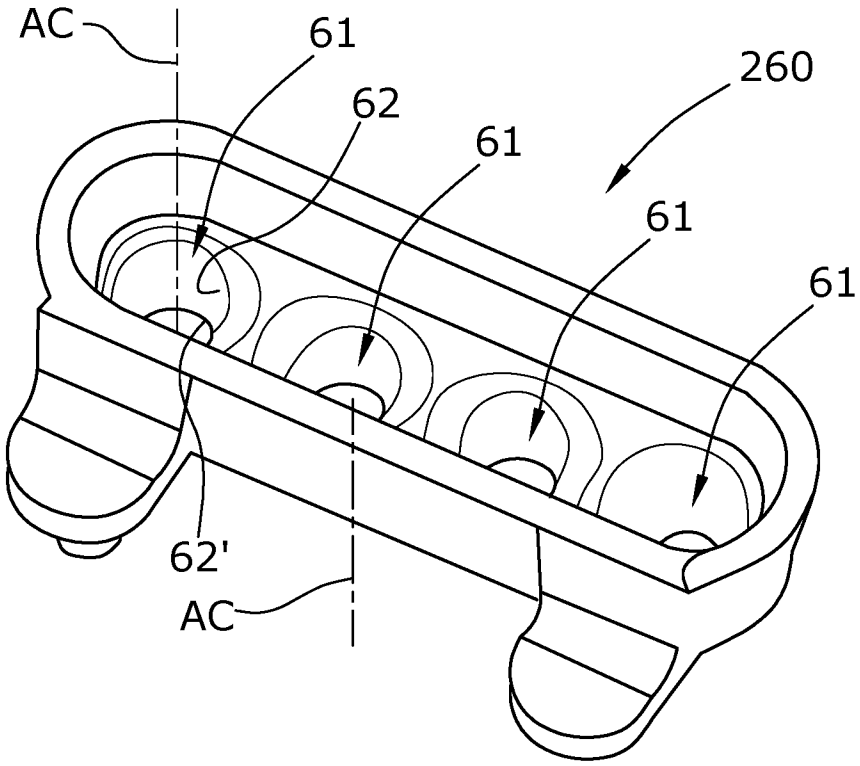

Fig.6

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2020/073299

A. CLASSIFICATION OF SUBJECT MATTER
INV. H02K5/22
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)
H02K

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	DE 44 11 960 A1 (PIERBURG GMBH [DE]) 12 October 1995 (1995-10-12) column 1, line 20 - line 21 column 1, line 46 - column 3, line 28; figures 1-4	1-4,8,9 5,6

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A	DE 195 48 866 A1 (TEVES GMBH ALFRED [DE]) 2 January 1997 (1997-01-02) column 7, line 28 - column 8, line 13; figure 7	1-10

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2020/073299

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