(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 3 239 532 A1

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
01.11.2017 Bulletin 2017/44

(21) Application number: **16167109.4**

(22) Date of filing: **26.04.2016**

(51) Int Cl.:
F04D 3/02 *(2006.01)* ***F04D 5/00*** *(2006.01)*
F04D 13/06 *(2006.01)* ***F04D 13/12*** *(2006.01)*
F04C 2/16 *(2006.01)*

(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
Designated Extension States:
BA ME
Designated Validation States:
MA MD

(71) Applicant: **TI Automotive Technology Center GmbH**
76437 Rastatt (DE)

(72) Inventors:
- **Boecker, Albert J.**
  76275 Ettlingen (DE)
- **Gmünd, Patrick**
  76149 Karlsruhe (DE)
- **Michaelis, Gerrit A.**
  76448 Durmersheim (DE)

(74) Representative: **dompatent von Kreisler Selting Werner -**
Partnerschaft von Patent- und Rechtsanwälten mbB
Deichmannhaus am Dom
Bahnhofsvorplatz 1
50667 Köln (DE)

(54) FUEL PUMP WITH REDUCED HEIGHT IN THE AXIAL DIRECTION

(57) Fuel pump (10), comprising, a housing (12) having a drive axis (14), an electric motor (16) arranged in the housing (12) and comprising a rotor (18) for rotation about the drive axis (14), a stator (20) interacting with the rotor (18) so as to cause a rotation of the rotor (18), a rotating fuel conveying element (22, 24a - 24c, 26) arranged inside the rotor (18) when seen in a radial direction (r), the rotating fuel conveying element (22, 24a - 24c, 26) at least partially overlapping with the rotor (18) in an axial direction (a) and being connected to the rotor (18) in a non rotatable manner, such that the rotation of the rotor (18) causes a rotation of the fuel conveying element (22, 24a - 24c, 26).

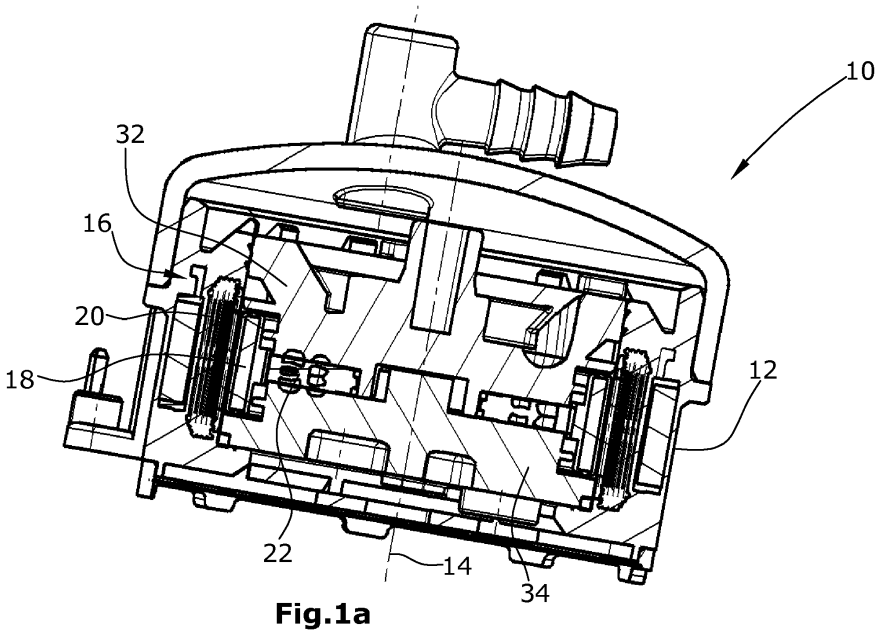

Fig.1a

EP 3 239 532 A1

Description

[0001] The invention is related to a fuel pump.

[0002] In brushless fuel pumps known from the state of the art, the rotor is surrounded by the stator and an impeller is connected to an axial end of the rotor. Thereby, a rotation of the rotor causes a rotation of the impeller which conveys the fuel. This layout leads to a big height of the fuel pump.

[0003] It is an object of the present invention to provide a fuel pump with a reduced height.

[0004] This object is achieved by the features of claim 1 of the invention.

[0005] The inventive fuel pump comprises a housing having a drive axis. This drive axis can be a virtual drive axis. The fuel pump further comprises an electric motor arranged in the housing and comprising a rotor for rotation about the drive axis. The fuel pump further comprises a stator, interacting with the rotor so as to cause a rotation of the rotor. A rotating fuel conveying element is arranged inside the rotor when seen in a radial direction, the rotating fuel conveying element at least partially overlapping with the rotor in an axial direction and being connected to the rotor in a non rotatable manner such that the rotation of the rotor causes a rotation of the fuel conveying element.

[0006] Since the rotor and the rotating fuel conveying element overlap in an axial direction, the inventive fuel pump has a reduced height. Further, it is possible to arrange a plurality of magnets at the periphery of the rotor which will have an increased diameter compared to the rotor of previous known fuel pumps. This is due to the reason that the fuel conveying element is arranged inside the rotor when seen in a radial direction. The increased diameter of the rotor makes it possible to use more magnets at its periphery. In addition, these magnets are arranged further away from the drive axis, thereby having a longer lever. Therefore, startup variations of the fuel pump can be reduced when compared to prior art pumps. Such startup variations can damage the connection of the fuel conveying element and the rotor (shaft cap joint).

[0007] In a preferred embodiment, the rotating fuel conveying element is an impeller.

[0008] In another preferred embodiment which may be an independent invention, the rotating fuel conveying element comprises at least one and in particular a plurality of rotating fuel conveying screws. Each screw rotates about its own longitudinal axis. For example, three rotating screws can be used. In this embodiment, the inventive fuel pump uses the principle of a screw pump. The rotating fuel conveying element further comprises a carrying element, carrying each screw in a longitudinal bore. Each bore is equidistantly spaced from the drive axis. Each screw intermeshes with a non rotating screw being arranged at the position of the virtual drive axis.

[0009] The non rotating screw can be connected in a non rotatable manner with the housing or a part connected to the housing.

[0010] The carrying element is connected with the rotor in a non rotatable manner so as to rotate with the rotor about the drive axis. The carrying element preferable has a circular cylindrical shape. This rotation of the carrying element causes a rotation of the fuel conveying screws about the drive axis. The intermeshing of the fuel conveying screws with the fixed screw at the position of the drive axis causes a rotation of each fuel conveying screw about its own longitudinal axis. This rotation causes the conveying of the fuel.

[0011] It is preferred that the electric motor is a brushless motor.

[0012] It is further preferred that the housing comprises an upper cap and a lower cap which together form a bearing for the fuel conveying element in a radial and/or axial direction.

[0013] It is further preferred that the fuel conveying element serves as a radial bearing for the rotor.

[0014] It is further preferred that the rotor is guided in an axial direction by a magnetic bearing.

[0015] In a further embodiment, the rotor can be surrounded in a radial direction by the stator, the rotor comprising magnets being arranged at its periphery.

[0016] In the following, preferred embodiments of the invention are described in the context of the figures.

Figures 1a and 1b show a first embodiment of the fuel pump,

Figures 2a - 2b show a second embodiment of a fuel pump,

Figure 3 shows a third embodiment of the fuel pump,

Figures 4 - 7 show the assembly process of the embodiment according to figure 3.

[0017] Figure 1a which is an intersected view of figure 1b shows a fuel pump 10 having a housing 12 which comprises an upper cap 32 and a lower cap 34. These serve as an axial and radial bearing for the impeller 22. Rotation of the impeller 22 takes place about the drive axis 14. The basic function of the impeller in order to cause a conveying of the fuel is known from the state of the art and is therefore not described in more detail.

[0018] The impeller 22 is surrounded in an axial direction by the rotor 18 which is connected in a non rotatable manner

to the impeller 22. This can be done for example by positive engagement elements.

[0019] The rotor 18 comprises a plurality of magnets at its periphery and is surrounded by the stator 20 which causes rotation of the rotor 18 about the drive axis 14.

[0020] Figure 1b is a top view of the same embodiment shown in figure 1a, whereby figure 1b shows i.a. the electrical connecting elements for the electric motor.

[0021] The embodiment shown in figure 3 is very similar to the one shown in figure 1, whereby this embodiment comprises an integrated fuel filter 38 arranged above the upper cap 32.

[0022] Figure 4 shows the assembly of the embodiment according to figure 3. First, the stator package comprising the stator 20 and the electrical contacts 42 is assembled and is overmolded so as to form the housing element 44. This process is shown in figure 5a. Figure 5b shows the result.

[0023] The next steps are shown in figure 6a: the inlet cover which is the lower cap 34 and the impeller 22 are assembled with the rotor 18 and fixed by the upper cap 32. This assembled pump section is placed inside the stator 20. The result is shown in figure 6b.

[0024] According to figure 7a, the filter 38 is assembled on the upper cap 32. Finally, a filter cover 40 can be connected by molding or laser-welding with housing element 44, thereby forming the filter shown in figure 7b.

[0025] The assembly of the first embodiment shown in figure 1 is very similar to figure 3, whereby the filter 38 is omitted.

[0026] Figures 2a and 2b show a second embodiment which can be an independent invention. This fuel pump 10 also comprises a housing 12 which is closed at its upper end by a cover 40. The fuel pump 10 comprises an upper cap 32 and a lower cap 34, serving as a bearing for the carrying element 26. This carrying element 26 is connected in a non rotatable manner with the rotor 18 which is surrounded by the stator 20. Rotation of the carrying element 26 causes the fuel conveying screws 24a - 24c to rotate about their respective longitudinal axis, since they intermesh with the fixed screw 30. This fixed screw 30 is connected in a non rotatable manner with the upper cap 32. In this embodiment, fuel conveying takes place according to the function of a screw pump with three fuel conveying screws.

Claims

1. Fuel pump (10), comprising,
a housing (12) having a drive axis (14),
an electric motor (16) arranged in the housing (12) and comprising a rotor (18) for rotation about the drive axis (14),
a stator (20) interacting with the rotor (18) so as to cause a rotation of the rotor (18),
a rotating fuel conveying element (22, 24a - 24c, 26) arranged inside the rotor (18) when seen in a radial direction (r),
the rotating fuel conveying element (22, 24a - 24c, 26) at least partially overlapping with the rotor (18) in an axial direction (a) and being connected to the rotor (18) in a non rotatable manner, such that the rotation of the rotor (18) causes a rotation of the fuel conveying element (22, 24a - 24c, 26).

2. Fuel pump (10) according to claim 1, **characterized in that** the rotating fuel conveying element (22) is an impeller.

3. Fuel pump (10) according to claim 1, **characterized in that** the rotating fuel conveying element (24a - 24c, 26) comprises one and in particular a pluralityof rotating fuel conveying screws (24a - 24c), each screw rotating about its own longitudinal axis,
the rotating fuel conveying element (24a - 24c, 26) further comprises a carrying element (26) carrying each screw (24a - 24c) in a longitudinal bore (28a - 28c), each bore being equidistantly spaced from the drive axis (14),
each screw (24a - 24c) intermeshing with a non rotating screw (30) being arranged at the drive axis (14),
the carrying element (26) being connected with the rotor (18) in a non rotatable manner, so as to rotate with the rotor (18) about the drive axis (14),
this rotation of the carrying element (26) causing a rotation of the fuel conveying screws (24a - 24c) about the drive axis (14),
the intermeshing of the rotating screws (24a - 24c) with the fixed screw (30) causing a rotation of each fuel conveying screw about its longitudinal axis, this rotation causing the conveying of the fuel.

4. Fuel pump (10) according to claims 1 - 3, **characterized in that** the electric motor (16) is a brushless motor.

5. Fuel pump (10) according to claims 1 - 4, **characterized in that** the housing (12) comprises an upper cap (32) and a lower cap (34) which together form a bearing for the fuel conveying element (22, 24a - 24c, 26) in a radial and/or axial direction.

6. Fuel pump (10) according to claims 1 - 5, **characterized in that** the fuel conveying element (22, 24a - 24c, 26)

serves as a radial bearing for the rotor (18).

7. Fuel pump (10) according to claims 1- 6, **characterized in that** the rotor (18) is guided in an axial direction by a magnetic bearing.

8. Fuel pump (10) according to claims 1- 7, **characterized in that** the rotor (18) is surrounded in a radial direction by the stator (20), the rotor (18) comprising magnets being arranged at is periphery.

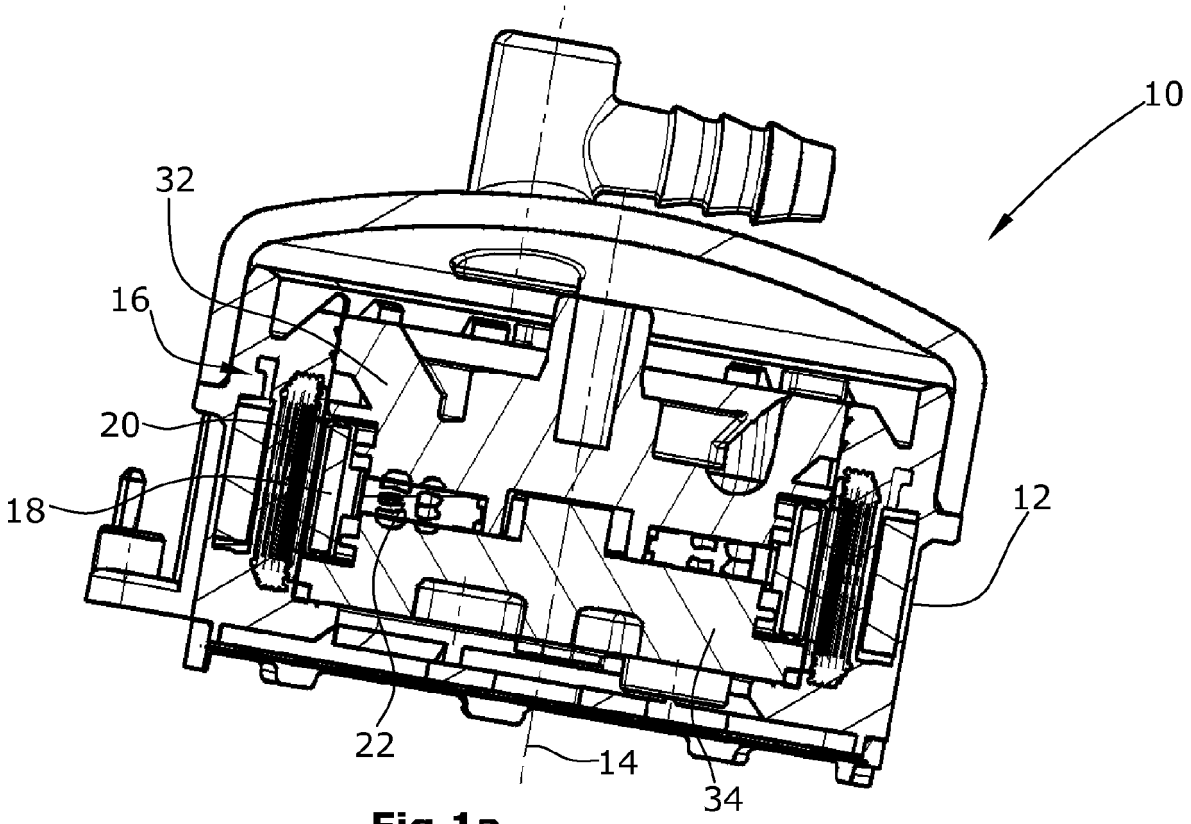

Fig.1a

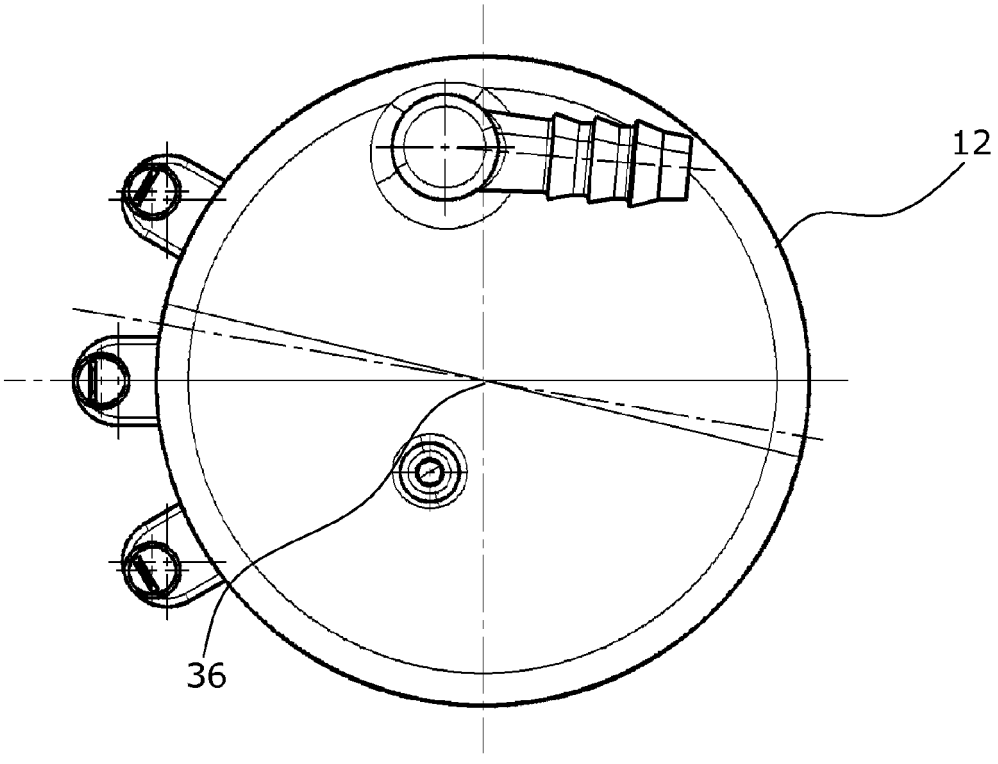

Fig.1b

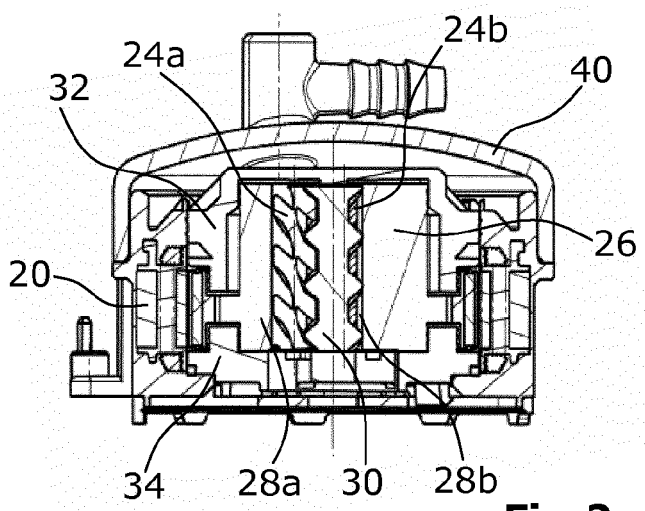

Fig.2a

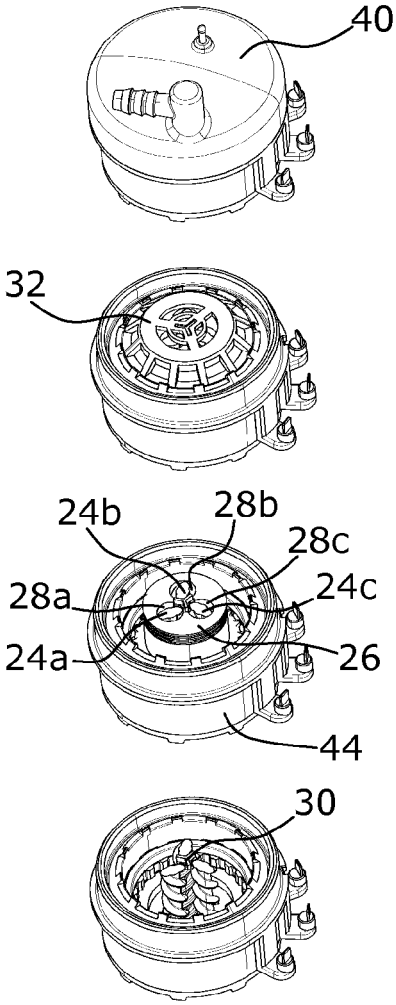

Fig.2b

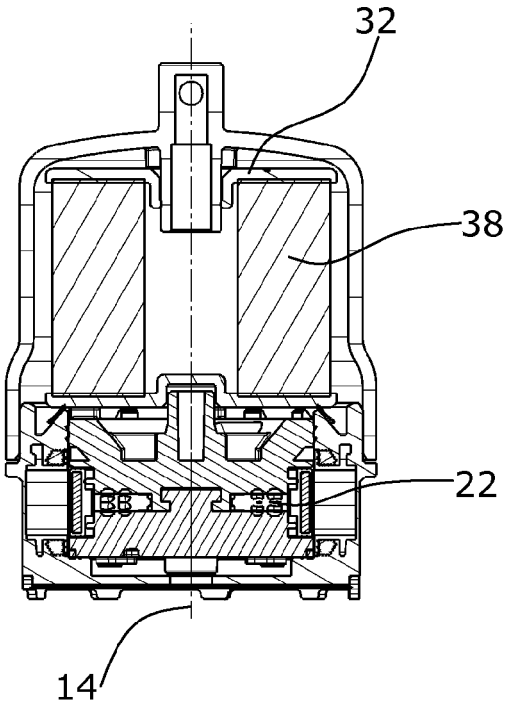

Fig.3

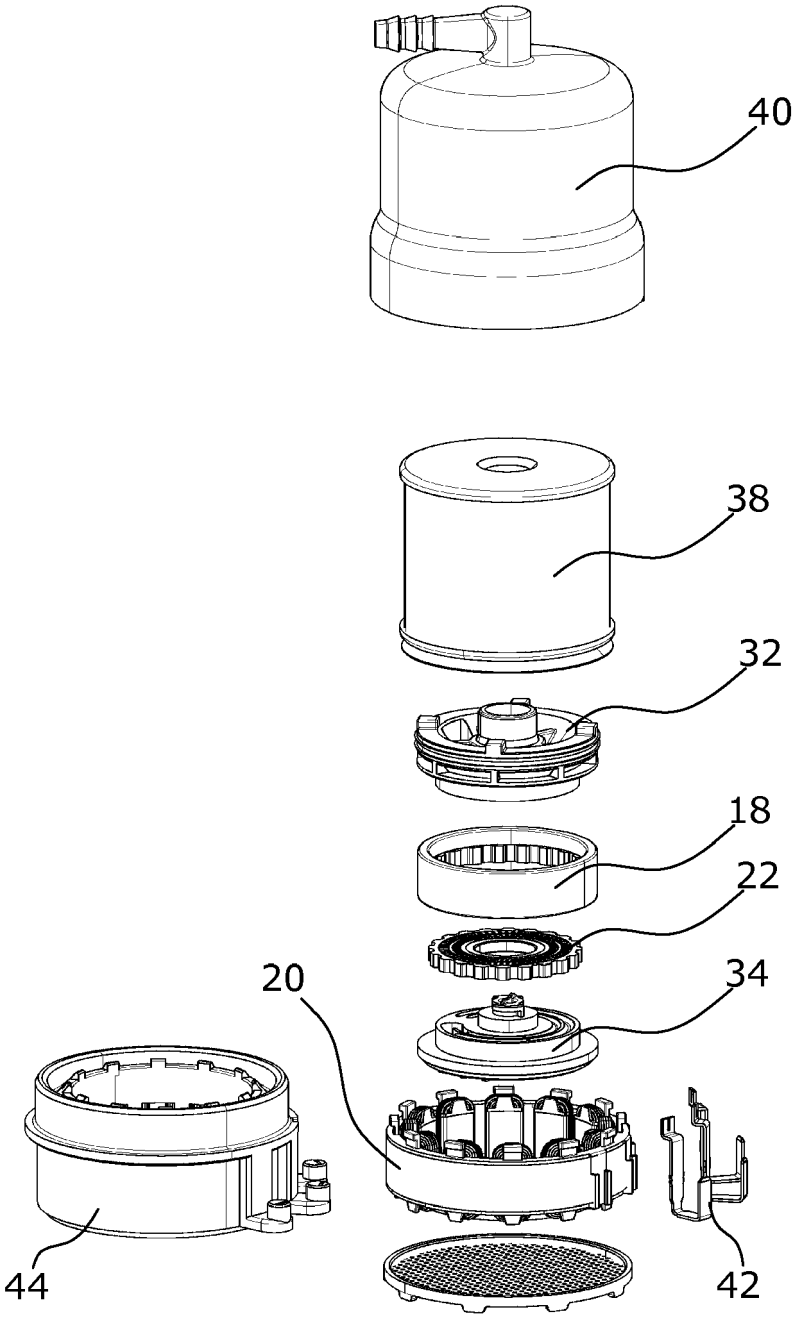

Fig.4

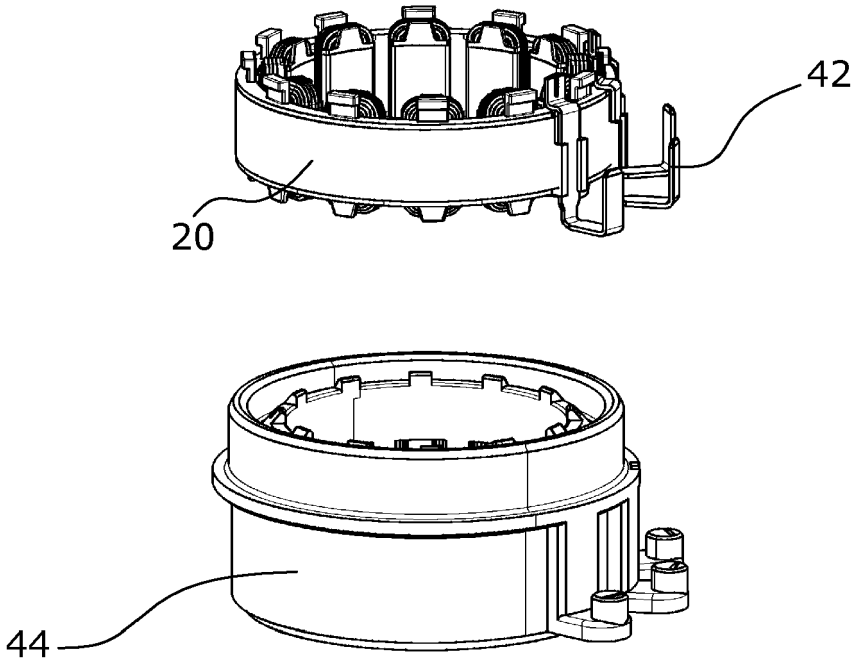

Fig.5a

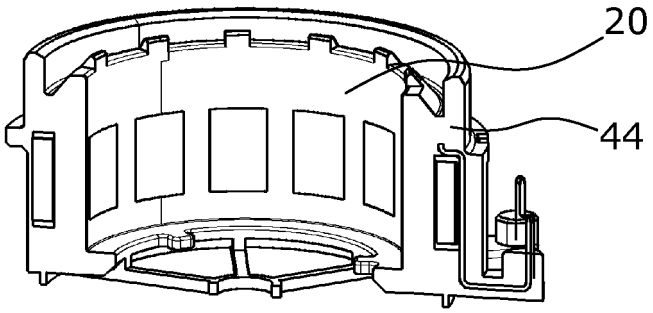

Fig.5b

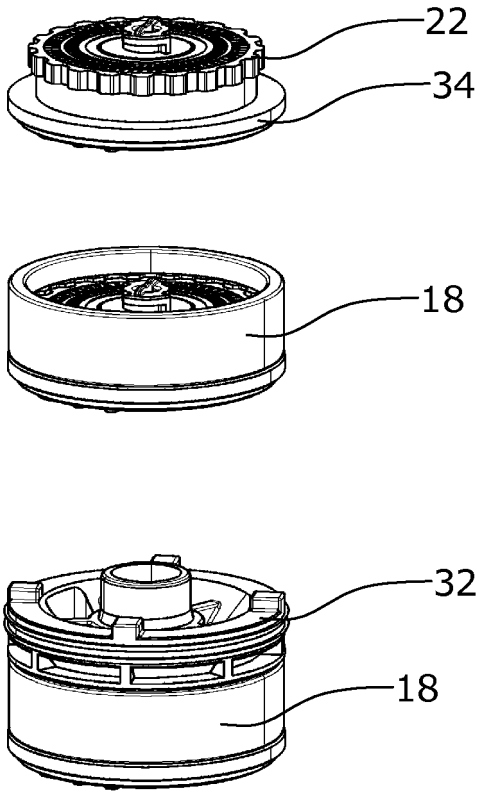

Fig.6a

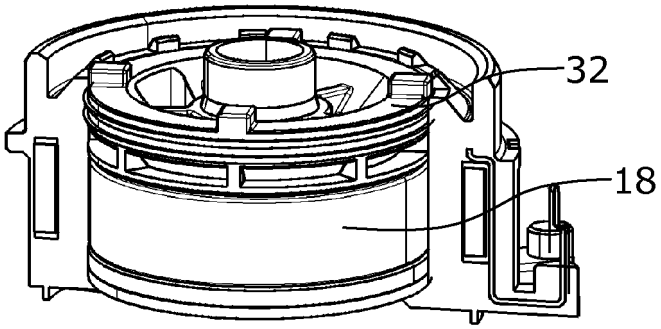

Fig.6b

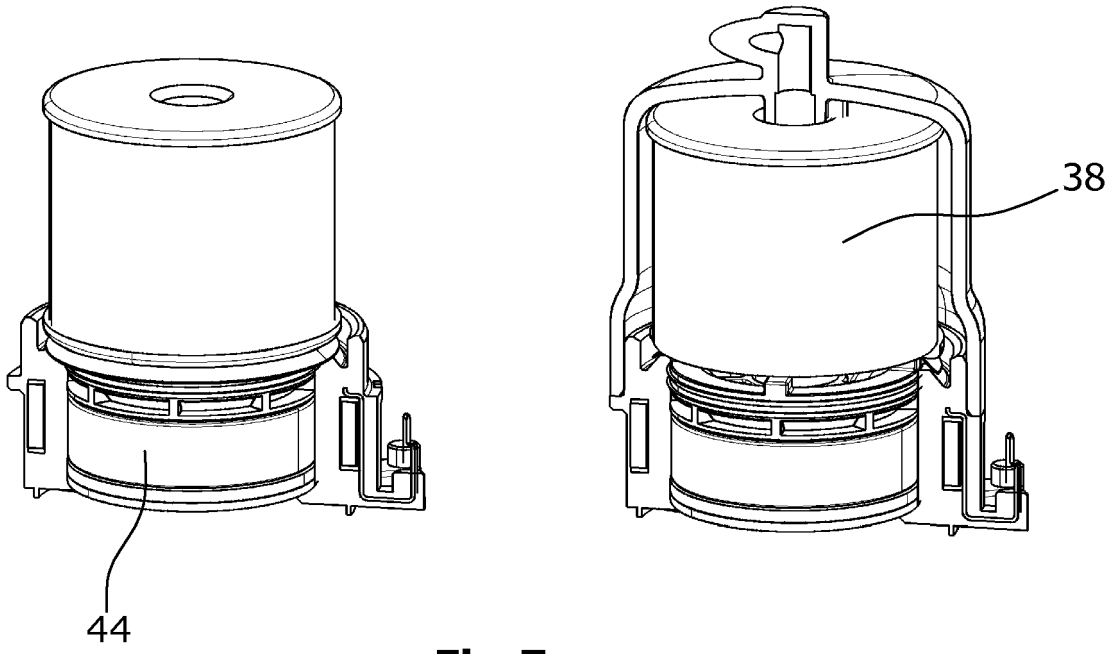

Fig.7a

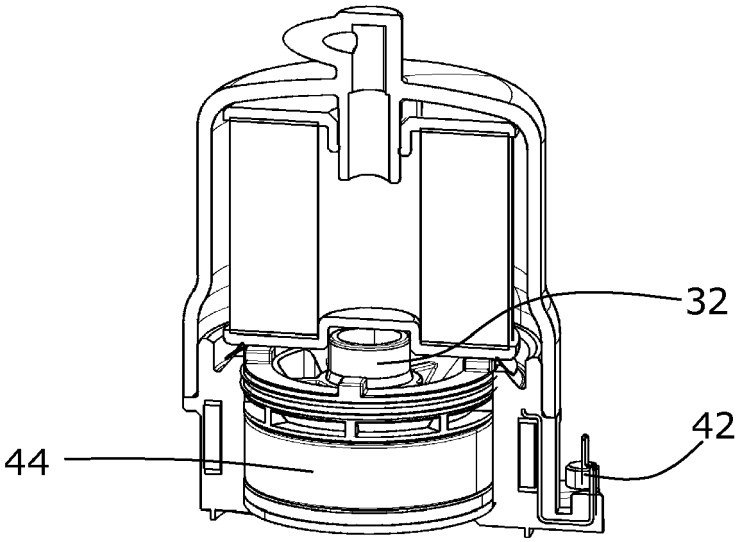

Fig.7b

Europäisches Patentamt
European Patent Office
Office européen des brevets

EUROPEAN SEARCH REPORT

Application Number
EP 16 16 7109

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X Y	US 6 149 404 A (DOBLER KLAUS [DE] ET AL) 21 November 2000 (2000-11-21) * claims 1,2; figures 1,2 * -----	1,2,4-6, 8 7	INV. F04D3/02 F04D5/00 F04D13/06
Y	EP 1 065 383 A1 (INGERSOLL DRESSER PUMP CO [US]) 3 January 2001 (2001-01-03) * claim 3 * -----	7	F04D13/12 F04C2/16
X	EP 1 475 539 A2 (AUTOMOTIVE MOTION TECH LTD [GB]) 10 November 2004 (2004-11-10) * paragraphs [0067] - [0098]; figure 3 * * paragraphs [0070] - [0073], [0076] - [0077], [0090], [0092], [0095], [0096], [0098] * -----	3	

TECHNICAL FIELDS SEARCHED (IPC)
F04D F04C

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	2 February 2017	Brouillet, Bernard

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P04C01)

Europäisches Patentamt
European Patent Office
Office européen des brevets

Application Number
EP 16 16 7109

CLAIMS INCURRING FEES

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

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

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

LACK OF UNITY OF INVENTION

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

see sheet B

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

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

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

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

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

Europäisches Patentamt
European Patent Office
Office européen des brevets

LACK OF UNITY OF INVENTION
SHEET B

Application Number
EP 16 16 7109

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

1. claims: 1, 2, 4-8

   Axially thin fuel pump of the side-channel type

   ---

2. claim: 3

   Axially thin fuel pump of the positive displacement type

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 16 16 7109

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

02-02-2017

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 6149404 A	21-11-2000	DE 19725941 A1	24-12-1998
		EP 0918937 A1	02-06-1999
		JP 2000517026 A	19-12-2000
		KR 20000068133 A	25-11-2000
		US 6149404 A	21-11-2000
		WO 9859173 A1	30-12-1998
EP 1065383 A1	03-01-2001	DE 60015018 D1	25-11-2004
		DE 60015018 T2	09-03-2006
		EP 1065383 A1	03-01-2001
		HK 1035019 A1	13-05-2005
		JP 2001123978 A	08-05-2001
		US 6280157 B1	28-08-2001
EP 1475539 A2	10-11-2004	EP 1475539 A2	10-11-2004
		GB 2401397 A	10-11-2004
		US 2004241016 A1	02-12-2004

EPO FORM P0459

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