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(71) Applicant: **Delphi Technologies IP Limited**
**Saint Michael (BB)**

(72) Inventors:
- **WILLMOTT, James**
  **Sittingbourne, Kent ME9 9SG (GB)**
- **PEDLEY, Toby**
  **London, SE12 8UX (GB)**

(74) Representative: **Delphi France SAS**
**c/o Delphi Technologies**
**Campus Saint Christophe**
**Bâtiment Galilée 2**
**10, avenue de l'Entreprise**
**95863 Cergy Pontoise Cedex (FR)**

(54) **FUEL PUMP ASSEMBLY**

(57) A high-pressure fuel pump assembly (60) comprising a pump head (11), an inlet valve (12) and a clamping plate (10) attaching the inlet valve (12) to the pump head (11). The clamping plate (10) comprises a clamping surface (20a, 20b, 20c) engaged with the inlet valve (12), an attachment region (22a, 22b. 22c) secured to the pump head (11). The attachment region (22a, 22b, 22c) comprises an attachment surface (46a, 46b, 46c) engaged with the pump head (11) and a deformable connection portion (24a, 24b, 24c, 24d, 24e, 24f) connecting the clamping surface (20a, 20b, 20c) and the attachment region (22a, 22b, 22c). The connection portion (24a, 24b, 24c, 24d, 24e, 24f) is configured to deform to maintain a flush engagement between the attachment surface (46a, 46b, 46c) and the pump head (11) as the attachment region (22a, 22b, 22c) is secured to the pump head (11).

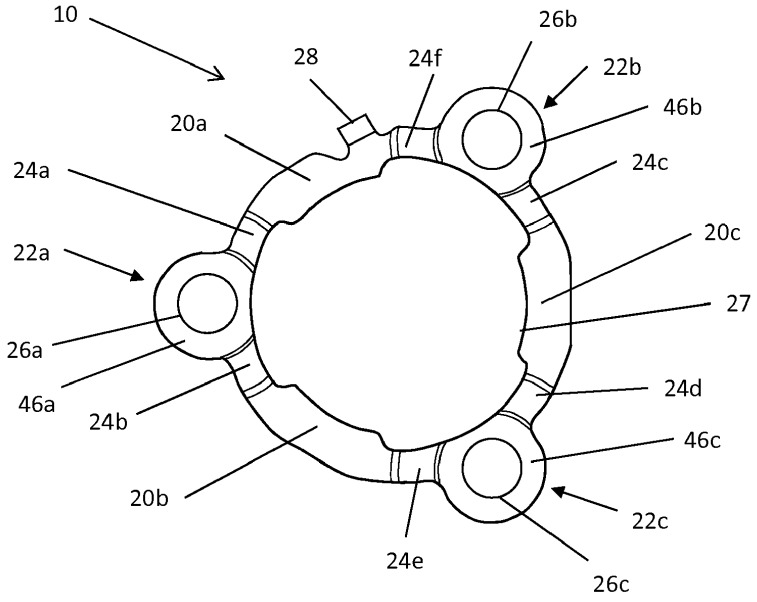



Figure 3

EP 3 578 801 A1

## Description

### TECHNICAL FIELD

**[0001]** The present disclosure relates to a fuel pump assembly and particularly, but not exclusively, to a high-pressure fuel pump assembly comprising a clamping plate for attaching an inlet valve to a fuel pump. Aspects of the invention relate to a fuel pump assembly.

### BACKGROUND

**[0002]** High-pressure fuel pumps for common rail fuel injection systems of compression-ignition internal combustion engines typically comprise one or more hydraulic pump heads where fuel is pressurised in a pumping chamber of the pump head by the reciprocating movement of a plunger. Typically, low-pressure fuel is fed to the pump heads by a low-pressure lift pump in the fuel tank, or alternatively by a transfer pump built into the high-pressure fuel pump. Once pressurised, the high-pressure fuel is fed from the pumping chamber to a common rail fuel volume.

**[0003]** An inlet metering valve is used to regulate the flow of fuel to the high-pressure pump. A conventional inlet valve assembly typically comprises a main body with an integrated flange. The integrated flange comprises a plurality of apertures configured to receive a fixing means to secure the main body to the pump head.

**[0004]** Manufacturing the main body of conventional inlet valves is achieved through a complex turning process. This process not only wastes material due to the turning and milling of a large bar of material to manufacture the main housing, but the process also results in an excessive machining cycle time.

**[0005]** It is against this background that the invention has been devised.

### SUMMARY OF THE INVENTION

**[0006]** According to an aspect of the present invention there is provided a high-pressure fuel pump assembly comprising a pump head, an inlet valve and a clamping plate attaching the inlet valve to the pump head, wherein the clamping plate comprises: a clamping surface engaged with the inlet valve; an attachment region secured to the pump head, the attachment region comprising an attachment surface engaged with the pump head; and, a deformable connection portion connecting the clamping surface and the attachment region, wherein the connection portion is configured to deform to maintain a flush engagement between the attachment surface and the pump head as the attachment region is secured to the pump head.

**[0007]** The clamping plate provides the advantage that the fixing means, typically a plurality of screws are subject to minimal non-axial loading the clamping plate is secured to the pump head. The connection portion deforms to maintain flush engagement between the attachment surface and the pump head when the clamping plate is secured to the pump head. Furthermore, the deformable connection portions may deform to allow for tolerances in the geometry of the fuel pump assembly resulting from manufacture.

**[0008]** In an embodiment the clamping plate may comprise three attachment regions and three clamping surfaces alternatively arranged in a substantially circumferential arrangement and wherein the attachment regions and clamping surfaces are connected via six connection portions.

**[0009]** In another embodiment the connection portion may be configured to deform when the clamping plate is secured to the pump head thereby causing a distance defined between the clamping surface and the attachment surface to increase.

**[0010]** The distance may increase by between 0.1mm and 0.5mm depending on the tolerancing of the inlet valve assembly. Deforming the connection portion helps to maintain flush engagement of the attachment surface and the pump head when the clamping plate is secured to the pump head by the screws.

**[0011]** In an embodiment the clamping surface may be convex prior to engaging the inlet valve. In another embodiment the clamping surface may be configured to deform upon engagement of the inlet valve and the clamping surface may be substantially planar when engaged with the inlet valve. This is advantageous when the clamping plate is required to have an increased stiffness to deliver an increased clamping force. The convex clamping surface engages the fuel pump assembly before deforming when the clamping plate is secured to the fuel pump assembly.

**[0012]** In one embodiment the clamping plate may comprise a locating feature engaged with a corresponding engagement slot on the pump head. This is advantageous as the locating feature enables an operator to locate the clamping plate on the fuel pump prior to securing the clamping plate in place. The locating feature may locate the clamping plate such that the attachment regions are orientated correctly to be secured to the pump head.

**[0013]** In another embodiment the attachment region comprises an aperture through which a screw is located. The screw may engage the pump head and provide a clamping force to secure the clamping plate to the pump head.

### BRIEF DESCRIPTION OF THE DRAWINGS

**[0014]** In order that the invention may be more readily understood, reference will now be made, by way of example, to the accompanying drawings, in which:

Figure 1 is a perspective view of an inlet valve assembly suitable for use with embodiments of the present invention;

Figure 2 is a perspective view of the inlet valve assembly of Figure 1 and a clamping plate in accordance with an embodiment of the invention for mounting the inlet valve assembly to a pump head;

Figure 3 shows a bottom view of the clamping plate of Figure 2; Figure 4 is a cross-sectional view of the inlet valve assembly and clamping plate of Figure 2 mounted on a pump head; and,

Figure 5 shows a perspective view of a high-pressure fuel pump assembly suitable for use with embodiments of the present invention.

## DETAILED DESCRIPTION

**[0015]** References in the following description to "top", "bottom" or any other terms having an implied orientation are not intended to be limiting and refer only to the orientation of the parts as shown in the accompanying drawings.

**[0016]** In general terms, embodiments of the invention provide a clamping plate configured to secure an inlet valve assembly to a hydraulic pump head of a high-pressure fuel pump for use in a compression-ignition internal combustion engine. The clamping plate comprises a clamping surface configured to engage the main housing of the inlet valve assembly and an attachment region configured to receive a fixing means to attach the clamping plate to the pump head. The attachment region and the clamping surface are connected by a deformable connection portion. The connection portion is designed to deform when the clamping plate is secured to the pump head such that the attachment region is maintained in flush engagement with the pump head. This is advantageous as maintaining the attachment region flush on the pump head ensures that the fixing means, typically a bolt or screw, experiences minimal non-axial loading.

**[0017]** To place embodiments of the invention in a suitable context, reference will firstly be made to Figure 1 which shows an inlet valve assembly 12 suitable for mounting on a pump head 11 (not shown in Figure 1) on a high-pressure fuel pump. The inlet valve assembly 12 comprises a main body 16, a protective cap 14 and an electrical connector 18 for receiving a control signal to operate the inlet valve assembly 12..

**[0018]** The inlet valve assembly 12 meters the flow of fuel into the pump head 11 of the high-pressure fuel pump. The pressure of the fuel within the inlet valve assembly 12 can reach pressure spikes in the order of 40 bar and as such the valve assembly 12 must be securely attached to the pump head 11 to prevent any leakage of pressurised fuel. To overcome this problem the main body 16 of the inlet valve assembly 12 comprises an outwardly protruding flange 15 positioned around its periphery. The flange 15 provides a sealing means such that a tight seal may be formed between the pump head 11 and the main body 16 when the inlet valve 12 is mounted to the pump head 11. A rubber O-ring or gasket (not shown) is located within a groove on the flange 15 to further improve the quality of the seal between the inlet valve assembly 12 and the pump head 11.

**[0019]** The inlet valve assembly 12 is secured to the pump head 11 by the clamping plate 10 shown in Figure 2. The clamping plate 10 is configured to engage the flange 15 of the main body 16 and to receive fixing means 50a, 50b, such as screws or bolts, to secure the clamping plate 10 to the pump head 11 thereby providing a clamping force to press the main body 16 toward the pump head 11 via the flange 15.

**[0020]** In the embodiment shown, the clamping plate 10 is a steel ring comprising a central aperture 27. The clamping plate 10 is configured to be positioned over the main body 16 of the inlet valve assembly 12 as shown in Figure 2 such that the main body 16 is at least partially received in the central aperture 27. A portion of the clamping plate 10, herein referred to as clamping surfaces 20a, 20b, 20c, engages the flange 15. When the fixing means 50a, 50b (not shown in Figure 2) engage the pump head 11 the clamping surfaces 20a, 20b, 20c are pressed toward and engage the flange 15. Pressing the flange 15 toward the pump head 11 in this manner secures the inlet valve assembly 12 to the pump head 11 and achieves a seal between the pump head 11 and the valve assembly 12.

**[0021]** The clamping plate 10 further comprises a plurality of attachment regions 22a, 22b, 22c configured to receive the fixing means 50a, 50b such that the clamping plate 10 may be secured to the pump head 11. In the embodiment shown the clamping plate 10 comprises three attachment regions 22a, 22b, 22c, however, the skilled person would appreciate that the invention may implemented with as few as a single attachment region or may be worked with more than three attachment regions. Furthermore, whilst only two fixing means 50a, 50b are shown in the accompanying figures, the skilled person would appreciate that each attachment region would receive a complementary fixing means.

**[0022]** The attachment regions 22a, 22b, 22c each comprise an aperture 26a, 26b, 26c for receiving the fixing means 50a, 50b, and an attachment surface 46a, 46b, 46c defined by the bottom surfaces of the attachment regions 22a, 22b, 22c. The fixing means 50a, 50b is typically in the form of a bolt or screw. As the fixing means 50a, 50b is tightened the head of the fixing means 50a, 50b engages the top surface of the attachment regions 22a, 22b, 22c thereby pressing the clamping plate 10 towards the pump head 11. This causes the attachment surfaces 46a, 46b, 46c to engage the pump head 11. It is desirable to maintain a flush engagement between the attachment surfaces 46a, 46b, 46c and the pump head 11 to minimise any non-axial loading on the fixing means 50a, 50b. The screws 50a, 50b screw into threaded holes in the pump housing 54, thus clamping the inlet valve assembly 12 and pump head 11 down together onto the pump housing 54, as best shown in Figure 5.

**[0023]** The clamping plate 10 is shown in further detail

in Figure 3. As previously mentioned the clamping plate 10 comprises three clamping surfaces 20a, 20b, 20c configured to engage the top surface 17 of the flange 15. The clamping surfaces 20a, 20b, 20c of the clamping plate 10 are connected to attachment regions 22a, 22b, 22c by way of connecting portions 24a, 24b, 24c, 24d, 24e, 24f herein referred to "connecting arms". The attachment regions 22a, 22b, 22c comprise apertures 26a, 26b, 26c configured to receive the fixing means 50a, 50b to secure the clamping plate 10 to the pump head 11.

**[0024]** For the purposes of clarity, the invention will be described herein with reference to a single attachment region 22a connected to clamping surfaces 20a, 20b via the connecting arm 24a, 24b respectively. However, the skilled person would appreciate that the invention may be worked with any number of attachment regions and corresponding clamping surfaces and connecting arms.

**[0025]** As best shown in Figure 4, the clamping surfaces 20a, 20b, 20c define a plane vertically offset from a plane defined by the attachment surfaces 46a, 46b, 46c of the attachment regions 22a, 22b, 22c. In other words, the attachment surface 46a is disposed by a vertical distance 40 below the clamping surfaces 20a, 20b, 20c. The distance 40 substantially equals the thickness of the flange 15 such that when the clamping surfaces 20a, 20b engage the flange 15 the attachment region 22a simultaneously engages the pump head 11. However, due to tolerancing constraints during manufacture of the clamping plate 10 and flange 15 there is variation between the distance 40 and the depth of the flange 15. As such, the manufacturing tolerance in the distance 40 is designed to be equal to or less than the depth of the flange 15. This is desirable because if the distance 40 was greater than the depth of the flange 15 the clamping surfaces 20a, 20b would not engage the flange 15 when the clamping plate 10 is secured to the pump head 11.

**[0026]** To address variations in the distance 40 between the clamping surfaces 20a, 20b and the attachment region 22a, the connecting arms 24a, 24b are deformable. When the fixing means 50a is tightened, thereby pressing down on the attachment region 22a and bringing the clamping surfaces 20a, 20b into engagement with the top surface 17 of the flange 15, the connecting arms 24a, 24b deform. Deforming the connecting arms 24a, 24b ensures that the attachment surface 46a maintains flush engagement with the pump head 11. Maintaining flush engagement between the attachment surface 46a and the pump head 11 minimises non-axial loading on the fixing means 50a thus ensuring that the majority of loading is imparted along the longitudinal axis of the fixing means 50a.

**[0027]** Figure 4 shows a cross-sectional schematic view of the clamping plate 10 and the main body 16. The clamping plate 10 is shown in a non-deformed position, prior to the clamping plate 10 being secured to the pump head 11 by the fixing means 50a, 50b. As a result, there is a gap 42 between a top surface or engagement surface 44 of the pump head 11 and a bottom surface or attachment surface 46 of the attachment region 22a. The gap 42 is typically between 0.2mm and 0.4mm although depending on tolerancing of the clamping plate 10 and flange 15 the gap 42 is typically less than 1mm in length. When the fixing means 50a, 50b is tightened thereby securing the clamping plate 10 to the pump head 11, the connecting arms 24a, 24b deform to bring the attachment surface 46 into flush engagement with the engagement surface 44 of the pump head 11. This causes the distance 40 defined between the clamping surface 20a, 20b, 20c and the attachment surface 46a, 46b, 46c to increase by between approximately 0.1mm and 0.5mm. The clamping force applied to the clamping plate 10 by the fixing means 50a, 50b is transferred through the connecting arms 24a, 24b and imparted on the flange 15 by the clamping surface 22a, 22b. The clamping force imparted on the flange 15 secures the inlet valve assembly 12 to the pump head 11.

**[0028]** The force imparted on the flange 15 by the clamping surfaces 22a, 22b may be varied by modifying parameters of the connecting arms 24a, 24b. The stiffer and more resistant to deformation the connecting arms 24a, 24b are, the more load is transferred from the fixing means 50a, 50b to the flange 15. This is advantageous as the connecting arms 24a, 24b may be tuned to exert the desired load on the flange 15 depending on the required clamping force for a particular application of the clamping plate.

**[0029]** The stiffness of the connecting arms 24a, 24b may be controlled by varying, for example, the length, thickness, width and material of the connecting arms 24a, 24b. Typically the clamping plate 10 is manufactured from pressed steel, however, the clamping plate may be manufactured from other metals such as aluminium or plastics material. Furthermore, the shape of the clamping surfaces 20a, 20b may be convex such that upon engagement between the flange 15 and the clamping surfaces 20a, 20b, the clamping surfaces 20a, 20b deform from their convex shape to a substantially planar surface. Deforming the clamping surfaces 20a, 20b in this manner achieves a larger clamping force to be imparted on the flange 15.

**[0030]** For example, if the inlet valve assembly 12 is subject to a low fluid pressure, the clamping force required to maintain engagement between the inlet valve 12 and the pump head 11 may be relatively low. In this scenario the connecting arms 24a, 24b may be designed to more easily deform. This is advantageous as in this scenario the tolerances in manufacture of the clamping plate 10 and flange 15 could be larger and taken up by deforming the connecting arms 24a, 24b thus any variations resulting from the larger tolerances can be compensated for. For example, the connecting arms 24a, 24b may deform by 1mm or more depending on the application and magnitude of the gap 42. Furthermore, reducing the stiffness of the clamping plate 10 further minimises any non-axial loading imparted on the fixing means 50a, 50b.

**[0031]** Alternatively, in situations where the inlet valve assembly 12 carries high pressure fluid the clamping force required to maintain engagement between the inlet valve 12 and the pump head 11 is relatively high. In this scenario the connecting arms 24a, 24b may be designed to less easily deform. In this situation more of the clamping force exerted by the fixing means 50a, 50b is transferred through the connecting arms 24a, 24b to the flange 15.

**[0032]** Figure 5 shows a high-pressure fuel pump assembly 60 comprising the pump head 11, the inlet valve assembly 12 and the clamping plate 10. In the example shown the clamping plate 10 comprises a locating feature 28. The locating feature 28 is a tab configured to engage a corresponding engagement slot 52 in the pump head 11. The locating feature 28 locates the clamping plate 10 in position relative to the pump head 11 prior to the fitment of the screws 50a, 50b. This is advantageous as it facilitates quick fitment of the screws 50a, 50b to the pump head 11 or electrical component 54 by ensuring the clamping plate 10 is orientated correctly.

**[0033]** Many modifications may be made to the above examples without departing from the scope of the present invention as defined in the accompanying claims.

LIST OF REFERENCES

**[0034]**

**10** Clamping Plate
**11** Pump Head
**12** Inlet Valve Assembly
**14** Protective Cap
**15** Flange
**16** Main Body of Inlet Valve Assembly
**17** Top Surface of the Flange
**18** Electrical Connector
**20a** First Clamping Surface
**20b** Second Clamping Surface
**20c** Third Clamping Surface
**22a** First Attachment Region
**22b** Second Attachment Region
**22c** Third Attachment Region
**24a** First Connecting Arm
**24b** Second Connecting Arm
**24c** Third Connecting Arm
**24d** Fourth Connecting Arm
**24e** Fifth Connecting Arm
**24f** Sixth Connecting Arm
**26a** First Aperture
**26b** Second Aperture
**26c** Third Aperture
**27** Central Aperture
**28** Locating Feature
**40** Distance between Attachment Region and Clamping Surface
**42** Gap between Pump Head and Attachment Region
**44** Engagement Surface
**46a** First Attachment Surface
**46b** Second Attachment Surface
**46c** Third Attachment Surface
**50a** First Screw
**50b** Second Screw
**52** Engagement Slot
**54** Pump Housing
**60** High-Pressure Fuel Pump Assembly

**Claims**

**1.** A high-pressure fuel pump assembly (60) comprising a pump head (11), an inlet valve (12) and a clamping plate (10) attaching the inlet valve (12) to the pump head (11), wherein the clamping plate (10) comprises:

a clamping surface (20a, 20b, 20c) engaged with the inlet valve (12);
an attachment region (22a, 22b. 22c) secured to the pump head (11), the attachment region (22a, 22b, 22c) comprising an attachment surface (46a, 46b, 46c) engaged with the pump head (11); and,
a deformable connection portion (24a, 24b, 24c, 24d, 24e, 24f) connecting the clamping surface (20a, 20b, 20c) and the attachment region (22a, 22b, 22c), wherein the connection portion (24a, 24b, 24c, 24d, 24e, 24f) is configured to deform to maintain a flush engagement between the attachment surface (46a, 46b, 46c) and the pump head (11) as the attachment region (22a, 22b, 22c) is secured to the pump head (11).

**2.** A high-pressure fuel pump assembly (60) as claimed in claim 1, wherein the clamping plate (10) comprises three attachment regions (22a, 22b, 22c) and three clamping surfaces (20a, 20b, 20c) alternatively arranged in a substantially circumferential arrangement and wherein the attachment regions (22a, 22b, 22c) and clamping surfaces (20a, 20b, 20c) are connected via six connection portions (24a, 24b, 24c, 24d, 24e, 24f).

**3.** A high-pressure fuel pump assembly (60) as claimed in claim 1 or claim 2, wherein the connection portion (24a, 24b, 24c, 24d, 24e, 24f) is configured to deform when the clamping plate (10) is secured to the pump head (11) thereby causing a distance (40) defined between the clamping surface (20a, 20b, 20c) and the attachment surface (46a, 46b, 46c) to increase.

**4.** A high-pressure fuel pump assembly (60) as claimed in any preceding claim, wherein the clamping surface (20a, 20b, 20c) is convex prior to engaging the inlet valve (12).

**5.** A high-pressure fuel pump assembly (60) as claimed in claim 4, wherein the clamping surface (20a, 20b, 20c) is configured to deform upon engagement of the inlet valve (12) and wherein the clamping surface (20a, 20b, 20c) is substantially planar when engaged with the inlet valve (12).

**6.** A high-pressure fuel pump assembly (60) as claimed in any preceding claim, wherein the clamping plate (10) comprises a locating feature (28) engaged with a corresponding engagement slot (52) on the pump head (11).

**7.** A high-pressure fuel pump assembly (60) as claimed in any preceding claim, wherein the attachment region (22a, 22b, 22c) comprises an aperture (26a, 26b, 26c) through which a screw (50a, 50b) is located.

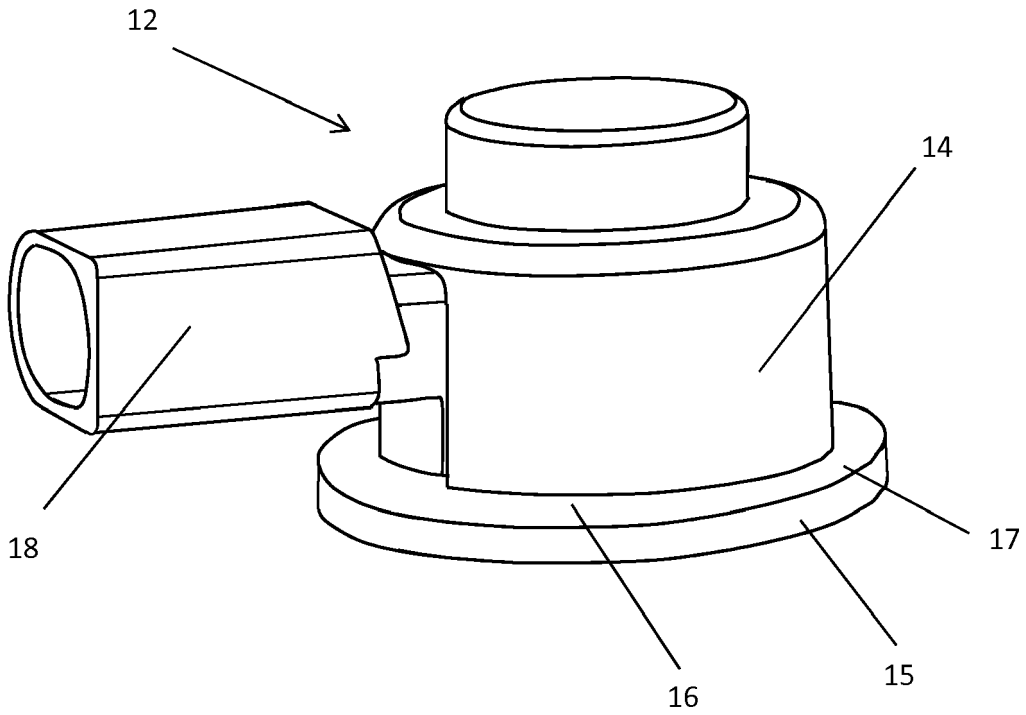



Figure 1

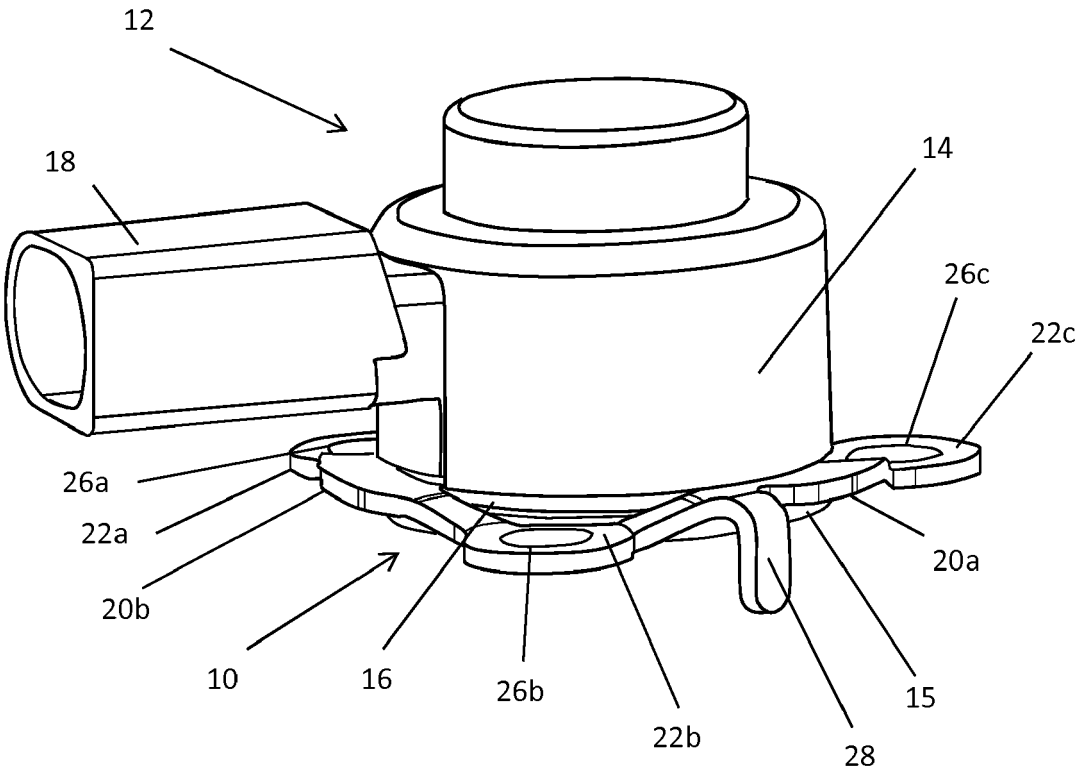
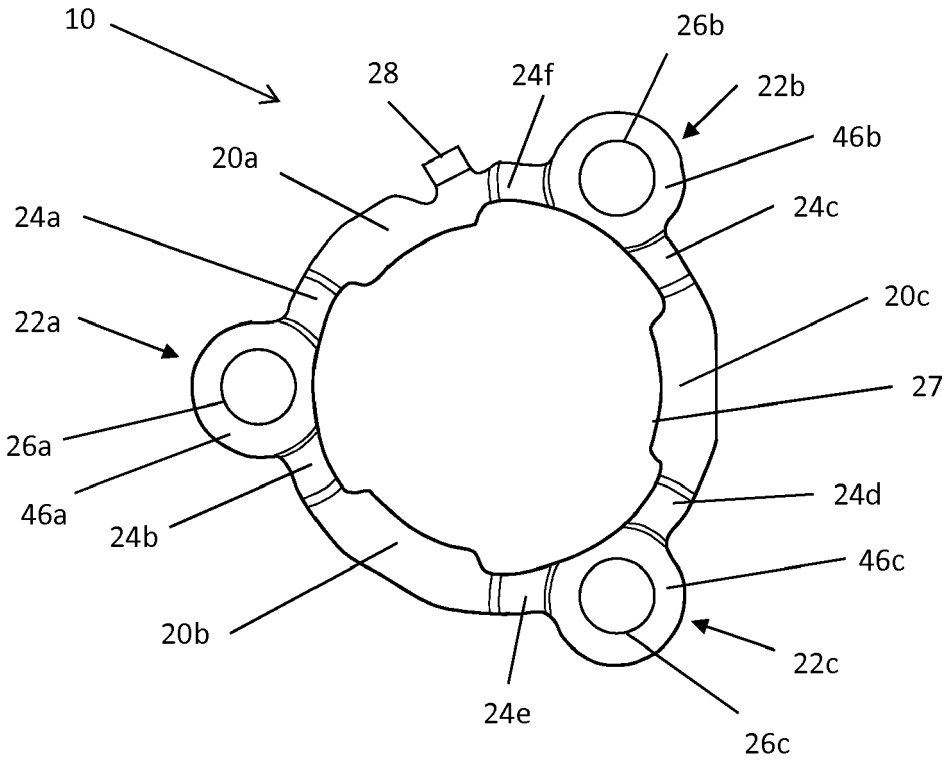



Figure 2


10
28
24f
26b
22b
46b
20a
24a
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22a
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24d
46c
20b
22c
24e
26c

Figure 3

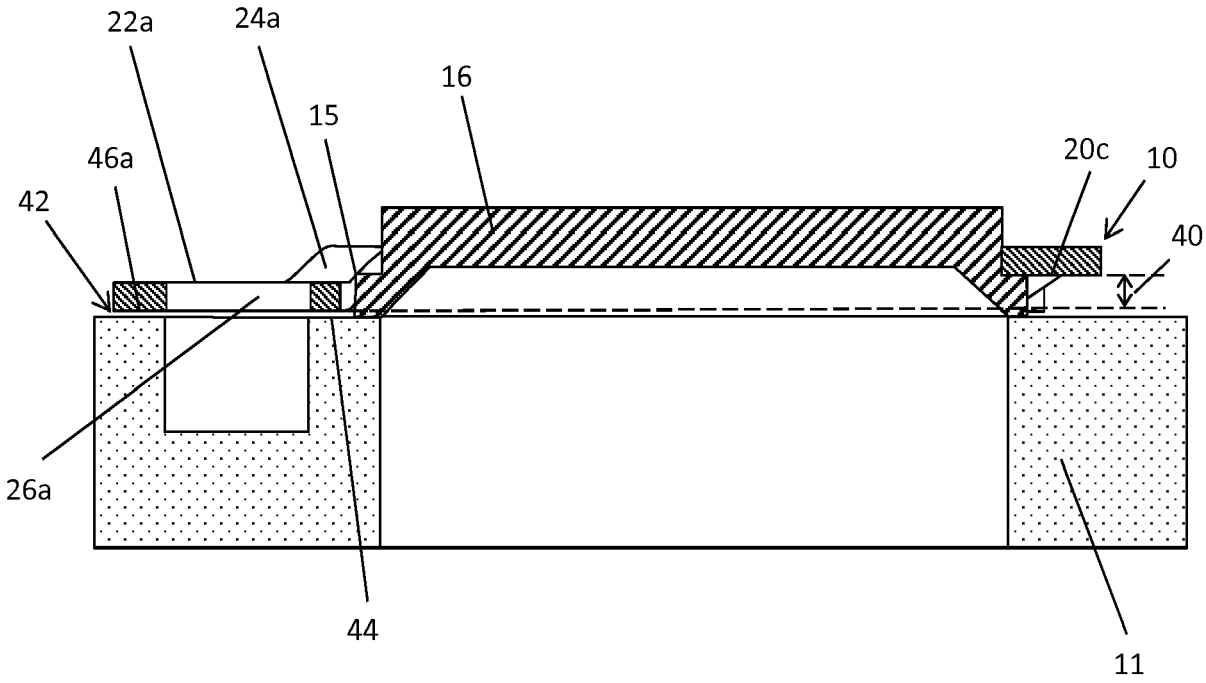


Figure 4

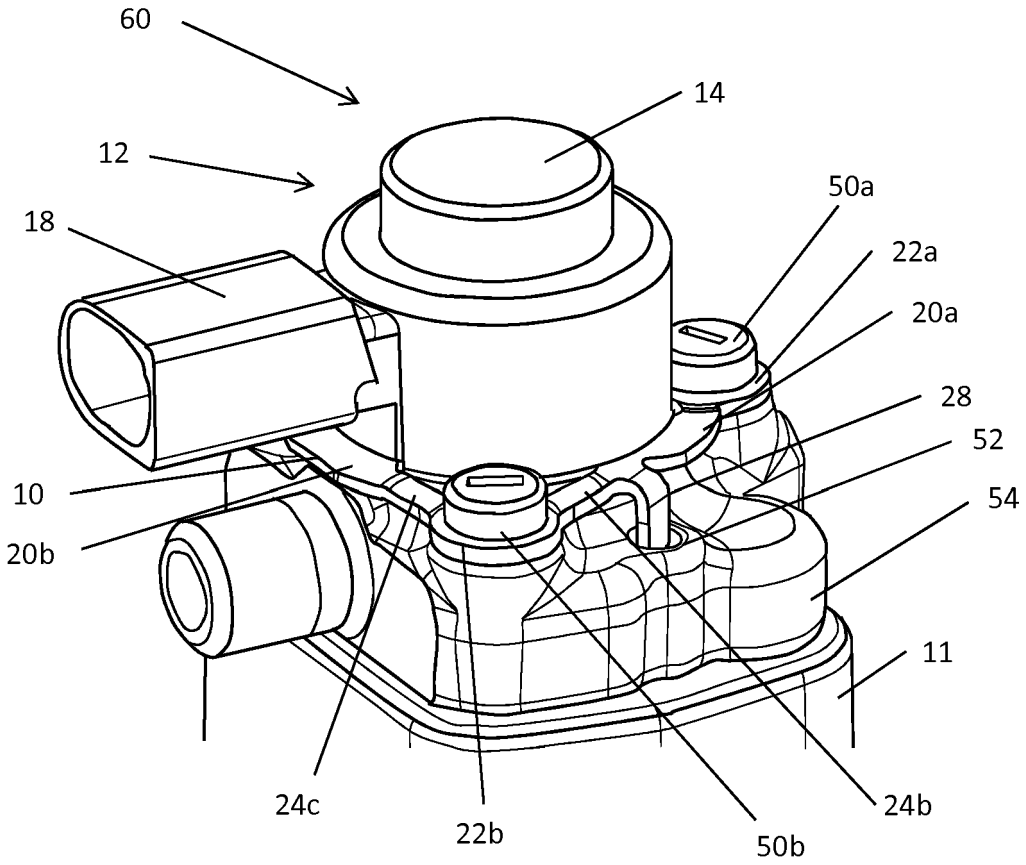


Figure 5

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Application Number
EP 18 17 6369

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F02M

The present search report has been drawn up for all claims

| Place of search | Date of completion of the search | Examiner |
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CATEGORY OF CITED DOCUMENTS

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## ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 18 17 6369

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