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

(11) **EP 3 470 662 A1**

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
17.04.2019 Bulletin 2019/16

(51) Int Cl.:
F02M 55/02 *(2006.01)* ***F02M 61/16*** *(2006.01)*
F02M 61/14 *(2006.01)*

(21) Application number: **17196165.9**

(22) Date of filing: **12.10.2017**

(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

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(54) **FUEL RAIL ASSEMBLY, METHOD OF MANUFACTURING A FUEL ADAPTER AND FIXING BRACKET FOR A FUEL RAIL ASSEMBLY**

(57) A fuel rail assembly for an internal combustion engine has an elongate fuel rail (2) and a plurality of fuel outlets spaced along the fuel rail (2), the fuel outlets each having a fuel adapter (6) secured to the fuel rail (2) for connecting a fuel injector to provide a mechanical and hydraulic connection to the fuel rail (2). Each adapter (6) is shaped to provide an exterior face to match a corresponding mating profile surface on the fuel rail (2) by which surfaces the adapter (6) is secured by brazing to the fuel rail (2).

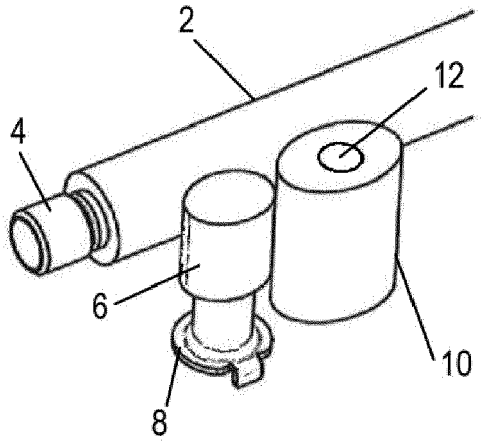

FIG 1

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Description

[0001] The present disclosure relates to a fuel rail assembly and a method of manufacturing a fuel adapter and a fixing bracket for a fuel rail assembly for an internal combustion engine.

[0002] Fuel rail assemblies for internal combustion engines utilising fuel injection are in widespread use, and comprise a fuel common rail, also known as a gallery, which forms a reservoir to which the fuel is supplied under high pressure by a fuel pump. The fuel rail typically comprises an elongate body which has a fuel inlet at one end and a plurality of fuel outlets spaced along the fuel rail which are connected to the fuel injectors. Typically, in modern installations a fuel injector is provided for each cylinder of a multicylinder engine for injecting fuel directly into the combustion chamber. It is desirable for practical reasons for the fuel rail to be as close to the cylinder combustion chambers as possible to enable the passage of fuel from the fuel rail to the fuel injector to be as short as possible.

[0003] As a consequence, the fuel rail assembly is located in a position in a harsh environment where it is subjected to high temperatures, high pressures, and vibrations. Providing the necessary durability and reliability for the assembly is therefore a major problem.

[0004] The fuel outlets formed in the wall of the fuel rail are connected to a fuel injector adapter which is secured to the fuel rail so as to be in mechanical and hydraulic connection with a fuel injector. Typically, the fuel injector is connected to the adapter through a fuel injector cup into which an inlet port of the fuel injector is inserted. The fuel injector cups may be connected directly to the fuel rail or via pipe elements.

[0005] The fuel injector adapters may be secured to the fuel rail by a bonding technique such as brazing and this bonding is subject to the considerable pressures which exist in the fuel rail which can be 200 bar or even more. The bonded connection is therefore a potential source of leakages and consequent failure.

[0006] The present disclosure seeks to provide a solution which mitigates the possibility of leakages and failure occurring.

[0007] According to the present disclosure there is provided a fuel rail assembly for an internal combustion engine, comprising an elongate fuel rail having a fuel inlet, and a plurality of fuel outlets spaced along the fuel rail. The fuel outlets are adapted to be in hydraulic communication with a fuel injector by which fuel is injected into the engine. In other words, the fuel outlets are shaped and arranged to provide a fluidic connection from the fuel rail to the fuel injector.

[0008] The fuel outlets each have a fuel adapter secured to the fuel rail for connection to a fuel injector, the fuel adapter providing a mechanical and hydraulic connection to the fuel rail, each fuel adapter having a surface by which surface the fuel adapter is secured by brazing to the fuel rail.

[0009] In the present context, that "the fuel adapter provides a mechanical connection to the fuel rail" means in particular that the fuel adapter is in direct mechanical contact with the fuel rail. That "the fuel adapter provides a hydraulic connection to the fuel rail" means in particular that the fuel adapter is in fluidic connection to the fuel rail so that fluid can flow from the fuel rail into - and in particular through - the fuel adapter.

[0010] Said surface of the fuel adapter may, in some embodiments, be shaped to provide an exterior face to match a profile surface on the fuel rail. For example, the fuel adapter has a tubular shape with a curved external circumferential surface comprising the exterior face, the curvature of the exterior face being smaller than the curvature of surface sections following the exterior face in both circumferential directions. In one development, the circumferential surface is in the shape of an elliptical cylinder, the semi-major axis of which is parallel to an elongation direction of the fuel rail and the semi-minor axis of which is perpendicular to the elongation direction of the fuel rail. In another development, the fuel adapter has a cylindrical shape with a flattening representing the exterior face. The flattening may extend along the entire length of the fuel adapter in direction of its cylinder axis in one embodiment.

[0011] The fuel adapter may have an elongate shape with a first axis or length that is longer than a second axis or length. For example, the fuel adapter may have a substantially elliptical form or rectangular form when viewed from above. The expression "viewed from above" is in particular understood to indicate a top view along an installation direction in which the fuel injector is insertable into the fuel adapter or into a fuel injector cup which may be fixed to (or in one piece with) the fuel adapter. The installation may expediently be perpendicular to an elongation direction of the fuel rail. Either the longer axis or length or the shorter axis or length may include the exterior face which is secured to the fuel rail. The exterior face and the fuel adapter may be secured to the fuel rail by brazing such that the fuel rail assembly comprises a brazed joint at the interface between the exterior face of the fuel adapter and the profile surface of the fuel rail.

[0012] Since the exterior face of the fuel adapter has a surface shaped to match the profile surface on the fuel rail, a brazed joint with a more uniform thickness than e. g. with a circular cylindrical fuel adapter can be formed between this exterior face of the fuel adapter and the profile surface on the fuel rail. A brazed joint with a more uniform thickness may be used to improve the reliability of the brazed joint.

[0013] The fuel rail assembly may further comprise one or more fixing brackets for securing the fuel rail assembly to an engine. The or each bracket may have a surface shaped to provide an exterior face shaped to match a profile surface on the fuel rail by which the fixing bracket is secured by brazing to the fuel rail. For example, as detailed above in connection with the fuel adapter, the fixing bracket may have a tubular shape with a curved

external circumferential surface comprising the exterior face, the curvature of the exterior face being smaller than the curvature of surface sections following the exterior face in both circumferential directions. The shape of the exterior face and the profile surface of the fuel rail may be used to increase the area of the interface between the fixing bracket and the fuel rail and increase the area of the brazed joint formed between the two parts. In some embodiments, the fixing bracket is integrally formed with a fuel adapter, wherein the fuel adapter may be a fuel adapter according to one of the embodiments, developments and examples described above.

[0014] Preferably, the or each adapter incorporates a fuel injector cup for receiving an inlet port of a fuel injector. For example, the tubular shape of the fuel adapter has a closed axial end and an open axial end, the fuel injector cup being fluid-tightly fixed to the open axial end.

[0015] Preferably the adapter is formed with said exterior face by deformation of the material of the adapter or, alternatively, the exterior face may be machined in the adapter.

[0016] In one embodiment, the adapter is provided with an elliptical profile in which said face is formed, the elliptical profile abutting the fuel rail.

[0017] For example, the adapter may be provided with a surface in the shape of a portion of the circumferential surface of an elliptic cylinder which represents or comprises said exterior face. In this and other embodiments, the profile surface of the fuel rail may be a cylindrical circumferential surface, in particular of a circular or elliptic cylindrical shape. Expediently, the cylinder axes of said circumferential surface and of the adapter and of the profile surface may be mutually perpendicular and in particular skew.

[0018] This arrangement has the advantage that a particularly large surface area is provided between the fuel rail and the adapter which increases the bonding area between the two components. This increases the strength of the bonding between the components.

[0019] The disclosure may also be adapted to secure a mounting bracket or brackets to the fuel rail by which the fuel rail is secured to the engine in the installed condition. Each bracket is shaped to provide an exterior face shaped to match a mating profile surface on the fuel rail by which surface the bracket is secured by a bonding technique such as brazing to the fuel rail. In a preferred embodiment, the bracket is formed with the said exterior face by mechanical deformation of the material of the bracket. In an alternative construction, the exterior face is formed by machining into the material of the bracket

[0020] In a preferred embodiment, the fixing bracket is formed by deforming a circular cylindrical member, such as a tube, into a generally elliptical cylindrical shape having said exterior face in the elliptical face. In this way, a greater surface area is formed in the mating surfaces between the two components which greatly increases the bonding area available to strengthen the bond between the two components.

[0021] The bracket may be forged or machined from a solid material or may be formed from a sheet metal material. The precise technique used will vary with the environmental conditions of the intended application.

[0022] A method of manufacturing a fuel adapter for a fuel rail assembly for an internal combustion engine is also provided. The fuel rail assembly and fuel adapter may include the features of any one of the embodiments described above. In the method, the fuel adapter is shaped to provide an exterior face shaped to match a profile surface on the fuel rail by which surfaces the fuel adapter is secured by brazing to the fuel rail.

[0023] In particular the method may comprise the following steps:

- shaping the fuel adapter to provide an exterior face shaped to match a profile surface on the fuel rail and
- securing said surface of the fuel adapter to the profile surface of the fuel rail by brazing.

[0024] The method may further comprise a step of providing a fuel adapter which is in particular in the basic shape of a circular cylindrical tubular body. This step in particular precedes the step of shaping the fuel adapter.

[0025] The fuel adapter may be deformed to provide the exterior face shaped to match the profile surface on the fuel rail. In some embodiments, the fuel adapter may be deformed to have an elliptical surface forming said exterior face. The exterior face of the fuel adapter is formed by deformation of the material of the adapter and/or by machining the material of the adapter.

[0026] A method of manufacturing a fixing bracket for a fuel rail assembly for an internal combustion engine is also provided. The fuel rail assembly and/or the fixing bracket may include the features of any one of the embodiments described above. The fixing bracket is shaped to provide an exterior face shaped to match a profile surface on the fuel rail by which surfaces the fixing bracket is secured by brazing to the fuel rail.

[0027] In particular the method may comprise the following steps:

- shaping the fixing bracket to provide an exterior face shaped to match a profile surface on the fuel rail and
- securing said surface of the fixing bracket to the profile surface of the fuel rail by brazing.

[0028] The method may further comprise a step of providing a fixing bracket which is in particular in the basic shape of a circular cylindrical tubular body. This step in particular precedes the step of shaping the fuel adapter. The tubular body of the fixing bracket is preferably open at both axial ends in this and other embodiments.

[0029] The fixing bracket may be deformed to form the exterior face shaped to match a profile surface on the fuel rail. The fixing bracket may be deformed to have an elliptical surface forming said exterior face. The exterior face of the fixing bracket may be formed by deformation

of the material of the fixing bracket and/or by machining the material of the fixing bracket.

[0030] A method of manufacturing a fuel rail assembly for an internal combustion engine is also provided. The fuel rail assembly for an internal combustion engine comprises a fuel rail which is elongate and has a fuel inlet and a plurality of fuel outlets spaced along the fuel rail, the fuel outlets being adapted to be in hydraulic communication with a fuel injector by which fuel is injected into the engine. A fuel adapter is provided for each of the fuel outlets and is secured to the fuel rail for connection to a fuel injector, the fuel adapter providing a mechanical and hydraulic connection to the fuel rail. The fuel adapter comprises a surface shaped to provide an exterior face to match a profile surface on a fuel rail of a fuel rail assembly is provided. The exterior face of the fuel adapter is aligned with the profile surface of the fuel rail and the exterior face of the fuel adapter is secured by brazing to the fuel rail.

[0031] In an embodiment, one or more fixing brackets for securing the fuel rail assembly to an engine are provided. The or each bracket comprises a surface shaped to provide an exterior face shaped to match a profile surface on the fuel rail. The exterior face of the fixing bracket is aligned with the profile surface of the fuel rail and secured by brazing to the fuel rail.

[0032] A brazing material may be applied to one or both of the exterior face and the profile surface and heat treated above its liquidus temperature to melt the braze material. Upon cooling a brazed joint is formed between the exterior face and the profile surface to secure the fuel adapter and/or fixing bracket to the fuel rail.

[0033] Preferred embodiments will now be described by way of example, with reference to the accompanying drawings, in which:-

Figure 1 illustrates a fuel rail to which a fixing bracket is secured together with a fuel adapter for a fuel injector,

Figure 2 illustrates an arrangement in which a fixing bracket is formed by deforming a cylindrical tubular element into an elliptical cross-section with a bore therethrough for a mounting bolt by which the bracket is secured to an engine,

Figure 3 illustrates an adapter for receiving a fuel injector which is secured to the fuel rail and incorporates two bores through which mounting bolts can pass to secure the fuel adapter to an engine, and

Figure 4 illustrates an alternative fuel adapter shaped by deformation to be secured to the fuel rail and to have a single bore through which the fuel adapter can be fastened to an engine.

[0034] Referring now to Figure 1, there is shown a fuel rail 2 for a fuel injection system for a multi-cylinder internal combustion engine. The fuel rail 2 comprises an elongate substantially tubular member forming a reservoir for fuel. The fuel rail 2 has a fuel inlet 4 connected to a fuel pump (not shown) which pumps fuel at high pressure into the reservoir in the fuel rail 2. The fuel rail 2 has a plurality of fuel outlets spaced along the fuel rail 2 to each of which a fuel adapter 6 is secured. For the purposes of illustration, only one such adapter 6 is illustrated. The fuel adapter 6 incorporates a fuel passage through which fuel can be supplied to a fuel injector cup 8 which accommodates a fuel inlet of a fuel injector (not shown) . The fuel outlets of the fuel rail 2 are thus each operable to establish a hydraulic - in particular in fluidic - communication with a fuel injector by which fuel is injected into the engine. The fuel injector may inject fuel into the inlet manifold of the engine but preferably the fuel is injected directly into the combustion chamber of the engine.

[0035] The fuel adapter 6 and its connection to the fuel rail 2 is subjected to severe operating conditions of high temperature, high internal pressure and vibration from the engine. The fuel adapter 6 is bonded to the fuel rail 2 typically by brazing. A brazing paste may be used which is coated onto the mating surfaces prior to baking in a furnace which completes the brazing step. In order to provide an increased surface area for the mating surfaces, the part of the fuel adapter 6 containing the mating surface is deformed to match as closely as practical the surface of the fuel rail 2 to which the fuel adapter 6 is brazed. The deformation of the fuel adapter 6 is formed by physical deformation of the material of the adapter 6 by a pressing, rolling, extruding, profile rolling, forging or stamping step. In a further embodiment, the shape of the fuel adapter 6 is formed by machining the appropriate shape in the body of the fuel adapter 6. A combination of physical deformation by pressing, rolling, extruding, profile rolling, forging or stamping and machining may also be used.

[0036] Figure 1 also illustrates a fixing bracket 10 by which the fuel rail 2 is secured to the engine. A plurality of such fixing brackets is provided spaced along the fuel rail 2 but only one is shown for the purpose of illustration. As also illustrated in the embodiment shown in Figure 2, the fixing bracket 10 is formed from a tubular bar material and is deformed into an elliptical shape on its outer surface to provide a mating surface adapted to cooperate with a mating surface on the fuel rail 2. In this way, the fixing bracket 10 is able to be brazed to the fuel rail 2 in the same manner as the fuel adapter 6. The fixing bracket 10 is provided with a cylindrical through bore 12 for receiving a bolt (not shown) by which the fixing bracket 10 and hence the fuel rail 2 is secured to the engine.

[0037] Both, the fuel adapter 6 and the fixing bracket 10 are in the shape of elliptical cylindrical tubular bodies. The fixing bracket is open at both axial ends with respect to its cylinder axis. The fuel adapter 6 is closed at the axial end remote from the fuel injector cup 8 but has a

radial bore (not visible in the figures) opening out into the fuel rail 2 for fluidly connecting the injector cup 8 to the fuel rail 2. Both elliptical cylindrical tubular bodies have their semi-major axes parallel to the elongation direction of the fuel rail and their semi-minor axes as well as their cylinder axes perpendicular to the elongation direction of the fuel rail 2.

[0038] The fuel adapter 6 and the fixing bracket 10 may also be brazed together to provide increased rigidity as shown in Figure 1, but in some embodiments they may be spaced apart.

[0039] In an alternative embodiment, illustrated in Figure 3, the function of the fuel adapter and the fixing bracket are formed in one component, a mounting adapter 14. In this embodiment, the mounting adapter 14 is a more substantial body and is deformed into an elliptical shape adapted to mate with a corresponding mating surface on the fuel rail 2 through which the mounting adapter 14 is brazed to the fuel rail. As in the embodiment illustrated in Figure 1, the adapter incorporates a fuel injector cup 8. The elliptical body of the mounting adapter has two spaced through bores by which the mounting adapter 14 and hence the fuel rail 2 can be secured to the engine.

[0040] Figure 4 illustrates a further embodiment of a combined mounting adapter and fixing bracket in which the combination adapter 18 has a deformed body provided with a surface adapted to mate with the fuel rail 2 and is provided with a single through bore 20 by which the adapter 18 and hence the fuel rail 2 can be secured to the engine. In a similar manner to the embodiment illustrated in Figure 3 the combination adapter 18 incorporates a fuel injector 8 for receiving the inlet of a fuel injector.

[0041] The precise size and shape of the deformed parts which provide the mating surfaces can vary depending upon the installation requirements in terms of robustness and also the space available for locating the fuel injector assembly in the engine environment. Although the fixing through-bores are described as cylindrical, it is possible in certain circumstances that these holes could be elliptical as part of the deformation process and in such a case the space between the elliptical parts of the holes and the securing bolt can be used to accommodate any slight misalignment in the assembly stage. It is possible for the fixing bracket to be formed by, for example, forging or by being machined from solid but it may also be a sheet metal component formed by pressing or stamping or similar known technique. The robustness and hence the construction required of the components will be determined by the particular installation. The fuel adapter and/or the fixing bracket are preferably secured by brazing but it is possible other bonding techniques may be used and the term brazing is intended to encompass such alternative techniques.

Claims

1. A fuel rail assembly for an internal combustion engine, comprising an elongate fuel rail (2) having a fuel inlet (4), and a plurality of fuel outlets spaced along the fuel rail, the fuel outlets being adapted to be in hydraulic communication with a fuel injector by which fuel is injected into the engine, the fuel outlets each having a fuel adapter (6) secured to the fuel rail (2) for connection to a fuel injector, the fuel adapter (6) providing a mechanical and hydraulic connection to the fuel rail (2), each fuel adapter (6) having a surface shaped to provide an exterior face to match a profile surface on the fuel rail (2) by which face the fuel adapter (6) is secured by brazing to the fuel rail.

2. A fuel rail assembly according to claim 1, the fuel adapter (6) has a tubular shape with a curved external circumferential surface comprising the exterior face, the curvature of the exterior face being smaller than the curvature of surface sections following the exterior face in both circumferential directions.

3. A fuel rail assembly according to any one of the preceding claims, wherein said surface of the fuel adapter (6) providing said exterior face is in the shape of a portion of the circumferential surface of an elliptic cylinder and said profile surface of the fuel rail is a cylindrical circumferential surface, the cylinder axes of said circumferential surface and of said profile surface being mutually perpendicular.

4. A fuel rail assembly according to any one of the preceding claims, further comprising a one or more fixing brackets (10) for securing the fuel rail assembly to an engine, the or each bracket (10) having a surface shaped to provide an exterior face shaped to match a profile surface on the fuel rail (2) by which the fixing bracket (10) is secured by brazing to the fuel rail (2).

5. A fuel rail assembly according to the preceding claim, wherein the fixing bracket (10) is integrally formed with the fuel adapter (6).

6. A fuel rail assembly according to any one of the preceding claims, wherein the fuel adapter (6) incorporates a fuel injector cup (8) adapted to receive an inlet port of a fuel injector.

7. A fuel injector assembly according to any one of the preceding claims, wherein the exterior face (s) of the fuel adapter (6) and/or the fixing bracket (10) are formed by deformation of the material of the adapter (6) and/or bracket (10).

8. A fuel injector assembly according to any one of claims 1 to 6, wherein the exterior face(s) are formed

by machining.

9. A fuel injector assembly according to any one of the preceding claims, wherein the fuel adapter (6) has an elliptical profile in cross section said exterior face is formed in the elliptical surface.

10. A fuel injector assembly according to the preceding claim, wherein two through bores are formed in the elliptical profile through which bolts can pass to secure the fuel adapter (6) to an engine.

11. A fixing bracket for mounting a fuel rail assembly to an internal combustion engine, the fuel rail assembly comprising an elongate fuel rail (2) having a fuel inlet (4), and a plurality of fuel outlets spaced along the fuel rail (2), the fuel outlets each being adapted to be in hydraulic communication with a fuel injector by which fuel is injected into the engine, the fixing bracket (10) having a surface shaped to provide an exterior face to match a profile surface on the fuel rail (2) by which face the bracket is secured by brazing to the fuel rail (2).

12. A method of manufacturing a fuel adapter for a fuel rail assembly for an internal combustion engine as claimed in any one of the preceding claims 1 to 10, comprising the following steps:

- deforming the fuel adapter (6) to provide an exterior face shaped to match a profile surface on the fuel rail (2)
- securing said face of the fuel adapter (6) by brazing to the profile surface of the fuel rail (2).

13. A method of manufacturing a fixing bracket for a fuel rail assembly for an internal combustion engine as claimed in claim 4 or 11 or in any one of claims 5 to 10 in direct or indirect dependence on claim 4, comprising the following steps:

- deforming the fixing bracket (10) to provide an exterior face shaped to match a profile surface on the fuel rail (2)
- securing said surface of the fixing bracket (10) by brazing to the profile surface of the fuel rail (2).

14. A method of manufacturing according to claim 12 or 13, wherein the fuel adapter (6) or the fixing bracket, respectively, is deformed to have an elliptical surface forming said exterior face.

15. A method of manufacturing according to any one of claims 12 to 14, wherein the exterior face of the fuel adapter (6) or the fixing bracket, respectively, is formed by deformation and/or by machining of the material of the adapter (6) or the fixing bracket (10), respectively.

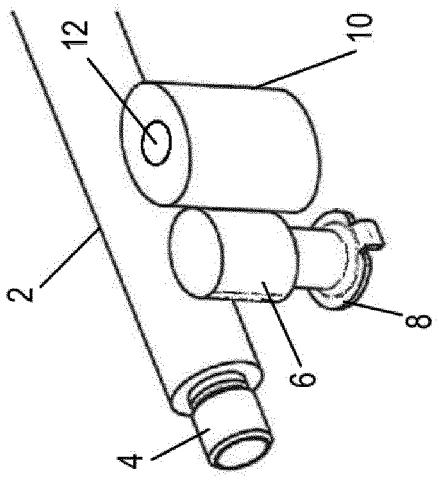

FIG 1

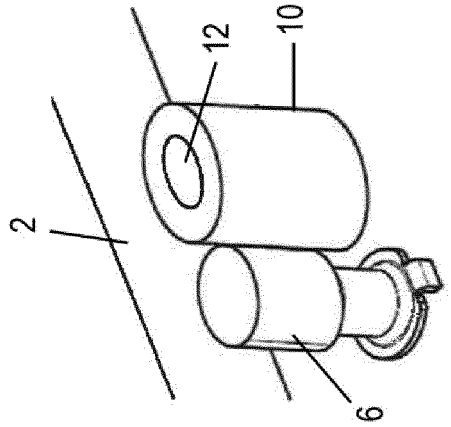

FIG 2

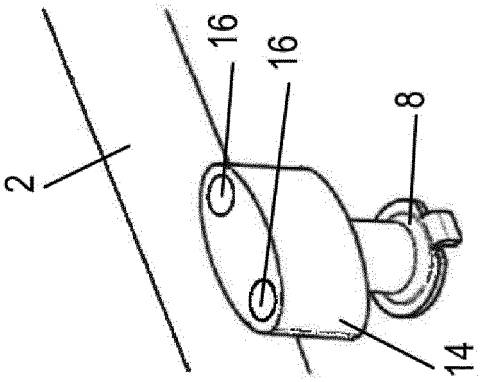

FIG 3

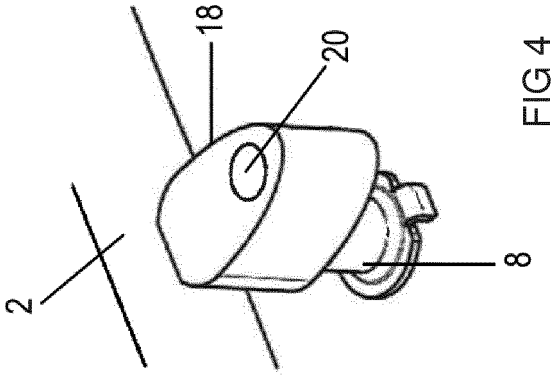

FIG 4

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EUROPEAN SEARCH REPORT

Application Number
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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	27 February 2018	Tortosa Masiá, A

CATEGORY OF CITED DOCUMENTS

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EUROPEAN SEARCH REPORT

Application Number
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The present search report has been drawn up for all claims

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