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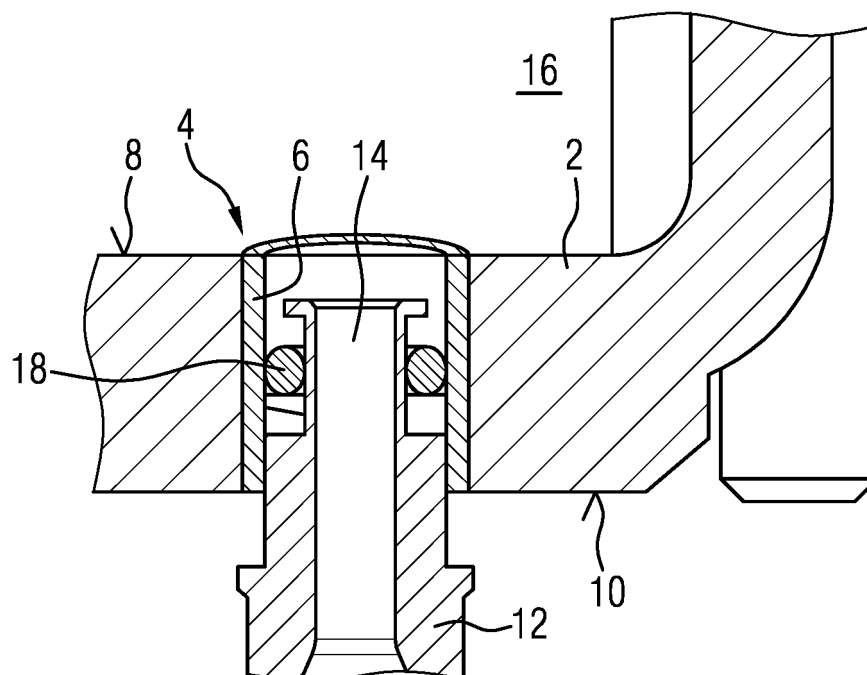
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(54) **FUEL RAIL ASSEMBLY FOR AN INTERNAL COMBUSTION ENGINE AND METHOD FOR MANUFACTURING A FUEL RAIL ASSEMBLY**

(57) A fuel rail assembly for a fuel injection system for an internal combustion engine, has a fuel rail (2) comprising an elongate tubular body having an internal volume comprising a reservoir for fuel, the fuel rail having

an inlet port through which fuel is supplied to the reservoir. The fuel rail body is formed of a mouldable material. The fuel rail has at least one port (4) having a reinforcing tube (6).

FIG 1



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Description

[0001] The present disclosure relates to a fuel rail assembly for an internal combustion engine, particularly but not exclusively, to a fuel rail assembly for a multi-cylinder gasoline direct injection engine and to a method of manufacturing the fuel rail assembly.

[0002] A fuel rail assembly typically includes an elongate fuel rail of generally tubular configuration having an interior volume defining a reservoir for fuel which is supplied at high pressure, typically 200 bar or higher, into an inlet port of the fuel rail by a high-pressure fuel pump. A plurality of fuel delivery outlets are spaced along the fuel rail and hydraulically couple the fuel rail to individual injectors which are operable to inject fuel into the engine. In some types of engine, the fuel injectors are each arranged to inject fuel directly into an associated cylinder.

[0003] A fuel rail may be formed from a mouldable material, such as a plastic material and may include more than one material. An example of such a fuel rail is disclosed in EP 3 470 661 A1. The use of a plastic material for the body of the fuel rail has advantages in terms of lower weight, cost of material and manufacturing cost but substantial difficulties occur in securing components to the fuel rail, particularly components subject to the high pressure of the fuel in the fuel rail. In addition to the stresses caused by the high pressure in the fuel rail, the harsh operating environment of a fuel rail in a vehicle involves additionally stresses caused by high temperatures, vibration and operational stresses in the vehicle.

[0004] Further improvements to provide a fuel rail with a reduced weight that is also reliable in the environment of a vehicle are desirable.

[0005] According to the present disclosure there is provided a fuel rail assembly for a fuel injection system for an internal combustion engine. The assembly has a fuel rail comprising an elongate tubular body having an internal volume comprising a reservoir for fuel. The fuel rail has an inlet port through which fuel is supplied to the reservoir. The fuel rail body is formed of a mouldable material and has at least one port having a reinforcing tube.

[0006] The reinforcing tube may be formed from a material more rigid, i.e. have a higher stiffness, than the mouldable material of the fuel rail body. In some embodiments, the mouldable material of the fuel rail body is a plastic material and the reinforcing tube is formed of a metal, for example steel.

[0007] The port may provide a hydraulic connection from external to the fuel rail to the reservoir and may be an outlet port or may be a port for a sensor, for example. The port is formed from a through-hole in the moulded material and the reinforcing tube is located in the through hole. The more rigid material of the reinforcing tube provides mechanical reinforcement of the port. The more rigid material of the reinforcing tube also provides an inner surface for providing an improved seal with a further component which is located in the reinforcing tube, for

example a fuel injector or a sensor. For example, stress on the zone between the port and the reservoir is transferred to the more rigid material of the reinforcing tube to provide an improved seal.

[0008] Additionally, deformation of the port and variations in size, e.g. diameter, caused by moulding can be better avoided by providing the reinforcing tube that has an inner surface providing the port and that is formed of a more rigid material. The reinforcing tube is typically preformed and may be manufactured by methods other than moulding.

[0009] In some embodiments, the port is an outlet port and reinforcing tube is located at an outlet port and is sized and shaped to form an injector cup adapted to receive a fuel injector. In this embodiment, stress on the zone between the injector cup and the fuel rail body is transferred to the more rigid material of the reinforcing tube. Additionally, the inner surface of the reinforcing tube provides the surface against which a seal between the fuel injector and the fuel rail body is formed. The more rigid material of the reinforcing tube may assist in providing a more reliable seal.

[0010] The reinforcing tube may be made of materials other than steel. In an embodiment, the reinforcing tube is formed of a plastics material that is more rigid than the plastics material of the fuel body. This may allow more flexibility to choose a plastics material that is easily and reliably mouldable to form the fuel body, with additional strength and/or better sealing being provided by the reinforcing tube.

[0011] In some embodiments, the reinforcing tube is cylindrical. The reinforcing tube may also be conical or have a cross-section that varies along its length. The contour and wall thickness of the reinforcing tube may be selected depending on the stresses to which it is subjected at that location in the engine. Different ports of the fuel rail, including different outlet ports, may have reinforcing tubes of differing designs.

[0012] In some embodiments, the fuel body has a wall thickness and the reinforcing tube extends through the entire wall thickness. In some embodiments, reinforcing tube extends through only a portion of the wall thickness. The reinforcing tube may extend to and form a portion of the inner surface of the reservoir so as to provide additional mechanical reinforcement at the interface between the port opening and the fuel rail body at the inner surface.

[0013] In a further embodiment, a resilient seal is located between the reinforcing tube and the body of the fuel rail. The resilient seal may be used to provide an additional seal against leakage of fuel at the joint between the different materials of the reinforcing tube and the body of the fuel rail. The resilient seal is typically provided between the outer surface of the reinforcing tube and the body of the fuel and may be conveniently provided in a groove formed in the body of the fuel rail around one or both ends of the reinforcing tube.

[0014] The resilient seal may be located adjacent the inner surface of the fuel rail or adjacent the outer surface

of the fuel rail. A resilient seal can also be located adjacent both the inner surface and outer surface of the fuel rail. The resilient seal may be an O-ring for example.

[0015] The fuel rail body may be formed so as to provide a ring for accepting the resilient seal that has a side wall formed by an outer wall of the reinforcing tube. The resilient seal may be placed around the reinforcing tube after the reinforcing tube has been attached to the port.

[0016] In an embodiment, the reinforcing tube has a shaped profile at its outer end for receiving a fuel injector to facilitate the entry of the fuel injector into the cylinder. The profile may be curved for example.

[0017] The reinforcing tube may also include one or more protruding members that interlock with the elongate tubular body. The protruding member(s) extend from the outer surface of the tube. The protruding members may be used to increase the mechanical strength of the joint between the reinforcing tube and the mouldable material of the body of the fuel rail. The design of the protruding member may be dependent on movement of the mouldable material around the mould in which the fuel rail is formed.

[0018] In some embodiments, the protruding member is an annular radially extending flange so that the reinforcing tube has an annular radially extending flange. The annular radially extending flange may overlie the inner surface of the fuel rail, in which case, the flange may be flush with the inner surface of the fuel rail.

[0019] In some embodiments, the reinforcing tube may have at its outer periphery adjacent the outer surface of the fuel rail an radially extending flange. A radially extending flange may be provided at each end of the reinforcing tube. This arrangement may be used to contain the shrinkage of the mouldable material in the axial direction and prevent the formation of a leak at the interface between the reinforcing tube and the body of the fuel rail.

[0020] In some embodiments, the radially extending flange of the reinforcing tube additionally has at its outer end an axially extending circumferential rib extending into the material of the fuel rail. This provides a U-type shape for providing additional interlocking between the reinforcing tube and the mouldable material of the fuel rail body.

[0021] In embodiments including a protruding member, an additional resilient seal such as an O-ring seal between the reinforcing tube and the fuel rail body may be omitted, since the form provided by the protruding member can contain shrinkage of the mouldable material during cooling down and ensure a good seal. Containment of the shrinkage of the mouldable material in the axial direction is also provided for embodiments in which protruding members are provided at the opposing ends of the reinforcing tube.

[0022] A method for manufacturing a fuel rail assembly according to any one of the embodiments described herein is provided. In some embodiments, the method comprises incorporating the reinforcing tube in the fuel rail body by overmoulding the reinforcing tube. The reinforcing tube is, therefore, overmoulded by the mouldable

material of the fuel rail body. This overmoulding may take place during the manufacturing of the body of the fuel rail.

[0023] Alternatively, in a further embodiment, the reinforcing tube is inserted into the port after the fuel rail body including the port has been moulded and has cooled. The reinforcing tube may be inserted into the through hole formed through the wall thickness of the fuel rail body forming the port and joined to the port by an interference fit or by glue.

[0024] Embodiments of the present invention will now be described by way of example with reference to the accompanying drawings, in which:-

Figure 1 shows a cross-section through a fuel rail containing a reinforcing tube,

Figure 2 shows an alternative embodiment in which a sealing ring is located adjacent the inner surface of the fuel rail,

Figure 3 shows an alternative embodiment in which the sealing ring is located adjacent the outer surface of the fuel rail,

Figure 4 illustrates a perspective view of the cylinder showing the end adapted to receive a fuel injector,

Figure 5 illustrates a cross-sectional view of a further embodiment in which the reinforcing tube includes reinforcing flanges, and

Figure 6 illustrates a perspective view of the reinforcing tube shown in Figure 5.

[0025] Referring now to Figure 1 there is shown a cross-sectional view of part of a fuel rail 2 formed of a mouldable material such as a plastics material. In a typical installation, the fuel rail 2 is an elongate body having a plurality of outlet ports spaced along the length of the fuel rail, only one of which is shown, as reference 4. The fuel rail may also include one or more other types of ports, for example for a port for a sensor. The port or ports, may include a reinforcing tube 6. The reinforcing tube 6 will be described with reference to an outlet port 4 of the fuel rail. However, the reinforcing tube 6 may also be used for other types or ports, such as a port for a sensor.

[0026] The outlet port 4 includes a reinforcing tube 6 which extends through the body of the fuel rail 2 from the inner surface 8 to the outer surface 10 of the fuel rail. The reinforcing tube 6 is formed of a more rigid, i.e. stiffer material than the mouldable material of the fuel rail 2 and may be formed of a plastics material, but is preferably a metal. The reinforcing tube 6 may be formed in the body of the fuel rail 2 by an over moulding process during the moulding of the fuel rail, but alternatively may be inserted in the fuel rail 2 after the moulding of the fuel rail and formation of a hole through the wall of the fuel rail 2 that

forms the port 4.

[0027] In the illustrated embodiments, the reinforcing tube 6 is a cylinder having a circular cross-section and a diameter that is substantially the same along its length. However, the reinforcing tube is not limited to a cylindrical form and may be conical or have a varying cross-sectional shape and/or area along its length.

[0028] In this embodiment, the reinforcing cylinder 6 is sized and shaped to as to form an injector cup adapted to receive a fuel injector 12. The fuel injector 12 has an inlet through which fuel from the interior volume of the fuel rail 2, which comprises a reservoir 16 enters the fuel injector for injection into a cylinder of the internal combustion engine.

[0029] Distortion of the port 4 by the high pressure of the fuel in the fuel rail 2 or by the harsh environmental conditions of temperature and vibration in which the fuel rail functions in a motor vehicle should be avoided. Should distortion of the port 4 occur there is a risk that high-pressure fuel from the reservoir 16 can leak past the seals 18 of the fuel injector 12 and spray fuel over the hot engine. This is avoided by means of the provision of the additional reinforcing tube 6 that lines the port 4. The reinforcing tube 6 may increase the strength of the port 4 and also provide a surface that is capable of providing a better and/or more reliable seal with the component sealed within it, i.e. the fuel injector 12 or sensor.

[0030] Referring now to Figure 2, there is shown a further embodiment of the outlet port 4 in which an additional resilient seal 20, for example in the form of an O-ring, is provided. The additional resilient seal 20 is located between the reinforcing cylinder 6 and the body of the fuel rail 2 and provides an additional seal at the joint between the outer surface of the reinforcing tube 6 and the mouldable material of the fuel rail body 2. In the embodiment illustrated in figure 2, the resilient seal 20 is located adjacent the inner surface 8 of the fuel rail 2 to accommodate stresses which may occur between the reinforcing cylinder 6 and the adjacent fuel rail body 2 and reservoir 16.

[0031] Referring now to Figure 3, an alternative embodiment is shown in which a resilient seal 22, also in the form of an O-ring, is located between the reinforcing cylinder 6 and the body of the fuel rail 2 adjacent the outer surface 10 of the fuel rail body. It is also possible to use two reinforcing seals, one located adjacent the inner surface 8 and one adjacent the outer surface 10 of the fuel rail body.

[0032] Figure 4 shows a perspective view of the reinforcing cylinder 6 from the direction 24 shown in Figure 3 and illustrated that the reinforcing tube 6 has a modified curved profile such as a chamfer at its peripheral or outer end 32 to facilitate the insertion of the fuel injector 12.

[0033] Referring now to Figures 5 and 6, there is shown a further embodiment of the reinforcing cylinder 6 which has a radially extending peripheral radial flange 26 adjacent the inner surface 8 of the fuel rail 2. At its outer end, the radial flange 26 has a circumferential rib 28 ex-

tending axially and downwardly into the body of the fuel rail 2.

[0034] The reinforcing cylinder 6 also has an outer radial flange 30 adjacent the outer surface 10 of the fuel rail 10 that extends radially from the reinforcing tube 6.

[0035] The reinforcing cylinder may include a radial flange at one or both ends. One or both of the radial flanges 26, 30 may include an axially extending circumferential rib 28.

[0036] The provision of the flanges 26, 30 on the reinforcing cylinder 6 improves the design for the overmoulding and can obviate the provision of the O-ring seals. The tightness of the fit and seal of the joint between the reinforcing cylinder 6 and the fuel rail body 2 is ensured thanks to the shape which contains the plastic radial shrinkage during the cooling down of the moulding which also serves to secure the cylinder 6 in the axial direction.

[0037] It is possible in certain installations that the reinforcing tube is conical and may have a variable thickness and special reinforcing zones to accommodate higher stress levels due to a particular installation. Similarly, the dimensions of the flanges can be changed according to design requirements and available space.

[0038] The mechanical resistance of the port and, in embodiments in which the port provides an injector cup, the mechanical resistance of the injector cup is increased at the sealing zone of the intersection with the main gallery. The design is useful for high pressure fuel rails and fuel rails having metallic wet surfaces.

Claims

1. A fuel rail assembly for a fuel injection system for an internal combustion engine, the assembly having a fuel rail (2) comprising an elongate tubular body having an internal volume comprising a reservoir for fuel, the fuel rail (2) having an inlet port through which fuel is supplied to the reservoir, the fuel rail (2) being formed of a mouldable material, wherein the fuel rail (2) has at least one port (4) having a reinforcing tube (6).
2. A fuel rail assembly according to claim 1, wherein the port (4) is an outlet port and the reinforcing tube (6) at the outlet port (4) is sized and shaped to form an injector cup adapted to receive a fuel injector.
3. A fuel rail assembly according to claim 1 or 2, wherein the reinforcing tube (6) is formed of a metal and/or the fuel rail (2) is formed of a mouldable plastic material.
4. A fuel rail assembly according to any one of claims 1 to 3, wherein the reinforcing tube (6) is cylindrical or conical or has a varying cross-section along its length.

5. A fuel rail assembly according to any one of claims 1 to 3, wherein the reinforcing tube (6) has a length that extends through a wall thickness of the elongate tubular body. 5
6. A fuel rail assembly according to any one of claims 1 to 5, further comprising a resilient seal (20; 22) located between the reinforcing tube (6) and the elongate tubular body of the fuel rail (2). 10
7. A fuel rail assembly according to claim 6, wherein the resilient seal (20; 22) is located adjacent an inner surface of the fuel rail (2) or adjacent the outer surface of the fuel rail (2). 15
8. A fuel rail assembly according to any one of the preceding claims, wherein the reinforcing tube (6) comprises a shaped profile (32) at its outer end for receiving a fuel injector to facilitate the entry of the fuel injector into the cylinder. 20
9. A fuel rail assembly according to any one of the preceding claims, wherein the reinforcing tube (6) comprises at least one protruding member (26, 30) interlocking with the elongate tubular body. 25
10. A fuel rail assembly according to claim 9, wherein the protruding member (26) comprises an annular radially extending flange overlying the inner surface (8) of the fuel rail (2). 30
11. A fuel rail assembly according to claim 10, wherein the flange (26) is flush with the inner surface (8) of the fuel rail (2) or the flange (30) is flush with an outer surface (10) of the fuel rail. 35
12. A fuel rail assembly according to claim 10 or claim 11 wherein the radially extending flange (26) has at its outer end an axially extending circumferential rib (28) extending into the material of the fuel rail (2). 40
13. A method for manufacturing a fuel rail assembly according to any one of claims 1 to 12, wherein the reinforcing tube (6) is incorporated in the fuel rail (2) body by over moulding during the moulding of the fuel rail (2). 45
14. A method for manufacturing a fuel rail assembly according to any one of claims 1 to 12, wherein the reinforcing tube (6) is inserted into the port (4) of the fuel rail body after the fuel rail body is moulded. 50
15. A method according to claim 14, wherein the reinforcing tube (6) has an interference fit with the port (4) or is glued to the port (4). 55

FIG 1

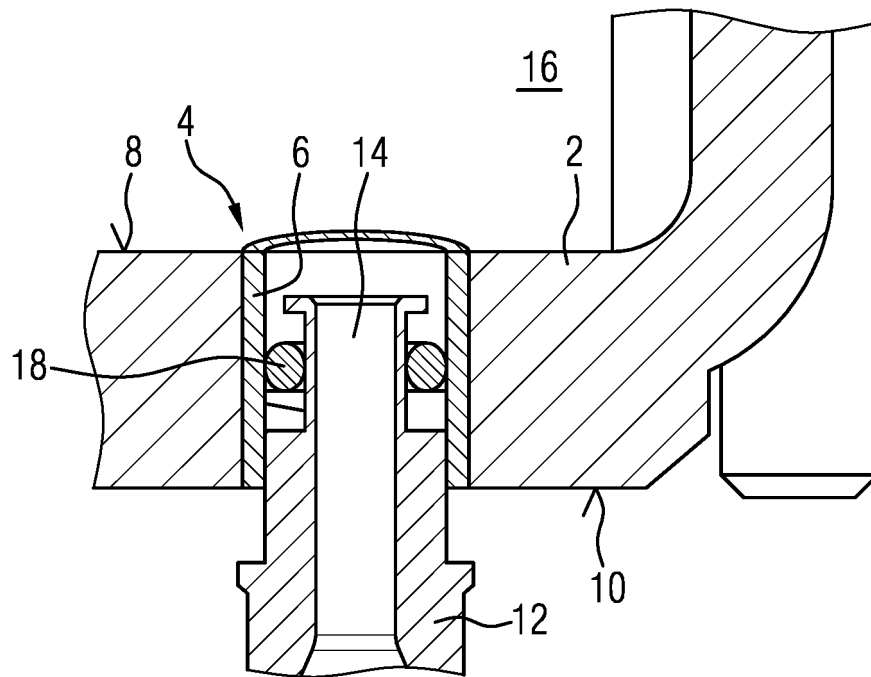


FIG 2

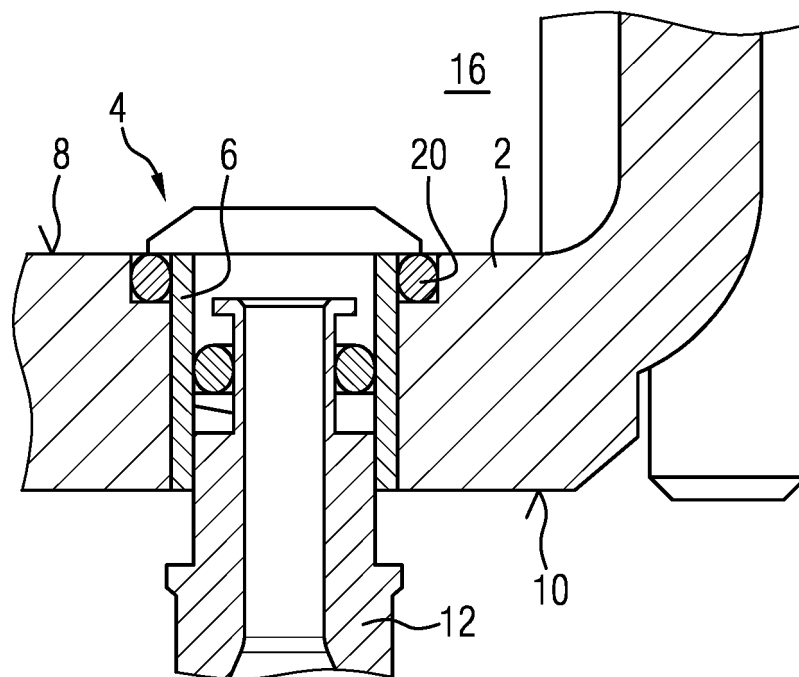


FIG 3

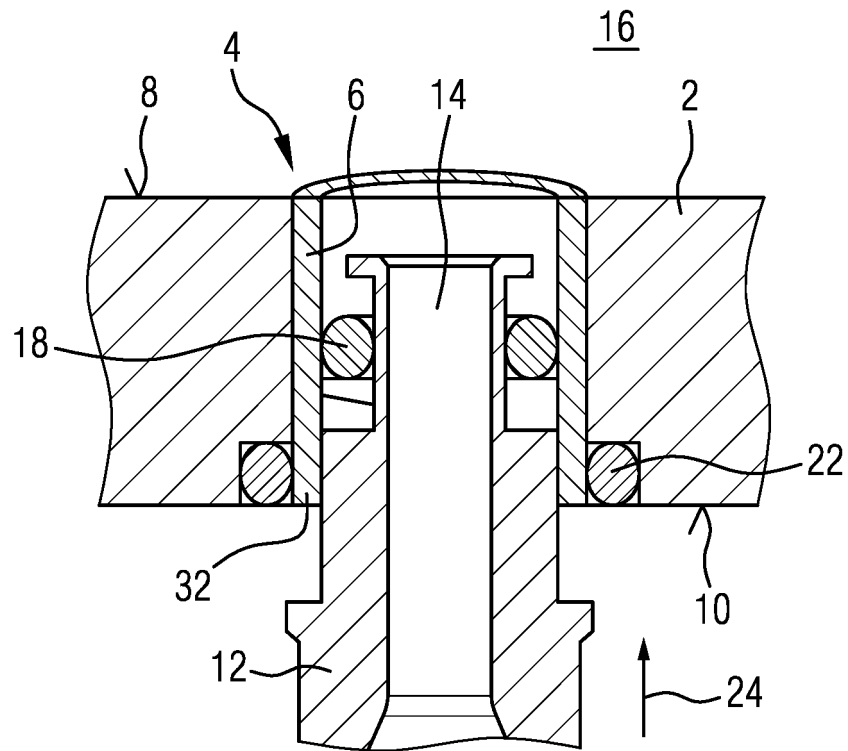


FIG 4

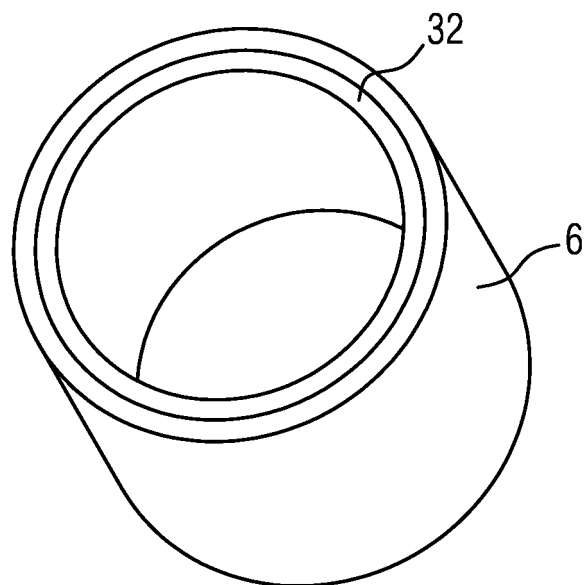


FIG 5

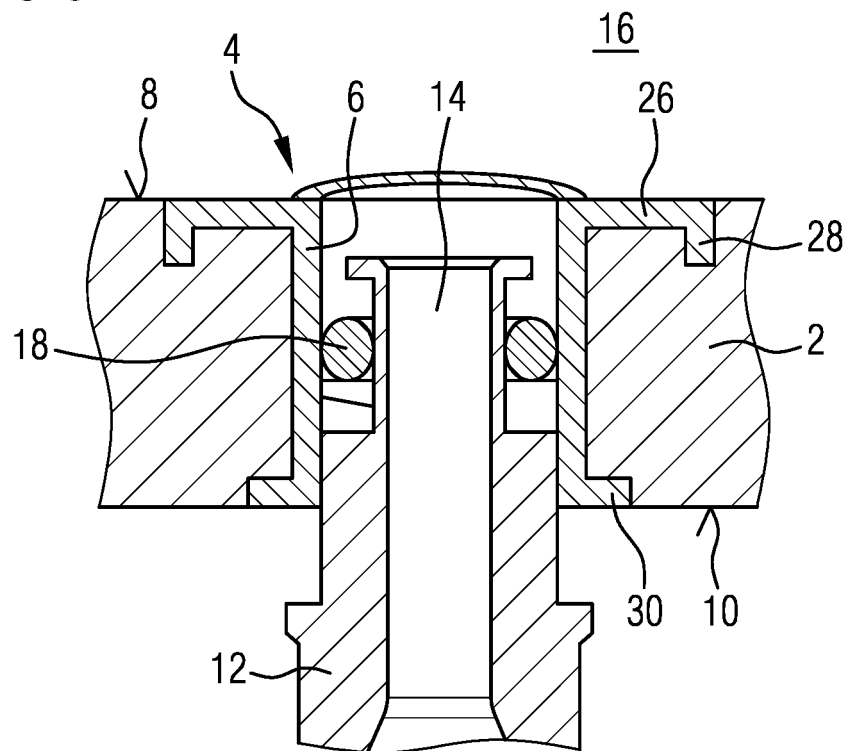
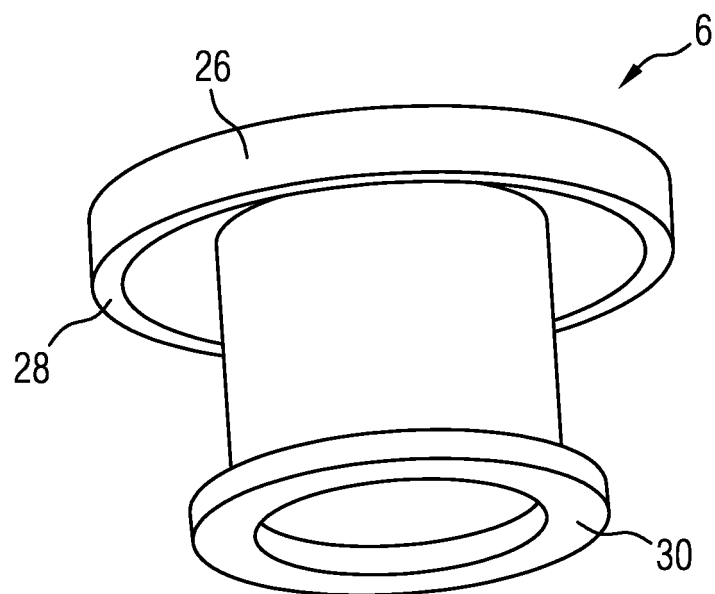


FIG 6





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Place of search The Hague		Date of completion of the search 15 April 2020	Examiner Barunovic, Robert
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5 This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
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