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(54) **Fuel injector, fuel injection assembly and use of a sealing ring**

(57) The present disclosure relates to a fuel injector (1) comprising an injector body (10) having a fuel inlet portion (100) at one of its ends and a sealing ring (30) extending circumferentially around the fuel inlet portion (100), wherein the sealing ring (30) has a non-circular cross-sectional shape. The present disclosure also relates to a fuel injection assembly and to the use of a sealing ring (30).

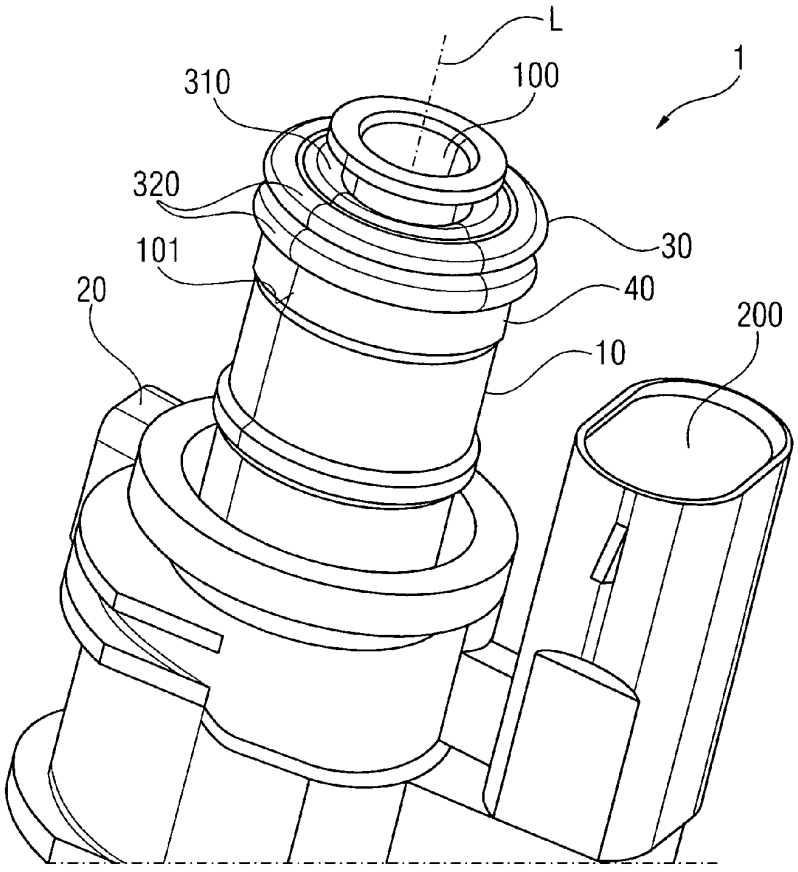

FIG 1

EP 2 700 806 A1

Description

[0001] The present disclosure relates to a fuel injector, to a fuel injection assembly and to the use of a sealing ring.

[0002] A fuel injection assembly is known, for example, from WO 2009/0886582 A2. This document discloses a fuel delivery system with a fuel injector and a receptor cup for receiving the fuel injector. The fuel injector and the receptor cup are sealingly coupled using an O-ring.

[0003] The sealing function in such fuel injector assemblies against external leakage at the injector to fuel-rail interface maybe unsatisfactory at high working pressures and/or at low temperatures.

[0004] This problem is solved by a fuel injector and by the use of a sealing ring according to the independent claims. Advantageous embodiments and developments of the fuel injector and of the use are specified in the dependent claims.

[0005] A fuel injector is specified. The fuel injector comprises an injector body. The injector body has a fuel inlet portion at one of its ends. Expediently, it has a fuel outlet portion at an end opposite of the fuel inlet portion. For example, the injector body has a longitudinal axis and extends along the longitudinal axis from the fuel inlet portion to the fuel outlet portion. The fuel outlet portion may comprise an injection nozzle. In an expedient development, the fuel injector has a valve needle, arranged in an interior of the injector body which is in particular axially moveable for controlling fluid flow through the injection nozzle.

[0006] The fuel injector further comprises a sealing ring. The sealing ring extends circumferentially around the fuel inlet portion of the injector body. In particular, the sealing ring is in direct mechanical contact with the injector body. Preferably, the sealing ring has a main extension plane and is arranged in such fashion that a surface normal to the main extension plane is parallel to the longitudinal axis of the injector body.

[0007] According to a second aspect, a fuel injection assembly is specified. The fuel injection assembly comprises the fuel injector. It further comprises an injector cup - sometimes also called receptor cup - in which the fuel inlet portion of the fuel injector is received. The injector cup may be arranged in engagement with a fuel rail or may be hydraulically coupled to the fuel rail by means of a fuel pipe so that fuel flowing the in fuel rail can be communicated to the fuel outlet portion of the fuel injector through the injector cup. The fuel injector and the injector cup are sealingly coupled to each other by means of the sealing ring.

[0008] The sealing ring, with advantage, has a non-circular cross section. In particular, it has a non-circular cross sectional shape when it is free from external tensile or compressive stress as well as in the mounted fuel injection assembly.

[0009] With advantage, such a sealing ring may provide a larger sealing surface than a ring with a circular cross section so that a particularly tight seal is achievable between the fuel injector and the injector cup.

[0010] The sealing ring may be provided to fit into a groove which is provided in the injector body and/or into a groove which is provided in the injector cup and which is/are designed for an O-ring. In this way, no redesign of the injector body or the injector cup may be necessary. Thus, the fuel injector and the fuel injector assembly are particularly cost effective.

[0011] In at least one embodiment, the sealing ring is elastically and/or plastically deformable. The sealing ring may comprise at least one of the following materials: an elastomer, a rubber-like material, a plastomer like polyurethane.

[0012] An "elastomer" is in particular a polymer which is viscoelastic. For example, the polymer material of the elastomer is made up from monomers which are made of carbon, hydrogen, oxygen and/or silicon. A "plastomer" is a polymer material which combines properties of elastomers and plastics. For example, it has rubber-like properties and is processable like plastic. For example, the plastomer is an ethylene-alpha olefin copolymer.

[0013] "Having rubber-like properties" or being a "rubber-like material" in particularly means that the material has stress-strain behavior comparable to that of rubber. In particular, it exhibits the Mullins effect and/or the Payne effect. When a material exhibits the Mullins effect, its stress-strain curve depends on the maximum loading previously encountered. For example, the stress-strain curve instantaneously and irreversibly softens whenever the load on the material increases beyond its prior all time maximum value. The Payne effect is manifest as a dependence of the viscoelastic storage modulus on the amplitude of the applied strain. In particular, the storage modulus decreases rapidly with increasing amplitude of the strain and approaches a lower bound at sufficiently large strain amplitudes. In the region where the storage modulus decreases, the loss modulus shows a maximum.

[0014] The deformable sealing ring having a non-circular cross sectional shape has a particularly low risk for spiral failure. Spiral failure can occur in sealing rings with circular cross section (also called "O-rings"), for example due to dynamic movement that may occur due to vibrations of the engine - e.g. an internal combustion engine -, for which the fuel injector assembly is provided. While parts of the O-ring roll on the injector body or the injector cup, other parts may slide, resulting in a spiraling motion of the O-ring. The spiraling motion may cause the cross section of the O-ring to be twisted so that cuts may develop in its sealing surface. Due to the non-circular cross section of the sealing ring according to the present disclosure, a risk for such spiral failure is particularly low.

[0015] The cross-sectional shape of the sealing ring may be rectangualr or quadratic, for example. In a preferred embodiment, a cross sectional shape of the sealing ring has three or more lobes. For example, the cross sectional shape of the sealing ring has three, four or five

lobes. The lobes are in particular projections having a curved surface. The cross sectional shape may have a kink or a flat section between two adjacent lobes.

[0016] Particularly preferably, the cross sectional shape of the sealing ring has four lobes. The cross sectional shape may in particular have a mirror symmetry, preferably a mirror symmetry with respect to two perpendicular mirror planes which may, for example, intersect in the geometric center of the cross sectional shape. In this way, a particularly stable position of the sealing ring is achievable.

[0017] At least two of the lobes preferably face the injector body. In case of a sealing ring with a cross sectional shape having four or more lobes, at least two of the lobes preferably face away from the injector body and in particular face the injector cup.

[0018] With advantage, the sealing ring having a cross section with three or more lobes may have at least approximately twice the sealing surface at its interface with the injector body as compared to an O-ring. If the sealing ring has four or more lobes, the sealing surface may also be increased on its side facing away from the injector body as compared to an O-ring.

[0019] Advantageously, due to the increased sealing surface, the squeeze, i.e. the amount of deformation, which is required to achieve a sufficient sealing function is reduced with respect to an O-ring. In this way, lower installation forces, less friction and less wear are achievable, so that the fuel injector assembly may have a particularly long life-time and the maintenance costs may be particularly low.

[0020] Further, when the sealing ring which has four lobes, for example, is manufactured with an injection molding process or the like, e.g. in a two part mold, the parting line between the mold parts is preferably located in a region of the sealing ring which does not contact the injector body or the injector cup. In this way, the danger that irregularities like burrs compromise the sealing function of the sealing ring is particularly low.

[0021] In case of a sealing ring having a cross sectional shape with four lobes, two of the lobes preferably share a first center axis and are subsequently arranged along the first center axis. The two other lobes preferably share a second center axis and are subsequently arranged along the second center axis. The first center axis and the second center axis extend obliquely or at a right angle with respect to each other. This form is also referred to as an X-shape, the sealing ring may therefore also be called an "X-ring" in this case.

[0022] In an expedient embodiment, two of the lobes abut the injector body. The third lobe or at least one of the remaining lobes face away from the injector body. For example, the sealing ring has a cross sectional shape with four lobes, wherein two of the lobes are in direct mechanical contact with the injector body and the remaining two lobes face away from the injector body and in particular abut the injector cup.

[0023] In particular, the two lobes which abut the injector body define a channel - referred to as "inner" channel in the following - together with the injector body. The inner channel is expediently arranged circumferentially around the fuel inlet portion between the injector body and the sealing ring.

[0024] In one embodiment, at least one of the lobes of the sealing ring abuts the injector cup. Preferably, two of the lobes abut the injector cup so that they define a channel together with the injector cup - denoted as "outer" channel in the following. The outer channel expediently extends circumferentially around the sealing ring between the sealing ring and the injector cup. In an advantageous development, the inner channel is filled with a lubricant and/or the outer channel is filled with a lubricant. In this way, friction maybe particularly low and the life time of the fuel injector and the fuel injector assembly, respectively, maybe particularly long.

[0025] According to another aspect, the present disclosure relates to the use of a sealing ring which has a non-circular cross section for sealingly coupling a fuel injector and an injector cup. To put it in other words, in a method for coupling a fuel injector and an injector cup, the method involves sealingly coupling the fuel injector and the injector cup by means of a sealing ring having a non-circular cross section. The fuel injector, the injector cup and the sealing ring are in particular the fuel injector, the fuel injection assembly and the sealing ring, respectively, according to at least one of the preceding aspects, embodiments and developments.

[0026] Further advantageous embodiments and developments of the fuel injector, the fuel injection assembly and the use of the sealing ring will become apparent from the exemplary embodiments described below in connection with the figures.

[0027] In the figures:

Figure 1	shows a perspective view of a section of a fuel injector according to first embodiment,
Figure 2a	shows a schematic cross section of a section of a fuel injector according to a variant of the first embodiment,
Figure 2b	shows a schematic cross section of a section of the fuel injector according to figure 1,
Figure 2c	shows a schematic cross section of a further variant of the fuel injector of the first embodiment,
Figure 3	shows a side view of a section of the fuel injector according to the first embodiment, and
Figure 4	shows a schematic cross section of a fuel injection assembly according to one embodiment.

[0028] The figures and the size relationships of the elements in the figures should not be regarded as true to scale. Rather, individual elements maybe exaggerated in size for better re-presentability or better understanding. In the figures, identical, identically acting or similar elements are provided with the same references.

[0029] Figure 1 shows a perspective view of a section of a fuel injector 1 according to one embodiment. Figure 2b show a schematic cross sectional view of a portion of the fuel injector 1. Figure 3 shows the fuel injector 1 of the first embodiment in a side view.

[0030] The fuel injector 1 one has an injector body 10 having a longitudinal axis L. The injector body may be made from a metal, for example. In a direction along the longitudinal axis L, it has a fuel inlet portion 100 at one end and a fuel outlet portion (not shown in the figures) at its other end.

[0031] For example in a middle region between the fuel inlet portion 100 and the fuel outlet portion, a housing 20 may surround the injector body 10. The housing 20 may comprise, for example, an actuator unit. The housing 20 may have an electrical connector 200.

[0032] The fuel injector 1 further comprises a sealing ring 30. The sealing ring 30 according to the present embodiment is elastically and/or plastically deformable. For example, it comprises an elastomer or a plastomer or consists thereof. Suitable materials for such sealing rings are in principle known to the skilled person and are not explained here in further detail.

[0033] A cross sectional shape, best viewed in figure 2b, of the sealing ring 30 has four lobes 310, 320. Two of the lobes, denoted as "first" lobes 310 in the following, abut the fuel inlet portion 100 of the injector body 10. The other two lobes, referred to as "second" lobes 320 in the following, are arranged further away from the injector body 10 in a radial direction, i. e. perpendicular to the longitudinal axis L. In other words, the second lobes 320 face away from the injector body 10.

[0034] One of the first lobes 310 and one of the second lobes 320 share a first center axis 301, along which they a subsequently arranged. The remaining first and second lobes 310, 320 are subsequently located along a second center axis 302.

[0035] The first and second center axes 301, 302 are arranged at right angles with respect to each other in the present embodiment. Expediently, the axes 301, 302 are also inclined with respect to the main plane of extension 303 of the sealing ring 30. For example, each of the first and second axis 301, 302 extends at an angle of 45° with respect to the main plane of extension 303. The main plane of extension 303 is arranged in such fashion, that its surface normal is parallel to the longitudinal axis L. In this way, the first lobes 310 which abut the fuel inlet portion 100 of the injector body 10 define an inner channel 330 which is enclosed by surface regions of the first lobes 310 and the fuel inlet portion 100.

[0036] The fuel injector 1 further comprises a backing ring 40. The backing ring 40 maybe a rigid ring. It may be provided to hold the sealing ring to its designated shape and/or its correct position. Such backing rings are in principle known to the person skilled in the art and, therefore, are not explained further here.

[0037] The injector body 10 may have a shoulder 101 (best seen in figure 4) for blocking axial movement of the sealing ring 30 - or of the sealing ring 30 and the backing ring 40 if a backing ring 40 is present - in a longitudinal direction, in particular towards the fuel outlet portion.

[0038] Figure 2a shows a first variant of the fuel injector 1 according to the first embodiment in a schematic cross section of a portion of the fuel injector 1.

[0039] The sealing ring according to this variant does not have a cross sectional shape with four lobes 310, 320. Instead, the cross sectional shape of the sealing ring 30 has three lobes 310, 320. It has two first lobes 310 which abut the fuel inlet portion 100 of the injector body 10. The single second lobe 320 which faces away from the injector body 10 is arranged between the first lobes 310 in longitudinal direction L.

[0040] In a second variant shown in a schematic cross section of a portion of the fuel injector 1 in figure 2c, the sealing ring 30 is a "W-ring" with five lobes 310, 320. Two of the lobes are first lobes 310 which abut the fuel inlet portion 100 of the injector body 10. The three second lobes 320 are arranged at the side of the sealing ring 30 which faces away from the injector body 10.

[0041] In a further variant, the W-shape is inverted as compared to the preceding variant, i.e. the sealing ring 30 has three first lobes 310 which abut the injector body 10 and two second lobes 320 which face away from the injector body 10. In this way, a particularly stable position of the sealing ring 30 on the injector body 10 is achievable.

[0042] Figure 4 shows a schematic cross sectional view of a fuel injection assembly according to one embodiment.

[0043] The fuel injection assembly has the fuel injector 1 according to the embodiment described in connection with figures 1, 2b and 3. It further has an injector cup 2.

[0044] The fuel inlet portion 100 of the fuel injector 1 is received in a recess 210 of injector cup 2. The injector cup 2 further has a fuel inlet opening 2020. The injector cup 2 maybe hydraulically coupled to a fuel rail (not shown) via the fuel inlet opening 2020, so that fuel may flow from the fuel rail through the fluid inlet opening 2020 into the recess 2010 of injector cup 2 and further into the fuel inlet portion 100 of fuel injector 1.

[0045] The fuel injector 1 and the injector cup 2 are sealingly coupled by means of the sealing ring 30. In particular, the second lobes 320 of sealing ring 30 abut a surface of recess 210.

[0046] Sealing ring 30 is squeezed when fuel injector 1 is inserted into injector cup 2, so that the sealing ring is elastically and/or plastically deformed. Thus, each of the first lobes 310 is pressed against fuel inlet portion 100 of the injector body 10 of fuel injector 1 and each of the second lobes 320 is pressed against the injector cup

2.

[0047] The first lobes 310 and the fuel inlet portion 100 define an inner channel between the injector body 10 and the sealing ring 30 and second lobes 320 and the injector cup 2 define an outer channel 340 between the sealing ring 30 and the injector cup 2. The inner channel 330 and the outer channel 340 are each filled with a lubricant in the present embodiment.

[0048] The invention is not limited to specific embodiments by the description on the basis of said exemplary embodiments but comprises any combination of elements of different embodiments. Moreover, the invention comprises any combination of claims and any combination of features disclosed by the claims.

Claims

1. Fuel injector (1) comprising an injector body (10) having a fuel inlet portion (100) at one of its ends and a sealing ring (30) extending circumferentially around the fuel inlet portion (100), wherein the sealing ring (30) has a non-circular cross-sectional shape.

2. The fuel injector (1) according to claim 1, wherein the sealing ring (30) is made from at least one of the following materials: an elastomer, a rubber-like material, a plastomer, polyurethane.

3. The fuel injector (1) according to one of the preceding claims, wherein the cross-sectional shape has three or more lobes (310, 320).

4. The fuel injector (1) according to claim 3, wherein the cross-sectional shape of the sealing ring (30) has four lobes (310, 320), wherein two of the lobes (310, 320) share a first center axis (301) and are subsequently arranged along the first center axis (301), the other two lobes (310, 320) share a second center axis (302) and are subsequently arranged along the second center axis (302), and the center axes (301, 302) extend obliquely or at a right angle with respect to each other.

5. The fuel injector (1) according to claim 3 or 4, wherein

   - two of the lobes (310) abut the injector body (10) and the third lobe (320) or at least one of the remaining lobes (320) face away from the injector body (10) and
   - the two lobes (310) which abut the injector body (10) and the injector body (10) define an inner channel (330), the inner channel (330) extending circumferentially around the fuel inlet portion (100) between the injector body (10) and the sealing ring (30).

6. Fuel injection assembly comprising a fuel injector (1) according to one of the preceding claims and an injector cup (2) in which the fuel inlet portion (100) is received, wherein the fuel injector (1) and the injector cup (2) are sealingly coupled to each other by means of the sealing ring (30).

7. The fuel injection assembly according to claim 6, comprising the fuel injector according to one of claims 3 to 5, wherein at least one of the lobes (320) of the sealing ring (30) abuts the injector cup (2).

8. The fuel injection assembly according to claim 7, wherein two of the lobes (320) abut the injector cup (2) so that they define an outer channel (340) together with the injector cup (2), the outer channel (340) extending circumferentially around the sealing ring (30) between the sealing ring (30) and the injector cup (2).

9. Use of a sealing ring (30) which has a non-circular cross section for sealingly coupling a fuel injector (1) and an injector cup (2).

10. The use according to claim 9, wherein the sealing ring (30) is made from at least one of the following materials: an elastomer, a rubber-like material, a plastomer, polyurethane.

11. The use according to claim 9 or 10, wherein the sealing ring (30) has a cross-sectional shape having three, four or five lobes (310, 320).

12. The use according to claim 11, wherein the cross-sectional shape of the sealing ring (30) has four lobes (310, 320), wherein two of the lobes (310, 320) share a first center axis (301) and are subsequently arranged along the first center axis (301), the other two lobes (310, 320) share a second center axis (302) and are subsequently arranged along the second center axis (302) , and the center axes (301, 302) extend obliquely or at a right angle with respect to each other.

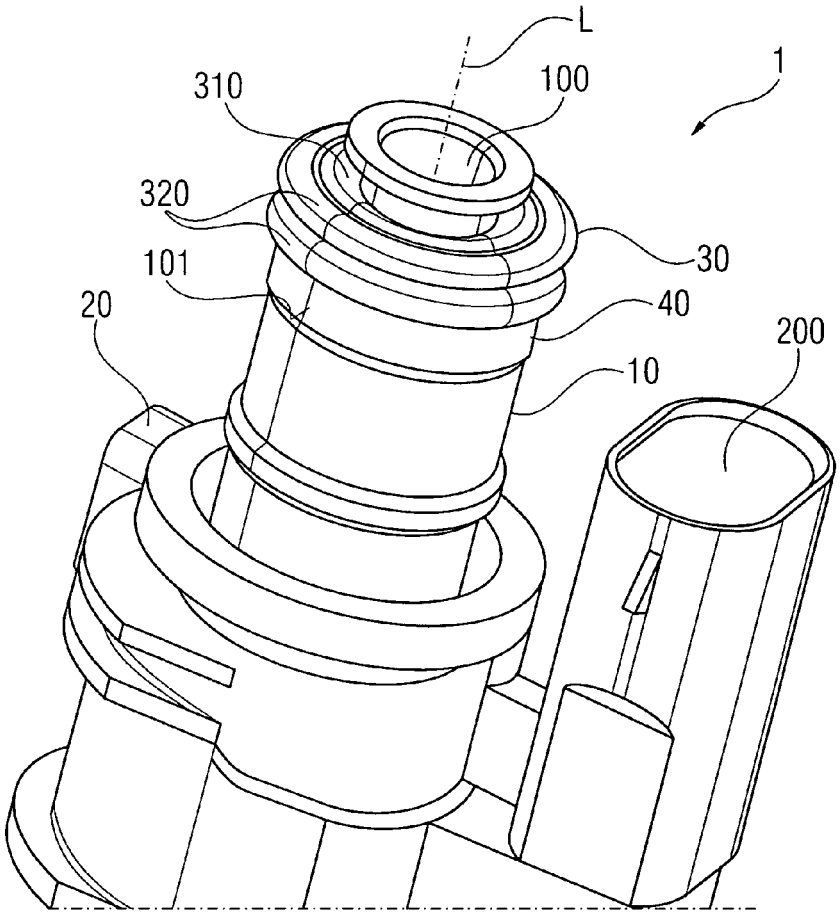

FIG 1

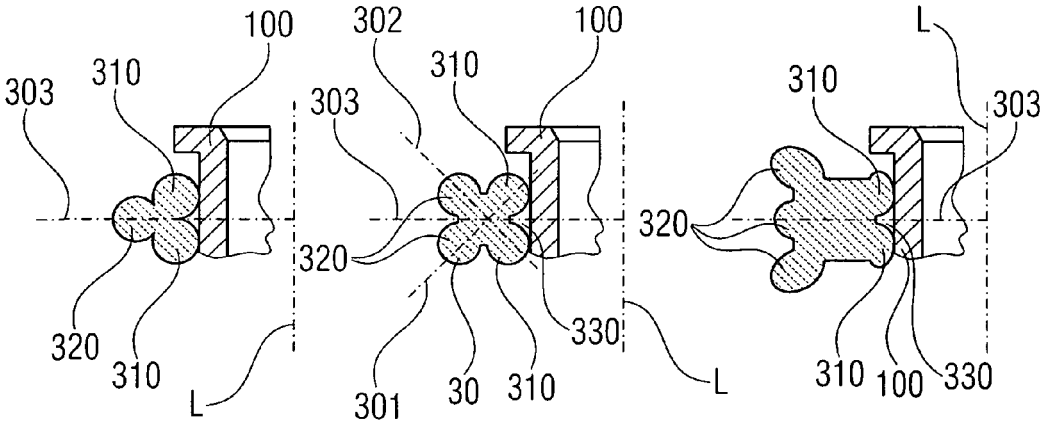

FIG 2a FIG 2b FIG 2c

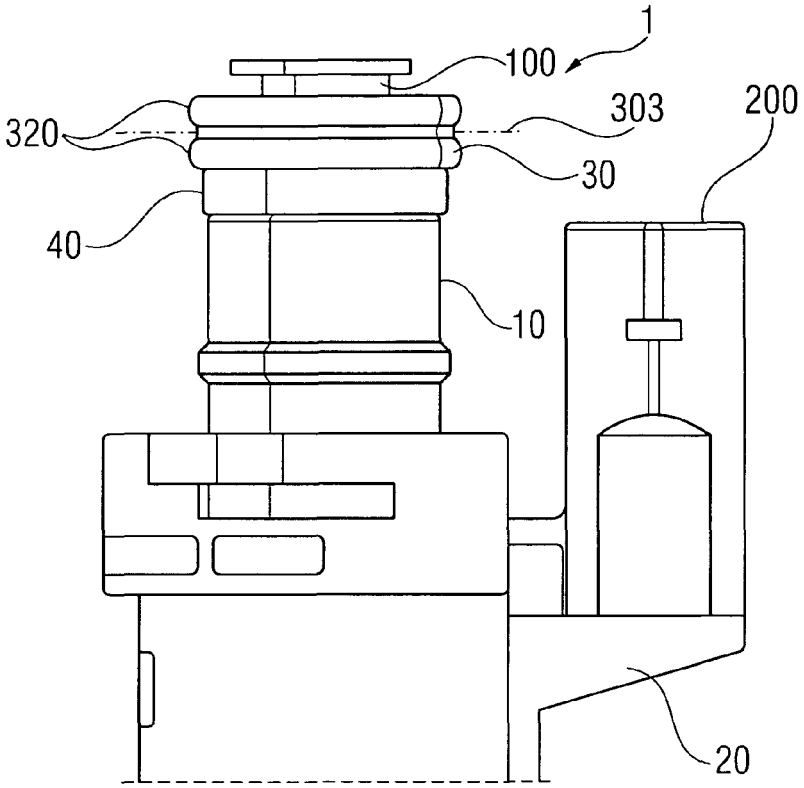
1
100
303
200
320
30
40
10
20

FIG 3

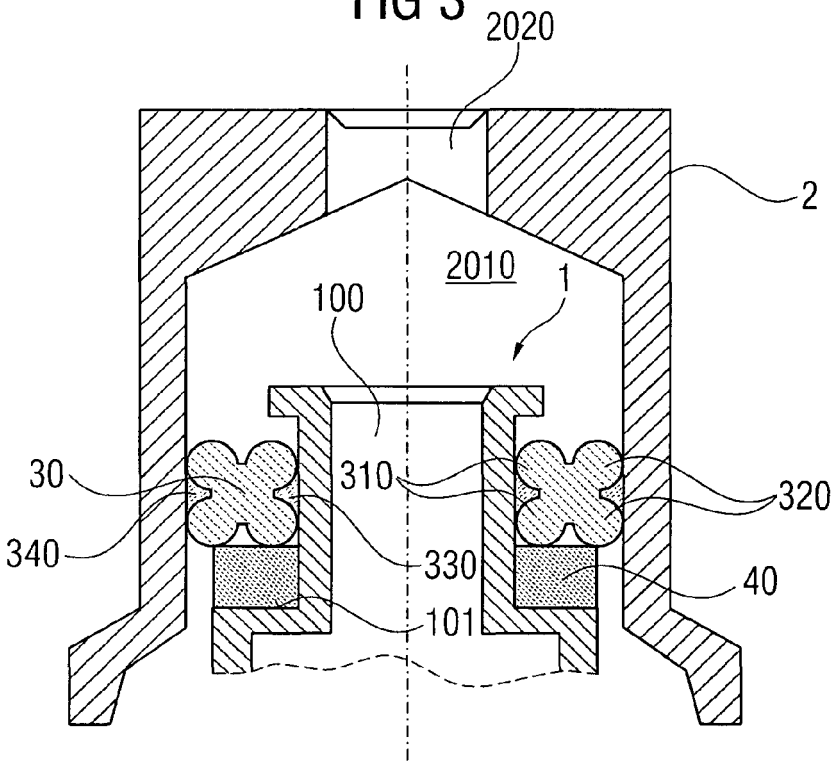
2020
2
2010
1
100
30
310
320
340
330
40
101

FIG 4

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EUROPEAN SEARCH REPORT

Application Number
EP 12 18 1467

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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
Munich	16 January 2013	Etschmann, Georg

CATEGORY OF CITED DOCUMENTS

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

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