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

(11) EP 3 816 431 A1

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
05.05.2021 Bulletin 2021/18

(51) Int Cl.:
F02M 61/20 *(2006.01)*

(21) Application number: **19206326.1**

(22) Date of filing: **30.10.2019**

(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

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(54) PRESSURE COMPENSATOR ELEMENT AND FLUID INJECTOR FOR AN INTERNAL COMBUSTION ENGINE COMPRISING THE PRESSURE COMPENSATOR ELEMENT

(57) The invention relates to a pressure compensator element (200) for a fluid injector (100) for an internal combustion engine, wherein the pressure compensator element (200) extends along a central longitudinal axis (180) and comprises:
- a containment ring (230) which comprises an elastic material and is configured to deform elastically when the pressure acting on the pressure compensator element (200) changes;
- a first ring (210) which is arranged at or in the containment ring (230) at a first portion of the containment ring (230) and extends out of the containment ring (230);
- a second ring (220) which is arranged at or in the containment ring (230) at a second portion of the containment ring (230) and extends out of the containment ring (230),
wherein the second portion of the containment ring (230) is arranged at a different axial position at the containment ring (230) with respect to the first portion of the containment ring (230),
wherein an elastic deformation of the containment ring (230) due to a change of the pressure acting on the pressure compensator element (200) results in an axial displacement of the first portion of the containment ring (230) with respect to the second portion of the containment ring (230) and therefore in an axial displacement of the first ring (210) with respect to the second ring (220).

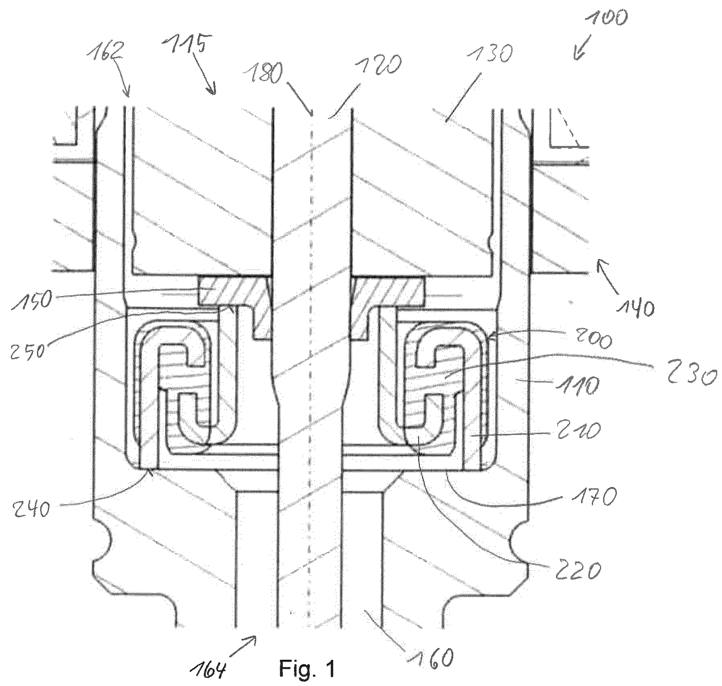

Fig. 1

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Description

[0001] The invention relates to a pressure compensator element and a fluid injector for an internal combustion engine comprising the pressure compensator element, wherein the fluid injector comprises a valve housing and a valve needle assembly.

[0002] Fluid injectors are in widespread use, in particular for internal combustion engines, where they may be arranged in order to doze a fluid or fuel amount into an intake manifold of the internal combustion engine or directly into a combustion chamber of a cylinder of the internal combustion engine.

[0003] Due to increasingly strict legal regulations concerning the admissibility of pollutant emissions by internal combustion engines, which are arranged for example in vehicles, it is necessary to take actions in various ways in order to reduce these pollutant emissions.

[0004] One possible starting point to reduce the pollutant emissions and in particular to reduce particle emissions is to increase the fluid pressure inside the fluid injector. Conventional fluid injectors are designed to operate at a fluid pressure of below 10 MPa. If the fluid pressure inside the fluid injector is increased it is possible to reduce pollutant emissions caused by the internal combustion engine. The increased fluid pressure inside the fluid injectors requires a change of design of the fluid injector. In conventional fluid injectors a valve needle is arranged which can be displaced away from a closing position to allow the fluid to flow out of the fluid injector. In the closing position the fluid flow out of the fluid injector is inhibited. The valve needle is conventionally displaced away from the closing position by an actuator assembly. If the fluid pressure inside the fluid injector increases, the required lifting force to displace the valve needle away from the closing position also has to increase due to an increased hydraulic load on the valve needle from the fluid. Conventionally, more powerful actuator assemblies are used which generate a stronger lifting force applied to the valve needle when the fluid pressure inside the fluid injector increases. But such actuator assembly are expensive and cause therefore an increase of cost of the fluid injector. In addition, such actuator assemblies which create a higher lifting force applied to the valve needle are conventionally not so accurate in the displacement of the valve needle which may harm the quality of the fluid injector and especially the fluid spray quality out of the fluid injector.

[0005] An object of the present disclosure is to provide an element to improve a fluid injector of an internal combustion engine and to provide a fluid injector with the element, wherein the fluid injector is in particular configured to operate at high fluid pressure inside the fluid injector.

[0006] The object is achieved by a pressure compensator element comprising the features of the independent claim and a fluid injector comprising the pressure compensator element. Advantageous embodiments of the pressure compensator element and the fluid injector are specified in the dependent claims.

[0007] A pressure compensator element for a fluid injector for an internal combustion engine is specified. The pressure compensator element extends along a central longitudinal axis. The pressure compensator element comprises a containment ring a first ring and a second ring. The containment ring comprises an elastic material and is therefore configured to deform elastically when the pressure acting on the pressure compensator element changes. The first ring is arranged at or in the containment ring at a first portion of the containment ring and extends out of the containment ring. Also, the second ring is arranged at or in the containment ring at a second portion of the containment ring and extends out of the containment ring. The first portion and the second portion of the containment ring are areas of the containment ring which contact or engage with the first ring or the second ring respectively. According to one embodiment, the containment ring, the first ring and the second ring are arranged coaxially with respect to each other.

[0008] The first portion and the second portion of the containment ring are according to the present disclosure arranged at different axial positions on the containment ring. In other words, the first portion is for example arranged at one axial end of the containment ring and the second portion is arranged at the other axial end of the containment ring. The elastic deformation of the containment ring due to a change of the pressure acting on the pressure compensator element results in a volume change of the containment ring. This volume change changes the axial position of the first portion of the containment ring with respect to the second portion of the containment ring. Due to the fact that the first ring is arranged at or in the first portion and that the second ring is arranged at or in the second portion, the volume change of the containment ring results in an axial displacement of the first ring with respect to the second ring. The first ring is, for example, arranged at one longitudinal end of the containment ring and the second ring is arranged at the other longitudinal end of the containment ring and the pressure acting on the pressure compensator element increases, than the volume of the containment ring will decrease which results in an axial displacement of the first ring towards the second ring and of the second ring towards the first ring if the pressure compensator element is fixed at its center. With the pressure compensator element according to the present disclosure it is possible to transform the pressure change of the pressure acting on the pressure compensator element into an axial displacement of the first ring with respect to the second ring or of the second ring with respect to the first ring. In addition, the deformation of the containment ring is proportional to the pressure change of the pressure acting on the pressure compensator element. Therefore, also the axial displacement is proportional to the pressure change of the pressure acting on the pressure compensator element. With the pressure compensator element according to the present disclosure it is possible to displace the first ring with respect to the second ring or to apply a force on two parts which are engaged with the first ring and the second ring.

[0009] According to one embodiment, the first ring comprises a radial portion which extends in radial direction and an axial portion which extends in axial direction, wherein the axial portion extends from one radial end of the radial portion of the first ring. In other words, the half section profile of a longitudinal section view of the first ring has a L-shape. According to this embodiment, the second ring comprises a radial portion which extends in radial direction and an axial portion which extends in axial direction, wherein the axial portion extends from one radial end of the radial portion of the second ring. In other words, the half section profile of a longitudinal section view of the second ring has also a L-shape. The angle between the radial portions and the axial portion could be for example between 70 degree or greater and 110 degree or smaller. According to this embodiment, the radial portion of the first ring is arranged at least partially at or in the first portion of the containment ring and the radial portion of the second ring is arranged at least partially at or in the second portion of the containment ring. The radial portions of the first ring and the second ring contact the containment ring. The axial portion of the first ring and the axial portion of the second ring extend according to this embodiment in opposite directions. It is in particular possible according to this embodiment to transfer the volume change of the containment ring to the desired displacement of the first ring and the second ring. In addition, the free axial ends of the axial portions can be used as stop surfaces and can therefore transfer the force generated by the pressure compensator element at the desired other parts in a particular simple way.

[0010] According to one embodiment, the axial portion of the first ring extends from the radial outer end of the radial portion of the first ring and the axial portion of the second ring extends from the radial inner end of the radial portion of the second ring. In other words, the axial portion of the first ring is at least partially arranged outside of the radial outer edge of the containment ring and the axial portion of the second ring is arranged at least partially inside of the radial inner edge of the containment ring. According to this embodiment extends the axial portion of the first ring in direction towards the second portion of the containment ring beyond the containment ring and beyond the second ring and the axial portion of the second ring extends in direction towards the first portion of the containment ring beyond the containment ring and beyond the first ring. In other words, the free axial end of the axial portion of the first ring forms one axial end of the pressure compensator element in one axial direction and the free axial end of the axial portion of the second ring forms the other axial end of the pressure compensator element in the other axial direction. This makes the assembling of the pressure compensator element in particularly simple.

[0011] According to one embodiment, the axial portion of the first ring is arranged partially at the first portion of the containment ring. In other words, the axial portion of the first ring contacts the containment ring. The second portion of the containment ring extends according to this embodiment further towards the free longitudinal end of the axial portion of the first ring than the first portion of the containment ring, which ensures that the movement between the first portion and the second portion of the containment ring is still possible. The arrangement of the axial portion at the first portion of the containment ring improves the connection between the first ring and the containment ring.

[0012] According to one embodiment, the axial portion of the first ring is partially detached from an area of the containment ring, wherein the area extends from the axial end of the containment ring which faces towards the free end of the axial portion of the first ring to the other end of the axial portion of the first ring. The deformation of the containment ring is in particular not inhibited by the first ring according to this embodiment.

[0013] According to one embodiment, the axial portion of the second ring is partially detached from an area of the containment ring, wherein the area extends from the axial end of the containment ring which faces towards the free end of the axial portion of the second ring to the other end of the axial portion of the second ring. The deformation of the containment ring is in particular not inhibited by the second ring according to this emebodiment.

[0014] According to another embodiment, the axial portion of the second ring is arranged partially at the second portion of the containment ring. The axial portion of the second ring contacts the containment ring. According to this embodiment extends the first portion of the containment ring further towards the free longitudinal end of the axial portion of the second ring than the second portion of the containment ring, which ensures that the movement between the first portion and the second portion of the containment ring is still possible. The arrangement of the axial portion at the second portion of the containment ring improves the connection between the second ring and the containment ring.

[0015] According to one embodiment, the first ring and/or the second ring is / are partially embedded within the containment ring. The containment ring is for example partially molded around the first ring and / or the second ring.

[0016] According to one embodiment, the containment ring consists of a material selected from a group which consists of a rubber material, a plastic material and an elastomeric material. According to one embodiment, the rubber material is NBR (Acrylonitrile Butadiene Rubber) or HNBR (Hydrogenated Acrylonitrile Butadiene Rubber), these materials are preferred used when the fluid which surrounds the containment ring is water. The elastomeric material is preferred used when the fluid which surrounds the containment ring is gasoline.

[0017] According to one embodiment, a fluid injector for internal combustion engine is specified. The fluid injector is in particular a fuel injector. It may preferably by provided for injecting fuel directly in the combustion chamber of the internal combustion engine. The fluid injector may be preferably provided for injecting gasoline or diesel fuel.

[0018] The fluid injector according to this embodiment comprises a valve housing. The valve housing extends along the central longitudinal axis and forms a valve cavity inside the valve housing. The valve cavity comprises an inlet opening and an outlet opening. The inlet opening is configured to allow fluid to flow into the valve cavity and the outlet opening is configured to allow the fluid to flow out of the valve cavity. The fluid injector further comprises a valve needle assembly which comprises a valve needle and an armature and which is arranged inside the valve cavity. The valve needle is displaceable with respect to the valve housing to inhibit or to allow the fluid to flow out of the fluid injector when the fluid injector is in operation. The valve needle forms therefore with a part of the valve cavity of the fluid injector a sealing edge so that no fluid can flow out of the fluid injector when the valve needle is in the closing position. When the valve needle is displaced away from the closing position fluid can flow out of the fluid injector. The fluid injector further comprises an actuator assembly which is configured to displace the valve needle away from the closing position so that fluid can flow out of the fluid injector. The fluid injector comprises according to this embodiment the pressure compensator element. The pressure compensator element is arranged in the valve cavity.

[0019] The first ring of the pressure compensator element is configured to engage with a valve cavity surface of the valve cavity. The first ring is for example arranged to be in contact with the valve cavity surface.

[0020] The second ring of the pressure compensator element is configured to engage with the valve needle assembly. For example, can the second ring be configured to contact the valve needle or a part which is rigidly fixed to the valve needle.

[0021] The first portion of the containment ring is according to this embodiment arranged further towards the inlet opening than the second portion of the containment ring so that the elastic deformation of the containment ring due to a change of the hydrostatic pressure of the fluid acting on the pressure compensator element inside the valve cavity results in a lifting force from the pressure compensator element to the valve needle assembly when the valve needle is in a closed position.

[0022] The containment ring is arranged in the valve cavity so that the containment ring is exposed to the fluid pressure inside the valve cavity. When the fluid pressure inside the valve cavity increases, then an elastic deformation of the containment ring is caused. The second ring and the first ring of the pressure compensator element are arranged at or in the containment ring so that the deformation of the containment ring will force the second ring and/or the first ring to move towards each other. The deformation of the containment ring due to the increasing fluid pressure inside the valve cavity will therefore result in a force applied to the second ring and the first ring. The first ring is engaged with the valve cavity and can for example not move with respect to the valve cavity. The second ring is engaged with the valve needle assembly. The second ring will therefore apply the lifting force caused by the deformation of the containment ring to the valve needle assembly. The pressure compensator element will therefore apply the lifting force to the valve needle assembly which is proportional to the fluid pressure inside the valve cavity.

[0023] According to one embodiment, the lifting force created by the pressure compensator element is always smaller than the force which is necessary to displace the valve needle away from the closing position so that the valve needle cannot be displaced away from the closing position only by the lifting force created by the pressure compensator element.

[0024] The lifting force of the pressure compensator element helps the actuator assembly to displace the valve needle away from the closing position. The actuator assembly does not need to provide the displacement force which is necessary to displace the valve needle away from the closing position alone. The force which is necessary to displace the valve needle away from the closing position is provided according to this embodiment by the pressure compensator element and the actuator assembly. Therefore, it is possible to use a conventional actuator assembly in combination with the pressure compensator element to displace the valve needle away from the closing position even if the fluid pressure inside the valve cavity increases beyond conventional operating pressures. In addition, the lifting force is proportional to the fluid pressure inside the valve cavity which means that even if the fluid pressure is increased even further the lifting force generated by the pressure compensator element will also increase which means that even at very high fluid pressures inside the valve cavity it is possible to operate the fluid injector with conventional actuator assemblies. It can be even possible to operate the fluid injector without the so-called free lift concept. Due to the proportionality between the fluid pressure inside the fluid injector and the lifting force generated by the pressure compensator element, the force provided by the actuator assembly to displace the valve needle away from the closing position can be over the range of fluid pressures inside the cavity. Overall the actuator assembly complexity can be reduced compared to an actuator assembly which normally has to handle with such high fluid pressure inside the fluid injector without the aid of the pressure compensator element.

[0025] According to one embodiment comprises the valve cavity along its axial extension two different diameters. The smaller diameter of the two different diameters is arranged closer to the outlet opening than the larger diameter so that a ring surface is formed on the valve cavity surface between the larger diameter and the smaller diameter. The ring surface can for example be a flat ring surface or a truncated cone surface. The first ring of the pressure compensator element is according to this embodiment configured to engage with the ring surface. The first ring is according to one embodiment fixed to the ring surface or rests on the ring surface when the pressure compensator element is arranged in the fluid injector. The valve cavity comprises according to this embodiment for example a step or a tapering area where the first ring can engage with the valve cavity. It is According to this embodiment in particular simple to arrange the pressure compensator element in the fluid injector at the desired position because the specific design of the valve cavity according to this embodiment provides a stop for the pressure compensator element. In addition, it is in particular simple to provide a stop for the pressure compensator element so that the lifting force of the pressure compensator element can be applied to the valve needle.

[0026] According to one embodiment, the longitudinal end of the axial portion of the second ring of the pressure compensator element which extends beyond the first ring contacts a surface of the valve needle assembly. The surface of the valve needle assembly could be for example a surface of the valve needle, a surface of a disc element which is fixed to the valve needle or a surface of the armature. A particular simple transformation of the force generated by the pressure compensator element is possible according to this embodiment.

[0027] According to one embodiment, the first ring of the pressure compensator element is coupled to the valve housing by a form fit connection or by a press fit connection. The second ring of the pressure compensator element is according to another embodiment coupled to the valve needle assembly by a form fit connection or by a press fit connection. The press fit connections or the form fit connections are in particular simple and fast connections between the first ring of the pressure compensator element and the valve housing and the second ring and the valve needle assembly so that the manufacturing of the fluid injector with the pressure compensator element is simplified.

[0028] According to one embodiment, the pressure compensator element is preloaded when assembled in the fluid injector and when the valve needle is in the closed position. The lifting force from the pressure compensator element is according to this embodiment also applied to the valve needle even when no fluid or fluid with ambient pressure is inside the valve cavity. The pressure compensator element according to this embodiment is held at its predefined position by the closing force of the valve needle applied to the valve needle by a calibration spring which is configured to urge the valve needle in the closed position, wherein the calibration spring is according to this embodiment also configured to push the second ring of the pressure compensator element towards the outlet opening of the valve housing which causes an elastic deformation of the containment ring and preloads therefore the pressure compensator element.

[0029] According to one embodiment is the lifting force generated by the pressure compensator element between 0 Newton at 0 - 1 MPa of fluid pressure inside the valve cavity and 750 Newton at 150 MPa of fluid pressure inside the valve cavity. With the fluid injector comprising the pressure compensator element it is possible to operate the fluid injector at fluid pressures of 45 MPa or greater and of 200 MPa or lower. This is only possible because the pressure compensator element generates the lifting force which is proportional to the pressure inside the valve cavity.

[0030] Further advantageous embodiments of the present disclosure will become apparent from the detailed description of exemplary embodiments in connection with the figures. In the figures:

Fig. 1 shows a schematic longitudinal section of a fluid injector according to a first exemplary embodiment with a pressure compensator element according to a first exemplary embodiment,

Fig. 2 shows a schematic longitudinal section of a pressure compensator element according to a second exemplary embodiment,

Fig. 3 shows a schematic longitudinal section of a pressure compensator element according to a second exemplary embodiment.

[0031] Fig. 1 shows a fluid injector 100, wherein the fluid injector 100 comprises a valve housing 110, a valve needle assembly 115, an actuator assembly 140, and a disc part 150. The valve needle assembly 115 comprises a valve needle 120 and an armature 130. The valve housing 110 extends from an inlet opening 162 along a central longitudinal axis 180 to an outlet opening 164. The valve housing 110 comprises a valve cavity 130 which defines a fluid path for fluid flowing through the valve housing 110 from the inlet opening 162 to the outlet opening 164. The valve cavity 160 is defined by a valve cavity surface 170. The valve cavity 160 is arranged coaxially with respect to the central longitudinal axis 118. The valve cavity 160 further comprises along its axial extension at least two different diameters wherein the smaller one of the two diameters is arranged closer to the outlet opening 164 than the larger diameter. Therefore, the valve cavity surface 170 comprises a ring surface 172 which defines a step along the axial extension of the valve cavity 170.

[0032] The valve needle 120 is also arranged coaxially with respect to the central longitudinal axis 180. As it can be seen in fig. 1 the disc part 150 is arranged at the valve needle 120 and the disc part 150 is therefore part of the valve needle assembly 115. The disc part 150 is for example a stop for the armature 130 when the armature 130 is not rigidly coupled to the valve needle 120. The actuator assembly 140 is arranged to attract the armature

130 which will displace the valve needle 120 away from a closing position in which no fluid can flow out of the fluid injector 100. The fluid injector 100 as shown in fig. 1 further comprises a pressure compensator element 200. The pressure compensator element 200 is arranged in the valve cavity 160 and comprises a first ring 210, a second ring 220 and a containment ring 230. The first ring 210 is configured to engage with the valve cavity surface 170. As shown in fig. 1 the first ring 210 contacts the ring surface 172 of the valve cavity surface 170. The containment ring 230 is arranged at the first ring 210.

[0033] The containment ring 230 comprises an elastic material. As it can be seen in fig. 1 the containment ring 230 almost completely surrounds the first ring 210 except of the portion of the first ring 210 which is in contact with the valve cavity surface 170. The first ring 210 as shown in fig. 1 comprises a radial portion and an axial portion. The radial portion has the shape of a disc and the axial portion has the shape of a sleeve. Combined they have the shape of an L. The radial portion extends from the radial inner end to the radial outer end. The axial portion extends from the radial outer end of the radial portion towards the outlet opening 164 of the valve cavity 160, wherein one longitudinal end of the axial portion contacts the ring surface 172.

[0034] The second ring 220 as shown in fig. 1 comprises also a radial portion and an axial portion. The radial portion extends from the radial outer end of the radial portion to the radial inner end of the radial portion, wherein the radial outer end of the radial portion of the second ring is arranged in the containment ring. The axial portion extends from the radial inner end of the radial portion towards the fluid inlet opening 162 of the valve cavity 160, wherein one longitudinal end of the axial portion contacts the disc element 150.

[0035] The first ring 210 of the pressure compensator element 200 comprises a first contact surface 240 which is arranged to be in contact with the valve cavity surface 170. The second ring 220 of the pressure compensator element 200 comprises a second contact surface 250 which is arranged to be in contact with the disc part 150 of the valve needle 120. As it can be seen in fig. 1, the pressure compensator element 200 is configured to force the second ring towards the inlet opening 162 of the valve cavity 160 when the containment ring 230 is deformed due to increasing fluid pressure inside the valve cavity 160.

[0036] Fig. 2 shows in a schematic manner a longitudinal section view of the pressure compensator element 200 according to a second exemplary embodiment. In contrast to the first exemplary embodiment of the pressure compensator element 200 as shown in fig. 1, the second exemplary embodiment shows that almost the entire second ring 220 of the pressure compensator element 200 is arranged in the containment ring 230. Only the portion of the second ring 220 which is arranged to engage with the valve needle assembly 115 is arranged outside of the containment ring 230. In addition, fig. 2 shows openings 260 in the second ring 220 and in the first ring 260 which are arranged to allow the fluid to flow from the inlet opening 162 of the valve cavity 160 through the openings 260 of the pressure compensator element 200 to the outlet opening 164 of the valve cavity.

[0037] Fig. 3 shows in a schematic manner a longitudinal section of a pressure compensator element 200 according to a third exemplary embodiment. In contrast to the first exemplary embodiment and the second exemplary embodiment of the pressure compensator element 200 shown in figs. 1 and 2 the third exemplary embodiment shows that the containment ring 230 of the pressure compensator element 200 is only arranged at the first ring 210 at the side of the radial portion of the first ring 210 which faces towards the outlet opening 164 of the valve cavity 160 when the pressure compensator element 200 is arranged in the valve cavity 160. The containment ring 230 shown in fig. 3 is not arranged at the axial portion of the first ring 210 as for example shown in figs. 1 and 2. The arrangement of the containment ring on the first ring 210 of the pressure compensator element 200 is according to the embodiment shown in fig. 3 is particular simple. As it can be seen in fig. 3 only a portion of the radial portion of the second ring 220 of the pressure compensator element 200 is arranged in the containment ring 230. It is according to this embodiment in particular simple to transfer the deformation caused by the fluid pressure inside the valve cavity 160 to the second ring 220.

Claims

1. A pressure compensator element (200) for a fluid injector (100) for an internal combustion engine, wherein the pressure compensator element (200) extends along a central longitudinal axis (180) and comprises:

   - a containment ring (230) which comprises an elastic material and is configured to deform elastically when the pressure acting on the pressure compensator element (200) changes;
   - a first ring (210) which is arranged at or in the containment ring (230) at a first portion of the containment ring (230) and extends out of the containment ring (230);
   - a second ring (220) which is arranged at or in the containment ring (230) at a second portion of the containment ring (230) and extends out of the containment ring (230), wherein the second portion of the containment ring (230) is arranged at a different axial position at the containment ring (230) with respect to the first portion of the containment ring (230), so that an elastic deformation of the containment ring (230) due to a change of the pressure acting on the pressure compensator element (200) results in

an axial displacement of the first portion of the containment ring (230) with respect to the second portion of the containment ring (230) and therefore in an axial displacement of the first ring (210) with respect to the second ring (220).

2. The pressure compensator element (200) according to claim 1, wherein the first ring (210) comprises a radial portion which extends in radial direction and an axial portion which extends in axial direction, wherein the axial portion extends from one radial end of the radial portion of the first ring (210),
wherein the second ring (220) comprises a radial portion which extends in radial direction and an axial portion which extends in axial direction, wherein the axial portion extends from one radial end of the radial portion of the second ring (220),
wherein the radial portion of the first ring (210) is arranged at least partially at or in the first portion of the containment ring (230) and the radial portion of the second ring (220) is arranged at least partially at or in the second portion of the containment ring (230), and
wherein the axial portion of the first ring (210) and the axial portion of the second ring (220) extend in opposite directions.

3. The pressure compensator element (200) according to any one of the preceding claims, wherein the axial portion of the first ring (210) extends from the radial outer end of the radial portion of the first ring (210) and the axial portion of the second ring (220) extends from the radial inner end of the radial portion of the second ring (220), and
wherein the axial portion of the first ring (210) extends in direction towards the second portion of the containment ring (230) beyond the containment ring (230) and beyond the second ring (220) and the axial portion of the second ring (220) extends in direction towards the first portion of the containment ring (230) beyond the containment ring (230) and beyond the first ring (220).

4. The pressure compensator element (200) according to claim 3, wherein the axial portion of the first ring (210) is arranged partially at the first portion of the containment ring (230), wherein the second portion of the containment ring (230) extends further towards the free longitudinal end of the axial portion of the first ring (210) than the first portion of the containment ring (230), and / or wherein the axial portion of the second ring (220) is arranged partially at the second portion of the containment ring (230), wherein the first portion of the containment ring (230) extends further towards the free longitudinal end of the axial portion of the second ring (210) than the second portion of the containment ring (230).

5. The pressure compensator element (200) according to any one of the preceding claims, wherein the first ring (210) and/or the second ring (220) is / are partially embedded within the containment ring (230).

6. The pressure compensator element (200) according to any one of the preceding claims, wherein the containment ring consists of a material selected from a group which consists of a rubber material, a plastic material and an elastomeric material.

7. A fluid injector (100) for an internal combustion engine, wherein the fluid injector (100) comprises a valve housing (110) which forms a valve cavity (160) inside the valve housing (110) comprising an inlet opening (162) and an outlet opening (164) for fluid flowing through the fluid injector (100) when the fluid injector (100) is in operation, a valve needle assembly (115) which comprises an armature (130) and a valve needle (120), which is arranged inside the valve cavity (160) and which is displaceable with respect to the valve housing (120) to inhibit or to allow the fluid flow out of the fluid injector (100), and an actuator assembly (140) which is configured to displace the valve needle (120),
wherein the fluid injector (100) further comprises the pressure compensator element (200) according to any one of the preceding claims, wherein the pressure compensator element (200) is arranged in the valve cavity (160), and
wherein the first ring (210) of the pressure compensator element (200) is configured to engage with a valve cavity surface (170) and the second ring (220) is configured to engage with the valve needle assembly (115), wherein the first portion of the containment ring (230) is arranged further towards the inlet opening (162) than the second portion of the containment ring (230) so that the elastic deformation of the containment ring (230) due to a change of the pressure of the fluid acting on the pressure compensator element (200) inside the valve cavity (160) results in a lifting force from the pressure compensator element (200) to the valve needle assembly (115) when the valve needle (120) is in a closed position.

8. The fluid injector (100) according to claim 7 comprising the pressure compensator element (200) according to any one of the claims 3 to 6, wherein the valve cavity (160) comprises along its axial extension two different diameters, wherein the smaller diameter is arranged closer to the outlet opening (164) than the larger diameter so that a ring surface (172) is formed on the valve cavity surface (170) between the larger diameter and the smaller diameter, wherein the longitudinal end of the axial portion of the first ring (210) of the pressure compensator element (230) which extends beyond the second ring (220) contacts the ring surface (172).

9. The fluid injector (100) according to any one of the claims 7 or 8 comprising the pressure compensator element (200) according to any one of the claims 3 to 6, wherein the longitudinal end of the axial portion of the second ring (220) of the pressure compensator element (230) which extends beyond the first ring (210) contacts a surface of the valve needle assembly (115).

10. The fluid injector (100) according to any one of the claims 7, 8 or 9 comprising the pressure compensator element (200) according to any one of the claims 1 to 6, wherein the first ring (210) of the pressure compensator element (200) is coupled to the valve housing (110) by a form fit connection or by a press fit connection.

11. The fluid injector (100) according to any one of the claims 7, 8, 9 or 10 comprising the pressure compensator element (200) according to any one of the claims 1 to 6, wherein the second ring (210) of the pressure compensator element (200) is coupled to the valve needle assembly (115) by a form fit connection or by a press fit connection.

12. The fluid injector (100) according to anyone of the claims 7, 8, 9, 10 or 11 comprising the pressure compensator element (200) according to any one of the claims 1 to 6, wherein the valve needle assembly (115) comprises a disc element (150) which is rigidly coupled to the valve needle (120) and wherein the second ring (220) of the pressure compensator element (200) is configured to engage with the disc element (150) of the valve needle assembly (115).

13. The fluid injector (100) according to any one the claims 7, 8, 9, 10, 11 or 12 comprising the pressure compensator element (200) according to any one of the claims 1 to 6, wherein the pressure compensator element (200) is preloaded when the valve needle (120) is in the closed position.

14. The fluid injector (100) to any one the claims 7, 8, 9, 10, 11, 12 or 13 comprising the pressure compensator element (200) according to any one of the claims 1 to 6, wherein the lifting force generated by the pressure compensator element (200) is between 0 N at 0-1 MPa of fluid pressure inside the valve cavity (160) and 750 N at 150 MPa of fluid pressure inside the valve cavity (160).

15. The fluid injector (100) to any one the claims 7, 8, 9, 10, 11, 12, 13 or 14 comprising the pressure compensator element (200) according to any one of the claims 1 to 6, wherein the fluid injector (100) is configured to operate at fluid pressures of 45 MPa or greater and of 200 MPa or lower.

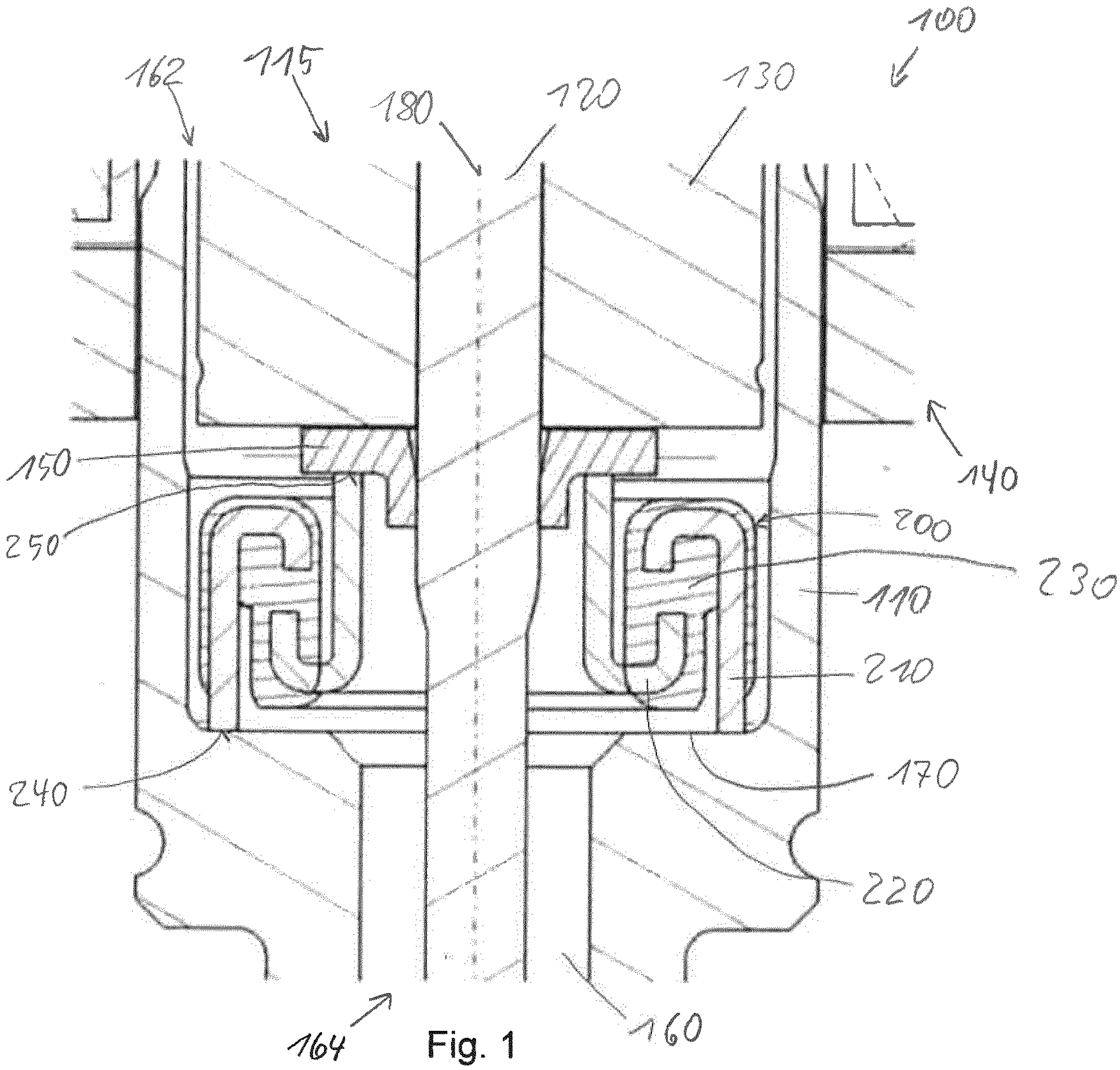
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Fig. 1

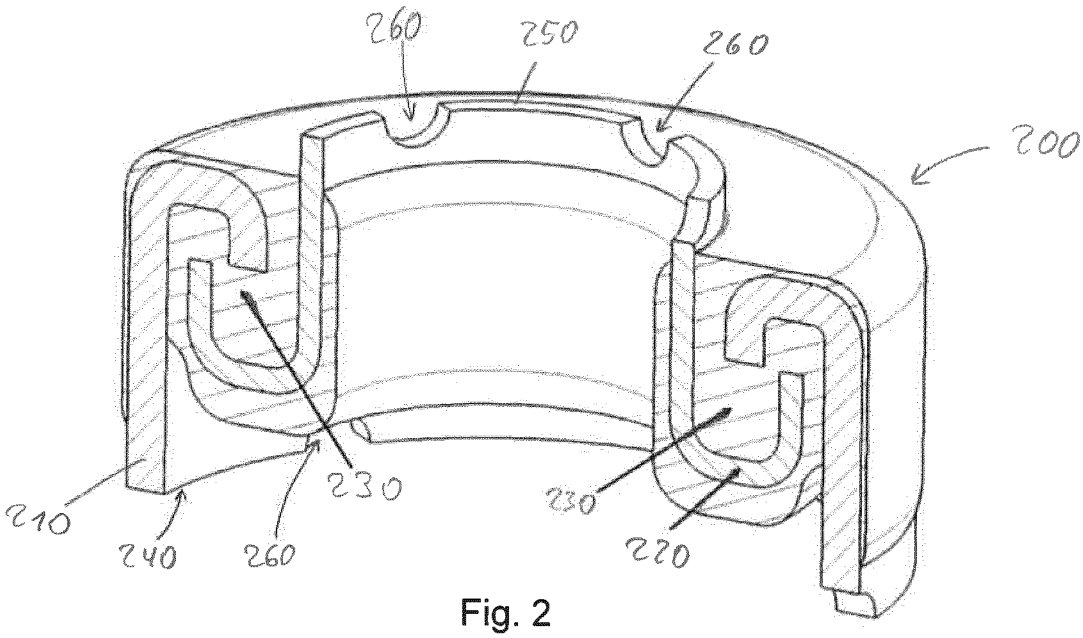
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Fig. 2

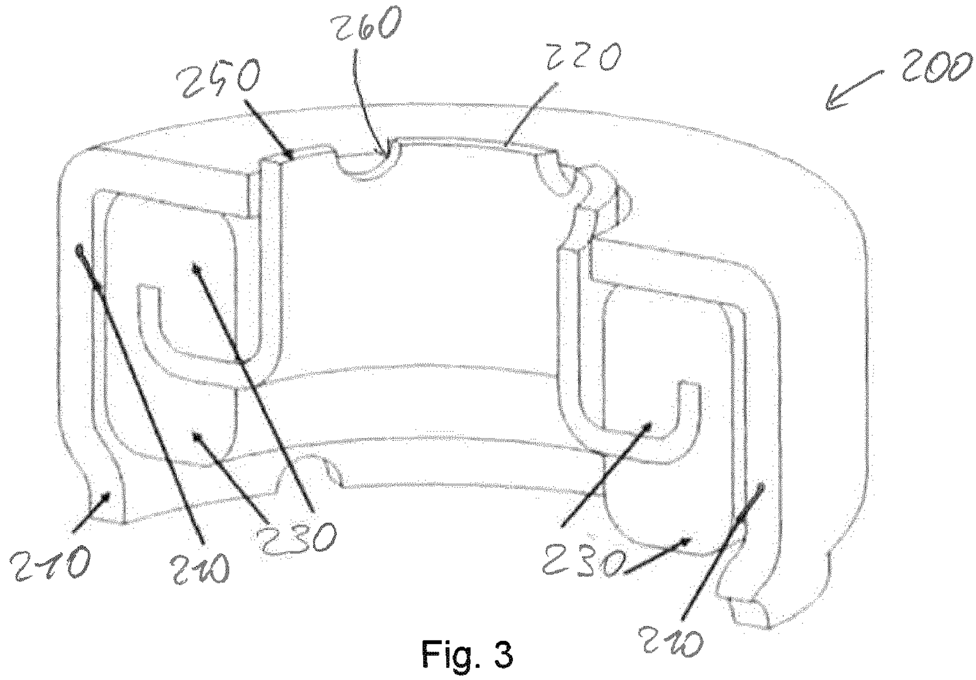

Fig. 3

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EUROPEAN SEARCH REPORT

Application Number
EP 19 20 6326

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F02M

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
The Hague	31 March 2020	Morales Gonzalez, M

CATEGORY OF CITED DOCUMENTS

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31-03-2020

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