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(54) **Fuel injector with lash compensator**

(57) A fuel injector comprises an injector body (12), a fuel inlet (16), an injecting valve (26) for selectively emitting fuel at a spray tip (20), an axially extendable actuator (30) associated with said valve group (26) for actuation thereof and a lash compensator (32), wherein the lash compensator (32) comprises a body (34) having a cylindrical bore (35) therein, which is closed at one end (36); and a plunger (38, 138, 310) axially slidable in said bore (35), said plunger (38, 138, 310) having a front face (40) that defines with the closed end (36) of said bore a working chamber (42) for a working fluid. Sealing means (56) are provided about the plunger (38, 138, 310) to seal the working chamber (42) against the bore (35); and the plunger (38, 138, 310) comprises a first restrictor orifice (50, 150, 322) in the plunger front face that opens into an internal plunger chamber (52) for storing working fluid therein, the plunger chamber (52) being in communication with a reference volume through a second restrictor orifice (54, 154, 322).

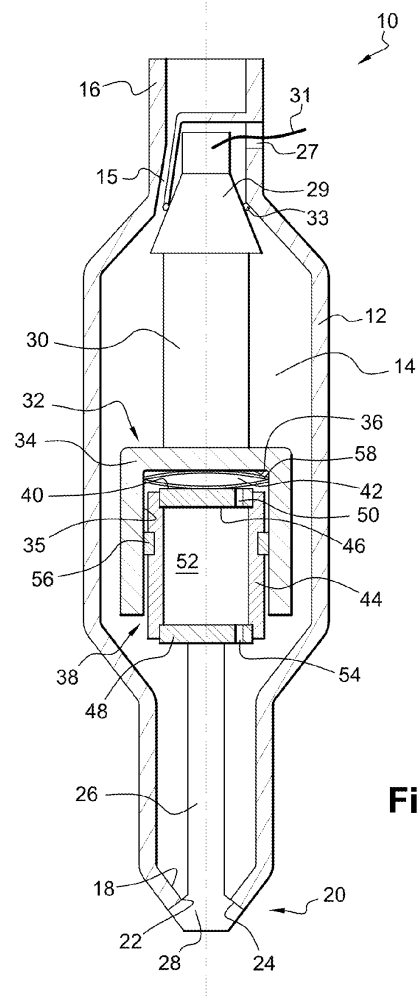


Fig. 1

Description

FIELD OF THE INVENTION

[0001] The present invention generally relates to the field of internal combustion engines and particularly to a lash compensator for a fuel injector of the type comprising a piezoelectric actuator.

BACKGROUND OF THE INVENTION

[0002] Fuel injectors now conventionally employ piezoelectric devices as actuators for lifting the injector pintle off its valve seat. The precise longitudinal deflection characteristic of piezoelectric devices in conjunction with their rapid dynamic response provides the potential of achieving meaningful control over the rate of fuel injection. Furthermore, the relative high load capability of piezoelectric devices is consistent with the high-pressure environment of fuel injectors.

[0003] As it is well known, piezoelectric devices have a small deflection capability. Nevertheless, in some injector designs the stroke of the piezoelectric device is considered sufficient for the pintle opening, whereby the pintle lift-off is identical to the actuating stroke of the piezoelectric device. In other designs, the piezoelectric device is used in combination with a control valve that is able to amplify the deflection for a longer stroke.

[0004] Unfortunately, a frequent shortcoming of using piezoelectric devices in fuel injectors is the creation of lash (clearance). Piezoelectric devices are made from materials that have a coefficient of thermal expansion that is much lower than that of the iron-based materials commonly used for the fuel injector housing, or the material of the other surrounding parts. Accordingly, piezoelectric devices cause thermally induced lash that is greater than their deflection capability. Therefore, lash compensators are commonly used in piezo-actuated fuel injectors for recovering the clearance that may be created between the injector internal parts due to thermal expansion, fuel pressure, and part to part variation.

[0005] Such a lash compensator typically comprises a body having an axial bore therein closed at one end and a plunger axially moveable inside the bore. The plunger defines with the axial bore and its closed end a working chamber filled with a working fluid, e.g. silicone oil. The bore and plunger are typically arranged inside a sealed enclosure filled with working fluid. When inserted between the piezoelectric actuator and the pintle, the plunger may e.g. have an extension member in contact with the actuating end of the piezoelectric actuator, while the compensator body is in contact with the pintle basis (i.e. opposite the injector tip). When the piezoelectric actuator is energized and increases its length, the lash compensator acts as a hard connection and the movement of the piezoelectric actuator is transmitted to the pintle.

[0006] Slow changes of dimensions are compensated by allowing the plunger to move inside the bore. Actually,

a tight radial clearance between the plunger and bore allows for flow of working fluid from and into the working chamber. This radial clearance is determined to obtain a predetermined leakage rate when the working fluid is pressurized in the working chamber due to activating the piezoelectric actuator.

[0007] Clearly, this technology requires small radial clearance at the plunger/bore interface with drastic tolerances to offer and maintain the required flow restriction.

The leakage through the radial clearance is sensitive to viscosity changes of the working fluid, which renders the performance of the compensator dependent on temperature changes and on the working fluid. To minimize problems due to viscosity changes of the working fluid, one solution, though expensive, is the use of special fluids of fairly constant viscosity over temperature, such as silicone oil.

OBJECT OF THE INVENTION

[0008] The object of the present invention is to provide a fuel injector with an alternative type of lash compensator that does not require special hydraulic fluids. This object is achieved by a fuel injector with lash compensator as claimed in claim 1.

SUMMARY OF THE INVENTION

[0009] According to the present invention, a fuel injector features a lash compensator comprising a body having a cylindrical bore therein, which is closed at one end; and a plunger axially slideable in the bore, the plunger having a front face that defines with the closed end of the bore a working chamber for a working fluid.

[0010] According to an important aspect of the invention the plunger comprises a first restrictor orifice in the plunger front face that opens into an internal plunger chamber for storing working fluid therein, the plunger chamber being in communication with a reference volume through a second restrictor orifice. Sealing means are provided about the plunger to seal the working chamber against the bore. It shall be appreciated that the first and second restrictor orifices are dimensioned to provide a predetermined leakage rate of working fluid.

[0011] Hence, the present lash compensator does not rely on the conventional design based on a fluid leakage through a radial clearance between plunger and bore. By contrast, the flow of working fluid in-between plunger and bore is inhibited by the sealing means, whereby flow to and from the working chamber must occur through the throttling flow path provided for in the plunger. Indeed, this first orifice together with the plunger chamber and second orifice act as flow restrictor means for the working fluid that tends to escape from the working chamber when pressurized due to injector actuation. In this connection, the pair of orifices is dimensioned to provide the desired leakage rate (preferably determined for a reference temperature and pressure), also preferably taking into ac-

count the intermediate volume formed by the plunger chamber. The second restrictor orifice can be arranged in a rear plunger front face or in the plunger sidewall in the region distal from the front face with the first orifice, downstream of the sealing means.

[0012] The present design is based on the inventors' assessment that a structure of a plunger chamber with a pair (or succession) of holes allows opposing to the flow of working fluid a flow restriction comparable to that of a single hole of smaller diameter. A design featuring a very small hole being difficult from the manufacturing point of view and also raising problems of obstruction due to contamination, the present inventors have developed the instant lash compensator comprising a flow restrictor function embodied in the plunger by way of a plunger chamber interfacing between the working chamber and a reference volume (at reference pressure) via the first and second orifices, respectively.

[0013] Within the injector body, the lash compensator may be arranged in axial alignment in the actuating line/direction, at any appropriate location, and can be used in various injector designs, whether based on direct or indirect actuation (through control valve and the like). Typically, the lash compensator may be arranged in-between the actuator and the pintle, or before the actuator on the side opposite from the pintle. In some cases, the lash compensator may be arranged between the actuator and a control valve (indirect design) that controls the valve lift and may increase or reduce its amplitude (as compared to the axial length increase of the actuator per se).

[0014] It is to be noted that the use of restrictor orifices as provided in the present plunger is less sensitive to the kind of working fluid and to viscosity as compared to throttling through a plunger's radial clearance. Accordingly, it is possible to operate the present lash compensator with a variety of fluids, whether hydraulic fluids or even with fuel. Hence, the present lash compensator may comprise a closed housing (allowing for axial expansion) that will provide for the reference volume of working fluid. In such case the interior of the lash compensator is not contaminated by the injector fuel and can be operated with any appropriate working fluid.

[0015] However, the present invention is particularly advantageous in that it allows using the injector fuel (e.g. gasoline or ethanol-fuel, or even diesel) as working fluid. In such case the lash compensator may be in fluid communication with fuel in the injector, which forms the reference volume of working fluid.

[0016] In one embodiment, the plunger comprises a sleeve-like body closed at one end by a front disk provided with the first restrictor orifice and at the other end by a rear disk provided with the second restrictor orifice. The plunger chamber is thus defined by the volume in-between said disks.

[0017] Alternatively, the plunger chamber may be subdivided into two or more sub-chambers serially connected via respective orifices dimensioned to provide a de-

sired flow restriction. In particular, such sub-division may be formed by providing one or more intermediate disks in between the front and rear disks, each of the intermediate disks being provided with a respective restrictor orifice.

[0018] In these embodiments, the disks may be affixed in the plunger body by any appropriate manner. This provides a plunger chamber and sub-chambers of fixed volume.

[0019] While the use of a sleeve-like body with disk elements is convenient for its modularity, any manufacturing technology may be used to provide a plunger with internal chamber, possibly with sub-chambers. In particular, the sleeve like plunger body and plunger portion bearing the first restrictor orifice may be manufactured in one piece, and the second disk element, or more, assembled therein.

[0020] To facilitate the flow of fluid towards the restrictor orifice, the disk members may comprise on one or both front sides a counter-bore in which the restrictor orifice opens.

[0021] Such shape of the disk members can be used to manufacture a plunger with sub-chambers by simply piling up such disk members within a sleeve-body, the sub-chambers being formed by the opposing counter-bores of two adjacent disk-members.

[0022] For improved flow conditions, each restrictor orifice in each disk member is advantageously shaped to comprise a narrow channel section continuing into an enlarged section. When using such orifice design in practice, the disk members are preferably oriented so that fluid flowing through the plunger in direction away from the working chamber has to first flow through the narrow channel section of each restrictor orifice.

[0023] Alternatively, the restrictor orifices may be oval or slot-shaped.

[0024] Furthermore, there may be provided a set of first restrictor orifices in the front side and/or a set of second restrictor orifices. In such case, the set of restrictor orifices may be designed to provide a similar leakage rate as in the case of a single restrictor orifice, thus having equivalent effective flow cross-section.

[0025] Piezo-electric type actuators are preferred as axially extendable actuator, although other appropriate technologies may be used such as e.g. magneto-strictive devices or solenoids.

BRIEF DESCRIPTION OF THE DRAWINGS

[0026] The present invention will now be described, by way of example, with reference to the accompanying drawings, in which:

FIG. 1: is a longitudinal cross-sectional view through a fuel injector featuring a first embodiment of the present lash compensator;

FIG. 2: is a section view through an alternative embodiment of the plunger;

Fig. 3 is a section view through a disk member for the plunger of the lash compensator, in an alternative variant;

FIG. 4: is a section view through a further embodiment of plunger comprising a stack of disks members as in Fig.3.

DETAILED DESCRIPTION OF A PREFERRED EMBODIMENT

[0027] A preferred variant of a fuel injector for an internal combustion engine is schematically depicted in Fig. 1. The fuel injector 10 generally includes a tubular injector body 12 having an axially extending fuel passage 14 therein.

[0028] Fuel, e.g. gasoline, under pressure is provided to an inlet fitting 16, from where it flows through a bypass 15 to the axial supply passage 14 and enters into an axial outlet section 18 of the body 12 at the injector's spray tip 20. The outlet section 18 ends with an outlet port 22 surrounded by a valve seat 24. A valve pintle 26 comprising an obturating member 28 is associated with this outlet port 22. In Fig.1, the pintle 26 is in closed position, whereby the obturating member rests 28 on the valve seat 24. The pintle 26 is preferably biased in this closed position by a return spring (not shown) or any other appropriate means. This part of the fuel injector 10 with the cooperating pintle 26 and outlet port 22 thus forms the injecting valve, also commonly referred to as valve group.

[0029] Also integrated in the body 12 is an axially extendable actuator 30, preferably of the piezoelectric type, provided to control the axial actuation of pintle 26 in order to open or close the injector's outlet port 22. Piezoelectric actuators being well known in the art, actuator 30 need not be further described herein. Reference sign 29 indicates a support member connected to the upper side of the actuator and centered in the lower fitting section 16. Electrical connections 31 are introduced through an opening 27 in the injector housing 12. Reference sign 33 generally indicates sealing means that seal the region of the electrical connection from the remainder of the injector's internal volume. Upon activation of the piezoelectric actuator 30, gasoline is released at the spray tip 20 and thus injected into the engine cylinder (not shown). As it is well known, when an electrical charge is supplied to the piezoelectric actuator by means of an applied current, its length in axial direction increases by a predetermined amount. The extension in length is transmitted (here via a lash compensator 32) to the valve pintle 26, which lifts off from the valve seat 24 and begins the injection of fuel. When the electrical charge is removed from the piezoelectric actuator the length of the piezoelectric actuator 30 decreases to its former (normal) value and the pintle 26 returns in its closed position.

[0030] In order to compensate for a change in clearance (lash), positive or negative, that may appear between actuator 30 and pintle 26, the present fuel injector 10 advantageously comprises a lash compensator 32

arranged in-between the piezoelectric actuator 30 and the valve pintle 26. Reasons for the occurrence of clearance in such a fuel injector include changes in the fuel pressure, part-to-part variation of the dimensions of the injector components, and thermal expansion of the components due to a change in their temperature. The latter is the main reason for the appearance of lash and is particularly due to the fact that the body 12, which is typically made of steel, has a higher coefficient of thermal expansion than the material of the piezoelectric actuator 30. Accordingly, the lash compensator 32 permits compensating for clearance in axial direction and thus ensuring a safe operation of the injector.

[0031] Essentially, the lash compensator 32 comprises a body 34 with a cylindrical bore 35 therein, which is closed at one end 36. A plunger 38 is axially slideable in the bore 35 and comprises a front face 40 that defines with the bore walls and closed end 36 a working chamber 42 for a working fluid. The plunger 38 and bore 35 diameter are mated to allow for a tight operating clearance. The plunger 38 may be generally designed as a cylindrical member closed at both ends. However, the plunger is provided with a bore in both its end faces. Accordingly, the plunger 38 here comprises a cylindrical sleeve body 44 having an external diameter mated with the diameter of the bore and the cylindrical body 44 is closed at both ends by a disk element 46, 48. Referring to the Figs, the top disk element 46, the front face 40 of which defines the working chamber 42, is provided with a first restrictor orifice 50. The first restrictor orifice 50 allows fluid communication between the working chamber 42 and an internal plunger chamber 52. The second restrictor orifice 54 is provided in the lower disk element 48 to provide fluid communication between the internal plunger chamber 52 and a reference volume. Sealing means 56 are provided around the plunger to seal the working chamber against the bore wall. Such sealing means 56 may e.g. take the form of an annular synthetic seal or a metallic segment inserted in an annular groove provided in the plunger's side wall.

[0032] In the present embodiment, the lash compensator 32 is configured and arranged in the injector 10 to operate with the to-be-injected fuel as working fluid. Accordingly, the second flow orifice 54 is in communication with the fuel volume contained in the injector 10. In other words, the volume of fuel (at the injection pressure) contained in the injector 10 forms a reference volume of working fluid, at given pressure.

[0033] Another important feature to be noted is that the two orifices 50 and 54 are dimensioned to provide a desired leakage characteristic for the working fluid contained in the working chamber 42 when the piezoelectric actuator 30 is energized. The leakage rate may typically be designed for given temperature and pressure. These orifices 50, 54 thus act as flow restrictors and are essentially designed for throttling the flow of working fluid out of the working chamber 42.

[0034] The working principle of the compensator 32 is

thus the following. When the piezoelectric actuator 30 is not activated, the plunger may axially move within the bore 35 to absorb the creation or diminution of lash/clearance in the injector. For example, heating up of the injector 10 will cause its housing 12 to expand and create lash between the internal components. In such case, the plunger 38 will move downward (bore 35 outward) and working fluid will be admitted in the working chamber 42. By contrast, a decrease in temperature would cause a retraction of the injector housing 10, tending to reduced lash, whereby the plunger 38 would move inward, reducing the volume of the working chamber, causing working fluid to exit the latter.

[0035] Now, in case the piezoelectric actuator 30 is energized, the working fluid acts as a rigid link/coupling between the compensator body 34 and plunger 38, so that the actuating force is transmitted to the pintle 26, which is lifted off it's the valve seat 24, as already mentioned. During this activation phase, the compensator body 34 is pushed downward (Fig.2), which forces the plunger into the bore 38, and which in turn forces working fluid contained inside the working chamber 42 to flow through the first restrictor orifice 50 into the plunger chamber 52. This also causes working fluid contained in the plunger chamber 50 to flow through the second restrictor orifice 54 into the reference volume (the injector's fuel passage 14). Hence, in such activation phase the only escape route for working fluid is through the restrictor orifices, the flow of fluid through the radial operating gap at the plunger's periphery being closed by seal 56. As it also appears, the design of the present plunger 38 strongly opposes to the flow of working fluid out of the working chamber 42, due to this succession of restrictor orifices 50, plunger chamber 52 and again restrictor orifice 54.

[0036] As it will be understood, the first function of the compensator 32 is thus to compensate for any dimensional change within the injector body 12, whether due to temperature, pressure, wear etc, in order to ensure a safe operation and accurate fuel metering. The second function is to transmit motion/stroke to the pintle 26, and preferably maintain pintle stroke. Accordingly, the two orifices 50 and 54 are dimensioned to provide a predetermined leakage rate during the activation phase that will allow for the required stiffness during the activation phase at the same time as rapid recovery of the initial phase during the deactivation of the piezoelectric actuator 30. Furthermore, the leakage rate is advantageously determined so that the pintle stroke does not fall below a certain value during a pintle lift event.

[0037] It has been considered that with such configuration of lash compensator 32 and for use with gasoline as working fluid, the compensator 32 being thus wetted by the injector fuel, each of the first and second orifices 50 and 54 shall offer an effective flow cross-section that is not greater than that of a hole having a diameter of 40 or 30 μm , preferably about 25 μm .

[0038] It remains to be noted that to allow tight contact between the internal parts, i.e. actuator 30, lash compen-

sator 32 and pintle 26, the compensator body 34 can be fixed to the actuator 30 while the rear disk may be attached to the pintle, in a so called coupled-mode. Alternatively, in a decoupled-mode as presented in the Fig., biasing means may be provided where appropriate to ensure that the internal parts remain in contact; for example, a compression spring 58 (here taking the form of two spring washers) may be axially arranged in the working chamber to push the body 34 and plunger 38 apart.

[0039] Fig.2 shows another possible plunger structure exploiting the principle of throttling the working fluid in the plunger through a series of restrictor holes and chambers to control the leakage rate. The plunger 138 can be used instead of plunger 38 of Fig.1. It comprises a cylindrical plunger body 144 closed at both ends via a respective disk member 146 and 148, each of which is provided with a respective restrictor orifice 150 and 154. The internal plunger chamber is subdivided into 4 chambers 152a, 152b, 152c, 152d. This is achieved by piling up alternatively, in-between the top and bottom disks 146 and 148, spacer rings 160 (preferably of square or rectangular section) and intermediate disks 162, each intermediate disk 162 being provided with a restrictor orifice 164. Preferably, the positions of the restrictor orifices are not aligned in axial direction. With such plunger configuration, the throttling passage for the working fluid includes a series of 5 restrictor orifices and 4 plunger chambers 154a..d. The rings 160 and disks 146, 148 and 162 can be assembled in the body 144 by press-fit or any other appropriate manner.

[0040] Using such configuration, one can use restrictor holes of greater diameter while obtaining a leakage rate equivalent to that of the plunger of Fig.1. For example, with plunger 138 an acceptable leakage rate is obtained when the disk members are provided with an orifice offering an effective flow cross-section that is equivalent to that of a hole having a diameter in the range of 50 to 100 μm , preferably about 80 μm .

[0041] Turning now to Fig.3, there is shown a disk member 210 where the restrictor orifice 212 has been designed to better control the throttling of working fluid. As can be seen, restrictor orifice 212 comprises a narrow channel section 214 continuing into an enlarged section 216. The relevant effective flow cross section of such orifice 212 is that of the narrow section 214. Such design of the restrictor orifice 212 tends to facilitate the flow from the disk member's backside 218 in which the enlarged section 216 opens, while the flow from the front side 220 (in which the narrow section 214 opens) to the backside 218 is comparatively more difficult. Such restrictor orifice profile can advantageously be used for the restrictor orifices 50, 54, 150, 154 and 164 in the embodiments of Figs. 1 and 2.

[0042] Still with respect to Fig.3, one may note that the front and back sides and of the disk member 210 may each comprise one or more shallow cavity (or counter-bore) 222 into which the restrictor orifice 212 opens. This is also meant to act on the flow of working fluid. Further,

a filter with a fine mesh size may be installed in a cavity 224 just before narrow section 214 of orifice 212. The mesh size of the filter may be adapted to the effective cross-section of the narrow orifice, so that it retains particle that may get stuck in the narrow section. For example, for a narrow section having an effective cross-section of a 30 μm hole, the mesh size of the filter may be 15 μm .

[0043] This disk member 210 can be used instead of the disk members 46, 48, 146, 148 and 162 used in the embodiments of Figs.1 and 2. In such case, the disk members are oriented in the plunger so that working fluid tending to escape from the working chamber first flows through the narrow section 214 of the restrictor orifice 212.

[0044] The design of the disk member 210 of Fig.3 can actually be advantageously used to form a plunger 138 with several sub-chambers comparable to the plunger 138 of Fig.2, however without the need for spacer rings 160. As can be seen in Fig.4, plunger 310 comprises a body 312 in which 5 disk members 314a..314e of the type of Fig. 3 are stacked. Four sub-chambers 316 are formed by opposing cavities 320 in the disk members 314. The restrictor orifices 322 are shaped as that of the disk member of Fig.3, and the disk members 314a..314e are oriented in the same way, but not restrictor orifices 322 are not axially aligned. As it will be understood, the three plunger designs in the embodiments of Figs.1, 2 and 4 have a front and rear disk with restrictor orifices that communicate with an internal plunger chamber of fixed volume. In plungers 138 and 310, this internal chamber is subdivided into four sub-chambers separated by a partition wall with a restrictor orifice. In the embodiment of Fig.1, the restrictor orifices may have an effective diameter of about 30 μm , while in the disk members of Figs. 2 and 4 the effective diameter of the narrow cross-section may be about 50 or 80 μm .

[0045] While in the shown embodiments the lash compensator is immersed in and uses the injector fuel, one may provide the lash compensator with a sealed housing allowing for axial extension, whereby the reference volume would be that of a closed volume of the housing. In such case the working fluid would not contact the remainder of the injector and thus allows operating with any appropriate fluid. It is particularly appropriate for use in fuel injectors, where the lash compensator does not operate with the fuel to be injected.

[0046] It remains to be noted that in the shown embodiments, each disk comprises a single restrictor orifice. Nevertheless, such disk may alternatively be featured with a set of orifices dimensioned to provide an effective diameter equivalent to that of a single orifice, for example equivalent to hole of 25 μm in diameter. Besides, although cylindrical (Fig.1, 2) or profiled (Fig.3) restrictor orifices are shown in the Figs, the restrictor orifices may alternatively be ovaly-or slit-shaped.

Claims

1. Fuel injector comprising an injector body (12), a fuel inlet (16), an injecting valve (26) for selectively emitting fuel at a spray tip (20), an axially extendable actuator (30) associated with said valve group (26) for actuation thereof and a lash compensator (32), wherein said lash compensator (32) comprises:

a body (34) having a cylindrical bore (35) therein, which is closed at one end (36);

a plunger (38, 138, 310) axially slidable in said bore (35), said plunger (38, 138, 310) having a front face (40) that defines with the closed end (36) of said bore a working chamber (42) for a working fluid;

characterized in that

sealing means (56) are provided about said plunger (38, 138, 310) to seal said working chamber (42) against said bore (35); and said plunger (38, 138, 310) comprises a first restrictor orifice (50, 150, 322) in said plunger front face that opens into an internal plunger chamber (52) for storing working fluid therein, the plunger chamber (52) being in communication with a reference volume through a second restrictor orifice (54, 154, 322),

wherein said first and second restrictor orifices are dimensioned to provide a predetermined leakage rate of working fluid.

2. Fuel injector according to claim 1, wherein said first and second restrictor orifices (50, 54) offer an effective flow cross-section equivalent to that of a hole having a diameter of no more than 40 μm , preferably no more than 30 μm , more preferably about 25 μm .
3. Fuel injector according to claim 1 or 2, wherein said working fluid is a fuel, namely gasoline, ethanol-fuel, diesel, methanol or a blend.
4. Fuel injector according to claim 1, 2 or 3, wherein said plunger chamber (52) has a fixed volume.
5. Fuel injector according to any one of the preceding claims, wherein said plunger comprises a sleeve-like body (44, 144, 312) closed at one end by a front disk (46, 146, 314a) provided with said first orifice (50, 150, 322) and at the other end by a rear disk (48, 148, 314e) provided with said second orifice (54, 154, 322).
6. Fuel injector according to any one of the preceding claims, wherein said plunger chamber is sub-divided into two or more sub-chambers serially connected via respective orifices dimensioned to provide a desired flow restriction.

7. Fuel injector according to claim 5 and 6, wherein said sub-division is formed by providing one or more intermediate disks in between said front and rear disks, each of said intermediate disks being provided with a respective restrictor orifice. 5
8. Fuel injector according to any one of claims 5 to 7, wherein the disk members comprise on one or both front side a counter-bore (222, 322), the restrictor orifice opening in said counter-bore(s). 10
9. Fuel injector according to claim 1, wherein said plunger (310) comprises a sleeve-like body (312) in which a stack of disk members (314a..314e) is arranged, each disk member comprising a respective restrictor orifice (322), both front sides of each disk member comprising a counter-bore (320) in which said restrictor orifice (322) opens. 15
10. Fuel injector according to any one of the claims 5 to 9, wherein each restrictor orifice (214, 322) in a disk member (210, 314) is shaped to comprise a narrow channel section (214) continuing into an enlarged section (216). 20
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11. Fuel injector according to any one of claims 5 to 10, wherein the disk members (314) are oriented so that fluid flowing through said plunger (310) in direction away from said working chamber has to first flow through the narrow channel section of each orifice. 30
12. Fuel injector according to any one of claims 7 to 11, wherein said restrictor orifices offer an effective flow cross-section equivalent to that of a hole having a diameter of no more than 100 μm , preferably within the range of 50 to 80 μm . 35
13. Fuel injector according to any one of the preceding claims, wherein said axially extendable actuator is a piezoelectric actuator. 40
14. Fuel injector according to any one of the preceding claims, wherein lash compensator (32) is immersed in the fuel and said plunger chamber (52) is in communication with the injector fuel volume via said second orifice (54). 45

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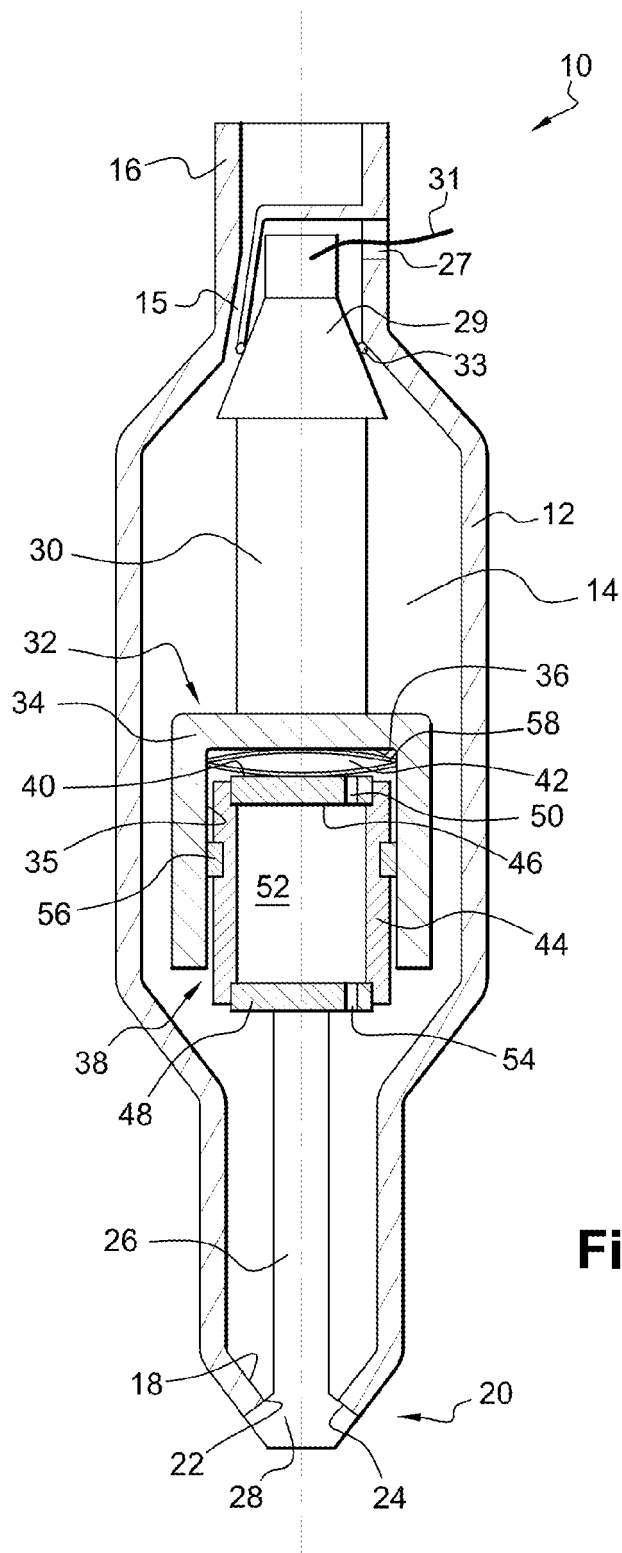


Fig. 2

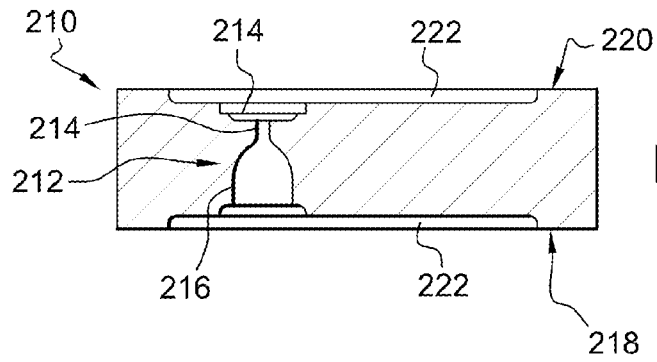
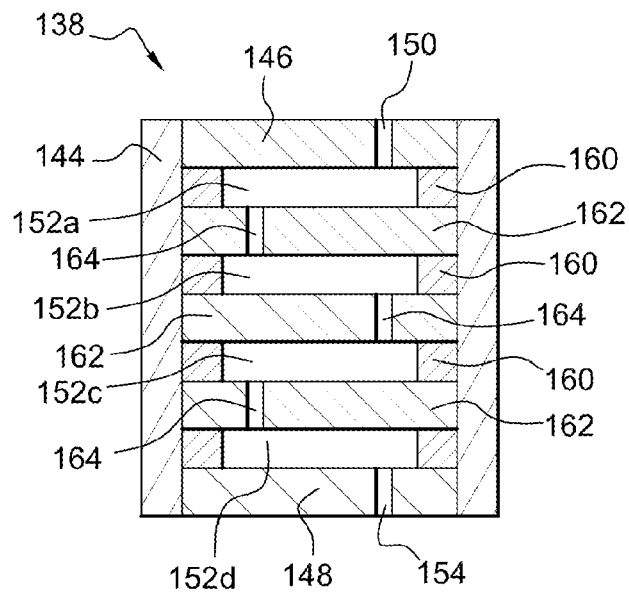
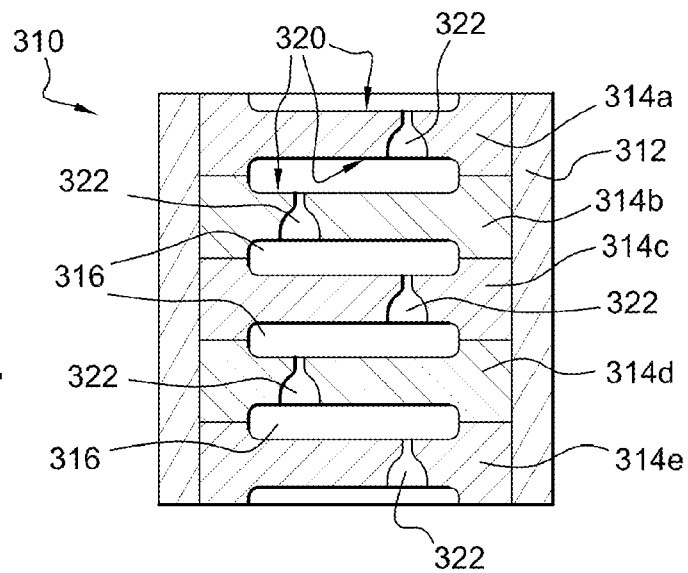


Fig. 3

Fig. 4





EUROPEAN SEARCH REPORT

Application Number
EP 09 16 2981

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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