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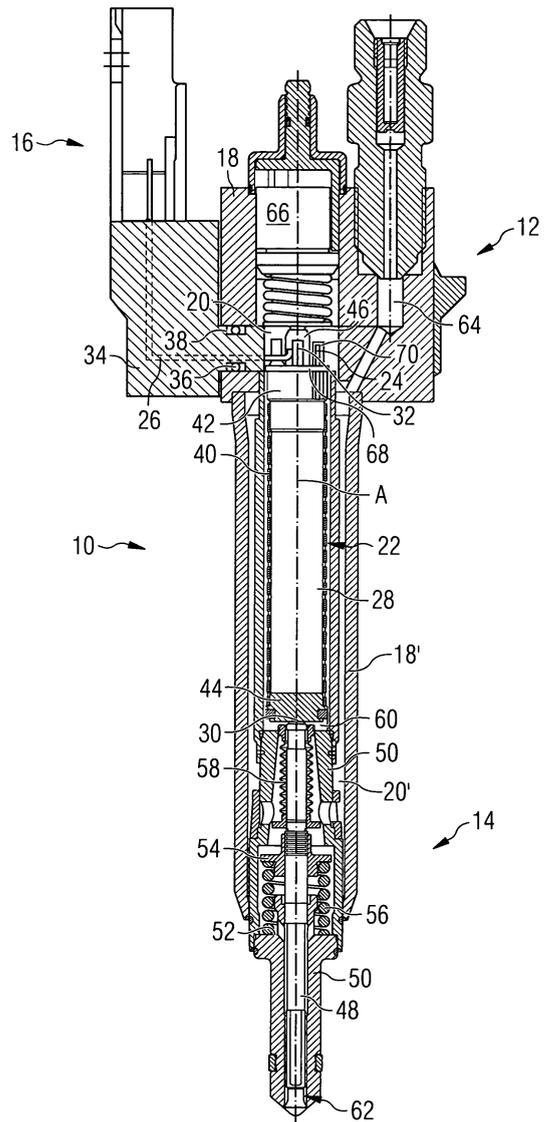
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(54) **Actuator arrangement and injection valve**

(57) Actuator arrangement (12), comprising a housing body (18) with a recess (20), and a solid state actuator unit (22) within the recess (20) with a longitudinal axis (A) being electrically coupable to a power supply, wherein the solid state actuator unit (22) comprises a first axial end area (30) designed to act as drive side and a second axial end area (32) facing an adapter (34) being designed and arranged such as to supply electric energy. A ring (36) is arranged intermediate the adapter (34) and the housing body (18), the ring (36) being designed and arranged such as to seal against an intrusion of liquid into the recess (20) and to provide an oxygen communication between the exterior of the actuator arrangement (12) and the recess (20).



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Description

[0001] The invention relates to an actuator arrangement and an injection valve.

[0002] Actuator arrangements are in wide spread use, in particular injection valves for instance for internal combustion engines comprise actuator arrangements, which comprise solid state actuator units. In order to inject fuel, the solid state actuator unit is energized so that a fluid flow through the fluid outlet portion of the injection valve is enabled.

[0003] In order to enhance the combustion process in view of the creation of unwanted emissions, the respective injection valve may be suited to dose fluids under very high pressures. The pressures may be in case of a gasoline engine, for example in a range of up to 200 bar or in the case of diesel engines in a range of up to 2,000 bar. In order to enable fast response times electric energy needs to be transmitted to or from the actuator arrangement in a very fast way.

[0004] The object of the invention is to create an actuator arrangement that is simply to be manufactured and which enables reliable operation.

[0005] This object is achieved by the features of the independent claims. Advantageous embodiments of the invention are given in the sub-claims.

[0006] According to a first aspect the invention is distinguished by an actuator arrangement, comprising a housing body with a recess, and a solid state actuator unit within the recess with a longitudinal axis being electrically coupable to a power supply, wherein the solid state actuator unit comprises a first axial end area designed to act as drive side and a second axial end area facing an adapter being designed and arranged such as to supply electric energy. A ring is arranged intermediate the adapter and the housing body, the ring being designed and arranged such as to seal against an intrusion of liquid into the recess and to provide an oxygen communication between the exterior of the actuator arrangement and the recess.

[0007] This has the advantage that the ring is not hermetically sealing the recess to enable the oxygen communication between the exterior of the actuator arrangement and the recess of the actuator arrangement. The ring may enable the oxygen communication between the exterior of the actuator arrangement and the recess and therewith at least a part of the surface of the solid state actuator unit. Furthermore, the ring may enable limiting the intrusion of vapours. For example, the ring may be permeable. For instance, the ring may avoid the intrusion of liquids into the recess, while allowing oxygen permeability into the recess of the housing body. Thus, the needed oxygen flow, for example for the ceramic of the solid state actuator unit, from the exterior may be provided, while sealing against liquids. Therefore, for example, the ceramic of the solid state actuator unit may be prevented to break. Thus, reliable operation of the actuator arrangement may be enabled. For example, the ring can

be fixed to the adapter. An O-ring geometry is simple to use and suitable for instance to a cylindrical geometry of a part of the adapter and a cylindrical geometry of a part of the housing body recess. Thus, a simple manufacturing may be provided. Moreover, the injector outline might not be affected by the measure. For example, the solid state actuator unit may comprise electric pins, which are electrically coupable to a power supply.

[0008] In an advantageous embodiment of the invention the adapter comprises a groove designed to at least partly take in the ring.

[0009] By this, the ring may be arranged in a simple and firm way intermediate the adapter and the housing body. The groove of the adapter may prevent the ring to be released. Thus, especially reliable operation of the actuator arrangement may be enabled.

[0010] In a further advantageous embodiment of the invention the ring comprises a silicon base.

[0011] This has the advantage that silicon may enable an especially advantageous and continuous flow of oxygen into the recess of the actuator arrangement. In particular, it may provide an oxygen flow especially advantageous for ceramic and therefore, may prevent breaking of the ceramic. Furthermore, silicon may seal against an intrusion of liquids into the recess and limit the intrusion of vapours into the recess, which may be harmful for the operation of the actuator arrangement. Thus, the needed oxygen flow from the exterior into the recess may be provided, while sealing against liquids. Therefore, especially reliable operation of the actuator arrangement may be enabled.

[0012] In a further advantageous embodiment of the invention the ring comprises fluorosilicone rubber.

[0013] This has the advantage that fluorosilicone material may be compatible with the engine environment, especially gasoline. In particular, it may provide an oxygen flow especially advantageous for ceramic and therefore, may prevent breaking of the ceramic. Furthermore, it may enable an especially advantageous and continuous flow of oxygen into the recess of the housing body. Moreover, fluorosilicone rubber may seal against an intrusion of liquids into the recess and limit the intrusion of vapours into the recess, which may be harmful for the operation of the actuator arrangement. Therefore, the needed oxygen flow from the exterior into the recess may be provided especially reliable, while sealing against liquids. Thus, especially reliable operation of the actuator arrangement may be enabled.

[0014] According to a second aspect the invention is distinguished by an injection valve with a valve assembly within a further recess and an actuator arrangement of the first aspect of the invention, comprising a solid state actuator unit within the further recess, wherein the solid state actuator unit is designed for acting on the valve assembly.

[0015] Exemplary embodiments of the invention are explained in the following with the help of a schematic drawing. This is as follows:

Figure 1, an exemplary actuator arrangement in an injection valve.

[0016] Figure 1 shows an injection valve 10 that may be used as a fuel injection valve for an internal combustion engine. The injection valve 10 comprises an actuator arrangement 12, a valve assembly 14 and a connector 16.

[0017] The injection valve 10 has a two-part housing body 18, 18' with a tubular shape which has the central longitudinal axis A. The housing body 18, 18' of the injection valve 10 comprises a recess 20 and a further recess 20', which are axially led through the housing body 18, 18'.

[0018] The actuator arrangement 12 comprises a solid state actuator unit 22 within the recess 20 of the housing body 18, 18' with the longitudinal axis A comprising electric pins 24 being electrically coupleable to a power supply. For example, the electric pins 24 might be coupled by weldings, in particular resistance weldings, or soldered connections to an electric conductor 26 of the connector 16, which is supplied with electric energy.

[0019] The solid state actuator unit 22 comprises a solid state actuator 28. The solid state actuator 28 changes its length in axial direction depending on a control signal applied to it such as electric energy supplied to it. The solid state actuator unit 22 is typically a piezo actuator unit. It may however also be any other solid state actuator unit known to the person skilled in the art such as a magnetostrictive actuator unit.

[0020] The solid state actuator unit 22 comprises a first axial end area 30 designed to act as drive side and a second axial end area 32, which is facing away from the first axial end area 30, facing an adapter 34. The electric pins 24 of the solid state actuator unit 22 may be arranged in optional direction, for instance in axial direction of the solid state actuator unit 24 or perpendicular to it. For example, the adapter 34 comprises the electric conductor 26 and the electric pins 24 are coupled to the electric conductor 26, which is at least partly arranged within the adapter 34 to supply electric energy.

[0021] A ring 36 is arranged intermediate the adapter 34 and the housing body 18, 18'. For example, the housing body 18 may comprise a tubular hole, in which the adapter 34 is at least partly arranged, and this part of the adapter 34 may comprise a cross section, which is at least partly circular shaped. In this case, O-ring geometry of the ring 36 is a simple and suitable geometry for sealing the recess 20 against an intrusion of liquids. Preferably, the adapter 34 comprises a groove 38, in which the ring 36 is at least partly arranged. The ring 36 is designed and arranged such as to seal against an intrusion of liquid into the recess 20 and to provide an oxygen communication between the exterior of the actuator arrangement 12 and the recess 20. This has the advantage that the ring 36 is not hermetically sealing the recess 20 to enable the oxygen communication between the exterior of the actuator arrangement 12 and the recess 20 of the actu-

ator arrangement 12. To enable an especially advantageous flow of oxygen into the recess 20 of the housing body 18, 18' and to seal against the intrusion of liquid, the ring 36 may comprise a silicon base. For instance, the ring 36 may comprise fluorosilicone rubber. This has the advantage that fluorosilicone material may be compatible with the engine environment, especially gasoline. The ring 36 may enable the oxygen communication between the exterior of the actuator arrangement 12 and the recess 20 and therewith at least a part of the surface of the solid state actuator unit 22. Thus, the needed oxygen flow, for example for the ceramic of the solid state actuator unit 22, from the exterior may be provided, while sealing against liquids. Therefore, for example, the ceramic of the solid state actuator unit 22 may be prevented to break. Thus, reliable operation of the actuator arrangement 12 may be enabled. Furthermore, the ring 36 may limit the intrusion of vapours into the recess 20.

[0022] On the drive side of the solid state actuator unit 22 facing the first axial end area 30 optional actuating elements may be arranged such as a valve needle 48 or a rotor.

[0023] An actuator housing enclosing the solid state actuator 28 may comprise a spring tube 40, a top cap 42 and a bottom cap 44. Part of the top cap 42 may form at least part of the second axial end area 32. Part of the bottom cap 44 may form at least part of the first axial end area 30 comprising the drive side of the solid state actuator unit 22. The solid state actuator unit 22 further comprises a piston 46, which is coupled to the top cap 42 or may in one piece form part of the top cap 42. It may apply an axial preload force on the solid state actuator unit 22.

[0024] The valve assembly 14 comprises a valve body 50 and the valve needle 48. The valve body 50 has a valve body spring rest 52 and the valve needle 48 comprises a valve needle spring rest 54, both spring rests 52, 54 supporting a spring 56 arranged between the valve body 50 and the valve needle 48. Between the valve needle 48 and the valve body 50 a bellow 58 is arranged which is sealingly coupling the valve body 50 with the valve needle 48. By this a fluid flow between the further recess 20' and a chamber 60 and therewith the recess 20 is prevented. Furthermore, the bellow 58 is formed and arranged in a way that the valve needle 48 is actuatable by the solid state actuator unit 22.

[0025] A fluid outlet portion 62 is closed or open depending on the axial position of the valve needle 48. By changing its length, the solid state actuator 28 can exert a force to the valve needle 48. The force from the solid state actuator 28 being exerted to the valve needle 48 in an axial direction allows or prevents a fluid flow through the fluid outlet portion 62. Furthermore, the injection valve 10 has a fluid inlet portion 64 which is arranged in the housing body 18, 18' and which for instance is coupled to a not shown fuel connector. In this example, the fuel connector is designed to be connected to a high pressure fuel chamber of an internal combustion engine, the fuel

is stored under high pressure, for example, under the pressure above 200 bar.

[0026] The valve assembly 14 is arranged in the injection valve 10 facing the first axial end area 30 on the drive side of the solid state actuator unit 22 sharing a part of the further recess 20' of the housing body 18' of the actuator arrangement 12 along the longitudinal axis A.

[0027] A thermal compensator unit 66 is arranged facing the second axial end area 32 of the solid state actuator unit 22 and facing the adapter 34 and is mechanically coupled to the piston 46 of the solid state actuator 28. The thermal compensator unit 66 enables to set an axial preload force on the solid state actuator unit 22 via the piston 46 to compensate changes of the fluid flow through the fluid outlet portion 62 in the case of temperature changes of the injection valve 10.

[0028] To supply the solid state actuator 28 with electric energy, the injection valve 10 further comprises the connector 16 with the adapter 34, in which the electric conductor 26 is at least partly arranged. Electric energy can be supplied to the electric conductor 26 of the connector 16. Furthermore, the solid state actuator unit 22 comprises a connecting element 68 consisting of terminal elements 70. The electric conductor 26 of the connector 16 is electrically coupled to one of the terminal elements 70 of the connecting element 68 which is electrically coupled to another of the terminal elements 70 which on its part is electrically coupled to the electric pins 24 of the solid state actuator 28. Consequently, electric energy can be simply supplied to the solid state actuator 28 via the connector 16.

[0029] In the following, the function of the injection valve 10 will be described in detail:

The fluid is led from the fluid inlet portion 64 through the housing body 18, 18' to the fluid outlet portion 62.

The valve needle 48 prevents a fluid flow through the fluid outlet portion 62 in the valve body 50 in a closing position of the valve needle 48. Outside of the closing position of the valve needle 48, the valve needle 48 enables the fluid flow through the fluid outlet portion 62.

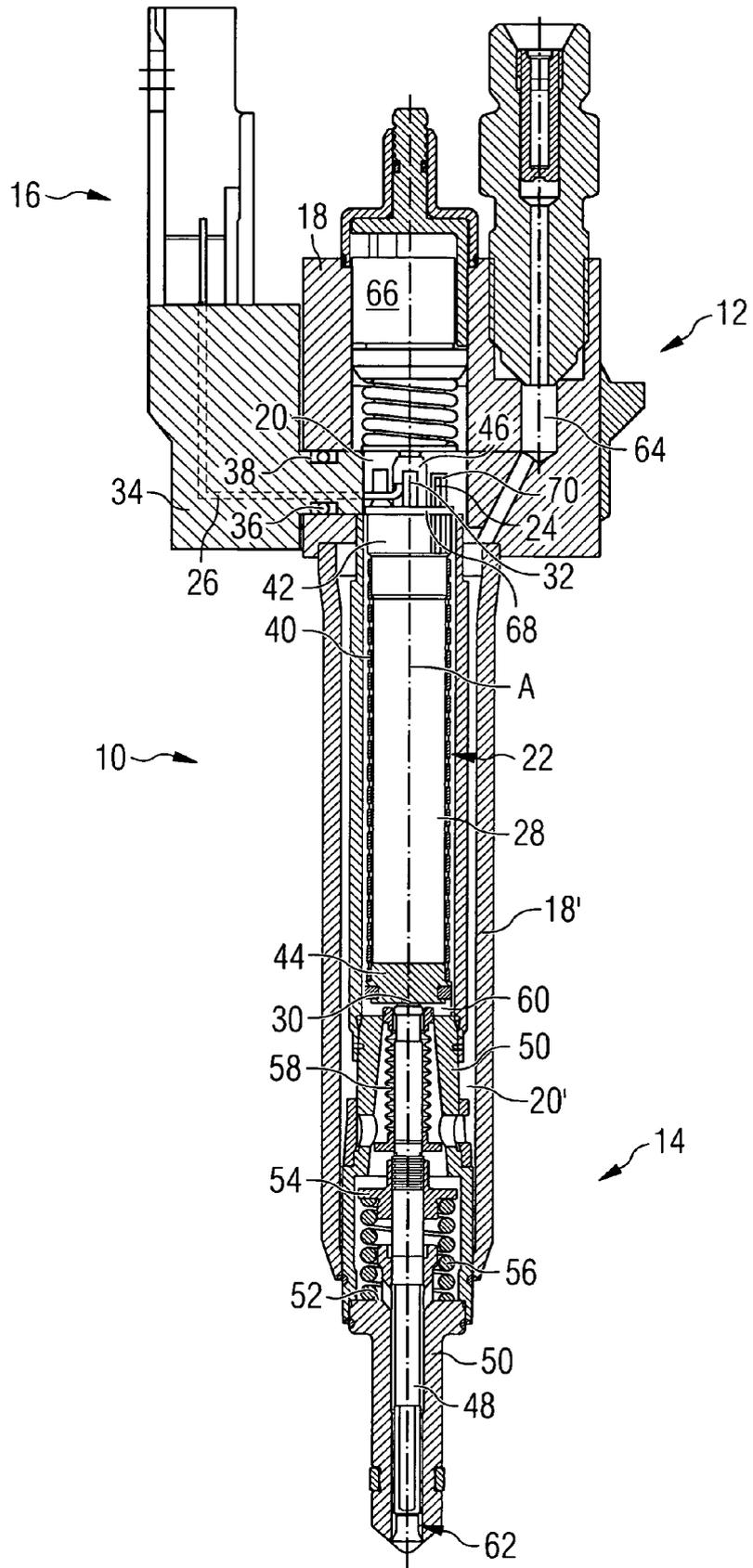
The solid state actuator 28 may change its axial length if it is energized. By changing its length the solid state actuator 28 may exert a force on the valve needle 48. The valve needle 48 is able to move in axial direction out of the closing position. Outside the closing position of the valve needle 48 there is a gap between the valve body 50 and the valve needle 48 at the first axial end area 30 of the injection valve 10 facing away from the solid state actuator 28. The spring 56 can force the valve needle 48 via the valve needle spring rest 54 towards the solid state actuator 28. In the case the solid state actuator 28 is de-energized, the solid state actuator 28 shortens its length. The spring 56 can force the valve needle 48

to move in axial direction in its closing position. It is depending on the force balance between the force on the valve needle 48 caused by the solid state actuator 28 and the force on the valve needle 48 caused by the spring 56 whether the valve needle 48 is in its closing position or not.

The invention is not restricted to the explained embodiment. For example, the adapter 34 of the actuator arrangement 12 may comprise alternative shapes. Further, the housing body 18, 18' and the recess 20 of the injection valve 10 may comprise alternative shapes.

Claims

1. Actuator arrangement (12), comprising
 - a housing body (18) with a recess (20), and
 - a solid state actuator unit (22) within the recess (20) with a longitudinal axis (A) being electrically coupable to a power supply, wherein the solid state actuator unit (22) comprises a first axial end area (30) designed to act as drive side and a second axial end area (32) facing an adapter (34) being designed and arranged such as to supply electric energy, wherein a ring (36) is arranged intermediate the adapter (34) and the housing body (18), the ring (36) being designed and arranged such as to seal against an intrusion of liquid into the recess (20) and to provide an oxygen communication between the exterior of the actuator arrangement (12) and the recess (20).
2. Actuator arrangement (12) according to claim 1, wherein the adapter (34) comprises a groove (38) designed to at least partly take in the ring (36).
3. Actuator arrangement (12) according to one of the preceding claims, wherein the ring (36) comprises a silicon base.
4. Actuator arrangement (12) according to one of the preceding claims, wherein the ring (36) comprises fluorosilicone rubber.
5. Injection valve (10) with a valve assembly (14) within a further recess (20') and an actuator arrangement (12) according to one of the preceding claims, comprising a solid state actuator unit (22) within the further recess (20'), wherein the solid state actuator unit (22) is designed for acting on the valve assembly (14).





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**ANNEX TO THE EUROPEAN SEARCH REPORT
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