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(54) **ELECTROMAGNETIC FUEL INJECTOR WITH AN ANNULAR RECESS ARRANGED IN THE AREA OF THE WELD OF AN EXTENSION**

ELEKTROMAGNETISCHES KRAFTSTOFFEINSPRITZVENTIL MIT RINGFÖRMIGER
AUSSPARUNG IM SCHWEISSBEREICH EINER ERWEITERUNG

INJECTEUR ÉLECTROMAGNÉTIQUE DE CARBURANT AVEC UN ÉVIDEMENT ANNULAIRE
DISPOSÉ DANS LA ZONE DE LA SOUDURE D'UNE EXTENSION

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Description

TECHNICAL FIELD

[0001] The present invention relates to an electromagnetic fuel injector.

PRIOR ART

[0002] An electromagnetic fuel injector (for example like the one described in patent application EP1619384A2) normally comprises a cylindrical, tubular supporting body provided with a central feeding channel which performs the function of a fuel duct and ends with an injection jet controlled by an injection valve operated by an electromagnetic actuator. The injection valve is provided with a plunger, which is displaced by the action of the electromagnetic actuator between a closed position and an open position of the injection jet against the action of a closing spring which pushes the plunger towards the closed position.

[0003] The electromagnet comprises a coil, which is arranged on the outside and in a fixed position around the supporting body, a mobile armature made of a ferromagnetic material, which is rigidly connected to the plunger and is mounted so as to be mobile on the inside of the supporting body, and a fixed armature made of a ferromagnetic material, which is arranged on the inside of the supporting body in the area of the coil and is designed to magnetically attract the mobile armature. The fixed armature has a central through hole, which fulfils the function of allowing fuel to flow towards the injection jet. On the inside of the central hole of the fixed armature there is provided the closing spring, which is compressed between a perforated striker body fitted into the central hole and the mobile armature, so as to push the mobile armature and, hence, the plunger integral to the mobile armature towards the closing position of the injection valve.

[0004] A metal extension is partially arranged on the inside of the supporting body, in a fixed position and immediately on the upper fixed armature, said extension having a central hole to allow fuel to flow towards the injection jet. The extension is only partially arranged on the inside of the supporting body, as an upper part of the extension is arranged on the outside of the supporting body. The extension is mechanically constrained to the supporting body by means of an annular weld, which is made in the area of an upper end of the supporting body and starting from an upper wall of the supporting body.

[0005] Manufacturers of Otto-cycle heat engines (i.e. engines with controlled ignition) need both to increase the fuel feeding pressure (above 70-80 Mpa) to improve the mixing of the fuel with the oxidizer (i.e. the air sucked into the cylinders) and reduce the production of black smoke (indicating bad combustion) and to increase the dynamic performance of the electromagnetic injectors (thus increasing the speed of reaction of the electromag-

netic injectors to orders) so as to inject small quantities of fuel for the purpose of dividing the injection of fuel into different injection operations (by so doing, the production of polluting substances during the combustion is reduced).

[0006] It has been proven that an increase in the fuel feeding pressure (above 70-80 Mpa) leads to an increase in the frequency of faults of the fuel injector due to the occurrence of cracking or other types of structural defects of the supporting body in the area of or close to the annular weld mechanically constraining the extension to the supporting body. In order to solve this problem, manufacturers have tried to increase the thickness of the supporting body, but this solution has the unavoidable drawback of increasing the manufacturing costs of the fuel injector (both due the greater quantity of material used and due to a greater manufacturing complexity) and of increasing the diameter of the fuel injector (thus making it more difficult for the fuel injector to be housed in the crown end of the cylinders, especially in case of internal combustion engines with small displacements).

[0007] Patent application US2002084362A1 describes a fuel injector 100 comprising: an injection jet; an injection valve 239, which is provided with a mobile plunger 266, so as to adjust the flow of fuel through the injection jet; an electromagnetic actuator to move the plunger 266 between a closed position and an open position of the injection valve 239 and provided with at an electromagnet comprising a coil 310, a fixed armature 220, and a mobile armature 262, which is mechanically connected to the plunger 266; a closing spring 270, which pushes the plunger 266 towards the closed position; a supporting body 240, which has a tubular shape and is provided with a central channel, which partially houses the fixed armature 220 and completely houses the mobile armature 262; and an extension 210, which is completely arranged on the outside of the supporting body 240 (i.e. it is spaced apart from the supporting body 240), is arranged on the fixed armature 220 and is mechanically constrained to the fixed armature 220 by means of an annular weld.

[0008] Patent US5769391A discloses an electromagnetic fuel injector with a reduced number of components so that the number of joints and connecting points is also reduced; the entire injector pipe is manufactured from magnetically conductive material, so that one can dispense with nonmagnetic adapters.

DESCRIPTION OF THE INVENTION

[0009] The object of the present invention is to provide an electromagnetic fuel injector, which is not affected by the aforementioned drawbacks and, at the same time, can be manufactured in a straightforward and low-cost manner.

[0010] According to the present invention, there is provided an electromagnetic fuel injector according to the appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] The present invention will now be described with reference to the accompanying drawings, showing a nonlimiting embodiment thereof, wherein:

- figure 1 is a longitudinal section of a fuel injector according to the present invention;
- figure 2 shows a detail of figure 1 on a larger scale;
- figure 3 shows a detail of figure 2 on a further larger scale;
- figure 4 shows a detail of figure 3 on a further larger scale;
- figure 5 shows an injection valve of the injector of figure 1; and
- figure 6 shows a detail of figure 5 on a larger scale.

PREFERRED EMBODIMENTS OF THE INVENTION

[0012] In Figure 1, number 1 indicates, as a whole, a fuel injector, which has a cylindrical symmetry around a longitudinal axis 2 and is designed to be operated so as to inject fuel through an injection jet 3, which leads directly into an explosion chamber (not shown) of a cylinder. The injector 1 comprises a supporting body 4, which has a tubular cylindrical shape with a variable cross-section along the longitudinal axis 2 and comprises a feeding channel 5 extending along the entire length of the supporting body 4 to feed the pressurized fuel to the injection jet 3.

[0013] The supporting body 4 houses an electromagnetic actuator 6 in the area of an upper portion of its and an injection valve 7 (better visible in figure 5) in the area of a lower portion of its; in use, the injection valve 7 is operated by the electromagnetic actuator 6 so as to adjust the flow of fuel through the injection jet 3, which is obtained in the area of the injection valve 7.

[0014] According to figures 2 and 3, the electromagnetic actuator 6 comprises a pair of twin electromagnets 8 (an upper one and a lower one, respectively), which are activated together, so as to operate simultaneously. Each electromagnet 8, when it is excited, is designed to move, along the axis 2, a respective mobile armature 9 made of a ferromagnetic material from a closed position to an open position of the injection valve 7 against the action of a single, common closing spring 10, which pushes the mobile armature 9 towards the closed position of the injection valve 7. Each electromagnet 8 comprises a coil 11, which is supplied with power by an electronic control unit (not shown) and is fitted on the outside relative to the supporting body 4, as well as a fixed armature 12 made of a ferromagnetic material, which is housed on the inside of the supporting body 4 in a fixed position and has a central hole 13, so as to allow fuel to flow towards the injection jet 3. The central channel 5 of the supporting body 4 entirely houses each fixed armature 12 and each mobile armature 9 so that each fixed armature 12 and each mobile armature 9 are completely arranged on the

inside of the supporting body 4 (namely, so that each fixed armature 12 and each mobile armature 9 do not project, even partially, out of the supporting body 4).

[0015] A metal extension 14 is partially arranged on the inside of the supporting body 4, in a fixed position and immediately on the upper fixed armature 12 (i.e. the fixed armature 12 of the upper electromagnet 8), said extension 14 having a central hole 15 to allow fuel to flow towards the injection jet 3. The extension 14 is only partially arranged on the inside of the supporting body 14, as an upper part of the extension 14 is arranged on the outside of the supporting body 4; in particular, the greatest part of the extension 14 is arranged on the outside of the supporting body 4, as you can clearly see in figure 1. On the inside of the central hole 15 of the extension 14 there is fitted, in a fixed position, a striker body 16, which has a cylindrical tubular shape (if necessary, open along a generating line) to allow fuel to flow towards the injection jet 3 and is designed to keep the closing spring 10 compressed against the upper mobile armature 9 (i.e. against the mobile armature 9 of the upper magnet 8).

[0016] Each coil 11 is directly wound on the inside of its own annular slot 17, which is obtained by removing material from the outer surface of the supporting body 4. Each coil 11 consists of an enamelled conductor wire, which is provided with a self-bonding layer and has an axial size (namely, measured along the longitudinal axis 2) that is kept small to minimize dispersed magnetic fluxes. In the area of the coils 11, a protection body 18 made of a ferromagnetic material is coupled around the supporting body 4, said protection body 18 having a tubular shape and being used to ensure an adequate mechanical protection of the coils 11, to enable the closing of the streamlines of the magnetic flux generated by the coils 11, and to increase the mechanical resistance of the supporting body 4 in the area of the structural weak spots unavoidably caused by the presence of the slots 17.

[0017] The mobile armatures 9 are part of a mobile equipment, which comprises, furthermore, a shutter or plunger 19 having an upper portion integral to each mobile armature 9 and a lower portion cooperating with a valve seat 20 (shown in figure 5) of the injection valve 7 so as to adjust, in a known manner, the flow of fuel towards the injection jet 3.

[0018] In use, when the electromagnets 8 are not excited, each mobile armature 9 is not attracted by its fixed armature 12 and the elastic force of the closing spring 10 pushes the mobile armatures 9, together with the plunger 19, downwards; in this situation, the injection valve 7 is closed. When the electromagnets 8 are excited, each mobile armature 9 is magnetically attracted by its fixed armature 12 against the elastic force of the closing spring 10 and the mobile armatures 9, together with the plunger 19, move upwards so as to determine the opening of the injection valve 7.

[0019] In order to precisely determine the upwards stroke covered by the plunger 19, the upper mobile armature 9 (i.e. the mobile armature 9 of the upper elec-

tromagnet 8) has a usable stroke that is shorter than the usable stroke of the lower mobile armature 9 (i.e. the mobile armature 9 of the lower electromagnet 8). In this way, when the electromagnets 8 are excited, it is always only the upper mobile armature 9 (i.e. the mobile armature 9 of the upper electromagnet 8) that moves so as to be in contact with and strike against its fixed armature 12, regardless of unavoidable building tolerances. In order to limit the usable stroke of the upper mobile armature 9 (i.e. the mobile armature 9 of the upper electromagnet 8), the lower surface of the upper fixed armature 12 or the upper surface of the upper mobile armature 9 are covered with a layer of a hard, non-ferromagnetic metal material, preferably chromium; in this way, the thickness of the chromium layer determines the reduction of the usable stroke of the upper mobile armature 9 (i.e. the mobile armature 9 of the upper electromagnet 8). Further functions of the chromium layer are: increasing the resistance to impacts of the area and, especially, avoiding magnetic adhesion phenomena due to a direct contact between the ferromagnetic material of the upper mobile armature 9 (i.e. the mobile armature 9 of the upper electromagnet 8) and the ferromagnetic material of the upper fixed armature 12. In other words, the chromium layer defines a gap, which prevents the magnetic attraction forces caused by the residual magnetism between the upper mobile armature 9 (i.e. the mobile armature 9 of the upper electromagnet 8) and the upper fixed armature 12 from reaching values that are too high, namely greater than the elastic force generated by the closing spring 10.

[0020] Furthermore, only the upper mobile armature 9 (i.e. the mobile armature 9 of the upper electromagnet 8) is subjected to precision mechanical processing so as to have an adjusted outer diameter, which is substantially equal (obviously, rounded down) to the inner diameter of the feeding channel 5; on the contrary, the lower mobile armature 9 (i.e. the mobile armature 9 of the lower electromagnet 8) has an unadjusted outer diameter, which is always smaller than the inner diameter of the feeding channel 5. In this way, only the upper mobile armature 9 (i.e. the mobile armature 9 of the upper electromagnet 8) fulfils the function of upper guide of the plunger 19 to control the axial sliding of the plunger 19 along the longitudinal axis 2. This building solution allows manufacturers to reduce manufacturing costs, as only the upper mobile armature 9 (i.e. the mobile armature 9 of the upper electromagnet 8) must be subjected to precision mechanical processing, which is very expensive.

[0021] According to figure 5, the valve seat 20 is defined in a sealing element 21, which is made in one piece, seals the feeding channel 5 of the supporting body 4 on the lower side, and is crossed by the injection jet 3. In particular, the sealing element 21 comprises a disc-shaped plugging element 22, which seals the feeding channel 5 of the supporting body 4 on the lower side and is crossed by the injection jet 3. A guide element 23 projects from the plugging element 22, has a tubular shape, receives, on the inside, the plunger 19 so as to

define a lower guide for the plunger 19 itself, and has an outer diameter that is smaller than the inner diameter of the feeding channel 5 of the supporting body 4 so as to define an outer annular channel 24, through which fuel under pressure can flow.

[0022] In the lower part of the guide element 23 there are obtained feeding through holes (not shown in figure 5), which lead to the valve seat 20, so as to allow fuel under pressure to flow towards the valve seat 20. The feeding holes can be staggered relative to the longitudinal axis 2, so as not to converge towards the longitudinal axis 2 itself and cause, in use, a vortex movement of the respective fuel flows, or the feeding holes can converge towards the longitudinal axis 2. In the embodiment shown in the appended drawings, the feeding holes are arranged so as to be inclined at an angle of 80° (more in general, at an angle ranging from 70° to 90°) with the longitudinal axis 2; according to a different embodiment that is not shown herein, the feeding holes form a 90° angle with the longitudinal axis 2.

[0023] The plunger 19 ends with a shutting head 25 with a substantially spherical shape, which is designed to rest against and seal the valve seat 20; alternatively, the shutting head 25 might have a basically cylindrical shape and have the sole striking area with a spherical shape. Furthermore, the shutting head 25 rests, in a sliding manner, against an inner surface of the guide element 23, so as to be guided in its movement along the longitudinal axis 2. The injection jet 3 is defined by a plurality of injection through holes (not shown), which are obtained starting from an injection chamber 26 arranged downstream of the valve seat 20.

[0024] As already mentioned above, the upper mobile armature 9 (i.e. the mobile armature 9 of the upper electromagnet 8) has an outer diameter that is substantially identical to the inner diameter of the corresponding portion of the feeding channel 5 of the supporting body 4; in this way, the upper mobile armature 9 can slide relative to the supporting body 4 along the longitudinal axis 2, but it cannot make any movement transversely to the longitudinal axis 2 relative to the supporting body 4. As the plunger 19 is rigidly connected to the upper mobile armature 9 (i.e. the mobile armature 9 of the upper electromagnet 8), the upper mobile armature 9 clearly fulfils the further function of upper guide of the plunger 19; as a consequence, the plunger 19 is guided by the upper mobile armature 9 (i.e. the mobile armature 9 of the upper electromagnet 8) on the upper side and by the guide element 23 on the lower side.

[0025] According to figures 2 and 3, the lower face of the upper mobile armature 9 (i.e. the mobile armature 9 of the upper electromagnet 8) is connected to a hydraulic braking device, which brakes (slows down) the movement of the plunger 19 both when the plunger 19 moves from the open position to the closed position of the injection valve 7 and when the plunger 19 moves from the closed position to the open position of the injection valve 7.

[0026] The plunger 19 has a stem with a cylindrical symmetry, to which the substantially spherical shutting head 26 is connected by means of an annular weld. In turn, the stem is connected to each mobile armature 9 by means of an annular weld.

[0027] According to figure 3, the lower fixed armature 12 (i.e. the fixed armature 12 of the lower electromagnet 8) is mechanically locked in a fixed position on the inside of the supporting body 4 by means of a spot weld 27 (alternatively, it could also be an annular weld), which constrains the lower fixed armature 12 to the supporting body 4; preferably, the supporting body 4 has a counter-bore, which is made in the area of the lower fixed armature 12 (i.e. the fixed armature 12 of the lower electromagnet 8) and houses, on the inside, the weld 27. The weld 27 is oriented radially (namely, perpendicularly to the longitudinal axis 2) and, therefore, it develops from the outside to the inside of the supporting body 4 along a radial direction (namely, perpendicularly to the longitudinal axis 2). The weld 27 is never mechanically stressed in a significant manner, as it is completely on the inside of the supporting body 4 (which means that it does not have to resist to hydraulic stresses caused by the pressure of the fuel) and it is not subjected to mechanical stresses (as already mentioned above, only the upper mobile armature 9 strikes against the upper fixed armature 12 at the end of the opening stroke of the plunger 19).

[0028] According to figure 3, the upper fixed armature 12 (i.e. the fixed armature 12 of the upper electromagnet 8) is mechanically locked in a fixed position on the inside of the supporting body 4 by means of an annular weld 28, which constrains the upper fixed armature 12 to the extension 14. In other words, a lower wall of the extension 14 is in contact with an upper wall of the fixed armature 12 and the two walls are constrained to one another because of the annular weld 28. Therefore, it is evident that, at first, the extension is separate from and independent of the fixed armature 12 and is constrained to the upper fixed armature 12 by means of the annular weld 28. The annular weld 28 between the upper fixed armature 12 (i.e. the fixed armature 12 of the upper electromagnet 8) and the extension 14 is made on the outside of the supporting body 4, namely before inserting the upper fixed armature 12 and the extension 14, together, into the supporting body 4; in other words, the upper fixed armature 12 and the extension 14 are connected to one another (pre-assembled) by means of the annular weld 28 on the outside of the supporting body 4 and then the upper fixed armature 12 and the extension 14, joined to one another, are inserted, together, into the supporting body 4. The annular weld 28 is oriented radially (namely, perpendicularly to the longitudinal axis 2) and, therefore, it develops between the upper fixed armature 12 and the extension 14 along a radial direction (namely, perpendicularly to the longitudinal axis 2). The annular weld 28 has a good mechanical resistance, as it is made in ideal conditions (namely, on the outside of the supporting body 4); furthermore, the annular weld 28 is never mechanically

stressed in a significant manner, as it is completely on the inside of the supporting body 4 (which means that it does not have to resist to hydraulic stresses caused by the pressure of the fuel) and works only in compression (when the upper mobile armature 9 strikes against the upper fixed armature 12 at the end of the opening stroke of the plunger 19).

[0029] It should be pointed out that the upper fixed armature 12 (i.e. the fixed armature 12 of the upper electromagnet 8) does not have any direct mechanical constraint to the supporting body 4, which means that the upper fixed armature 12 does not have any direct mechanical connection to the supporting body 4; as a matter of fact, the upper fixed armature 12 is kept still on the inside of the supporting body 4 exclusively through the annular weld 28, which mechanically constrains the fixed armature 12 to the extension 14.

[0030] According to figure 3, the extension 14 is mechanically constrained to the supporting body 4 by means of an annular weld 29, which is made in the area of an upper end of the supporting body 4 and starting from an upper wall of the supporting body 4. The annular weld 29 is oriented axially (namely, parallel to the longitudinal axis 2) and, therefore, it develops between the supporting body 4 and the extension 14 along an axial direction (namely, parallel to the longitudinal axis 2). The annular weld 29 has a good mechanical resistance, as it is made in ideal conditions (namely, on the outside of the supporting body 4) and between materials having a high mechanical resistance (the extension 14 is not affected by the magnetic flux and, therefore, it is made of a non-ferromagnetic steel having high mechanical performances, and the supporting body 4 is made of a steel having high mechanical performances, as well). It is important for the annular weld 29 to have a good mechanical resistance, as the annular weld 29 is mechanically stressed in a significant manner; the annular weld 29 must ensure the upper sealing of the supporting body 4 and, therefore, it must resist hydraulic stresses caused by the pressure of the fuel and, furthermore, the annular weld 29 must resist a shearing stress when the upper mobile armature 9 hits the upper fixed armature 12 at the end of the opening stroke of the plunger 19.

[0031] According to figure 4, the supporting body 4 has an annular recess 30, which is obtained starting from an inner surface of the supporting body 4 (namely, it faces the extension 14, which is arranged on the inside of the supporting body 4) and is arranged (immediately) below the annular weld 29 (namely, below the root of the annular weld 29). The annular recess 30 is arranged below the annular weld 29 at a very small distance from the annular weld 29 itself; basically, the beginning of the annular recess 30 borders (i.e. is arranged flush with) the end of the annular weld 29 (i.e. the root of the annular weld 29). Alternatively, the annular recess 30 could also partially overlap the annular weld 29 (namely, the root of the annular weld 29). According to a preferred, though not binding, embodiment, the annular recess 30 has, in its cross-

sectional view, a semicircular shape. Furthermore, according to a preferred, though not binding, embodiment, the annular recess 30 has an axial length that is equal to or greater than the axial length of the annular weld 29. The annular recess 30 fulfils the function of protecting the root of the annular weld 29 from mechanical stresses; obviously, mechanical stresses cannot go through the annular recess 30, which is empty, and, therefore, they must go from the supporting body 4 to the extension 14 moving past the annular recess 30 and spreading relatively far from the root of the annular weld 29; in other words, the annular recess 30 allows the root of the annular weld 29 to be released from tensions (in this area of the annular weld 29 there is a concentration of tensions) and to have a more uniform distribution of stresses in the weld section. To sum up, thanks to the presence of the annular recess 30, it is possible to significantly reduce the chance of formation of cracks or slits in the area of the root of the annular weld 29 (which is the most fragile area and, therefore, the one most subjected to risks in the annular weld 29) and it is also possible to allow the weld section to work in a more uniform and distributed manner.

[0032] According to figure 4, the extension 14 has an annular recess 31, which is obtained starting from an outer surface of the extension 14 and is arranged (immediately) above the annular weld 29 (namely, above the base of the annular weld 29). In other words, the annular recess 31 is arranged above the annular weld 29 at a very small distance from the annular weld 29 itself; generally speaking, the axial distance between the annular recess 31 and the annular weld 29 is other than zero (namely, greater than zero) and is smaller than 50% of the axial length of the annular weld 29 (it should be pointed out that the axial distance between the annular recess 31 and the annular weld 29 could also be equal to zero). According to a preferred, though not binding, embodiment, the annular recess 31 has, in its cross-sectional view, a rectangular shape with rounded vertices. Furthermore, according to a preferred, though not binding, embodiment, the annular recess 31 has an axial length that is equal to or greater than the axial length of the annular weld 29. The annular recess 31 fulfils the function of directing the mechanical stresses transmitted between the supporting body 4 and the extension 14 in such a way that said mechanical stresses move past the annular recess 31 and spread relatively far from the outer surface of the annular weld 29 (area of concentration of tensions), thus allowing the weld section to work in a more uniform and distributed manner. In other words, thanks to the presence of the annular recess 31, it is possible to have the annular weld 29 work better, thus substantially reducing the chance of formation of cracks or slits in the area of the outer surface of the annular weld 29. It should be pointed out that the two annular recesses 30 and 31 work in synergy; as they are arranged above and below the annular weld 29, they ensure a significant variation in the direction of mechanical stresses, which

turn out to spread far away from both points of concentration of tensions in the weld (root and outer surface), which constitute the most fragile areas and, therefore, the ones most subjected to risks in the annular weld 29; if there were only one of the annular recesses 30 and 31, there would not be a simultaneous reduction of the stress state in the root and in outer surface of the annular weld 29, but, on the contrary, only one of them would be released from stresses to the detriment of the other one.

[0033] In order to obtain a high precision in the length of the axial stroke of the upper mobile armature 9 (i.e. the mobile armature 9 of the upper electromagnet 8), thus compensating possible errors caused by unavoidable building tolerances, the upper fixed armature 12, together with the extension 14 (as already mentioned above, the upper fixed armature 12 was previously welded to the extension 14 by means of the annular weld 28), is inserted into the supporting body 4, is caused to strike against the upper mobile armature 9 and, then, it is axially pulled away from the upper mobile armature 9 by a distance that is correlated to the desired axial stroke of the upper mobile armature 9 and permits a compensation of the shrinkages following the welding (in particular, the distance can be greater or smaller than the desired axial stroke so as to take into account the shrinkages following the welding); finally, the extension 14 is locked in the final position by means of the annular weld 29, which constrains the extension 14 (integral to the upper fixed armature 12) to the supporting body 4.

[0034] According to a preferred embodiment shown in the appended drawings, part of the supporting body 4 and part of the extension 14 are covered by a plastic coating 32, which is overmoulded and fulfils the function of protecting them from outer agents.

[0035] According to a preferred embodiment shown in the appended drawings, the extension 14 is also used to connect the fuel injector 1 to a pressurized fuel feeding pipe; to this aim, the upper part of the extension 14 is threaded, so as to be connected to the pressurized fuel feeding pipe by means of screwing.

[0036] According to figures 5 and 6, the sealing element 21 is mechanically constrained to the supporting body 4 by means of an annular weld 33, which is made in the area of a lower end of the supporting body 4 and starting from a lower wall of the supporting body 4. The annular weld 33 is oriented axially (namely, parallel to the longitudinal axis 2) and, therefore, it develops between the supporting body 4 and the extension 14 along an axial direction (namely, parallel to the longitudinal axis 2). The annular weld 33 has a good mechanical resistance, as it is made in ideal conditions (namely, on the outside of the supporting body 4) and between materials having a high mechanical resistance (the sealing element 21 and the supporting body 4 are both made of a steel having high mechanical performances). It is important for the annular weld 33 to have a good mechanical resistance, as the annular weld 33 is mechanically stressed in a significant manner; on the one hand, the annular

weld 33 must ensure the the lower sealing of the supporting body 4 and, therefore, it must resist hydraulic stresses caused by the pressure of the fuel and, on the other hand, the annular weld 33 is arranged on the inside of a cylinder and, therefore, it is subjected to all the mechanical stresses of the combustion cycle.

[0037] According to figures 5 and 6, the supporting body 4 has an annular recess 34, which is obtained starting from an inner surface of the supporting body 4 (namely, it faces the sealing element 21) and is arranged (immediately) above the annular weld 33 (namely, above the root of the annular weld 33). The annular recess 34 is arranged above the annular weld 33 at a very small distance from the annular weld 33; basically, the beginning of the annular recess 34 borders (i.e. is arranged flush with) the end of the annular weld 33 (i.e. the root of the annular weld 33). Alternatively, the annular recess 34 could also partially overlap the annular weld 33 (namely, the root of the annular weld 33). According to a preferred, though not binding, embodiment, the annular recess 34 has, in its cross-sectional view, a semicircular shape. Furthermore, according to a preferred, though not binding, embodiment, the annular recess 34 has an axial length that is equal to or smaller than three times the axial length of the annular weld 33. The annular recess 34 fulfils the function of protecting the root of the annular weld 33 from mechanical stresses; obviously, mechanical stresses cannot go through the annular recess 34, which is empty, and, therefore, they must go from the supporting body 4 to the extension 14 moving past the annular recess 34 and spreading relatively far from the root of the annular weld 33; in other words, the annular recess 34 allows the root of the annular weld 33 (area of concentration of tensions) to be released from tensions and to have a more uniform distribution of stresses in the weld section. To sum up, thanks to the presence of the annular recess 34, it is possible to significantly reduce the chance of formation of cracks or slits in the area of the root of the annular weld 33 (which is the most fragile area and, therefore, the one most subjected to risks in the annular weld 33) and it is also possible to allow the weld section to work in a more uniform and distributed manner.

[0038] The fuel injector 1 described above has numerous advantages.

[0039] First of all, the fuel injector 1 described above has a low frequency of faults due to the occurrence of cracking or other types of structural defects of the supporting body 4 in the area of or close to the annular welds 28, 29 and 30, even when the fuel injector 1 operates with a high fuel feeding pressure (above 70-80 Mpa).

[0040] Furthermore, the fuel injector 1 described above is simple and cheap to be manufactured, as, compared to a known similar fuel injector, it has differences that can easily be produced.

[0041] It should be pointed out that the fuel injector 1 described above can be used for the injection of any type of fuel in internal combustion engines operating accord-

ing to the Otto cycle (namely, with a controlled ignition of the mixture) or in internal combustion engines operating according to the Diesel cycle (namely, with a spontaneous ignition of the mixture).

Claims

1. A fuel injector (1) comprising:

an injection jet (3);
 an injection valve (7), which is provided with a mobile plunger (19), so as to adjust the flow of fuel through the injection jet (3);
 an electromagnetic actuator (6) to move the plunger (19) between a closed position and an open position of the injection valve (7) and provided with at least one first electromagnet (8) comprising a first coil (11), a first fixed armature (12), and a first mobile armature (9), which is mechanically connected to the plunger (19);
 a closing spring (10), which pushes the plunger (19) towards the closed position;
 a supporting body (4), which has a tubular shape and is provided with a central channel (5), which entirely houses the first fixed armature (12) and the first mobile armature (9) so that the first fixed armature (12) and the first mobile armature (9) are completely arranged on the inside of the supporting body (4); and
 an extension (14), which is partially arranged on the inside of the supporting body (4) on the first fixed armature (12) so that a lower wall of the extension (14) is in contact with an upper wall of the first fixed armature (12), at first is separate from and independent of the first fixed armature (12), and is mechanically constrained to the supporting body (4) by means of a first annular weld (29);
 the injector (1) is **characterized in that** the supporting body (4) has a first annular recess (30), which is obtained starting from an inner surface of the supporting body (4) and is arranged below the first annular weld (29).

2. An injector (1) according to claim 1, wherein the beginning of the first annular recess (30) borders the end of the first annular weld (29) or the first annular recess (30) partially overlaps the first annular weld (29).

3. An injector (1) according to claim 1 or 2, wherein the first annular recess (30) has, in its cross-sectional view, a semicircular shape.

4. An injector (1) according claim 1, 2 or 3, wherein the extension (14) has a second annular recess (31), which is obtained starting from an outer surface of

the extension (14) and is arranged above the first annular weld (29).

5. An injector (1) according to claim 4, wherein the second annular recess (31) is arranged close to the first annular weld (29). 5
6. An injector (1) according to claim 4 or 5, wherein the second annular recess (31) has, in its cross-sectional view, a rectangular shape. 10
7. An injector (1) according to any of the claims from 1 to 6, wherein the first annular weld (29) is made in the area of an upper end of the supporting body (4) and starting from an upper wall of the supporting body (4). 15
8. An injector (1) according to any of the claims from 1 to 7, wherein the first fixed armature (12) is mechanically locked in a fixed position on the inside of the supporting body by means of a second annular weld (28), which constrains the first fixed armature (12) to the extension (14). 20
9. An injector (1) according to claim 8, wherein the first fixed armature (12) has no direct mechanical constraint to the supporting body (4) and is kept still on the inside of the supporting body (4) only through the second annular weld (28), which mechanically constrains the first fixed armature (12) to the extension (14). 25
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10. An injector (1) according to any of the claims from 1 to 9, wherein the extension (14) has a central hole (15), which allows fuel to flow towards the injection jet (3) and partially houses the closing spring (10); and on the inside of the central hole (15) of the extension (14) there is fitted, in a fixed position, a striker body (16), which has a cylindrical tubular shape and is designed to keep the closing spring (10) compressed against the first mobile armature (9). 35
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11. An injector (1) according to any of the claims from 1 to 10, wherein: 45

the electromagnetic actuator (6) is provided with a second electromagnet (8), which is arranged below the first electromagnet (8) and comprises a second coil (11), a second fixed armature (12), and a second mobile armature (9), which is mechanically connected to the plunger (19); the first mobile armature (9) has a usable stroke that is shorter than the usable stroke of the second mobile armature (9); and 50

the second fixed armature (12) is mechanically locked in a fixed position on the inside of the supporting body (4) by means of a third weld 55

(27), which directly constrains the second fixed armature (12) to the supporting body (4) and develops from the outside to the inside of the supporting body (4) along a radial direction.

12. An injector (1) according to claim 11, wherein the supporting body (4) has a spot-face, which is obtained in the area of the second fixed armature (12), so that the third weld (27) can be made therein.
13. An injector (1) according to any of the claims from 1 to 12, wherein the extension (14) has an upper threaded part for the connection to a feeding pipe for fuel under pressure.

Patentansprüche

1. Kraftstoffeinspritzvorrichtung (1), die Folgendes umfasst:
 - eine Einspritzdüse (3),
 - ein Einspritzventil (7), das mit einem beweglichen Kolben (19) versehen ist, um den Kraftstoffstrom durch die Einspritzdüse (3) einzustellen;
 - einen elektromagnetischen Aktor (6), um den Kolben (19) zwischen einer geschlossenen Position und einer offenen Position des Einspritzventils (7) zu bewegen, und der mit mindestens einem ersten Elektromagneten (8) versehen ist, der eine erste Spule (11), einen ersten feststehenden Anker (12) und einen ersten beweglichen Anker (9), der mit dem Kolben (19) mechanisch verbunden ist, umfasst;
 - eine Schließfeder (10), die den Kolben (19) in Richtung der geschlossenen Position drückt;
 - einen Trägerkörper (4), der eine Röhrenform aufweist und mit einem Mittenkanal (5) versehen ist, der den ersten feststehenden Anker (12) und den ersten beweglichen Anker (9) vollständig aufnimmt, derart, dass der erste feststehende Anker (12) und der erste bewegliche Anker (9) vollständig auf der Innenseite des Trägerkörpers (4) angeordnet sind; und
 - eine Erweiterung (14), die teilweise auf der Innenseite des Trägerkörpers (4) auf dem ersten feststehenden Anker (12) angeordnet ist, derart, dass sich eine untere Wand der Erweiterung (14) mit einer oberen Wand des ersten feststehenden Ankers (12) in Kontakt befindet, zunächst vom ersten feststehenden Anker (12) getrennt und davon unabhängig ist und mittels einer ersten ringförmigen Schweißstelle (29) am Trägerkörper (4) mechanisch eingespannt ist; wobei die Einspritzvorrichtung (1) **dadurch gekennzeichnet ist, dass** der Trägerkörper (4) eine erste ringförmige Vertiefung (30) aufweist,

- die beginnend von einer Innenfläche des Trägerkörpers (4) erhalten wird und unter der ersten ringförmigen Schweißstelle (29) angeordnet ist.
2. Einspritzvorrichtung (1) nach Anspruch 1, wobei der Anfang der ersten ringförmigen Vertiefung (30) an das Ende der ersten ringförmigen Schweißstelle (29) angrenzt oder die erste ringförmige Vertiefung (30) mit der ersten ringförmigen Schweißstelle (29) teilweise überlappt. 5
 3. Einspritzvorrichtung (1) nach Anspruch 1 oder 2, wobei die erste ringförmige Vertiefung (30) in ihrer Querschnittsansicht eine Halbkreisform aufweist. 10
 4. Einspritzvorrichtung (1) nach Anspruch 1, 2 oder 3, wobei die Erweiterung (14) eine zweite ringförmige Vertiefung (31) aufweist, die beginnend von einer Außenfläche der Erweiterung (14) erhalten wird und über der ersten ringförmigen Schweißstelle (29) angeordnet ist. 15
 5. Einspritzvorrichtung (1) nach Anspruch 4, wobei die zweite ringförmige Vertiefung (31) nahe an der ersten ringförmigen Schweißstelle (29) angeordnet ist. 20
 6. Einspritzvorrichtung (1) nach Anspruch 4 oder 5, wobei die zweite ringförmige Vertiefung (31) in ihrer Querschnittsansicht eine rechtwinklige Form aufweist. 25
 7. Einspritzvorrichtung (1) nach einem der Ansprüche von 1 bis 6, wobei die erste ringförmige Schweißstelle (29) im Bereich eines oberen Endes des Trägerkörpers (4) hergestellt ist und an einer oberen Wand des Trägerkörpers (4) beginnt. 30
 8. Einspritzvorrichtung (1) nach einem der Ansprüche von 1 bis 7, wobei der erste feststehende Anker (12) mittels einer zweiten ringförmigen Schweißstelle (28), die den ersten feststehenden Anker (12) an der Erweiterung (14) einspannt, an einer feststehenden Position auf der Innenseite des Trägerkörpers mechanisch verriegelt ist. 35
 9. Einspritzvorrichtung (1) nach Anspruch 8, wobei der erste feststehende Anker (12) keine direkte mechanische Einspannung am Trägerkörper (4) aufweist und lediglich durch die zweite ringförmige Schweißstelle (28), die den ersten feststehenden Anker (12) an der Erweiterung (14) mechanisch einspannt, nach wie vor auf der Innenseite des Trägerkörpers (4) gehalten wird. 40
 10. Einspritzvorrichtung (1) nach einem der Ansprüche von 1 bis 9, wobei die Erweiterung (14) ein Mittenloch (15) aufweist, das ermöglicht, dass Kraftstoff in Richtung der Einspritzdüse (3) strömt, und die 45
- Schließfeder (10) teilweise aufnimmt; und auf der Innenseite des Mittenlochs (15) der Erweiterung (14) an einer feststehenden Position ein Verriegelungskörper (16) eingepasst ist, der eine zylindrische Röhrenform aufweist und konstruiert ist, die Schließfeder (10) gegen den ersten beweglichen Anker (9) komprimiert zu halten.
11. Einspritzvorrichtung (1) nach einem der Ansprüche von 1 bis 10, wobei: 50
 - der elektromagnetische Aktor (6) mit einem zweiten Elektromagneten (8) versehen ist, der unter dem ersten Elektromagneten (8) angeordnet ist und eine zweite Spule (11), einen zweiten feststehenden Anker (12) und einen zweiten beweglichen Anker (9), der mit dem Kolben (19) mechanisch verbunden ist, umfasst; der erste bewegliche Anker (9) einen nutzbaren Axialweg aufweist, der kürzer als der nutzbare Axialweg des zweiten beweglichen Ankers (9) ist; und
 - der zweite feststehende Anker (12) mittels einer dritten Schweißstelle (27), die den zweiten feststehenden Anker (12) direkt am Trägerkörper (4) einspannt und sich von der Außenseite zur Innenseite des Trägerkörpers (4) entlang einer radialen Richtung entwickelt, an einer feststehenden Position auf der Innenseite des Trägerkörpers (4) mechanisch verriegelt ist.
 12. Einspritzvorrichtung (1) nach Anspruch 11, wobei der Trägerkörper (4) eine Ansenkung aufweist, die in dem Bereich des zweiten feststehenden Ankers (12) erhalten wird, derart, dass die dritte Schweißstelle (27) darin ausgebildet werden kann.
 13. Einspritzvorrichtung (1) nach einem der Ansprüche von 1 bis 12, wobei die Erweiterung (14) eine obere Gewindekomponente zur Verbindung mit einem Zuführrohr für druckbeaufschlagten Kraftstoff aufweist.

Revendications

1. Injecteur de carburant (1) comprenant :

un jet d'injection (3) ;
 une soupape d'injection (7) qui est prévue avec un piston plongeur mobile (19), afin d'ajuster l'écoulement de carburant à travers le jet d'injection (3) ;
 un actionneur électromagnétique (6) pour déplacer le piston plongeur (19) entre une position fermée et une position ouverte de la soupape d'injection (7) et prévu avec au moins un premier électro-aimant (8) comprenant une première bobine (11), une première armature fixe (12), et

- une première armature mobile (9), qui est mécaniquement raccordée au piston plongeur (19) ;
 un ressort de fermeture (10), qui pousse le piston plongeur (19) vers la position fermée ;
 un corps de support (4) qui a une forme tubulaire et est prévu avec un canal central (5) qui loge entièrement la première armature fixe (12) et la première armature mobile (9) de sorte que la première armature fixe (12) et la première armature mobile (9) sont complètement agencées à l'intérieur du corps de support (4) ; et
 une extension (14) qui est partiellement agencée à l'intérieur du corps de support (4) sur la première armature fixe (12) de sorte qu'une paroi inférieure de l'extension (14) est en contact avec une paroi supérieure de la première armature fixe (12), est tout d'abord séparée de et indépendante de la première armature fixe (12), et est mécaniquement contrainte sur le corps de support (4) au moyen d'une première soudure annulaire (29) ;
 l'injecteur (1) est **caractérisé en ce que** le corps de support (4) a un premier évidement annulaire (30) qui est obtenu à partir d'une surface interne du corps de support (4) et est agencé au-dessous de la première soudure annulaire (29).
2. Injecteur (1) selon la revendication 1, dans lequel le commencement du premier évidement annulaire (30) borde l'extrémité de la première soudure annulaire (29) ou bien le premier évidement annulaire (30) chevauche partiellement la première soudure annulaire (29).
 3. Injecteur (1) selon la revendication 1 ou 2, dans lequel le premier évidement annulaire (30) a, sur sa vue transversale, une forme semi-circulaire.
 4. Injecteur (1) selon la revendication 1, 2 ou 3, dans lequel l'extension (14) a un second évidement annulaire (31) qui est obtenu à partir d'une surface externe de l'extension (14) et est agencé au-dessus de la première soudure annulaire (29).
 5. Injecteur (1) selon la revendication 4, dans lequel le second évidement annulaire (31) est agencé à proximité de la première soudure annulaire (29).
 6. Injecteur (1) selon la revendication 4 ou 5, dans lequel le second évidement annulaire (31) a, sur sa vue transversale, une forme rectangulaire.
 7. Injecteur (1) selon l'une quelconque des revendications 1 à 6, dans lequel la première soudure annulaire (29) est réalisée dans la zone d'une extrémité supérieure du corps de support (4) et à partir d'une paroi supérieure du corps de support (4).
 8. Injecteur (1) selon l'une quelconque des revendications 1 à 7, dans lequel la première armature fixe (12) est mécaniquement verrouillée dans une position fixe à l'intérieur du corps de support au moyen d'une deuxième soudure annulaire (28), qui contraint la première armature fixe (12) sur l'extension (14).
 9. Injecteur (1) selon la revendication 8, dans lequel la première armature fixe (12) n'a pas de contrainte mécanique directe sur le corps de support (4) et est maintenue encore à l'intérieur du corps de support (4) uniquement par le biais de la deuxième soudure annulaire (28), qui contraint mécaniquement la première armature fixe (12) sur l'extension (14).
 10. Injecteur (1) selon l'une quelconque des revendications 1 à 9, dans lequel l'extension (14) a un trou central (15) qui permet au carburant de s'écouler vers le jet d'injection (3) et loge partiellement le ressort de fermeture (10) ; et
 à l'intérieur du trou central (15) de l'extension (14), est monté, dans une position fixe, un corps de percuteur (16) qui a une forme tubulaire cylindrique et est conçu pour maintenir le ressort de fermeture (10) comprimé contre la première armature mobile (9).
 11. Injecteur (1) selon l'une quelconque des revendications 1 à 10, dans lequel :
 l'actionneur électromagnétique (6) est prévu avec un second électro-aimant (8) qui est agencé au-dessous du premier électro-aimant (8) et comprend une seconde bobine (11), une seconde armature fixe (12), et une seconde armature mobile (9) qui est mécaniquement raccordée au piston plongeur (19) ;
 la première armature mobile (9) a une course utile qui est plus courte que la course utile de la seconde armature mobile (9) ; et
 la seconde armature fixe (12) est mécaniquement verrouillée dans une position fixe à l'intérieur du corps de support (4) au moyen d'une troisième soudure (27) qui contraint directement la seconde armature fixe (12) sur le corps de support (4) et se développe de l'extérieur vers l'intérieur du corps de support (4) le long d'une direction radiale.
 12. Injecteur (1) selon la revendication 11, dans lequel le corps de support (4) a une face ponctuelle, qui est obtenue dans la zone de la seconde armature fixe (12), de sorte que la troisième soudure (27) peut être réalisée à l'intérieur de cette dernière.
 13. Injecteur (1) selon l'une quelconque des revendications 1 à 12, dans lequel l'extension (14) a une partie filetée supérieure pour le raccordement à un tuyau

d'alimentation pour le carburant sous pression.

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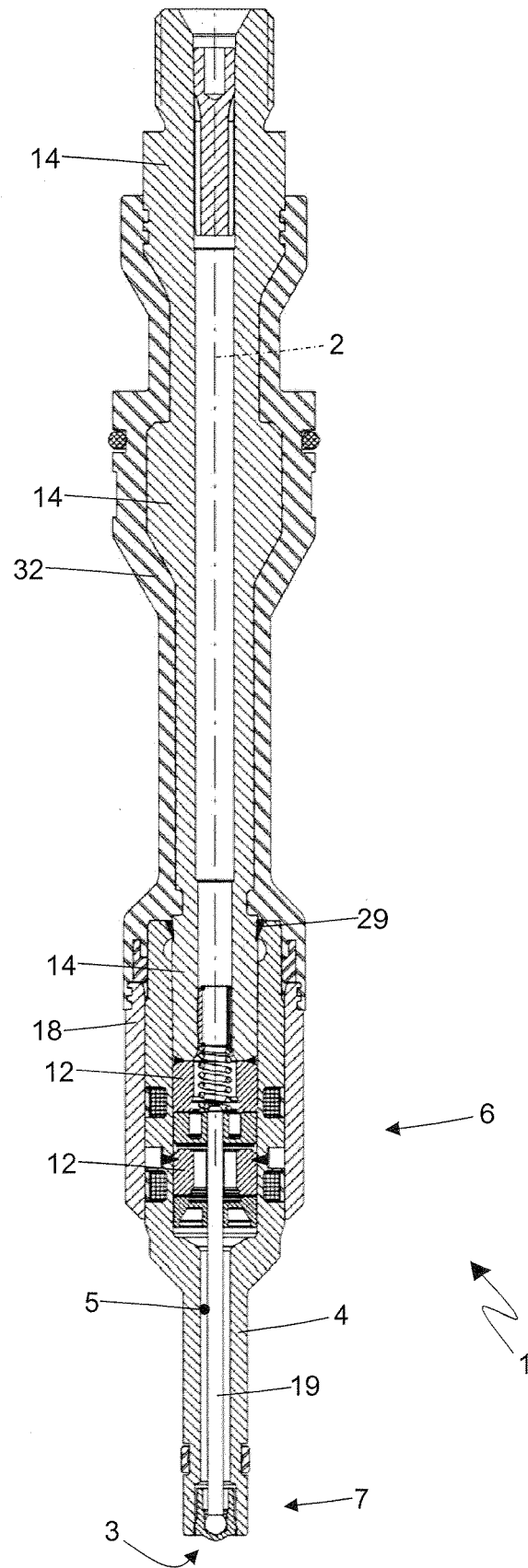


Fig.1

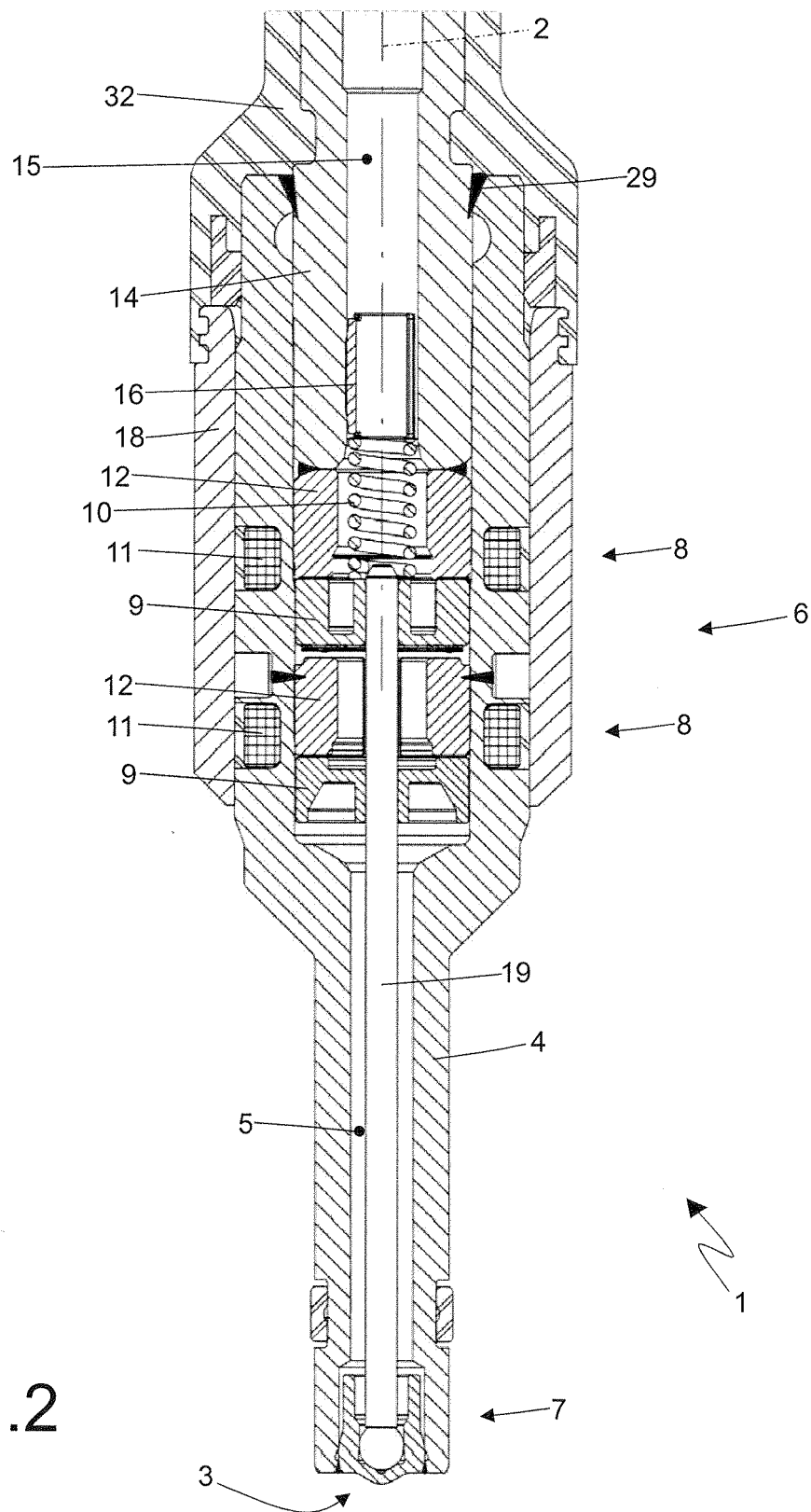


Fig.2

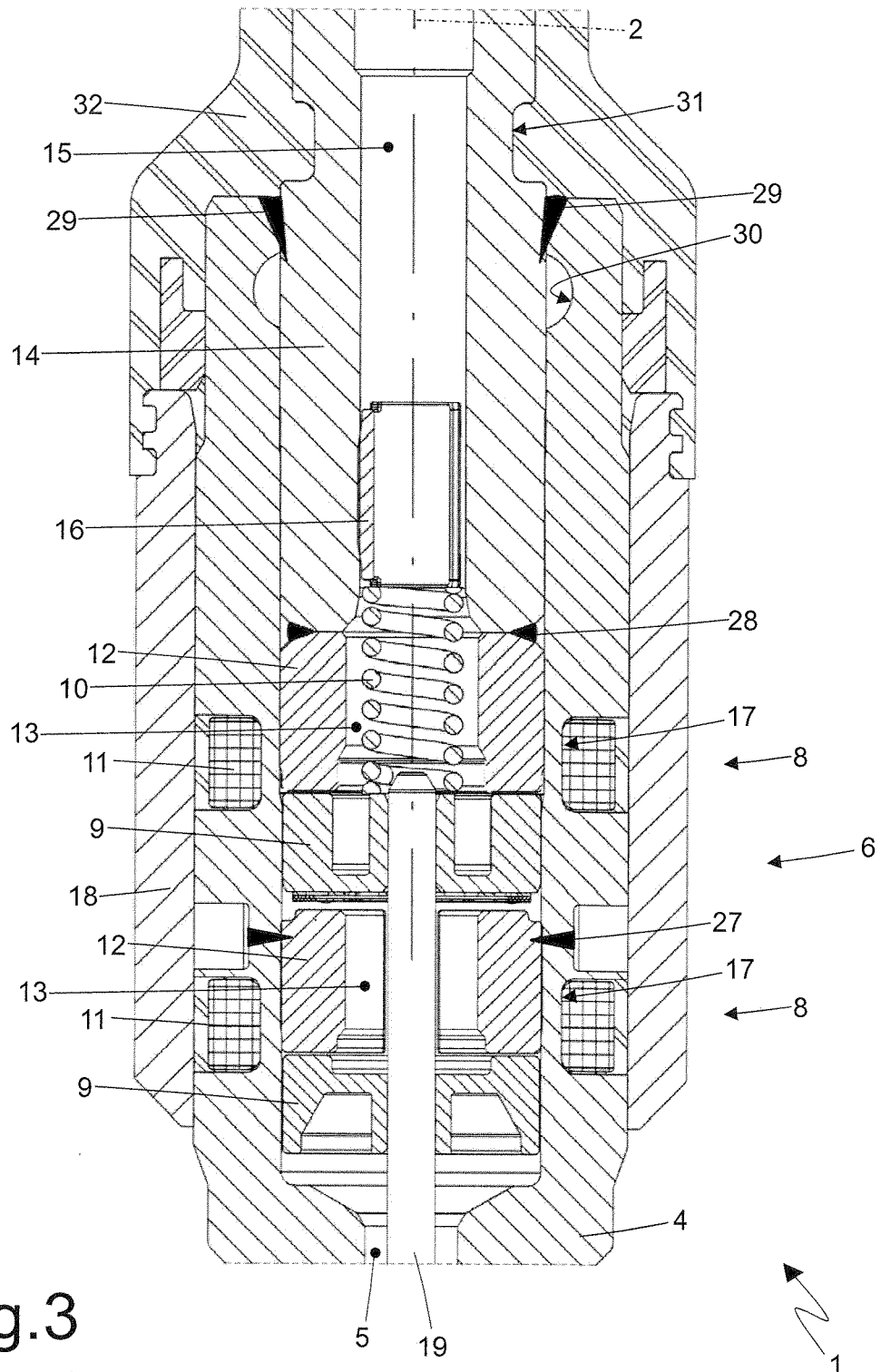


Fig.3

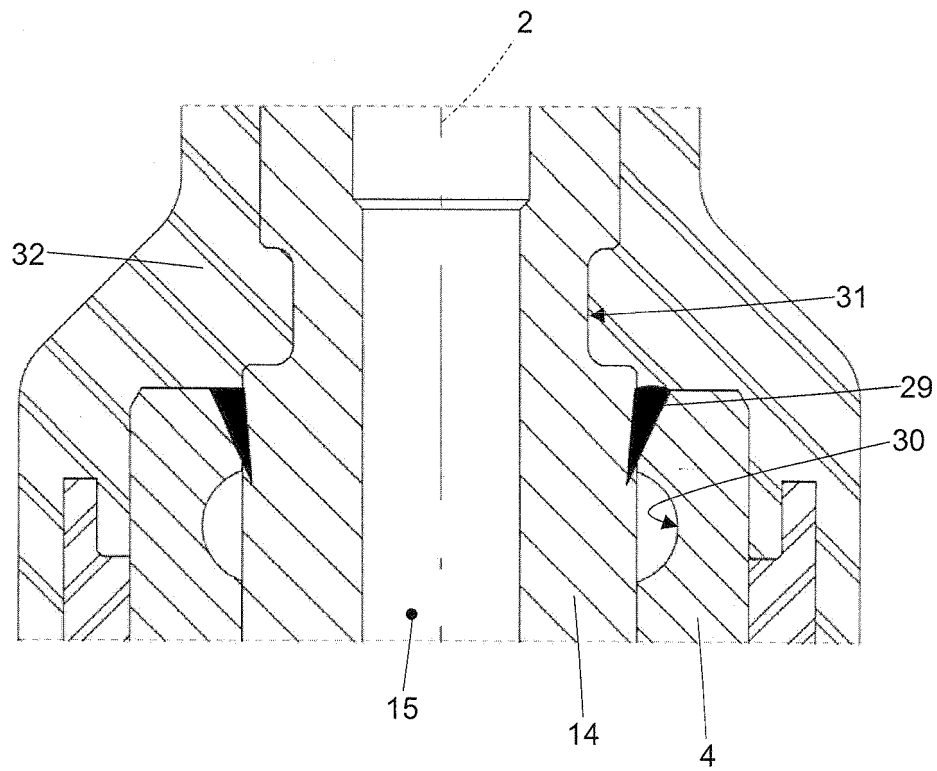
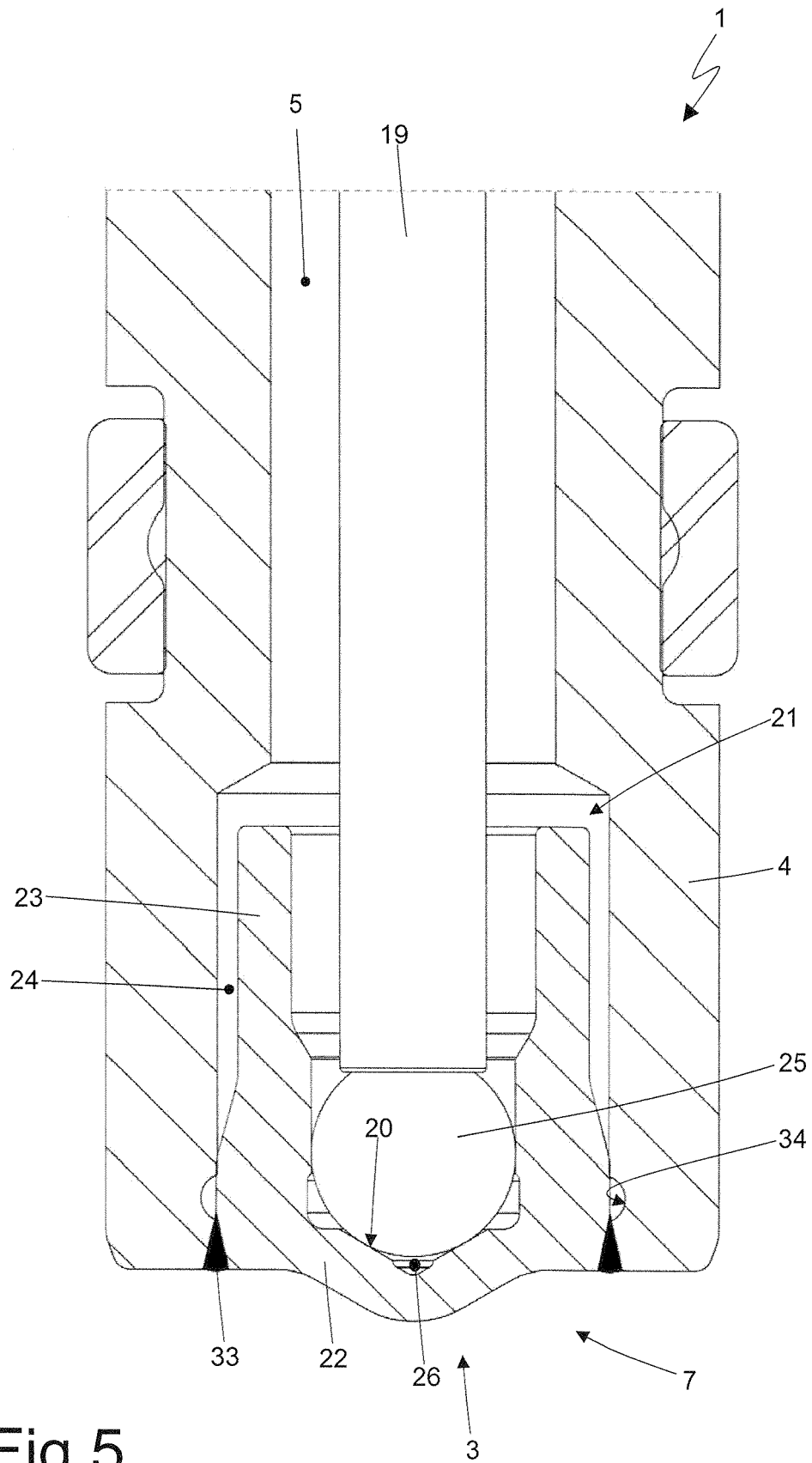


Fig.4



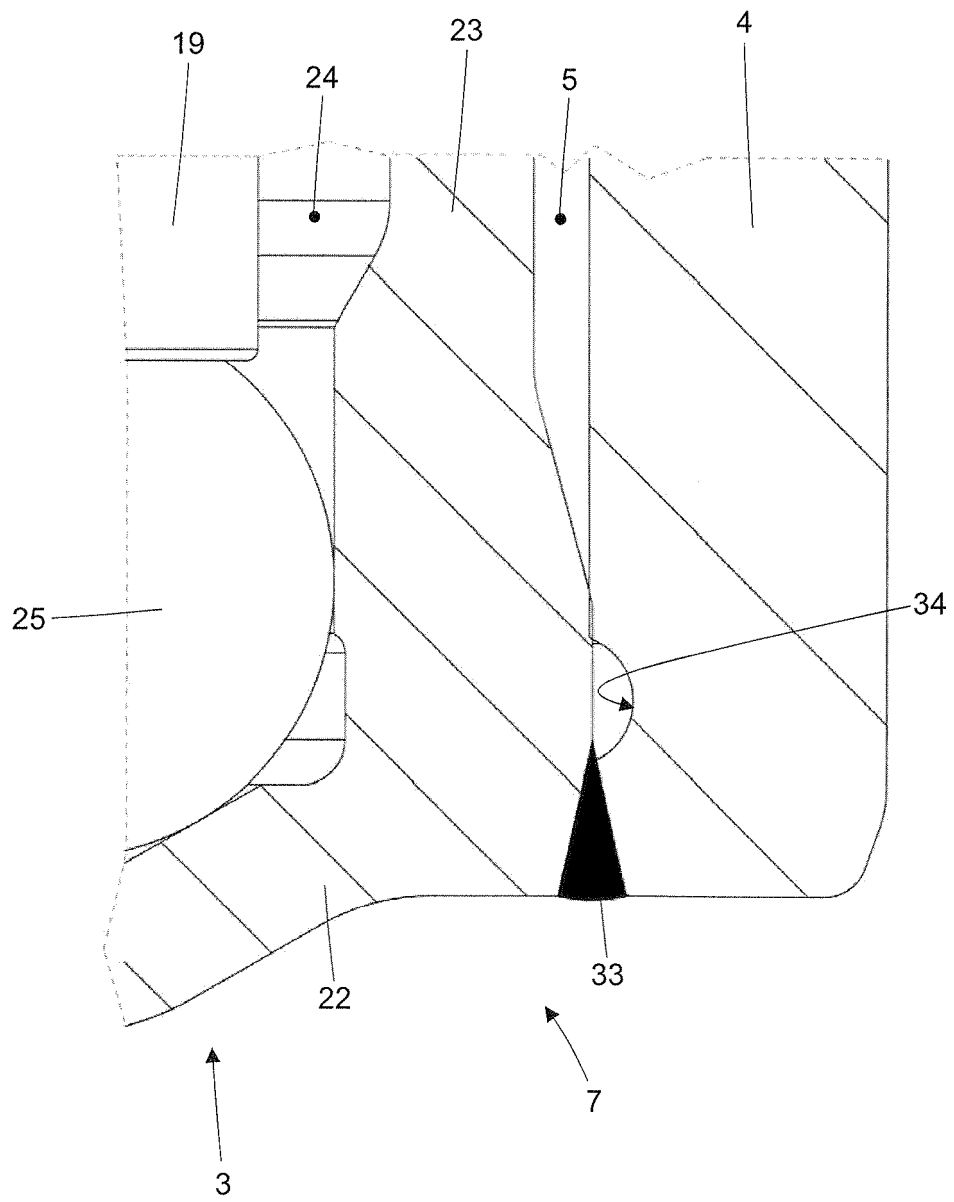


Fig.6

REFERENCES CITED IN THE DESCRIPTION

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