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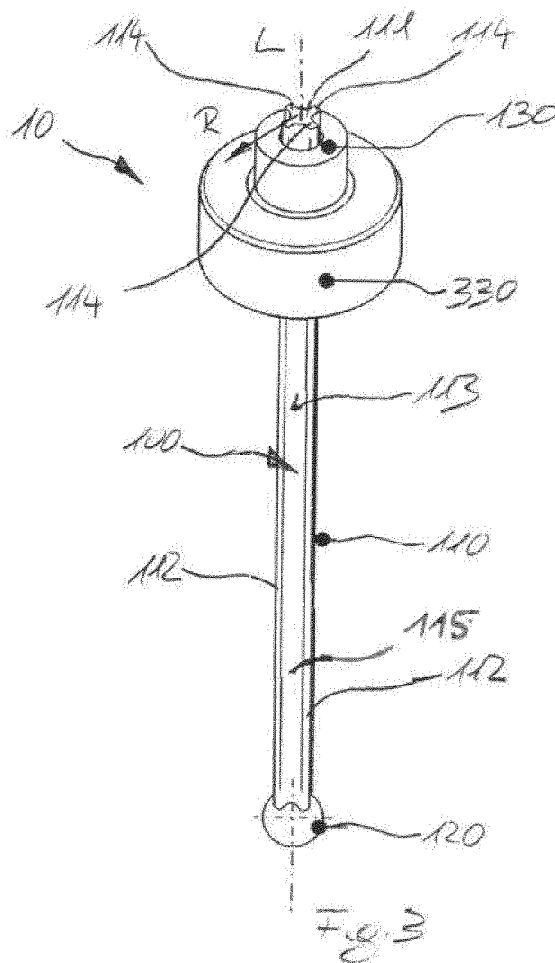
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(54) **Valve needle for a fluid injector, valve needle assembly, valve assembly and fuel injector**

(57) The invention relates to a valve needle (100) for a fluid injector for opening and closing a fluid outlet side of the fluid injector, wherein the valve needle (100) has an elongated needle body (110), and the elongated needle body (110) is rod-shaped and has a multi-legged (114, 114, ...) cross-section (111).

Further, the invention relates to a valve needle assembly and a valve assembly for a fluid injector. Furthermore, the invention relates to a fuel injector for an intake manifold or an internal combustion engine of a motor vehicle.



Description

[0001] The present disclosure relates to a valve needle for a fluid injector for opening and closing a fluid outlet side of the injector. Further, the present disclosure relates to a valve needle assembly and a valve assembly for a fluid injector. Furthermore, the present disclosure relates to a fuel injector for an intake manifold or an internal combustion engine of a motor vehicle.

[0002] Fluid injectors, which may also be denoted as injection valves (in particular in the case of gasoline injectors) or injection nozzles (in particular in the case of diesel injectors), are widely used, particularly for internal combustion engines in which they are arranged in order to dose fuel into an intake manifold of the internal combustion engine or directly into a combustion chamber of a cylinder of the internal combustion engine. In order to enhance a combustion process in view of the creation of unwanted emissions, the respective injector is suited to dose the fuel under comparatively high pressures. In case of a gasoline engine, the pressures may for example be in the range of up to over 200 bar, and in case of diesel engines, for example in the range of up to over 2.500 bar.

[0003] Fuel injectors are manufactured in various forms in order to satisfy the needs for various combustion engines. They accommodate an actuator for actuating a valve needle of the fuel injector. Such an actuator is for example an electromagnetic or a piezoelectric actuator. - A flow rate of fuel through an injector is controlled by a dynamic behaviour of the needle which opens and closes the injector by a mechanical contact with a seat of the injector. A well known problem of injectors is a bounce of the needle on the seat during a closing phase of the needle at the end of an injection event (cf. fig. 2).

[0004] Such an undesirable and uncontrolled bounce of the needle during its closing phase dispenses unwanted fuel from the injector and results in a degraded performance of the injector and of an internal combustion engine. The bounce is a result of a spring-effect of the impacting components on the seat of the injector.

[0005] It is an object of the invention to provide an improved fuel injector for an intake manifold or an internal combustion engine of a motor vehicle, wherein a bouncing effect of a needle of the injector during a closing phase of the needle is particularly small. Moreover, the improved injector should be easy to manufacture and to use, as well as being cost-efficient.

[0006] The object of the invention is achieved by means of a valve needle for a fluid injector for opening and closing a fluid outlet side of the fluid injector according to claim 1. Advantageous embodiments, features and developments of the valve needle, a valve needle assembly comprising the valve needle, a valve assembly comprising the valve needle assembly and of a fuel injector are specified in the dependent claims and the following description.

[0007] According to one aspect, a valve needle for a fluid injector, for example a gasoline injection valve or a

diesel injection nozzle, is disclosed. According to another aspect, a valve needle assembly comprising the valve needle and an armature is disclosed. According to a further aspect, a valve assembly comprising a base body with a central cavity and the valve needle assembly being accommodated in the central cavity is disclosed. According to yet another aspect, a fluid injector comprising the valve assembly is disclosed. The fluid injector may be a fuel injector, in particular for dosing fuel into an intake manifold or directly into a combustion chamber of an internal combustion engine, for example of an internal combustion engine of a motor vehicle.

[0008] The valve needle comprises an elongated needle body, wherein the needle body is in particular rod-shaped. The needle body has a multi-legged cross-section. A multi-legged cross-section may also be denoted as a multi-limbed, multi-winged, multi-branched, multi-beamed, multi-tipped or multi-toothed cross-section.

[0009] The needle body is in particular elongated along a longitudinal axis. In other words, it has a main extension direction along the longitudinal axis. Its dimension along the longitudinal axis may be at least five times as large as its dimensions perpendicular thereto in one embodiment.

[0010] A "rod" in the present context is in particular a body which has its main extension greatly exceeding its lateral extension, perpendicular to the direction of the main extension. The rod is elongated in its direction of the main extension. The dimension of the rod in the direction of the main extension may be, for example at least five times as large, in particular at least ten times as large as its maximum lateral dimension. The rod preferably extends straight in the direction of its main extension, i.e. in particular without curves or kinks or steps. In the present context, the term "rod" should in particular not be understood to have a completely circular contour in top view along its main extension.

[0011] In one embodiment, the elongated valve body comprises a plurality of axial fluid channels in an outer surface, the fluid channels being formed by means of the multi-legged cross-section (111). In other words, by means of the legs of the multi-legged cross-section, channels are defined which extend in direction along the longitudinal axis. The outer surface is in particular a circumferential surface of the needle body which preferably extends from one axial end to the opposite axial end and around the longitudinal axis.

[0012] In one embodiment, the needle body itself may be made from a plurality of pieces. In another embodiment, it is made from a single piece. Producing the elongated needle body from one piece, e.g. by machining, may be particularly cost-efficient and precise.

[0013] The valve needle and/or the needle body is preferably free from an inner fluid channel. In particular the needle body is solid, i.e. it is a non-hollow part. By means of the non-hollow multi-legged shape, a high mechanical stability and a particularly small weight are simultaneously achievable. Due to the small weight, bouncing of the

valve needle may be small or completely avoided. The mechanical stability may be in particular be improved as compared to a tubular needle. With advantage, the valve needle according to the present disclosure may be less fragile than a tubular needle. In addition, once the tube of the tubular needle is filled with fuel, its effective weight is increased by the fuel. Although the tubular needle may have holes in a side wall of the needle, fluid flow may be sufficiently possible only if the injector is open. At a very end of the closing of the needle there may be a bottleneck which traps the fuel inside the tubular needle and increases its inertia and/or the flow may be limited and/or delayed by hydraulic interactions.

[0014] For example, the needle body comprises a solid profile being open towards a radially outer face of the needle body. A primary outline of the needle body is preferably a circle. In other words, the legs of the multi-legged cross-section may be bounded by circle segments in radial direction. Additionally or alternatively, a secondary outline of the needle body is preferably serrated. Further, the cross-section of the needle body is in particular constituted by peripheral legs or by peripheral and inner legs. A peripheral leg may have a free end which preferably is facing radially or laterally outwards. An inner end is in particular adjacent to other legs at two opposite sides of its main extension direction. For example a H-shape consists of two peripheral (vertical) legs and one (horizontal) inner leg.

[0015] In one embodiment, one leg of the multi-legged cross-section merges into an adjacent leg by a concavely rounded transition for forming one of the fluid channels. In particular, the cross section of each of the fluid channels is defined by at least two adjacent legs of the multi-legged cross section and a concavely rounded transition between said two legs. For example, the fluid channels each have a U-shaped cross-sectional shape. In this way, an advantageous flow behaviour of the fluid in the fluid channels may be achievable.

[0016] In one embodiment, the valve needle comprises a sealing body. The sealing body is in particular fixed to an axial end of the elongated needle body, in particular to that axial end which is provided to face towards the fluid outlet side of the valve assembly or of the fluid injector. The sealing body of the valve needle is spherical, partially spherical and/or partially conical in one embodiment. In another embodiment, the sealing body may be partially planar and/or partially concave.

[0017] In one development, the valve needle comprises at least one retainer, for example an upper retainer and a lower retainer, which is/are arranged in an axial end section of the elongated needle body remote from the sealing body. The retainer(s) extend(s) radially outward from the elongated needle body. The retainer(s) is/are provided in particular for mechanically interacting with the armature of the valve needle assembly. The armature is in particular axially displaceable with respect to the needle body. For example the upper retainer is operable to limit the axial displacement of the armature

relative to the needle body in axial direction away from the sealing body. Alternatively or additionally, the lower retainer may be operable to limit the axial displacement of the armature relative to the needle body in axial direction towards the sealing body. The axial fluid channels preferably extend in direction along the longitudinal axis from the retainer(s) - in particular from the retainer which is furthest away from the sealing body, i.e. in particular the upper retainer - to the sealing body.

[0018] By means of the armature being axially displaceable with respect to the needle body, bouncing of the valve needle may be reduced or avoided by a reduction of the impact energy of the valve needle assembly on a valve seat of the valve assembly by decoupling an armature from the needle. Therefore, a kinetic energy for the impact only originates from the needle, a mass of the armature no longer participates in the impact on the seat.

[0019] In one embodiment, the retainer, at least one of the retainers or each of the retainers is a separate piece which is fixed to the elongated needle body in such fashion that the fluid channels extend through the respective retainer in direction along the longitudinal axis. In this way, an advantageously large hydraulic diameter of the valve assembly is achievable.

[0020] In one embodiment, the valve assembly comprises a flow-restrictive device upstream the needle. In an alternative device, the lower retainer is dimensioned to represent a flow restrictive device. Such a flow-restrictive device is a sort of dynamic brake that is operable to decrease a fuel flow through a main fuel channel in the injector and reduces a needle speed during the closing of the needle. The flow-restrictive device may also be called an "anti-bounce disc". In case the anti-bounce disc is installed, the bouncing effect is smaller but the injector needs more time for closing and a maximum operative pressure of the injector is significantly reduced. With advantage, a satisfactorily small bounce effect is also achievable with embodiments of the valve needle assembly and the valve assembly according to the present disclosure having no such anti-bounce disc.

[0021] In one embodiment, the needle body may be constituted by a plurality of elongated bars rigidly connected to one another at their longitudinal sides, in particular in such fashion that the side faces of each pair of adjacent or adjoining side faces of the bars extend non-parallel to one another. The legs of the cross-section of the valve needle may be constituted by the cross-sections of the elongated bars. A needle body which is made from one piece, may have a shape which is congruent thereto.

[0022] The legs of the multi-legged cross-section of the needle body may be symmetrically arranged. In particular they may be arranged symmetrically with regard to an angle, a centre and/or an axis. I. e. the cross-section of the needle body has an inherent rotational, central and/or axial symmetry.

[0023] In one embodiment, the cross section may be polygon-shaped, for example star-shaped, i.e. in partic-

ular the cross-section may have an outer contour which is a regular non-convex polygon having $2n$ vertices (n of them acute-angled and n obtuse angled) and being invariant to rotations around its center by $360^\circ/n$, n being a natural number greater than 2. In one embodiment, the cross-section of the needle body is Y-shaped, Z-shaped, H-shaped, cross-shaped (sometimes also denoted as X-shaped) or multiple-branch cross-shaped.

[0024] According to one embodiment, the valve needle assembly comprises the valve needle according to at least one of the previously described embodiments and developments and the armature. The armature is displaceable with respect to the needle body in direction along the longitudinal axis. In this way, the armature is mechanically decoupled from the needle body. The needle body may be operable to guide the armature in axial direction. For example, the armature has a central opening through which the needle body of the valve needle extends. Disregarding the retainer(s) - and springs of the valve assembly as the case may be -, the armature may reciprocate along the needle body. The armature is preferably moveable between the upper retainer and the lower retainer on/at the needle body. In one embodiment, the upper retainer is rigidly coupled to the needle body, preferably by laser welding and/or by a press fit, and/or the lower retainer is rigidly coupled to the needle body, also preferably by laser welding and/or by a press fit. Alternatively, for example the upper retainer may be in one piece with the needle body. For example, it may be represented by a collar at an axial end of the needle body.

[0025] The valve assembly comprises a hollow base body, wherein inside the base body the valve needle or the valve needle assembly according to at least one of the above described embodiments and developments is accommodated.

[0026] The valve assembly may comprise an armature spring in one embodiment. The armature of the valve needle assembly may be retained by an armature spring which in turn retains at an inner projection of the base body. In particular, the armature spring may be operable to bias the armature towards the upper retainer by means of one axial end of the armature spring bearing against the armature and an opposite axial end of the armature bearing against the projection of the base body.

[0027] In one embodiment, a fluid passage of the valve assembly is shaped by means of a central cavity of the base body, in which the valve needle and the armature are arranged, and by the fluid channels in the serrated outer surface of the needle body of the valve needle. Other elements such as the armature and/or the retainer(s) may also contribute to shaping the fluid passage through the fluid injector.

[0028] Advantages may result from the fact of mechanically decoupling the armature from the needle body. A weight and consequently an inertia of the valve needle assembly can thereby be reduced by approx. 50%, for example. Further, the remaining 50% of weight and inertia of the valve needle may further be reduced - for

example by approx. 40% - without losing a stiffness of the valve needle, which is of importance in order to avoid buckling. Hence, especially a combination of the presently disclosed needle body and a decoupled armature is of advantage. Such a mass reduction means reduction of impact energy when the valve needle hits its seat, so bouncing becomes so small that it has nearly no or no influence on a behaviour of the injector and therefore of the internal combustion engine. Furthermore, the valve needle body is easy to manufacture and therefore cost-efficient.

[0029] Further advantages and advantageous embodiments and developments of the valve needle, the valve needle assembly, the valve assembly and the fluid injector will become apparent from the exemplary embodiments which are explained below in more detail with reference to the accompanying figures. Elements of the same design and function that appear in different figures (fig.) are identified by the same reference numerals. In the figures:

- Fig. 1 shows an embodiment of a fuel injector according to the state of the art in a central and longitudinal sectional view;
- Fig. 2 shows a graph of a dynamic behaviour of a valve needle according to the state of the art before, during and after an injection of a fluid;
- Fig. 3 shows a valve needle assembly comprising a valve needle according to an exemplary embodiment in a perspective side view; and
- Fig. 4 shows the valve needle assembly of fig. 3 in a longitudinal sectional view.

[0030] In the following description of the drawing, the invention is explained as an application for an injector 1 configured as a gasoline injection valve 1 (cf. fig. 1) for dosing gasoline into an intake manifold or directly into a combustion chamber of an internal combustion engine of a motor vehicle. However, the invention is not restricted to such injectors 1; the invention is also applicable to a diesel injection nozzle of a common-rail injection system or to other injection valves or injectors. An injectable fluid may be a fuel, but it may also be any other kind of fluid such as water, oil or any process liquid; i. e. the invention is not limited to the automotive industry.

[0031] Fig. 1 shows an injection valve 1 suitable for dosing fuel. The injection valve 1 comprises a valve base body 200 (sometimes also denoted as valve body or as nozzle base body) and an inlet tube 400. The inlet tube 400 may also be denoted as a second valve body 400 or as an injector body. The inlet tube 400 may be in one piece (not shown) with a pole piece 320. The valve base body 200 has a central longitudinal axis L or direction L and comprises an outer housing 300 arranged around the injection valve 1. Here, the outer housing 300 is partially arranged at the valve base body 200 and at the inlet tube 400. Further, a radial direction R is shown in fig. 1, the radial direction is perpendicular to the longitudinal

axis L. Furthermore, the valve base body 200 has a circumferential side wall 210 defining a central cavity 212 extending from a fluid inlet side 41 to a fluid outlet side 11 of the valve base body 200.

[0032] The outer housing 300 accommodates an electrical supply connector of the injection valve 1 and houses a bobbin 302 which is provided with a coil of an electromagnetic actuator assembly 30 of the injection valve 1. The electromagnetic actuator assembly 30 further comprises the pole piece 320, an armature 330, an armature spring 332 and a main spring 310.

[0033] In the central cavity 212, a valve needle assembly 10 for opening and closing the fuel outlet side 11 of the injection valve 1 is accommodated. The valve needle assembly 10 comprises a valve needle 100, the armature 330 connected to the valve needle 100 and an upper retainer 130 formed as a collar or sleeve at the valve needle 100 and functioning as a guide for the valve needle 100 in the pole piece 320. Specifically, the upper retainer 130 is mechanically in contact with an inner side of the recess of the pole piece 320 and guides the valve needle 100 in longitudinal direction L.

[0034] The main spring 310 is arranged in a recess provided in the inlet tube 400 (not shown) or in a recess provided in the pole piece 320, wherein the recess is preferably in fluid communication with the central cavity 212. The main spring 310 is coupled to the upper retainer 130. The main spring 310 is arranged and designed to act upon the valve needle 100 via the upper retainer 130 and to move the valve needle 100 into its closed position in longitudinal direction L. A filter element 390 is arranged in the inlet tube 400 and/or the pole piece 320 and forms a further seat for the main spring 310.

[0035] In the closed position of the valve needle 100, a sealing body 120 of the valve needle 100 abuts with a sealing area at a sealing edge of the valve base body 200 of the injection valve 1 in a sealing manner, thereby preventing fuel from being injected through the fuel outlet 11. The sealing edge of the valve base body 200 is preferably part of a valve seat 220 for the sealing body 120. The valve seat 220 further acts as a guidance for the sealing body 120 and comprises at least one orifice (fuel outlet 11) for injecting fuel into a combustion chamber of the internal combustion engine. Accordingly, in an open position of the valve needle 100, fuel may be injected through the orifice of the outlet side 11. The outlet side 11 is in fluid communication with the fuel inlet 41.

[0036] For actuating the injection valve 1, the armature 330 and the valve needle 100 are moveable in a reciprocating manner inside the central cavity 212. The upper retainer 130 is arranged longitudinally adjacent to the armature 330 and is coupled to the valve needle 100 by a rigid joint 132, for example by a laser welding and/or a press fit. Also, the upper retainer 130 and the valve needle 100 or a needle body 100 (see below) of the valve needle 100 may be integrally formed. The armature 330 is longitudinally movable relative to the valve needle 100. A kinetic energy of the moveable armature 330 may be

absorbed by the armature spring 332 below - i.e. downstream - of the armature 330. Here, the armature spring 332 is preferably accommodated in the central cavity 212, as well.

[0037] Fig. 3 and 4 show a valve needle assembly 10 according to an exemplary embodiment of the invention.

[0038] The valve needle assembly 10 comprises a valve needle 100. The valve needle 100 has an elongated needle body 110 which is shaped as a preferably solid rod and extends along a longitudinal axis L. The longitudinal axis L coincides in particular with the longitudinal axis of a valve assembly 20 comprising the valve needle assembly 10 and of a fluid injector 1 comprising the valve assembly 20. The valve assembly 20 according to an exemplary embodiment of the invention comprises the hollow base body 200, wherein inside of the base body 200, in its central cavity 212, the valve needle assembly 10 - for example according to the present exemplary embodiment - is accommodated.

[0039] The needle body 110 has a cross-section 111 which comprises no inner fluid channel, the valve needle 100 is preferably solid, i.e. non-hollow. However, an inner fluid channel may additionally be provided.

[0040] The needle body 110 is combined with or composed of a plurality of elongated bars 112 which are connected to each other at their longitudinal sides. The needle body 110 may be constituted by a plurality of pieces (bars 112) or it may be in one piece, the bars 112 representing different regions of the one, single piece. According to the latter embodiment, the needle body 110 may also be denoted as being integrally formed. Each bar 112 has a cross-section, wherein all cross-sections of the bars 112 of the needle body 110 constitute the multi-legged cross-section 111 of the needle body 110. In the present embodiment, the cross-section 111 of the needle body 110 is constituted by four peripheral legs 114 (not shown) and is cross-shaped. Particularly, one leg 114 merges into an adjacent leg 114 of the cross-section 111 by a concavely rounded transition. This also relates to directly adjacent bars 112 of the needle body 110.

[0041] As can be seen from fig. 3 and 4, a preferred multi-legged cross-section 111 of the needle body 110 approximately has the form of a single cross, sometimes also denoted as a star with four teeth/legs 114 or an "X", wherein all legs 114 of the cross have the same length in the present embodiment. Especially the cross-section 111 is symmetrically with regard to an angle (between two preferably adjacent legs 114), a centre (longitudinal axis L) or an axis (through a leg 114). Further, such a leg 114 or tooth 114 may be referred to as a limb 114, a wing 114, a branch 114, a beam 114 or a tip 114 of the cross-section 111. Furthermore, the cross-section 111 may be regularly or the cross-section 111 or -sections 111 may be irregularly shaped.

[0042] At a lower tip end of the needle body 110, i.e. at an axial end of the needle body 110 which is configured for facing towards the fluid outlet side 11, the valve needle 100 comprises the sealing body 120 which is coupled to

the needle body 110 by a rigid joint 122, for example by laser welding.

[0043] The sealing body 120 is preferably made from a solid body of rotation, such as a ball or a cylinder. The sealing body 120 may be designed as a smooth ball. Further, the sealing body 120 may be partially spherical and/or partially conical. Furthermore, the sealing body 120 may be a partially planar and/or a partially concave sealing body 120. Such a bevelled sealing body 120 comprises at least one facet-surface (planar and/or concave) which serves as a surface for a fluid passage. The valve seat 220 for interacting with the sealing body 120 is preferably free from a fluid channel at an internal side of its guidance section. Therefore, a tip end of the injection valve 1 may be reduced in its diameter which in turn facilitates a packaging in a cylinder head of the internal combustion engine.

[0044] At an upper end section of the needle body 110, i.e. an axial end section remote from the sealing body 120, the valve needle 100 comprises the upper retainer 130. Below and adjacent to the upper retainer 130, the armature 330 is provided and coupled to the needle body 110 in a slidable manner. The armature 330 extends circumferentially around the needle body 110 so that the latter extends through a central opening of the armature 330 in axial direction. Further below (downstream) adjacent to the armature 330, a lower retainer 140, formed as a collar or sleeve, is provided at the needle body 110 and is coupled to the needle body 110 by a rigid joint 142, for example by laser welding. The upper retainer 130 and the lower retainer 140 extend radially outward from the needle body 110. The valve needle 100 and the valve needle assembly 10 are guided relative to the base body 200 by the upper retainer 130 in the stepped central cavity 212 and by the needle body 110 in the valve seat 220. The distance between the upper retainer 130 and the lower retainer 140 is selected larger than the axial extension of the armature 330, so that the armature is axially displaceable between the upper retainer 130 and the lower retainer 140.

[0045] By means of the multi-legged cross section, fluid channels 115 are formed in the outer, circumferential surface 113 of the elongated needle body 110. The fluid channels 115 extend from an axial end of the needle body 110 which is remote from the sealing body 120 in axial direction L to the sealing body 120. Preferably, the fluid channels 115 extend through the upper guide 130 and through the lower guide 114. By means of in each case two of the bars 112 and the concavely curved transition portion between the bars 112, a U-shaped cross-sectional contour of the respective fluid channel 115 is achieved. In this way, the fluid channels 115 represent indentations in an otherwise circular outer contour of the cross-section 111 of the needle body, the circular portions of the outer contour being comprised by radially outward facing ends of the legs 114.

[0046] An axially distributed main flow of fuel through a radial gap between an outer face 113 of the needle

body 110 and the upper retainer 130 and armature 330 allows high efficiency in fuel injection, because the fuel goes straight to the seat 220 without much loss of energy, in contrast to the fuel flowing through the comparatively narrow tubes according to the state of the art injection valves. Further, a friction is reduced between the needle body 110 and the armature 330 thanks to the lubricating fuel reservoir present in the recessed areas (inner outer face 113) of the needle body 110. Furthermore, a reduced press fit force is required during an assembly of the upper retainer 130 on the needle body 110, so that a risk of contamination of the injection valve 1 and buckling of the needle body 110 is reduced.

Claims

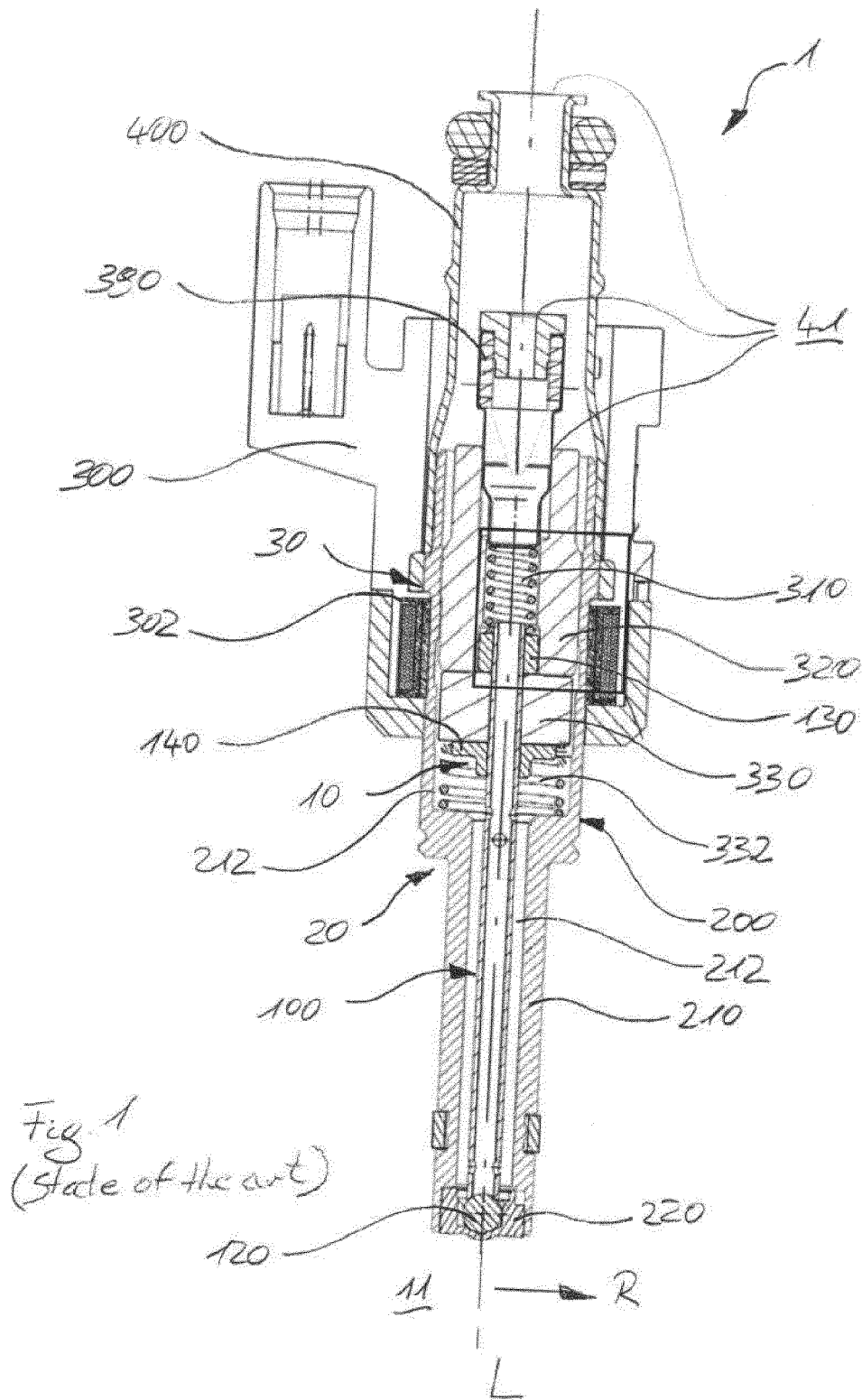
1. Valve needle for a fluid injector (1) for opening and closing a fluid outlet side (11) of the fluid injector (1), wherein the valve needle (100) has an elongated needle body (110), **characterised in that** the elongated needle body (110) is rod-shaped and has a multi-legged (114, 114, ...) cross-section (111).
2. Valve needle according to claim 1, wherein the needle body (110) is elongated along a longitudinal axis (L) and comprises a plurality of axial fluid channels (115) in an outer surface, the fluid channels (115) being formed by means of the multi-legged cross-section (111).
3. Valve needle according to claim 2, wherein one leg (114) of the multi-legged cross-section (111) merges into an adjacent leg (114) by a concavely rounded transition for forming one of the fluid channels (115).
4. Valve needle according to claim 2 or 3, wherein
 - the valve needle (100) comprises a sealing body (120) which is fixed to an axial end of the elongated needle body (110) which is provided to face the fluid outlet side (11)
 - the valve needle (100) comprises at least one retainer (130, 140) which is arranged in an axial end section of the elongated needle body (110) remote from the sealing body (120) and extends radially outward from the elongated needle body (110), and
 - the axial fluid channels (115) extend in direction along the longitudinal axis (L) from the retainer (130, 140) to the sealing body (110).
5. Valve needle according to claim 4, wherein the retainer (130, 140) is a separate piece which is fixed to the elongated needle body (110) in such fashion that the fluid channels (115) extend through the retainer (130, 140) in direction along the longitudinal

axis (L).

6. Valve needle according to any one of the preceding claims, wherein the elongated needle body (110) is not hollow. 5
7. Valve needle according to any one of the preceding claims, wherein the elongated needle body (110) is made from one piece. 10
8. Valve needle according to any one of the preceding claims, **characterised in that** the needle body (110) is constituted by a plurality of elongated bars (112) rigidly connected to one another at their longitudinal sides in such fashion that each leg (114) of the cross-section (111) of the valve needle (100) is constituted by a cross-section of an elongated bar (112) of the needle body (110). 15
9. Valve needle according to any of the preceding claims, **characterised in that** the needle body (110) comprises a solid profile being open towards the outside. 20
10. Valve needle according to any of the preceding claims, **characterised in that** the cross-section (111) of the needle body (110) is Y-shaped, H-shaped, cross-shaped, or polygon-shaped. 25
11. Valve needle assembly for a fluid injector (1) for opening and closing a fluid outlet side (11) of the fluid injector (1), **characterised in that** the valve needle assembly (10) comprises a valve needle (100) according to any one of the preceding claims and an armature (330) which is displaceable with respect to the needle body (100). 30 35
12. Valve needle assembly according to claim 11 comprising the valve needle (100) according to claim 4 or according to any one of claims 5 to 10 in direct or indirect dependence on claim 4, wherein the valve needle (100) comprises an upper retainer (130) and a lower retainer (140), the armature (330) being axially moveable between the upper retainer (130) and the lower retainer (140). 40 45
13. Valve assembly for a fluid injector (1) **characterised in that** the valve assembly (20) comprises a hollow base body (200) and a valve needle assembly (10) according to claim 11 or 12 being accommodated in a central cavity (210) of the base body (200) . 50
14. Valve assembly according to claim 13 comprising the valve needle (100) according to claim 2 or according to any one of claims 3 to 10 in direct or indirect dependence on claim 2, **characterised in that** a fluid passage (210, 113) of the valve assembly (20) is formed by means of the central cavity (210) and 55

the axial fluid channels (115) of the elongated needle body (110).

15. Fuel injector for an intake manifold or an internal combustion engine of a motor vehicle, **characterised in that** the fuel injector (1) comprises a valve needle (100) according to any of claims 1 to 10, a valve needle assembly (10) according to claim 11 or 12, or a valve assembly (20) according to claim 13 or 14.



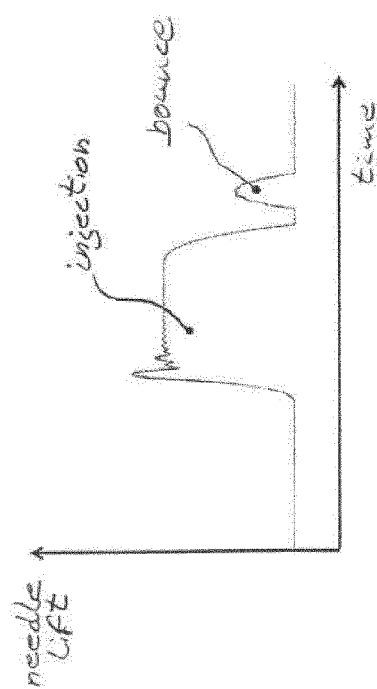
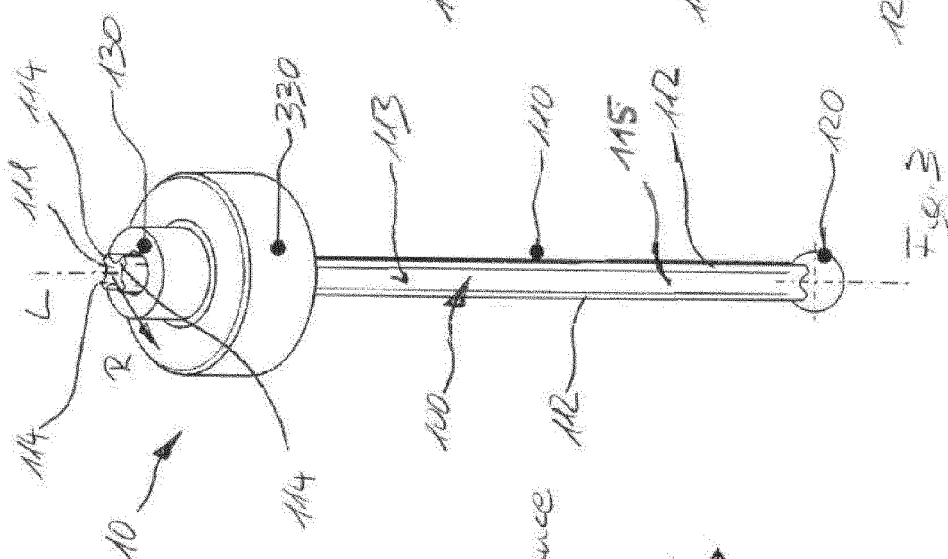
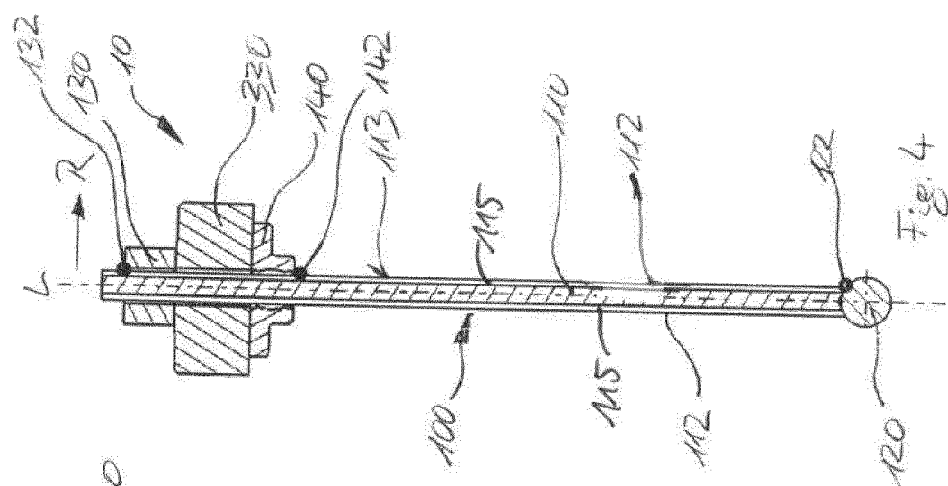


Fig. 2
(State of the art)



EUROPEAN SEARCH REPORT

Application Number
EP 13 16 7954

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	US 5 820 031 A (REITER FERDINAND [DE] ET AL) 13 October 1998 (1998-10-13)	1-10	INV.
Y	* abstract; figures 1,2,3,4,5,6,9,10 *	11-15	F02M51/06
	* claim 1 *		F02M61/04
	* claims 2,3 *		
	* claim 5 *		
	* claims 6-8 *		
	* column 1, line 39 - line 49 *		
	* column 1, line 53 - line 62 *		
	* column 3, line 5 - line 7 *		
	* column 3, line 48 - line 53 *		
	* column 4, line 11 - line 12 *		
	* column 4, line 65 - column 5, line 6 *		
	* column 1, line 11 - line 15 *		
	* column 4, line 12 - line 16 *		
	* column 3, line 18 - line 21 *		
	* column 1, line 34 - line 38 *		
	* column 3, line 35 - line 39 *		
	* column 4, line 16 - line 18 *		
	* column 1, line 32 - line 34 *		

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Application Number
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