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(54) Title: FLUID INJECTION VALVE

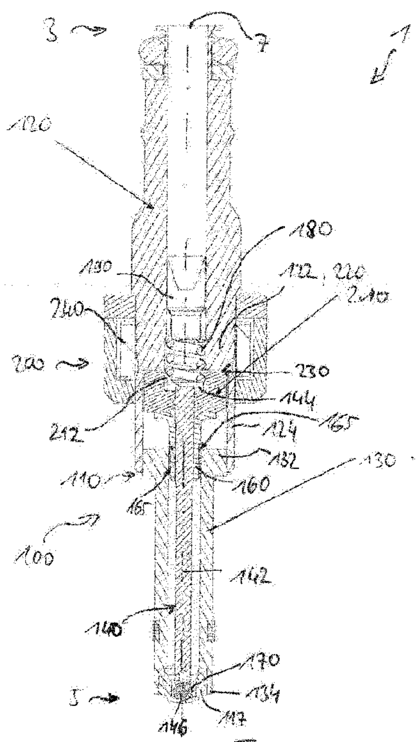

Fig. 1

(57) Abstract: A fluid injection valve (1) is disclosed. It comprises a valve assembly (100) with a tubular valve body (110) and a valve needle (140) and an electromagnetic actuator assembly (200) with a moveable core (210). The tubular valve body (110) comprises a one-pieced upper part with a pole portion positioned axially subsequent to the moveable core (210) in direction towards the fluid inlet end (3), and with a connection portion (124) axially projects beyond the moveable core (210) in direction towards the fluid outlet end (5). The tubular valve body (110) comprises a one-pieced lower part (130) in which the valve needle (140) is received. The valve needle (140) and/or the valve body (110) comprise first (160) and second (170) guide elements for axially guiding the valve needle (140) with respect to the lower part (130) of the valve body (110).

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Description

Fluid injection valve

The present disclosure relates to a fluid injection valve.

A fluid injection valve is disclosed, for example, in EP 1789673 B1.

It is an object of the present disclosure to specify a fluid injection valve which is particularly simple and/or cost-effective and/or which permits easy assembly of its constituent parts.

This object is achieved by a fluid injection valve according to claim 1. Advantageous embodiments and developments of the fluid injection valve are specified in the dependent claims, in the following description and in the figures.

A fluid injection valve is specified. It has a valve assembly and an electromagnetic actuator assembly. In a preferred embodiment, the fluid injection valve is a fuel injection valve, which is in particular configured for injecting fuel directly into a combustion chamber of an internal combustion engine.

The valve assembly comprises a tubular valve body which hydraulically connects a fluid inlet end of the fluid injection valve to a fluid outlet end of the fluid injection valve. The valve body has a longitudinal axis. In particular, the valve body extends along the longitudinal axis from the fluid inlet end to the fluid outlet end.

Further, the valve assembly has a valve needle for controlling fluid flow through the fluid outlet end. In particular, the valve needle cooperates with a valve seat of the valve body for sealing and unsealing an injection hole at the fluid outlet end of the fluid injection valve. Preferably, the valve needle is in sealing mechanical contact with the valve seat in a closing position for preventing fluid flow out of the fluid injection valve through the injection hole and is axially displaceable relative to the valve body for establishing a gap between the valve needle and the valve seat to enable fluid flow through the injection hole.

The electromagnetic actuator assembly comprises a moveable core, a stationary core and a coil. The coil is in particular a solenoid. The moveable core can also be denoted as an armature. The moveable core is axially displaceable relative to the stationary core. In particular, it is attracted towards the stationary core when the coil is energized.

The moveable core is positioned in the valve body and axially displaceable relative to the valve body with respect to the longitudinal axis of the valve body. The moveable core is operable to interact with the valve needle for moving the valve needle away from the fluid outlet end. For example, the moveable core is operable to engage in a form fit connection with the valve needle for taking the valve needle with it when it moves in axial direction away from the fluid outlet end.

The valve body comprises a one-pieced upper part and a one-pieced lower part.

The expression “one-pieced” means in the present context that the respective part (i.e. the upper part or the lower part) is not assembled from a plurality of parts which are connected to one another during the manufacturing process of the respective part. Rather, the respective part is a single workpiece or made from a single workpiece.

The upper part and the lower part are separate pieces. The upper part and the lower part are in particular connected to one another during assembly of the valve assembly. In particular, the upper part is shaped and configured such that it can be connected to the lower part subsequently to assembling the lower part, the valve needle and the moveable core.

The one-pieced upper part comprises a pole portion and a connection portion. The pole portion represents the stationary core of the electromagnetic actuator assembly. In particular, the moveable core is attracted towards the pole portion when the coil of the electromagnetic actuator assembly is energized.

The pole portion is positioned axially subsequent to the moveable core in direction towards the fluid inlet end. The connection portion follows the pole portion in direction towards the fluid outlet end. It laterally surrounds the moveable core and axially projects beyond the moveable core in direction towards the fluid outlet end.

The one-pieced lower part extends from the upper part to the fluid outlet end. It has a first axial end which is fluid-tightly connected to the connection portion of the upper part, for example by means of a ring weld. The first axial end of the lower part may be shifted into the connection portion of the upper part or vice versa.

The lower part further has a second axial end adjacent to the fluid outlet end. In particular, the lower part either comprises the valve seat adjacent to the second axial end or the valve body comprises a seat body which is directly and fluid-tightly connected to the lower part at its second axial end.

Expediently, the valve needle is received in the lower part. In an expedient embodiment, the valve needle projects axially beyond the lower part in direction towards the fluid inlet end, in particular so that an upper end of the valve needle axially overlaps the upper part of the valve body. The upper end of the valve needle is in particular the axial end of the valve needle which is remote from the fluid outlet end and, thus, from the valve seat.

Further, the valve needle and/or the valve body comprise first and second guide elements for axially guiding the valve needle with respect to the lower part of the valve body. The first guide element is positioned adjacent to the first axial end of the lower part. The second guide element is positioned adjacent to the second axial end of the lower part.

With advantage, the number of components of the fluid injection valve may be particularly small. The lower part with the valve needle and the moveable core can advantageously be pre-assembled before connecting to the upper part. The subassembly which comprises the valve needle and the moveable core projects from the lower part even in the assembled state so that the subassembly is particularly easily accessible for shifting into the lower part. This allows for precise guiding of the valve needle for mounting the guide elements. In addition, axial guidance of the valve needle may be particularly precise and may involve only a small number of components in the tolerance chain.

Further, when the lower part is connected to the upper part during assembly of the fluid injection valve, the needle guides are already properly assembled. This may reduce the requirements on tolerances during connection of the upper and lower parts of the valve body. Press-fitting of a complexly shaped pole piece into the valve body is also not necessary.

In one embodiment, the first guide element is a guiding sleeve which is fixed to a shaft of the valve needle. For example, the guiding sleeve is press-fitted and/or welded to the shaft. Preferably, the guiding sleeve is in sliding mechanical contact with the lower part of the valve body in the region of its first axial end. With advantage, such construction is particularly simple, lightweight and cost-effective. In one development, the guiding sleeve laterally overlaps the moveable core and is operable to limit axial displacement of the moveable core relative to the valve needle in direction towards the fluid outlet end, in particular by engaging into a form-fit connection. In this way, the guiding sleeve has a double function which may further help to reduce the number of parts.

In one embodiment, the first guide element comprises axial fluid channels. In this way, axial fluid flow along the first guide element towards the fluid outlet end may be enabled in particularly simple fashion.

In one embodiment, the second guide element is comprised by the seat body. Preferably, the valve needle has a sealing element, for example a sealing ball, which is fixed to the shaft of the valve needle at its axial end facing towards the fluid outlet end. The second guide element is preferably in sliding mechanical contact with the sealing element. Further axial fluid channels may be provided in the sealing element and/or in the seat body for enabling fluid flow along the second guide element to the valve seat.

In one embodiment, the moveable core projects axially beyond the valve needle in direction towards the fluid inlet end. For example, the upper end of the valve needle is positioned in a recess of the moveable core. In this way, the valve needle does in particular not project into the pole portion of the upper part of the valve body. Therefore, no tolerance requirements have to be observed between the upper portion of the valve body and the valve needle during assembly and operation of the fluid injection valve.

In an expedient embodiment, the fluid injection valve further comprises a return spring. The return spring is operable to bias the valve needle towards the fluid outlet end. It is in particular seated against the upper end of the valve needle. Further, the fluid injection valve preferably comprises a calibration tube. The calibration tube is in particular operable to preload the return spring. One end of the return spring expediently bears against the calibration tube. The calibration tube is press-fitted into the upper part of the valve body, preferably into the pole portion.

In one embodiment, an end of the return spring remote from the calibration tube – this is in particular the end of the return spring which bears on the valve needle – projects axially beyond the pole portion in direction towards the fluid outlet end. This configuration may be particularly insensitive to tolerances.

In one embodiment, the spring rate of the return spring and the electromagnetic actuator assembly are adapted to one another in such fashion that a fluid filled axial gap is maintained between the pole portion of the valve body and the moveable core throughout the operation of the fluid injection valve. In other words, the moveable core does not hit the stationary core and is not held in form-fit connection with the stationary core or with another hard stop while the fluid injection valve is held at rest in a fully open position for dispensing fluid. With advantage, anti-wear coatings of the pole portion and/or the moveable core can be omitted in this way.

The fluid injection valve may expediently comprise a fluid port at the fluid inlet end for feeding fluid into the valve body, in particular from a fluid rail. In one embodiment, the fluid port is comprised by the one-pieced upper part of the valve body. In this way, a particularly low number of parts is achievable. As an alternative, the fluid port may be comprised by a separate fluid inlet tube. The separate fluid inlet tube can be manufactured particularly lightweight and cost-effective.

Further advantages, advantageous embodiments and developments of the fluid injection valve will become apparent from the exemplary embodiments which are described below in association with the figures.

In the figures:

Figure 1 shows a longitudinal section view of a fluid injection valve according to a first exemplary embodiment and

Figure 2 shows a longitudinal section view of a fluid injection valve according to a second exemplary embodiment.

In the exemplary embodiments and figures, similar, identical or similarly acting elements are provided with the same reference symbols. In some figures, individual reference symbols may be omitted to improve the clarity of the figures.

Figure 1 shows a fluid injection valve 1 according to a first exemplary embodiment in a longitudinal section view. The fluid injection valve 1 of this embodiment is a fuel injection valve which is configured for injection fuel - such as gasoline - directly into the combustion chamber of an internal combustion engine. The fluid injection valve 1 comprises a valve assembly 100 and an electromagnetic actuator assembly 200.

The valve assembly 100 comprises a valve body 110 which has a cavity that extends along a longitudinal axial L of the valve body 110 from a fluid inlet end 3 to a fluid outlet end 5 of the fluid injection valve 1. The valve body 110 is composed of a one-pieced upper part 120, a one-pieced lower part 130 and an – in particular also one-pieced – seat body 170.

The upper part 120 comprises a fluid inlet port 7 of the fluid injection valve 1 at its axial end region adjacent to the fluid inlet end 3. In the opposite axial end region, the upper part is fixedly and fluid-tightly connected to a first axial end 132 of the lower part 130. In the present embodiment, the first axial end 132 of the lower part 130 is shifted into the connection portion 124 of the upper part 120 of the valve body 110. A fluid-tight connection between these parts may be achieved by a ring weld, for example.

From its first axial end 132, the lower part 130 extends further in direction towards the fluid outlet end 5 where it has a second axial end 132. The seat body 110 is fluid-tightly and fixedly connected to the lower part 130 in the region of the second axial end 134. Specifically, the seat body 117 is shifted into the lower part 130 at the second axial end 134 in the present embodiment.

Further, the valve assembly 100 has a valve needle 140. The valve needle 140 has an upper end 144 facing towards the fluid inlet end 3 and a sealing element 164 adjacent to the fluid outlet end 5. A shaft 142 of the valve needle 140 extends from a flange portion of the valve needle 140 at the upper end 144 to the sealing element 146. The flange portion radially protects beyond the shaft 142 at the upper end 144 of the valve needle 140.

The valve needle 140 is received in the lower part 130 of the valve body 110 and projects in an axial direction towards the fluid inlet 3 beyond the lower part 130 into the upper part 120. Thus, the upper end 144 of the valve needle 140 is axially displaced towards the fluid inlet end 3 with respect to the lower part 130 of the valve body 110.

The seat body 117 comprises a valve seat of the valve assembly 100 which mechanically interacts with the sealing element 146 of the valve needle 140 for controlling fluid flow through an injection hole. The injection hole is also comprised by the seat body 117 and is positioned downstream of the valve seat.

In a closing position, the sealing element 146 of the valve needle 140 is in sealing mechanical contact with the valve seat to prevent fluid flow through the injection hole. The valve needle is axially displaceable relative to the valve body in direction towards the fluid inlet end 3 so that a gap is established between the sealing element 146 and the valve seat to enable fluid flow through the injection hole.

The electromagnetic actuator assembly 200 comprises a moveable core 210 and a stationary core 220. The stationary core 220 is positionally fix relative to the valve body 110 and the moveable core 210 is axially displaceable in reciprocating fashion relative to the valve body 110. Further, the electromagnetic actuator assembly 200 comprises a coil, specifically a solenoid 40, for generating a magnetic field that attracts the moveable core 210 towards the stationary core 220. The solenoid 40 is positioned outside of the valve body 110 and circumferentially surrounds the upper part 120.

The moveable core 210 mechanically interacts with the valve needle for moving the valve needle 140 away from the fluid outlet end 5, away from the closing position. Specifically, the upper end 144 of the valve needle 140 is positioned in a recess 212 of the moveable core 210 so that the moveable core 210 axially projects beyond the upper end 144 of the valve needle 140 in axial direction towards the fluid inlet end 3. The shaft 142 of the valve needle 140 extends through a central opening of the moveable core 210 from the recess 212 towards the fluid outlet end 5 and beyond the moveable core 210.

The moveable core 210 is operable to engage into a form-fit connection with the valve needle 140. Specifically, the form-fit connection is established between the flange at the upper end 144 of the valve needle 140 and the bottom surface of the recess 212 of the moveable core 210. In this way, the moveable core 210 is operable to take the valve needle 140 with it in direction towards the fluid inlet end 3 when it moves in this direction towards the stationary core 220.

The one-pieced upper part 120 of the valve body 110 comprises a pole portion 122 which represents the stationary core 220 of the actuator assembly 200 and a connection portion 124 which follows the pole portion 122 in direction towards the fluid outlet end 5. At the interface between the pole portion 122 and the connection portion 124, a step is shaped in an inner circumferential surface of the valve body 110, which inner circumferential surface defines the cavity, so that the cross-sectional area of the cavity widens at the step in direction towards the fluid outlet end 5.

The pole portion 122 is positioned axially subsequent to the moveable core 210 in direction towards the fluid inlet end 3. By means of the step, a radially extending contact surface of the pole portion 122 is formed, which faces towards the moveable core

210. The contact surface may represent a hard stop which limits axial displaceability of the moveable core 210 in direction towards the fluid inlet end 3 by means of engagement into a form-fit connection. The connection portion 124 laterally surrounds the moveable core 210 and axially projects beyond the moveable core in direction towards the fluid outlet end 5.

Further, the valve assembly 100 comprises a return spring 180. The return spring 180 is positioned in the cavity of the valve body 110 such that it axially overlaps the pole portion 122 of the upper part 120 of the valve body 110. Specifically, one end of the return spring 180 is seated against a calibration tube 190 which is press-fitted into the pole portion 122 of the upper part 120.

The opposite axial end of the return spring 180 protrudes from the pole portion 122 in axial direction towards the fluid outlet end 5 and is received in the recess 112 of the moveable core 210 where it bears on the flange at the upper end 144 of the valve needle 140.

By means of the calibration tube 190, which in some developments may comprise a fluid filter, the return spring 180 is preloaded. In this way, it is operable to bias the valve needle 140 in direction towards the fluid outlet end 5. In this way, the return spring 180 is operable to move the valve needle 140 into the closing position and to retain it in the closing position when the actuator unit 200 is de-energized.

In one embodiment, the return spring 180 and the actuator assembly 200 are configured such that the electromagnetic force generated by the actuator assembly 200 exceeds the spring force of the return spring 180 when the valve assembly 100 is held at rest in a stable fully open position after the opening transient. In this embodiment, movement of the moveable core 210 in direction towards the stationery core 220 is stopped by a hard stop such as the contact surface of the pole portion 122.

In another embodiment, the spring rate of the return spring 180 and the electromagnetic actuator assembly 200 are adapted to one another in such fashion, that a fluid filled axial gap 230 is maintained between the contact surface of the pole portion 122 and the moveable core 210 throughout the operation of the fluid injection valve, in particular also when the valve assembly is held at rest in a stable fully opened position after the opening transient. In this embodiment, specifically the spring force generated by the return spring 180 and the electromagnetic force generated by the actuator assembly 200 cancel one another when the valve assembly 100 is in the fully open position. Thus, in this embodiment, the armature is spaced apart from any hard stops which are positionally fix relative to the valve body 110, in the fully open position. In particular it is axially spaced apart from the contact surface of the pole portion 122. In this way, the armature is free to oscillate around its fully open position in both axial directions. With advantage, wear between the mutually facing contact surfaces of the pole portion 122 and the moveable core 210 is avoided or is at least last particularly small.

In the present embodiment, the moveable core 210 is also axially displaceable relative to the valve needle 140. Axial displaceability of the moveable core 210 relative to the valve needle 140 in direction towards the upper end 144 of the valve needle 140 is limited by the flange of the valve needle at the upper end 144.

On the side of the moveable core 210 opposite of the stationary core 220, the valve needle comprises a first guide element 160 which is rigidly fixed to the shaft 142 of the valve needle 140. The first guide element 160 has a double function. Firstly, it is operable to limit the axial displaceability of the moveable core 210 relative to the valve needle 140 in direction towards the sealing element 146. Secondly, it is in sliding mechanical contact with the lower part 130 of the valve body 110 in the region of the first axial end 132 of the lower part 130 for axially guiding the valve needle 140.

The first guide element 160 has a generally rotational symmetric shape with an L-shaped cross-section. The L-shaped cross-section has a long leg which is elongated in axial direction and abuts the shaft 142 and a short leg which extends radially outward from the long leg at the side of the first guide element 160 facing towards the moveable core 210. The long leg of the guide element 160 is fixed to the shaft 142 of the valve needle 140.

Axial displacement of the moveable core 210 in direction towards the sealing element 146 is stopped by form fit connection with a surface of the short leg of the L-shape. In the region of this short leg, the first guide element 160 is positioned in the connection portion 124 of the upper part 120 of the valve body 110. The long leg extends from there into the lower part 130 so that in particular an end region of the long leg axially overlaps the first axial end 132 of the lower part 130 to establish the sliding mechanical contact. At least in the region where the first guide element 160 overlaps the lower part 130 of the valve body 110, fluid channels 165 may be provided - in particular in an outer circumferential surface of the first guide element 160 - to guarantee sufficient axial fluid flow along the first guide element 160 through the lower part 130 to the fluid outlet end 5 of the fluid injection valve 1.

A second guide element 170 is positioned adjacent to the second axial end 132 of the lower part 130 of the valve body 110. In the present embodiment, the second guide element 170 is comprised by the seat body 117. Specifically, the seat body 117 has an inner circumferential surface which is in sliding mechanical contact with the sealing element 146 of the valve needle 140. By means of the sliding mechanical contact of the valve needle 140 with the lower part 130 of the valve body 110, tilting of the valve needle relative to the longitudinal axis L is prevented or at least largely limited.

Figure 2 shows a fluid injection valve 1 according to a second exemplary embodiment in a longitudinal section view. The fluid injection valve 1 according to the second exemplary embodiment corresponds in general to that of the first embodiment.

However, the fluid inlet portion 7 is not comprised by the one-pieced upper portion 120 of the valve body 110 which comprises the pole portion 122. Instead, the valve body 110 comprises an additional fluid inlet tube 115 which comprises the fluid inlet port 7 at one axial end and is fluid-tightly fixed to the pole portion 122 of the upper part 120 at its opposite axial end.

The invention is not limited to specific embodiments by the description on basis of these exemplary embodiments. Rather, it comprises any combination of elements of different embodiments. Moreover, the invention comprises any combination of claims and any combination of features disclosed by the claims.

Claims

1. Fluid injection valve (1) having a valve assembly (100) and an electromagnetic actuator assembly (200), wherein
- the valve assembly (100) comprises a tubular valve body (110) which hydraulically connects a fluid inlet end (3) of the fluid injection valve (1) to a fluid outlet end (5) of the fluid injection valve (1) and a valve needle (140) for controlling fluid flow through the fluid outlet end (5),
- the electromagnetic actuator assembly (200) comprises a moveable core (210), the moveable core (210) being positioned in the valve body (210) and being axially displaceable relative to the valve body (110) with respect to a longitudinal axis of the valve body (110) for moving the valve needle (140) away from the fluid outlet end (5),
- the tubular valve body (110) comprises a one-pieced upper part (120) and a one-pieced lower part (130) which are separate pieces,
- the upper part (120) comprises
-- a pole portion, the pole portion (122) representing a stationary core (220) of the electromagnetic actuator assembly (200) and being positioned axially subsequent to the moveable core (210) in direction towards the fluid inlet end (3) and
-- a connection portion (124) which follows the pole portion (122) in direction towards the fluid outlet end (5), laterally surrounds the moveable core (210) and axially projects beyond the moveable core (210) in direction towards the fluid outlet end (5),
- the lower part (130) extends from the upper part (120) to the fluid outlet end (5), has a first axial (132) end which is fluid-tightly connected to the connection portion (124) of the upper part (120) and has a second axial end (134) adjacent to the fluid outlet end (5),
- the valve needle (140) is received in the lower part (130), and
- the valve needle (140) and/or the valve body (110) comprise first (160) and second (170) guide elements for axially guiding the valve needle (140) with respect to the lower part (130) of the valve body (110), the first guide element (160) being positioned adjacent to the first axial end (132) of the lower part

(130) and the second guide element (170) being positioned adjacent to the second axial end (134) of the lower part (130).

2. Fluid injection valve (1) according to the preceding claim, wherein the upper part (120) is shaped and configured such that it can be connected to the lower part (130) subsequently to assembling the lower part (130), the valve needle (140) and the moveable core (210).

3. Fluid injection valve (1) according to one of the preceding claims, wherein the first axial end (132) of the lower part (130) is shifted into the connection portion (124) of the upper part (120) or vice versa.

4. Fluid injection valve (1) according to one of the preceding claims, wherein the first axial (132) end of the lower part (130) is fluid-tightly connected to the connection portion (124) of the upper part (120) by means of a ring weld.

5. Fluid injection valve (1) according to one of the preceding claims, wherein the valve needle (140) projects axially beyond the lower part (130) in direction towards the fluid inlet end (3) into the upper part (120).

6. Fluid injection valve (1) according to one of the preceding claims, wherein the first guide element (160) is a guiding sleeve which is fixed on a shaft (142) of the valve needle (140) and is in sliding mechanical contact with the first axial end (132) of the lower part (130) of the valve body (110).

7. Fluid injection valve (1) according to the preceding claim, wherein the first guide element (160) comprises axial fluid channels.

8. Fluid injection valve (1) according to one of the preceding claims, wherein the moveable core (210) projects axially beyond the valve needle (140) in direction towards the fluid inlet end (3).

9. Fluid injection valve (1) according to the preceding claim, wherein an upper end (144) of the valve needle (140) is positioned in a recess (212) of the moveable core (210).

10. Fluid injection valve (1) according to one of the preceding claims, further comprising a return spring (180) for biasing the valve needle (140) towards the fluid outlet end (5) and a calibration tube (190), wherein the calibration tube (190) is press-fitted into the upper part (120) and one end of the return spring (180) bears against the calibration tube (190).

11. Fluid injection valve (1) according to the preceding claim, wherein an end of the return spring (180) remote from the calibration tube (190) projects axially beyond the pole portion (122) in direction towards the fluid outlet end (5).

12. Fluid injection valve (1) according to one of the preceding claims 10 and 11, wherein the spring rate of the return spring (180) and the electromagnetic actuator assembly (200) are adapted to one another in such fashion that a fluid filled axial gap (230) is maintained between the pole portion (122) and the moveable core (210) throughout the operation of the fluid injection valve (1).

13. Fluid injection valve (1) according to one of the preceding claims, further comprising a fluid port (7) at the fluid inlet end (3) for feeding fluid into the valve body (11), wherein the fluid port (7) is comprised by the one-pieced upper part (120) of the valve body (110).

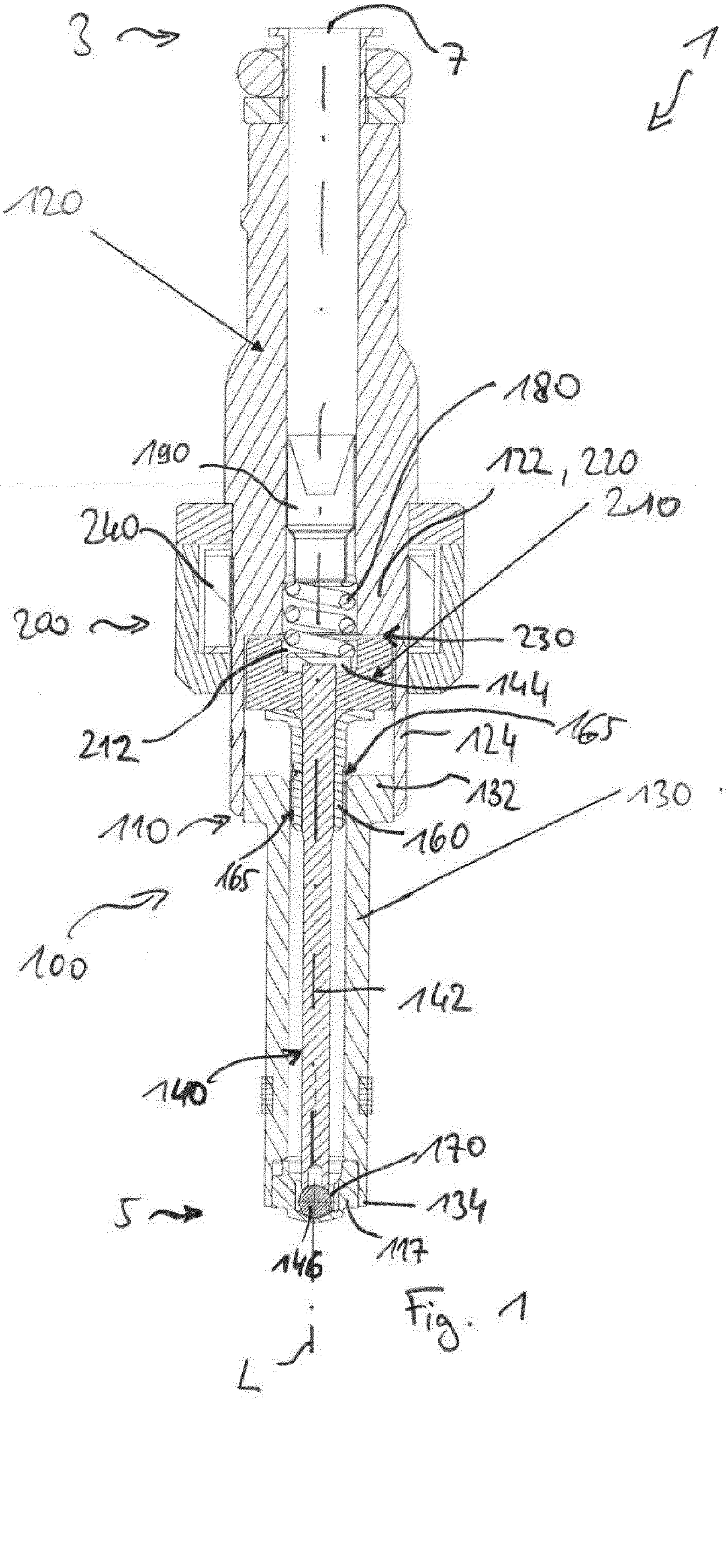
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Fig. 1

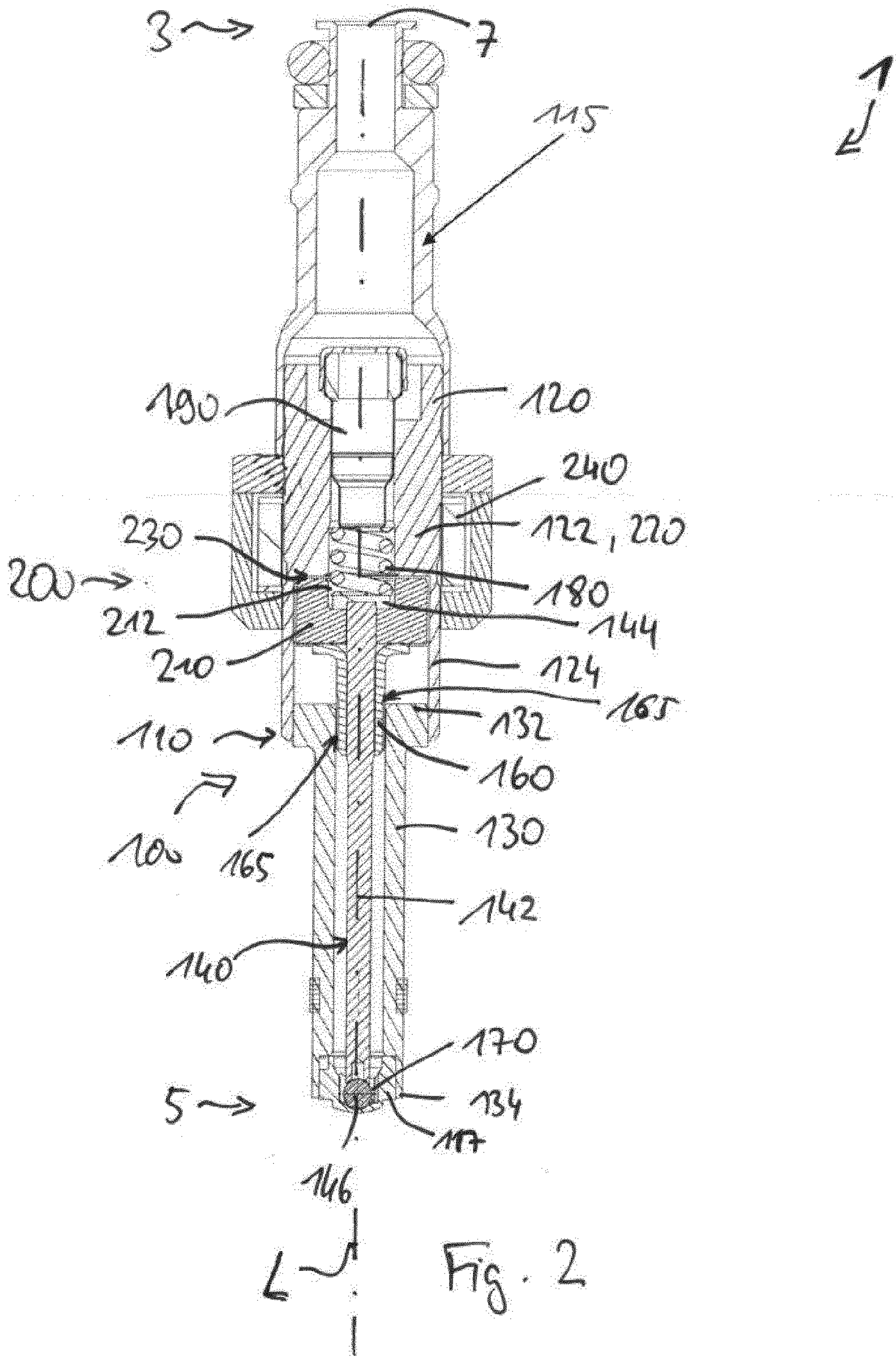
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Fig. 2