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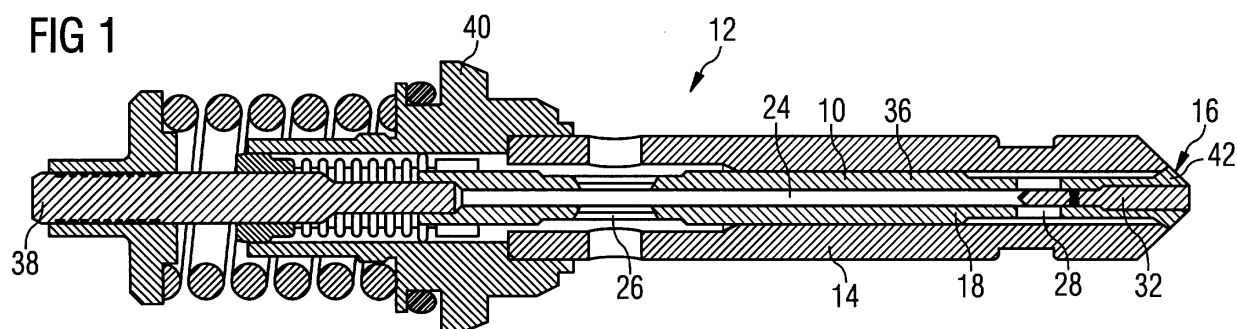
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(54) **Valve needle, metering device, and method of calibrating a metering device**

(57) A hollow valve needle (10) that provides a fluid passage (24) is provided for an injection valve (12). The valve needle (10) comprises fluid entrance openings (26) and fluid exit openings (28). Between these openings (26, 28) a cylindrical section (36) is located for providing a close sliding fit of the valve needle in the valve

cartridge (14). At the plunger end of the valve needle, a calibration means (32), e. g. a pin or a screw, can be inserted, and the free fluid path through the fluid exit openings (28) can be influenced in dependence of the insertion depth of the calibration means (32). Thereby, a calibration of the injection valve (12) is possible without further manipulation of the injection valve (12).



Description

[0001] The present invention relates to a valve needle for a high-pressure fuel injector, in which axial movement of the valve needle in a valve cartridge controls opening and closing of a metering opening of the injector for dosing a fluid, comprising a valve needle body section that is formed for providing a fluid passage from an upstream portion of the valve needle to a downstream portion of the valve needle.

[0002] The present invention further relates to a combination of a valve needle and a calibration means.

[0003] The present invention still further relates to a metering device for dosing pressurized fluids, particularly an injection valve for a fuel injection system in an internal combustion engine.

[0004] The present invention further relates to a method of calibrating and metering device.

[0005] Prior art valve needles for use in high-pressure direct injection gasoline engines provide a fluid passage between the valve needle and the valve cartridge, as can be seen for example in EP 1 046 809 A2. In order to ensure a proper operation of the injector, it is necessary to guide the valve needle during its axial movement inside the cartridge. According to prior art, this is achieved by defining guide elements surrounding the valve needle body and providing a close sliding fit of the valve needle in the cartridge.

[0006] Due to the guiding elements the free flow path of the injector is reduced and the problem of spray asymmetries is a general issue. Further, since the valve needle is only guided by the guide elements which provide a limited sliding area that can contact the cartridge, insufficient guiding can probably lead to a deteriorating of the performance of the injection valve.

[0007] Another aspect related to high-pressure direct injection valves concerns calibration of these valves. According to prior art, the injector calibration operation is usually performed by adjusting the position of a thermal compensator or by changing a preload of the valve spring. These calibration techniques are quite cumbersome, in particular, since a disassembling and re-assembling of the injection valve might become necessary.

[0008] It is an object of the present invention to provide a valve needle, equipment associated therewith and a method of calibrating a metering device so that the problems related to the guiding of the valve needle and the calibrating of the valve needle are reduced or overcome.

[0009] The above object is achieved by subject matter of the independent claims.

[0010] Advantageous embodiments of the invention are disclosed in the dependent claims.

[0011] The present invention improves the valve needle according to prior art in that at least a part of the valve needle body section is hollow so that a fluid passage through the valve needle is provided, the valve

needle body section provides at least one fluid entrance opening in the upstream portion of the valve needle for fluid entering the fluid passage through the valve needle and at least one fluid exit opening in the downstream portion of the valve needle for fluid leaving the fluid passage through the valve needle, and an axially extending opening in the downstream portion of the valve needle into which a calibration means can be inserted, the calibration means sealing the axially extending opening and influencing the fluid passage through the valve needle in dependence of an insertion depth of the calibration means. Since the fluid to be dosed can be transported through the hollow valve needle body section, there are no more restrictions with respect to the guiding of the valve needle by providing a close sliding fit to the cartridge. Furthermore, since the calibration means are inserted into an axially extending opening that is accessible in a completely assembled state of the injector, a convenient calibration process can be performed.

[0012] Particularly, it is advantageous that the calibration means comprises a calibration pin with sealing means for sealing the axially extending opening. The pin can be inserted in different depths into the axially extending opening, so that the influence on the flow passage can be adjusted. In order to seal the axially extending opening during the calibration process so that no fluid can leave the hollow valve needle body section through the axially extending opening, a sealing means is provided. The sealing means can also contribute to the sealing of the axially extending opening after calibration, i. e. in the completely assembled state of the injector.

[0013] In another preferred embodiment, the calibration means comprises a calibration screw with sealing means for sealing the axially extending opening. By using a screw, the calibration process can be performed in a very convenient and precise way, since the insertion depth can be varied precisely by turning the screw.

[0014] According to an advantageous embodiment of the valve needle according to the present invention, the sealing means comprises an o-ring sitting on the calibration means. An o-ring is a commercially available component which ensures sufficient sealing, in particular during the calibration process.

[0015] In a further preferred embodiment, the calibration means can be welded to the valve needle. Due to this welding, a precise insertion depth of the calibration means into the axially extending hole is conserved. Further, the welding can seal the axially extending opening hermetically.

[0016] In the valve needle according to the present invention, it is preferred that the calibration means influences a free flow path through the at least one fluid exit opening in the downstream portion of the valve needle. Thus, the flow passage through the valve needle is only influenced in the exit region, which is sufficient in order to calibrate the amount of fluid leaving through the at least one fluid exit opening.

[0017] Moreover, in a preferred embodiment of the valve needle according to the present invention, the valve needle comprises at least one cylindrical section as a valve needle guide inside the cartridge. Prior art valve needles are provided with guiding elements that build only part of the outer surface of the guiding length of the valve needle, since the rest of the outer surface has to be in a certain distance to the cartridge in order to provide a flow passage. According to the present invention, it is possible to realize the guiding by a close sliding fit between a cylindrical section and the cartridge. This improves the guiding, and the valve needle can be shorter than according to prior art.

[0018] According to an advantageous embodiment, a further valve needle body section is provided that is solid and mounted to an upstream end of the hollow valve needle body section. Thus, the part of the valve needle that is not needed for fluid passage purposes is realized in a solid manner as according to prior art.

[0019] Furthermore, it is advantageous that the at least one fluid entrance opening and/or the at least one fluid exit opening comprise one or more holes and/or slots. Such holes and slots are easy to manufacture, and the fluid path through an axially extending slot in the wall of the hollow needle can be ideally influenced by a longitudinal calibration means, e. g. a pin or a screw.

[0020] The present invention is further realized by a combination of a valve needle according to the present invention and a calibration means that can be inserted into an axially extending opening in the downstream portion of the valve needle, the calibration means sealing the axially extending opening and influencing the fluid passage through the valve needle in dependence of an insertion depth of the calibration means. Such a combination of a valve needle and calibration means exhibits the same advantages and particularities as stated above in connection with the valve needle according to the present invention. This also applies to the preferred embodiments of the combination as stated below.

[0021] In particular, the combination is favorable in that the calibration means comprises a calibration pin with sealing means for sealing the axially extending opening.

[0022] Furthermore, the combination is particularly advantageous in that the calibration means comprises a calibration screw with sealing means for sealing the axially extending opening.

[0023] Further, in an advantageous combination of a valve needle and a calibration means, the sealing means comprises an o-ring sitting on the calibration means.

[0024] Further, according to a preferred embodiment of the combination of a valve needle and a calibration means, the calibration means can be welded to the valve needle.

[0025] Moreover, the combination of the valve needle and the calibration means is particularly advantageous in that the calibration means influences a free flow path

through the at least one fluid exit opening in the downstream portion of the valve needle.

[0026] Further, the present invention is realized by a metering device for dosing pressurized fluids, particularly an injection valve for a fuel injection system in an internal combustion engine, comprising a valve cartridge, and the combination of a valve needle and a calibration means according to the present invention. Thus, a metering device is provided that is advantageous due to the improvements and particularities of the valve needle according to the present invention and the combination of a valve needle and a calibration means according to the present invention.

[0027] Another aspect of the present invention is a method of calibrating a metering device according to the present invention, the method comprising the steps of inserting the calibration means into the axially extending opening in the downstream portion of the valve needle, observing the amount of fluid that is ejected by the injection valve, when the metering opening is opened, adjusting the insertion depth of the calibration means until a desired amount of fluid is ejected, when the metering opening is opened, and fastening the calibration means to the valve needle. Due to this calibration method the injector can be completely and finally mounted before calibration. Only the calibration means has to be inserted and no further changes to the injector set up are necessary in order to ensure a correct calibration.

[0028] It is particularly advantageous that fastening the calibration means to the valve needle comprises welding. Thereby a hermetically sealing of the axially extending opening in the valve needle is achieved.

[0029] Thus, the present invention provides a solution by which a new guiding concept of the valve needle inside the cartridge is realized and that allows a very precise and convenient calibration process. The tubular valve needle is less expensive than valve needles according to prior art, and the valve needle can be shorter than before. The injector can be flushed through the axially extending opening so that the seat zone of the valve needle has not to be used for flushing. The hollow valve needle body section provides the possibility to insert a screen filter inside the needle and/or to insert an anti-bounce device inside the needle. As an additional effect, the fluid path inside the needle provides a cooling, so that the thermal expansion of the needle is reduced.

[0030] The invention, both its construction and its method of operation together with additional objects and advantages thereof, will best be understood from the following description of specific embodiments when read in connection with the accompanying drawings, wherein

Figure 1 is a cross sectional view of a metering device according to the present invention;

Figure 2 is an exploded side elevational view of a valve needle according to the present invention;

Figure 3 is a cross sectional view of a valve needle according to the present invention and of a calibration means used in a combination of a valve needle and a calibration means according to the present invention;

Figure 4 is a cross sectional view of a combination of a valve needle and a calibration means according to the present invention; and

Figure 5 is a flow chart illustrating a preferred embodiment of a calibration method according to the present invention.

[0031] In the following description of preferred embodiments of the present invention, the same reference numbers refer to similar or comparable components.

[0032] Figure 1 is a cross sectional view of a metering device according to the present invention. The injection valve 12 comprises of a valve cartridge 14 that is mounted to a valve body 40. Inside the cartridge 14 and the valve body 40, a valve needle 10 is arranged. The valve needle 10 ends with a plunger 42 for closing and opening a metering opening 16. A valve needle body section 18 is hollow so that a fluid passage 24 is provided inside the valve needle 10. Fluid entrance openings 26 allow fluid to enter into the fluid passage 24, and fluid exit openings 28 allow fluid to leave the fluid passage 24. The valve needle 10 comprises of an axially extending opening 30 (cf. Figure 3) that is located at the plunger end of the valve needle 10. Into this axially extending opening, a calibration pin 32 is inserted so as to influence the free fluid path through the fluid exit openings 28. The valve needle 10 comprises a cylindrical section 36 providing a close sliding fit of the valve needle 10 in the cartridge 14. It is possible to provide this cylindrical section 36, because the fluid passage 24 is inside in the valve needle 10 and not between the valve needle 10 and the cartridge 14. The valve needle 10 further comprises a solid valve needle body section 38 that is mounted to an upstream portion of the hollow valve needle body section 18.

[0033] Figure 2 is an exploded side elevational view of a valve needle according to the present invention and Figure 3 is a cross sectional view of a valve needle according to the present invention and of a calibration means used in a combination of a valve needle and a calibration means according to the present invention. Figure 2 illustrates how the fluid entrance openings 26 and the fluid exit openings 28 are provided. The fluid entrance openings 26 are provided as elongated slots in an upstream portion 20 of the valve needle 10. The fluid exit openings 28 are provided as elongated slots in a downstream portion 22 of the valve needle 10. The calibration pin 32 comprises of several sections with different diameters, thereby providing the possibility of pulling an o-ring 34 over the calibration pin 32. This o-ring 34 seals the fluid passage 24 at least during the

calibration procedure.

[0034] Figure 4 is a cross sectional view of a combination of a valve needle and a calibration means according to the present invention. The valve needle 10 is shown in a similar manner as in Figure 1 without the further injector components.

[0035] Figure 5 is a flow chart illustrating a preferred embodiment of a calibration method according to the present invention. After assembling the injector valve with the hollow valve needle 10 (S01) the calibration pin 32 is inserted into the axially extending opening 30 of the valve needle 10 (S02). The valve needle 10 is operated and the amount of fluid that is ejected through the metering opening 16 is observed (S03). On the basis of this amount of fluid observed, the insertion depth of the calibration pin 32 is adjusted until a desired amount of fluid is ejected (S04). Thereafter, the calibration pin 32 is welded to the valve needle (S05).

[0036] The present invention can be summarized as follows: A hollow valve needle 10 that provides a fluid passage 24 is provided for an injection valve 12. The valve needle 10 comprises fluid entrance openings 26 and fluid exit openings 28. Between these openings 26, 28 a cylindrical section 36 is located for providing a close sliding fit of the valve needle in the valve cartridge 14. At the plunger end of the valve needle, a calibration means 32, e. g. a pin or a screw, can be inserted, and the free fluid path through the fluid exit openings 28 can be influenced in dependence of the insertion depth of the calibration means 32. Thereby, a calibration of the injection valve 12 is possible without further manipulation of the injection valve 12.

[0037] The features disclosed in the foregoing description, in the drawings, and in the claims may alone as well as in any possible combination be important for the realization of the invention.

Claims

1. A valve needle (10) for a high-pressure fuel injector (12), in which axial movement of the valve needle (10) in a valve cartridge (14) controls opening and closing of a metering opening (16) of the injector (12) for dosing a fluid, comprising a valve needle body section (18) that is formed for providing a fluid passage from an upstream portion (20) of the valve needle (10) to a downstream portion (22) of the valve needle (10)

characterized in that

- at least a part of the valve needle body section (18) is hollow so that a fluid passage (24) through the valve needle (10) is provided,
- the valve needle body section (18) provides at least one fluid entrance opening (26) in the upstream portion (20) of the valve needle (10) for

- fluid entering the fluid passage (26) through the valve needle (10) and at least one fluid exit opening (28) in the downstream portion (22) of the valve needle (10) for fluid leaving the fluid passage (24) through the valve needle (10), and
- an axially extending opening (30) in the downstream portion (22) of the valve needle (10) into which a calibration means (32) can be inserted, the calibration means (32) sealing the axially extending opening (30) and influencing the fluid passage through the valve needle (10) in dependence of an insertion depth of the calibration means (32).
2. The valve needle according to claim 1, **characterized in that** the calibration means (32) comprises a calibration pin with sealing means (34) for sealing the axially extending opening (30).
 3. The valve needle according to claim 1, **characterized in that** the calibration means comprises a calibration screw with sealing means for sealing the axially extending opening.
 4. The valve needle according to claim 2 or 3, **characterized in that** the sealing means (34) comprises an o-ring sitting on the calibration means (32).
 5. The valve needle according to any of the preceding claims, **characterized in that** the calibration means (32) can be welded to the valve needle (10).
 6. The valve needle according to any of the preceding claims, **characterized in that** the calibration means (32) influences a free flow path through the at least one fluid exit opening (28) in the downstream portion (22) of the valve needle (10).
 7. The valve needle according to any of the preceding claims, **characterized in that** the valve needle comprises at least one cylindrical section (36) as a valve needle guide inside the cartridge (14).
 8. The valve needle according to any of the preceding claims, **characterized in that** a further valve needle body section (38) is provided
- that is solid and mounted to an upstream end of the hollow valve needle body section (18).
9. The valve needle according to any of the preceding claims, **characterized in that** the at least one fluid entrance opening (26) and/or the at least one fluid exit opening (28) comprise one or more holes and/or slots.
 10. A combination of
 - a valve needle (10) according to any of the preceding claims and
 - a calibration means (32) that can be inserted into an axially extending opening (28) in the downstream portion (22) of the valve needle (10), the calibration means (32) sealing the axially extending opening (28) and influencing the fluid passage through the valve needle (10) in dependence of an insertion depth of the calibration means (32).
 11. The combination according to claim 10, **characterized in that** the calibration means (32) comprises a calibration pin with sealing means (34) for sealing the axially extending opening (30).
 12. The combination according to claim 10, **characterized in that** the calibration means comprises a calibration screw with sealing means for sealing the axially extending opening.
 13. The combination according to claim 11 or 12, **characterized in that** the sealing means (34) comprises an o-ring sitting on the calibration means (32).
 14. The combination according to any of claims 10 to 13, **characterized in that** the calibration means (32) can be welded to the valve needle (10).
 15. The combination according to any of claims 10 to 14, **characterized in that** the calibration means influences a free flow path through the at least one fluid exit opening (28) in the downstream portion (22) of the valve needle (10).
 16. A metering device for dosing pressurized fluids, particularly an injection valve (12) for a fuel injection system in an internal combustion engine, comprising

- a valve cartridge (14), and
- the combination of a valve needle (10) and a calibration means (32) according to any of claims 10 to 15.

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17. A method of calibrating a metering device according to claim 16, the method comprising the steps of

- inserting the calibration means (32) into the axially extending opening (30) in the downstream portion (22) of the valve needle (10), 10
- observing the amount of fluid that is ejected by the injection valve (12), when the metering opening (16) is opened, 15
- adjusting the insertion depth of the calibration means until a desired amount of fluid is ejected, when the metering opening (16) is opened, and 20
- fastening the calibration means (32) to the valve needle (10) .

18. The method according to claim 17

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characterized in that

fastening the calibration means to the valve needle (10) comprises welding.

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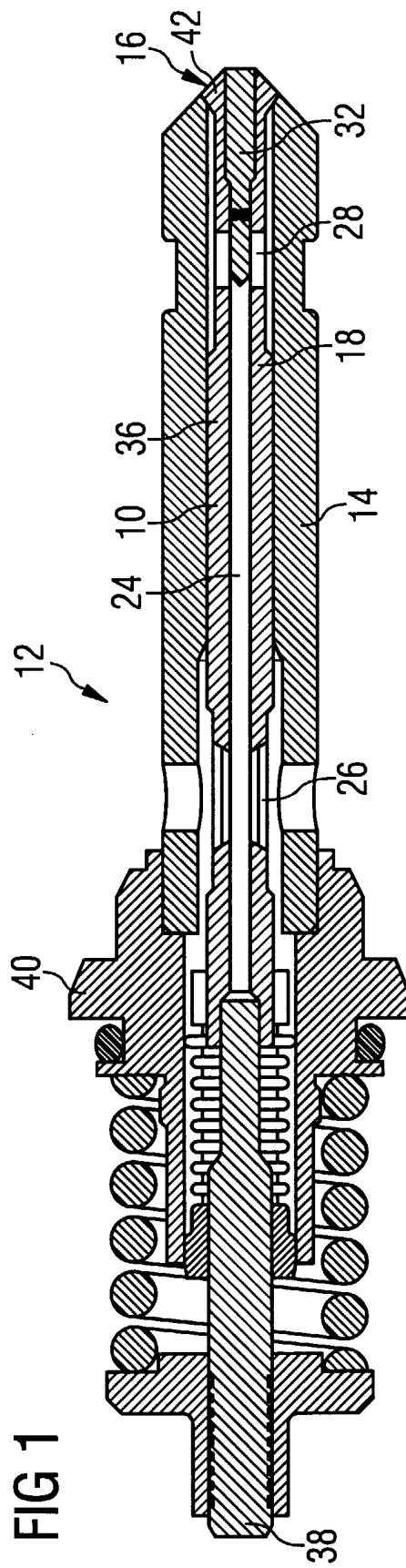


FIG 2

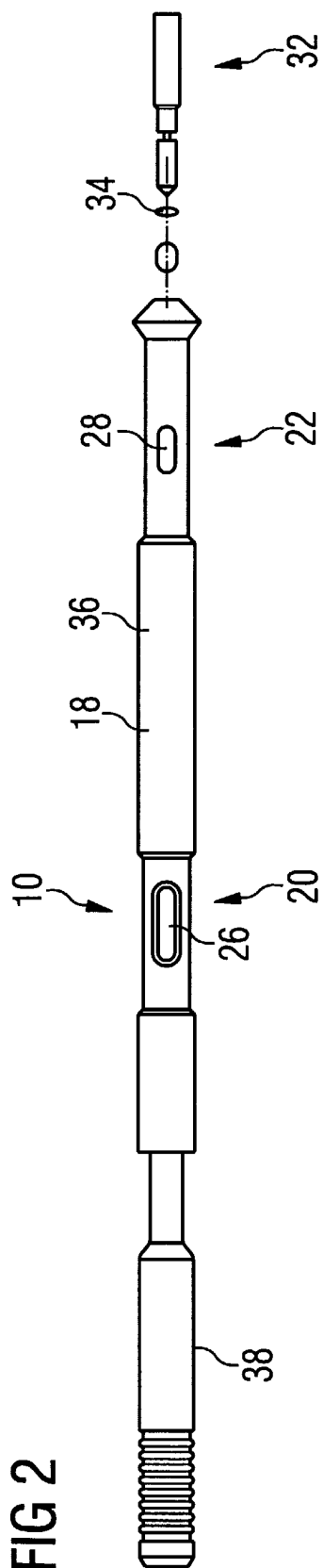


FIG 3

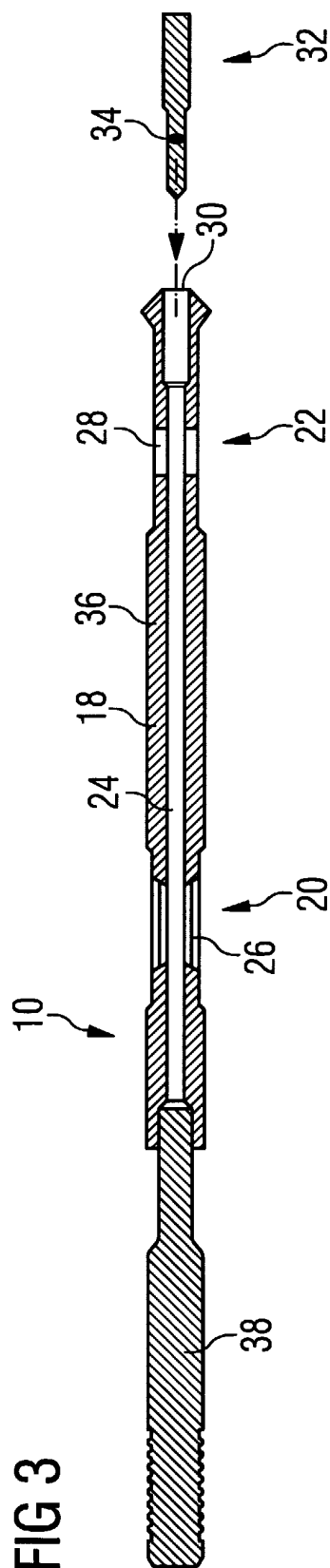


FIG 4

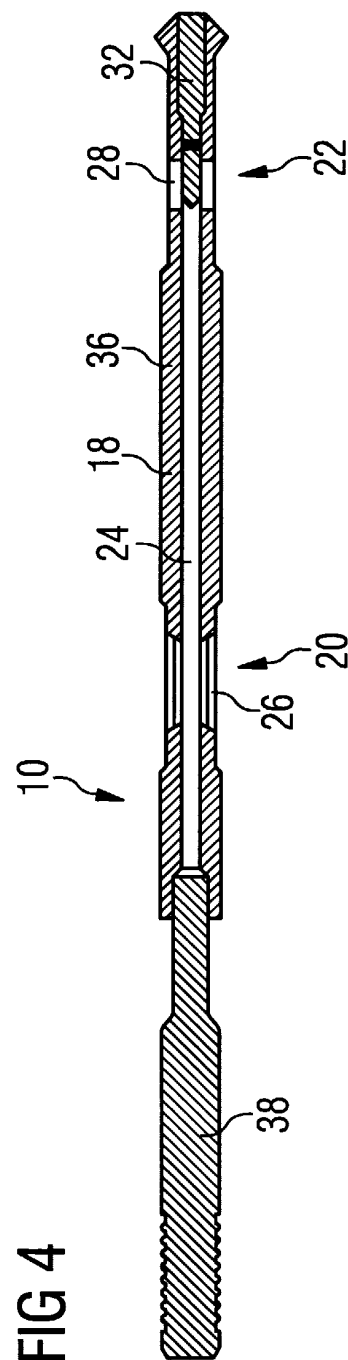
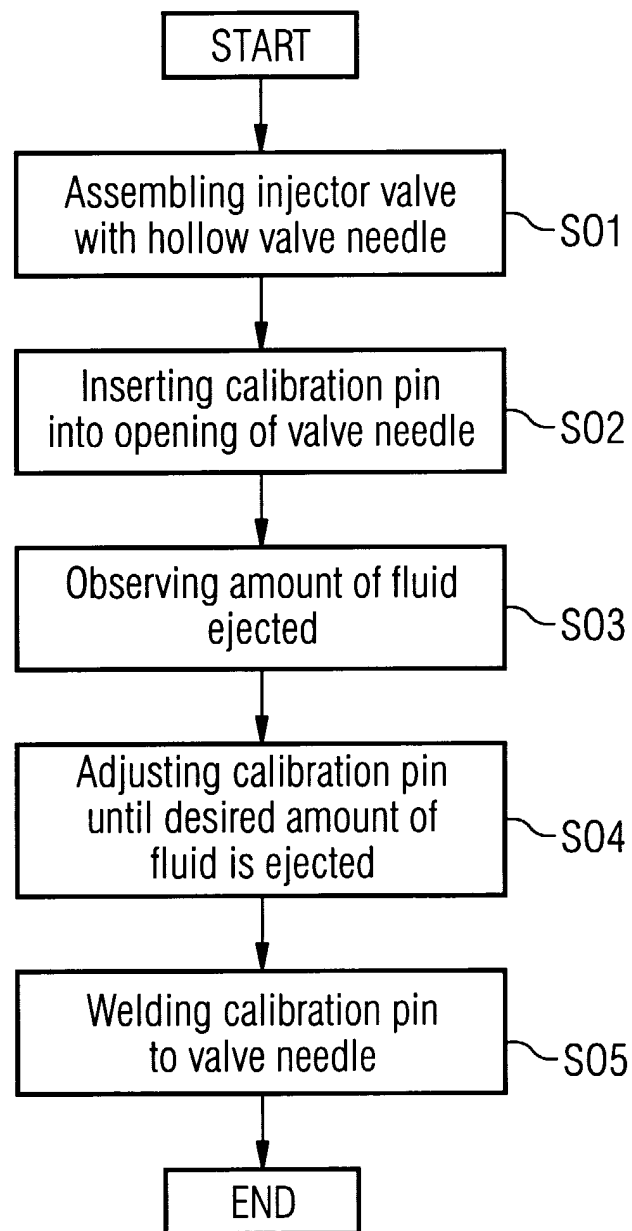


FIG 5





European Patent
Office

EUROPEAN SEARCH REPORT

Application Number
EP 03 01 2437

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The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 9 October 2003	Examiner Blanc, S
CATEGORY OF CITED DOCUMENTS		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	
X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document			

EPO FORM 1503 03.82 (P04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT
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EP 03 01 2437

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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