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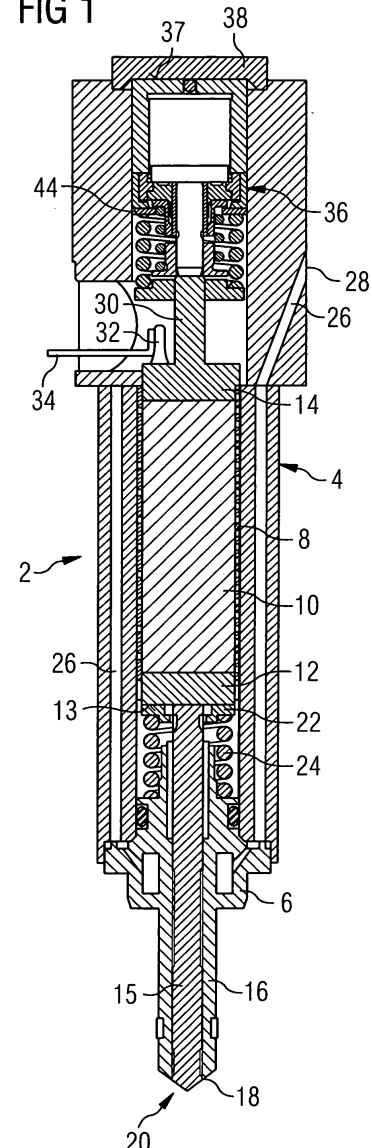
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(54) **Injector for dosing fluid and method for assembling the injector**

(57) An injector (2) for dosing fluid comprises an injector body (4) having a recess (8) and an injection nozzle (18) at a tip (20) of the injector body (4). A needle (15) is arranged in the recess (8) of the injector body (4) movable in axial direction. The needle (15) prevents a fluid flow through the injection nozzle (18) in a closed position of the needle (15) and otherwise enables the fluid flow through the injection nozzle (18). An actor arrangement is arranged in the recess (8) of the injector body (4) and coupled to the needle (15) at a first axial end (13) of the actor arrangement for moving the needle (15). The actor arrangement is coupled with the injector body (4) at a second axial end (37) of the actor arrangement in such a way that the second axial end (37) is fixed relative to the injector body 4. Further, the actor arrangement comprises a piezo-actuator (10) and a calibration shim (44) for calibrating the injector (2).

FIG 1



Description

[0001] The invention relates to an injector for dosing fluid. The injector comprises an injector body, an injection nozzle, and a needle. The injector body has a recess. An injection nozzle is formed at a tip of the injector body. The needle is arranged in the recess of the injector body movable in axial direction. The needle prevents a fluid flow through the injection nozzle in a closed position of the needle and otherwise enables the fluid flow through the injection nozzle.

[0002] Because of stringent laws for pollution emissions of combustion engines, especially of combustion engines for cars, a modern injector has to enable the dosing of fluid in a very precise way. For this reason in general, the injector is calibrated before it is finally assembled. In general, the calibration of the injectors is complicated and time- and cost-consuming. However, without the calibration the injector is not able to dose the fluid in such a precise way as the stringent laws stipulate.

[0003] It is an object of the present invention to create an injector and a method for assembling the injector which enable a precise dosing of fluid by the injector in a simple way.

[0004] The object of the invention is achieved by the features of independent claims 1 and 4. Advantageous embodiments of the invention are given in the subclaims.

[0005] The invention is distinguished concerning a first aspect of the invention by an injector for dosing fluid. The injector comprises an injector body, an injection nozzle, a needle and an actor arrangement. The injector body has a recess. The injection nozzle is formed at a tip of the injector body. The needle is arranged in the recess of the injector body movable in axial direction. The needle prevents a fluid flow through the injection nozzle in a closed position of the needle and otherwise enables the fluid flow through the injection nozzle. The actor arrangement is arranged in the recess of the injector body. The actor arrangement is coupled to the needle at a first axial end of the actor arrangement for moving the needle. Further, the actor arrangement is coupled with the injector body at a second axial end of the actor arrangement in such a way that the second axial end is fixed relative to the injector body. The actor arrangement comprises a piezo-actuator and a calibration shim for calibrating the injector.

[0006] The calibration shim simply enables a calibration of the injector. This is especially advantageous, if the injector is calibrated by measuring a fluid flow of fluid dosed by the injector and by determining a thickness of the calibration shim dependent on the measured fluid flow. The simple calibration of the injector contributes to a very precise calibration. The very precise calibration contributes to a very precise dosing of fluid by the injector in a simple way.

[0007] Preferably, the second axial end of the actor arrangement is fixed relative to the injector body by preventing a movement of the second axial end away from

the needle and by applying a force on the actor arrangement in direction away from the needle, for example through the needle spring.

[0008] In an advantageous embodiment of the first aspect of the invention the actor arrangement comprises a compensation assembly for compensating a different thermal expansion of the piezo-actuator and of the injector body. The piezo-actuator is coupled to the compensation assembly in axial direction. If the injector body expands differently with rising temperature relative to the piezo-actuator, the compensation assembly assures a proper coupling of the piezo-actuator with the needle. The coupling of the piezo-actuator and the needle may be achieved hydraulically and/or mechanically.

[0009] In a further advantageous embodiment of the first aspect of the invention the calibration shim is arranged between a first spring and a supporting element of the compensation assembly for supporting the first spring. This enables to increase the axial length of the actor arrangement by the calibration shim in a very simple way. The increasing of the length of the actor arrangement enables the calibration of the injector dependent on the thickness of the calibration shim.

[0010] The actor arrangement comprises the actor, the calibration shim, and it may comprise the compensation assembly. The calibration shim may be alternatively coupled to the actor arrangement at the first or the second axial end of the actor arrangement. Alternatively, the calibration shim may be arranged between the piezo-actuator and the compensation assembly.

[0011] The invention is distinguished concerning a second aspect of the invention by a method for assembling the injector. The actor arrangement is inserted into the recess of the injector body without the calibration shim. The actor arrangement is coupled with the needle at the first axial end of the actor arrangement. The second axial end of the actor arrangement is provisionally fixed relative to the injector body. Fluid is dosed with the injector in a given way. A fluid flow of the fluid dosed by the injector is measured. A thickness of the calibration shim is determined dependent on the measured fluid flow. The fixation of the second axial end of the actor arrangement relative to the injector body is severed. The calibration shim with the determined thickness is added to the actor arrangement in such a way that an axial length of the unloaded actor arrangement is increased by the calibration shim. The second axial end of the actor arrangement is coupled to the injector body and the recess of the injector body is closed. The second axial end of the actor arrangement is coupled to the injector body in such a way that the second axial end of the actor arrangement is fixed relative to the injector body.

[0012] This enables to calibrate the injector in a very simple way. This contributes to a low cost assembling of the injector and to a very precise dosing of fluid by the injector in a simple way.

[0013] The unloaded actor arrangement means in this context that no load is applied on the actor arrangement

in axial direction. However, the parts of the actor arrangement are coupled to each other in such a way that they are in direct contact with each other.

[0014] Further, a first axial end of the piezo-actuator may be representative for the first axial end of the actor arrangement and a first axial end of the compensation assembly may be representative for the second axial end of the actor arrangement. Alternatively, the first axial end of the compensation assembly may be representative for the first axial end of the actor arrangement and the first axial end of the piezo-actuator may be representative for the second axial end of the actor arrangement.

[0015] In an advantageous embodiment of the second aspect of the invention the actor arrangement is inserted into the recess of the injector body by inserting the piezo-actuator and the compensation assembly into the recess of the injector body. The piezo-actuator is coupled to the compensation assembly in axial direction by fixing a spring washer of the compensation assembly to a pin of the piezo-actuator. This contributes to a simple assembling of the actor arrangement. Further, this enables a short axial length of the actor arrangement and so a short axial length of the injector. The short axial length of the injector may contribute to a low cost production of the injector and to a space-saving arrangement of the injector in the internal combustion engine.

[0016] In a further advantageous embodiment of the invention the piezo-actuator is connected to an electric circuitry before the spring washer is fixed to the pin of the piezo-actuator. The piezo-actuator is connected to the electric circuitry for driving the piezo-actuator. This contributes to the simple dosing of fluid by the injector.

[0017] In a further advantageous embodiment of the second aspect of the invention the recess of the injector body is closed by rigidly coupling the second axial end of the actor arrangement with the injector body. This contributes very effectively to the easy assembling of the injector.

[0018] The invention is explained in the following with the aid of schematic drawings.

[0019] These are as follows:

figure 1 an injector,

figure 2 a detailed view of the injector according to Figure 1,

figure 3 a compensation assembly,

figure 4 a relieving device for the compensation assembly, and

figure 5 a flowchart for assembling the injector.

[0020] Elements with the same design or function that appear in the different illustrations are identified by the same reference characters.

[0021] An injector 2 (figure 1) for dosing fluid comprises

an injector body 4 with a recess 8, a valve body 6, and an actor arrangement. The injector 2 may be used for dosing fuel into a combustion chamber of an internal combustion engine. In this embodiment, the injector 2 is of an outward opening type. In an alternative embodiment, the injector 2 may be of an inward opening type.

[0022] The actor arrangement at least comprises a piezo-actuator 10 and a calibration shim 44. Preferably, the actor arrangement comprises a compensation assembly 36.

[0023] The valve body 6 has a recess 16 of the valve body 6. The recess 16 of the valve body 6 contains a needle 15 movable in axial direction. A needle spring 24 is arranged circumferential an axial section of the needle 15. In axial direction, the needle spring 24 is arranged intermediate the valve body 6 and a needle spring washer 22. The valve body 6 forms a first needle spring rest and the needle spring washer 22 forms a second needle spring rest for the needle spring 24. The needle spring 24 is formed and arranged in such a way that the needle spring 24 is preloaded and in that way the needle 15 is pressed from the outside against the valve body 6 via the needle spring washer 22 and so the needle 15 is in its closed position.

[0024] The needle spring washer 22 is coupled to the piezo-actuator 10 via a ground plate 12 of the piezo-actuator 10. The piezo-actuator 10 is coupled to the compensation assembly 36 via a top plate 14 of the piezo-actuator 10. Preferably, the ground plate 12 of the piezo-actuator 10 comprises a first axial end 13 of the actor arrangement. The first axial end 13 of the actor arrangement is coupled to the needle 15.

[0025] The injector 2 further comprises a fluid inlet 28 for connecting the injector 2 to an external fluid line. A fluid line 26 of the injector 2 may be formed in the injector body 4 of the injector 2 by forming the injector body 4 double-tube-shaped and by guiding the fluid between the inner and the outer tube of the double-tube-shaped injector body 4.

[0026] Whether the needle 15 is in its closed position or not depends on a force balance. A first force on the needle 15 in closing direction of the needle 15 is applied by the needle spring 24. A second force on the needle 15 against the closing direction of the needle 15 may be applied on the needle 15 by the piezo-actuator 10. A third force on the needle 15 may be applied on the needle 15 by the fluid in the recess 16 of the valve body 6.

[0027] If the piezo-actuator 10 gets energized, it may change its axial length in a time range of about some microseconds. If a force acts on the compensation assembly 36 that fast, the compensation assembly 36 reacts like a stiff body. In that way, the force applied by the piezo-actuator 10 is transferred to the needle spring washer 22 and/or the needle 15. In that way, the piezo-actuator 10 is able to force the needle 15 away from the compensation assembly 36 and away from the closed position of the needle 15. If the needle 15 is not in its closed position, there is an opening formed between the

needle 15 and the valve body 6 at an injector tip 20 of the injector 2 facing away from the piezo-actuator 10. This opening forms the injection nozzle 18 of the injector 2.

[0028] The piezo-actuator 10 gets energized via a terminal 34 which is electrically coupled to a connector 32. Preferably, the piezo-actuator comprises at least one further connector 32 which is coupled to a further terminal 34. The piezo-actuator 10 gets energized by applying a given voltage on the connector 32.

[0029] The compensation assembly 36 comprises a relieving device and a compensation device 42 (figure 2). If the injector body 4 of the injector 2 changes its axial length, for example, because of an increasing temperature of the injector body 4, there is a slowly changing force applied on the compensation assembly 36 relative to the time range in which the piezo-actuator 10 may change its axial length, if the piezo-actuator 10 gets energized. If the slowly changing force is applied on the compensation assembly 36, the compensation assembly 36 is able to change its axial length and in that way is able to compensate the different thermal expansion of the injector body 4 and of the piezo-actuator 10.

[0030] For example, the compensation device 42 comprises a cup-shaped compensation body 49 and a piston 50 (figure 3). The piston 50 comprises a piston head and a piston rod 54. The cup-shaped compensation body 49 is preferably sealed by a membrane 53 of the compensation device 42. The piston 50 separates a first working volume 51 from a second working volume 57. Further, the first working volume 51 is bordered by a bottom portion of the first compensation body 50. The first working volume 51 hydraulically communicates with the second working volume 57, preferably, via a clearance between the piston 50 and an inner wall of the cup shaped compensation body 49 and/or the first working volume 51 hydraulically communicates with the second working volume 57 via a fluid line 55 of the piston 50. The fluid line 55 of the piston 50 may comprise, for example, a throttle, a check valve, and/or a control valve. Preferably, the bottom portion of the cup-shaped compensation body 49 comprises a second axial end 37 of the actor arrangement. The position of the second axial end 37 relative to the injector body 4 is fixed. Preferably, the second axial end 37 is fixed relative to the injector body 4 by sealingly welding a closing body 38 to the injector body 4 and by the force which acts on the actor arrangement because of the needle spring 24.

[0031] The clearance, the fluid line 55 of the piston 50, the throttle, the check valve, and/or the control valve are formed and arranged in such a way that the piston 50 is moved towards the bottom portion of the cup-shaped compensation body 49, if the slowly changing force in axial direction is applied on the piston 50, for example, because of the different thermal expansion of the injector body 4 and the piezo-actuator 10. In that way, a fluid in the first working volume 51 is pressed through the clearance and/or, respectively, through the fluid line 55 of the

piston 50 to the second working volume 57 and then, the piston 50 moves towards the bottom portion of the cup-shaped compensation body 49 for compensating the fluid flow in the compensation device 42. In this way, the compensation device 42 is able to compensate the different thermal expansion of the injector body 4 and of the piezo-actuator 10.

[0032] If there is the fast changing force applied on the piston 50, the fluid in the first working volume 51 is not able to flow fast enough to the second working volume 57 and the cup-shaped compensation body 49 and the piston 50 are not able to move relative to each other. In this way, the whole compensation device 42 acts like the stiff body.

[0033] The relieving device comprises a relieving body 40. The relieving body 40 comprises a ground plate and at least one transferring element 66 (figure 4). The relieving device further comprises a relieving ring 56, a first spring 46, and a relieving spring washer 48.

[0034] Preferably, the ground plate has a spherical shape. The transferring element 66 extends from an outer area of the ground plate parallel to an axis of the compensation assembly 36 towards the relieving ring 56. The relieving ring 56 comprises a first spring rest for the first spring 46. Alternatively, the first spring rest may be of another type which enables a proper support for the first spring 46. The relieving spring washer 48 forms a second spring rest for the first spring 46.

[0035] Preferably, a second spring 58 is arranged intermediate the membrane 53 and a compensation washer 60. The second spring 58 is preloaded and in this way the membrane 53 is deformed.

[0036] The relieving device relieves the compensation device 42, if a force acts on the compensation device 42. The force on the compensation device 42 is split up in two force components. The first force component is transferred to the compensation device 42 and the second force is transferred by the relieving device itself. Further, a stress on the membrane 53 because of the deformation of the membrane 53 is diminished by the relieving device.

[0037] In order to achieve a proper dosing by the injector 2, the injector 2 is calibrated before the final assembling. Preferably, the injector 2 is assembled and calibrated as follows:

[0038] In a step S1 the parts needed for assembling the injector 2 and the machines for the assembling are prepared.

[0039] In a step S2, the piezo-actuator 10 is inserted into the recess 8 of the injector body 4. Alternatively, in step S2 the compensation assembly 36 may be inserted into the recess 8 of the injector body 4.

[0040] In a step S3 the piezo-actuator 10 is connected to an electric circuitry. The electric circuitry comprises the terminal 34. Preferably, the piezo-actuator 10 is connected to the electric circuitry by welding or by soldering the connector 32 to the terminal 34.

[0041] In a step S4, the relieving spring washer 48 of the compensation assembly 36 is fixed to a pin 30 of the

piezo-actuator 10. Afterwards, the compensation assembly 36 is inserted into the recess 8 of the injector body 4 in such a way that the first spring 46 of the compensation assembly 36 is axially coupled to the relieving spring washer 48 of the compensation assembly 36. Alternatively, the injector 2 may be assembled without the compensation assembly 36. Further, if in step S2 the compensation assembly 36 has been inserted into the recess of the injector body 4, in step S4 the piezo-actuator 10 is inserted into the recess 8 of the injector body 4 and is connected to the electric circuitry.

[0042] In a step S5, the second axial end 37 of the actor arrangement facing away from the needle 50 is fixed relative to the injector body 4. The second axial end 37 of the actor arrangement may be fixed relative to the injector body 4 by clamping a closing body 38 at the injector body 4 by an external clamping device and by the force which is applied on the actor arrangement by the needle spring 24. In particular, the actor arrangement may be pressed against the closing body 38 by the needle spring 24. Afterwards, fluid is dosed by the injector 2 in a given way. For dosing fluid with the injector 2 in the given way, a given voltage is applied on the piezo-actuator 10 for a given time interval and/or different voltages at different durations are applied on the piezo-actuator 10. Further in step S5, a fluid flow FLOW of the dosed fluid is measured.

[0043] In a step S6, a thickness L of the calibration shim 44 is determined dependent on the measured fluid flow FLOW. Then, the calibration shim 44 with the determined thickness L is added to the actor arrangement. Independent from the particular arrangement, the calibration shim 44 has to be added to the actor arrangement in such a way that the unloaded actor arrangement is increased in its axial length by the calibration shim 44 relative to the actor arrangement without the calibration shim 44. The increasing of the axial length of the actor arrangement in the unloaded situation leads to an increased pressure on the actor arrangement, if the actor arrangement is inserted into the recess 8 of the injector body 4 and if the recess 8 of the injector body 4 is closed by the closing body 38. The increased pressure on the actor arrangement leads to an increased pressure on the needle 15 and on the needle spring 24. This leads to a different closing behaviour of the needle 15 and so to a different dosing behaviour of the injector 2 and can be used for calibrating the injector 2.

[0044] The calibration shim 44 may be added to the actor arrangement by arranging the calibration shim 44 at the first or the second axial end 13, 37 of the actor arrangement. Alternatively, the calibration shim 44 may be arranged between the piezo-actuator 10 and the compensation assembly 36. Preferably, the calibration shim 44 is arranged between the first spring 46 of the compensation assembly 36 and a supporting element of the compensation assembly 36 for supporting the first spring 46. The supporting element of the compensation assembly 36 may be the relieving spring washer 48 of the com-

pensation assembly 36 and/or the relieving ring 56 or further parts of the compensation assembly 36.

[0045] In a step S7, the fixation of the second axial end 37 of the actor arrangement is severed. Preferably, the fixation is severed by removing the external clamping device and the closing body 38. Afterwards, those parts of the actor arrangement which had to be taken out for inserting the calibration shim 44 are taken out from the recess 8 of the injector body 4.

[0046] In a step S8, the complete actor arrangement is inserted into the recess 8 of the injector body 4, the second axial end 37 of the actor arrangement is fixed relative to the injector body 4 and the recess 8 of the injector body 4 is closed by the closing body 38. Preferably, the recess 8 of the injector body 4 is closed by the closing body 38. Preferably, the second axial end 37 of the actor arrangement is fixed relative to the injector body 4 by closing the recess 8 of the injector body 4. Preferably, the closing body 38 is pressed towards the actor arrangement and is fixed to the injector body 4 by welding. If the closing body 38 is properly welded to the injector body 4, the recess 8 of the injector body 4 is sealed up properly.

[0047] In a step S9, the injector 2 is finally assembled and may be taken out of the machines for assembling the injector 2.

[0048] The invention is not restricted by the explained embodiments. For example, in this embodiment, the ground plate 12 of the piezo-actuator 10 comprises the first axial end 13 of the actor arrangement and the bottom portion of the cup-shaped compensation body 49 comprises the second axial end 37 of the actor arrangement. Alternatively, the piezo-actuator 10 and/or the compensation assembly 36 and/or the actor arrangement may be turned around 180 degrees relative to the injector body 4 and in that way may be introduced into the recess 8 of the injector body 4. Further, there may be arranged a different compensation device 42. Further, the compensation assembly 36 may be arranged without the relieving device.

Claims

1. Injector (2) for dosing fluid comprising

- an injector body (4) having a recess (8),
- an injection nozzle (18) at a tip (20) of the injector body (4),
- a needle (15) which is arranged in the recess (8) of the injector body (4) movable in axial direction and which prevents a fluid flow through the injection nozzle (18) in a closed position of the needle (15) and which otherwise enables the fluid flow through the injection nozzle (18),
- an actor arrangement which is arranged in the recess (8) of the injector body (4), which is coupled to the needle (15) at a first axial end (13) of the actor arrangement for moving the needle

- (15), which is coupled with the injector body (4) at a second axial end (37) of the actor arrangement in such a way that the second axial end (37) is fixed relative to the injector body (4), and which comprises a piezo-actuator (10) and a calibration shim (44) for calibrating the Injector (2). 5
2. Injector (2) in accordance with claim 1 with the actor arrangement comprising a compensation assembly (36) for compensating a different thermal expansion of the piezo-actuator (10) and of the injector body (4), with the piezo-actuator (10) being coupled to the compensation assembly (46) in axial direction. 10
3. Injector (2) in accordance with claim 2 with the calibration shim (44) being arranged between a first spring (46) and a supporting element of the compensation assembly (36) for supporting the first spring (46). 15
4. Method for assembling the Injector (2) according to one of the preceding claims comprising the steps of: 20
- inserting the actor arrangement without the calibration shim (44) into the recess (8) of the injector body (4) and coupling the first axial end (13) of the actor arrangement with the needle (15), 25
 - provisionally fixing the second axial end (37) of the actor arrangement relative to the injector body (4), 30
 - dosing fluid with the injector (2) in a given way,
 - measuring a fluid flow (FLOW) of the fluid dosed by the injector (2),
 - determining a thickness (L) of the calibration shim (44) dependent on the measured fluid flow (FLOW), 35
 - sever the fixation of the second axial end (37) of the actor arrangement relative to the injector body (4), 40
 - adding the calibration shim (44) with the determined thickness to the actor arrangement in such a way that an axial length of the unloaded actor arrangement is increased by the calibration shim (44), 45
 - coupling the second axial end (37) of the actor arrangement to the injector body (4) and closing the recess (8) of the injector body (4), with the second axial end (37) of the actor arrangement being coupled to the injector body (4) in such a way that the second axial end (37) of the actor arrangement is fixed relative to the injector body (4). 50
5. Method in accordance with claim 4 comprising the steps of inserting the actor arrangement into the recess (8) of the injector body (4) by inserting the piezo-actuator (10) and the compensation assembly (36) 55
- into the recess (8) of the injector body (4) and coupling the piezo-actuator (10) to the compensation assembly (36) in axial direction by fixing a spring washer (48) of the compensation assembly (36) to a pin (30) of the piezo-actuator (10).
6. Method in accordance with one of the claims 4 or 5 comprising the step of connecting the piezo-actuator (10) to an electric circuitry, for driving the piezo-actuator (10), before the spring washer (48) is fixed to the pin (30) of the piezo-actuator (10).
7. Method in accordance with one of the claims 4 to 6 comprising the step of closing the recess (8) of the injector body (4) by rigidly coupling the second axial end (37) of the actor arrangement with the injector body (4).

FIG 1

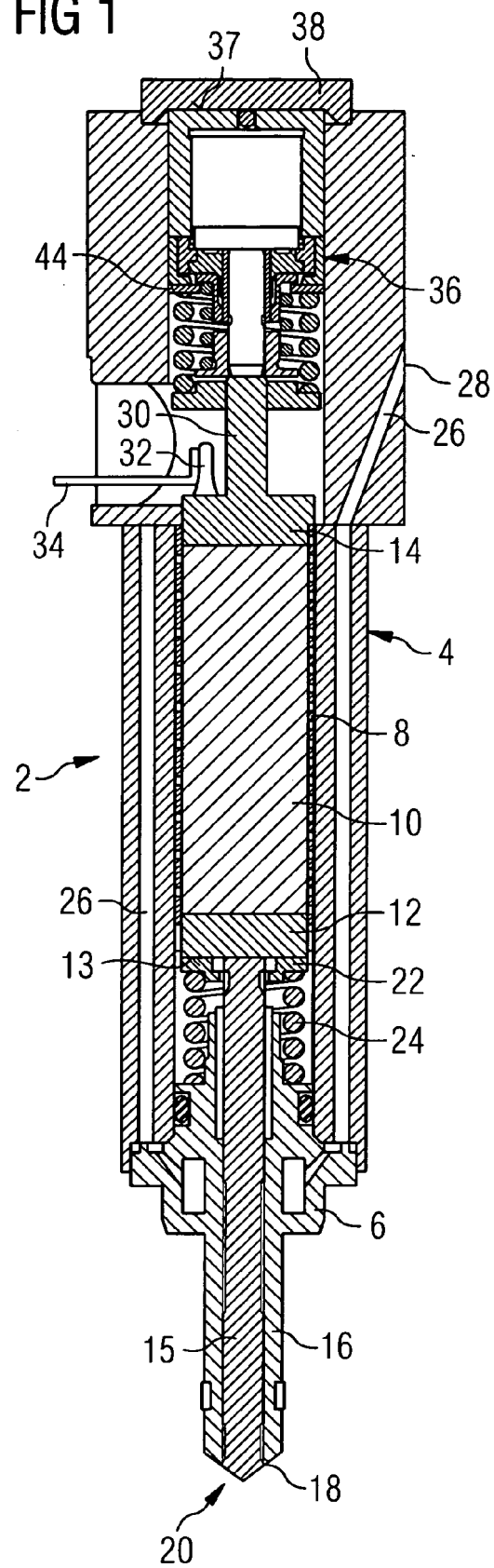


FIG 2

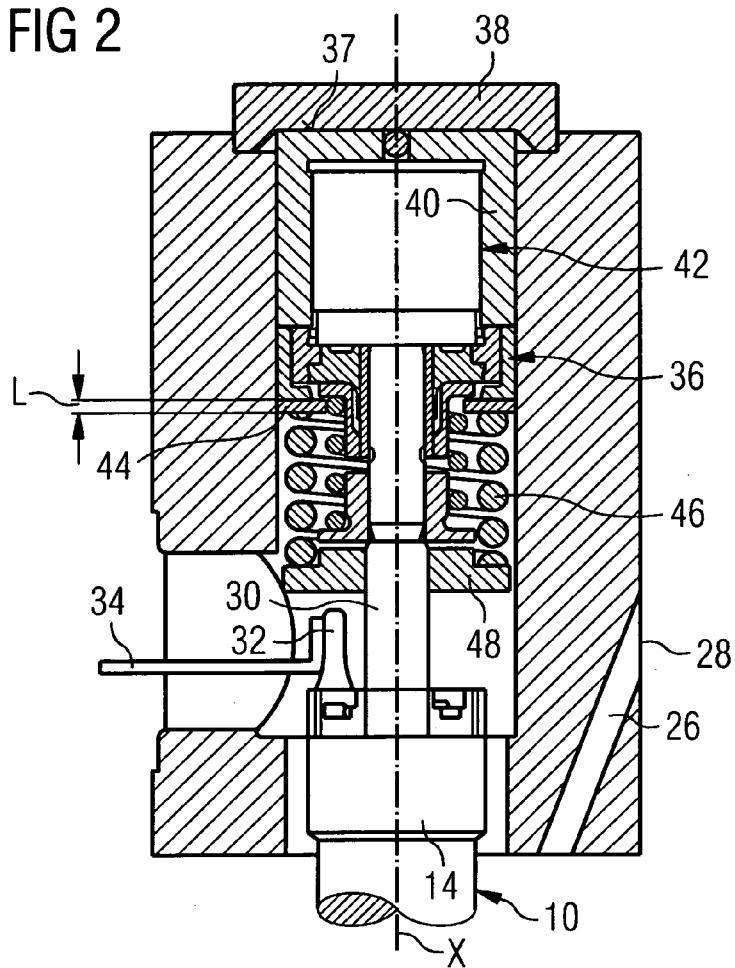


FIG 3

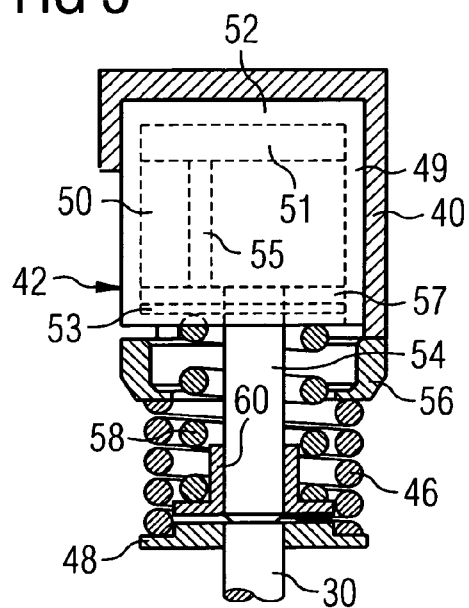


FIG 4

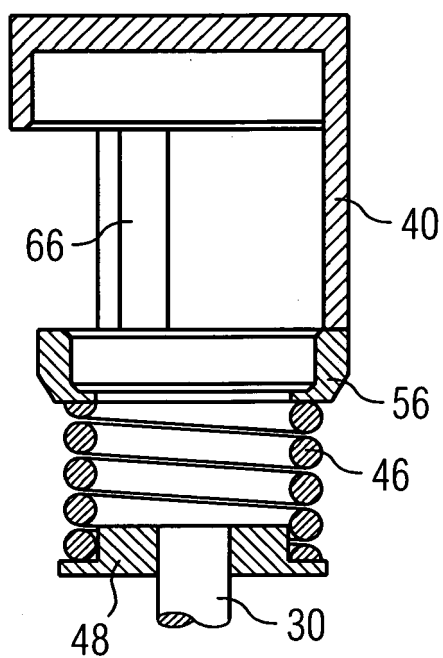
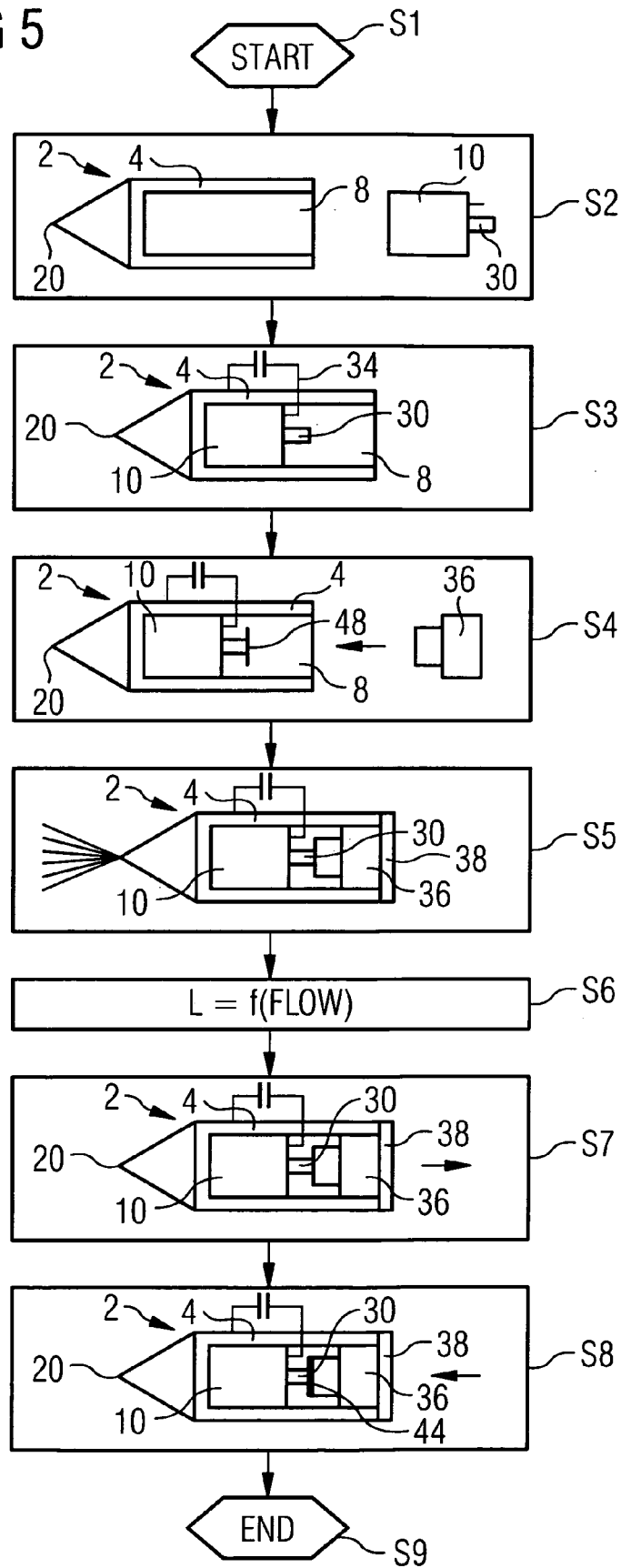


FIG 5





European Patent
Office

EUROPEAN SEARCH REPORT

Application Number
EP 06 02 2853

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The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 26 January 2007	Examiner Etschmann, Georg
CATEGORY OF CITED DOCUMENTS 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 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			

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EPO FORM 1503 03.82 (P04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT
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EP 06 02 2853

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