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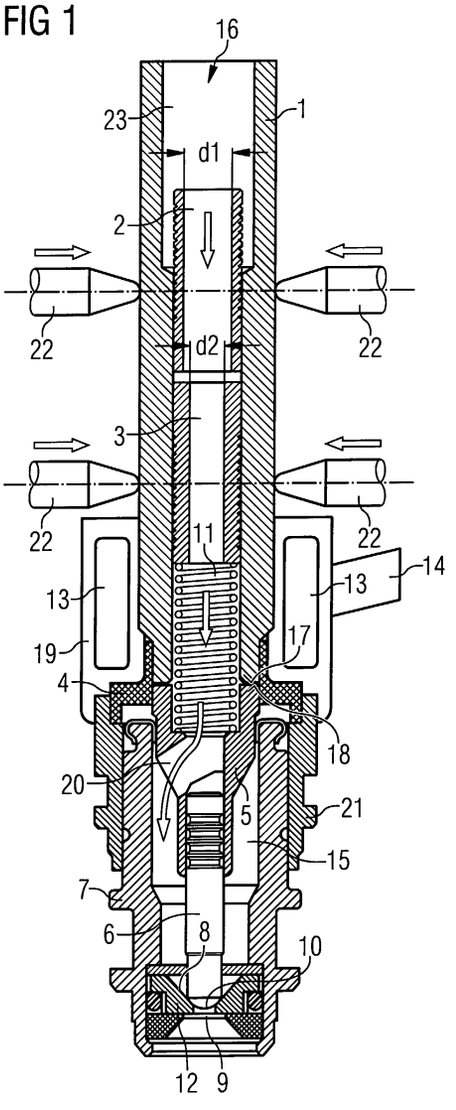
Remarks:
Amended claims in accordance with Rule 86 (2) EPC.

(54) Injection valve with two adjusting tubes and method for adjusting a pretension of a spring on a closing member of an injection valve

(57) The invention describes an injection valve and a process for adjusting a preload of a spring that biases a valve member of the injection valve against the valve seat. The injection valve comprises two adjusting tubes (2,3) that are arranged behind each other and the second tube (3) is adjacent to the spring (11). The spring (11) biases an armature (5) with a needle (6) against a valve seat. In a first calibration step, the first adjusting tube (2) is fixed to an inlet tube (1) determining the preload of the spring (11). Then the function of the injection valve is checked and if necessary, the tension of the spring (11) is increased by the second adjusting tube (3) that is moved towards the spring (11) and fixed to the inlet tube (1) in a respective position. The advantage of the invention is that after a first determination of the tension of the spring, it is possible to increase the tension of the spring with a second adjusting tube.

FIG 1



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Description

[0001] The invention relates to an injection valve with a closing member that is dedicated to a valve seat. The closing member is stressed towards the valve seat by a spring. The spring itself is adjacent to an adjusting tube that pre-stresses the spring against the valve closing element. For a precise function of the injection valve, the spring has to push the valve closing element towards the valve seat with a predetermined preload. For adjusting the preload of the spring, the adjusting tube is pushed nearer to the closing element step by step. At each step, the injection valve is opened during a predetermined time and the injected amount of fuel is ascertained. If the injected amount of fuel is the same as the predetermined amount, then the position of the adjusting tube is correct and the adjusting tube is fixed with the housing of the injection valve. If the injected amount is too much, the adjusting tube is positioned a step nearer to the closing element increasing the preload with which the spring is acting on the closing member. Using this procedure, the injecting function of the injection valve is calibrated. After fixing the adjusting tube, the function of the injection valve is ascertained again. If the injection function of the injection valve deviates from a predetermined function, the injection valve cannot be used as the preload of the spring cannot be adjusted in such a way that the injection valve injects the predetermined amount of fuel. The faulty injection valve has to be separated out.

[0002] The US patent 5,967,419 describes a fuel injector with a valve, with a valve seat, with a valve closing element that is dedicated to the valve seat. The valve closing element is connected to an armature. The armature is preloaded by a spring to the valve seat. The spring is arranged in a tube and adjacent to a spring pin that is arranged in the tube as well. The spring pin is press-fit within the tube. The spring normally biases the armature in a closing direction of the valve.

[0003] The object of the invention is to provide an injection valve with a spring the pre-tension of which could be changed after fixing the adjusting tube, if a test of the injection valve shows that the pre-tension of the spring is not correct.

[0004] A further task of the invention is to provide a method for adjusting an injection valve with a valve closing member that is preloaded by a spring towards a valve seat providing the possibility to adjust the pre-tension of the spring after a first fixing of an adjusting tube that pre-tenses the spring towards the valve closing member.

[0005] The task of the invention is solved by an injection valve according to claim 1 and by a method for adjusting the injection valve according to claim 9.

[0006] A main advantage of the injection valve according to claim 1 is that it is possible to adjust the tension of the spring that biases the valve closing element in a valve closing position of the valve more precisely. By using the upper first adjusting tube, it is possible to determine the tension of the spring at a first step. However, if the injection function of the injection valve does not fulfill predetermined requirements, a second step allows for increasing the tension of the spring using the second lower adjusting tube. As a result, it is possible to adjust more injection valves to the predetermined requirements.

[0007] In a preferred embodiment of the invention, the first and the second adjusting tubes have different inner diameters, whereby the lower, second adjusting tube comprises a smaller diameter than the upper first adjusting tube. Using this embodiment, the second adjusting tube can be pushed by means of a pushing tube that is inserted into the first adjusting tube. The pushing tube can also be used for supplying fuel to the fuel chamber. The test and adjusting process is therefore easily carried out.

[0008] In a further preferred embodiment, the first and the second tube are guided within a cylindrical chamber which has roughly the same inner diameter as the outer diameter of the first and the second tube. This embodiment provides a precise guiding of the first and the second tube. Furthermore, the first and the second tube could easily be fixed with the wall of the cylindrical chamber by small plastic deformations of the wall, for example by a crimping process.

[0009] In an advantageous embodiment of the invention, the first and/or the second tube comprise at the outer face circular grooves. The circular grooves support the fixing to the first and the second tube to the inlet tube within that they are guided. Using the grooves, a secure connection between the first and the second tube and the inlet tube is possible by a small plastic deformation of the inner diameter of the inlet tube.

Brief description of the drawings

[0010]

Figure 1 is a longitudinal sectional view of an injector according to an embodiment of the present invention.

Figure 2 depicts the two stages of the first and the second tube using the inventive adjusting procedure.

Detailed description of the preferred embodiments

[0011] A preferred embodiment of an injection valve according to the present invention will now be described with reference to the drawings.

[0012] Figure 1 is a schematic view of an injection valve as it is used for motor vehicle engines. The injection valve is basically symmetrical to a central axis of symmetry. Prior to explaining an embodiment of the invention in detail, it is to be understood that the invention

is not limited in this application to the details of construction and the arrangements of the components set forth in the following description or illustrated in the drawings. The invention is capable of other embodiments and of being practiced or being carried out in various ways.

[0013] The injection valve includes a valve body 7. On the inside, the valve body 7 has an orifice plate 12 adjacent to a lower end of the valve body 7. The orifice plate 12 includes an orifice 9. The valve body 7 comprises an injection chamber 15, in which a needle 6 is arranged. The needle 6 is connected by an upper end with an armature 5. The armature 5 has the shape of a hollow cylinder that is guided in a support tube 4. The support tube 4 is fixed to the valve body 7 by a sleeve body 21. The lower end of the needle 6 comprises a sealing face 10 that is dedicated to a valve seat 8 of the orifice plate 12. The valve seat 8 surrounds the orifice 9.

[0014] Adjacent to the armature 5, an inlet tube 1 is fixed within the support tube 4. Within the inlet tube 1, a spring 11 is arranged which is biased between the armature 5 and a second tube 3. The second tube 3 is fixed in the inner bore of the inlet tube 1. At a given distance above the second tube 3, a first tube 2 is arranged as well within the bore of the inlet tube 1. The fixing of the first and second tube 2, 3 with th e inlet tube 1 is preferably attained by a plastic deformation of the inlet tube 1. The first tube 2 is also fixed to the inlet tube 1. The spring 11 biases the armature 5 and the needle 6 with its sealing face 10 to the valve seat 8 in a closing position of the valve.

[0015] The support tube 4 is circumvented by a housing 19, in which a coil assembly 13 is arranged. The coil assembly 13 is electrically connected with a connector terminal which is arranged in a connector 14.

[0016] The armature 5 comprises a second ring face 18 that is adjacent to a first ring face 17 of the inlet tube 1. In the closed position of the valve, the first and the second ring faces 17, 18 are arranged at a given distance. The injection valve comprises a fuel passage way 16 that guides through the bore of the inlet tube 1, the bore of the first and the second tube 2, 3, via the spring 11 to a bore 20 of the armature, that is connected to the injection chamber 15. The inlet tube 1 can be connected with a fuel supply, delivering fuel to the injection chamber 15.

[0017] The fuel is injected when the coil assembly 13 is energized by a voltage that is applied to the connector terminal. The energized coil of the coil assembly 13 lifts the armature 5 up to the first ring face 17 compressing the spring 11. As a result, the sealing face 10 of the needle 6 is lifted off the valve seat 8, opening a fluid connection between the injection chamber 15 and the orifice 9. Therefore, fuel is injected by the orifice 9.

[0018] The coil assembly 13 is re-energized to stop the injection. The result is that the armature 5 is pushed in the direction of the valve seat 8 by the spring 11, until the sealing face 10 rests upon the valve seat 8, thereby disconnecting the fuel chamber 15 from the orifice 9. The valve is now in a closed position.

[0019] The first and the second tube 2, 3 are fixed to the inlet tube 1 by means of a plastic deformation of the inner diameter of the inlet tube 1. For the plastic deformation, two crimping tools 22 are used which are pushed against the outer face of the inlet tube 1 at opposite sides.

[0020] The inlet tube 1 advantageously comprises an inner bore 23 that has a greater diameter in an upper section than in a lower section. The first tube 2 is arranged partly in the upper and in the lower section of the inner bore 23. The first tube 2 is fixed within the lower section of the inlet tube 1.

[0021] The embodiment shown in Figure 1 is an example for an injection valve with a spring-preloaded needle the spring tension of which can be adjusted twice. After a first step by means of which the tension of the spring 11 was determined by the position of the first tube 2, in a second step the tension of the spring 11 could be increased by moving the second tube 3 down towards the spring 11 and also fixing the second tube 3 to the inlet tube 1. Therefore, the first and the second tube 2, 3 are arranged at a given distance and the first and the second tube 2, 3 are fixed to the inlet tube 1.

[0022] If the tension of the spring 11 could be precisely adjusted in the first step, only the first tube 2 is fixed to the inlet tube 1 and the second tube 2 is adjacent to the first tube 2 and not fixed to the inlet tube 1.

[0023] The first tube 2 has an inner diameter D1 that is greater than a second inner diameter D2 of the second tube 3. The outer diameters of the first and the second tube 2, 3 are roughly the same and approximately the same as the inner diameter of the inlet tube 1 in the second section.

[0024] Referring to Figure 2, the inventive procedure for a precise preloading of the spring 11 will be explained in the following. The first and the second tubes 2, 3 comprise circular grooves at the outer surface which support the fixing of the first and the second tube by a plastic deformation of the inlet tube 1. Instead of the circular grooves, other shapes of grooves or structures could be used in order to improve the fixing connection.

[0025] At a first step, a pre-calibration run is operated and, if required, in a second step a calibration operation is follows. Basically, the injection valve is a solenoid valve. Fuel is delivered when the coil assembly 13 is energized. When the coil assembly 13 is energized, the armature/needle assembly 5, 6 actually moves upwards, pulling the needle 6 of the valve seat 8 to start an injection of fuel. A bias force is provided by the spring 11 in order to keep the needle 6 on the valve seat 8 and to prevent an injection in the deenergized condition. When the injection valve is energized for a short duration (dynamic flow), the fuel flow through the injection valve is highly sensitive to the bias force provided by the spring 11. Therefore, the bias force of the spring 11 is used in order to calibrate the dynamic flow function of the injection valve.

[0026] In Figure 2, the situation for the pre-calibration process is shown on the left side. At this point of time, the first and the second tube 2, 3 are free to slide inside the inlet tube 1 prior to calibration. During the calibration, a rod 24 extends from a manufacturing line into the inlet tube at a given speed, forcing the first and the second adjusting tubes 2, 3 down towards the spring 11. The coil assembly 13 of the injection valve is continually cycled with short pulses of electric energy and the injected amount of fuel is measured. During the calibration step, the rod 24 and the first and second tubes 2, 3 are pushed down step by step. After each step, the position of the first and second tube 2, 3 are held and the coil assembly is energized. The injected amount of fuel is measured. When the injected amount of fuel is roughly the same as a predetermined amount of fuel, the first tube 2 is locked in its position by a mechanical deformation of the inner diameter of the inlet tube 1. For the mechanical deformation, crimping tools 22 are used in order to deform the outer and the inner diameter of the inner tube 1. It is possible that by the crimping process the ideal position of the first tube 2 is changed. This results in an undesired dynamic injection function of the injection valve.

[0027] During the crimping process, material of the inlet tube 1 is forced to flow into the grooves of the first adjusting tube 2. As the inlet tube 1 material flows into notches of the first adjusting tube, an actual force is created. The actual force may move the first tube 2, changing the preload of the spring 11.

[0028] After the crimping operation the injection valve is submitted to a post-calibration run for a final flow-check. If the injected fuel in the final flow-check is outside a required specification, a second calibration step is carried out. If in the final check the injection valve injects too much fuel during the injection phase, a second adjusting tool 25 is used to move down the second tube 3 step by step. The second tool 25 is a pipe that has an outer diameter that is smaller than the inner diameter of the first tube 2 and a larger diameter than the inner diameter of the second tube 3. With the second tool 25, the second tube 3 is pushed down towards the armature 5. The inner bore of the second tool 25 is used to supply fuel to the fuel chamber that is needed for the injection. At each step, the injection valve is opened and the injected amount of fuel is measured and compared with a predetermined range of the specification. If the injected amount of fuel is not within the predetermined range, the second tube 3 is pushed down a further step to the spring 11. Then, the injection valve is opened again, the injected amount of fuel is measured and compared with the predetermined range. If the injected amount of fuel is within the predetermined range of the specification, the second tube 3 is fixed to the inlet tube 1 by a crimping process by means of crimping tools 22.

[0029] In this position, there is a distance D between the lower end of the first tube 2 and the upper and of the second tube 3. Now the second tube 3 determines the tension of the spring 11 and the preload of the needle 6 against the valve seat 8. The first and the second tube 2, 3 can be made of copper alloy. Instead of the described process for fixing the adjusting tubes 2, 3 to the inlet tube 1, the adjusting tubes 2, 3 could be welded, swaged or glued to the inlet tube 1. The inlet tube 1 could be realized as a welded tube, a seamless welded tube or a tube formed from a rolled thin sheet. It could be a flanged or a dished part, an extruded part, a press-forged part or a machined part from a solid rod. The inlet tube could have different material thickness along the body.

Claims

1. Injection valve with a housing, in which an injection chamber (15) is arranged, the injection chamber (15) being connected with a fuel line, the injection chamber (15) comprising a valve with a valve seat (8) and a valve closing element (6) that is dedicated to the valve seat (8), whereby an actor (5, 13) is arranged in the housing, that is usable for moving the valve closing element (6) to close or to open the valve, whereby a spring (11) that is arranged between the valve closing element (6) and a first tube (2), whereby the first tube (2) is arranged within an inlet tube (1), whereby the first tube (2) is fixed to the inlet tube (1),
characterized in that a second tube (3) is arranged between the spring (11) and the first tube (2), and that the second tube (3) is adjacent to a lower end of the spring (11).

2. Injection valve according to claim 1, **characterized in that** the second tube (3) comprises a face with which the second tube (3) is movable in the direction of the spring (11), that the second tube (3) has a smaller inner diameter than the first tube (2) and that the face is a ring face of an upper end of the second tube (3).

3. Injection valve according to claim 1 or 2, **characterized in that** an outer diameter of the first and second tube (2, 3) is roughly the same as an inner diameter of the inlet tube (1) guiding the first tube and the second tube (2, 3) in one direction.

4. Injection valve according to any one of the claims 1 to 3, **characterized in that** the inlet tube (1) can be used for delivering fuel to the injection chamber (15).

5. Injection valve according to any one of the claims 1 to 4, **characterized in that** the second tube (3) is arranged at a given distance to the first tube (2), that the second tube (3) is fixed to the inlet tube (1) and that the second tube stresses (3) the spring

(11).

6. Injection valve according to any one of the claims 1 to 5, **characterized in that** the first and/or second tube (2, 3) comprise grooves (21) at an outer face.

7. Injection valve according to any one of the claims 4 to 6, **characterized in that** the first and/or the second tube (2, 3) are fixed to the inlet tube (1) by a plastic deformation of the inlet tube (1).

8. Injection valve according to any one of the claims 4 to 7, **characterized in that** the inlet tube (1) has a first section with a greater inner diameter and a second section with a smaller inner diameter, and that the second section is arranged downstream of the fuel flow, that the second tube (3) is arranged in the second section, and that the first tube (2) is partly arranged in the second and in the first section.

9. Method for adjusting an injection function of a fuel injection valve with an actor (5, 13), a valve closing member (6), a spring (11) stressing the valve closing member (6) onto a valve seat (8) of an injection chamber (15), whereby the spring (11) is stressed by two tubes (2, 3) that are movably arranged one behind the other in an inlet tube (1), whereby fuel is delivered to the injection chamber (15) over the inlet tube, whereby the two tubes (2, 3) are moved in given steps nearer to the spring (11) increasing the preload of the spring (11), whereby after each step, the actor (5, 13) of the valve is activated for a given time to open the valve against the preload of the spring (11), whereby after each injection the injected amount of fuel is checked, the injected amount of fuel is compared with a given amount and the process is stopped, if the amount injected by the valve is the same as the predetermined amount and the upper tube (2) is fixed to the inlet tube (1),
Whereby in a second process fuel is delivered to the injection chamber (15), whereby the actor of the valve is activated for a given time to lift the valve closing member (6) off the valve seat (8) against the preload of the spring (11), whereby after the injection the injected amount of fuel is checked, the injected amount of fuel is compared with a given amount and the process is stopped if the injected amount of fuel is the same as the given amount, whereby the process is proceeded if the injected amount is not the same as the given amount, whereby the lower tube (3) is moved in given steps nearer to the spring increasing the preload of the spring (11), whereby after each step, the actor (13, 5) of the valve is activated for a given time to lift the valve closing member (6) off the valve seat (8) against the preload of the spring (11), whereby after each injection the injected amount of fuel is checked, whereby the injected amount of fuel is compared with a given amount and the process is stopped and the nearer tube is fixed with the inlet tube (1), if the amount injected by the valve is the same as the predetermined amount.

10. Method according to claim 9, **characterized in that** the first or second tube (2, 3) are fixed to the inlet tube (1) by plastically deforming the inlet tube (1), narrowing the inner diameter of the inlet tube (1).

Amended claims in accordance with Rule 86(2) EPC

1. Injection valve with a housing, in which an injection chamber (15) is arranged, the injection chamber (15) being connected with a fuel line, the injection chamber (15) comprising a valve with a valve seat (8) and a valve closing element (6) that is dedicated to the valve seat (8), whereby an actor (5, 13) is arranged in the housing, that is usable for moving the valve closing element (6) to close or to open the valve, whereby a spring (11) that is arranged between the valve closing element (6) and a first tube (2), whereby the first tube (2) is arranged within an inlet tube (1), whereby the first tube (2) is fixed to the inlet tube (1), whereby a second tube (3) is arrabged between the spring (11) and the first tube (2),
characterized in that the second tube (3) comprises a face with which the second tube (3) is movable in the direction of the spring (11), that the second tube (3) has a smaller inner diameter than the first tube (2) and that the face is a ring face of an upper end of the second tube (3).

2. Injection valve according to claim 1, **characterized in that** an outer diameter of the first and second tube (2, 3) is roughly the same as an inner diameter of the inlet tube (1) guiding the first tube and the second tube (2, 3) in one direction.

3. Injection valve according to any one of the claims 1 or 2, **characterized in that** the inlet tube (1) can be used for delivering fuel to the injection chamber (15).

4. Injection valve according to any one of the claims 1 to 3, **characterized in that** the second tube (3) is arranged at a given distance to the fisrt tube (2), that the second tube (3) is fixed to the inlet tube (1) and that the second tube stresses (3) the spring (11).

5. Injection valve according to any one of the claims 1 to 4, **characterized in that** the fisrt and/or second tube (2, 3) comprise grooves (21) at an outer face.

6. Injection valve according to any one of the claims 3

to 5, **characterized in that** the fisrt and/or the second tube (2, 3) are fixed to the inlet tube (1) by a plastic deformation of the inlet tube (1).

7. Injection valve according to any one of the claims 3 to 6, **characterized in that** the inlet tube (1) has a first section with a greater inner diameter and a second section with a smaller inner diameter, and that the second section is arranged downstream of the fuel flow, that the second tube (3) is arranged in the second section, and that the first tube (2) is partly arranged in the second and in the first section.

8. Method for adjusting an injection function of a fuel injection valve comprising an actor (5, 13), a valve closing member (6), a spring (11) stressing the valve closing member (6) onto a valve seat (8) of an injection chamber (15), whereby the spring (11) is stressed by a first and a second tube (2, 3) that are movably arranged one behind the other in an inlet tube (1), said method comprising:

a first calibration process,

- whereby fuel is delivered to said injection chamber (15) over said inlet tube (1),
- whereby said first and second tube (2, 3) are moved in given steps nearer to the spring (11) increasing the preload of said spring (11),
- whereby after each step, said actor (5, 13) of said valve is activated for a given time to open said valve against the preload of said spring (11),
- whereby after each injection the injected amount of fuel is checked, said injected amount of fuel is compared with a predetermined amount,
- and if said amount injected by said valve is the same as said predetermined amount, then said first calibration process is stopped and said first tube (2) is fixed to said inlet tube (1),

and a second calibration process,

- whereby fuel is delivered to said injection chamber (15),
- whereby said actor (5, 13) of said valve is activated for a given time to lift said valve closing member (6) off said valve seat (8) against the preload of said spring (11),
- whereby after the injection the injected amount of fuel is checked, said injected amount of fuel is compared with a predeterminded amount,
- and if said amount injected by said valve is the same as the predeterminded amount, then said second calibration process is stopped, if said amount injected is not the same as said predeterminded amount, said second calibration process is proceeded,
- whereby said second tube (3) is moved in given steps nearer to the spring increasing the preload of said spring (11),
- whereby after each step, said actor (13, 5) of said valve is activated for a given time to lift said valve closing member (6) off said valve seat (8) against the preload of said spring (11),
- whereby after each injection the injected amount of fuel is checked, said injected amount of fuel is compared with a predetermined amount,
- and if said amount injected by said valve is the same as said predetermined amount, then said second calibration process is stopped and said second tube (3) is fixed to said inlet tube (1).

9. Method according to claim 8, **characterized in that** the first or second tube (2, 3) are fixed to the inlet tube (1) by plastically deforming the inlet tube (1), narrowing the inner diameter of the inlet tube (1).

FIG 1

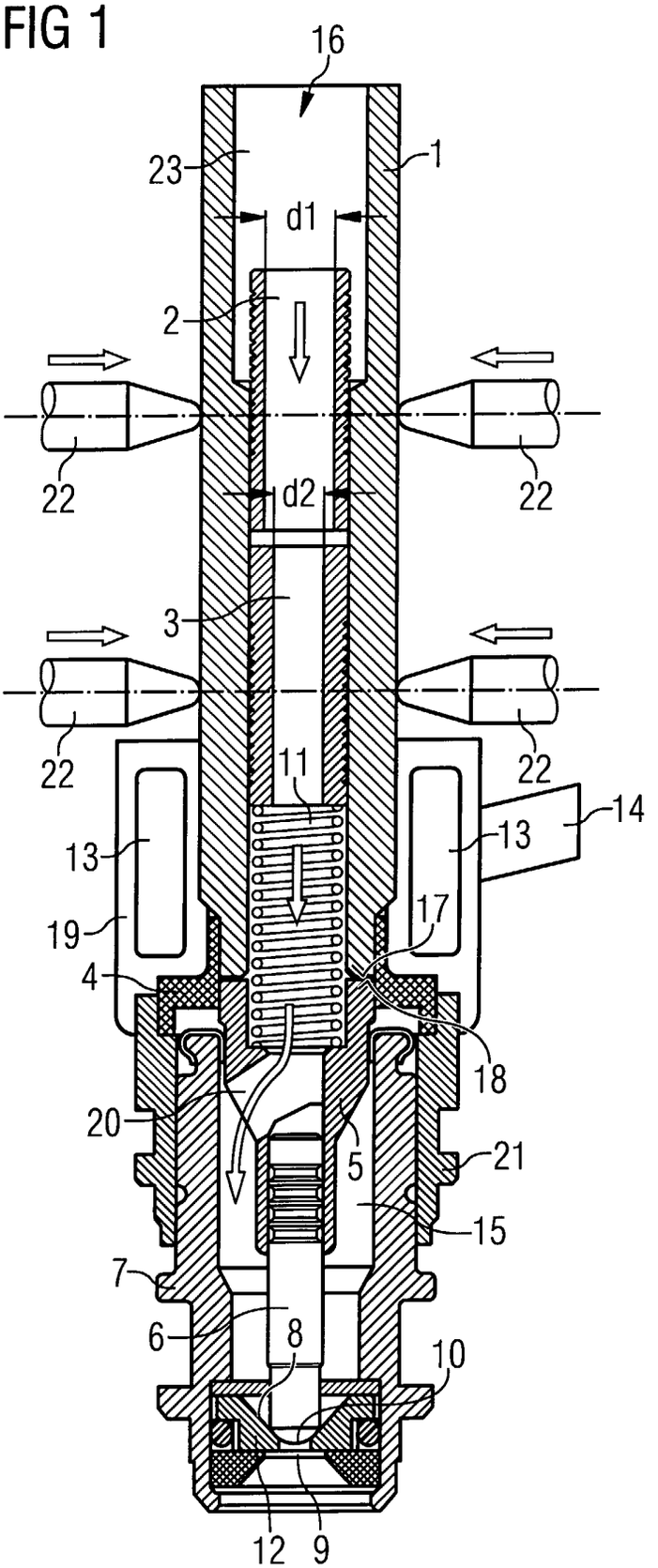
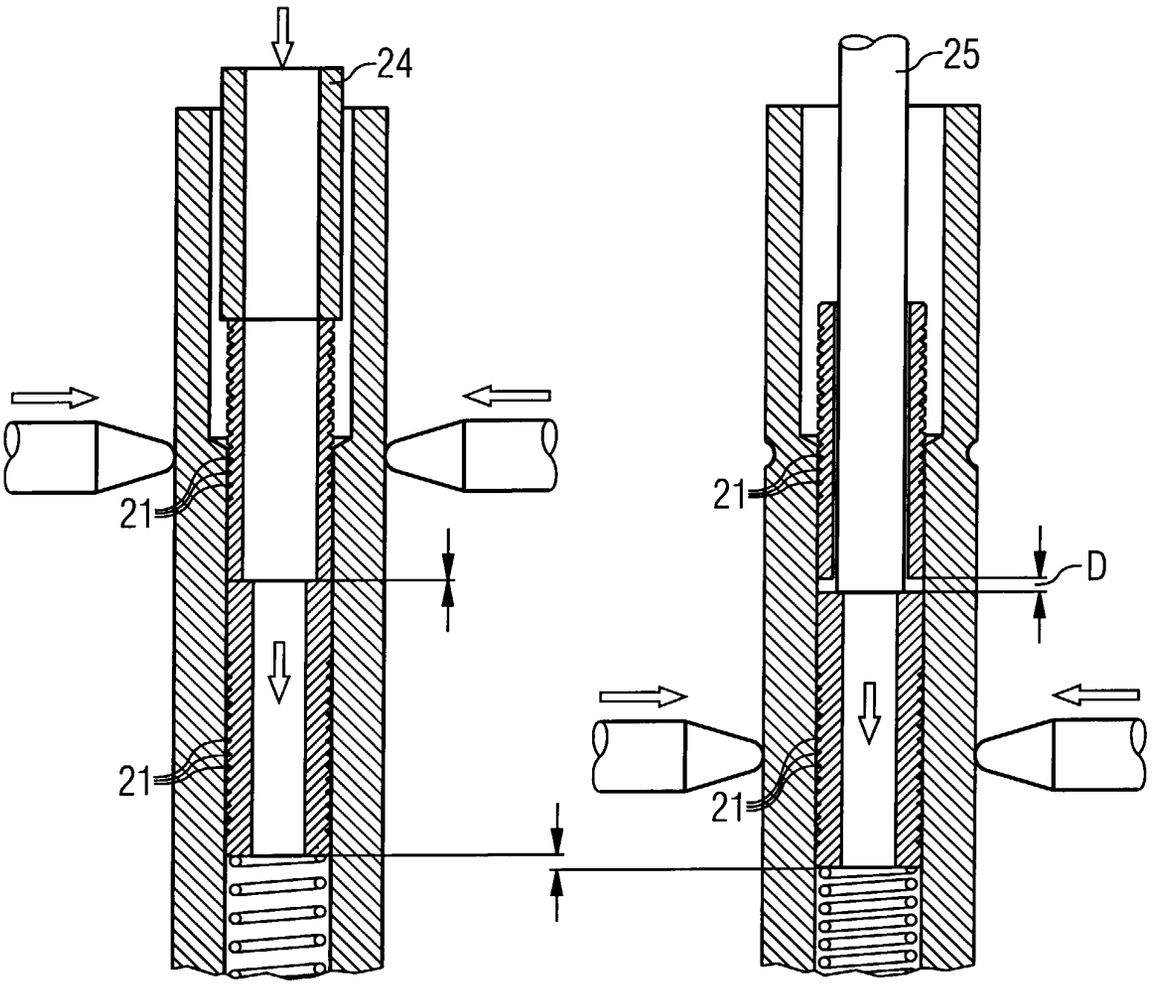


FIG 2



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EUROPEAN SEARCH REPORT

Application Number
EP 03 00 8178

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
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TECHNICAL FIELDS SEARCHED (Int.Cl.7)

F02M

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	20 August 2003	Schmitter, T

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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