(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 2 719 886 A1

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
16.04.2014 Bulletin 2014/16

(51) Int Cl.:
F02M 51/06 *(2006.01)* ***F02M 61/16*** *(2006.01)*

(21) Application number: **12187905.0**

(22) Date of filing: **10.10.2012**

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME

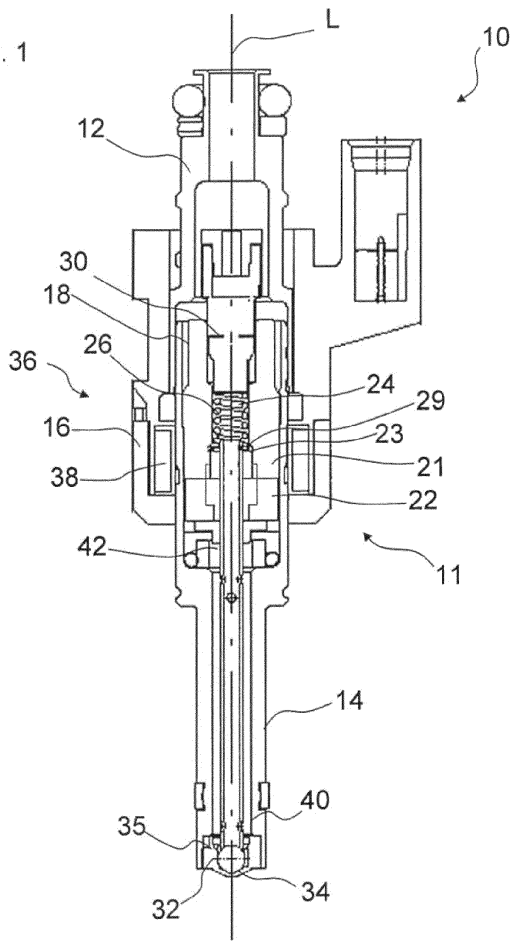
(71) Applicant: **Continental Automotive GmbH**
30165 Hannover (DE)

(72) Inventors:
- **Grandi, Mauro**
  57128 Livorno (IT)
- **Filippi, Stefano**
  57014 Collesalvetti (IT)
- **Conversano, Barbara**
  56021 Cascina (PI) (IT)

(54) Valve assembly for an injection valve

(57) A valve assembly (11) for an injection valve (10) is provided, comprising a valve body (14) comprising a cavity (18), a valve needle (20) axially movable in the cavity (18) and an electro-magnetic actuator (36) unit being designed to actuate the valve needle (20). The electro-magnetic actuator unit (36) comprises a pole piece (21) being fixedly coupled with respect to the valve body (14) and an armature part (22) being axially moveable with respect to the valve body (14), wherein the pole piece (21) comprises a first contact surface (51) and the armature part comprises a second contact surface (52), wherein the pole piece (21) and the armature part (22) are configured to collide with each other at the respective contact surfaces (51, 52). The pole piece (21) and the second armature part (22) comprise at least two different metal materials (25a, 25b), wherein one of the metal materials has a higher hardness than the at least one other metal material, and wherein the harder metal material (25b) is located at least in a first section of the first contact surface (51) and a second section of the second contact surface (52), and wherein the harder metal material (25b) located at the first section of the first contact surface (51) at least partially overlaps with the harder metal material (25b) located at the second section of the second contact surface (52) in a radial direction with respect to a central longitudinal axis (L) of the valve assembly (11).

Fig. 1



EP 2 719 886 A1

Description

[0001] The invention relates to a valve assembly for an injection valve.

[0002] Injection valves are in wide spread use, in particular for internal combustion engines where they may be arranged in order to dose the fluid into an intake manifold of the internal combustion engine or directly into the combustion chamber of a cylinder of the internal combustion engine.

[0003] Injection valves are manufactured in various forms in order to satisfy the various needs for the various combustion engines. Therefore, for example, their length, their diameter and also various elements of the injection valve being responsible for the way the fluid is dosed may vary in a wide range. In addition to that, injection valves may accommodate an actuator for actuating a needle of the injection valve, which may, for example, be an electromagnetic actuator or a piezoelectric actuator.

[0004] In order to enhance the combustion process in view of the creation of unwanted emissions, the respective injection valve may be suited to dose fluids under very high pressures. The pressures may be in case of a gasoline engine, for example, in the range of up to 200 bar and in the case of diesel engines in the range of up to 2000 bar.

[0005] The object of the invention is to create a valve assembly which facilitates a reliable and precise function.

[0006] These objects are achieved by the features of the independent claim. Advantageous embodiments of the invention are given in the sub-claims.

[0007] The invention is distinguished by a valve assembly for an injection valve, comprising a valve body comprising a cavity, a valve needle being axially movable in the cavity and an electro-magnetic actuator unit being designed to actuate the valve needle. The electro-magnetic actuator unit comprises a pole piece being fixedly coupled with respect to the valve body and an armature part being axially moveable with respect to the valve body, wherein the pole piece comprises a first contact surface and the armature part comprises a second contact surface, wherein the pole piece and the armature part are configured to collide with each other at the respective contact surfaces. The pole piece and the armature part comprise at least two different metal materials, wherein one of the metal materials has a higher hardness than the at least one other metal material, and wherein the harder metal material is located at least in a first section of the first contact surface and a second section of the second contact surface. The harder metal material located at the first section of the first contact surface at least partially overlaps with the harder metal material located at the second section of the second contact surface in a radial direction with respect to a central longitudinal axis of the valve assembly.

[0008] According to one embodiment, the armature part is fixedly coupled to the needle. Thereby, the needle is moved when the armature part is moved.

[0009] According to a further embodiment, the valve assembly comprises an attachment member which is fixedly coupled to the needle and the armature part is axially moveable with respect to the needle. The armature part is configured to mechanically couple with the attachment member when the armature part is moved in a direction towards the pole piece, and wherein a movement of the armature part causes a movement of the needle when the armature part mechanically couples with the attachment member. The attachment member may be formed as one piece with the needle or it may be a separate part which is fixedly attached to the needle, for example by welding.

[0010] According to one embodiment, the armature part may move a first distance in a direction towards the pole piece before the armature part may mechanically couple with the attachment member. According to a further embodiment, the armature part may immediately couple with the attachment member when the armature part is moved in a direction towards the pole piece. For example, the attachment member may be pressed against the armature part by means of a spring.

[0011] The advantage of the pole piece and the armature part comprising a hard metal material which is arranged as previously described is that only little wear may occur at the contact surfaces of the pole piece and the armature part. Thereby, the injector closing time drift during the lifecycle of the injection valve may be reduced. In particular, the distance which the valve needle is moved during an opening or a closing operation may be invariable during the lifecycle of the injection valve. Thereby, a high accuracy of a fluid dose which is delivered by the injection valve during one injection operation may be achieved.

[0012] In one embodiment, the harder metal material may extend over the whole contact surface of one or both of the pole piece and the armature part. Alternatively, the harder metal material may be located only in a section of the contact surface.

[0013] In one embodiment, the harder metal material is a martensitic steel. It may comprise the following elements: Cr, C, Mn, Si, P, S, and Mo. In one development, it comprises 16-18 % of Cr, 0.6-1.2 % of C, $\leq$ 1 % of Mn, $\leq$ 1 % of Si, $\leq$ 0.04 % of P, $\leq$ 0.03 % of S, and $\leq$ 0.75 % of Mo. The harder metal material may be for example 440 Standard-Steel. The harder metal material has, for example, a Rockwell hardness of C50 or higher, for example between C50 and C70, in particular between C55 and C66, where the limits are included in each case.

[0014] In a preferred embodiment, the pole piece and the armature part may comprise at least one soft metal material. Preferably, the soft metal material is a magnetic material. The soft metal material may be configured to establish a magnetic performance of the first and the second armature part. The harder metal material may be non-magnetic in one embodiment.

[0015] In one embodiment, the soft metal material is a

ferritic steel. It may comprise the following elements: Cr, C, Mn, Si, P, and S. Additionally, it may comprise Ni or Mo. In one development, it comprises 16-18 % Cr, ≤ 0.75 % Ni, ≤ 0.12 % C, ≤ 1 % Mn, ≤ 1 % Si, ≤ 0.04 % P and ≤ 0.03 % S. For example the soft metal material may be 430 Standard-Steel. The soft metal material has, for example, a Rockwell hardness of B100 or lower, for example between B70 and B100, in particular between B80 and B90, where the limits are included in each case.

[0016] The advantage of the pole piece and the armature part having a hard metal material which may be arranged as described above and a soft magnetic metal material is that the pole piece and the armature part show a good magnetic performance as well as a good mechanical performance.

[0017] In one embodiment, the pole piece comprises two separatly manufactured portions which are positionally fixed with respect to each other, wherein one of the portions comprises the soft metal material and the other portion comprises the harder metal material. Alternatively or additionally, the armature piece may comprise two separatly manufactured portions which are positionally fixed with respect to each other, wherein one of the portions comprises the soft metal material and the other portion comprises the harder metal material. In this way, functional separation between mechanical and magnetical properties is easily achievable in a cost effective manner.

[0018] According to one embodiment of the invention, the harder metal material may be located at an inner circumference of the pole piece. For example, the harder material may be configured as a sleeve being arranged at the inner circumference of the pole piece. The sleeve may be attached to the pole piece by interference fitting.

[0019] According to one embodiment of the invention, the armature part may comprise a recess, wherein the harder metal material may be designed as an insert being placed in the recess. The insert may be attached in the recess by interference fitting.

[0020] According to a further embodiment of the invention, one or both of the pole piece and the armature part may be two-component metal injection molded parts. Thereby, the harder metal material may be efficiently distributed at the contact surface of the pole piece and the armature part. In particular, only little volume of the harder metal material may be required. For example, the harder metal material may be a thin layer which extends over the whole contact surface of the pole piece and the armature part. For example, the layer may have a thickness of 1 mm.

[0021] In a further embodiment, a coating may be applied to one or both of the first and the second contact surfaces. For example, the coating may be applied at least on the harder metal material, in order to improve the wearing resistance of the hard metal material. The coating may be, for example, a chrome coating. According to one embodiment of the invention, the pole piece and the armature part collide with each other during an opening operation of the valve assembly. In particular, the pole piece and the armature part collide such that the harder metal material which is located at the first section of the first contact surface of the pole piece may collide with the harder metal material which is located at the second section of the second contact surface of the armature part. The harder metal material may be configured to withstand the impact generated at the contact surfaces by the opening operation.

[0022] According to a preferred embodiment, the armature part is arranged relative to the pole piece in axial direction towards a fluid outlet portion of the injection valve.

[0023] According to a further embodiment of the invention, the armature part is axially movable between the pole piece and a stop device. This has the advantage, that a defined axial movement range of the armature part can be obtained. For example, the stop device may be a step or a protrusion in the valve body.

[0024] Exemplary embodiments of the invention are explained in the following with the aid of schematic drawings. These are as follows:

Figure 1 an injection valve in a longitudinal section view,

Figure 2 an enlarged section of the elector-magnetic actuator unit of the injection valve of figure 1,

Figure 3 an enlarged section of a further embodiment of an elector-magnetic actuator unit of an injection valve.

[0025] Figure 1 shows an injection valve 10 that is in particular suitable for dosing fuel to an internal combustion engine comprising a valve assembly 11 and an inlet tube 12.

[0026] The valve assembly 11 comprises a valve body 14 with a central longitudinal axis L and a housing 16. The housing 16 is partially arranged around the valve body 14. A cavity 18 is arranged in the valve body 14.

[0027] The cavity 18 takes in a valve needle 20, a pole piece 21 and an armature 22 which will be described in detail later. An attachment member 23 is fixedly coupled to the valve needle. For example, the attachment member 23 is formed as a collar around the valve needle 14. A main spring 24 is arranged in a recess 26 provided in an inner recess of the pole piece 21. The main spring 24 is mechanically coupled to the attachment member 23 at an axial end 29 of the attachment member 23. The attachment member 23 is in contact with an inner side of the pole piece 21 and can guide the valve needle 20 in axial direction inside the valve body 14.

[0028] A component 30 is arranged in the inlet tube 12 and forms a further seat for the main spring 24. During the manufacturing process of the injection valve 10 the component 30 can be axially moved in the inlet tube 12 in order to preload the main spring 24 in a desired man-

ner. By this the main spring 24 exerts a force on the valve needle 20 towards an injection nozzle 34 of the injection valve 10. The component 30 may comprise a fuel filter, for example.

[0029] In a closing position of the valve needle 20 it sealingly rests on a seat plate 32, by this preventing a fluid flow through the at least one injection nozzle 34. The injection nozzle 34 may be, for example, an injection hole. However, it may also be of some other type suitable for dosing fluid. In addition to that a lower guide 35 is provided adjacent to the seat plate 32. The lower guide 35 is adapted to guide the valve needle 20 near the injection nozzle 34. The seat plate 32 may be made in one part with the lower guide 35 or a separate part from the lower guide 35.

[0030] The valve assembly 11 is provided with an actuator unit 36 that is preferably an electro-magnetic actuator. The electro-magnetic actuator unit 36 comprises a coil 38, which is preferably arranged inside the housing 16 and overmolded. Furthermore, the electro-magnetic actuator unit 36 comprises the pole piece 21 and the armature 22. The armature 22 is axially movable in the cavity 18. The armature part 22 is arranged relative to the pole piece 21 in an axial direction towards a fluid outlet portion 40 which is a part of the cavity 18 near the seat plate 32. The fluid outlet portion 40 communicates with a fluid inlet portion 42 which is provided in the valve body 14.

[0031] The housing 16, the pole piece 21 and the armature part 22 are forming an electromagnetic circuit together with the valve body 14.

[0032] Figure 2 shows an enlarged section of the injection valve 10 of Figure 1. In particular, Figure 2 shows the electro-magnetic actuator unit 36 of the injection valve 10 of figure 1 in more detail. The electromagnetic actuator unit 36 comprises a pole piece 21 and an armature part 22. The pole piece 21 comprises a first contact surface 51 and the armature part comprises a second contact surface 52. The pole piece 21 and the armature part 22 may collide with each other at the respective contact surfaces 51, 52. In particular, the pole piece 21 and the armature part may collide with each other during an opening operation of the valve needle 20. The pole piece 21 is fixedly coupled with respect to the valve body 14, while the armature part 22 is axially moveable with respect to the pole piece 21 and, thus, to the valve body 14.

[0033] The pole piece 21 and the armature part 22 each comprise a first metal material 25a and a second metal material 25b wherein the second metal material 25b has a higher hardness than the first metal material 25a. The first metal material 25a is a soft magnetic material which may establish a good magnetic performance of the electromagnetic actuator unit 36.

[0034] Regarding the pole piece 21, the hard metal material 25b is located at an inner circumference of the pole piece 21. In particular, the hard metal material 25b is designed in form of a cylindrical sleeve which is arranged at an inner circumference of the pole piece 21, for example by interference fitting - in particular with the soft metal material 25a. Regarding the armature part 22, the hard metal material 25b may be designed as an insert. The insert is placed in a recess 46 in the soft metal material 25a of the armature part 22. In this way, each of the pole piece 21 and the armature part 22 are in particular composed of two separately manufactured and rigidly coupled portions, one of the portions comprising the soft metal material 25a and the other portion comprising the hard metal material 25b in each case.

[0035] The hard metal material 25b located at the contact surface 51 of the pole piece 21 and the hard metal material 25b located at the contact surface 52 of the armature part 22 at least partially overlap in a radial direction with respect to the central longitudinal axis L of the valve assembly 11.

[0036] In the described embodiment, the soft metal material 25a and the hard metal material 25b of the pole piece 21 and the armature part 22 comply with each other. However, in a further embodiment, different soft and hard metal materials may be used for the pole piece and the armature part.

[0037] Figure 3 shows an enlarged section view of a further embodiment of an electro-magnetic actuator unit 36 of an injection valve.

[0038] In particular, Figure 3 shows a pole piece 21 and an armature part 22 which are manufactured by metal injection molding. In case that the pole piece 21 and the armature part 22 are manufactured by metal injection molding, the distribution of the first metal material 25a and the second metal material 25b may be different from the embodiment shown in Figure 2. In particular, the hard metal material 25b may be a thin layer arranged at the first and second contact surfaces 51, 52. In this embodiment, the distribution of the hard metal material 25b may be very efficient, since only little volume of the hard metal material 25b may be required. Therefore, the magnetic properties of the first metal material 25a may be predominant.

[0039] In the embodiment shown in Figure 3, the layer of hard metal material 25b extends over the whole contact surface 52 of the armature part 22. In a further embodiment, the hard metal material 25b may be distributed only in a section of the contact surface 52 which may be in contact with the contact surface 51 of the pole piece 21. In particular, the hard metal material 25b may be located in a section of the contact surface 52 which overlaps with the hard metal material 25b which is located at least in a section of the contact surface 51 of the pole piece 21.

[0040] The embodiments shown in figures 2 and 3 may also be combined with each other. For example, one of the pole piece and the armature part may be a metal injection molded part as shown in figure 3, while the other one of the pole piece and the armature part may comprise an insert of hard metal material or a sleeve of hard metal material located at an inner circumference of the part as shown in figure 2.

[0041] In the following, the function of the injection valve 10 is described in detail with reference to figures 1 to 3:

The fluid is led from the fluid inlet portion 42 towards the fluid outlet portion 40.

The valve needle 20 prevents a fluid flow through the fluid outlet portion 40 in the valve body 14 in a closing position of the valve needle 20. Outside of the closing position of the valve needle 20, the valve needle 20 enables the fluid flow through the fluid outlet portion 40.

[0042] In case that the electro-magnetic actuator unit 36 with the coil 38 gets energized, the actuator unit 36 may effect a electro-magnetic force on the armature part 22. The armature part 22 may move in axial direction away from the fluid outlet portion 40, in particular upstream of a fluid flow, due to the electro-magnetic force acting on the armature part 22. The armature part 22 may take the valve needle 20 with it, for example by moving the attachment member 23, such that the valve needle 20 moves in axial direction out of the closing position. Outside of the closing position of the valve needle 20, a gap between the valve body 14 and the valve needle 20 at an axial end of the valve needle 20 facing away from of the actuator unit 36 forms a fluid path and fluid can pass through the injection nozzle 34.

[0043] In the case when the actuator unit 36 is de-energized the main spring 24 may force the valve needle 20 to move in axial direction in its closing position. It is depending on the force balance between the force on the valve needle 20 caused by the actuator unit 36 with the coil 38 and the force on the valve needle 20 caused by the main spring 24 whether the valve needle 20 is in its closing position or not.

Claims

1. Valve assembly (11) for an injection valve (10), comprising

   - a valve body (14) comprising a cavity (18),
   - a valve needle (20) axially movable in the cavity (18),
   - an electro-magnetic actuator (36) unit being designed to actuate the valve needle (20), the electro-magnetic actuator unit (36) comprising a pole piece (21) being fixedly coupled with respect to the valve body (14) and an armature part (22) being axially moveable with respect to the valve body (14), wherein the pole piece (21) comprises a first contact surface (51) and the armature part comprises a second contact surface (52), wherein the pole piece (21) and the armature part (22) are configured to collide with each other at the respective contact surfaces (51, 52), and wherein the pole piece (21) and the second armature part (22) comprise at least two different metal materials (25a, 25b), wherein one of the metal materials has a higher hardness than the at least one other metal material, and wherein the harder metal material (25b) is located at least in a first section of the first contact surface (51) and a second section of the second contact surface (52), and wherein the first section of the first contact surface (51) and the second section of the second contact surface (52) at least partially overlap in a radial direction with respect to a central longitudinal axis (L) of the valve assembly (11).

2. Valve assembly (11) according to claim 1, wherein the armature part (22) comprise a recess (46), and wherein the harder metal material (25b) is designed as an insert being placed in the recess (46).

3. Valve assembly according to claim 1 or 2, wherein the harder metal material (25b) is located at an inner circumference of the pole piece (21).

4. Valve assembly (11) according to any of claims 1 to 3, wherein the pole piece (21) and/or the armature part (22) comprises two separatly manufactured portions which are positionally fixed with respect to each other, wherein one of the portions comprises the harder metal material (25b) and the other portion comprises the at least one other metal material (25a).

5. Valve assembly (11) according to any of claims 1 to 3, wherein one or both of the pole piece (21) and the armature part (22) are two-component metal injection molded parts.

6. Valve assembly (11) according to any of the preceding claims, wherein a coating is applied on one or both of the first and the second contact surface (51, 52).

7. Valve assembly (11) according to any of the preceding claims, wherein the harder metal material (25b) has a Rockwell hardness of C50 or more and the at least one other metal material (25a) has a Rockwell hardness of B100 or less.

8. Valve assembly (11) according to any of the preceding claims, wherein the harder metal material (25b) is non-magnetic and the at least one other metal material (25a) is a magnetic material.

9. Valve assembly (11) according to any of the preceding claims, wherein the armature part (22) is fixedly coupled to the needle (20).

10. Valve assembly (11) according to any of claims 1 to 8 comprising an attachment member (23) which is fixedly coupled to the needle (20), wherein the armature part (22) is axially moveable with respect to the needle (20), and wherein the armature part (22) is configured to mechanically couple with the attachment member (23) when the armature part (22) is moved towards the pole piece (21).

Fig. 1

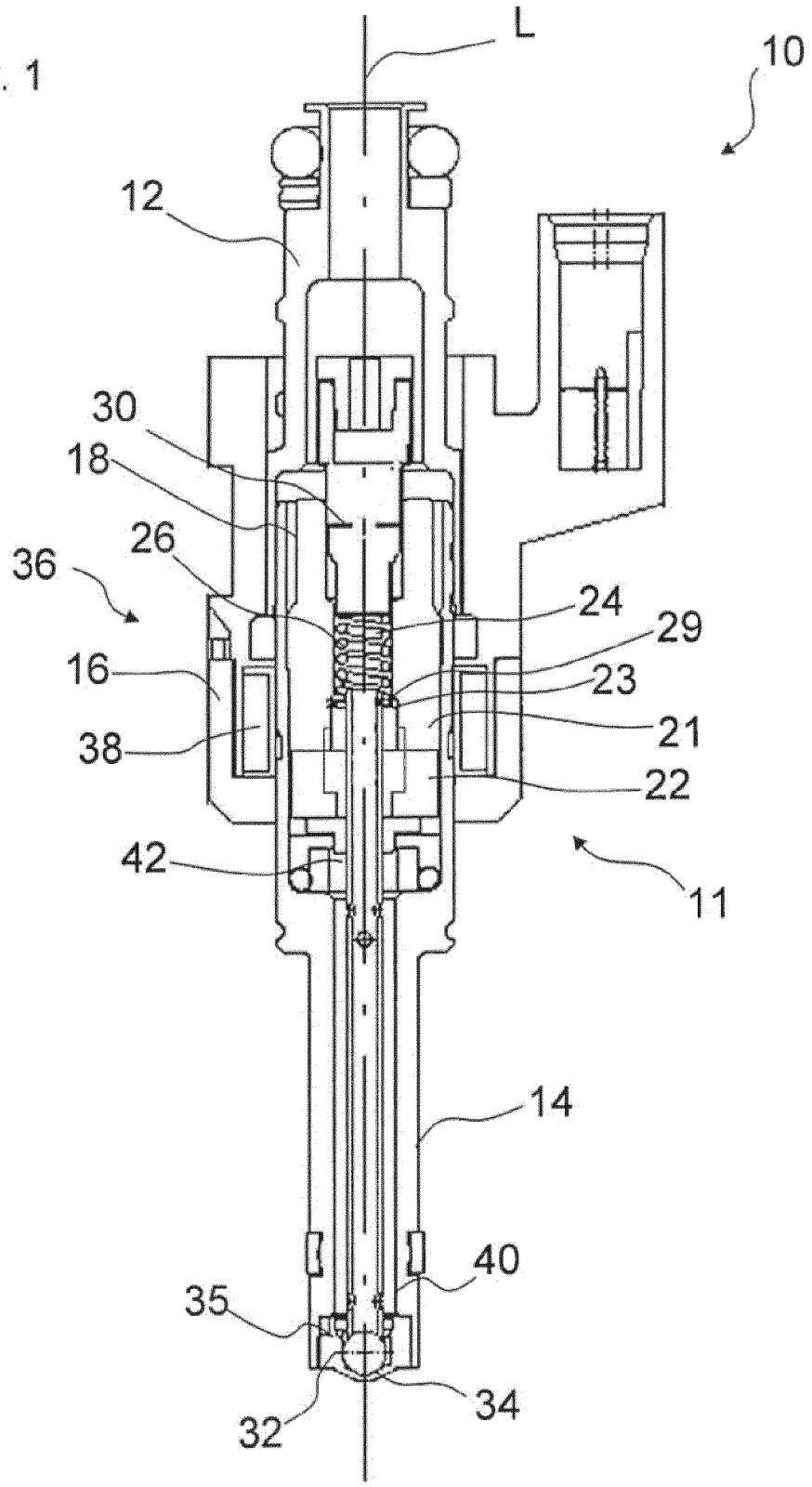


Fig. 2

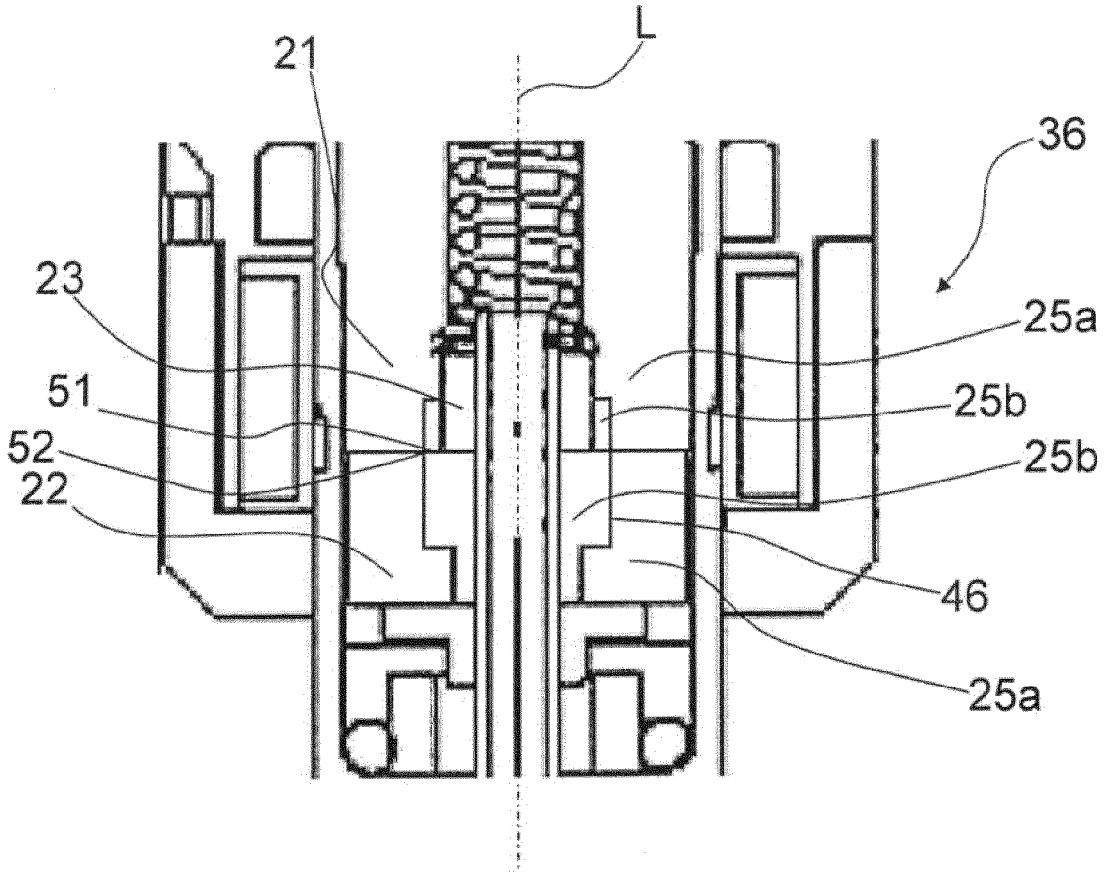
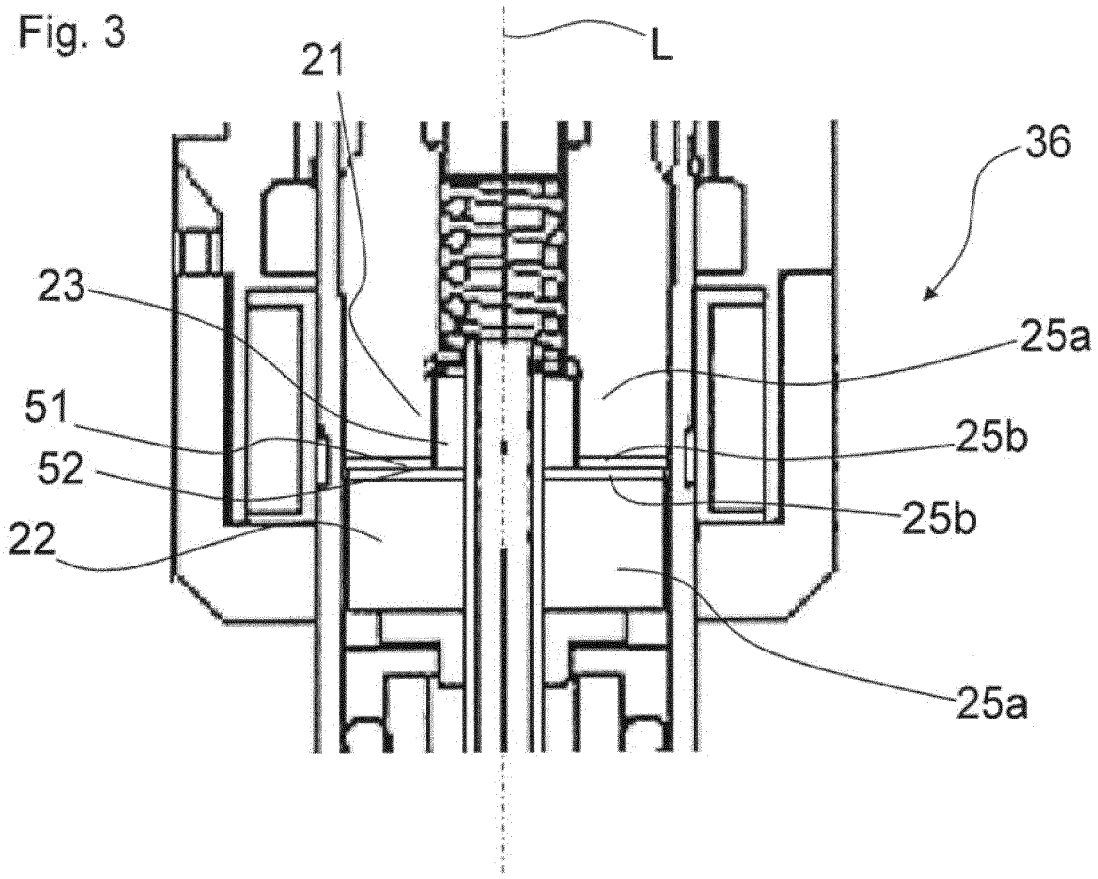


Fig. 3



Europäisches Patentamt
European Patent Office
Office européen des brevets

EUROPEAN SEARCH REPORT

Application Number
EP 12 18 7905

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X Y	DE 44 21 947 A1 (BOSCH GMBH ROBERT [DE]) 14 June 1995 (1995-06-14) * column 4, line 22 - column 5, line 16; figures 2,3 * * abstract * -----	1,5-7,9, 10 2,3,8	INV. F02M51/06 F02M61/16
Y	EP 1 754 882 A1 (KEIHIN CORP [JP]) 21 February 2007 (2007-02-21) * paragraph [0018] - paragraph [0021]; figure 2 * * abstract * -----	2,3,8	
X	EP 2 492 488 A1 (HITACHI AUTOMOTIVE SYSTEMS LTD [JP]) 29 August 2012 (2012-08-29) * paragraph [0022] - paragraph [0023]; figure 2 * * abstract * -----	1,6,9	

TECHNICAL FIELDS SEARCHED (IPC)

F02M

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	29 January 2013	Hermens, Sjoerd

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

EPO FORM 1503 03.82 (P04C01)

2

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 12 18 7905

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
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

29-01-2013

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
DE 4421947 A1	14-06-1995	DE 4421935 A1	14-06-1995
		DE 4421947 A1	14-06-1995
EP 1754882 A1	21-02-2007	BR PI0508235 A	17-07-2007
		CN 1926325 A	07-03-2007
		EP 1754882 A1	21-02-2007
		JP 3819906 B2	13-09-2006
		JP 2005240732 A	08-09-2005
		MY 138041 A	30-04-2009
		US 2008035761 A1	14-02-2008
		WO 2005083260 A1	09-09-2005
EP 2492488 A1	29-08-2012	CN 102575627 A	11-07-2012
		EP 2492488 A1	29-08-2012
		JP 2011089432 A	06-05-2011
		US 2012204839 A1	16-08-2012
		WO 2011048736 A1	28-04-2011

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82