



(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
13.02.2008 Bulletin 2008/07

(51) Int Cl.:
F02M 63/00 (2006.01) F02M 61/16 (2006.01)

(21) Application number: **06016135.3**

(22) Date of filing: **02.08.2006**

(84) Designated Contracting States:
AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HU IE IS IT LI LT LU LV MC NL PL PT RO SE SI SK TR
Designated Extension States:
AL BA HR MK YU

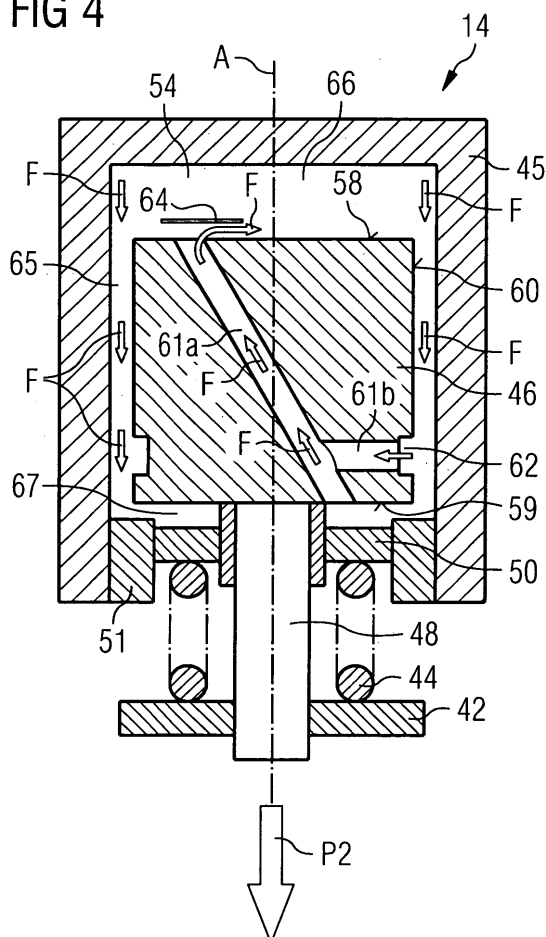
(71) Applicant: **SIEMENS AKTIENGESELLSCHAFT**
80333 München (DE)

(72) Inventor: **Cipriani, Emiliano, Dr.**
57100 Livorno (IT)

(54) **Thermal compensation arrangement in an injection valve**

(57) Thermal compensation arrangement (14) for an injection valve (10). The thermal compensation arrangement (14) comprises a casing (45) being coupable to the housing (12) and comprising a recess (54), a piston (46) axially movable in the recess (54) and being coupable to a valve needle actuator unit (16), the piston (46) having a lateral surface (60), a first front surface (58) pointing in axial direction and a second front surface (59) pointing in axial direction and away from the first front surface (58), a gap (65) between the lateral surface (60) of the piston and the casing (45), a first piston channel (61a) being arranged in the piston (46) and extending from the first front surface (58) to the second front surface (59) of the piston (46), and a second piston channel (61b) extending from the lateral surface (60) to the first piston channel (61a) thereby enabling a fluid flow through the second piston channel (61b) between the gap (65) and a recess section (66) extending in axial direction between the first front surface (58) of the piston (46) and the casing (45).

FIG 4



Description

[0001] The invention relates to a thermal compensation arrangement for an injection valve and 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 for an internal combustion engine comprise actuator units. In order to inject fuel, the actuator unit is energized so that a fluid flow through the fluid outlet portion of the injection valve is enabled.

[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 the range of up to 200 bar or in the case of diesel engines in the range of up to 2,000 bar. The injection of fluids under such high pressures has to be carried out very precisely.

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

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

[0007] According to a first aspect the invention is distinguished by a thermal compensation arrangement for an injection valve, the injection valve comprising a housing including a central longitudinal axis, the housing comprising a cavity, a valve needle axially movable in the cavity, and an actuator unit being coupled to the valve needle and enabling the axial movement of the valve needle relative to the housing upon actuation of the actuator unit. The thermal compensation arrangement comprises a casing being coupable to the housing and comprising a recess, a piston axially movable in the recess and being coupable to the actuator unit. The piston has a lateral surface, a first front surface pointing in axial direction and a second front surface pointing in axial direction and away from the first front surface. Furthermore, the thermal compensation arrangement comprises a gap being formed in the recess and extending in radial direction between the lateral surface of the piston and the casing, a first piston channel being arranged in the piston and extending from the first front surface to the second front surface of the piston, and a second piston channel extending from the lateral surface to the first piston channel thereby enabling a fluid flow through the second piston channel between the gap and a recess section extending in axial direction between the first front surface of the piston and the casing.

[0008] This has the advantage that in the case of an axial movement of the piston in direction to the actuator unit a high fluid flow rate from the gap to the recess section

between the front surface and the casing via the piston channels is possible. In this case a high circulation flow rate of the fluid flowing from the recess section between the front surface and the casing through the gap and the piston channels back to the recess section between the front surface and the casing is possible. By this deposits of components of the fluid in the recess and in particular in the gap can be prevented.

[0009] In an advantageous embodiment the thermal compensation arrangement has a groove being arranged on the lateral surface of the piston and being hydraulically coupled to the second piston channel. This allows a good performance of the fluid flow from the gap into the piston channel.

[0010] In a further advantageous embodiment the groove is extending circumferentially over the lateral surface of the piston. The advantage of this is that a good fluid flow performance from the whole gap over the whole circumference of the piston into the piston channel is possible.

[0011] According to a second aspect the invention is distinguished by an injection valve comprising a thermal compensation arrangement.

[0012] Exemplary embodiments of the invention are explained in the following with the help of schematic drawings. These are as follows:

Figure 1, an injection valve in a longitudinal section view,

Figure 2, an enlarged view of a part of the injection valve according to figure 1 with a thermal compensation arrangement,

Figure 3, an enlarged view of the thermal compensation arrangement for the injection valve in a first operating condition, and

Figure 4, an enlarged view of the thermal compensation arrangement for the injection valve in a second operating condition.

[0013] Elements of the same design and function that appear in different illustrations are identified by the same reference characters.

[0014] An injection valve 10 (figure 1) that is used as a fuel injection valve for an internal combustion engine, comprises a housing 12, a thermal compensation arrangement 14 and an actuator unit 16.

[0015] The housing 12 has a tubular shape. The actuator unit 16 is inserted into the housing 12 and comprises a piezo actuator, which changes its axial length depending on a control signal applied to it. The actuator unit 16 may, however, also comprise another type of actuator, which is known to person skilled in the art for that purpose. Such an actuator may be, for example, a solenoid.

[0016] The injection valve 10 comprises a valve body 20 with a central longitudinal axis A and a cavity 24 which

is axially led through the valve body 20. On one of the free ends of the cavity 24, a fluid outlet portion 28 is formed which is closed or open depending on the axial position of a valve needle 22. The injection valve 10 further has a fluid inlet portion 26 which is arranged in the housing 12 and which is hydraulically coupled to the cavity 24 and a not shown fuel connector. The fuel connector is designed to be connected to a high pressure fuel chamber of an internal combustion engine, the fuel is stored under high pressure, for example, under the pressure above 200 bar.

[0017] The valve body 20 has a valve body spring rest 32 and the valve needle 22 comprises a valve needle spring rest 34, both spring rests 32, 34 supporting a main spring 30 arranged between the valve body 20 and the valve needle 22.

[0018] The injection valve 10 is of an outward opening type. In an alternative embodiment of the injection valve 10 may be of an inward opening type. Between the valve needle 22 and the valve body 20 a bellow 36 is arranged which is sealingly coupling the valve body 20 with the valve needle 22. By this a fluid flow between the cavity 24 and a chamber 38 is prevented. Furthermore, the bellow 36 is formed and arranged in a way that the valve needle 22 is actuatable by the actuator unit 16.

[0019] Figure 2 shows a longitudinal sectional view of the thermal compensation arrangement 14 arranged in the housing 12 and coupled to the actuator unit 16.

[0020] The thermal compensation unit 14 has a casing 45 of a cylindrical shape which has a recess 54, in which a piston 46 is arranged which is of a cylindrical shape and extends in the axial direction of the casing 45 and is coupled to the actuator unit 16 by a connecting bar 48.

[0021] The thermal compensation unit 14 comprises a sealing element 50 arranged in a piston rest 51 being part of the casing 45 and supporting the piston 46 in an initial state of the thermal compensation unit 14 as described below.

[0022] A spring retaining element 42 is mechanically coupled to the thermal compensation unit 14 by the connecting bar 48. A compensation spring 44 is arranged between the sealing element 50 of the thermal compensation unit 14 and a spring retaining element spring rest 52 of the spring retaining element 42 to support the compensation spring 44.

[0023] The thermal compensation arrangement 14 is rigidly coupled to the housing 12 of the injection valve 10 by a welding seam 56 extending circumferentially over a side surface 57 of the casing 45 of the thermal compensation arrangement 14.

[0024] Figure 3 and 4 show the thermal compensation arrangement 14 in a longitudinal sectional and in large detailed view. The piston 46 of the thermal compensation arrangement 14 has a first front surface 58 pointing in axial direction away from the actuator unit 16 and a second front surface 59 pointing in axial direction and facing the actuator unit 16 thereby pointing away from the first front surface 58. The cylindrical shaped piston 46 further-

more has a lateral surface 60 extending between the first front surface 58 and the second front surface 59.

[0025] Between the lateral surface 60 of the piston 46 and the casing 45 of the thermal compensation arrangement 14, a gap 65 is formed being a part of the recess 54 of the casing 45. Between the first front surface 58 of the piston 46 and the casing 45 a recess section 66 is extending in axial direction. Between the second front surface 59 of the piston 46 and the sealing element 50 a bottom recess section 67 is arranged. The recess section 66 and the bottom recess section 67 are part of the recess 54 of the casing 45.

[0026] It will be described in the following that the recess section 66 and the bottom recess section 67 are changing their volumes in the case of an axial movement of the piston 46 in the casing 45.

[0027] A first piston channel 61a is arranged in the piston 46 and extends from the first front surface 58 of the piston 46 to the second front surface 59 of the piston 46. The first piston channel 61a allows a hydraulic coupling of the recess section 66 between the first front surface 58 of the piston 46 and the casing 45 and the bottom recess section 67 extending between the sealing element 50 and the second front surface 59 of the piston 46.

[0028] A second piston channel 61b is extending from the lateral surface 60 of the piston 46 to the first piston channel 61a. The second piston channel 61b enables a hydraulic coupling between the gap 65 and the first piston channel 61a.

[0029] On the lateral surface 60 of the piston 46 a groove 62 is arranged in the piston 46 which extends circumferentially over the lateral surface 60 of the piston 46 and is hydraulically coupled to the second piston channel 61b. By this a good hydraulic coupling of the gap 65 to the second piston channel 61b can be obtained. The width of the groove 62 in axial direction is larger than the width of the second piston channel 61b. By that the groove 62 and the second piston channel 61b are forming a funnel with good values for the fluid dynamic properties of the hydraulic coupling between the gap 65 and the second piston channel 61b.

[0030] At one end of the first piston channel 61a on the first front surface 58 of the piston 46 a flap 64 is arranged.

[0031] In the following, the function of the injection valve 10 will be described:

[0032] The fuel is led from the fluid inlet portion 26 in the housing 12 towards the valve body 20 and then towards the fluid outlet portion 28.

[0033] The valve needle 22 prevents a fluid flow through the fluid outlet portion 28 in the valve body in a closing position of the valve needle 22. Outside of the closing position of the valve needle 22, the valve needle 22 enables the fluid flow through the fluid outlet portion 28.

[0034] In the case that the actuator unit 16 has a piezo electric actuator, the piezo electric actuator may change its axial length if it gets energized. By changing its length

the actuator unit 16 may effect a force on the valve needle 22. Due to the elasticity of the bellow 36 the valve needle 22 is able to move in axial direction out of the closing position. Outside the closing position of the valve needle 22 there is a gap between the valve body 20 and the valve needle 22 at an axial end of the injection valve 10 facing away from the actuator unit 16. The gap is forming a valve nozzle 29.

[0035] The main spring 30 can force the valve needle 22 via the valve needle spring rest 34 towards the actuator unit 16. In the case the actuator unit 16 is de-energized the actuator unit 16 shortens its length. Due to the elasticity of the bellow 36 the main spring 30 can force the valve needle 22 to move in axial direction its closing position. It is depending on the force balance between the force on the valve needle 22 caused by the actuator unit 16 and the force on the valve needle 22 caused by the main spring 30 whether the valve needle 22 is in its closing position or not. If the valve needle 22 is not in its closing position a fuel flow is enabled through the valve nozzle 29.

[0036] The thermal compensation arrangement 14 serves two purposes: first the compensation of changes of the length of the actuator unit 16 due to thermal variations which are comparable slow changes and second the compensation of impulsive forces of the actuator unit 16 due to an energizing and a de-energizing of the actuator unit 16 which result in relative fast movements of the piston 46 in the casing 45 of the thermal compensation arrangement 14. In the following the function of the thermal compensation arrangement 14 concerning the fast movements of the piston 46 due to energizing and de-energizing of the actuator unit 16 will be described in detail:

[0037] In figure 3 the thermal compensation arrangement 14 is shown in its initial state. This means that the actuator unit 16 is de-energized and the piston 46 is in contact with the piston rest 51 due to the spring forces of the compensation spring 44.

[0038] If the actuator unit 16 is energized and therefore changes its length to move the valve needle 22 out of the closing position simultaneously the piston 46 in the recess 54 of the casing 45 is moved in axial direction in a first piston movement direction P1 (Fig. 3) away from the sealing element 50. This movement causes a pressure wave in the recess section 66 between the first front surface 58 of the piston 46 and the casing 45 of the thermal compensation arrangement 14. The pressure wave in the fluid forces the fluid in the recess 54 to flow in a fluid flow direction F from the recess section 66 to the gap 65. When the piston 46 starts to move in the first piston direction P1 the piston 46 loses contact with the piston rest 51 allowing the fluid flowing from the gap 65 to the bottom recess section 67 adjacent to the sealing element 50. During this the volume of the bottom recess section 67 is increasing while the volume of the recess section 66 is decreasing. As the pressure wave in the recess section 66 caused by the movement of the piston

46 forces the flap 64 to be closed a fluid flow through the first piston channel 61a is prevented.

[0039] If the actuator unit 16 is de-energized and consequently, the actuator unit 16 shortens its length to force the valve needle 22 to move in axial direction into its closing position, the piston 46 of the thermal compensation arrangement 14 is forced to move in a second piston movement direction P2 (Fig. 4) towards the sealing element 50. During this the volume of the recess section 66 is increasing and the volume of the bottom recess section 67 is decreasing. The movement of the piston 46 creates a pressure wave in the fluid being in the first piston channel 61a which opens the flap 64. By this fluid flows through the first piston channel 61a into the recess section 66 between the first front surface 58 of the piston 46 and the casing 54.

[0040] Due to the pressure wave of the fluid in the first piston channel 61a, low pressure is generated in the second piston channel 61b which allows to suck fluid from the gap 65 into the second piston channel 61b and further into the first piston channel 61a. By this a good circulation of fluid in the gap 65 is achieved. Additionally, the groove 62 allows sucking the fluid in the gap 65 into the second piston channel 61b over the whole circumference of the piston 46. Due to the second piston channel 61b a good circulation of fluid from the piston channel 61a to the recess section 66 and further to the gap 65 and the second piston channel 61b in fluid flow direction F is possible. By this a deposition of components of the fluid in the recess 54 and in particular in the gap 65 may be prevented.

Claims

1. Thermal compensation arrangement (14) for an injection valve (10), the injection valve (10) comprising
 - a housing (12) including a central longitudinal axis (A), the housing (12) comprising a cavity (24),
 - a valve needle (22) axially movable in the cavity (24), and
 - an actuator unit (16) being coupled to the valve needle (22) and enabling the axial movement of the valve needle (22) relative to the housing (12) upon actuation of the actuator unit (16),

the thermal compensation arrangement (14) comprising

- a casing (45) being coupable to the housing (12) and comprising a recess (54),
- a piston (46) axially movable in the recess (54) and being coupable to the actuator unit (16), the piston (46) having a lateral surface (60), a first front surface (58) pointing in axial direction and a second front surface (59) pointing in axial di-

- rection and away from the first front surface (58),
- a gap (65) being formed in the recess (54) and
extending in radial direction between the lateral
surface (60) of the piston and the casing (45),
- a first piston channel (61a) being arranged in 5
the piston (46) and extending from the first front
surface (58) to the second front surface (59) of
the piston (46), and
- a second piston channel (61b) extending from 10
the lateral surface (60) to the first piston channel
(61a) thereby enabling a fluid flow through the
second piston channel (61b) between the gap
(65) and a recess section (66) extending in axial
direction between the first front surface (58) of 15
the piston (46) and the casing (45).
2. Thermal compensation arrangement (14) in accord-
ance with claim 1 with a groove (62) being arranged
on the lateral surface (60) of the piston (46) and being 20
hydraulically coupled to the second piston channel
(61b).
3. Thermal compensation arrangement (14) in accord-
ance with claim 2 with the groove (62) extending cir- 25
cumferentially over the lateral surface (60) of the pis-
ton (46).
4. Injection valve (10) comprising the thermal compen-
sation arrangement (14) in accordance with one of 30
the preceding claims.

35

40

45

50

55

FIG 1

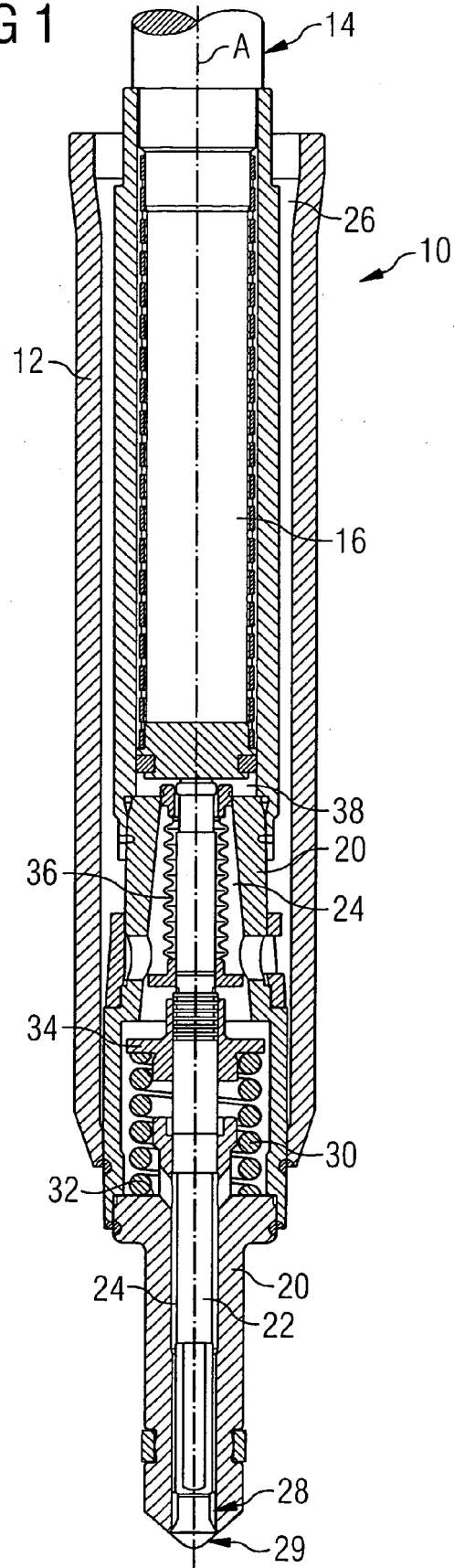


FIG 2

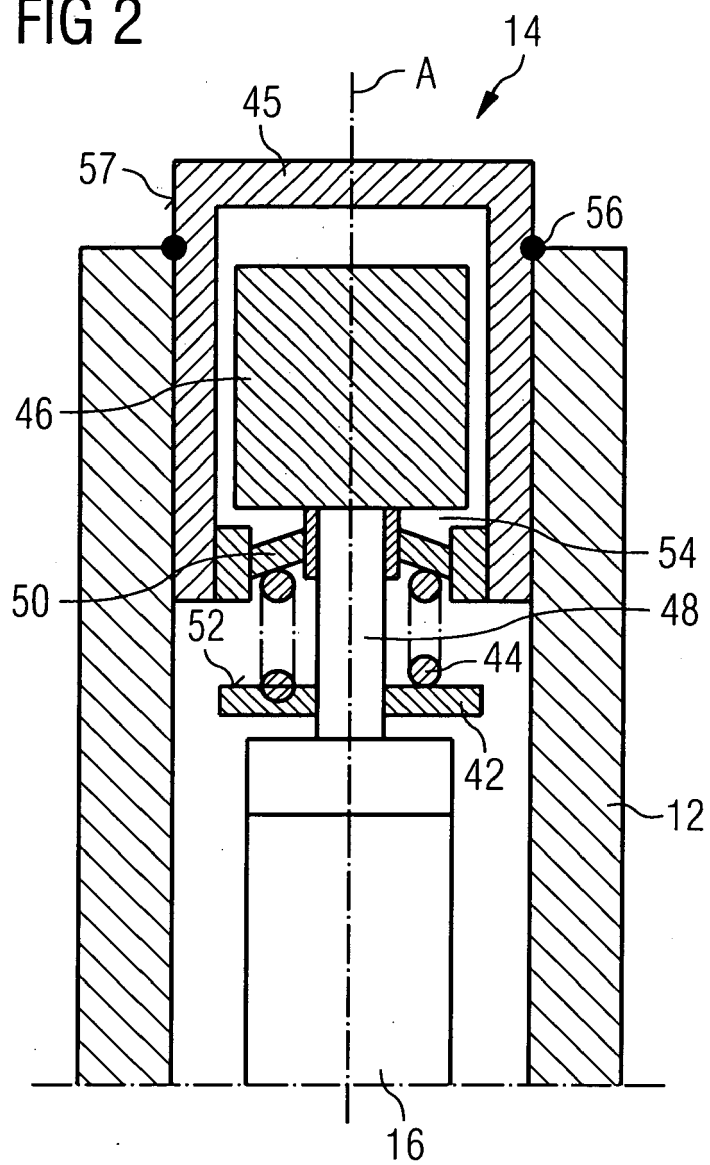


FIG 3

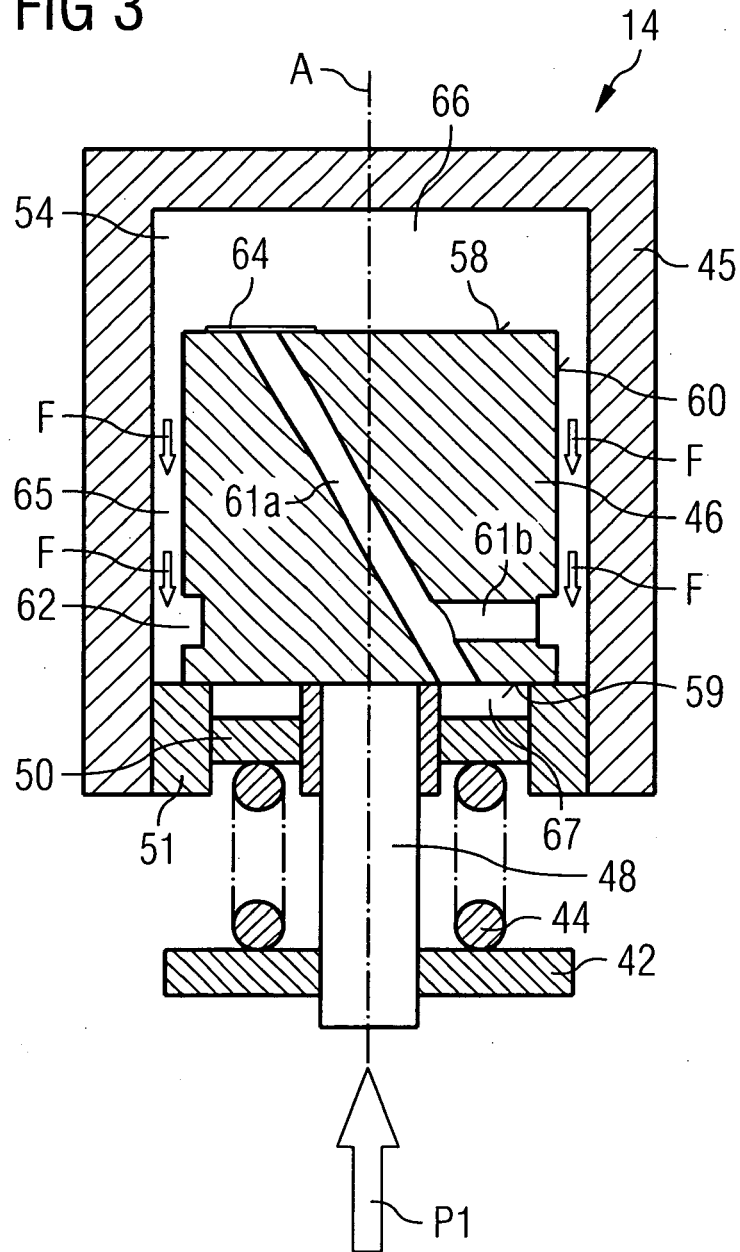
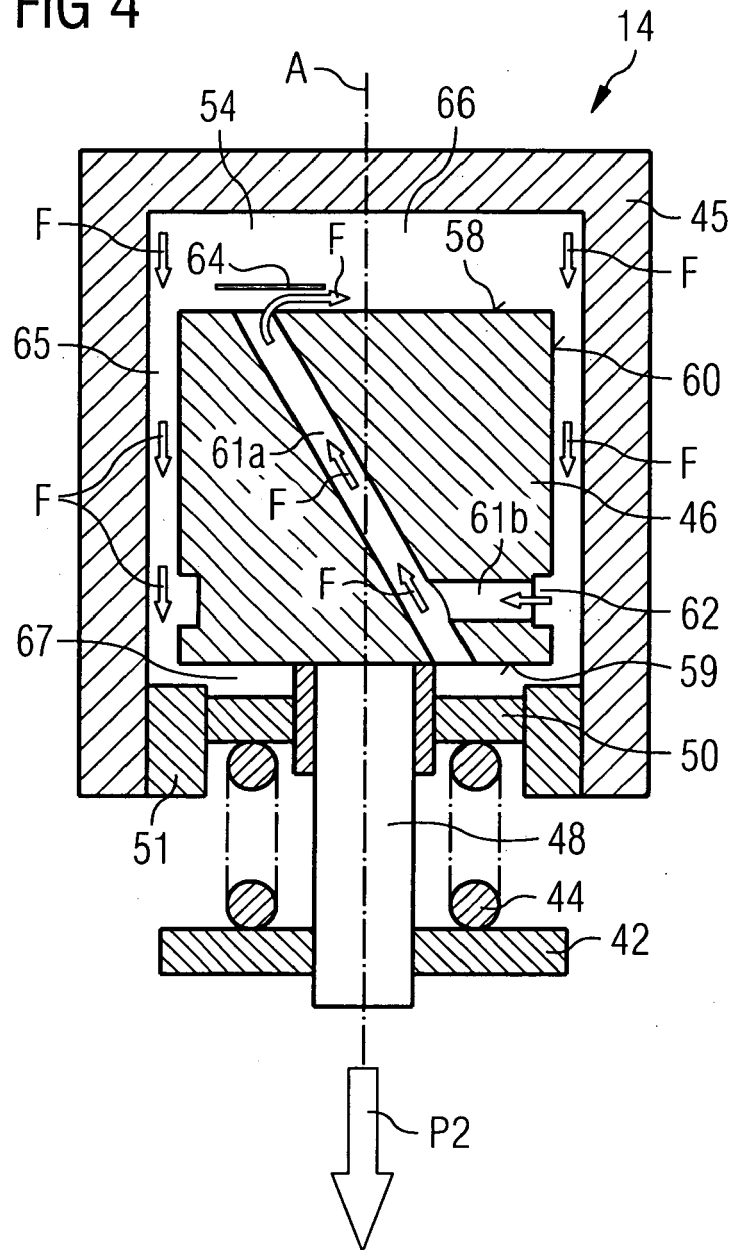


FIG 4





DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A	WO 02/31349 A (SIEMENS AUTOMOTIVE CORP LP [US]) 18 April 2002 (2002-04-18) * page 6, line 9 - page 7, line 9; figures 1,2 *	1,4	INV. F02M63/00 F02M61/16
A	EP 1 591 656 A2 (ISUZU MOTORS LTD [JP]) 2 November 2005 (2005-11-02) * paragraphs [0063], [0064]; figures 1,2 *	1,4	
A	EP 1 519 035 A (BOSCH GMBH ROBERT [DE]) 30 March 2005 (2005-03-30) * paragraph [0027]; figures 1,2 *	1,4	
A	EP 1 391 608 A1 (SIEMENS VDO AUTOMOTIVE S P A [IT]) 25 February 2004 (2004-02-25) * paragraphs [0031] - [0034]; figures 1,3 *	1,4	
The present search report has been drawn up for all claims			TECHNICAL FIELDS SEARCHED (IPC)
			F02M
Place of search		Date of completion of the search	Examiner
Munich		4 January 2007	Kolland, Ulrich
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			

3

EPO FORM 1503 03.82 (P04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 06 01 6135

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.

04-01-2007

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
WO 0231349	A	18-04-2002	EP 1325224 A1	09-07-2003
			EP 1325225 A1	09-07-2003
			EP 1325226 A1	09-07-2003
			EP 1325227 A1	09-07-2003
			EP 1325229 A1	09-07-2003
			JP 3838974 B2	25-10-2006
			JP 2004515672 T	27-05-2004
			JP 2004511700 T	15-04-2004
			JP 3828490 B2	04-10-2006
			JP 2004513278 T	30-04-2004
			JP 2004514083 T	13-05-2004
			JP 2004511701 T	15-04-2004
			WO 0231344 A1	18-04-2002
			WO 0231345 A1	18-04-2002
			WO 0231346 A1	18-04-2002
			WO 0231347 A1	18-04-2002

EP 1591656	A2	02-11-2005	US 2005236499 A1	27-10-2005

EP 1519035	A	30-03-2005	DE 10343017 A1	14-04-2005

EP 1391608	A1	25-02-2004	DE 60204565 D1	14-07-2005
			DE 60204565 T2	03-11-2005
