



(11) **EP 3 139 028 A1**

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
08.03.2017 Bulletin 2017/10

(51) Int Cl.:
F02M 51/06 (2006.01) **F02M 61/08** (2006.01)
F02M 61/16 (2006.01)

(21) Application number: **15183646.7**

(22) Date of filing: **03.09.2015**

(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
Designated Validation States:
MA

(72) Inventor: **COOKE, Michael**
Rochester, Kent ME1 1LZ (GB)

(74) Representative: **Delphi France SAS**
Patent Department
22, avenue des Nations
CS 65059 Villepinte
95972 Roissy CDG Cedex (FR)

(71) Applicant: **Delphi International Operations**
Luxembourg S.à r.l.
4940 Bascharage (LU)

(54) **DOUBLE ENDED COUPLER FOR SERVO ACTUATOR**

(57) An actuator assembly (12) of a fuel injector (10) has an elongated body provided with an internal bore (22) extending from an opening (24) to a bottom face (26) and wherein a servo actuator member (46) is arranged to extend and retract in order to cooperate with a valve member. The actuator assembly (12) further comprises a hydraulic lash adjuster (HLA) filled with fluid, the HLA being provided with a first reaction chamber (90) wherein pressure rises when the actuator member (46) extends and pressure drops when the actuator member (46) retracts and, a second reaction chamber (92) wherein pressure drops when the actuator member (46) extends and pressure rises when the actuator member (46) retracts so that, the HLA is adapted to resist both the extensions and the contractions of the servo actuator member (46).

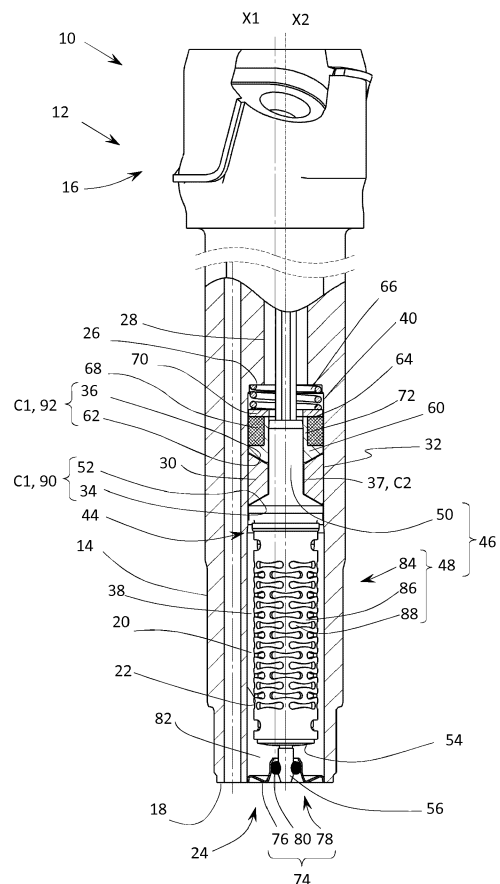


Figure 1

Description

TECHNICAL FIELD

[0001] The present invention relates to an actuator assembly for a fuel injector and more particularly to servo actuator provided with an integral hydraulic lash adjuster.

BACKGROUND OF THE INVENTION

[0002] In fuel injectors, injection events are indirectly commanded by energizing an actuator displacing a valve opening a spill orifice. When the actuator is no longer energized, a spring displaces the valve closing said orifice.

[0003] Servo actuators, such as piezo or magneto-restrictive actuators, require hydraulic lash adjuster, hereafter HLA, also called "coupler" in order to adapt to slow variations of the lengths of the parts caused by temperature changes and wear. DE102010029106, DE102009000203, EP1519037, WO2013053594, WO2013053594 disclose examples of such injectors.

[0004] The working volume of the HLA becomes pressurized when control valve is opened as the actuator is energized, but after an injection, inertia of the moving parts and the fluid leaked out during operation can cause cavities to form in the working fluid, meaning that motion of the parts is only well controlled in the compression direction.

SUMMARY OF THE INVENTION

[0005] Accordingly, it is an object of the present invention to resolve the above mentioned problems in providing an actuator assembly of a fuel injector. The actuator assembly has an elongated body provided with an internal bore extending from an opening to a bottom face and wherein a servo actuator member is arranged to extend and retract in order to cooperate with a valve member.

[0006] The actuator assembly further comprises a hydraulic lash adjuster (hereafter HLA) filled with fluid, the HLA being provided with a first reaction chamber wherein pressure rises when the actuator member extends and wherein pressure drops when the actuator member retracts and, a second reaction chamber wherein pressure drops when the actuator member extends and wherein pressure rises when the actuator member retracts so that, the HLA is adapted to resist both the extensions and the contractions of the servo actuator member.

[0007] Also, the first reaction chamber and the second reaction chamber are in fluid communication with each other.

[0008] In an embodiment, the first reaction chamber of the HLA is defined between a first inner shoulder face of the bore and a first outer shoulder face of the actuator member.

[0009] Also, the second reaction chamber of the HLA is defined between a second inner shoulder face of the

bore and a second outer shoulder face of the actuator member.

[0010] The actuator assembly may further comprise an annular reacting plug arranged in the bore and fixed to the actuator body. The plug locally restricts the section of the bore, the first inner shoulder face and the second inner shoulder face being integral to said annular plug.

[0011] Also, the actuator member has a thin head portion extending with clearance fit through a central opening of the annular plug and protruding in a secondary chamber defined between said second inner shoulder face and the bottom face of the bore.

[0012] The actuator assembly may further comprise an annular collar engaged and fixed to the thin head portion protruding in a secondary chamber, the second outer shoulder face being integral to said collar.

[0013] The annular collar may be threaded onto the head portion of the actuator member so that the volume of the second reaction chamber can be chosen by adjusting the axial position of the collar on the head portion.

[0014] Also, the actuator assembly may further comprise a locking screw adapted to lock the position of the annular collar over the head portion.

[0015] Also, the actuator assembly may further comprise a fluid absorbing member arranged in said secondary chamber, said fluid absorbing member being made of a material such as felt or sponge which by capillary action can attract the fluid ensuring that there is fluid present in the first reaction chamber and in the second reaction chamber irrespective of the orientation of the assembly.

[0016] Also, the actuator assembly may further comprise at least one securing member, such as a screw, securing the reacting plug to the actuator body.

[0017] The fluid may be high viscosity silicone oil.

[0018] The invention also extends to a fuel injector comprising an actuator assembly as described above.

BRIEF DESCRIPTION OF THE DRAWINGS

[0019] The present invention is now described by way of example with reference to the accompanying drawings in which:

Figure 1 is an axial section of a first embodiment of an actuator assembly comprising an integral hydraulic lash adjuster as per the invention.

Figure 2 is an axial section of a, alternative embodiment of an actuator assembly as per the invention.

Figure 3 is an axial section of a second embodiment of an actuator assembly as per the invention.

Figure 4 is an external view of the actuator assembly of figure 3.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0020] In reference to the figures is described the actuator assembly 12 of a fuel injector 10, the assembly 12

comprising an actuator body 14 extending along a longitudinal axis X1, drawn vertical on the figures the top-down arbitrary orientation of the figures being utilized to ease, simplify and clarify the present description without any intention to limit the invention. The actuator body 14 extends from an upper region 16, top of the figures, where can be placed an electrical connector not represented, to a lower transverse face 18 adapted to be in sealing surface contact against the top face of a control valve assembly not represented. The body 14 is also provided with an internal cylindrical cavity 20 extending inside the body 14 along a cavity axis X2 parallel to the longitudinal axis X1. The cavity 20 comprises a large bore 22 upwardly extending from an opening 24 in the lower transverse face 18, up to a bottom face 26 wherefrom a thinner conduit 28 upwardly extends toward the upper region 16.

[0021] In the large bore 22 is arranged an annular reacting plug 30 fixed to the body 14 the reacting plug 30 having a peripheral cylindrical face 32 that is in contact with the inner wall of the large bore, a first inner shoulder face 34, or lower face 34, a second inner shoulder face 36, or upper face 36 and, a central axial aperture 37 defining an inner cylindrical face. On the illustrated example of the figures the cross section of the annular plug 30 is an isosceles trapezium, first 34 and second 36 shoulder faces being conical and symmetrical. The advantages attached to such embodiment are detailed below but alternatively, any other cross section would fit the purpose of the invention and in particular, acute or obtuse, symmetric or non-symmetric, trapezium sections. A reacting plug 30 having parallel plane upper and lower faces could also be chosen.

[0022] In place in the large bore 22, the reacting plug 30 divides said large bore 22 into a main chamber 38, extending below the reacting plug 30 toward the opening 24 in the lower transverse face and, a secondary chamber 40 extending above the reacting plug 30 to the bottom face 26 of the large bore 22.

[0023] The reacting plug 30 may be fixed in the large bore 22 by press-fit, as represented on figure 1, or via securing members 42 such as pressing-screws 42, represented on figures 2 and 4, said screws being radially threaded in the wall of the body 14, the sealing of the threaded holes being ensured after assembly with tightening glue or sealing paste. In the particular press-fit arrangement, to minimize the pressing distance of the plug 30 into the large bore 22, said bore 22 may be provided with a small pressing step 44 so that the section of the main chamber 38 below said step 44 is slightly enlarged facilitating the insertion of the plug 30.

[0024] In the cavity 20 is arranged with clearance fit C a servo actuator member 46, such as a piezo-electric or a magneto restrictive actuator, which has a large cylindrical actuation portion 48, a thinner head portion 50 and a first outer shoulder face 52 in-between them. The actuation portion 48 extends in the main chamber 38 from a lower face 54 to the first outer shoulder face 52 which faces the first inner shoulder face 34 of the reacting plug

30 then, the thinner head portion 50 upwardly extending from said first outer shoulder face 52 engages through the central opening 37 of the plug and protrudes on the opposite side in the secondary chamber 40. A male actuation pin 56 protrudes from the lower face 54 and, electrical wires departing from the thinner head portion 50 upwardly extend in the thinner conduit 28, toward the electrical connector.

[0025] In the secondary chamber 40 is arranged with clearance fit a collar 60 that is fixed on the protruding portion of the head portion 50, the collar 60 having a lower face 62, or second outer shoulder face 62, arranged facing the second inner shoulder face 36 of the reacting plug, the two shoulder faces 36, 62, having complementary parallel profiles and, in the chosen illustrated example the lower face 62 is conical.

[0026] In a non-represented embodiment, the collar 60 has right-angled trapezium cross section, the lower face 62 being the sloped leg of the trapezium opposed to a transverse upper face 64 that is the right angle leg above which, in the secondary chamber 40, an actuator spring 66 compressed between said upper face 64 and the bottom face 26 of the large bore permanently downwardly solicits the actuator member 46.

[0027] Otherwise, in the represented embodiments the collar 60 is provided on its upper face with a recess in which is arranged an absorbing member 68 made of a material such as felt or sponge. On the figures, the absorbing member 68 is a thick washer above which a closing washer 70 closes the recess and receives the actuator spring 66, the axial force of the spring 66 being transmitted from the closing washer 70 to the collar 60 via an inner tubular spacer 72 through which is engaged the head portion 50. The spacer 72 can be integral to the collar 60, as represented on the figure, or can be provided separately as an independent component.

[0028] At the opposite extremity of the large bore, the opening 24 in the lower transverse face 18 is closed by a resilient sealing assembly 74 comprising a resilient sealing member 76 provided with a central aperture 78 through which extends the actuation pin 56, said sealing assembly 74 sealingly closing the cavity 20, thanks to an O-ring 80 arranged in the central aperture 78 and radially compressed between the sealing member 76 and the actuation pin 56.

[0029] The actuator member 46 is arranged in the cavity 20 so that its lower face 54 remains inside the cavity 20 at a distance of the sealing member 76 defining between them a reservoir 82.

[0030] Inside the cavity 20, the actuator member 46 is immersed in high viscosity fluid F such as silicone oil having typically a viscosity in the 1,000-800,000 centistokes range, said fluid F filling a fluid filling volume VF comprising all available spaces of the cavity 20, all said spaces being in fluid communication with each other. The fluid filling volume VF comprises the main chamber 38, the reservoir 82, the secondary chamber 40 wherein the fluid F is absorbed and captured in the absorbing washer

68 and also, the clearances for instance between the inner and outer shoulder faces. In the non-represented embodiment where no absorbing member is arranged in the secondary chamber 40, the fluid F may fill part of the secondary chamber, half for instance, so that said secondary chamber may act as a compensation reservoir ensuring that fluid is always present in the rest of the filling volume VF even if the actuator assembly is arranged in a slightly non vertical way, and also to allow for thermal expansion and contraction of the fluid.

[0031] In a first embodiment depicted on figure 1, the actuation portion 48 of the actuator member comprises a piezo stack 84 axially compressed in a very stiff cage spring 86 having a tubular body provided with a plurality of regularly spaced transverse apertures 88 providing to the tubular body the required axial stiffness. Also, the silicone oil F having a high dielectric strength of around 10-15kV/mm, and variants being compatible with silicone coatings often used to passivate the piezo stack, it is acceptable to have the oil F flowing through the transverse apertures 88 and to be in direct contact with the piezo stack 84 without generating dielectric breakdown.

[0032] In said first embodiment, the clearance C is to be distinguished in several portions each varying in thickness. For example, a large clearance C1 of few tens of microns is between first inner and first outer shoulder faces 34, 52, defining there between a first reaction chamber 90 and, similar large clearance C1 is also between the second inner and second outer shoulder faces 36, 62, defining there between a second reaction chamber 92. A small clearance C2 of few microns separates the head portion 50 of the actuator from the cylindrical wall of the central aperture 37 of the reacting plug. A similar small clearance C2 is also between the collar 60 and the wall of the secondary chamber 40.

[0033] The above values actually depend on the characteristics chosen oil and are here given as illustrating examples. Considering the large range of viscosity of silicone oils, a specific clearance can vary by a factor ten or even hundred.

[0034] In a preferred arrangement represented on the figure, the first reacting chamber 90 and the second reacting chamber 92 are sloped in order to help evacuating toward the top of the injector any bubble of air that would be captured in the silicone oil F.

[0035] In operation, the fuel injector 10 is connected to a control unit not represented which alternatively energizes or not the actuator member in order to command or to forbid injection events.

[0036] When the actuator assembly 12 is energized, the actuator member 46 axially X2 expands so that the actuation pin 56 solicits and pushes a control valve that opens a spill orifice through which pressurized fuel gushes flowing toward an outlet consequently enabling fuel injection event. While the actuator 46 expands the pressure rises in the first reaction chamber 90 and drops in the second reaction chamber 92. The first reaction chamber 90 acts as a top mounted hydraulic lash adjuster

(HLA) resisting and controlling the expansion motions of the actuator member 46.

[0037] To the contrary, when the actuator assembly 12 is not energized, the actuator member 46 retracts to a rest length so the actuation pin 56 lifts off and the control valve closes the spill orifice, as being biased by a spring valve and consequently, fuel injection event is prevented. While the actuator 46 retracts it remains downwardly biased by the actuator spring 66 and, the pressure drops in the first reaction chamber 90 while it rises in the second reaction chamber 92. The second reaction chamber 92 acts as a top mounted hydraulic lash adjuster (HLA) resisting and controlling the contraction motions of the actuator 46.

[0038] Also, in time the dimensions of the actuator assembly 12 slightly vary for instance due to wear or heat dilation of the parts. Thanks to the HLA provided by clearances C and occupied by the fluid F, the actuator member 46 is able to accommodate with said dimensions variations.

[0039] It is important to isolate the silicone oil from exposure to fuel, one reason being that fuel has low viscosity and could affect the HLA performances. The sealing performance of the sealing assembly 74 is assured by the O-ring 80 compressed between the wall of the central aperture 78 of the sealing member 76 and the actuation pin 56. Several alternative embodiments of the sealing assembly 74, as well as methods of assembly and operations are detailed in application GB1511355 filed 29 June 2015.

[0040] Instead of the sealing assembly 74 previously described, a metal diaphragm or bellows welded to the actuator body 14 and also to the actuation pin 56 could be used, such embodiments being described in application GB1512350 filed 15 July 2015. As being welded prior to filling the silicone oil, this in order to avoid weld contamination, a separate filling orifice would be added and would typically be plugged with a metal ball, or a plug, after filling the oil the filling orifice extending in the wall of the actuator body from an opening in the lower transverse face of the body, or alternatively in the outer peripheral face, to another opening inside the cavity.

[0041] In an alternative embodiment represented on figure 2, the actuation portion 56 is further provided with a metal encapsulation tube 94 enclosing the cage spring 86 and the piezo stack 84. Said encapsulation tube 94 protects the stack 84 from direct fluid contact and consequent dielectric breakdown. This may occur either if the fluid F has intrinsically a low dielectric strength or, if the sealing performance of the sealing assembly 74 is not sufficient enabling minor fuel leaks inside the cavity. In this alternative embodiment a small clearance, similar to the previously described small clearance C1, is reserved between the tubular encapsulation 94 and the cylindrical wall of the main chamber 38 of the large bore 22. The fluid filling volume VF comprises the reservoir 82, said small clearance C1 surrounding the encapsulation tube 94, the first reaction chamber 90 and the second

reaction chamber 92 and, the secondary chamber 40 wherein the fluid F is absorbed and captured in the absorbing member 68.

[0042] The assembly process 110 of this first embodiment depends upon the fixation means of the plug 30 in the body 14.

[0043] In the case the reacting plug 30 is fixed by press-fit, figure 1, the procedure follows the following steps:

- providing 112 an equipped actuator member by:
 - engaging 114 the reacting plug 30 over the head portion 50;
 - press fitting 116 the collar 60 in position over the head portion 50;
 - arranging 118 in place the absorbing member 68, the spacer 72 and the closing washer 70 if required and, the actuator spring 66;
- engaging 120 said equipped actuator member in the cavity 20 by inserting it via the opening 24 and adjusting the position by forcing the reacting plug 30 to be press-fit inside the bore 24;
- arranging 122 the sealing member 76 in the opening 24 of the large bore;
- filling 124 with the fluid filling volume VF with fluid F;
- sealing 126 the assembly by arranging the O-ring 80 in position in the sealing member 76 and around the actuation pin 56.

[0044] In the case the reacting plug 30 is fixed to the body with securing members 42, figure 2, the procedure varies by the engaging step 120 that becomes:

- engaging 120 the equipped actuator member in the cavity 20 by inserting it via the large bore opening 24, adjusting the position so the reacting plug 30 is in the desired position, locking the securing member 42 so that the plug 30 is fixed to the body 14 and,
- sealing 121 the securing member 42 for instance with glue applied on the threads or with sealing paste.

[0045] A second embodiment, now described in reference to figures 3 and 4, enables tuning of the resisting force and controlling motion of the actuator member 46 due to its contractions when not energized. Said adjustment is provided with adjusting means for trimming the large clearance C1 of the second reacting chamber 92.

[0046] In this second embodiment the collar 60 is no longer permanently fixed on the head portion 50. The central bore of the collar and the head portion 50 are complementary threaded and so, the collar 60 is screwed onto the head portion 50 to a position where the lower face 62 of the collar is precisely at a desired distance from the upper face 36 of the restricting plug. Once said precise distance adjusted, the collar's position is locked thanks to a locking screw 96 provided with an external thread so that, as visible of the figure, it is engaged and

screwed in the central aperture of the collar 60 to the point where said locking screw 96 comes in abutment against the head portion 50 of the actuator member, where it is tightened locking the collar 60 in a fixed position.

[0047] To enable to firmly lock the collar 60 in position, the locking screw 96 is provided with an axial drive feature such as a slot and, the collar 60 with a radial drive feature such as a hexagon socket, a compact tool 98 can be made which can access both features whilst having room for a bore to pass the actuator electrical connections through.

[0048] This adjusting means enables to set the collar 60 in an operating assembly and therefore to trim it to provide the same performances of a particular parameter for a given electrical drive signal. In an injector, this parameter could for example be opening delay, or fuelling.

[0049] This second embodiment might be easier to assemble should the annular reacting plug 30 be fixed to the body 14 by securing members 42 as shown on figure 4.

[0050] The assembly process 110 of this second embodiment comprises the following steps:

- providing 112 an equipped actuator member by:
 - engaging 114 the reacting plug 30 over the head portion 50,
 - screwing 128 the collar 60 in position over the head portion 50,
 - screwing 130 the locking screw 96 and locking the collar 60 in a preset position,
 - arranging 118 in place the absorbing washer 68 and the actuator spring 66 and, eventually if required, the closing washer 70;
- engaging 120 said equipped actuator member in the cavity 20 by inserting it via the large bore opening 24;
- fixing 132 the reacting plug 30 in position by tightening the securing members 42;
- sealing 121 the securing member 42 for instance with glue applied on the threads or with sealing paste.
- arranging 122 the sealing member 76 in the opening 24 of the large bore;
- filling 124 the fluid filling volume VF with fluid F;
- sealing 126 the assembly by arranging the O-ring 80 in position in the sealing member 76 and around the actuation pin 56;
- tuning 134 the resisting motion of the actuator member 46 by inserting the tool 98 in the body 14 and adjusting the position of the collar 60.

LIST OF REFERENCES

[0051]

X1 longitudinal axis
X2 cavity axis

C	clearance	
F	fluid - silicone oil	
VF	fluid filling volume	
C1	large clearance	
C2	small clearance	5
HLA	hydraulic lash adjuster	
10	injector	
12	actuator assembly	
14	actuator body	10
16	upper region of the body	
18	lower transverse face of the body	
20	cavity	
22	large bore	
24	opening of the large bore in the lower transverse face	15
26	bottom face of the large bore	
28	thinner conduit	
30	annular reacting plug	
32	peripheral cylindrical face of the reacting plug	20
34	first inner shoulder face - lower face of the reacting plug	
36	second inner shoulder face - upper face of the reacting plug	
37	central opening of the reacting plug	25
38	main chamber	
40	secondary chamber	
42	securing member	
44	pressing step	
46	actuator member	30
48	large actuation portion	
50	thinner head portion	
52	first outer shoulder face of the actuator member	
54	lower face of the actuator member	
56	actuation pin	35
57	central opening of the reacting plug	
60	collar	
62	lower face of the collar - second outer shoulder face	
64	upper face of the collar	
66	actuator spring	40
68	absorbing member - washer	
70	closing washer	
72	spacer	
74	sealing assembly	
76	sealing member	45
78	central aperture	
80	O-ring	
82	reservoir	
84	piezo stack	
86	cage spring	50
88	transverse apertures	
90	first reaction chamber	
92	second reaction chamber	
94	metal encapsulation	
96	locking screw	55
98	tool	
110	assembly process	

112	step: providing equipped actuator assembly
114	step: engaging the reacting plug
116	step: press fit the collar
118	step: arranging absorbing washer, spring...
120	step: engaging the equipped actuator in the cavity
121	step: sealing securing members
122	step: arranging the sealing member
124	step: filling the fluid
126	step: sealing with the O-ring
128	step: screwing the collar
130	step: screwing the locking screw
132	step: fixing the reacting plug
134	step: tuning

Claims

1. Actuator assembly (12) of a fuel injector (10), the actuator assembly (12) having an elongated body (14) provided with an internal bore (22) extending from an opening (24) to a bottom face (26) and wherein a servo actuator member (46) is arranged to extend and retract in order to cooperate with a valve member, **characterized in that** the actuator assembly (12) further comprises a hydraulic lash adjuster (HLA) filled with fluid (F), the HLA being provided with a first reaction chamber (90) wherein pressure rises when the actuator member (46) extends and wherein pressure drops when the actuator member (46) retracts and, also with a second reaction chamber (92) wherein pressure drops when the actuator member (46) extends and wherein pressure rises when the actuator member (46) retracts so that, the HLA is adapted to resist both the extensions and the contractions of the servo actuator member (46).
2. Actuator assembly (12) as claimed in the preceding claim wherein the first reaction chamber (90) and the second reaction chamber (92) are in fluid communication with each other.
3. Actuator assembly (12) as claimed in any one of the preceding claims wherein the first reaction chamber (90) of the HLA is defined between a first inner shoulder face (34) of the bore (22) and a first outer shoulder face (52) of the actuator member (46).
4. Actuator assembly (12) as claimed in claim 3 wherein the second reaction chamber (92) of the HLA is defined between a second inner shoulder face (36) of the bore (22) and a second outer shoulder face (62) of the actuator member (46).
5. Actuator assembly (12) as claimed in claim 4 further comprising an annular reacting plug (30) arranged in the bore (22) and fixed to the actuator body (14), said plug (30) locally restricting the section of the

bore (22), the first inner shoulder face (34) and the second inner shoulder face (36) being integral to said annular plug (30).

6. Actuator assembly (12) as claimed in claim 5 wherein the actuator member (46) has a thin head portion (50) extending with clearance fit through a central opening (37) of the annular plug (30) and protruding in a secondary chamber (40) defined between said second inner shoulder face (36) and the bottom face (26) of the bore (22). 5
10
7. Actuator assembly (12) as claimed in claim 6 wherein, the actuator assembly (12) further comprises an annular collar (60) engaged and fixed to the thin head portion (50) protruding in a secondary chamber (40), the second outer shoulder face (62) being integral to said collar (60). 15
8. Actuator assembly (12) as claimed claim 7 wherein the annular collar (60) is threaded onto the head portion (50) of the actuator member (46) so that the volume of the second reaction chamber (92) can be chosen by adjusting the axial position of the collar (60) on the head portion (50). 20
25
9. Actuator assembly (12) as claimed in claim 8 further comprising a locking screw (96) adapted to lock the position of the annular collar (60) over the head portion (50). 30
10. Actuator assembly (12) as claimed in any one of the claims 6 to 9 further comprising a fluid absorbing member (68) arranged in said secondary chamber (40), said fluid absorbing member (68) being made of a material such as felt or sponge which by capillary action can attract the fluid (F) ensuring that there is fluid present in the first reaction chamber (90) and in the second reaction chamber (92) irrespective of the orientation of the assembly (12). 35
40
11. Actuator assembly (12) as claimed in any one of the claims 5 to 10 further comprising at least one securing member (42), such as a screw, securing the reacting plug (30) to the actuator body (14). 45
12. Actuator assembly (12) as claimed in any one of the preceding claims wherein the fluid (F) is high viscosity silicone oil. 50
13. Fuel injector (10) comprising an actuator assembly (12) as claimed in any of the preceding claims. 55

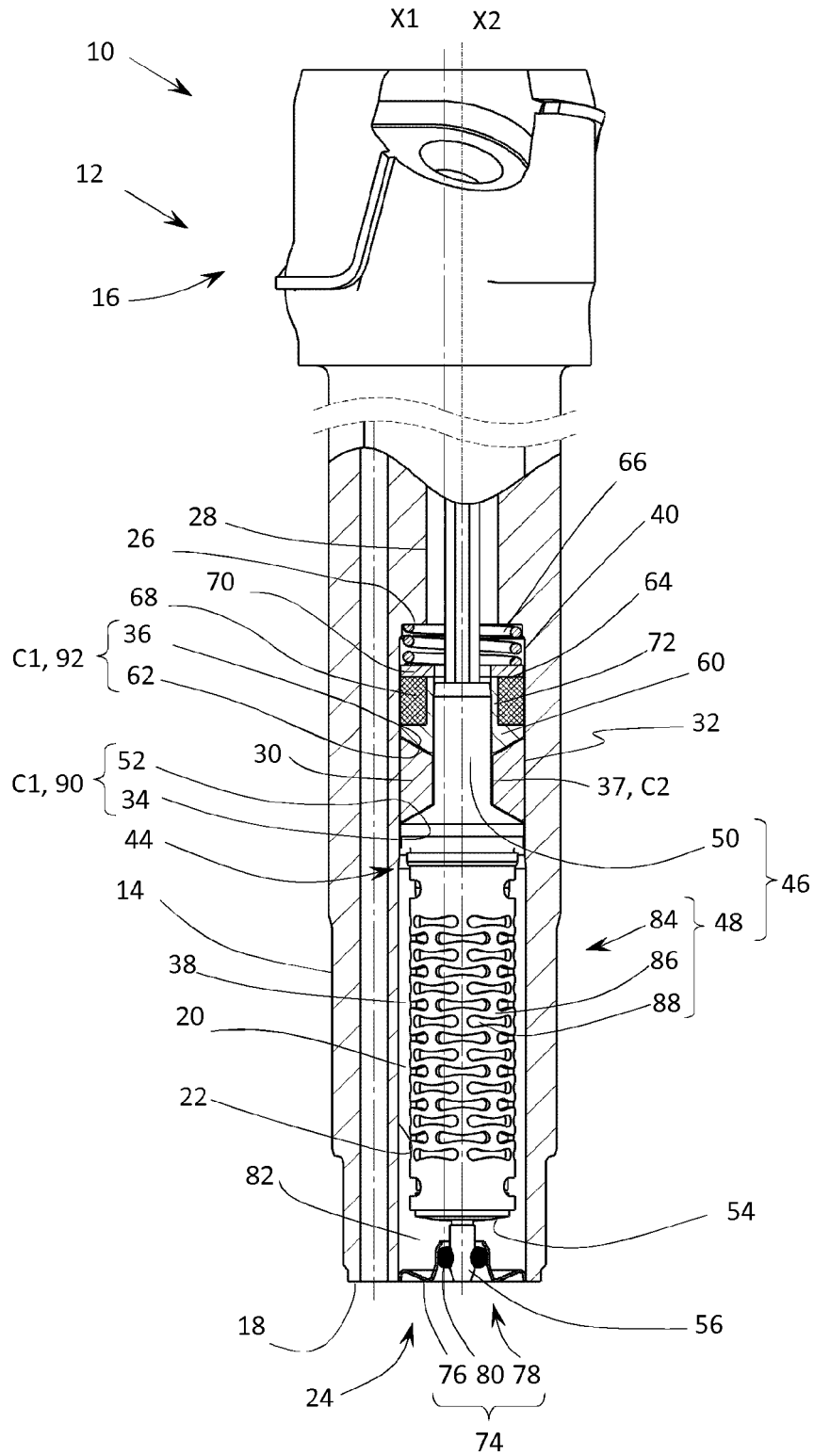


Figure 1

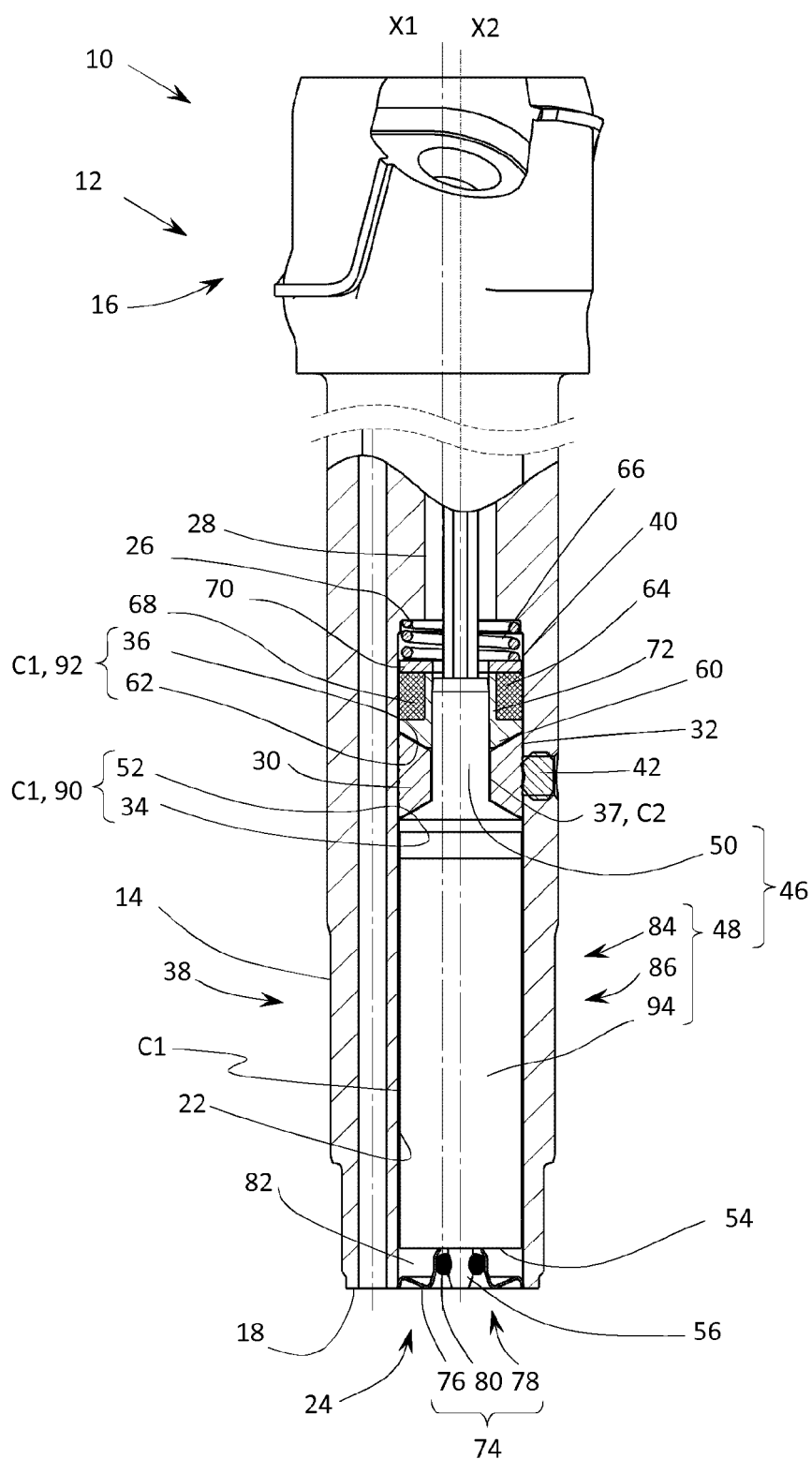


Figure 2

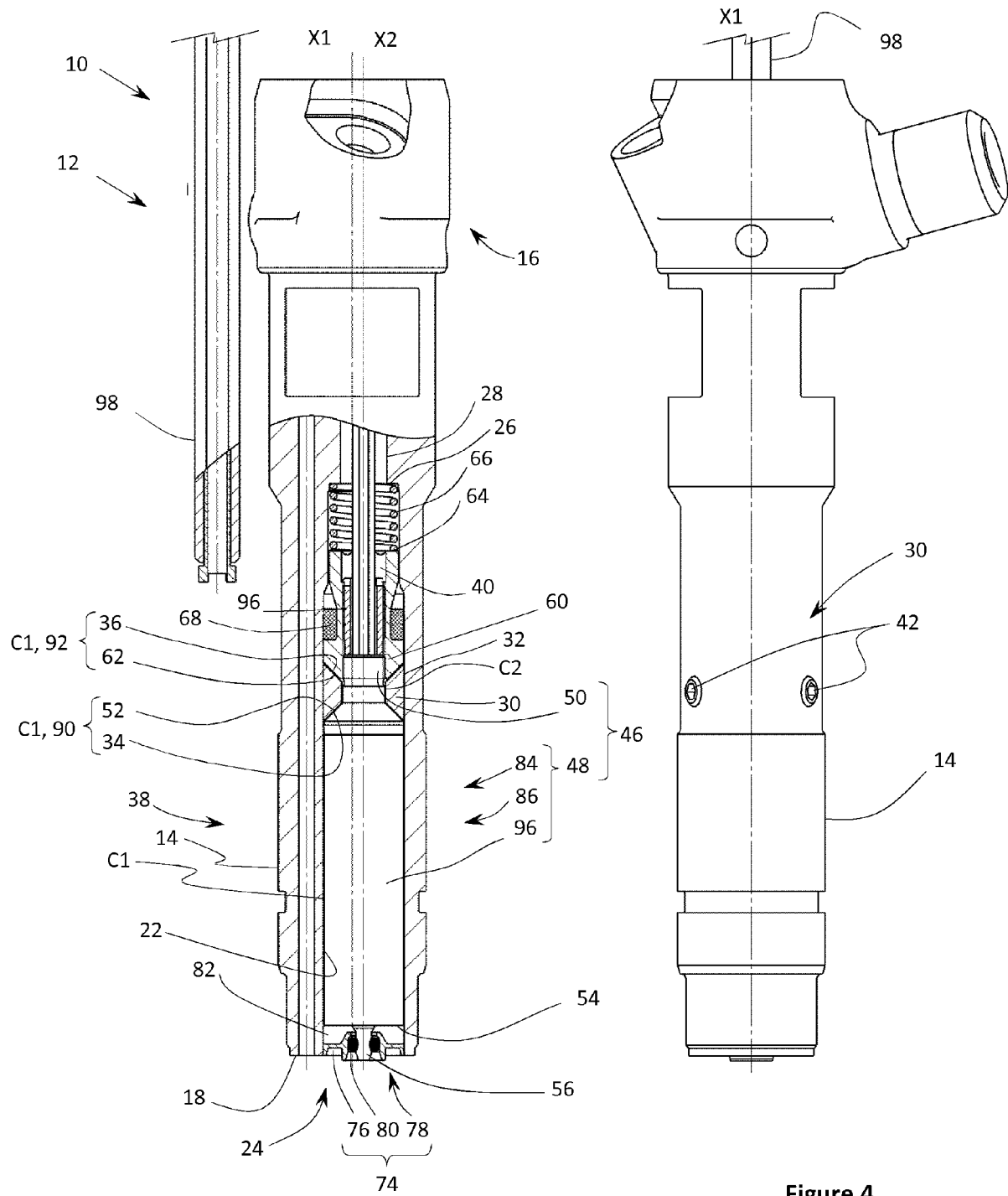


Figure 3

Figure 4



EUROPEAN SEARCH REPORT

Application Number
EP 15 18 3646

5

10

15

20

25

30

35

40

45

50

55

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	DE 10 2005 045893 A1 (SIEMENS AG [DE]) 5 April 2007 (2007-04-05)	1-4,13	INV. F02M51/06 F02M61/08 F02M61/16
Y	* figures 1-4 *	5-12	
Y	EP 1 591 656 A2 (ISUZU MOTORS LTD [JP]) 2 November 2005 (2005-11-02) * figures 1-7 *	5-12	
X	WO 2005/026532 A1 (SIEMENS AG [DE]; BACHMAIER GEORG [DE]; FISCHER BERNHARD [DE]; GOTTLIEB) 24 March 2005 (2005-03-24) * figures 1-5 *	1,13	
X	DE 100 39 543 A1 (DAIMLER CHRYSLER AG [DE]) 28 February 2002 (2002-02-28) * figures 1,2 *	1,13	
The present search report has been drawn up for all claims			TECHNICAL FIELDS SEARCHED (IPC)
Place of search		Date of completion of the search	Examiner
The Hague		8 January 2016	Morales Gonzalez, M
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 03/02 (P04C01)

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

EP 15 18 3646

5

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.

08-01-2016

10

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
DE 102005045893 A1	05-04-2007	NONE	
EP 1591656 A2	02-11-2005	DE 602005005242 T2 EP 1591656 A2 US 2005236499 A1	02-04-2009 02-11-2005 27-10-2005
WO 2005026532 A1	24-03-2005	EP 1664525 A1 JP 4264449 B2 JP 2007505254 A US 2007131884 A1 WO 2005026532 A1	07-06-2006 20-05-2009 08-03-2007 14-06-2007 24-03-2005
DE 10039543 A1	28-02-2002	NONE	

15

20

25

30

35

40

45

50

55

EPO FORM P0459

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

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- DE 102010029106 [0003]
- DE 102009000203 [0003]
- EP 1519037 A [0003]
- WO 2013053594 A [0003]
- GB 1511355 A [0039]
- GB 1512350 A [0040]