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(54) CONTROL VALVE ARRANGEMENT

(57) A control valve assembly is provided with a deflector arranged in a recess, between a magnetic armature and the bottom face of the recess. The deflector is adapted to deflect away from the under face of the armature the flow of fuel entering the recess when the valve is in open position so that, the displacements of the armature-spool assembly are not disturbed by said entering flow.

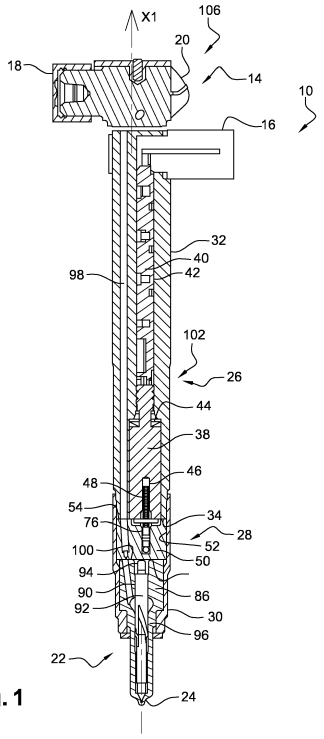


Fig. 1

EP 3 431 747 A1

Description

TECHNICAL FIELD

[0001] The present invention relates generally to a fuel injector and more particularly to a control valve arrangement.

BACKGROUND OF THE INVENTION

[0002] In a fuel injector, a control valve indirectly controls the motions of a valve member, also identified as a needle in reference to its elongated shape, by opening and closing an outlet conduit enabling fuel at high pressure to exit a control chamber which internal pressure solicits the needle.

[0003] The control valve comprises a body provided with a hydraulic bore opening in a recess and with a magnetic armature-and-valve-spool-assembly. The spool is slidably arranged in the bore while the disc-shape armature displaces in the recess as a function of a magnetic field generated by a controlled solenoid. The spool and body further define a valve seat which opens or closes when said assembly translates. When the seat opens, fuel at high pressure exiting the control chamber flows through the open passageway and hits the under face of the disc-shape armature when entering the recess. This violent impact disrupts the travel of the armature-and-spool-assembly and the functioning of the control valve.

[0004] Developments have conducted to design the under face of the armature with a slope mitigating the impact but without totally eliminating the motions disturbances.

SUMMARY OF THE INVENTION

[0005] It is an object of the invention to resolve or at least mitigate the above mentioned problem in providing a control valve assembly for a fuel injector, the valve comprising a cylindrical body and, an armature-spool assembly adapted to translate within the body. The body extends from a first, or upper, face to an opposed second, or lower, face, and is provided with a large recess opening in the first face and also with a hydraulic distribution bore extending in the body along a main axis from the bottom face of the recess. A fixed valve seat is provided around the opening of the bore in said bottom face of the recess. The body is further provided with a hydraulic outlet conduit extending through the body and opening in the hydraulic bore and also with a return conduit extending from the large recess.

[0006] The armature-spool assembly comprises a disc shape magnetic armature having an upper face opposed to an under face and a stem forming valve spool fixed to the armature and perpendicularly extending from its under face. The armature-spool assembly is further provided with a spool seat arranged in the vicinity of the under face the armature.

[0007] The armature-spool assembly is arranged in the body, the spool being slidably adjusted in the hydraulic bore and the armature being moveable in the recess. Said assembly is able to translate between a closed position where the spool seat is in sealing contact against the fixed valve seat and, an open position where the spool seat is lifted away from the fixed valve seat enabling, in use, fuel to flow to enter in the recess.

[0008] The control valve assembly is further provided with a deflector arranged in the recess, between the armature and the bottom face of the recess, the deflector being adapted to deflect away from the under face of the armature the flow of fuel entering the recess when the valve is in open position so that, the displacements of the armature-spool assembly are not disturbed by said entering flow.

[0009] Also, the deflector comprises a deflector face, or bottom face, provided with a central opening, said deflector face being arranged transverse to the valve axis and being pushed toward the bottom face of the recess by a pusher feature, while being maintained at a distance of the bottom face of the recess by a spacer feature.

[0010] The pusher feature can be a cylindrical wall integral to the deflector face and erecting from the periphery of said deflector face to an upward circular edge, said cylindrical wall outwardly protruding from the recess above the level of first face of the body so that, when the control valve assembly is arranged in a fuel injector, another part of the body of the injector that comes in surface contact with the first face of the valve body downwardly biases the deflector.

[0011] Also, the spacer feature is arranged between the deflector face of the deflector and the bottom face of the recess and it has resilient characteristics so that said spacer feature always biases the deflector face away from the bottom face of the recess.

[0012] The first face of the body is further provided with a plurality of notches, said notches opening in the recess. The deflector also comprises a transverse deflector face provided with a central opening, and with tabs radially extending from the edge of said deflector face, each tab being arranged in a notch.

[0013] In another embodiment, the deflector further comprises a tubular spacer ring non-integral to the deflector face, said spacer ring being placed over the deflector face and outwardly protruding from the recess above the level of first face of the body so that, when the control valve assembly is arranged in a fuel injector, another part of the body of the injector that comes in surface contact with the upper face of the valve body downwardly biases said the spacer ring and the deflector face.

[0014] The invention also extends to a fuel injector comprising a control valve assembly as claimed in any one of the preceding claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015] 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 fuel injector provided with a control valve arrangement as per a first embodiment of the invention.
- Figure 2 is an axial section of the control valve of figure 1.
- Figure 3 is an exploded view of the control valve of figure 2, said valve being provided with a deflector.
- Figures 4, 5 and 6 are three different embodiments of the deflector of figure 3.
- Figure 7 is a second embodiment of a control valve as per the invention.
- Figure 8 is a top view of the second embodiment of figure 4.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0016] In reference to figure 1 is described a fuel injector 10, particularly adapted to diesel fuel although the invention is also applicable to gasoline injectors. The injector 10 has a generally elongated body 12, the injector 10 extending along a main axis X1 from a head 14 to a nozzle assembly 22. The head arrangement 14, arbitrarily drawn on the top of figure 1, comprises an electric connector 16, a fuel inlet 18 and a fuel outlet 20. The pointy tip extremity of the nozzle assembly 22, at the extreme bottom of the figure, is provided with spray holes 24 for delivering fuel in a combustion chamber.

[0017] The injector 10 generally comprises an actuator member 26 arranged above a control valve 28 arranged above the nozzle assembly 22. Said three main sub-assemblies are coaxially X1 fixed to each other's by an injector cap nut 30.

[0018] The actuator member 26 comprises an actuator body 32 extending from the head 14 to a lower face 34 where opens a recess 36 upwardly extending in the body 32. A solenoid 38 is arranged in the recess 36 and is electrically connected to the connector 16 via electric conductors 40 upwardly extending in a specific conduit 42 opening in the upper part of the recess 36. Between the solenoid 38 and the bottom of the recess 36 is arranged a compression leaf spring 44 downwardly soliciting the solenoid 38. The solenoid itself is provided with an internal blind bore 46 wherein is compressed a coil spring 48.

[0019] The control valve 28 has a valve body 50 axially X1 extending between a upper face 52 and an opposed lower face 54. The valve body 50 is provided with a hydraulic bore 56 axially extending along a valve axis X2 that is parallel and slightly offset with the main axis X1. The bore 50 upwardly opens in the bottom face 58 of a large recess 60 itself opening in the upper face 52 of the valve body 50. The opening of the hydraulic bore 56 in the bottom face 58 of the recess is surrounded by a conical face forming a fixed valve seat 62.

[0020] Said axial offset introduced in European patent EP0740068 presents multiple advantages and is utilized in this description. Despite these advantages, the present invention can be implemented in other injector wherein the two axis are strictly aligned.

[0021] In the large recess 60 is arranged a deflector 64, a first embodiment of which being detailed on figures 2 and 3. Said first embodiment of the deflector 64 is a punched metal sheet having a cup-like shape with a bottom face 66 provided with a central hole 68 and with a peripheral cylindrical wall 70 perpendicularly upwardly erecting from the circular edge of the bottom face 66 up to an upper circular edge 72. The deflector 64 is arranged in the large recess 60 so the central hole 68 is aligned with the hydraulic bore 56 and, the bottom face 66 of the deflector is parallel to the bottom face 58 of the recess, a leaf spring 74 being arranged between said two bottom faces 58, 66 so that, an inter-space S remains open under the deflector 64. Alternatively to a washer type leaf spring, any type of spring, such as resilient tongues, enabling to maintain a distance between said two bottom faces 58, 66, fits the purpose. For instance figures 4, 5 and 6 present different alternatives of spring 74 that are integral to the bottom face 66 of the deflector 64. The springs 74 are provided by partially cutting said bottom face 66 in order to form tongues 75 that are outwardly bent around a non-cut edge, said bending providing resilient characteristics to the tongue 75.

[0022] The embodiment of figure 4 comprises three rectangular tongues 75 each being cut on three sides and slightly bent on the fourth. To provide stability when arranged in the large recess 60, the tongues 75 are arranged every 120° relative to the valve axis X2.

[0023] The embodiment of figure 5 comprises six rectangular tongues 75 arranged by pair of face to face tongues that are cut along their common length and a common width. The tongues 75 are bent about their non-cut width. To provide stability when arranged in the large recess 60, the pair of tongues 75 are arranged every 120° relative to the valve axis X2.

[0024] The embodiment of figure 6 comprises three tongues 75 each forming a circular segment. The cut is operated along the circular edge of the bottom face 58 and the binding is done along the chord of said segment. Again, to provide stability when arranged in the large recess 60, the tongues 75 are arranged every 120° relative to the valve axis X2.

[0025] In the above examples the tongues 75 are arranged every 120° while other embodiments of four or more tongues arranged every 90° or less is also possible.

[0026] In a free state, when not assembled in the injector, the upper circular edge 72 of the peripheral wall slightly protrudes above the level of the upper face 52 of the valve body.

[0027] Finally, the control valve 28 is provided with an armature-spool assembly 76 comprising a magnetic disc-shape armature 78 and a stem-like cylindrical spool 80. The spool 80 downwardly axially X2 extends from an upper end that is inserted and crimped in a central orifice

of the armature 78, the top face 82 of said upper end slightly protruding above the armature 78. The spool 80 is provided with a plurality of cylindrical portions of different diameters and, just below the armature 80, with a conical face forming a spool seat 84.

[0028] When arranged in the valve body 50, as shown on figure 2, the spool 80 is slidably adjusted in the hydraulic bore 56, the spool seat 84 cooperates with the fixed valve seat 62 and, the spool extends through the central hole 68 of the deflector 64 for the armature 78 to be inside the cup-like deflector 64.

[0029] The nozzle assembly 22 has a body 86 which extends from an upper face 88 down to the tip provided with the spray holes 24. The body 86 is provided with an axial valve bore 90 in which is slidably arrange a valve member 92, also known as a needle valve in reference to its elongated shape. Said member 92 extends from a needle head protruding in a control chamber 94, close to the upper face 88, down to a pointy tip that forms another valve seat cooperating with the spray holes 24.

[0030] Externally the lower portion of the nozzle body 86 is thinner than its upper portion, a transverse shoulder face 96 joining both portions.

[0031] The three main parts of the injector 10 are fixed together by the cap nut 30, the thinner part of the nozzle being inserted in the nut 30 which comes in abutment against the shoulder face 96, the nut 30 being then threaded to the actuator body 32.

[0032] By tightening the cap nut 30, the valve body 50 is axially X1 compressed between the actuator body 32 and the nozzle body 86. In particular, the lower face 34 of the actuator body comes in sealing surface contact with the upper face 52 of the valve body and, in doing so, the deflector 64, which upper circular edge 72 was protruding above the upper face 52, is slightly pushed downward inside the large recess 60 compressing the leaf spring 74 which still maintains open the inter space S.

[0033] As it is well known, the coil spring 48 protruding out of the solenoid is further compressed as it comes in contact against the top face 82 of the spool.

[0034] Also well-known and now briefly described, the injector 10 is provided with a high pressure conduit 98, for conveying fuel at high pressure from the fuel inlet 18 down to the spray holes 24. This high pressure conduit 98 comprises a plurality of portions aligned throughout the actuator, the valve and the nozzle bodies 32, 50, 86. It also diverts from its main path, inlet 18 to holes 24, by having a branch 100 joining the control chamber 94.

[0035] Furthermore, the injector 10 is also provided with a return conduit 102 comprising a first portion 104, or outlet conduit extending in the valve body 50 from the control chamber 94 to the hydraulic bore 56 then, a second portion 106 extending in the actuator body 32 from the large recess 60 to the fuel outlet 20.

[0036] In use, the injector 10 is arranged in a fuel injection equipment of an internal combustion engine and, a control unit, not represented, is connected to the injector to enable piloting to energize the solenoid 38.

[0037] When the solenoid 38 is not energized, the coil spring 48 downwardly pushes the armature-spool assembly 76 in a closed position CPV where the spool seat 84 is in sealing contact against the fixed valve seat 62. Fuel at several thousands of bars flows in the high pressure conduit 98 and its diverting branch 100, fills in the control chamber 94, the outlet conduit 104 and the hydraulic bore 56. The high pressure in the control chamber 94 solicits the needle valve 92 in a closed position CPN where fuel injection through the spray holes 24 is prohibited.

[0038] When the solenoid 38 is energized, it generates a magnetic field that attracts the armature 78 which then translates toward the solenoid 38 further compressing the coil spring 48. The armature-spool assembly 76 moves to an open position OPV where the spool seat 84 lifts away from the fixed valve seat 62 and opens passageway for the high pressure fuel to spring out of the hydraulic bore 56 and enter the large recess 60. The decreasing pressure in the control chamber 94 enables the needle valve 92 to lift in an open position OPN enabling fuel injection through the spray holes 24.

[0039] The jet flow entering the large recess 60 hits the under face of the deflector 64 then flows in the inter space S toward the second portion 106 of the return conduit. The deflector 64 deflects the jet flow away from the armature 78, the displacements of the armature-spool assembly 76 being undisturbed.

[0040] In reference to figures 7 and 8 is now described a second embodiment of the deflector 64, keeping the references of features having similar a function as in the first embodiment.

[0041] In this second embodiment, the valve body 50 is provided on its upper face 52 with two notches 108 diametrally arranged about the opening of the large recess 60. The deflector 64 comprises a deflector face 110 which is a circular disc plate provided with a central hole 68 and also with two arms 112 radially extending from the outer edge 114 of the disc. Said arms 112 are slightly angled relative to the plan of the disc 110 so, when in position, the deflector face 110 is placed in deep inside the recess and parallel to the bottom face 58 of the recess and, the two radial arms 112 are set in the notches 108. In that position the inter space S is preserved.

[0042] The deflector 64 further comprises a cylindrical tubular spacer ring 116 placed on the top deflector face 110 and the radial arms 112. The spacer ring 116 has a height such that in place before the general assembly of the injector 10, it slightly protrudes above the level of the upper face 52 of the valve body and, it also has an outer diameter smaller that the opening of the large recess 60 so that, when the injector 10 is assembled and the cap nut 30 is tightened, the spacer ring 116 is pushed downward, pushing in turn the deflector face 110 and obliging the radial arms 112 to further resilient bending while still keeping open the inter space S. In this second embodiment there is no need for leaf spring 74 placed in the inter space S.

[0043] The deflector face has been described with two radial arms 112 although an embodiment with another number of flexible arms is possible.

LIST OF REFERENCES

[0044]

10	fuel injector
12	injector body
14	injector head
16	electric connector
18	fuel inlet
20	fuel outlet
22	nozzle assembly
24	spray holes
26	actuator member
28	control valve
30	injector cap nut
32	actuator body
34	lower face of the actuator body
36	recess
38	solenoid
40	electric conductors
42	conductors conduit
44	leaf spring
46	blind bore internal to the solenoid
48	coil spring
50	valve body
52	upper face of the valve body
54	lower face of the valve body
56	hydraulic bore
58	bottom face of the large recess
60	large recess
62	fixed valve seat
64	deflector
66	bottom face of the deflector - deflector face
68	central hole provided in the bottom face of the deflector
70	peripheral cylindrical wall
72	upper circular edge of the peripheral wall
74	leaf spring
75	tongue
76	armature-spool assembly
78	magnetic armature
80	spool
82	top face of the spool
84	spool seat
86	nozzle body
88	upper face of the nozzle body
90	valve bore
92	valve member
94	control chamber
96	shoulder face
98	high pressure conduit
100	branch of the high pressure conduit
102	return conduit
104	first portion of the return conduit - outlet conduit
106	second portion of the return conduit
108	notches - 2nd embodiment
110	deflector face - 2nd embodiment
112	radial arms - 2nd embodiment
114	outer edge of the deflector face - 2nd embodiment
116	spacer ring - 2nd embodiment
X1	main axis
X2	valve axis
S	inter space
CPV	closed position of the valve
OPV	open position of the valve
CPN	closed position of the needle
OPN	open position of the needle

Claims

1. Control valve assembly (28) for a fuel injector (10), the valve (28) comprising a cylindrical body (50) and, an armature-spool assembly (76) adapted to translate within the body (50),
the body (50) extending from a first, or upper, face (52) to an opposed second, or lower, face (54), and being provided with a large recess (60) opening in the first face (52) and also with, a hydraulic distribution bore (56) extending in the body along a main axis (X2) from the bottom face (58) of the recess, a fixed valve seat (62) being provided around the opening of the bore (56) in said bottom face (58) of the recess,
the body (50) being further provided with a hydraulic outlet conduit (102, 104) extending through the body and opening in the hydraulic bore (56) and also with, a return conduit (102, 106) extending from the large recess (60),
the armature-spool assembly (76) comprising a disc shape magnetic armature (78) having an upper face opposed to an under face and, a stem, forming valve spool (80), fixed to the armature (78) and perpendicularly extending from its under face, the armature-spool assembly (76) being further provided with a spool seat (84) arranged in the vicinity of the under face the armature,
the armature-spool assembly (76) being arranged in the body (50), the spool (80) being slidably adjusted in the hydraulic bore (56) and the armature (78) being moveable in the recess (60), said assembly (76) being able to translate between a closed position (CPV) where the spool seat (84) is in sealing contact against the fixed valve seat (62) and, an open position (OPV) where the spool seat (84) is lifted away from the fixed

valve seat (62) enabling, in use, fuel to flow to enter in the recess (60),

characterized in that

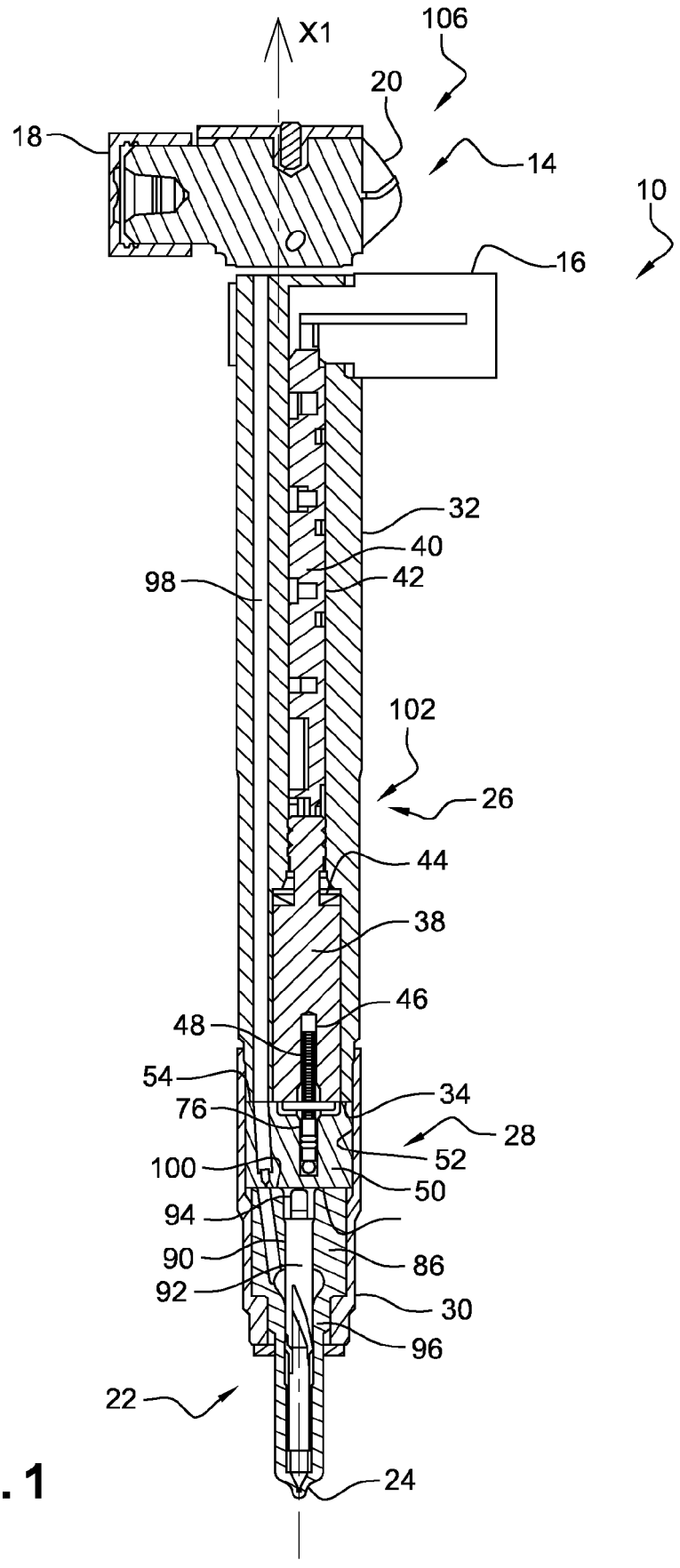
the control valve assembly (28) is further provided with a deflector (64) arranged in the recess (60), between the armature (78) and the bottom face (58) of the recess, the deflector (64) being adapted to deflect away from the under face of the armature the flow of fuel entering the recess (60) when the valve is in open position (OPV) so that, the displacements of the armature-spool assembly (76) are not disturbed by said entering flow and,

the deflector (64) comprises a deflector face, or bottom face, (66) provided with a central opening (68), said deflector face (66) being arranged transverse to the valve axis (X2), and being pushed toward the bottom face (58) of the recess by a pusher feature (70, 116) while being maintained at a distance of the bottom face (58) of the recess by a spacer feature (74, 112) and, the pusher feature (74) is a cylindrical wall integral to the deflector face (66) and erecting from the periphery of said deflector face (66) to an upward circular edge (72), said cylindrical wall (74) outwardly protruding from the recess (60) above the level of first face (52) of the body (50) so that, when the control valve assembly (28) is arranged in a fuel injector (10), another part of the body of the injector that comes in surface contact with the first face (52) of the valve body downwardly biases the deflector (64) and wherein,

the spacer feature (74) is arranged between the deflector face (66) of the deflector and the bottom face (58) of the recess and it has resilient characteristics so that, said spacer feature (74) always biases the deflector face (66) away from the bottom face (58) of the recess and wherein,

said spacer feature (74) is provided by partially cutting said bottom face (66) to form tongues (75) that are outwardly bent around a non-cut edge, said bending providing resilient characteristics to the tongue (75).

2. Fuel injector (10) comprising a control valve assembly (28) as claimed in any one of the preceding claims.


X1
106
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18
14
10
16
32
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98
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102
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Fig. 1

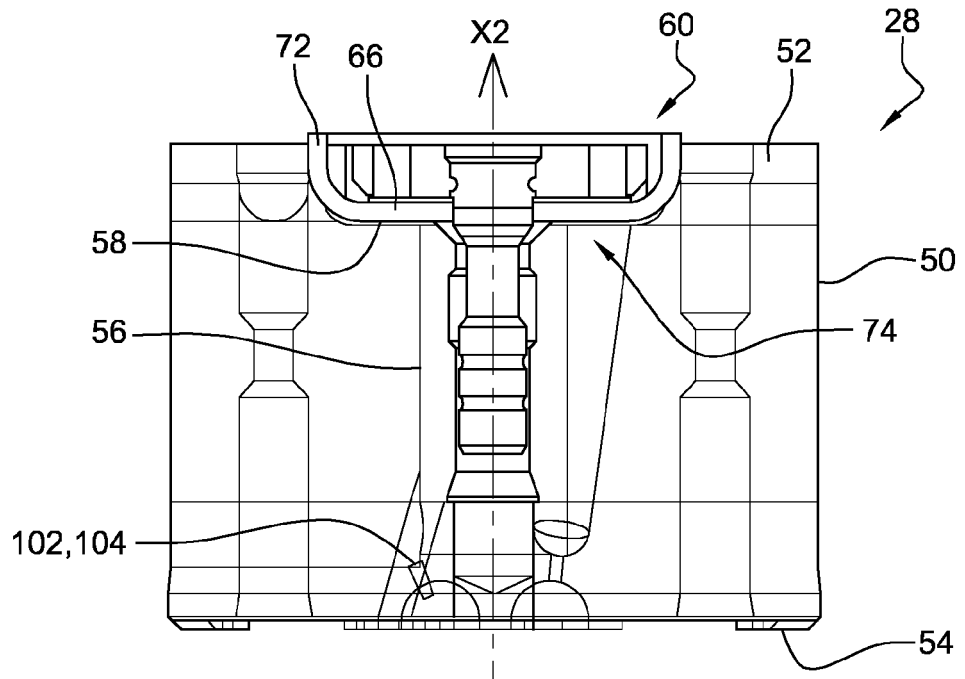
72
66
X2
60
52
28
58
50
56
74
102,104
54

Fig. 2

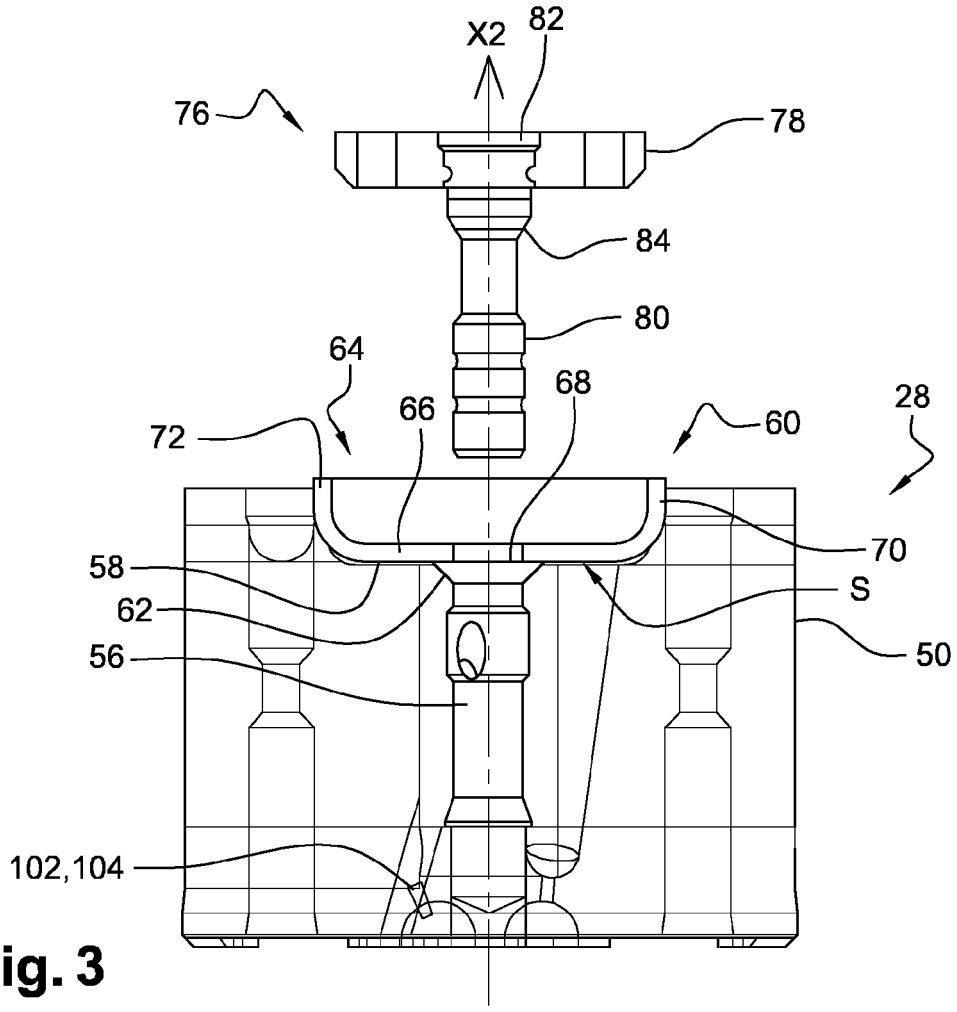
X2
82
76
78
84
80
64
68
66
72
60
28
70
58
S
62
50
56
102,104

Fig. 3

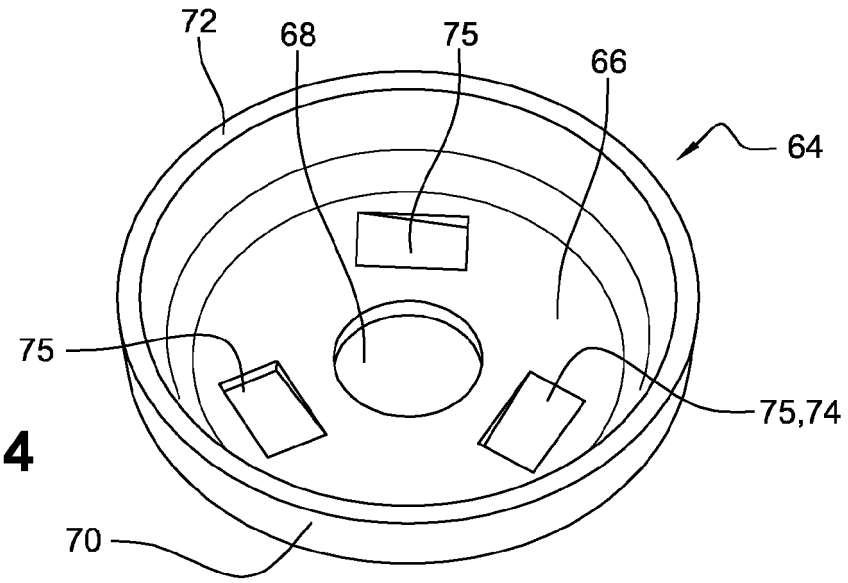

Fig. 4

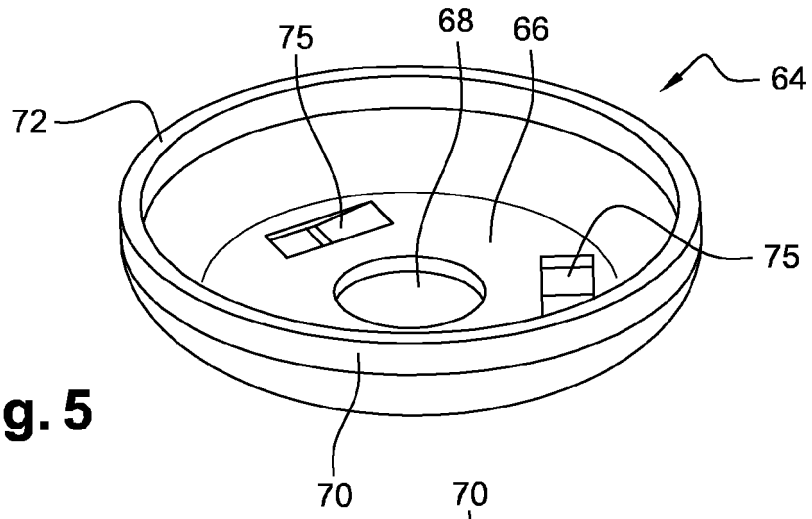

Fig. 5

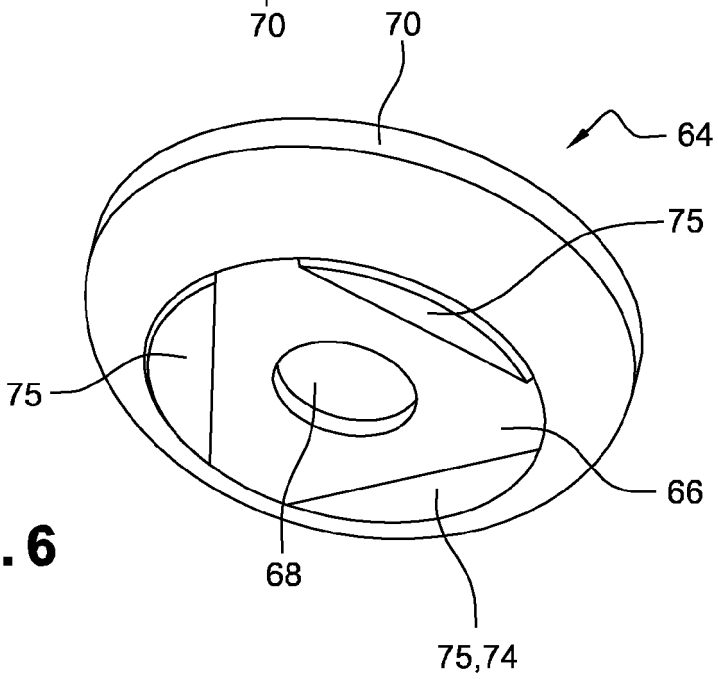

Fig. 6

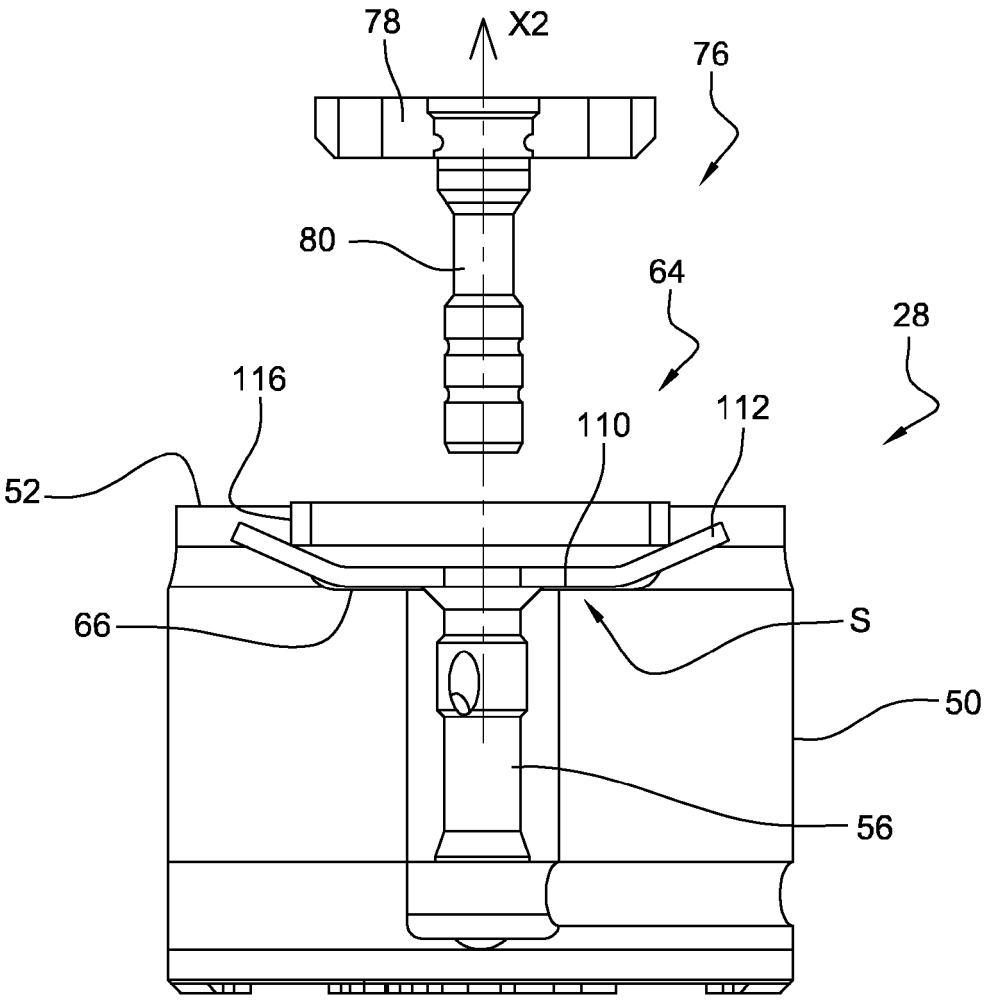
78
X2
76
80
64
28
116
110
112
52
66
S
50
56

Fig. 7

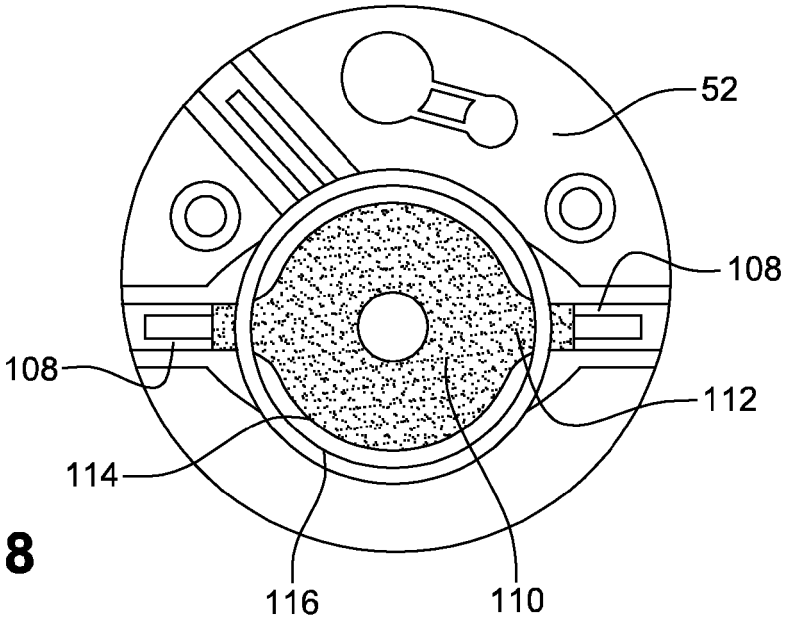
52
108
108
112
114
116
110

Fig. 8

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EUROPEAN SEARCH REPORT

Application Number
EP 18 18 8428

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	DE 10 2007 047152 A1 (BOSCH GMBH ROBERT [DE]) 9 April 2009 (2009-04-09) * abstract; figures 4,5,6 * * claims 1,4,5,6,7,13 * * paragraph [0016] * * paragraph [0038] * * paragraph [0046] * * paragraph [0040] * * paragraph [0047] *	1,2	INV. F02M47/02 F02M51/06 F02M63/00 F02M55/00
A	EP 0 781 913 A2 (LUCAS IND PLC [GB]) 2 July 1997 (1997-07-02) * abstract; figure 7 * * claims 1,16,17 * * column 6, line 39 - line 46 *	1,2	
A	DE 10 2011 078564 A1 (BOSCH GMBH ROBERT [DE]) 10 January 2013 (2013-01-10) * abstract; figure 2 * * paragraph [0025] * * paragraph [0004] * * paragraph [0009] - paragraph [0011] * * claims 1,3,7,8,9,10 *	1,2	TECHNICAL FIELDS SEARCHED (IPC) F02M
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A	EP 1 231 378 A2 (DELPHI TECH INC [US]) 14 August 2002 (2002-08-14) * abstract; figures 1,3 *	1,2	
A	DE 10 2007 001556 A1 (BOSCH GMBH ROBERT [DE]) 17 July 2008 (2008-07-17) * abstract; figures 1,2,3 *	1,2	

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	10 December 2018	Barunovic, Robert

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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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)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 18 18 8428

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