



(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
30.08.2017 Bulletin 2017/35

(51) Int Cl.:
F02M 55/02 ^(2006.01) **F02M 55/04** ^(2006.01)
F02M 63/02 ^(2006.01)

(21) Application number: **17157270.4**

(22) Date of filing: **21.02.2017**

(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 MD

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(30) Priority: **29.02.2016 GB 201603471**

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(54) **COMMON RAIL WITH VARIABLE INNER VOLUME RESERVOIR**

(57) A reservoir assembly (10) having an inner cavity (40) adapted to receive and store pressurized fuel and being arranged so that when pressure reaches a prede-

termined first threshold (P1), the volume wherein is stored the pressurized fuel increases.

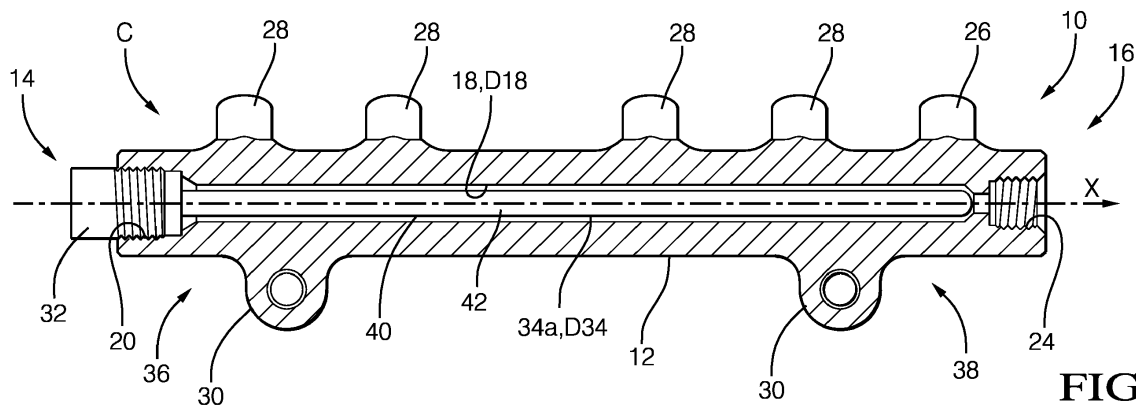


FIG. 1

Description

TECHNICAL FIELD

[0001] The present invention relates to a high pressure reservoir assembly specially adapted to be arranged in a fuel injection equipment of an internal combustion engine.

BACKGROUND OF THE INVENTION

[0002] A direct injection engine is provided with a fuel injection equipment where a high pressure pump flows pressurized fuel to a high pressure reservoir, such as the well-known common rail, from which pressurized fuel is sent to fuel injectors.

[0003] Pressure in the reservoir depends upon the engine operating conditions and it ranges from no pressure at all when engine is stopped to a maximum pressure when the engine runs full speed. In a diesel engine said maximum pressure can reach 2500 bars or above.

[0004] A minimum fuel pressure in the rail is required to start the engine, and it is expected to reach said minimum start pressure within the minimum time. In normal operating conditions the pressure in the rail is above said minimum start pressure and, the volume of the rail serves to damp pressure waves propagating in the fuel. Current common rail reservoirs have an inner cavity which volume is a compromise between said minimum time to reach the start pressure, this requiring to minimize said volume and, the damping of pressure waves required in normal operation, this requiring a large volume cavity.

SUMMARY OF THE INVENTION

[0005] Accordingly, it is an object of the present invention to resolve the above mentioned problems in providing a reservoir assembly having a body defining an inner cavity, the reservoir being adapted to be arranged in a fuel injection equipment of an internal combustion engine. Pressurized fuel is received and stored in said inner cavity prior to be delivered toward fuel injectors.

[0006] Advantageously, the reservoir assembly is arranged so that when pressure in the inner cavity increases and reaches a predetermined first threshold, the volume of the reservoir wherein is stored said pressurized fuel increases above the volume initially occupied by the inner cavity.

[0007] In an alternative, the reservoir assembly comprises an insert member arranged in the inner cavity, said insert member being made of material, such as rubber, that is slightly compressible under high pressure.

[0008] In an embodiment, the reservoir further comprises a flexible balloon inserted in the inner cavity, the balloon being pressurized so that, in use the balloon collapses when pressure in the cavity increases.

[0009] More particularly, the balloon is pressurized at the first threshold pressure and, the balloon may be pres-

surized with fuel.

[0010] In a second embodiment, the reservoir comprises a second inner cavity defined in the body and a valve opening a fluid communication between the first inner cavity and the second inner cavity when the pressure in the first inner cavity increases and reaches the predetermined first threshold.

[0011] More specifically, the first inner cavity and the second inner cavity may be coaxially arranged, the second inner cavity comprising a tube coaxially arranged inside first cavity.

[0012] Furthermore, the valve has a body in which a valve member is received in a bore and is adapted to translate, slidably guided, between a closed position closing the fluid communication between the two inner cavities, and, an open position wherein said fluid communication is open.

[0013] Also, a spring member bias the valve member toward the closed position.

[0014] The valve may further comprise a leak prevention device for preventing or limiting pressurized fuel leaks from the first cavity to a low pressure return circuit when the valve member is in open position.

[0015] In yet another embodiment, the reservoir assembly is provided with a pressure limiter, adapted to open another fluid communication between the first inner cavity and a low pressure return circuit when pressure in said first inner cavity increases and reaches a second threshold superior to the first threshold.

[0016] Particularly, the pressure limiter is an electro valve piloted to open or close said another fluid communication between the first inner cavity and a low pressure return circuit.

BRIEF DESCRIPTION OF THE DRAWINGS

[0017] The present invention is now described by way of example with reference to the accompanying drawings in which:

Figure 1 is an axial section a high pressure reservoir assembly as per a first embodiment of the invention. Figure 2 is an axial section a high pressure reservoir assembly as per a second embodiment of the invention.

Figure 3 is an axial section a high pressure reservoir assembly as per a third embodiment of the invention. Figure 4 is an axial section a high pressure reservoir assembly as per a third embodiment of the invention. Figure 5 is a first embodiment of a valve arranged in either one of the reservoir assembly of figure 1 or 2. Figure 6 is a second embodiment of the valve for a reservoir assembly as in figure 3.

Figure 7 is a third embodiment of the valve arranged in either one of the reservoir assembly of figure 1 or 2. Figure 8 is a fourth embodiment of the valve arranged in either one of the reservoir assembly of figure 1 or 2, said valve being couples with a mechanical pres-

sure limiter.

Figure 9 is a fifth embodiment of the valve arranged in a reservoir having a radial outlet.

Figure 10 is an alternative construction to the fifth embodiment of the valve, the valve of figure 9 being coupled to a piloted pressure limiter.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0018] In reference to figure 1 is presented a longitudinal section of a first embodiment of a high pressure reservoir assembly 10, of the well-known type "common rail", the reservoir 10 being adapted to be arranged in a non-represented fuel injection equipment of an internal combustion engine. The presented examples are diesel equipment's and the invention was first thought for such diesel engines. The invention can still be used and benefit other injection equipment's such as for gasoline or bio-fuels.

[0019] The reservoir assembly 10 comprises a steel body 12 having an elongated shape extending along a longitudinal axis X going from a first end 14, arbitrary drawn on the left of figure 1, to a second end 16, on the right of the figure. The body 12 is pierced from one end to the other defining a through bore 18 that has a constant diameter D18 all along the body 12 except at both ends 14, 16, where, by the first end 14 the bore enlarges into a first threaded bore 20 and, by the opposed second end 16, the bore firstly diminishes creating a restriction 22 prior to open in a second threaded bore 24 adapted to receive, in use, a pressure sensor not represented. Multiple other alternative internal geometries are known where rail are provided with a bore having a non-constant diameter, and where the end portions differ from the above description. Externally, the body 12 accommodates five radial cylindrical protrusions 26, 28, each being centrally pierced define radial channels creating fluid communication with the bore 18. One of said protrusions is a high pressure fuel inlet and, in use, said inlet protrusion 26 is tightly connected to a high pressure pipe enabling entry of pressurized fuel into the bore 18. The four other protrusions 28 are fuel outlets which, in use, are tightly connected to high pressure pipes enabling pressurized fuel to exit the bore 18 and flow toward fuel injectors. Also, in order to fix the reservoir 10 on the engine, the body 12 is provided with two radial ears 30, each being centrally pierced for a fixing screw to extend through.

[0020] The examples described and represented are limited to reservoirs having four outlets and two fixation ears. Many other alternatives exist having as many outlets as there are injectors connected to it; for instance, this can be three, five, six or any other number. Furthermore, the body represented is forged but it can as well be welded or obtained with any other known process.

[0021] The reservoir assembly 10 further comprises a valve 32 fixedly tightened in the first threaded bore 20 and an elongated cylindrical tube 34a having an outer

diameter D34 smaller than the bore diameter D18. Said tube 34a is arranged inside the bore 18 and it extends from a first extremity 36 fluidly connected to the valve 32 to a second extremity 38 that is closed, said second extremity 38 being in the vicinity of the restriction 22.

[0022] The description of a bore diameter D18 and of a tube diameter D34 limits the described embodiment to cylinders of revolution, both for the bore 18 and for the tube 34a. Other components will use a similar limitation made for clarity and easiness of the description. Having another cross-section such as elliptic, oval, oblong, or any shape, even an angular cross-section is possible and within the scope of the invention, any skilled person will be able to derive from the described simplified example the required shapes and dimensions necessary to any other cross-section.

[0023] The tube 34a being coaxial to the bore 18 and, also smaller in section than the bore 18, the reservoir assembly 10 defines in the bore 18 a first inner cavity 40 that is an annular cavity surrounding the tube 34a, and a second inner cavity 42 inside the tube 34a, the two cavities 40, 42 being coaxial as are the tube 34a in the bore 18. The valve 32, several embodiments of which are described hereafter, opens or closes a fluid communication C between said two cavities 40, 42.

[0024] A general behavior of the reservoir assembly 10 is now described. The reservoir assembly 10 is arranged in the fuel injection equipment controlled by a command unit (ECU) that, among other parameters, monitors the pressure of the fuel that is required by the engine.

[0025] In a first starting phase of the engine, phase extending from initial start of the engine up to idle running condition, the fluid communication C between the cavities 40, 42, is closed by the valve 32 thus, limiting to the first cavity 40 the volume to be pressurized by the fuel entering via the inlet 26. Because of said reduced volume to pressurize, the pressure rapidly increases and reaches a first minimum pressure threshold P1 corresponding to the fuel pressure required by the engine to run in idle condition. This reduced pressurized volume fulfills the minimum start time condition. The first threshold P1 is substantially comprised between 100 and 200 bars.

[0026] In a subsequent second phase 202 of the engine operation, phase extending from the idle and beyond, the pressure in the first cavity 40 has reached the first threshold P1, the valve 32 opens the fluid communication C between the two cavities 40, 42, thus, increasing to the volume of the second inner cavity 42 the volume to be occupied by the pressurized fuel. This enlarged pressurized volume fulfills the pressure waves damping function, said waves propagating in the fuel as the engine runs.

[0027] In a subsequent third phase 203 of operation the engine's velocity decreases and so does the required fuel pressure. When the pressure inside the cavities 40, 42, reaches down the first threshold P1, the valve 32 closes the fluid communication C so that the pressure in the

second cavity 42, inside the tube 34a, stabilizes at said pressure threshold P1 while the pressure in the first cavity 40 continues to drop down to zero and, when the engine finally stops, the second cavity 42 remains pressurized to the level of the first threshold P1.

[0028] In the following operating phase of the engine, when the valve 32 opens the fluid communication C, both cavities 40, 42, are at the same pressure P1.

[0029] A second embodiment of the reservoir assembly 10 as per the invention is now described in reference to figure 2. Said second embodiment differs from the first in that in the second embodiment the tube is flexible and pressurized at the pressure of the first threshold P1, while it is rigid in the first embodiment, the numeral reference of said flexible tube being 34b. In an alternative depending on the material used for the flexible tube 34b, in order to ensure that in use the flexible tube 34b that is subject to inner and outer pressure variations remains in place in the bore 18 and does not accidentally seals the fuel inlet 26 or outlets 28, said flexible tube 34b is arranged in a cage member 46 and maintained therein.

[0030] The operation of said second embodiment of the reservoir assembly 10 is similar to the preceding description made for the first embodiment.

[0031] A third embodiment of the invention is described in reference to figure 3. The main difference with the first and second embodiments is that the two cavities 40, 42, are no longer coaxially arranged but are parallel to each other.

[0032] The body 12 is provided with a first bore 50, defining the first cavity 40, said first bore 50 extending along the longitudinal axis X throughout the body 12 and opening at both extremities, in a larger third threaded bore 52, on the left of the figure and, the already described second threaded bore 24 on the right end of the figure. The third threaded bore 52 enables during piecing of the first bore 50 to easily engage the piercing tool while, in use, said third bore 52 is sealingly closed by a non-represented plug.

[0033] The body is further provided with a second bore 54, defining the second cavity 42, said second bore 54 extending in parallel to the first bore 50 along a second longitudinal axis X2. The second bore 52 is a blind bore closed in the vicinity of the second end 16 of the body and opening only on the first end 14 of the body in the already described first threaded bore 20 wherein is arranged the valve 32.

[0034] The body 12 is further provided with a communication channel 56 extending angularly relative to the longitudinal axis and joining the two cavities 40, 42. Said communication channel 56 creates the controlled fluid communication C between the first cavity 40 and the second cavity 42.

[0035] The operation of said third embodiment of the reservoir assembly is similar to the preceding description made for the first or second embodiments. The fluid communication C is alternatively opened or closed by the valve 32 as the pressure in the first cavity 40 reaches the

first threshold P1.

[0036] The reservoir embodiments differing from each other, the valve 32 controlling the fluid communication C also differs from one embodiment to the other. In the first and second embodiments the valve 32 controls a coaxial fluid communication C while, in the third embodiment the valve 32 controls an angularly oriented communication C. Several valve embodiments are described below, after the description of a fourth embodiment of the reservoir assembly 10 now presented in reference to figure 4.

[0037] In said fourth embodiment a closed flexible inflatable balloon 58 having a general elongated tube shape is arranged inside a cage 60 having lateral openings, the balloon and cage being inserted in the bore 18. The first threaded bore 20 is sealed with a plug 62. The balloon 58 is filled with fuel pressurized to the first threshold P1. Alternatively the balloon 58 could be pressurized at said threshold P1 with a compressible gas, such as a nitrogen, and the volume occupied by the fuel is limited to the space in the bore 18 surrounding the balloon 58.

[0038] Although the general principle remains, the operation of said fourth embodiment of the reservoir assembly differs from the preceding descriptions in that as long as the fuel pressure in the bore 18 is below the threshold P1 the balloon 58 does not really change its volume and, when said pressure in the bore reaches and increases above the threshold P1, the balloon 58 collapse reducing its volume and increasing its inner pressure. Similarly to the second embodiment, the cage 60 maintains the balloon 58 in place and prevents accidental closing or inlet 26 or outlets 28.

[0039] A direct consequence of this fourth embodiment is that the volume pressurized by the fuel varies and regularly adjusts to the fuel pressure. When the pressure is very low in the first starting phase of operation of the engine, the volume of the balloon 58 is maximum and the space available for the fuel is minimum.

[0040] In a fifth embodiment not represented, an elongated insert member is arranged in the bore 18, said member being slightly smaller in section than the bore and extending from one end to the other of the bore. The elongated insert member is made of material that slightly compresses under very high pressure. Certain grades of rubber are suitable for the application. In use, the pressurized fuel fills the bore 18 surrounding the insert member and, as the fuel pressure increases the insert member compresses leaving more volume to be occupied by the fuel.

[0041] A first embodiment of the valve 32 is now described in reference to figure 5, said first embodiment being particularly adapted to the first and second embodiments of the reservoir assembly 10 as they are represented on figures 1 and 2, where the first 40 and second 42 inner cavities are coaxially arranged.

[0042] The valve 32 comprises, from right to left of figure 5, the complementary assembly of an inner valve member 80 which has a body 82a abutting against an annular first shoulder face 72 of the reservoir body 12, a

central member 120 and an outer cylindrical plug member 140 complementary screwed in the first threaded bore 20 of the first end 14 of the reservoir body. Said plug 140 axially compresses the central member 120 against the inner valve member 80, in turn compressed against said first shoulder face 72 of the reservoir body.

[0043] More precisely, the first end 14 of the reservoir body is provided, between the bore 18 and the first threaded bore 20, with an intermediate bore portion 70 having a larger diameter than the bore 18, defining between them the first shoulder face 72, and a smaller diameter than the first threaded bore 20.

[0044] The body 82a of the inner valve member comprises a cylindrical base 84 axially extending from a transverse rear face 88 to a transverse annular shoulder face 87 at the center of which axially extends a front portion 85 extending in the bore 18 toward a transverse front face 86 wherefrom axially protrudes a tubular portion 90 also extending in the bore 18 toward a distant extremity 92. The base 84 is adjusted within said intermediate bore 70 and is arranged so that the annular shoulder face 87 abuts against the annular first shoulder face 72 of the body 12. The front portion 85 and the tubular portion 90 have an outer diameters smaller than the inner diameter of the bore 18, leaving between them a part of the first cavity 40. Said diameters are also complementary adjusted to receive the extremity of the tube 34, said extremity of the tube 34 being engaged over and surrounding the tubular portion 90 to which it is fixed either by press-fitting, screwing or any other fixing known technic such as welding, laser welding.

[0045] The body 82a of the inner valve member is further provided with an axial cylindrical bore 94 having a main diameter D94 opening in the rear face 88 while restricting and tapering in the vicinity of the front face 86. The tapering portion of the bore 94 defines a fixed seating face 96 which central tip opens 98 in the front face 86 at the center of the tubular portion 90.

[0046] Furthermore, a communication channel 100a radially extends in the body 82a of the inner member radially from the outer face of the tubular portion 90 thus opening in the first inner cavity 40 to the vicinity of the seating face 96.

[0047] Inside the cylindrical bore 94 is arranged a needle valve member 102 adapted and adjusted to axially slide within the bore 94. The needle 102 extends from a head 104, protruding from the opening of the bore 94 in the rear face 88 of the body, to a opposed tip extremity having a conical face defining a needle thrust face 106 from the apex of which further extends a small cylindrical protrusion which end face defines a needle valve seat 108 arranged to cooperate with the seating face 96. As visible on the figure, said tip extremity of the needle 102 and the bore 96 define between them a control chamber 110 in which opens the radial communication channel 100a.

[0048] The central member 120 of the valve 32 comprises a cylindrical body 122 of similar outer diameter

than the intermediate bore portion 70, said body 122 axially extending from a transverse front face 124, arranged in surface abutment against the rear face 88 of the body of the inner valve member, to an opposed transverse rear face 126. The body 122 is further provided with an axial blind bore 128 opening in the front face 124 and having a diameter sufficient to enable the head 104 of the needle to protrude inside said bore 126. From the bottom of the bore 128 depart a smaller axial communication channel 130 opening in the rear face 126 of the central member, the bottom of the bore 126 being then reduced to an annular peripheral shoulder face 132 surrounding said axial communication channel 130.

[0049] Inside the bore 128, a spring 134 is axially compressed between the shoulder face 132 and the head 104 of the needle so that, said spring 134 permanently imparts to the needle 102 a closing force CF biasing said needle 102 in a closed position CP where the needle valve seat 108 is in sealing contact against the seating face 96 of the valve body thus sealingly closing the opening 98 of the bore 94 of the body 82a of the inner valve member.

[0050] The outer cylindrical plug member 140 is screwed and firmly tightened in the first threaded bore 20 extending from a transverse front face 142, that is in surface contact against the rear face 126 of the central body, to an opposed transverse rear face 144, that is outside the body 12 of the reservoir. Between said front 142 and rear 144 faces, the plug member 140 comprises, from front-right to rear-left, a front cylindrical portion 146 that extends in the intermediate bore portion 70 of the reservoir body, a central threaded portion 148, screwed in the first threaded bore 20 and, a rear head portion 150 that protrudes outside the body 12 of the reservoir and which has a larger cross section than the central threaded portion 148. Indeed, said head portion 150 may be provided with an interface profile, for instance a hexagonal shape, enabling complementary engagement with a tool that will impart to the plug the coupling necessary for the compression of the valve 32.

[0051] The plug member 140 is further provided with a large blind bore 152 extending in the central 148 and rear 150 portions of the plug, said bore 152 opening in the rear face 144 of the plug. From the bottom of said bore 152 axially extends in the front cylindrical portion 146 of the plug, another communication channel 154 opening in the front face 142 of the plug.

[0052] The plug member 140 is further provided with an O-ring 160 arranged in a peripheral groove 162 surrounding the front cylindrical portion 148. The O-ring 160 ensures sealing as it is compressed between the plug and the intermediate bore portion 70 of the reservoir body.

[0053] As it is visible on figure 5 and understandable from the above description, the first cavity 40, that is the annular space surrounding the tube 34 is in permanent fluid communication, via the radial communication channel 100a, with the control chamber 110. The control

chamber 110 is consequently at the same pressure as the first cavity 40 and, the pressurized fuel in the control chamber 110 imparts on the needle thrust face 106 an opening force OF biasing the needle 102 toward an open position OP where the needle valve seat 108 is distant from the seating face 96 of the inner valve body. The opening force OF is aligned and opposed to the closing force CF of the spring 134. Displacing the needle in the open position OP leads to open the fluid communication C, via the opening 98, between the first cavity 40 and the second cavity 42 that is inside the tubular portion 90 and inside the tube 34. The needle 102 translating back and forth between the closed position CP and the open position OP, the spring 134 compression varies and the closing force CF varies accordingly. Since the range of displacement is minimal, the range of force variation is also minimal and to simplify, the closing force CF can be assumed constant.

[0054] The operation is now described in reference to the previously identified phases. During the first starting phase 201 of the engine, phase going from initial start to idle running condition, the fuel entering in the first cavity 40 and in the control chamber 110 is at a very low pressure and, consequently the opening force OF imparted to the needle 102 does not overcome the closing force CF of the spring and thus, does not displace the needle 102 which remains in the closed position CP, the fluid communication C remaining closed. During this first phase 201 the volume to pressurize is limited to the volume of the first cavity 40, this minimizing the first phase timing duration.

[0055] As the pressure in the first cavity 40 and in the control chamber 110 increases during said first phase 201 the opening force OF increases accordingly. The closing force CF being constant, the first phase 201 ends when the pressure in the first cavity 40 and in the control chamber 110 reaches the first pressure threshold P1 where the opening force OF is equal and balances the closing force CF.

[0056] As fuel pressure in the first cavity 40 and in the control chamber 110 rises above said first threshold P1, the engine operation enters the second phase 202 where the opening force OF overcomes the closing force CF thus raising the needle 102 in the open position OP, and opening the fluid communication C so that, the space to be pressurized is augmented to the volume of the second cavity 42 and, during said second phase 202 both cavities 40, 42, are at the same pressure.

[0057] In the subsequent third phase 203 of operation the engine's RPM decreases and so does the required fuel pressure. As the pressure inside the cavities 40, 42, drops the opening force OF decreases and, when said pressure reaches back the first threshold P1 where the opening force OF is balanced by the closing force CF. When the pressure drops further the closing force CF overcomes the opening force OF and the valve 32 displaces in the closed position CP, closing the fluid communication C. Starting that point, the pressure in the two

cavities are no longer equal, the pressure in the first cavity 40 decreasing while, in the second cavity the pressure remains constant to said pressure threshold P1.

[0058] The skilled person knows that translation of the needle 102 is the inner bore 94 requires a functional gap G that will be used as a fuel leak path when the pressure in the control chamber 110 rises. The fuel leaking through said gap G is at low pressure and it flows back to a general fuel tank. After going through the gap G the leaking fuel flows via the valve central member 120, through the bore 128 and the communication channel 130, then via the plug member 140, through the communication channel 154 and the larger bore 152, then via a return circuit not represented.

[0059] As described above, said first embodiment of the valve 32 is particularly adapted to either one of the first or second embodiment of the reservoir assembly 10. Indeed, the distinctive feature of said reservoir assemblies 10 is the cage 46 of the second embodiment preventing undesired distortions of the tube 34. The valve 32 is not directly impacted with such change. The skilled person will easily determine several ways to fix, or simply maintain, the cage 46, either to the tube 34, or to the tubular portion 90 of the valve inner member or even to the body 12 of the reservoir.

[0060] A second embodiment of the valve 32 is now described in reference to figure 6, said second embodiment being particularly adapted to the third embodiment of the reservoir assembly 10 as it is represented on figure 3, where the first 40 and second 42 inner cavities are parallel to each other.

[0061] In said second embodiment, the valve 32 differs by the body of the inner member that is now referenced 82b. Said body 82b comprises the cylindrical base 84 axially extending from the transverse rear face 88 to the front face 86 that sealingly abuts against the first annular shoulder face 72. To the difference with the first embodiment, the body 82b does not comprise tubular portion. The base 84 is adjusted within said intermediate bore 70 and is arranged so that the shoulder face 87 abuts against the annular first shoulder face 72. The body 82b of the inner valve member is provided with the axial cylindrical bore 94 opening in the rear face 88 while restricting and tapering in the vicinity of the front face 86. The tapering portion of the bore 94 defines the fixed seating face 96 which central tip opens 98 in the center of the front face 86.

[0062] Furthermore, the communication channel, now referenced 100b, extends radially in the body 82b from the control chamber 110, similarly defined as in the first embodiment, to the outer face of the cylindrical base 84 where said channel 100b opens in a peripheral annular groove 101 provided on the outer face of the base 84. In an alternative, no groove 101 could be in the base 84 and the communication channel 100b could open directly in the outer face of the base 84. In any case, the communication channel continues into the other communication channel 56 that is angularly pierced through the

body 12 of the reservoir between the first cavity 40 and the intermediate bore portion 70 of the reservoir body.

[0063] An advantage of the groove 101 may be to ease the assembly process without having to angularly index the valve 32 to align the communication channels 100b, 56.

[0064] The operation of this second embodiment of the valve 32 is similar to operation of the first embodiment. In figure 6, as in figure 3, the first cavity 40 is drawn above the second cavity 42. During the first phase 201 of engine start, the pressure rises in the first cavity 40 and in the control chamber 110 where the opening force OF is still not sufficient to balance the closing force CF of the spring 134. Once the pressure reaches the first threshold P1 and continues to rise in the second phase 202 of engine operation, the fluid communication C opens. The third phase 203 of dropping pressure is similar to the previous embodiment.

[0065] A third embodiment of the valve 32 is now described in reference to figure 7, said third embodiment being particularly adapted to the first and second embodiments of the reservoir assembly 10 as they are represented on figures 1 and 2 where the first 40 and second 42 inner cavities are coaxially arranged.

[0066] Said third embodiment is particularly adapted to minimize the fuel leaks mentioned above, and occurring when the pressure rises in the control chamber 110, said leaks flowing through the functional gap G and returning toward the low pressure reservoir.

[0067] In said third embodiment of the valve 32 is provided with a leak prevention device 162 comprising an intermediate plate 164 arranged compressed between the rear face 88 of the inner member and the front face of the central member 124. Said intermediate plate 164 is provided with a central hole 166, of diameter D166 and, as can be seen on the figure, said hole 166 is axially aligned with the inner bore 94 of the valve and also with the bore 128 of the central member. Also, the diameter D166 of said central hole is smaller than the diameter D94 of the needle bore 94.

[0068] Furthermore, a cylindrical pusher member 168 comprises a rod 170 of diameter D170, at an extremity of which is a flat head 172. The pusher 168 is arranged so the rod 170 is freely engaged through the central hole 166 of the intermediate plate, the rod diameter D170 being smaller than the hole and the head 172 being on the spring side. The needle 102 is provided with an axial blind bore 174 opening in its transverse head face 104, the rod 170 being complementarily engaged and fixed in said blind bore 174, the fixing being done by screwing, press fitting, or any other known technic such as gluing, welding, laser welding... In such constructional embodiment, the pusher 168 and needle 102 form a subassembly able to axially slide, since the needle 102 remains guided in the inner bore 94, the spring 134, compressed against the head 172 of the pusher, biasing the needle in the closed position CP. In operation, when the pressure in the control chamber 110 reaches and exceeds the first

threshold pressure P1, the needle 102 moves away from the closed position CP to the open position OP where the head 104 of the needle comes in abutment in sealing contact against an annular surface of the intermediate plate 164, said annular surface surrounding the central hole 166. Consequently this annular contact prohibits fuel leaks to flow through the functional gap G and return toward the low pressure tank.

[0069] In an alternative not represented, the same principle of leak prevention device 162 with intermediate plate and pusher and needle assembly can be implemented in the valve of the second embodiment where the two inner cavities are not coaxial.

[0070] A fourth embodiment of the valve 32 is represented in figure 8 and is again adapted to be arranged in either the first or second embodiment of the reservoir assembly 10 as they are represented on figures 1 or 2. In said fourth embodiment, the plug member is replaced by a known pressure limiter 180 of mechanical construction. The valve 32 comprises an inner member 80, an intermediate plate 164 and a central member 120 compressed in place by said mechanical pressure limiter 180.

[0071] Another communication channel 182 is provided through the valve 32 establishing a permanent and non-restricted fluid communication between the first cavity 40, annularly surrounding the tube 34, and the rear face 126 of the central member 120. Said another communication channel 182 comprises a first portion extending through the body of the inner member, a second portion through the intermediate plate and, a third portion through the body of the central member, said third portion finally opening in the rear face 126.

[0072] A shallow recess is provided in the front face of the pressure limiter, said another communication channel 182 opening in said shallow recess. As visible on the figure, in operation the fuel pressure is identical in the first cavity 40, in the control chamber 110, in said another communication channel 182 and in the shallow recess where the fuel pressure imparts to a valve member another opening force, the valve member being here a ball biased in closed position by a pusher and a spring.

[0073] In such fourth embodiment, during the first phase 201 of operation the valve 32 and the pressure limiter 180 are both in closed position. The pressure rises until it reaches the first pressure threshold P1, where the valve 32 opens the fluid communication C between the two cavities. The pressure limiter 180 remains closed until the pressure in the cavities continue to rise and reaches a second pressure threshold P2 opening the pressure limiter 180 enabling an excess of fuel to flow back to the low pressure tank. In a subsequent operation phase, when pressure drops, the pressure limiter 180 closes again.

[0074] Fuel leaks around the needle 102, even limited because of the leak prevention device 162, can evacuate toward the general fuel tank via the communication channel 130 which radially extends from the bottom end 132 of the bore toward an annular space 192 from which said

leaks follow a path between the threads of the first threaded bore 20 and of the pressure limiter 180, then the leaks continue through a channel entering in the pressure limiter 180 which leads to the low pressure return circuit.

[0075] A non-represented alternative embodiment can easily be arranged using the concept of the pressure limiter associated to the valve 32 all arranged in a two-channel rail such as represented in figure 3.

[0076] A fifth embodiment of the valve 32 is represented in figure 9 and is again adapted to be arranged in either the first or second embodiment of the reservoir assembly 10 as they are represented on figures 1 or 2.

[0077] The valve 32 is similar to the valve of the third embodiment of figure 7, the valve being provided with a leak prevention device 162. The major distinctive feature with said third embodiment is related to the fact that on the body 12 of the reservoir assembly, the low pressure return circuit is radial, the body 12 being provided with a radial evacuation channel 190 opening in the intermediate bore portion 70 of the reservoir body.

[0078] To accommodate this structural difference the smaller communication channel 130 departing from the bottom of the bore 128 wherein is compressed the spring 134, is radially oriented, and not axially as in previous embodiments, joining said bore 128 to an annular space 192 surrounding the central member 120 of the valve, the radial evacuation channel 190 pierced through the body 12 of the reservoir opening in said annular space 192. As being no longer required, the plug member 140 is solid with no bore nor communication channel of any kind. The plug 140 sealingly closes the first end 14 of the body.

[0079] In an alternative not represented, a valve 32 of the first embodiment, represented on figure 5, can easily be arranged in a reservoir assembly having said radial evacuation channel 190. The modification to the valve being said another three portions communication channel 182 and, the communication channel 130 radially extending in the central member 120 of the valve and joining the annular space 192.

[0080] Also, a non-represented alternative embodiment can easily be arranged using a valve as per the fifth embodiment arranged in a two-channel rail such as represented in figure 3.

[0081] An alternative construction is now described in reference to figure 10, said alternative having the same body 12 with radial evacuation channel 190 and the same fifth embodiment of the valve 32 as described above. As can be seen, the main difference is that the solid plug previously utilized is replaced by an electromagnetically controlled pressure limiter 184 enabling radial exit of fuel when the pressure exceeds the second threshold P2. Similarly as in the fourth embodiment of figure 8, the fuel leaks evacuate through the radial communication channel 130 leading to the annular space 192, then through the evacuation channel 190 either directly or through the radial channel provided in the controlled pressure limiter 184.

[0082] In an alternative not represented, a valve 32 of the first embodiment, represented on figure 5, can easily be arranged in a reservoir assembly having said radial evacuation channel 190 and said controlled pressure limiter 184. The only modification to the valve being said another communication channel 182 comprising three portions and, the communication channel 130 radially extending in the central member 120 of the valve and joining the annular space 192.

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[0083]

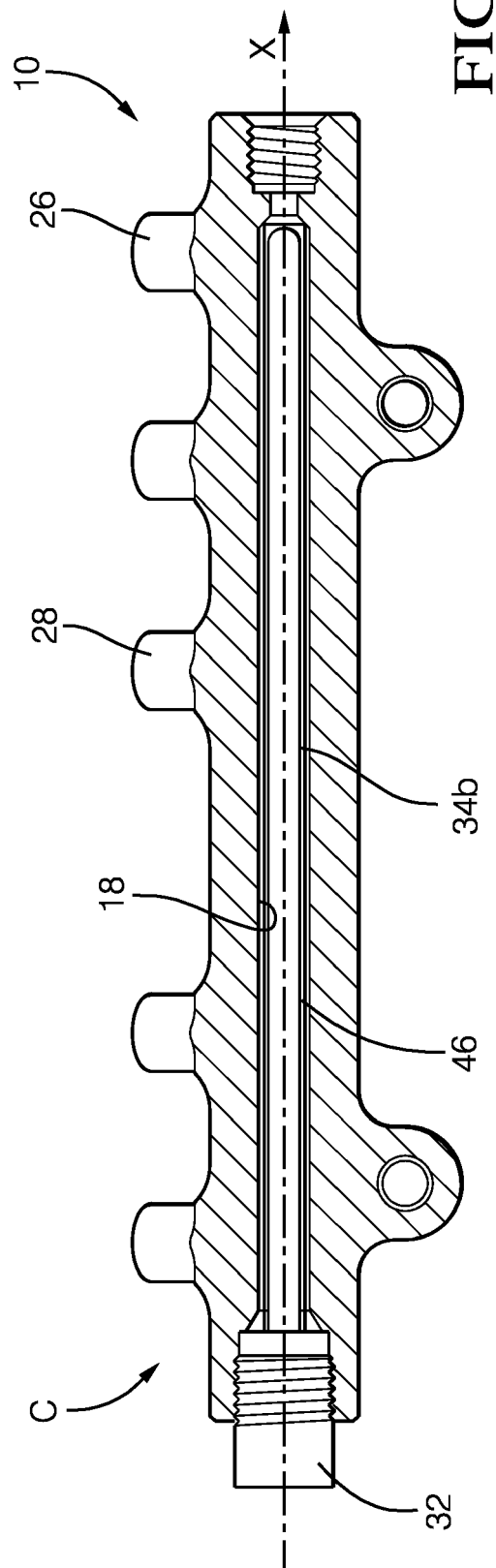
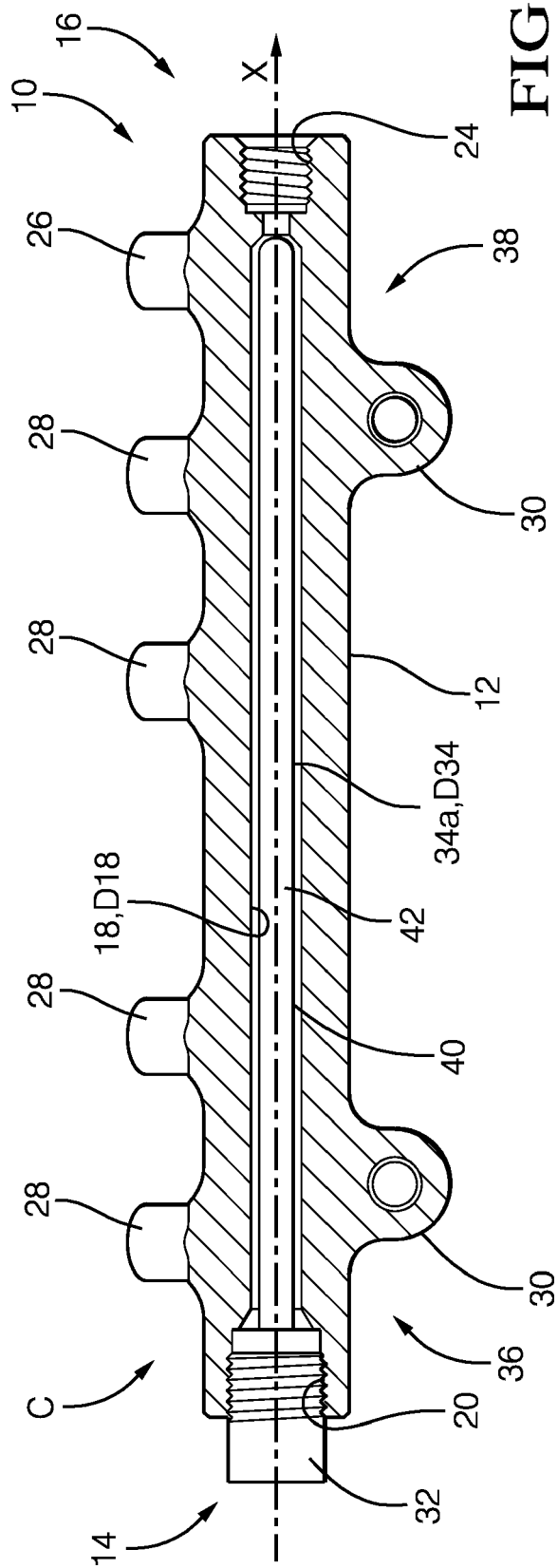
15	X	longitudinal axis
	X2	second longitudinal axis
	D18	diameter of the bore
	D34	outer diameter of the inner tube
	D94	diameter of the bore of the valve
20	D166	diameter of the hole of the intermediate plate
	C	fluid communication between the cavities
	P1	first pressure threshold
	P2	second pressure threshold
25	CP	closed position of the valve
	OP	open position of the valve
	CF	closing force
	OF	opening force
	G	functional gap
30	10	high pressure reservoir - common rail
	12	reservoir body
	14	first end of the body
	16	second end of the body
	18	bore
35	20	first threaded bore
	22	restriction
	24	second threaded bore
	26	inlet protrusion
	28	outlet protrusion
40	30	ears
	32	valve
	34a	tube - first embodiment
	34b	flexible tube - second embodiment
	36	first extremity of the tube
45	38	second extremity of the tube
	40	first inner cavity
	42	second inner cavity
	46	cage - second reservoir asm embodiment
	50	first bore - third reservoir asm embodiment
50	52	third threaded bore
	54	second bore - third reservoir asm embodiment
	56	communication channel
	58	balloon - fourth reservoir asm embodiment
	60	cage - fourth reservoir asm embodiment
55	62	plug - fourth reservoir asm embodiment
	70	intermediate bore portion of the reservoir body
	72	first shoulder face
	80	inner valve member

82a	body of the inner valve member - first embodiment	
82b	body of the inner valve member - second embodiment	
84	cylindrical base	5
85	front portion	
86	front face of the body of the inner member	
88	rear face of the body of the inner member	
90	tubular portion	
92	distant extremity of the tubular portion	10
94	inner bore of the valve	
96	seating face of the valve body	
98	opening of the inner bore in the front face	
100a	radial communication channel - first embodiment	15
100b	radial communication channel - second embodiment	
101	annular groove	
102	needle valve member	
104	head of the needle	20
106	needle thrust face	
108	needle valve seat	
110	control chamber	
120	central member	
122	body of the central member	25
124	front face of the body of the central member	
126	rear face of the body of the central member	
128	bore	
130	communication channel	
132	shoulder face bottom of the bore	30
134	spring	
140	outer plug member	
142	front face of the plug	
144	rear face of the plug	
146	front cylindrical portion of the plug	35
148	central threaded portion of the plug	
150	rear head portion of the plug	
152	bore	
154	communication channel	
160	O-ring	40
164	intermediate plate - third valve embodiment	
166	central hole	
168	pusher member	
170	rod	
172	head of the pusher	45
174	blind bore in the needle	
180	mechanical pressure limiter	
182	another communication channel	
184	controlled pressure limiter	
190	evacuation channel	50
192	annular space	
201	first phase - starting phase of the engine	
202	second phase of engine operation	
203	third phase of engine operation	55

Claims

1. Reservoir assembly (10) having a body (12) defining an inner cavity (40), the reservoir (10) being adapted to be arranged in a fuel injection equipment of an internal combustion engine, the pressurized fuel being received and stored in said inner cavity (40) prior to be delivered toward fuel injectors,
characterized in that
the reservoir assembly (10) is arranged so that when pressure in the inner cavity (40) increases and reaches a predetermined first threshold (P1), the available volume of the reservoir for storing said pressurized fuel increases above the volume initially occupied by the inner cavity (40).
2. Reservoir assembly (10) as claimed in claim 1 further comprising an insert member arranged in the inner cavity (40), said insert member being made of material, such as rubber, that is slightly compressible under high pressure.
3. Reservoir assembly (10) as claimed in claim 1 further comprising a flexible balloon (58) inserted in the inner cavity (40), the balloon being pressurized so that, in use the balloon (58) collapses when pressure in the cavity increases.
4. Reservoir assembly (10) as claimed in claim 3 wherein the balloon (58) is pressurized to the first threshold (P1).
5. Reservoir assembly (10) as claimed in any of the claims 3 or 4 wherein the balloon (58) is filled and pressurized with fuel.
6. Reservoir assembly (10) as claimed in claim 1 further comprising a second inner cavity (42) defined in the body (12) and a valve (32) opening a fluid communication (C) between the first inner cavity (40) and the second inner cavity (42) when the pressure in the first inner cavity increases and reaches the predetermined first threshold (P1).
7. Reservoir assembly (10) as claimed in claim 6 wherein the first inner cavity (40) and the second inner cavity (42) are coaxially arranged, the second inner cavity (42) comprising a tube (34a, 34b) coaxially arranged inside first cavity (40).
8. Reservoir assembly (10) as claimed in any of the claims 6 or 7 wherein the valve (32) has a body (82a, 82b, 122) in which a valve member (102) is received in a bore (94) and is adapted to translate between a closed position (CP) closing the fluid communication (C) between the two inner cavities (40, 42) and, an open position (OP) wherein said fluid communication (C) is open.

9. Reservoir assembly (10) as claimed in claim 6 further comprising a spring member (134) biasing the valve member (102) toward the closed position (CP).
10. Reservoir assembly (10) as claimed in claim 9 further comprising a leak prevention device (162) for preventing pressurized fuel leaks from the first cavity (40) to a low pressure return circuit when the valve member (102) is in open position (OP). 5
11. Reservoir assembly (10) as claimed in any one of the preceding claims wherein the reservoir assembly (10) is further provided with a pressure limiter (180, 184) adapted to open another fluid communication between the first inner cavity (40) and a low pressure return circuit when pressure in said first inner cavity (40) increases and reaches a second threshold (P2) superior to the first threshold (P1). 10 15
12. Reservoir assembly (10) as claimed in claim 11 wherein the pressure limiter (184) is an electro valve piloted to open or close said another fluid communication between the first inner cavity (40) and a low pressure return circuit. 20 25 30 35 40 45 50 55



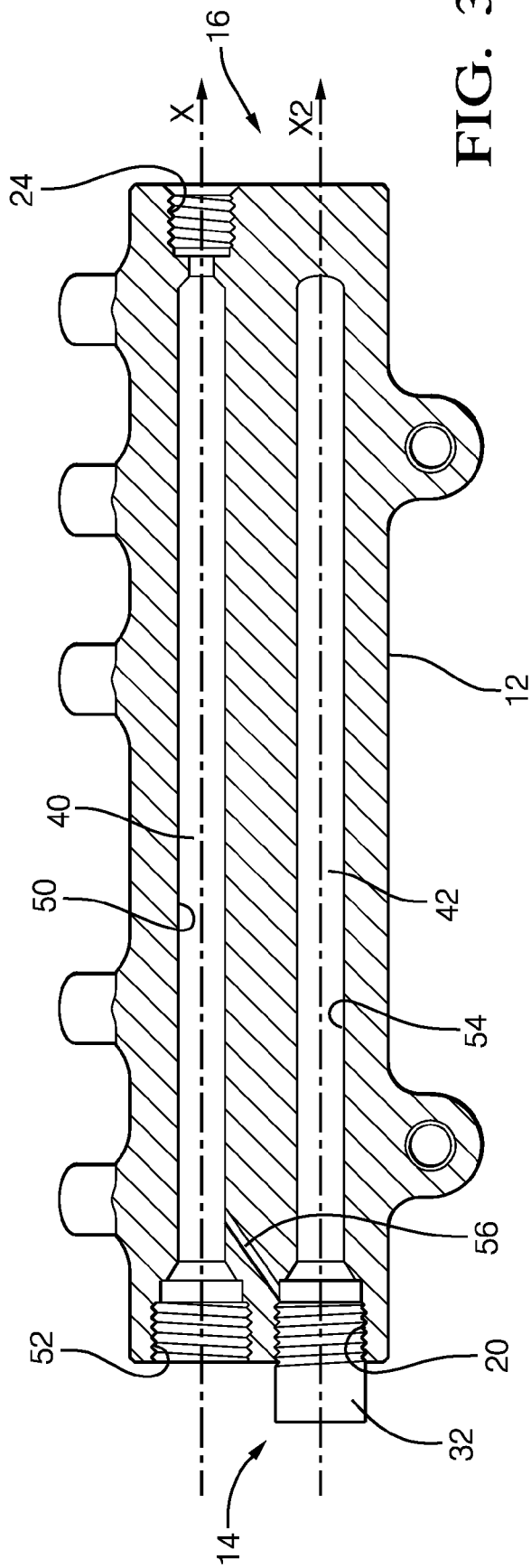


FIG. 3

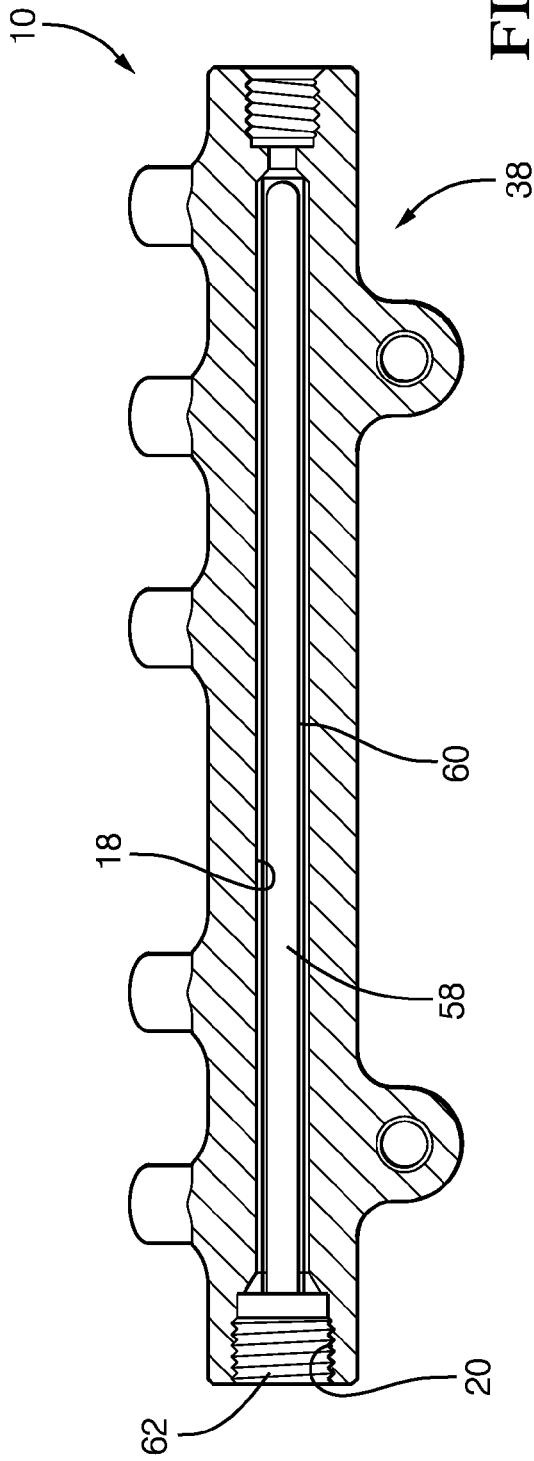


FIG. 4

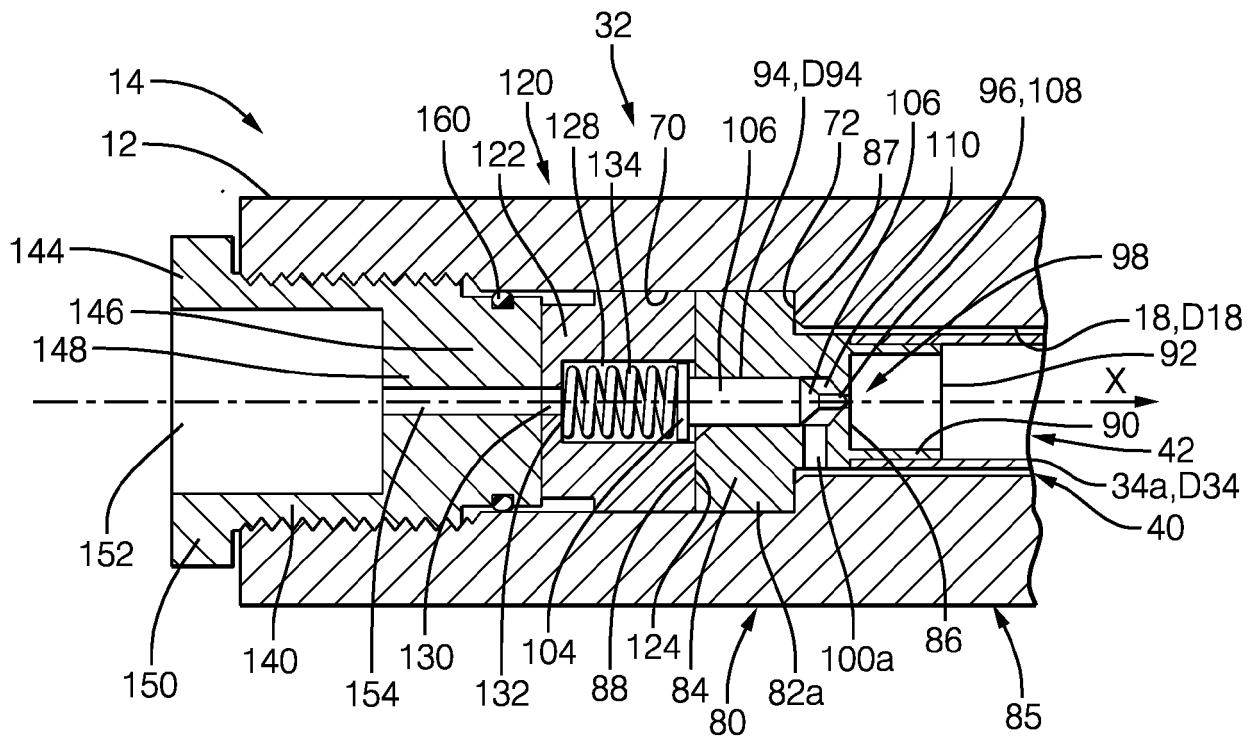


FIG. 5

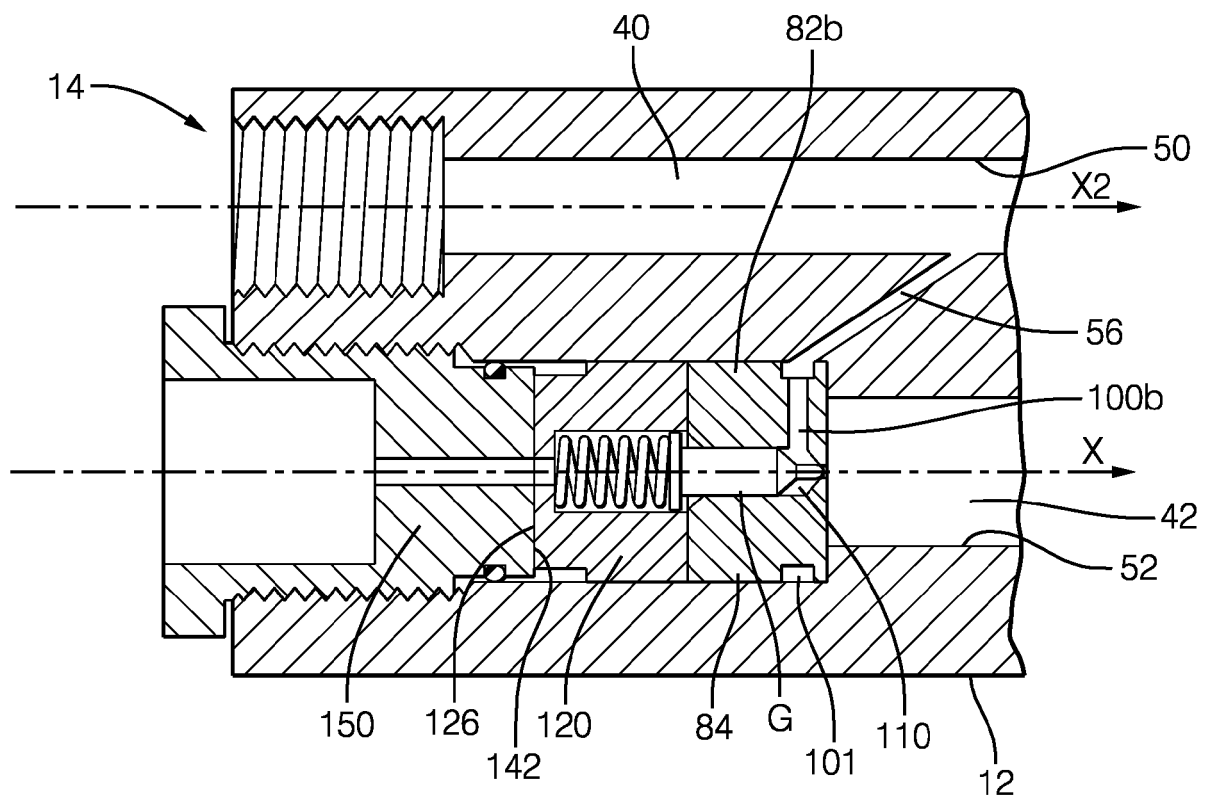


FIG. 6

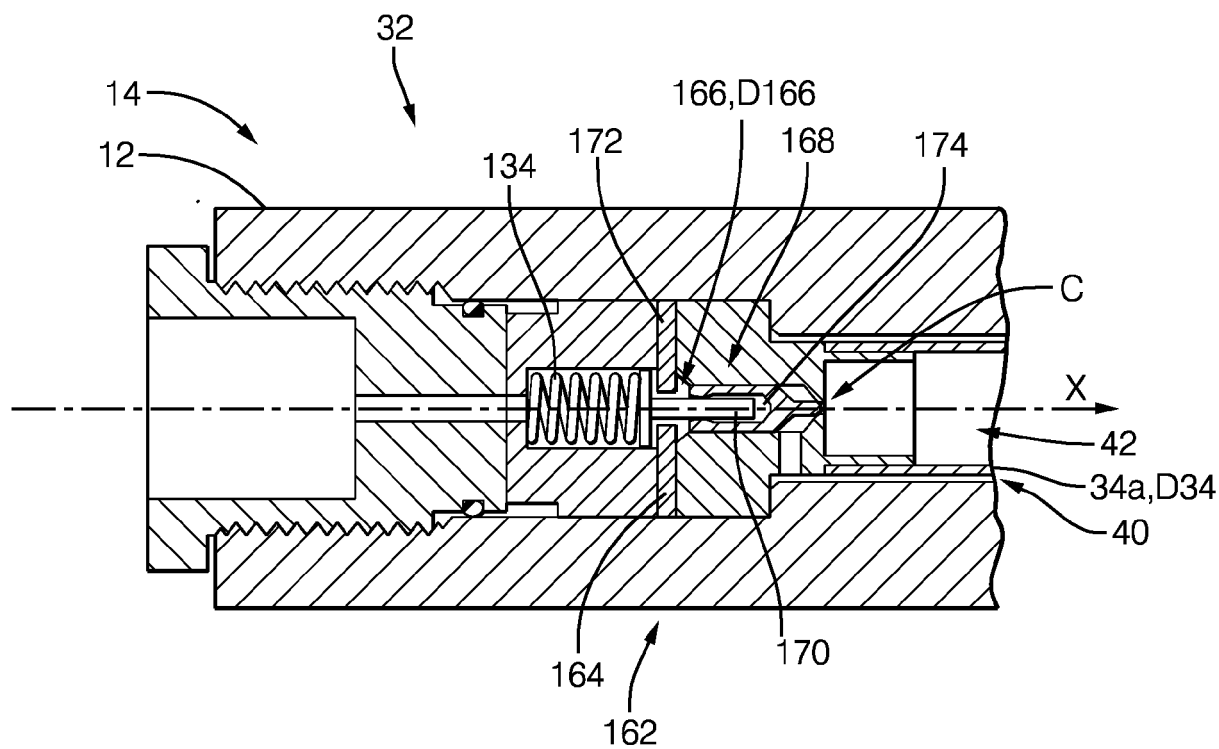


FIG. 7

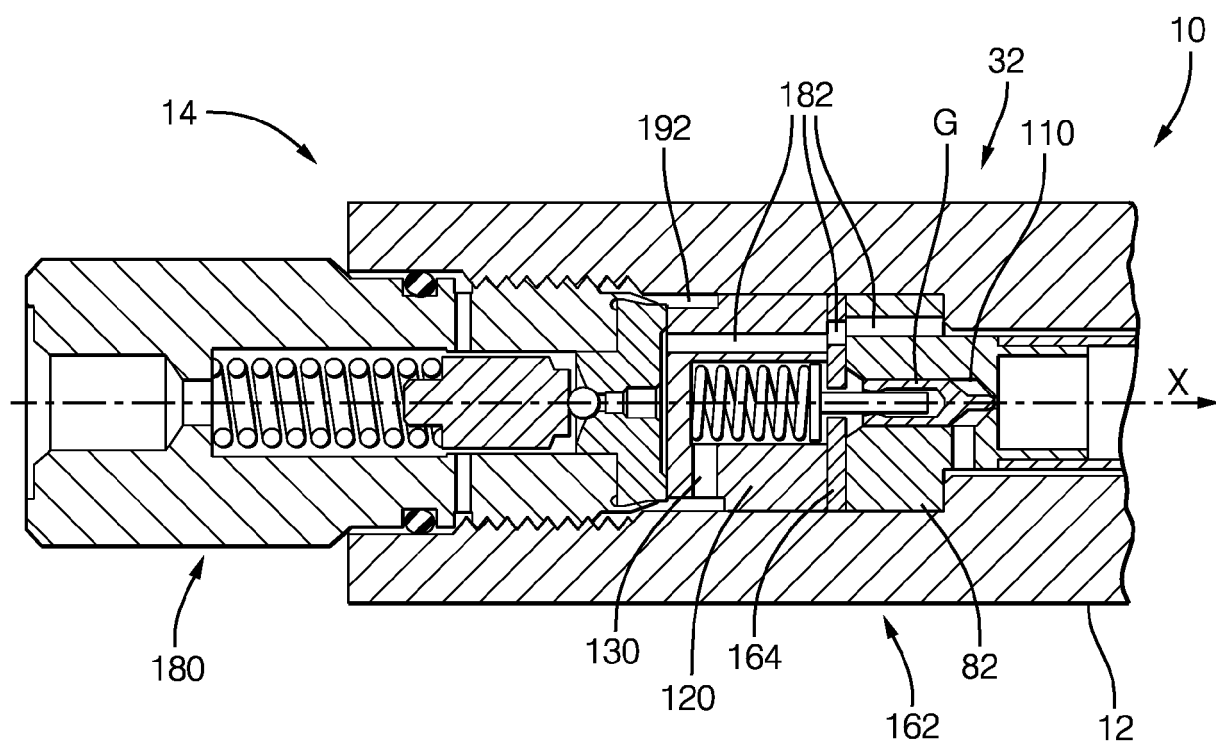


FIG. 8

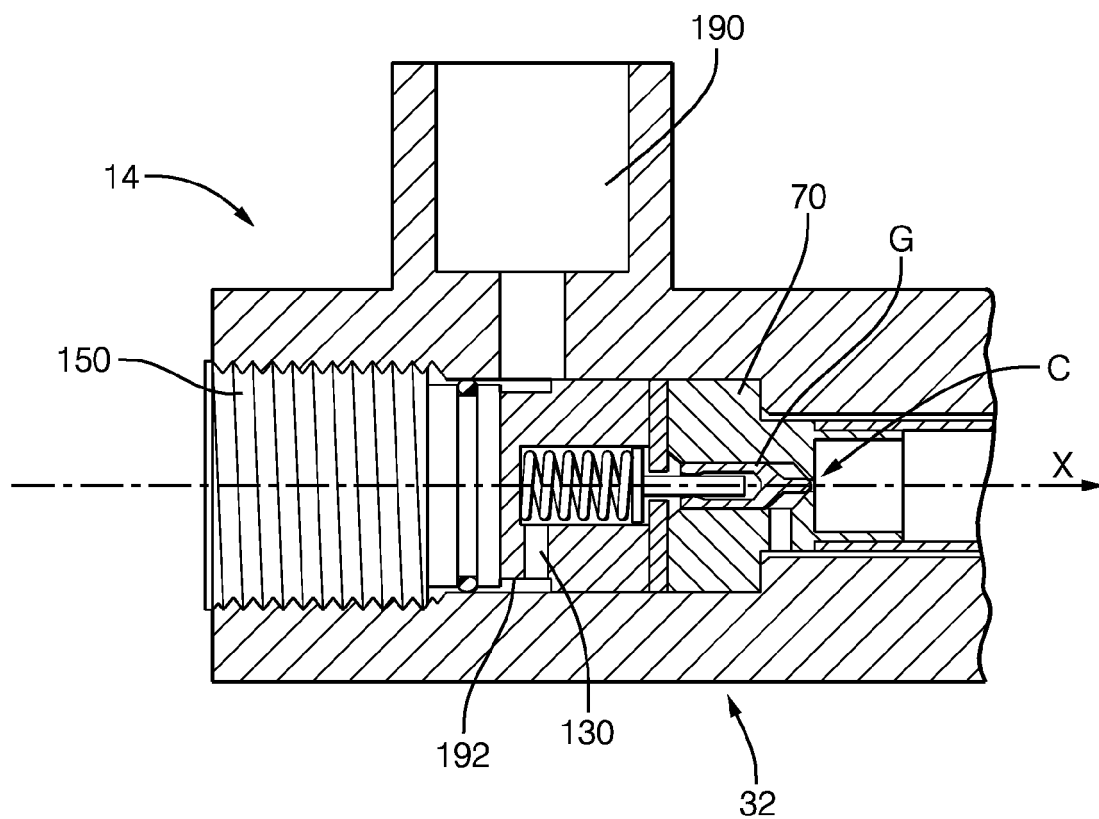


FIG. 9

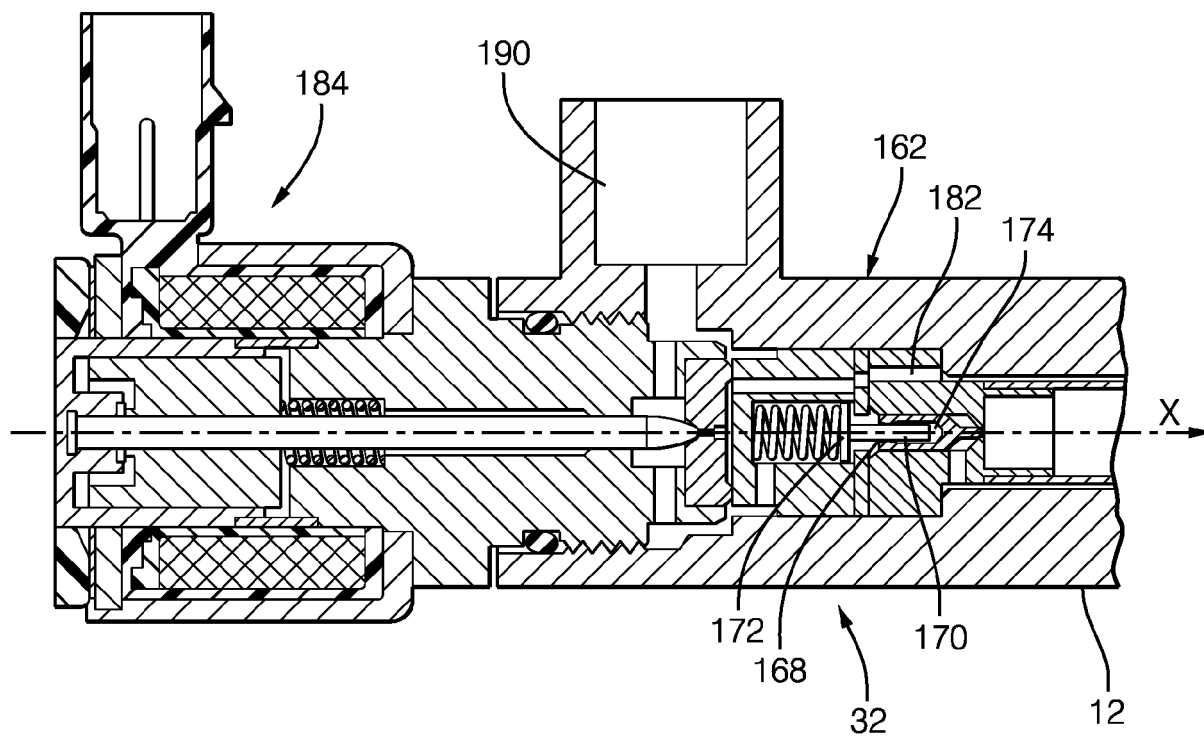


FIG. 10



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Application Number
EP 17 15 7270

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			TECHNICAL FIELDS SEARCHED (IPC)
			F02M
The present search report has been drawn up for all claims			
Place of search The Hague		Date of completion of the search 14 June 2017	Examiner 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	

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The members are as contained in the European Patent Office EDP file on
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