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(54) **Valve arrangement**

(57) A valve arrangement for use in an injector, the valve arrangement arranged to be moveable between an open configuration in which the valve arrangement provides a flow path for pressurised fuel from a control chamber of the injector to a low pressure drain and a closed configuration in which the valve arrangement closes the flow path, the valve arrangement comprising: a valve guide (106) located within the injector, the valve guide comprising at least a part of the flow path; a valve head portion (104) arranged to close a first end (110) of the valve guide when the valve arrangement is in the closed configuration; a biasing member (120) arranged to bias the valve arrangement towards the closed configuration wherein the biasing member (120) comprises an elastic member located within the valve guide and the biasing member defines a volume (124) within the valve guide.

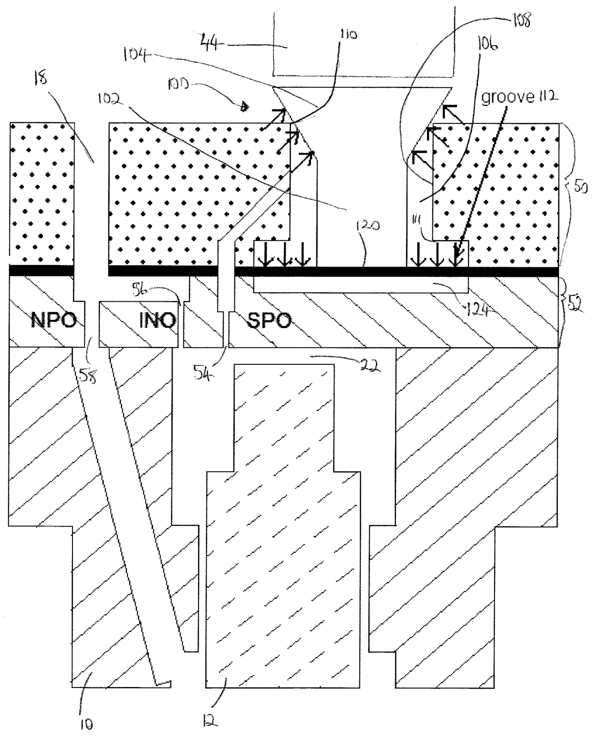

FIG.3

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Description

Field of the Invention

[0001] The present invention relates to a valve arrangement. In particular, the present invention relates to a valve arrangement for a fuel injector.

Background to the Invention

[0002] The present invention relates to a valve arrangement used in the delivery of fuel to a cylinder of a diesel internal combustion engine of the type in which fuel is supplied to a high pressure accumulator (the "common rail") by a suitable pump and is delivered from the accumulator to the fuel injectors of the engine, the nozzles of which are arranged to actuate in turn to deliver fuel to the respective cylinders of the engine.

[0003] Such fuel injectors generally comprise a needle which is slidable within a body and engageable with a valve seat to control the flow of fuel from a high pressure fuel supply line through the body.

[0004] The maximum injection pressures within a fuel injector may be of the order of 1800 bar or higher and as a consequence the forces to be overcome in order to lift the needle of the injector are large. It is not therefore possible to directly control the injector using an electromagnetic actuator unless very high currents are used. The injector is therefore indirectly controlled by means of a valve arrangement which controls the pressurising or discharging of a control chamber located above the valve needle.

[0005] An example of such an injector is disclosed in EP0647780 in which the end of the needle remote from the valve seat extends within a chamber, the chamber being arranged to receive fuel from the supply line through a restrictor. In use, injection is controlled by varying the pressure within the control chamber. A solenoid actuator acts upon a valve arrangement to cause a flow path between the control chamber and a low pressure drain to open. As the pressure falls within the control chamber the needle leaves the valve seat due to pressure acting against a portion of the needle adjacent the valve seat. Within common rail injection systems two types of valve arrangements are known, pressure-balanced valve arrangements (sometimes referred to as equilibrium valves) and non-pressure balanced valve arrangements.

[0006] In a pressure balanced valve arrangement a valve stem located within a bore is slidable under the action of the electromagnetic actuator to open and close a flow path between the high pressure region of the control chamber and the low pressure region of a low pressure drain. In the closed configuration the valve arrangement is in contact with a valve seat and is substantially in hydraulic equilibrium, with the valve arrangement being held in the closed position by the action of a spring on the valve arrangement. Upon actuating the electromagnetic actuator the spring force is overcome and the valve arrangement moves away from its seat thereby allowing fuel to move between the stem and bore to the low pressure drain. Equilibrium based valve arrangements tend to demonstrate a degree of static leakage. In other words, even in the closed position high pressure fuel will leak along the flow path defined between the bore of the valve arrangement and the valve stem to the low pressure drain.

[0007] In a non-pressure balanced valve arrangement the valve is held in its seated and closed position by the pressure of the high pressure fuel within the system. Such a valve arrangement is not therefore substantially in hydraulic equilibrium in the closed position and consequently requires a greater activation force in order to open. However, the degree of static leakage within such a non-pressure balanced valve arrangement is lower than in the pressure balanced valve arrangement.

[0008] The two types of valve arrangement described above therefore either have a low actuation force requirement with a relatively high degree of static leakage (pressure balanced valve arrangement) or high actuation force requirement with a relatively low degree of static leakage (non-pressure balanced valve arrangement).

[0009] It is an object of the present invention to provide a valve arrangement that has a low actuation force requirement but which has improved static leakage performance.

Statements of Invention

[0010] According to a first aspect of the present invention there is provided a valve arrangement for use in an injector, the valve arrangement arranged to be moveable between an open configuration in which the valve arrangement provides a flow path for pressurised fuel from a control chamber of the injector to a low pressure drain and a closed configuration in which the valve arrangement closes the flow path, the valve arrangement comprising: a valve guide located within the injector, the valve guide comprising at least a part of the flow path; a valve head portion arranged to close a first end of the valve guide when the valve arrangement is in the closed configuration; a biasing member arranged to bias the valve arrangement towards the closed configuration wherein the biasing member comprises an elastic member located within the valve guide and the biasing member defines a volume within the valve guide.

[0011] The present invention provides a valve arrangement in which the valve arrangement (/valve head portion) is biased towards a closed configuration by the action of an elastic member that is located within a valve guide and which defines a volume within the valve guide. The elastic member is in contrast to known arrangements which use a spring arrangement.

[0012] The use of an elastic member allows the valve arrangement to be arranged to be substantially in hydraulic equilibrium when in the closed configuration. The presence of a valve head portion allows the valve guide to be closed by the head portion in the closed configuration such that static leakage is minimised.

[0013] The valve arrangement of the present invention therefore provides a valve with a relatively low degree of static leakage and a relatively low actuation force requirement.

[0014] It is noted that the elastic member/biasing member partitions the valve guide and defines a volume within the valve guide (such that one part of the valve guide is not in fluid communication with a second part of the valve guide).

[0015] Conveniently, the valve arrangement may be arranged to be substantially hydraulically balanced when in the closed configuration. Forces resulting from fuel pressure within the valve guide on the valve head portion may be arranged to be substantially equal to forces resulting from fuel pressure within the valve guide on the biasing member, the forces on the head portion and biasing member acting in substantially opposing directions.

[0016] Conveniently, the valve arrangement comprises a valve stem portion arranged to be located within the valve guide, the valve head portion being located at a first end of the valve stem portion and the biasing member being located at a second end of the valve stem portion.

[0017] In one variant of the present invention, the biasing member may comprise a substantially planar elastic plate. In another variant of the present invention, the biasing member may comprise a ridged plate. The presence of ridges in the plate may conveniently allow the response characteristics of the biasing member to be varied.

[0018] In a further variant of the present invention the biasing member may be formed into a substantially planar elastic portion and a stem portion, the valve head portion being located at a first end of the stem portion and the elastic portion being located at a second end of the stem portion. This variant has the advantage that it is lighter than a version with a solid stem portion which may have performance benefits (e.g. a more responsive valve arrangement). The stem portion may be substantially cylindrical and comprise a number of grooves. The valve head portion may be mounted at one end of the stem portion. Alternatively, the valve head may be of annular construction and the stem portion may protrude through the valve head portion. This alternative arrangement may result in a simpler construction process .

[0019] The valve guide may comprise a valve groove at a second end of the guide remote from the first end, the biasing member being located within the valve groove. The valve groove may have a greater cross sectional area than a main bore of the valve guide. The biasing member forms a partition across the valve groove such that the valve head portion and valve stem portion/ valve bore are located on one side of the partition and the volume is formed on the other side of the partition (the two sides of the partition not being in fluid communication with each other). The volume may be filled with fuel and be arranged to be in fluid communication with a fuel return back leak circuit.

[0020] According to a second aspect of the present invention there is provided an injector for use in the delivery of fuel to a cylinder of an internal combustion engine, the injector comprising : a body provided with a bore; a valve needle slidable within the bore of the nozzle body; an actuator; a fuel supply line for supplying pressurised fuel to a control chamber; a valve arrangement according to the first aspect of the present invention actuable by the actuator for permitting fuel to flow from the control chamber to a low pressure drain.

[0021] Preferred features of the second aspect of the present invention may comprise preferred features of the first aspect of the present invention.

<u>Brief Description of the Drawings</u>

[0022]

Figure 1 shows a known pressure balanced valve arrangement;

Figures 2a and 2b show the fuel injection process for a typical injector;

Figure 3 shows a valve arrangement (closed position) in accordance with an embodiment of the present invention;

Figure 4 shows the valve arrangement of Figure 3 in an open position;

Figures 4 to 9 show further embodiments of the present invention.

<u>Detailed Description</u>

[0023] Figure 1 shows an example of a pressure balanced valve arrangement as described in EP0740068.

[0024] The known fuel injector illustrated in Figure 1 comprises a valve body 10 including a first region of relatively narrow diameter and a second, enlarged region. The valve body 10 is provided with a bore 11 which extends through both the first and second regions, the bore terminating at a position spaced from the free end of the first region. An elongate valve needle 12 is slidable within the bore, the valve needle 12 including a tip region 14 which is arranged to engage a valve seat defined by the inner surface of the valve body 10 adjacent the blind end of the bore. The valve body 10 is provided with one or more apertures 15 communicating with the bore, the apertures being positioned such that engagement of the tip 14 with the valve seat prevents fluid escaping from the valve body 10 through the apertures, and when the tip 14 is lifted from the valve seat, fluid may be delivered through the apertures.

[0025] As shown in Figure 1, the valve needle 12 is shaped such that the region thereof which extends within the first region of the valve body 10 is of smaller diameter than the bore to permit fluid to flow between the valve needle 12 and the inner surface of the valve body 10. Within the second region of the valve body 10, the valve needle 12 is of larger diameter, substantially preventing fluid flowing between the valve needle 12 and the valve body 10.

[0026] In the second region of the valve body 10, an annular gallery 16 is provided, the annular gallery 16 communicating with a fuel supply line 18 which is arranged to receive high pressure fuel from an accumulator of an associated fuel delivery system. In order to permit fuel to flow from the gallery 16 to the first region of the valve body 10, the valve needle 12 is provided with a fluted region 20 which permits fuel to flow from the annular gallery 16 to the first part of the valve body 10, and also acts to restrict lateral movement of the valve needle 12 within the valve body 10 but not restricting axial movement thereof.

[0027] A chamber 22 is provided within the second region of the valve body 10 at a position remote from the first region thereof, the chamber 22 communicating with the high pressure fuel line 18 through a restrictor 24. As shown in Figure 1, the chamber 22 is provided at an end of the valve body 10, the chamber 22 being closed by a plate 26.

[0028] The end of the valve needle 12 remote from the tip 14 thereof is provided with a reduced diameter projection 28, the projection 28 guiding a compression spring 30 which is engaged between the valve needle 12 and the plate 26 to bias the valve needle 12 to a position in which the tip 14 thereof engages the valve seat.

[0029] A body 34 engages the side of the plate 26 opposite that engaged by the valve body 10, the body 34 and plate 26 together defining a chamber 35 which communicates with the chamber 22 through an aperture 32. The body 34 is further provided with a bore which is spaced apart from the axis of the body 34 and within which a valve member 36 ("the valve arrangement") is slidable. The valve member 36 comprises a cylindrical rod provided with an axially extending blind bore, the open end of the bore being able to communicate with the chamber 35 when the valve member 36 is lifted such that the end thereof is spaced from the plate 26, such communication being broken when the valve member 36 engages the plate 26. A pair of radially extending passages 38 communicate with the blind bore adjacent the blind end thereof, the passages 38 communicating with a chamber which is connected to a suitable low pressure drain.

[0030] The body 34, plate 26 and valve body 10 are mounted on a nozzle holder 42 by means of a cap nut 40 which engages the end of the second region of the valve body 10 adjacent its interconnection with the first region thereof. The nozzle holder 42 includes a recess within which a solenoid actuator 44 is provided.

[0031] As illustrated in Figure 1, the solenoid actuator 44 comprises a generally cylindrical core member 44a including an axial blind bore, windings 44b being wound upon the core member 44a and being connected to a suitable controller, and a cylindrical yoke 44c extending around the core member 44a and windings 44b. The faces of the core member 44a and yoke 44c facing the valve member 36 define pole faces.

[0032] The valve member 36 carries an armature 36a such that upon energization of the solenoid actuator 44, the armature 36a and valve member 36 are lifted such that the valve member 36 disengages the plate 26. On de-energizing the solenoid actuator 44, the valve member 36 returns to its original position under the action of a spring 46 received within the blind bore of the core member 44a.

[0033] A movement limiter 47 is also received within the blind bore of the core member 44a, the movement limiter 47 being arranged to limit movement of the valve member 36 against the action of the spring 46 in order to prevent the armature 36a contacting the pole faces of the core member 44a and yoke 44c. It is noted that the spring 46 provides a closing force for the valve and also maintains a contact pressure on the valve seat when the valve is closed.

[0034] As shown in the drawing, the supply line 18 comprises bores provided in the nozzle holder 42, body 34, plate 26 and valve body 10. In order to ensure that these bores align with one another, pins 48 are provided, the pins 48 being received within suitable recesses provided in each of the nozzle holder 42, body 34, plate 26 and valve body 10.

[0035] In use, in the position shown in Figure 1 the valve needle 12 is biased by the spring 30 such that the tip 14 thereof engages the valve seat and thus delivery of fuel from the apertures does not occur. In this position, the pressure of fuel within the chamber 22 is high, and hence the force acting against the end of the valve needle 12 due to the fuel pressure, and also due to the resilience of the spring 30, is sufficient to overcome the upward force acting on the valve needle 12 due to the high pressure fuel acting against the angled surfaces of the valve needle 12.

[0036] In order to lift the tip 14 of the valve needle 12 away from the valve seat to permit fuel to be delivered from the apertures, the solenoid actuator 44 is energized to lift the valve member 36 against the action of the spring 46 such that the end of the valve member 36 is lifted away from the plate 26. Such lifting of the valve member 36 permits fuel from the chamber 35 and hence the chamber 22 to escape to drain through the bore of the valve member 36 and passages 38. The escape of fuel from the chamber 22 reduces the pressure therein, and due to the provision of the restrictor 24, the flow of fuel into the chamber 22 from the fuel supply line 18 is restricted. As the pressure within the chamber 22 falls, a point will be reached at which the force applied to the valve member 12 due to the pressure within the chamber 22 in combination with that applied by the spring 30 is no longer sufficient to retain the tip 14 of the valve member 12 in engagement with the valve seat, and hence a further reduction in pressure within the chamber 22 will result in the valve needle 12 being lifted to permit fuel to be delivered from the apertures.

[0037] If a low initial injection rate is desired, this may be achieved by arranging the solenoid actuator 44 to lift the valve member 36 by only a small amount, thus the flow of fuel from the chamber 22 to drain is restricted. Similarly, the aperture 32 may be of restricted diameter so as to restrict the flow of fuel from the chamber 22.

[0038] As the valve needle 12 lifts, the projection 28 approaches the aperture 32 restricting the flow of fuel therethrough. It will be recognised that this has the effect of decelerating the valve needle 12 towards the end of its travel.

[0039] In order to terminate delivery, the solenoid actuator 44 is de-energized and the valve member 36 moved downwards under the action of the spring 46 until the end thereof engages the plate 26. Such movement of the valve member 36 breaks the communication of the chamber 35 with the drain, and hence the pressure within the chamber 35 and chamber 22 will increase, a point being reached at which the force applied to the valve needle 12 due to the pressure within the chamber 22 and due to the spring 30 exceeds that tending to open the valve, and hence the valve needle 12 will move to a position in which the tip 14 thereof engages the valve seat to prevent further delivery of fuel.

[0040] It will be recognised from the above description and from Figure 1 that since the valve member 36 and solenoid actuator 44 are not coaxial with the valve needle 12, the nozzle holder 42 and body 34 each include a region of relatively large wall thickness compared to the conventional arrangement and by arranging for the supply line 18 to extend within the relatively thick part of the wall, the risk of rupture of the injector due to the application of high pressure fuel to the fuel supply line 18 is reduced.

[0041] Figures 2a and 2b show the injection process within a typical known injector 1. Like features between Figures 1 and 2 are denoted by like reference numerals. The injector in Figures 1 and 2 comprises an electromagnetic actuator arrangement 44 located above a valve arrangement 50. A spacer component 52 is situated underneath the valve arrangement 50 and above the needle 12. The spacer 52 integrates the control chamber 22 and three calibrated orifices (54, 56, 58) which allow operation of the injector.

[0042] The valve arrangement 50 comprises a valve stem portion 60 which carries an armature 62 at one end of the stem portion. The stem portion is slidable within a bore 64. The valve stem portion carries a number of depressurisation grooves and, at the armature end of the stem portion, there is a sealing face 66 which is engageable with a seat 68 at an end of the bore. When the sealing face is brought into contact with the seat a contact making pressure seal is made. A valve spring 46 (not shown in Figures 2a-2b) is located above the armature and acts to urge the sealing face into engagement with its seat.

[0043] Within the spacer component 52 there is an injection supply orifice 58 (also referred to as the nozzle path orifice or NPO), a control chamber discharge orifice 54 (also referred to as the spill orifice or SPO) and a control chamber filling orifice 56 (also referred to as the inlet orifice or INO).

[0044] The operation of the injector will now be briefly described with reference to Figures 2a and 2b.

[0045] In Figure 2a, the valve arrangement 50 is closed and the sealing face 66 is engaged with the seat 68. The control chamber 22 is therefore subjected to the pressure within the common rail. The high pressure fuel exerts a force on the top of the needle 12 which exceeds the pressure of fuel acting on a pressure surface 70 of the needle 12. The needle is therefore held closed such that there is no injection through the orifices 15.

[0046] In Figure 2b, the actuator 44 is energised and lifts the armature 62 such that the valve arrangement 50 is in its open position in which the sealing face 66 lifts from its seat 68. Fuel contained within the control chamber 22 now has a flow path through the spill control orifice 54 (SPO) to a low pressure drain and fuel consequently flows from the control chamber 22. Initially the pressure exerted on the top of the needle 12 by fuel within the control chamber 22 and the injector spring 30 exceeds the pressure exerted on the pressure surface 70.

[0047] However, as soon as the pressure exerted by fuel on the pressure surface 70 exceeds the spring force and the force exerted by fuel in the control chamber 22 then the needle 12 lifts and injection of fuel through the orifices 15 commences as fuel flows from the common rail through the nozzle path orifice 58 as in Figure 2b.

[0048] To stop injection, the electromagnetic actuator 44 is de-energised and the valve spring 46 (not shown in Figure 2) closes the valve arrangement 50. High pressure fuel passes from the supply line 18 through the control chamber filling orifice 56(INO) and the pressure rises within the control chamber 22 until injection ceases.

[0049] Figures 3 and 4 show the operation of a valve arrangement 100 in accordance with an embodiment of the present invention. In Figures 3 and 4, like features between Figures 1 to 4 are denoted by like features.

[0050] The valve arrangement 100 of Figures 3 and 4 comprises a valve stem portion 102 and a valve head portion 104 located at one end of the valve stem portion 102. The valve arrangement 100 is generally located within a valve guide 106. The valve guide comprises a bore 108 which is open at a first end 110 and which opens into a valve groove 112 at a second end (111) of the bore (108).

[0051] Figure 3 shows the valve arrangement 100 in a closed configuration in which there is no fuel flow path from the control chamber 22 to a low pressure drain (not shown). It is noted that the cross sectional area of the valve head 104 varies such that in the closed configuration of the valve arrangement 100 as shown in Figure 3 the valve head 104 seats against the opening 110 of the valve guide 106 to form a seal.

[0052] Figure 4 shows the valve arrangement in an open configuration in which there is a flow path 114 for fuel from the control chamber 22 through the spill orifice 54 to the low pressure drain.

[0053] Instead of a valve spring as shown in Figure 1, the valve arrangement of Figures 3 and 4 comprises a biasing member 120 located at the end of the valve stem 102 remote from the valve head 104, the biasing member being arranged to bias the valve arrangement towards the closed configuration. The biasing member in Figures 3 and 4 comprises a substantially planar elastic plate which is located within the valve groove 112.

[0054] The biasing member 120 is arranged such that in the closed configuration the pressure exerted by fuel on the valve head 104 is substantially equal to the pressure exerted on the elastic plate 120. In this manner the valve arrangement 100 is substantially hydraulically balanced in the closed configuration and the valve is held closed against small pressure variations by the elastic plate which exerts a force in a downward direction (i.e. from the actuator arrangement towards the needle in the configuration of Figure 3).

[0055] In Figure 4 the actuator arrangement 44 has been energised. The upwards force exerted by the actuator arrangement 44 exceeds the downwards force from the elastic plate 120 and consequently the valve arrangement 100 has been lifted upwards into its open configuration. The valve head 104 is no longer seated against the orifice 110 of the valve bore 108 and the fuel flow path 114 to the low pressure drain has been opened such that fuel can flow from the control chamber 22 and the needle 12 can lift from its seat. It can be seen that the elastic plate 120 has deformed slightly (122) as a result of the force exerted by the actuator.

[0056] When the actuator arrangement 44 is de-energised the elastic plate 120 regains its previous substantially planar configuration and as a result closes the flow path by bringing the valve head back to its seat 110. The pressure in the control chamber 22 then rises again as described above in relation to Figures 2a and 2b as fuel flows into the control chamber via the INO 56.

[0057] It is noted that the volume 124 beneath the biasing member 120 is a fuel filled volume that is connected to a back leak return passage (connection not shown in Figures 3 to 9) to allow the elastic plate to deform as required.

[0058] The elastic plate may comprise a steel plate. The steel plate is arranged to provide a closing force for the valve member 106 that is sufficient such that the spring 46 shown in Figure 1 is not required. It is noted that once the spring 46 is removed from the injector then there is more space available for the magnetic material within the actuator (for example, the core member 44a of Figure 1 could be larger). The increase in material within the actuator core member results in improved actuator performance and therefore improved valve performance. It is also noted that once the spring 46 has been removed the stop member 47 can be simplified which reduces the cost of the valve.

[0059] Typically the steel plate is designed to provide a force equal or higher to the previous design in a range of 25 to 50 N according injector type. The use of a steel plate (biasing member) in place of a wound spring improves the functionality of the valve. Valve response times are improved compared to spring based arrangements and the initial opening force from the actuator has a lower tolerance level which reduces the variation between the performance of different valves in production.

[0060] Figures 5 to 8 show further embodiments of the present invention. It is noted that in each of Figures 5 to 8 the valve arrangement is shown in the closed configuration. Like numerals are used to denote like features in Figures 3 to 9.

[0061] In Figure 5 the substantially planar elastic plate of Figures 3 and 4 has been replaced with a ridged plate 126. Figure 5 shows the second embodiment of the invention in its closed configuration in which the pressures on the plate 126 and head 104 are substantially equal. Providing ridges 128 in the plate alters the speed at which the valve plate 126 can close the valve.

[0062] Figure 6 shows a third embodiment of the present invention in which the valve stem portion 102 is formed from a portion of the biasing member 120. The biasing member in Figure 6 comprises a substantially planar portion 130 and a stem portion 132 which is formed integrally with the planar portion 130. The stem portion 132 comprises a generally cylindrical section and carries a number of grooves 134 and ridges 136 on its surface. The valve head 104 is located at one end of the stem portion 132.

[0063] As noted above in relation to Figure 5, the force applied by the valve plate (and therefore the rate at which the valve closes) can be adjusted by providing a ridged plate 126. It is noted however that there are limitations on the maximum thickness of the ridge that can be used and also the location of the ridge on the plate. Figures 6 to 8 provide further embodiments of the present invention in which the stem portion 102 has been replaced with an extension (stem portion 132) of the planar portion 130 of the biasing member 120. The stem portion 132 provides greater flexibility in locating the groove features which in turn provides greater flexibility in the force that the biasing member can exert on the valve head 104.

[0064] Figures 7 and 8 are similar to each other. In these embodiments the biasing member 120 is formed into a stem portion 132 and the valve head 104 is of annular construction which is arranged to be of complementary shape to a first part 138 of the stem portion 132 of the biasing member 120. In both Figures 7 and 8 the valve head 104 is retained on the first part 138 of the stem portion 132 of the biasing member.

[0065] The stem portion in Figures 7 and 8 also comprises a second part 140 which carries a number of grooves 134 and ridges 136 on its surface. The biasing member of Figures 7 and 8 also comprises a planar portion 130.

[0066] Figures 7 and 8 provide an alternative way of attaching the biasing element 120 to the valve head 104. In Figures 3 to 6, the valve stem portion 102 or valve head 104 are welded to the biasing member 120. Due to the configuration of these embodiments the bond surface is blind and the attachment process is consequently difficult to control with lower cost production equipment.

[0067] In Figures 7 and 8 however the stem portion 132 protrudes through the annular valve head 104 such that the stem portion is visible from the outside. This in turn allows a crimping fixing method of attachment to be used which is cheaper and a more easily controlled production process.

[0068] It is noted that Figures 6 to 8 reduce the mass contained within the valve arrangement compared to Figures 3 to 5 and 9. The embodiments of Figures 6 to 8 therefore potentially have faster valve response times.

[0069] Figure 9 provides a further embodiment of the present invention in which the control orifices 54, 56 and 58 are integrated into the biasing member 120 instead of within the spacer 52. The biasing member 120 is of lower thickness than the spacer 52 and so the manufacturing time and manufacturing cost for producing the control orifices is reduced.

[0070] It will be understood that the embodiments described above are given by way of example only and are not intended to limit the invention, the scope of which is defined in the appended claims. It will also be understood that the embodiments described may be used individually or in combination.

Claims

1. A valve arrangement (100) for use in an injector, the valve arrangement arranged to be moveable between an open configuration in which the valve arrangement provides a flow path (114) for pressurised fuel from a control chamber of the injector to a low pressure drain and a closed configuration in which the valve arrangement closes the flow path, the valve arrangement comprising:

   a valve guide (106) located within the injector, the valve guide comprising at least a part of the flow path;
   a valve head portion (104) arranged to close a first end (110) of the valve guide when the valve arrangement is in the closed configuration;
   a biasing member (120) arranged to bias the valve arrangement towards the closed configuration
   wherein
   the biasing member (120) comprises an elastic member located within the valve guide and the biasing member defines a volume (124) within the valve guide.

2. A valve arrangement as claimed in Claim 1, wherein the arrangement is arranged to be substantially hydraulically balanced when in the closed configuration.

3. A valve arrangement as claimed in Claim 2, wherein forces resulting from fuel pressure within the valve guide on the valve head portion (104) are substantially equal to forces resulting from fuel pressure within the valve guide on the biasing member (120), the forces on the head portion and biasing member acting in substantially opposing directions.

4. A valve arrangement as claimed in any preceding claim, further comprising a valve stem portion (102) arranged to be located within the valve guide, the valve head portion (104) being located at a first end of the valve stem portion (102) and the biasing member (120) being located at a second end of the valve stem portion.

5. A valve arrangement as claimed in any preceding claim, wherein, in the closed configuration, the biasing member (120) comprises a substantially planar elastic plate.

6. A valve arrangement as claimed in any one of Claims 1 to 4, wherein the biasing member comprises a ridged plate (126).

7. A valve arrangement as claimed in any one of Claims 1 to 3, wherein the biasing member comprises a substantially planar elastic portion (130) and a stem portion (132), the valve head portion (104) being located at a first end of the stem portion and the elastic portion being located at a second end of the stem portion.

8. A valve arrangement as claimed in Claim 7, wherein the stem portion is substantially cylindrical and comprises a number of grooves (134).

9. A valve arrangement as claimed in Claim 7 or 8, wherein the valve head portion is mounted at one end of the stem portion.

10. A valve arrangement as claimed in Claim 7 or 8, wherein the valve head portion is of annular construction and the stem portion protrudes through the valve head portion.

11. A valve arrangement as claimed in any preceding claim, wherein the valve guide (106) comprises a bore (108) which is open at the first end (110) and a valve groove (112) at a second end (111) of the bore (108) remote from the first end (110), the biasing

member (120) being located within the valve groove.

12. A valve arrangement as claimed in Claim 11, wherein the valve groove (112) has a greater cross sectional area than the bore (108).

13. A valve arrangement as claimed in Claim 11 or Claim 12, wherein the biasing member forms a partition across the valve groove (112) such that the valve head portion (104) and valve bore (108) are located on one side of the partition and the volume (124) is formed on the other side of the partition.

14. A valve arrangement as claimed in Claim 13, wherein the volume (124) is filled with fuel and is arranged to be in fluid communication with a fuel return back leak circuit.

15. An injector for use in the delivery of fuel to a cylinder of an internal combustion engine, the injector comprising :

a body (10) provided with a bore (11);
a valve needle (12) slidable within the bore (11) of the nozzle body (10) ;
an actuator (44) ;
a fuel supply line (18) for supplying pressurised fuel to a control chamber (22) ;
a valve arrangement according to any one of Claims 1 to 14 actuable by the actuator (44) for permitting fuel to flow from the control chamber (22) to a low pressure drain.

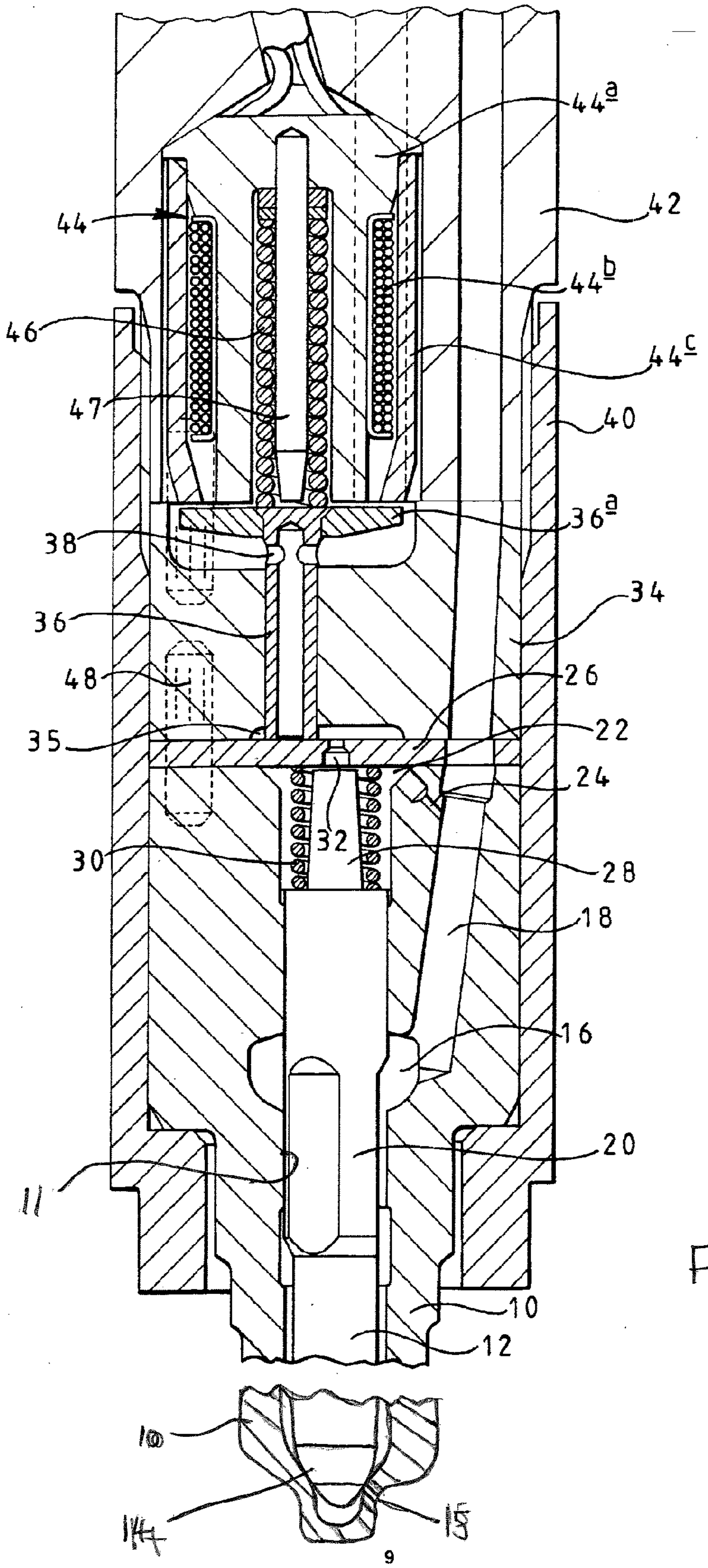
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FIG. 1

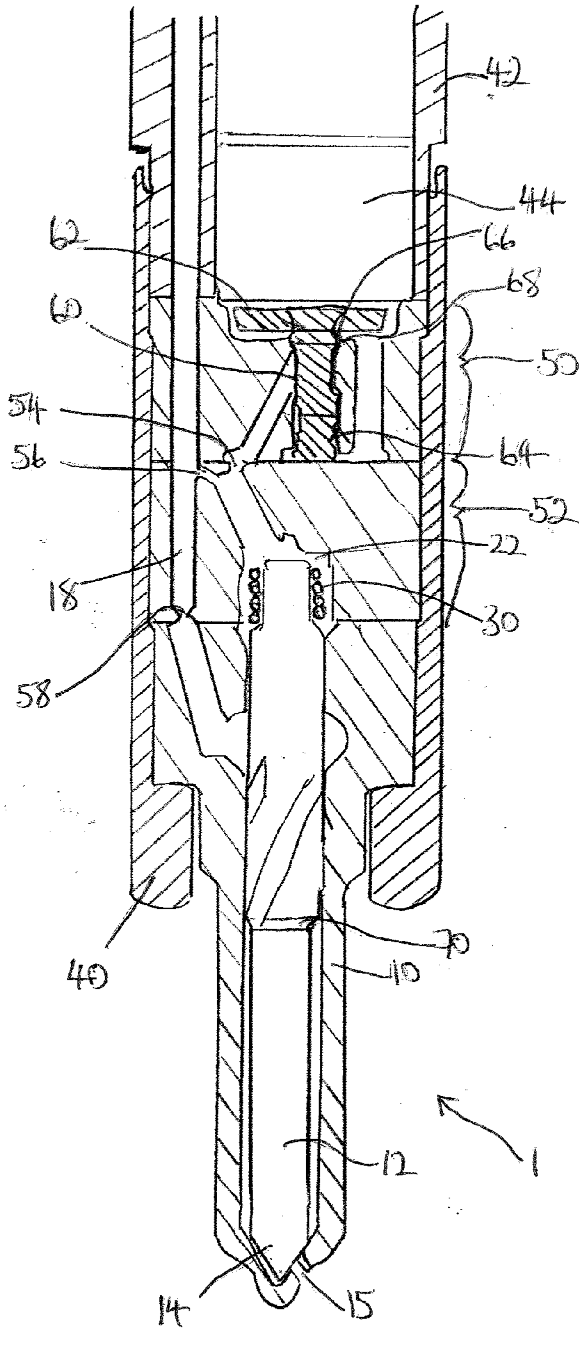
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FIG. 2A

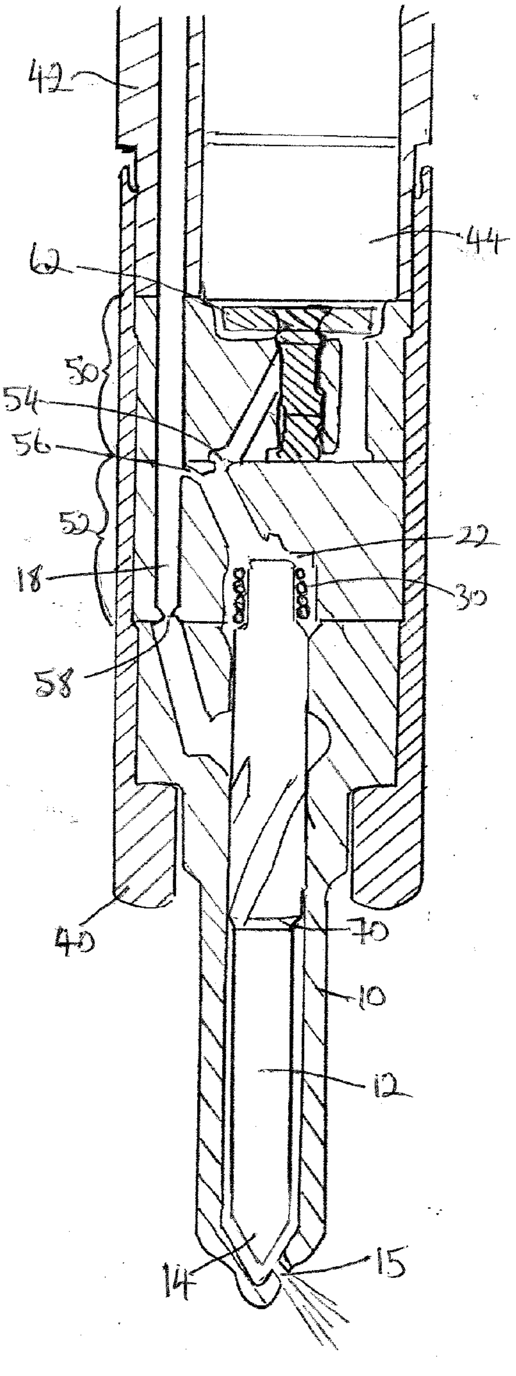
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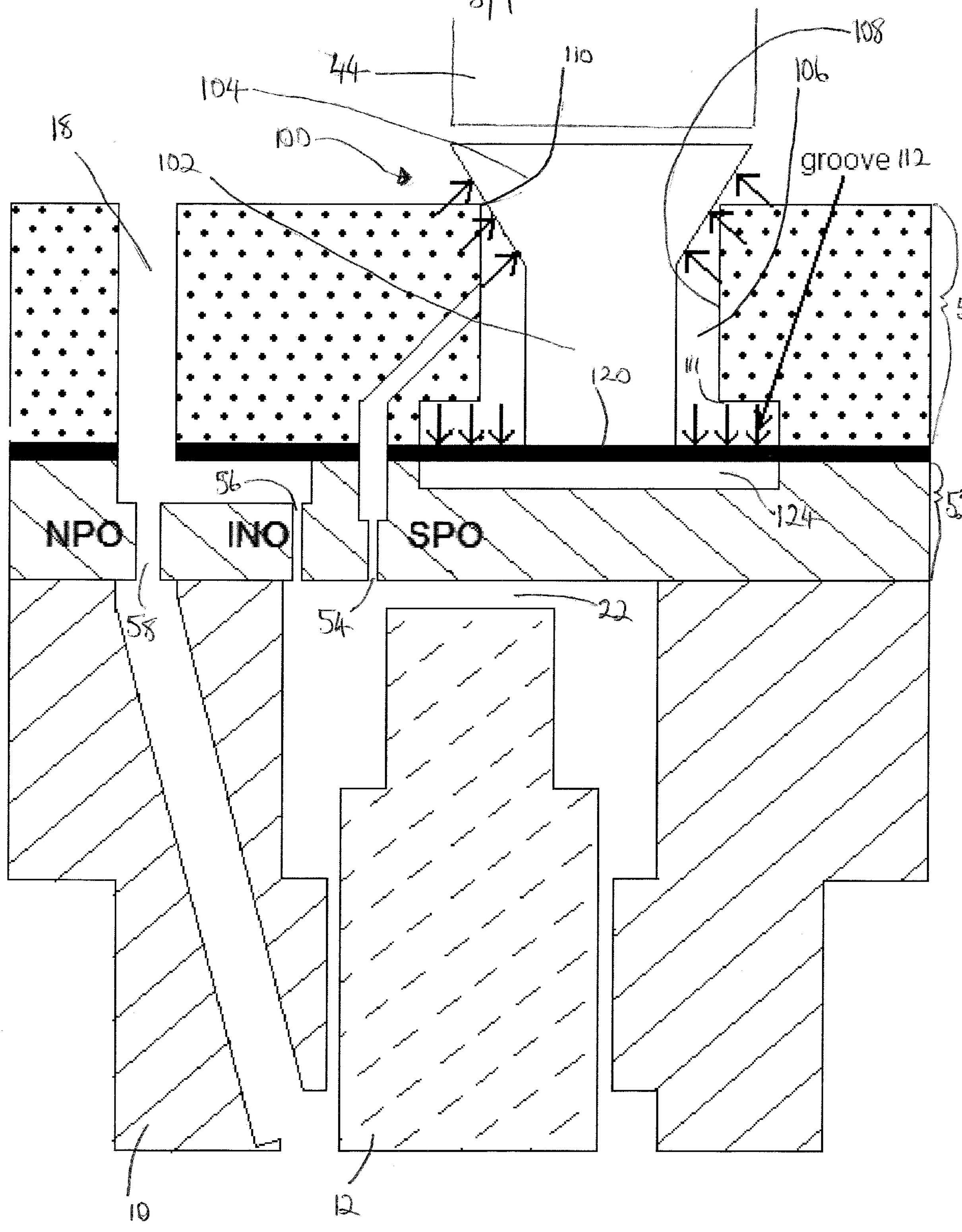
FIG. 2B

3/9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SPO
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22
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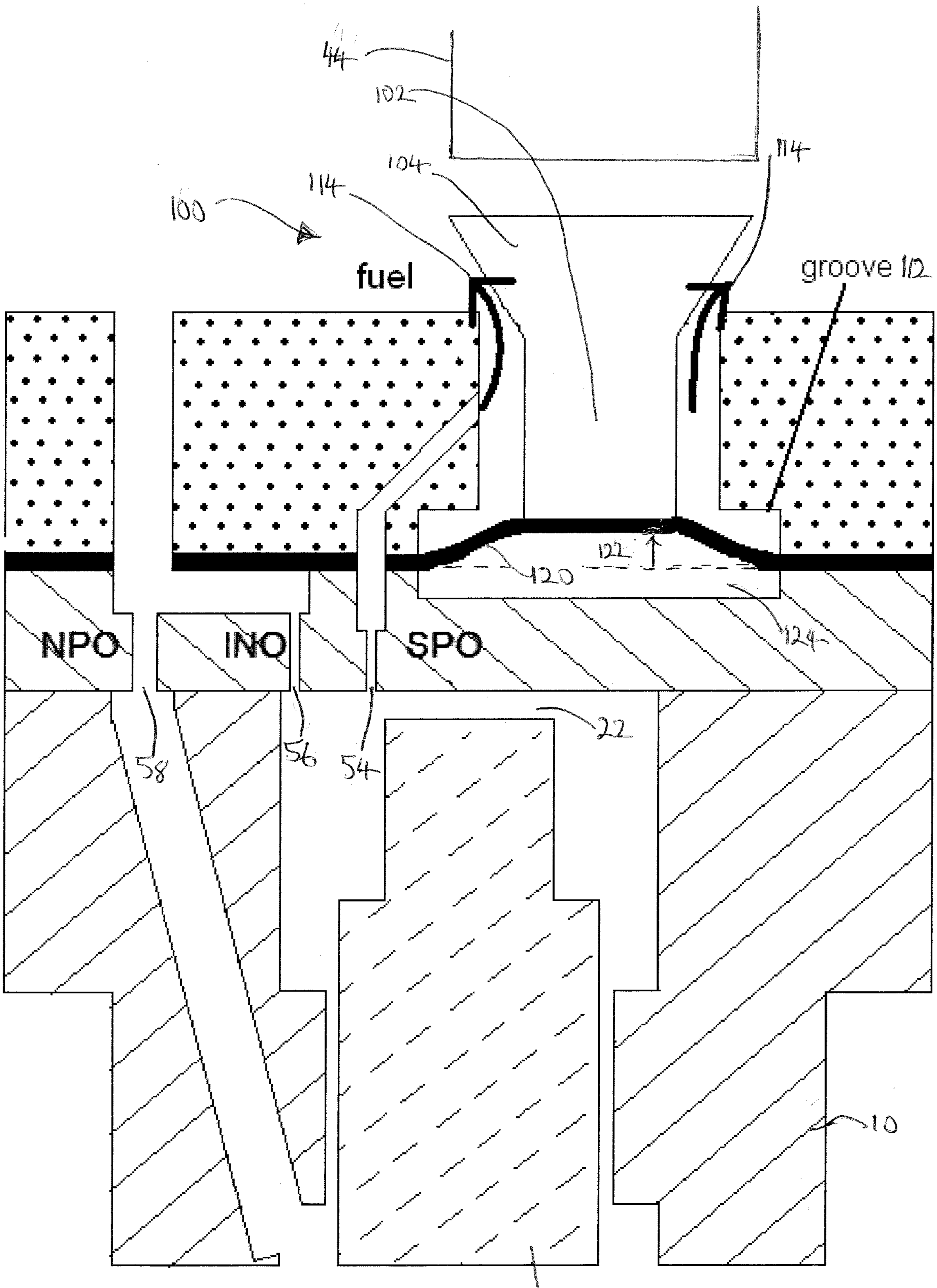
12

FIG.3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NPO
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SPO
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22
10
12

FIG. 4

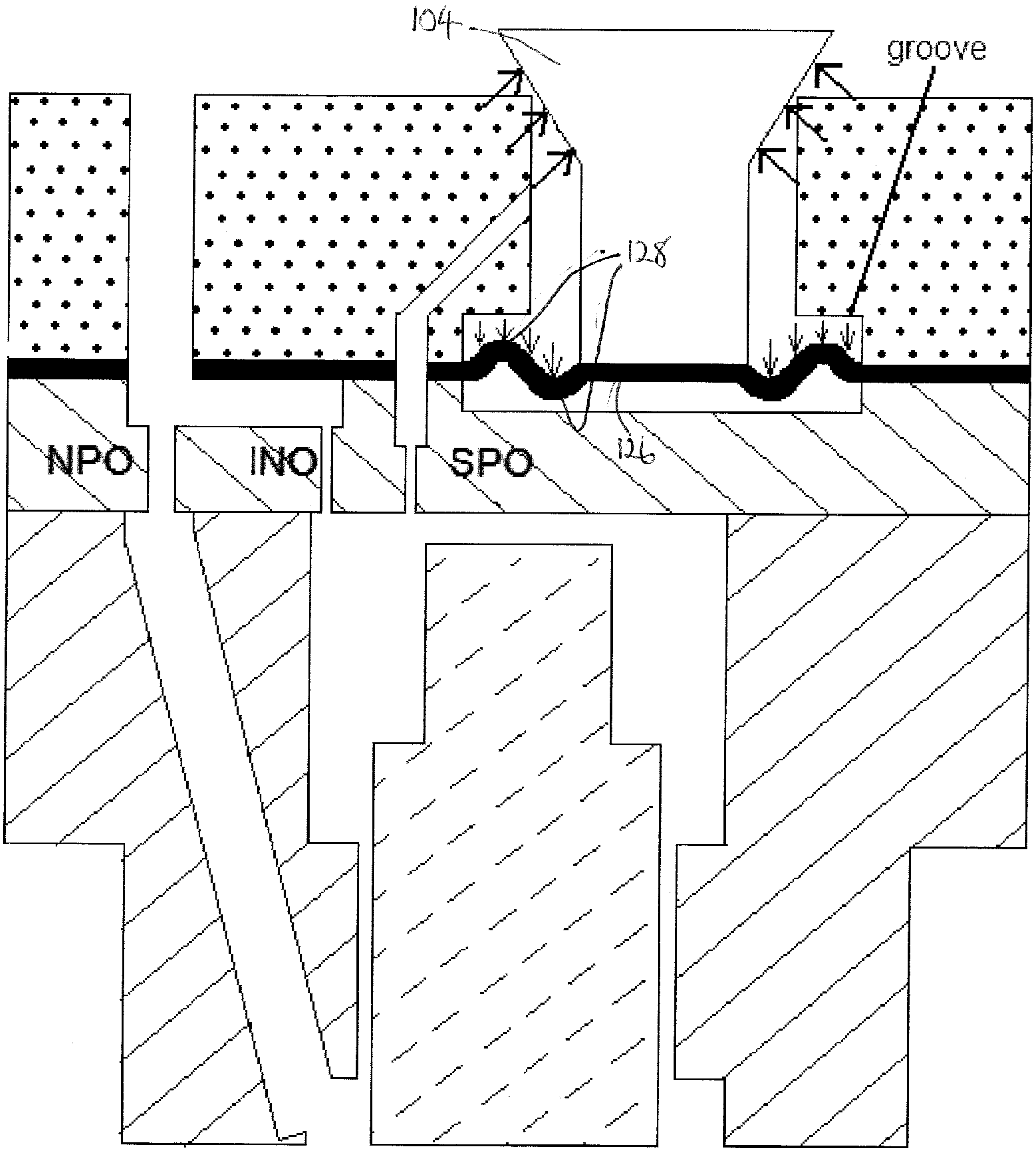

FIG. 5

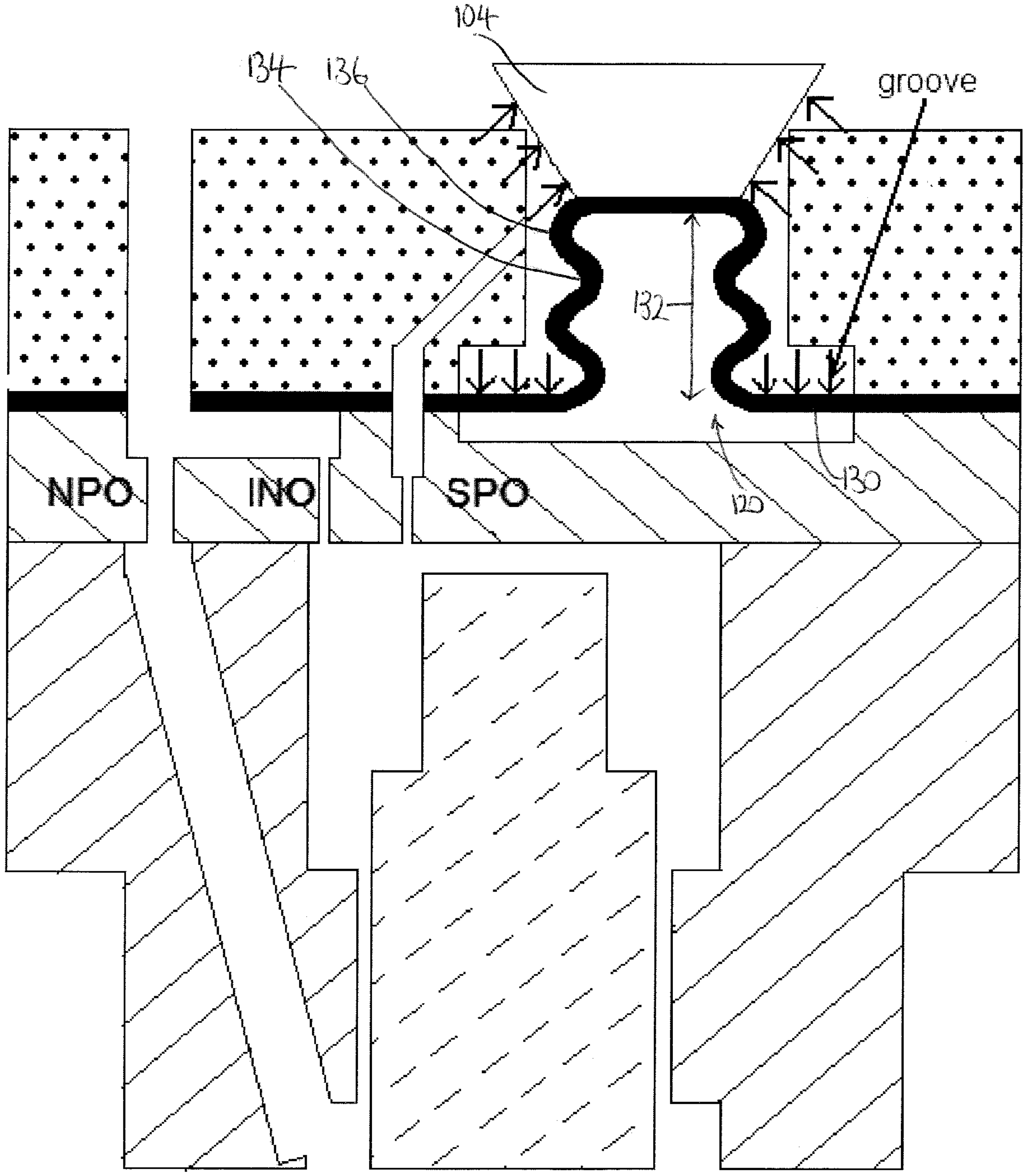

FIG. 6

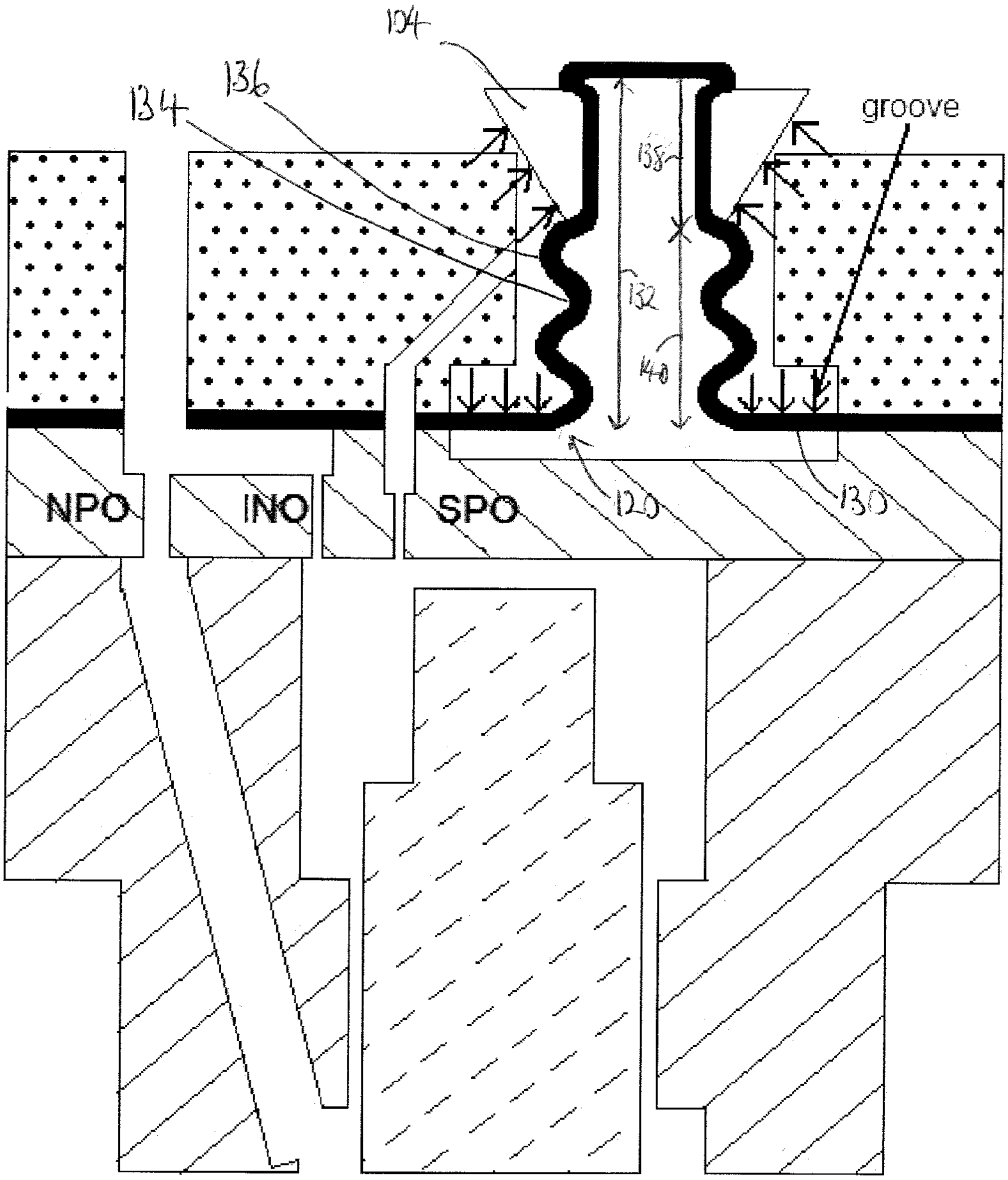

FIG 7

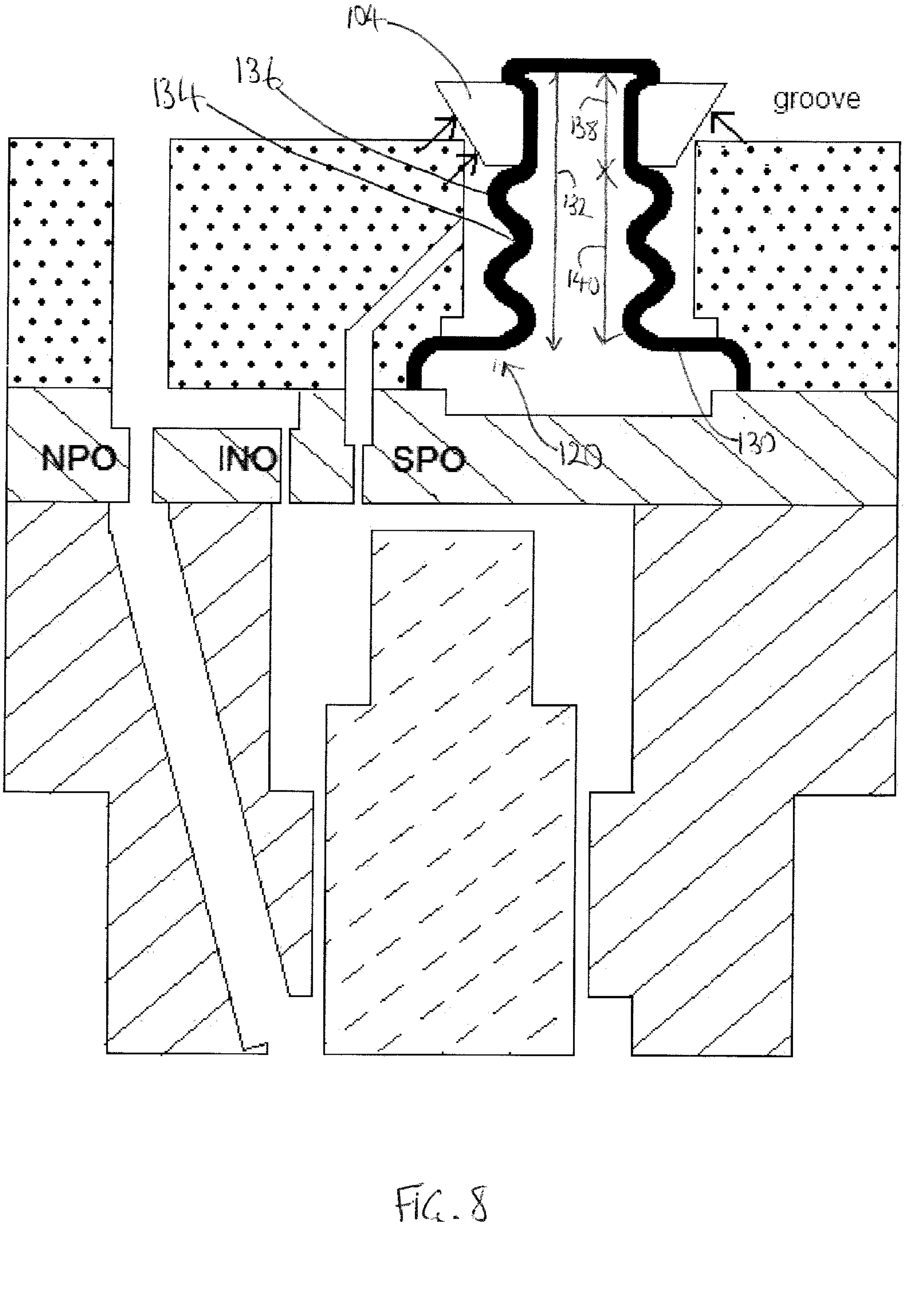

FIG. 8

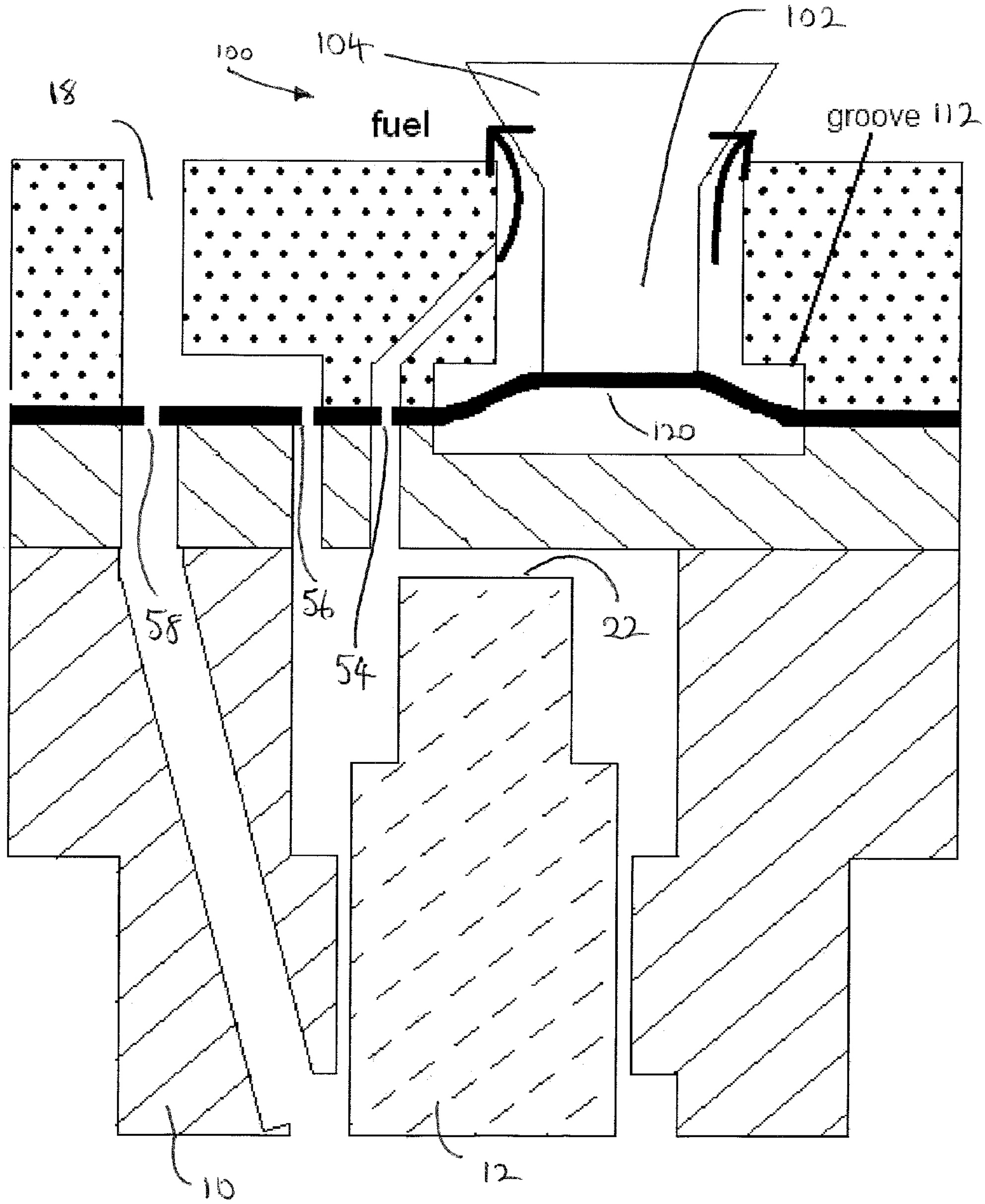

FIG. 9

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EUROPEAN SEARCH REPORT

Application Number
EP 12 16 3288

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 029473 A1 (SIEMENS AG [DE]) 28 December 2006 (2006-12-28) * figures 1-8 * -----	1,4,7,9, 15	INV. F02M63/00
X	US 6 168 096 B1 (POTSCHIN ROGER [DE] ET AL) 2 January 2001 (2001-01-02) * column 4, lines 17-61; figure 2 * -----	1,15	

TECHNICAL FIELDS SEARCHED (IPC)
F02M

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	4 July 2012	Godrie, Pierre

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The members are as contained in the European Patent Office EDP file on
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04-07-2012

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

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