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(54) **Fuel injector**

Brennstoffeinspritzventil

Injecteur de combustible

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(56) References cited:
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Description

[0001] This invention relates to a fuel injector for use in supplying fuel under pressure to a combustion space of a compression ignition internal combustion engine. The injector is particularly suitable for use in a fuel system of the type known as a common rail fuel system.

[0002] A known common rail fuel injector is controlled using a piezoelectric actuator to vary the fuel pressure within a control chamber, the fuel pressure within the control chamber acting upon a surface associated with a valve needle such that variations in the fuel pressure result in variations in the magnitude of a force applied to the needle urging the needle towards a seating.

[0003] The actuator used in such an injector typically takes the form of an undesirably large piezoelectric stack which requires the application of large magnitude drive voltages and currents. Further, accurate control of the distance through which the needle moves, in use, is difficult, overshoot of the valve needle sometimes occurring, when rapid needle movement is required.

[0004] A feel injector according to the preamble of claim 1 is known from document WO 99 15778A.

[0005] It is an object of the invention to provide a fuel injector in which these disadvantages are of reduced effect.

[0006] According to the present invention there is provided a fuel injector comprising a valve needle slidable within a bore, a surface associated with the valve needle being exposed to the fuel pressure within a control chamber, and a valve arrangement controlling the fuel pressure within the control chamber, the valve arrangement comprising an inlet fluid pressure actuable valve controlling communication between a supply passage and the control chamber, and an outlet fluid pressure actuable valve controlling communication between the control chamber and a drain chamber, the inlet and outlet fluid pressure actuable valves being operable under the influence of the fluid pressure within a common pressure chamber.

[0007] The fluid pressure within the pressure chamber is conveniently controlled by controlling the position occupied by a piston member. The piston member may be movable under the influence of a piezoelectric actuator. The piston member is conveniently of effective area greater than the sum of the effective areas of the inlet and outlet valves exposed to the fluid pressure within the pressure chamber.

[0008] Such an arrangement is advantageous in that a relatively small piezoelectric actuator can be used, and as a result the drive arrangement for the actuator is simplified, the magnitude of the force which the actuator must be capable of applying and the distance through which a movable end thereof must be capable of moving, in use, being reduced compared to a typical arrangement.

[0009] The outlet valve conveniently comprises a tubular valve member which is engageable with the surface associated with the needle to control fuel flow from the control chamber. In such an arrangement, by controlling the distance through which the outlet valve member moves, the distance through which the needle moves can be accurately controlled, even where rapid needle movement occurs.

[0010] The invention will further be described, by way of example, with reference to the accompanying drawings, in which:

Figure 1 is a sectional view of a fuel injector in accordance with an embodiment of the invention;

Figure 2 is an enlargement of part of Figure 1;

Figure 3 is a sectional view illustrating part of the injector in another plane; and

Figure 4 is a diagrammatic view illustrating parts of the injector.

[0011] The fuel injector illustrated in the accompanying drawings comprises a nozzle body 10 within which is formed a blind bore 11. The bore 11 defines, adjacent its blind end, a seating, and downstream of the seating, a plurality of outlet openings (not shown) are provided, the outlet openings communicating with the bore 11. A valve needle 12 is located within the bore 11, the valve needle 12 including a guide region 12a of diameter substantially equal to the diameter of the adjacent part of the bore 11 and arranged to guide the needle 12 for sliding movement within the bore 11 such that the needle 12 remains substantially coaxial with the bore 11. The needle 12 is shaped for engagement with the seating to control communication between a delivery chamber 13 defined between the needle 12 and the nozzle body 10 and the outlet openings. The bore 11 is shaped to define an annular gallery 14 which communicates through a drilling 15 with a supply passage 16 through which fuel is supplied, in use, to the nozzle body 10 from a source of fuel under high pressure, for example the common rail of a common rail type fuel system which is charged with fuel to a suitably high pressure by an appropriate high pressure fuel pump. The needle 12 is shaped to define flutes 17 whereby fuel is able to flow from the annular gallery 14 to the delivery chamber 13.

[0012] The upper end of the nozzle body 10, in the orientation illustrated, abuts a valve housing 18 which is provided with a drilling forming part of the supply passage 16 and which communicates with the drilling 15 in the nozzle body 10. The drilling forming part of the supply passage 16 provided in the valve housing 18 includes a region 19 of reduced diameter forming a restriction to the rate at which fuel is able to flow along the supply passage 16 to the nozzle body 10. As illustrated most clearly in Figures 2 and 4, the lower surface of the valve housing 18, the wall defining the upper part of the bore 11 and the upper end surface of the needle 12 to-

gether define a control chamber 20, the fuel pressure within which applies a force to the needle 12 urging the needle 12 towards the seating.

[0013] As shown in Figure 4, the valve housing 18 is provided with a pair of through bores 21, 22 which open into the control chamber 20. An inlet valve member 23 is slidable within the bore 21. The inlet valve member 23 includes, at its lower end in the orientation illustrated, a region of enlarged diameter which is engageable with a frusto-conical seating surface defined around a lower end of the bore 21 to control communication between a drilling 24 which opens into the supply passage 16 and the control chamber 20. A spring 25 is provided within a bore formed in the inlet valve member 23, the spring 25 engaging the upper end surface of the nozzle body 10 and applying a biasing force to the inlet valve member 23 urging the inlet valve member 23 into engagement with its seating to prevent communication between the drilling 24 and the control chamber 20. Movement of the inlet valve member 23 away from its seating is limited by the nozzle body 10.

[0014] An outlet valve member 26 is slidable within the bore 22. The outlet valve member 26 includes a region of tubular form defining a passage 27 which communicates through a cross-drilling 28 with a region of the bore 22 of enlarged diameter forming a drain chamber 29. The drain chamber 29 communicates through a drilling 29a with a connection of the injector arranged to communicate, in use, with a low pressure fuel reservoir, and so is at low pressure, in use. The lower end of the outlet valve member 26 is engageable with the upper end surface of the valve needle 12 to control communication between the control chamber 20 and the drain chamber 29, communication between these chambers being permitted when the outlet valve member 26 is spaced from the upper end surface of the needle 12 and prevented when the lower end of the outlet valve member 26 engages the upper end surface of the valve needle 12. The upper end of the outlet valve member 26 abuts a servo piston member 30 which is slidable within an upper part of the bore 22. A light spring 31 is engaged between the servo piston member 30 and the outlet valve member 26 to ensure that, when the injector is not in use, the outlet valve member 26 is biased into engagement with the upper end surface of the needle 12.

[0015] The valve housing 18 abuts, at its upper end, a piston housing 32 which is provided with a large diameter bore 33 within which a piston member 34 is slidable. The bore 33, piston member 34 and upper surface of the valve housing 18 together define a pressure chamber 35 into which the upper ends of the bores 21, 22 open. It will be appreciated that the upper end of the inlet valve member 23 and the upper end of the servo piston member 30 are exposed to the fluid pressure within the pressure chamber 35. The pressure chamber 35 is arranged to be supplied with fuel, at a low rate, from the supply passage 16, the fuel being supplied to the pressure chamber 35 as a result of leakage between the inlet valve member 23 and the bore 21 and as a result of leakage between the servo piston member 30 and the bore 22. As illustrated in the accompanying drawings, the servo piston member 30 is provided with a region of reduced diameter forming, with the bore 22, an annular chamber which communicates through a drilling 36 with the supply passage 16, the provision of this connection reducing the rate at which fuel is able to escape from the pressure chamber 35 past the servo piston member 30 to the drain chamber 29. The bores 21, 22, the inlet valve member 23 and the servo piston member 30 are manufactured to sufficient tolerances that the rate at which fuel is able to flow to and from the pressure chamber 35 is restricted to a very low level. In order to ensure that leakage of fuel past the piston member 34 from the pressure chamber 35 is minimised or avoided, the piston member 34 is provided with high pressure seal formations 34a. Further, an O-ring 37 is provided between a region of the piston member 34 of enlarged diameter and a step defined by an enlarged diameter region of the bore 33. The O-ring 37 serves as a resilient bias means for the piston member 34 biasing the piston member 34 in an upward direction, in the orientation illustrated.

[0016] The upper end surface of the piston member 34 abuts the lower end of a piezoelectric actuator stack 38 located within a bore or recess formed in a nozzle holder 39. As illustrated in Figure 1, the piezoelectric actuator stack 38 is of relatively short axial length. Suitable electrical connections are provided to enable appropriate driving of the actuator stack 38 to control operation of the injector. The nozzle body 10, the valve housing 18 and the piston housing 32 are secured to the nozzle holder 39 using a cap nut 40 in the conventional manner. The O-ring 37 prevents fluid flow from the bore or recess within which the stack 38 is housed. Conveniently, a drilling vents the space below the O-ring 37 to a suitable reservoir.

[0017] With the injector in the position illustrated, with fuel under high pressure supplied to the supply passage 16 from, for example, a common rail, and with the piezoelectric actuator stack 38 energised to a level such that it is of relatively great axial length, the piston member 34 occupies a position in which the fuel within the pressure chamber 35 is pressurized to a relatively high level. The fuel under pressure within the pressure chamber 35 applies a relatively large magnitude downward force to the servo piston member 30. As a result, the outlet valve member 26 is urged into engagement with the upper end surface of the needle 12 and thus fuel is unable to flow from the control chamber 20 to the low pressure drain chamber 29. A force is also applied by the servo piston member 30 through the outlet valve member 26 to the needle 12, urging the needle 12 towards its seating. The inlet valve member 23 is initially urged to a position in which fuel is able to flow to the control chamber 20 from the supply passage 16. As fuel flows to the control chamber 20, the pressure therein

rises to substantially that within the pressure chamber 35 and the inlet valve member 23 gradually moves into engagement with the seating under the action of the spring 25. The control chamber 20 is therefore pressurized to a high level applying a relatively large magnitude downward force to the needle 12 urging the needle 12 towards its seating. The delivery chamber 13 is also pressurized to a high level, the fuel pressure within the delivery chamber 13 acting upon angled thrust surfaces of the needle 12 applying a force to the needle 12 urging it away from its seating. However, the magnitude of the force applied to the needle 12 urging it away from its seating is relatively small compared to that applied by the fuel pressure within the control chamber 20. The needle 12 thus occupies a position in which it engages its seating and fuel is unable to flow from the delivery chamber past the seating to the outlet openings. Fuel injection is not, therefore, taking place.

[0018] When fuel injection is to commence, the actuator stack 38 is energized to reduce the axial length of the stack, and as a result, the piston member 34 moves under the action of the biasing force applied by the O-ring 37 and the pressure within the pressure chamber 35 to increase the volume of the pressure chamber 35. The movement of the piston member 34 causes the fuel pressure within the pressure chamber 35 to fall, reducing the magnitude of the downward forces applied to the inlet valve member 23 and the servo piston member 30. As a result, and as the fuel pressure within the control chamber 20 is relatively high, the inlet valve member 23 seats firmly against its seating, preventing communication between the supply passage 16 and the control chamber 20. Further, the fuel under pressure within the control chamber 20 will tend to lift the outlet valve member 26, following the servo piston member 30, and allowing fuel to flow from the control chamber 20 to the drain chamber 29, relieving the fuel pressure within the control chamber 20. The distance through which the outlet valve member 26 moves is governed by the distance through which the servo piston member 30 moves, and this is governed, in turn, by the distance through which the piston member 34 is moved. The piston member 34 is of relatively large diameter, and has an effective area greater than the sum of the effective areas of the servo piston member 30 and the inlet valve member 23. As a result of the piston member 34 being of large diameter, a relatively small amount of movement of the piston member 34 will cause the servo piston member 30 to lift by a relatively large distance, and it is this amplification of the distance through which the servo piston member 30 moves relative to the distance through which the piston member 34 moves which is one of the reasons which permits a piezoelectric stack 38 of reduced axial length to be used in the injector.

[0019] In order for injection to commence, a small quantity of fuel must be lost from the control chamber 20. As the control chamber 20 is of relatively small volume, the quantity of fuel which is lost does not result in the fuel system being particularly inefficient, parasitic high pressure losses being low.

[0020] The reduction in fuel pressure within the control chamber 20 results in a reduction in the magnitude of the downward force applied to the needle 12, and a point will be reached beyond which the force acting upon the thrust surfaces of the needle 12 will cause the needle 12 to lift away from its seating. Such movement permits fuel to flow to the outlet openings of the injector, thus fuel injection commences. During fuel injection, as the rate at which fuel is able to flow to the bore 11 is restricted by the presence of the region 19 in the supply passage 16, the fuel pressure within the delivery chamber 13 will fall, thus the magnitude of the upward force applied to the needle 12 will fall, during injection.

[0021] In order to terminate injection, the actuator stack 38 is re-energized, forcing the piston member 34 to move to repressurize the pressure chamber 35. As a result, the servo piston member 30 and outlet valve member 26 are moved in a downwards direction, forcing the outlet valve member 26 into engagement with the upper end surface of the needle 12, breaking the communication between the control chamber 20 and the drain chamber 29. Further, the inlet valve member 23 will move as a result of the difference in the fuel pressures applied thereto, against the action of the spring 25, permitting fuel to flow from the supply passage 16 to the control chamber 20, re-pressurizing the chamber 20. The re-pressurization of the control chamber 20 results in the magnitude of the downward force applied to the needle 12 increasing, and a point will be reached beyond which the magnitude of the downward force is sufficient to overcome the reduced upward force applied to the thrust surfaces of the needle 12 and the needle 12 will return into engagement with its seating, thus terminating fuel injection. Once injection has terminated, the fuel pressure within the delivery chamber 13 will rise, as a result of continued fuel flow along the supply passage 16, to substantially its original pressure.

[0022] At the termination of injection, it will be appreciated that an additional downward force is applied to the needle by the application of the fuel under pressure within the pressure chamber 35 to the upper end surface of the servo piston member 30, this downward force being transmitted through the outlet valve member 26. Indeed, as the distance through which the inlet valve member 23 can move is limited by the nozzle body, once this position has been reached, only the servo piston member 30 can move in response to the movement of the piston member 34, thus increasing the magnitude of the downward force applied to the needle.

[0023] It will be appreciated that, during injection, the distance through which the valve needle lifts is governed by the distance through which the outlet valve member 26 moves. As the valve needle 12 lifts and approaches the lower end surface of the outlet valve member 26, then the rate at which fuel is able to flow from the control chamber 20 will be throttled, damping the movement of

the valve needle 12 and bringing the valve needle 12 to rest when the upper end surface of the valve needle 12 moves into engagement with the lower end surface of the outlet valve member 26.

[0024] The control chamber 20 and the pressure chamber 35 are both of relatively small volumes, thus there is relatively little dead volume within the injector, and a relatively small amount of movement of the piston 34 is sufficient to cause operation of the injector with a high degree of control. Such control is particularly important where the injector is of the type in which the nozzle body is provided with several outlet openings, the distance through which the valve needle 12 moves controlling the number of outlet openings through which fuel is delivered.

[0025] As the piezoelectric actuator arrangement of the injector is used to control the operation of a pair of fluid pressure actuable valves which, in turn control the operation of the injector rather than controlling the movement of the valve needle of the injector directly, the magnitude of the forces which must be applied by the actuator stack and the distance through which the moveable end of the stack must be capable of moving can be reduced compared to typical arrangements, thus permitting the use of a stack of reduced length in the injector. The reduction in the length of the actuator stack reduces the cost of the injector. As the chamber within which the piezoelectric actuator stack 38 is located is isolated from the fuel, the chamber can be filled, if desired, with a suitable fluid to increase thermal conduction and improve electrical insulation of the stack.

Claims

1. A fuel injector comprising a valve needle (12) slidable within a bore (11), a surface associated with the valve needle (12) being exposed to the fuel pressure within a control chamber (20), and a valve arrangement (23, 26) controlling the fuel pressure within the control chamber (20), the valve arrangement comprising an outlet fluid pressure actuable valve (26) controlling communication between the control chamber (20) and a drain chamber (29), **characterised in that** the valve arrangement comprises an inlet fluid pressure actuable valve (23) controlling communication between a supply passage (16) and the control chamber (20), the inlet and outlet fluid pressure actuable valves (23, 26) being operable under the influence of fluid pressure within a common pressure chamber (35).

2. The fuel injector as claimed in Claim 1, comprising a piston member (34), whereby movement of the piston member (34) controls the fluid pressure within the pressure chamber (35).

3. The fuel injector as claimed Claim 2, wherein the piston member (34) is of effective area greater than the sum of the effective areas of the inlet and outlet valves (23, 26) exposed to the fluid pressure within the pressure chamber (35).

4. The fuel injector as claimed in Claim 2 or Claim 3, wherein a surface of the piston member (34) is exposed to fluid pressure within the pressure chamber (35).

5. The fuel injector as claimed in any of Claims 2 to 4, wherein the piston member (34) is movable under the influence of a piezoelectric actuator.

6. The fuel injector as claimed in Claim 5, comprising a chamber for receiving the piezoelectric actuator, the chamber being arranged to receive fluid, in use.

7. The fuel injector as claimed in any of Claims 1 to 5, wherein the outlet valve (26) comprises a tubular valve member which is engageable with the surface associated with the valve needle (12) to control fuel flow from the control chamber (20).

8. The fuel injector as claimed in any of Claims 1 to 7, wherein the outlet valve member (26) is slidable within a further bore (22), wherein the upper end of the outlet valve member (26) abuts a servo piston member (30) which is slidable within an upper part of the bore (22).

9. The fuel injector as claimed in any of Claims 1 to 8, wherein the nozzle body (10) is provided with a plurality of outlet openings, the distance through which the valve needle (12) moves controlling the number of outlet openings through which fuel is delivered.

Patentansprüche

1. Kraftstoffeinspritzventil, umfassend eine innerhalb einer Bohrung (11) bewegbare Ventilnadel (12), eine mit der Ventilnadel (12) in Verbindung stehende Oberfläche, die dem Kraftstoffdruck innerhalb einer Steuerkammer (20) ausgesetzt ist, und eine Ventilanordnung (23, 26), die den Kraftstoffdruck innerhalb der Steuerkammer (20) steuert, wobei die Ventilanordnung ein durch Flüssigkeitsdruck aktivierbares Auslassventil (26) umfasst, das die Verbindung zwischen der Steuerkammer (20) und einer Entleerungskammer (29) steuert, **dadurch gekennzeichnet, dass** die Ventilanordnung ein durch Flüssigkeitsdruck aktivierbares Einlassventil (23) aufweist, das die Verbindung zwischen einer Versorgungsleitung (16) und der Steuerkammer (20) steuert, wobei die durch Flüssigkeitsdruck betätigbaren Einlassund Auslassventile (23, 26) unter der Wirkung von Flüssigkeitsdruck innerhalb einer ge-

meinsamen Druckkammer (35) betätigt werden können.

2. Kraftstoffeinspritzventil nach Anspruch 1, umfassend ein Kolbenelement (34), wobei die Bewegung des Kolbenelements (34) den Flüssigkeitsdruck innerhalb der Kammer (35) steuert.

3. Kraftstoffeinspritzventil nach Anspruch 2, worin das Kolbenelement (34) eine wirksame Fläche besitzt, die größer ist als die Summe der wirksamen Flächen des Auslass- und des Einlassventils (23, 26), die dem Flüssigkeitsdruck innerhalb der Druckkammer (35) ausgesetzt sind.

4. Kraftstoffeinspritzventil nach Anspruch 2 oder Anspruch 3, worin eine Oberfläche des Kolbenelements (34) dem Flüssigkeitsdruck innerhalb der Druckkammer (35) ausgesetzt ist.

5. Kraftstoffeinspritzventil nach einem der Ansprüche 2 bis 4, worin das Kolbenelement (34) unter dem Einfluss eines piezoelektrischen Stellglieds bewegbar ist.

6. Kraftstoffeinspritzventil nach Anspruch 5, umfassend eine Kammer zur Aufnahme des piezoelektrischen Stellglieds, wobei die Kammer so angeordnet ist, dass sie während des Betriebs Flüssigkeit aufnehmen kann.

7. Kraftstoffeinspritzventil nach einem der Ansprüche 1 bis 5, worin das Auslassventil (26) ein röhrenförmiges Ventilelement umfasst, das mit der mit der Ventilnadel (12) verbundenen Oberfläche zur Anlage kommen kann, um den Kraftstofffluss aus der Steuerkammer (20) zu steuern.

8. Kraftstoffeinspritzventil nach einem der Ansprüche 1 bis 7, worin das Auslassventilelement (26) innerhalb einer weiteren Bohrung (22) bewegbar ist, wobei das obere Ende des Auslassventilelements (26) an ein Arbeitskolbenelement (30) angrenzt, das innerhalb eines oberen Teils der Bohrung (22) bewegbar ist.

9. Kraftstoffeinspritzventil nach einem der Ansprüche 1 bis 8, worin der Düsenkörper (10) mit einer Mehrzahl von Auslassöffnungen versehen ist, wobei die Weglänge, über die sich die Ventilnadel (12) bewegt, die Anzahl der Auslassöffnungen steuert, durch die Kraftstoff abgegeben wird.

Revendications

1. Injecteur de carburant comprenant un pointeau de soupape (12) pouvant coulisser à l'intérieur d'un alésage (11), une surface associée au pointeau de soupape (12) étant exposée à la pression du carburant dans une chambre de commande (20), et un agencement de soupapes (23, 26) régulant la pression du carburant à l'intérieur de la chambre de commande (20), l'agencement de soupapes comprenant une soupape de refoulement actionnable par la pression du fluide (26) régulant la communication entre la chambre de commande (20) et une chambre d'évacuation (29), **caractérisé en ce que** l'agencement de soupapes comprend une soupape d'admission actionnable par la pression du fluide (23) régulant la communication entre un passage d'amenée (16) et la chambre de commande (20), les soupapes d'admission et de refoulement actionnables par la pression du fluide (23, 26) pouvant être actionnées sous l'influence de la pression du fluide à l'intérieur d'une chambre de pression commune (35).

2. Injecteur de carburant selon la revendication 1, comprenant un élément de piston (34), de telle sorte que le mouvement de l'élément de piston (34) commande la pression du fluide à l'intérieur de la chambre de pression (35).

3. Injecteur de carburant selon la revendication 2, dans lequel l'élément de piston (34) a une surface utile plus grande que la somme des surfaces utiles des soupapes d'admission et de refoulement (23, 26) exposées à la pression du fluide à l'intérieur de la chambre de pression (35).

4. Injecteur de carburant selon la revendication 2 ou la revendication 3, dans lequel une surface de l'élément de piston (34) est exposée à la pression du fluide à l'intérieur de la chambre de pression (35).

5. Injecteur de carburant selon l'une quelconque des revendications 2 à 4, dans lequel l'élément de piston (34) peut se déplacer sous l'influence d'un actionneur piézoélectrique.

6. Injecteur de carburant selon la revendication 5, comprenant une chambre pour recevoir l'actionneur piézoélectrique, la chambre étant agencée pour recevoir le fluide, en service.

7. Injecteur de carburant selon l'une quelconque des revendications 1 à 5, dans lequel la soupape de refoulement (26) comprend un élément de soupape tubulaire qui peut venir en prise avec la surface associée au pointeau de soupape (12) pour réguler l'écoulement de carburant en provenance de la chambre de commande (20).

8. Injecteur de carburant selon l'une quelconque des revendications 1 à 7, dans lequel l'élément de sou-

pape de refoulement (26) peut coulisser à l'intérieur d'un alésage supplémentaire (22), dans lequel l'extrémité supérieure de l'élément de soupape de refoulement (26) vient en butée contre un élément de servopiston (30) qui peut coulisser à l'intérieur d'une partie supérieure de l'alésage (22).

9. Injecteur de carburant selon l'une quelconque des revendications 1 à 8, dans lequel le corps de buse (10) est muni d'une pluralité d'ouvertures d'évacuation, la distance sur laquelle se déplace le pointeau de soupape (12) commandant le nombre d'ouvertures d'évacuation à travers lesquelles est délivré le carburant.

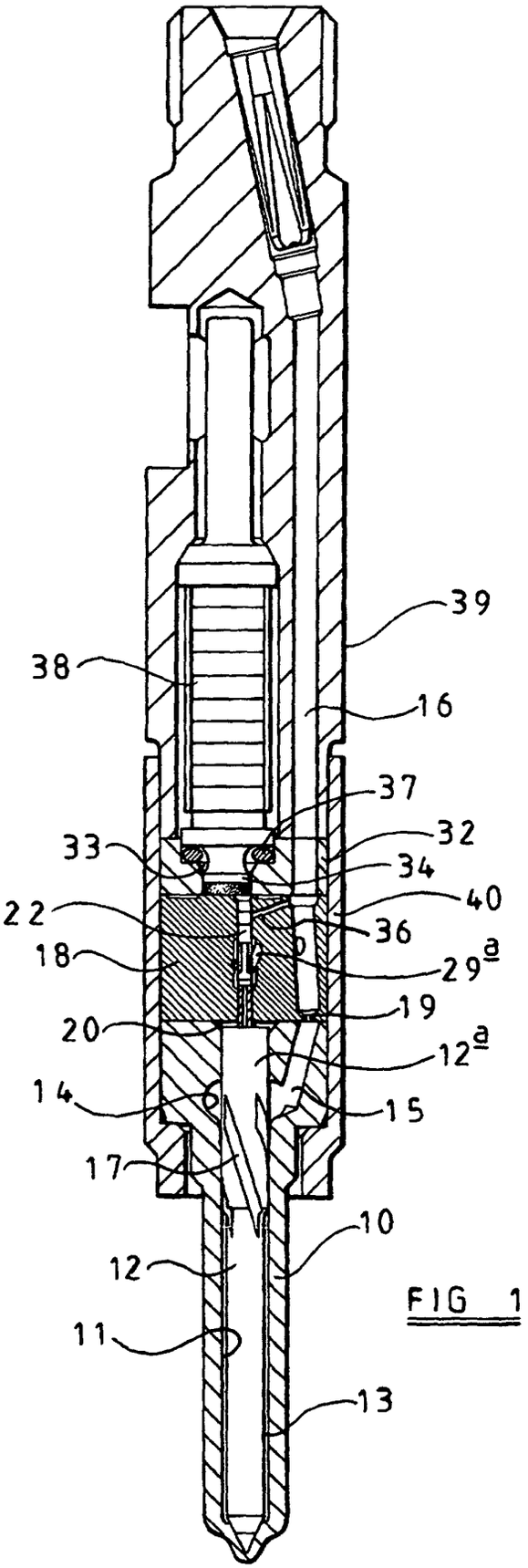
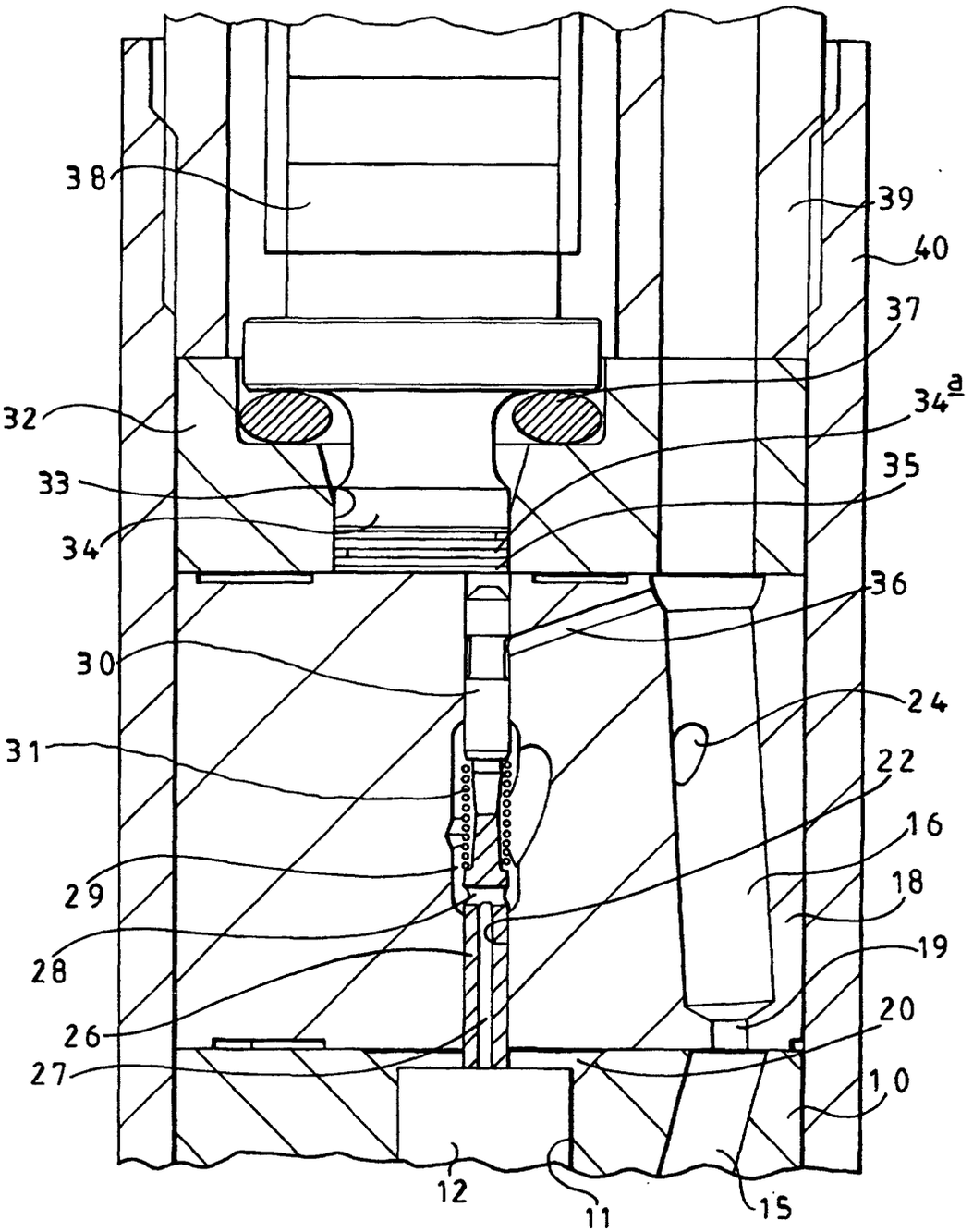


FIG 1

FIG 2


38
39
40
37
32
34a
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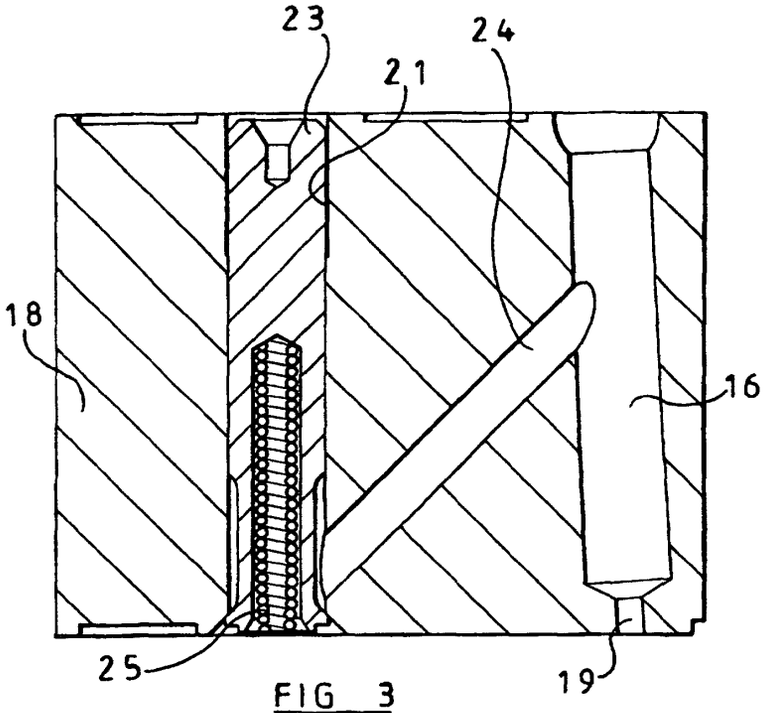


FIG 3

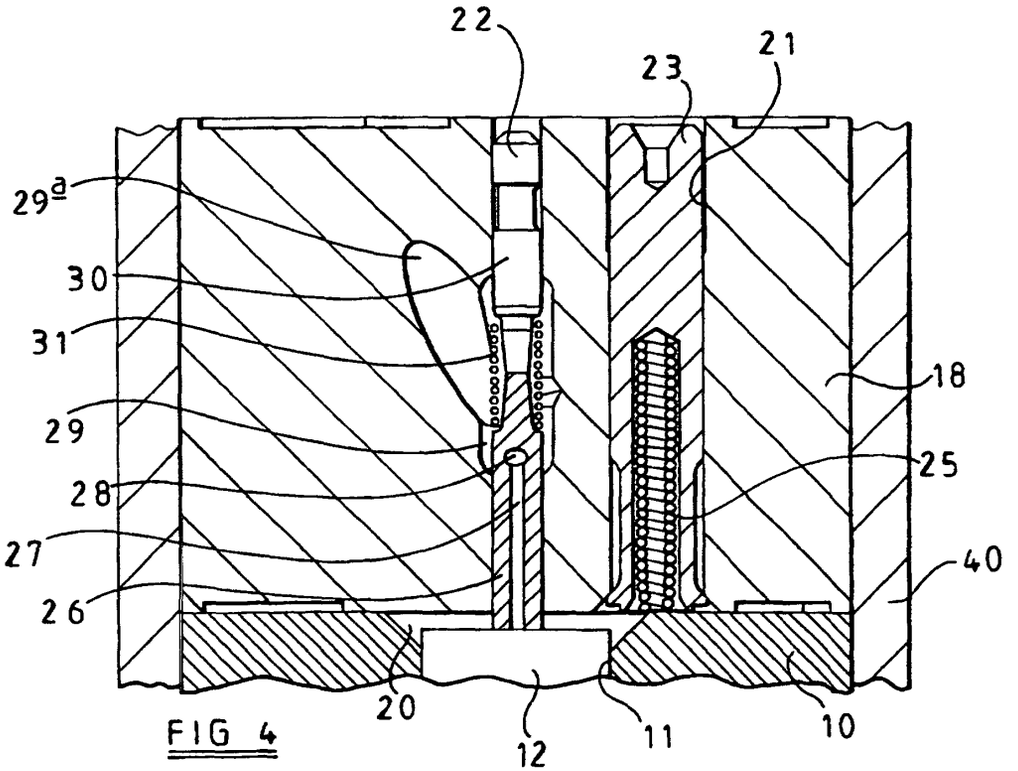


FIG 4