(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 3 150 839 A1

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
05.04.2017 Bulletin 2017/14

(51) Int Cl.:
F02M 47/02 *(2006.01)* ***F02M 63/00*** *(2006.01)*
F02M 61/20 *(2006.01)*

(21) Application number: **16190307.5**

(22) Date of filing: **23.09.2016**

(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

(30) Priority: **29.09.2015 GB 201517148**

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(54) **FUEL INJECTOR**

(57) A fuel injector (10) for a compression ignition internal combustion engine is described. The fuel injector (10) comprises a fuel injection valve having an injection valve member (14) moveable, in use, under the influence of fuel pressure within a control chamber (20) acting upon it, between a closed position and an open position. The fuel injector comprises a moveable plate (28) located inside the control chamber (20). The moveable plate (28) is configured to move into and out of contact with a sealing surface (34) of the control chamber (20). The moveable plate (28) includes an inlet orifice (38) and a spill orifice (40). The provision of inlet and spill orifices (38, 40) in the moveable plate allows both orifices to be made very small, resulting in a significant reduction in dynamic leakage. An embodiment of the invention is described in which the moveable plate (28) defines additional fluid channels (60a, 60b, 62a, 62) for high pressure fuel entering the control chamber (20) when the moveable plate (28) is moved out of sealing contact with the sealing surface (34) of the control chamber (20). The additional flow paths allow high pressure fuel to enter the control chamber (20) bypassing the inlet orifice, resulting in a rapid termination of an injection event.

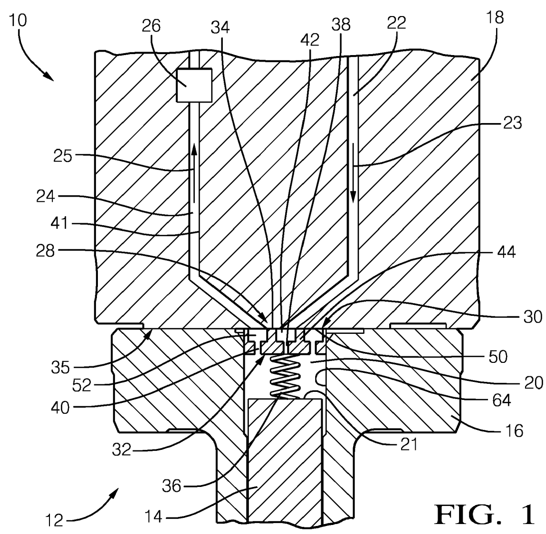

FIG. 1

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Description

Technical field

[0001] The present invention relates to a fuel injector with an improved valve control arrangement for positioning a valve needle of a fuel injector in a position whereby injection of fuel occurs, and in a position whereby injection of fuel is prevented. In particular, the present invention relates to a fuel injector with a valve control arrangement which utilises a moveable plate to control the flow of high pressure fuel between a high pressure fuel supply and an injection valve needle control chamber.

Background

[0002] It is known to control the movement of a valve needle within a fuel injector, to commence and cease fuel injection, by utilising a discharge valve operated by an actuator to control the pressure of fuel within a valve needle control chamber. A valve control arrangement of this type is described in EP 1 163 440. In the described arrangement a thrust surface provided at the end of the valve needle that is distal from the valve seat can be subjected to a force resulting from pressurised fuel within the needle control chamber acting against it and a medial thrust surface provided between the distal and proximal ends of the valve needle can be subjected to a force resulting from pressurised fuel within an associated annular chamber in the nozzle body.

[0003] Fuel from a high pressure fuel supply source can flow into the valve needle control chamber through an inlet orifice (INO) in the inlet passage. Fuel can flow out from the valve needle control chamber to a low pressure reservoir or drain through an outlet orifice, commonly referred to as a 'spill orifice' (SPO), when the discharge valve is opened by a solenoid actuator. Fuel flows into the annular chamber within the nozzle body from the high pressure fuel supply source and flows out from the chamber through injection orifices which are opened and closed as the valve needle is raised or lowered respectively.

[0004] In operation, to raise the valve needle and hence open the injection orifices, the discharge valve is opened, under the direct control of the solenoid actuator. The fuel within the valve needle control chamber is then able to flow out to the low pressure drain via the SPO. Because the INO is present in the high pressure fuel supply line to the valve needle control chamber the pressure of the fuel within the valve needle control chamber is reduced and thus the downwards force applied to the valve needle, as a result of the fuel acting upon the distal thrust surface, is reduced. High pressure fuel is still acting on the medial thrust surface of the valve needle and the resulting upwards force applied to the valve needle thrust surface is greater than the downwards force applied to the valve needle and thus the valve needle starts to move upwards. When the injection orifices open, the fuel within the chamber in the nozzle body flows out to an engine cylinder, which is at a relatively low pressure, and thus the fuel pressure within the annular chamber in the nozzle body reduces. As the pressure of the fuel within the annular chamber in the nozzle body reduces, the upwards force acting on the valve needle reduces. However, at this point the upwards force acting on the thrust surface is still greater than the downwards force applied to the valve needle and thus the valve needle remains in a raised position and fuel injection through the injection orifices continues.

[0005] In order to lower the valve needle, close the injection orifices and thus cease the injection of fuel, the discharge valve is moved to a closed position. This is achieved by stopping the supply of electrical current to the solenoid and under the direct action of a helical compression spring acting on the discharge valve member. This closes the outlet from the valve needle control chamber to the low pressure drain and thus, since high pressure fuel is still being supplied to the needle control chamber, via the INO, the pressure of fuel within the needle control chamber is raised. The downwards force applied to the valve becomes greater than the upwards force and thus the valve needle moves downwards.

[0006] This prior art valve control arrangement utilises a hydraulically balanced discharge valve. It is necessary to use a hydraulically balanced discharge valve because a small solenoid actuator is used to control movement of the discharge valve and such an actuator is not able to generate sufficient force to close an unbalanced valve against the high pressure of the fuel within the valve needle control chamber acting against it. It is desired to use a small solenoid actuator as this enables the actuator to be placed within the body of the injector. Furthermore, there is a cost reduction associated with the use of a small actuator.

[0007] A disadvantage of hydraulically balanced valves is that they suffer from static leak. This is leak across the discharge valve from the high pressure side, i.e. the valve needle control chamber, to the low pressure drain and is exacerbated by the high pressures and temperatures of the fuel to which the discharge valve is subjected. This static leak requires a higher pump capacity and results in wasted energy as pressurised fuel escapes to the low pressure drain.

[0008] As mentioned above, it is not possible to use an unbalanced valve as the force required to drive it could only be supplied by a larger solenoid actuator, which would not fit within the injector body, or by a different type of actuator, such as a piezo-electric actuator, which would be prohibitively expensive.

[0009] Also, the prior art control arrangement suffers from dynamic fuel leakage when the valve needle is raised. The dynamic leakage occurs between the high pressure fuel inlet and the low pressure reservoir or drain when the discharge valve is open. The dynamic leakage is disadvantageous for the same reasons set forth above in respect to static leakage.

[0010] The inlet orifice and the spill orifice are present in the valve control arrangement of the prior art to enable the greatest closing speed of the valve needle, i.e. the shortest delay between the discharge valve being closed and the pressure of fuel within the valve needle control chamber reaching a level at which the downwards force applied to the valve needle is greater than the force applied upwards, and to enable the greatest opening speed of the valve needle, i.e. the shortest delay between the discharge valve being opened and the pressure of fuel within the valve needle control chamber reducing to a level whereby the upwards force applied to the valve needle is greater than the downwards force applied to the needle.

[0011] In order to have the greatest closing speed for the valve needle it is necessary to fill the valve needle control chamber as quickly as possible. The ideal situation would be to have an unrestricted fuel inlet, i.e. no inlet orifice and a heavily restricted fuel outlet, i.e. a small spill orifice. However, it is also desirable to have a high opening speed for the valve needle and this requires that the valve needle control chamber is emptied as quickly as possible through the outlet passage. In this case it is desirable to have an unrestricted fuel outlet, i.e. no spill orifice and a heavily restricted fuel inlet, i.e. a small inlet orifice.

[0012] There is hence a conflict between the requirements for fast opening and fast closing of the valve needle. A compromise is sought and the inlet orifice and spill orifice are matched to give the best attainable operating characteristics.

[0013] Thus, the prior art control arrangement is limited by suffering from undesirable levels of static and dynamic leakage and from having a relatively long delay time between actuation of the discharge valve and movement of the valve needle.

[0014] There is hence a requirement for a fuel injector which provides a reduction in valve needle movement time with reduced leakage.

Summary of the invention

[0015] Accordingly, the present invention provides a fuel injector for an internal combustion engine, in particular a compression ignition internal combustion engine, the fuel injector comprising: a fuel injection valve having an injection valve member moveable, in use, under the influence of fuel pressure within a control chamber acting upon it, between a closed position and an open position; a high pressure fuel supply channel to the control chamber; a fuel outlet channel leading from the control chamber to a low pressure reservoir or drain; an actuator operable to open and close a discharge valve located in the fuel outlet channel; a moveable plate located in the control chamber and arranged to move into and out of contact with a sealing surface of the control chamber; a spill orifice provided in the moveable plate and arranged to communicate with the fuel outlet channel when the moveable plate is located in contact with the sealing surface of the control chamber, the spill orifice defining a restricted flow path for fuel to flow out of the control chamber to the fuel outlet channel; and an inlet orifice provided in the moveable plate and arranged to communicate with the high pressure fuel supply channel when the moveable plate is located in contact with the sealing surface of the control chamber, the inlet orifice defining a restricted flow path for fuel to flow from the high pressure fuel supply channel into the control chamber.

[0016] The provision of inlet and spill orifices in the moveable plate enables significantly smaller inlet and outlet orifices to be used in comparison to the prior art. Consequently, the present invention results in a significant reduction of dynamic leakage as low pressure fuel flows out of the control chamber during an emptying phase of the control chamber.

[0017] In use, when the moveable plate is in contact with the sealing surface of the control chamber and the discharge valve is open, fuel flows from the high pressure fuel supply channel into the control chamber through the inlet orifice in the moveable plate, and fuel flows out of the control chamber through the spill orifice in the moveable plate and through the fuel outlet channel to the low pressure reservoir or drain. The provision of the inlet orifice in the moveable plate therefore allows a restricted flow of fuel to enter the control chamber during the emptying phase of the control chamber. The relative sizes of the inlet and spill orifices can advantageously be selected to enable a smooth and controlled lifting of the injection valve member.

[0018] The moveable plate is preferably configured such that one or more additional fluid passages are defined between the control chamber and the high pressure fuel supply channel when the moveable plate is moved out of contact with the sealing surface of the control chamber. The additional fluid passages may be defined at least in part by formations such as flats or grooves in a periphery of the moveable plate.

[0019] The additional fluid passages advantageously enable fuel from the high pressure fuel supply channel to enter the control chamber bypassing the inlet orifice. Hence the rate of filling of the control chamber is not governed exclusively by the size of the inlet orifice. The inlet orifice can therefore be made smaller without compromising the rate at which the control chamber is filled, and hence the fuel injector can terminate an injection event rapidly despite having a small inlet orifice. Preferably the high pressure fuel supply channel upstream of the additional fluid passage(s) is substantially unrestricted. This allows a substantially unrestricted flow of fuel to enter the control chamber via the additional fluid passages resulting in a very rapid termination of an injection event.

[0020] The injector may be configured such that, in use, when the moveable plate moves out of contact with the sealing surface of the control chamber, fuel flows from the high pressure fuel supply channel into the control chamber through the additional fluid passage(s) and through the inlet orifice and spill orifice in the moveable plate. A plurality of flow paths for high pressure fuel entering the control chamber are therefore provided thus allowing faster termination of an injection event in comparison to the prior art.

[0021] The fuel injector preferably comprises bias means, for example in the form of a helical spring, in the control chamber for biasing the moveable plate into contact with the sealing surface of the control chamber. The bias means may advantageously assist with returning the moveable plate into sealing contact with the sealing surface of the control chamber, and assist with retaining the moveable plate in sealing contact with the sealing surface.

[0022] In a preferred embodiment of the invention, the inlet orifice is located substantially centrally in the moveable plate. This advantageously provides an even force distribution on the plate and prevents the plate from twisting in the control chamber. The spill orifice is preferably laterally offset from the inlet orifice.

[0023] The moveable plate may comprise a substantially central recess via which the inlet orifice communicates with the high pressure fuel supply channel when the moveable plate is in contact with the sealing surface of the control chamber. The substantially central recess may be defined by a circular inner wall of the moveable plate. The inner wall preferably comprises a sealing surface arranged to seal against the sealing surface of the control chamber when the moveable plate is in contact with the sealing surface of the control chamber. The size of the central recess may be selected to achieve an appropriate force differential across the moveable plate to retain the plate in sealing contact with the sealing surface of the control chamber during the emptying phase of the control chamber.

[0024] The moveable plate may comprise an annular recess via which the spill orifice communicates with the fuel outlet channel when the moveable plate is in contact with the sealing surface of the control chamber. The annular recess and the substantially central recess may be substantially concentric. The annular recess may be defined between a circular outer wall of the moveable plate and the circular inner wall of the moveable plate. The outer wall preferably comprises a sealing surface arranged to seal against the sealing surface of the control chamber when the moveable plate is in contact with the sealing surface of the control chamber. The size of the annular recess may be selected to achieve an appropriate force differential across the plate when the discharge valve is closed to cause the plate to move out of sealing contact with the sealing surface of the control chamber.

[0025] Within the scope of this application it is expressly intended that the various aspects, embodiments, examples and alternatives set out in the preceding paragraphs, in the claims and/or in the following description and drawings, and in particular the individual features thereof, may be taken independently or in any combination. That is, all embodiments and/or features of any embodiment can be combined in any way and/or combination, unless such features are incompatible.

Brief description of the drawings

[0026] In order that the present invention may be more readily understood, an example of the invention will now be described in detail with reference to the accompanying figures, in which:

Figure 1 is a partial schematic view of a fuel injector according to an embodiment of the invention, in which a moveable plate defining an inlet orifice and a spill orifice is located inside a control chamber;

Figure 2 is a schematic plan view of the moveable plate shown in Figure 1;

Figure 3 is a partial schematic view of the fuel injector of Figure 1, in which the moveable plate is shown in contact with a sealing surface of the control chamber; and

Figure 4 is a partial schematic view of the fuel injector of Figure 1, in which the moveable plate is moved out of contact with the sealing surface of the control chamber.

Detailed description

[0027] Figure 1 shows a fuel injector 10 according to an embodiment of the present invention. The fuel injector 10 comprises an injector valve 12 comprising a valve needle 14 located within an injector nozzle body 16. The injector nozzle body 16 is connected to a lower part 18 of an injector housing. Only a lower part 18 of the injector housing and upper parts of the valve needle 14 and injector nozzle body 16 are shown in Figure 1. A lower end (not shown) of the valve needle 14 controls the flow of fuel out of the injector 10 as the valve needle 14 moves up and down in the injector nozzle body 16 between open and closed positions, as described by way of background.

[0028] Movement of the valve needle 14 is controlled by fuel pressure within a control chamber 20. The control chamber 20 is defined within the injector nozzle body 16 at an upper end 21 of the valve needle 14. The control chamber 20 is supplied with high pressure fuel via a high pressure fuel supply channel 22 defined in the injector housing part 18. A fuel outlet channel 24 is also defined in the injector housing part 18 and is arranged to convey fluid which empties from the control chamber 20 to a low pressure reservoir or drain (not shown). Accordingly, the control chamber 20 is filled via the high pressure fuel supply channel 22 and emptied via the fuel outlet channel 24. The arrows 23 and 25 in Figure 1 indicate the direction of fuel flow into and out of the control chamber via the high pressure fuel supply channel 22 and the fuel outlet channel 24 respectively.

[0029] In general, and as described by way of background, filling the control chamber 20 with high pressure fuel causes a downward force to act on the upper end 21 of the valve needle 14. This causes the needle 14 to move downwards in the nozzle body 16 to terminate an injection event. Conversely, emptying the control chamber 20 causes a reduction in pressure in the control chamber 20 resulting in the needle 14 lifting to commence an injection event.

[0030] A discharge valve 26 is provided in the fuel outlet channel 24. The discharge valve 26 is operated by a solenoid actuator (not shown). The discharge valve 26 is opened to commence an injection event, which causes fuel to exit the control chamber 20 via the fuel outlet channel 24, resulting in the valve needle 14 lifting in the nozzle body 16. Conversely, the discharge valve 26 is closed to terminate an injection event, which causes the control chamber 20 to be re-filled with high pressure fuel, resulting in the lower end (not shown) of the valve needle 14 re-engaging with a valve seat (not shown) at a lower end of the nozzle body 16.

[0031] A moveable plate 28 is provided inside the control chamber 20. Referring also to Figure 2, the moveable plate 28 is substantially circular, and is made from metal. The material from which the moveable plate is made may be a high performance steel (such as high speed steel) which has high wear resistance and hardness up to high temperatures (around 500°C). The moveable plate 28 comprises a first side 30 and a second side 32. In the orientation of the injector 10 shown in Figure 1, the first side 30 is an upper side and the second side 32 is a lower side. The first (upper) side 30 faces a sealing surface 34 of the control chamber 20, whilst the second (lower) side 32 faces the upper end 21 of the valve needle 14. The sealing surface 34 of the control chamber 20 is provided by a portion of a lower end surface 35 of the injector body 18. The sealing surface 34 is highly polished such that it has a mirror finish.

[0032] A helical spring 36 is provided inside the control chamber 20 between the second (lower) side 32 of the plate 28 and the upper end 21 of the valve needle 14. The second (lower) side 32 of the moveable plate 28 is substantially flat. The spring 36 is arranged to bias the upper side 30 of the moveable plate 28 into sealing contact with the sealing surface 34 of the control chamber 20.

[0033] An inlet orifice 38 and a spill orifice 40 are defined in the moveable plate 28. Each orifice 38, 40 extends through the full thickness of the plate 28 between the first and second sides 30, 32 of the plate 28. The inlet orifice 38 is located substantially centrally in the plate 28, whilst the spill orifice 40 is laterally offset from the inlet orifice 38. When the moveable plate 28 is in contact with the sealing surface 34 of the control chamber 20 (as shown in Figure 1), the inlet orifice 38 is in fluid communication with the high pressure fuel supply channel 22, and provides a restricted flow path for fuel entering the control chamber 20. Similarly, with the moveable plate 28 in contact with the sealing surface 34 of the control chamber 20, the spill orifice 40 is in fluid communication with the fuel outlet channel 24, and provides a restricted flow path for fuel exiting the control chamber 20. A spill volume 41 is defined in the fuel outlet channel 24 between the discharge valve 26 and the spill orifice 40.

[0034] The inlet orifice 38 communicates with the high pressure fuel supply channel 22 via a substantially central recess 42 defined in the first (upper) side 30 of the moveable plate 28. The central recess 42 is substantially circular and defined by a substantially circular inner wall 44 of the moveable plate 28. An upper surface 46 of the inner wall 44 defines a sealing surface for sealing against the sealing surface 34 of the control chamber 20. The central recess 42 defines a circular surface 48 on the first (upper) side 30 of the moveable plate 28 against which the force of the high pressure fuel in the fuel supply channel 22 acts when the moveable plate 28 is sealed against the sealing surface 34 of the control chamber 20.

[0035] The spill orifice 40 communicates with the fuel outlet channel 24 via an annular recess 50 defined in the first (upper) side 30 of the moveable plate 28. The annular recess 50 is defined between the inner wall 44 and a substantially circular outer wall 52 of the moveable plate 28. The inner and outer walls 44, 52 are substantially concentric. An upper surface 54 of the outer wall 52 defines a sealing surface for sealing against the sealing surface 34 of the control chamber 20. The annular recess 50 defines an annular surface 56 on the first (upper) side 30 of the moveable plate 28 against which the force of the high pressure fuel between the spill orifice 40 and discharge valve 26 acts when the moveable plate 28 is sealed against the sealing surface 34 of the control chamber 20 and the discharge valve 26 is closed.

[0036] As shown in Figure 2, the moveable plate 28 comprises a generally circular peripheral surface 58, which is provided with flats 60a, 60b and grooves 62a, 62b. Specifically, in this embodiment, the peripheral surface 58 of the plate 28 includes a pair of diametrically opposed flat surfaces 60a, 60b, and a pair of diametrically opposed grooves 62a, 62b. As will be described in further detail later, when the moveable plate 28 is moved out of sealing contact with the sealing surface 34 of the control chamber 20, the flats 60a, 60b and grooves 62*a*, 62b provide additional fluid flow paths between the peripheral surface 58 of the plate 28 and side wall 64 (see Figure 1) of the control chamber 20 for high pressure fluid entering the control chamber 20.

[0037] The operation of the fuel injector 10 will now be described.

[0038] Referring still to Figure 1, this shows the fuel injector 10 at rest, i.e. prior to commencing an injection event, or after termination of an injection event. The discharge valve 26 is closed, and the control chamber 20 is full of high pressure fuel. The spill volume 41 between the discharge valve 26 and the spill orifice 40 is also full of high pressure fuel. The forces acting on both sides of the moveable plate 28 due to the pressure of fuel in the control chamber 20 and fuel supply and outlet channels 22, 24 are substantially equal, and the moveable plate 28 is maintained in sealing contact with the sealing surface 34 of the control chamber 20 by the helical spring 36.

[0039] In order to initiate an injection event, the discharge valve 26 is opened. Referring now to Figure 3, opening the discharge valve 26 causes a sudden large pressure drop in the spill volume 41 downstream of the spill orifice 40 as the fuel in the spill volume 41 flows past the discharge valve 26 (shown in Figure 1) to the low pressure reservoir or drain. The control chamber 20 then begins to empty via the spill orifice 40. As the control chamber 20 empties, the pressure acting on the upper end 21 of the nozzle needle 14 reduces, and a net upward force acts on the nozzle needle 14 causing the needle 14 to lift inside the nozzle body 16 to commence injection of fuel through the outlets at the lower end of the nozzle body 16 (not shown).

[0040] At the same time as the control chamber 20 empties via the spill orifice 40, a restricted supply of high pressure fuel is continually supplied to the control chamber 20 through the inlet orifice 38, as indicated by the arrow 66 in Figure 3. The relative sizes of the inlet and spill orifices 38, 40 are selected to achieve a steady and controlled lifting of the valve needle 14 and to minimise dynamic leakage of fuel.

[0041] The moveable plate 28 remains sealed against the sealing surface 34 of the control chamber 20 during this nozzle opening phase, due to the spring biasing force and due to the relative forces acting on the respective first and second sides 30, 32 of the moveable plate 28. In particular, the fuel pressure in the control chamber 20 acts over a larger area of the second (lower) side 32 of the moveable plate 28 compared to the fuel pressure in the high pressure fuel supply channel 22, which acts against the relatively small circular surface 48 of the central recess 42. Consequently, a net upward force on the moveable plate 28 maintains the plate 28 in sealing contact with the sealing surface 34 of the control chamber 20 during emptying on the control chamber 20.

[0042] In order to terminate the injection event, the discharge valve 26 (shown in Figure 1) is closed. This causes the spill volume 41 between the spill orifice 40 and the discharge valve 26 to fill with high pressure fuel. The accumulation of high pressure fuel in the sealed annular recess 50 exerts a downwards force on the annular surface 56 of the moveable plate 28. This initially causes the forces acting on both sides 30, 32 of the moveable plate 28 to equalise, bringing the plate 28 into equilibrium. As fuel pressure increases in the annular recess 50, a net downward force acts on the moveable plate 28 causing the plate 28 to move downwardly.

[0043] Referring now to Figure 4, when the plate 28 moves downwardly, it moves out of sealing contact with the sealing surface 34 of the control chamber 20. Fuel from the high pressure fuel supply channel 22 then rapidly flows into the region of the control chamber 20 above the moveable plate 28. The flats 60a, 60b and grooves 62a, 62b in the moveable plate 28, discussed above with reference to Figure 2, then provide additional flow paths 65 around the periphery 58 of the plate 28 between the high pressure fuel supply channel 22 and the control chamber 20 below the plate 28. As shown by the arrows 68 in Figure 4, fuel from the high pressure fuel supply channel 22 rapidly flows into the control chamber 20 via the additional flow paths 65 and via both the inlet and spill orifices 38, 40. This plurality of flow paths 65 results in very rapid filling of the control chamber 20 and hence a rapid descent of the valve needle 14 to terminate the injection event.

[0044] The high pressure fuel entering the control chamber 20 via the additional flow paths 65 is able to bypass the inlet orifice 38. Hence the rate of filling of the control chamber 20, and hence the rate of termination of the injection event, is not governed exclusively by the size of the inlet orifice 38. Consequently, the provision of the inlet orifice 38 in the moveable plate 28 allows a much smaller inlet orifice 38 to be used than in the prior art, whilst at the same time achieving a more rapid filling of the control chamber 20 and hence a more rapid termination of an injection event.

[0045] As the inlet orifice 38 is able to be made smaller with the present arrangement, the spill orifice 40 can also be made smaller. This is because the smaller inlet orifice 38 results in a more restricted flow of fuel entering the control chamber 20 during emptying of the control chamber 20 to initiate an injection event (as shown in Figure 3) and hence a more restricted spill orifice 40 can be used without compromising the rate at which the control chamber 20 is emptied. Hence a rapid lifting of the nozzle needle 14 is still achieved.

[0046] The moveable plate 28 provided with inlet and outlet orifices 38, 40 therefore allows both the inlet and outlet orifices 38, 40 to be made smaller in comparison to prior art injectors, whilst still achieving rapid initiation of an injection event and even faster termination of the injection event. The relatively small inlet and outlet orifices 38, 40 results in a significant reduction of dynamic leakage during emptying of the control chamber 20, as shown in Figure 3, since the fuel flow path from the high pressure fuel supply channel 22 to the fuel outlet channel 24 via the control chamber 20 is more restricted than in the prior art.

[0047] The provision of the inlet orifice 38 in the movable plate 28 results in a permanent flow path from the high pressure fuel supply channel 22 to the control chamber 20. Consequently, when the fuel injector 10 is in the rest state, with the moveable plate 28 in sealing contact with the sealing surface 34 of the control chamber 20, as shown in Figure 1, small amounts of high pressure fuel are able to enter and exit the control chamber 20 through the inlet orifice 38 and spill orifice 40 respectively to compensate for any static leakage of fuel that may occur across the discharge valve 26. The injector 10 therefore does not suffer from any pressure loss in the control chamber 20 due to static leakage.

[0048] Many modifications may be made to the example described above without departing from the scope of the present invention as defined in the accompanying claims. For example, the additional flow paths 65 need not be defined by the particular arrangement of flats 60a, 60b and grooves 62a, 62b shown in Figure 2. Any number of flats or grooves alone or in combination may be used, or indeed any other suitable formations in the outer periphery 58 of the moveable plate 28 may provide the additional flow paths 65.

Claims

1. A fuel injector (10) for a compression ignition internal combustion engine, the fuel injector comprising:

    a fuel injection valve having an injection valve member (14) moveable, in use, under the influence of fuel pressure within a control chamber (20) acting upon it, between a closed position and an open position;
    a high pressure fuel supply channel (22) to the control chamber (20);
    a fuel outlet channel (24) leading from the control chamber (20) to a low pressure reservoir or drain;
    an actuator operable to open and close a discharge valve (26) located in the fuel outlet channel (24);
    a moveable plate (28) located in the control chamber (20) and arranged to move into and out of contact with a sealing surface (34) of the control chamber (20);
    a spill orifice (40) provided in the moveable plate (28) and arranged to communicate with the fuel outlet channel (24) when the moveable plate (28) is located in contact with the sealing surface (34) of the control chamber (20), the spill orifice (40) defining a restricted flow path for fuel to flow out of the control chamber (20) to the fuel outlet channel (24); and
    an inlet orifice (38) provided in the moveable plate (28) and arranged to communicate with the high pressure fuel supply channel (22) when the moveable plate (28) is located in contact with the sealing surface (34) of the control chamber (20), the inlet orifice (38) defining a restricted flow path for fuel to flow from the high pressure fuel supply channel (22) into the control chamber (20).

2. The fuel injector of Claim 1, wherein, in use when the moveable plate (28) is in contact with the sealing surface (34) of the control chamber (20) and the discharge valve (26) is open, fuel flows from the high pressure fuel supply channel (22) into the control chamber (20) through the inlet orifice (38), and fuel flows out of the control chamber (20) through the spill orifice (40) and through the fuel outlet channel to the low pressure reservoir or drain.

3. The fuel injector of Claim 1 or Claim 2, wherein the moveable plate (28) is configured such that one or more additional fluid passages (60a, 60b, 62a, 62b) are defined between the control chamber (20) and the high pressure fuel supply channel (22) to permit fuel flow therethrough when the moveable plate (28) is moved out of contact with the sealing surface (34) of the control chamber (20).

4. The fuel injector of Claim 3, wherein the one or more additional fluid passages are defined at least in part by formations such as flats or grooves (60a, 60b, 62a, 62b) in a periphery of the moveable plate (28).

5. The fuel injector of Claim 3 or Claim 4, wherein, in use when the moveable plate (28) moves out of contact with the sealing surface (34) of the control chamber (20), fuel flows from the high pressure fuel supply channel (22) into the control chamber (20) through the additional fluid passage(s) and through the inlet orifice (38) and spill orifice (40) in the moveable plate (28).

6. The fuel injector of Claim 5, wherein the high pressure fuel supply channel (22) upstream of the additional fluid passage(s) is substantially unrestricted.

7. The fuel injector of any preceding claim, further comprising bias means (36) provided in the control chamber (20) for biasing the moveable plate (28) into contact with the sealing surface (34) of the control chamber (20).

8. The fuel injector of any preceding claim, wherein the inlet orifice (38) is located substantially centrally in the moveable plate (28).

9. The fuel injector of Claim 8, wherein the spill orifice (40) is laterally offset from the inlet orifice (38).

10. The fuel injector of any preceding claim, wherein the moveable plate (28) comprises a substantially central recess (42) via which the inlet orifice (38) communicates with the high pressure fuel supply channel (22) when the moveable plate (28) is in contact with the sealing surface (34) of the control chamber (20).

11. The fuel injector of Claim 10, wherein the substantially central recess (42) is defined by an inner wall (44) of the moveable plate (28), and wherein the inner wall comprises a sealing surface arranged to seal against the sealing surface of the control chamber when the moveable plate is in contact with the seal-

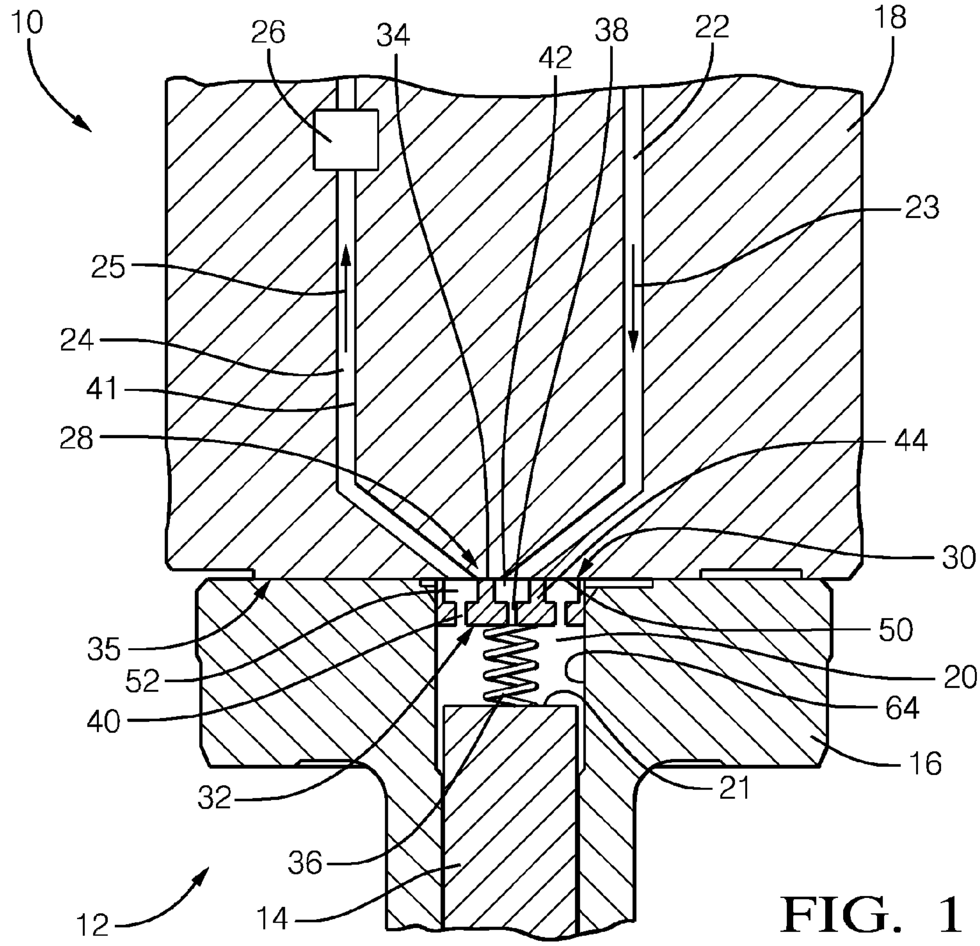
ing surface (34) of the control chamber (20).

12. The fuel injector of any preceding claim, wherein the moveable plate (28) comprises an annular recess (50) via which the spill orifice (40) communicates with the fuel outlet channel (24) when the moveable plate is in contact with the sealing surface (34) of the control chamber (20).

13. The fuel injector of Claim 12 when dependent on Claim 11, wherein the annular recess (50) is defined between an outer wall (52) of the moveable plate (28) and the inner wall (44) of the moveable plate (28), and wherein the outer wall (52) comprises a sealing surface arranged to seal against the sealing surface (34) of the control chamber (20) when the moveable plate (28) is in contact with the sealing surface (34) of the control chamber (20).

14. The fuel injector of Claim 12 or Claim 13 when dependent upon Claim 10 or Claim 11, wherein the annular recess (50) and the substantially central recess (42) are substantially concentric.

15. The fuel injector of any preceding claim, wherein the actuator is a solenoid actuator.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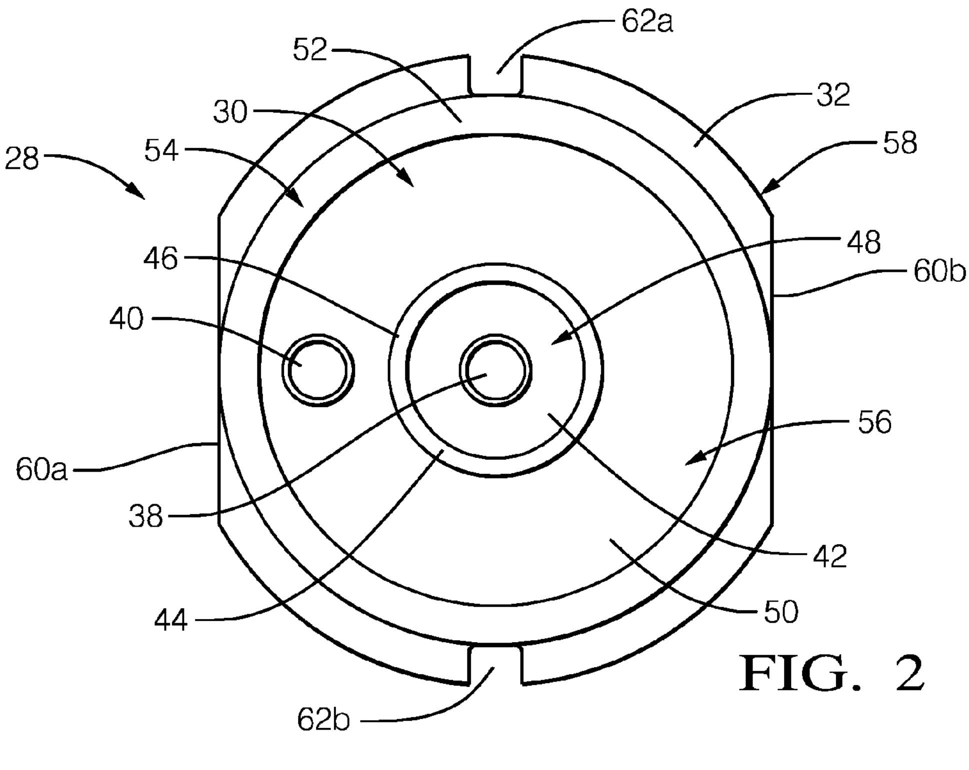
14

FIG. 1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42
44
50
62b

FIG. 2

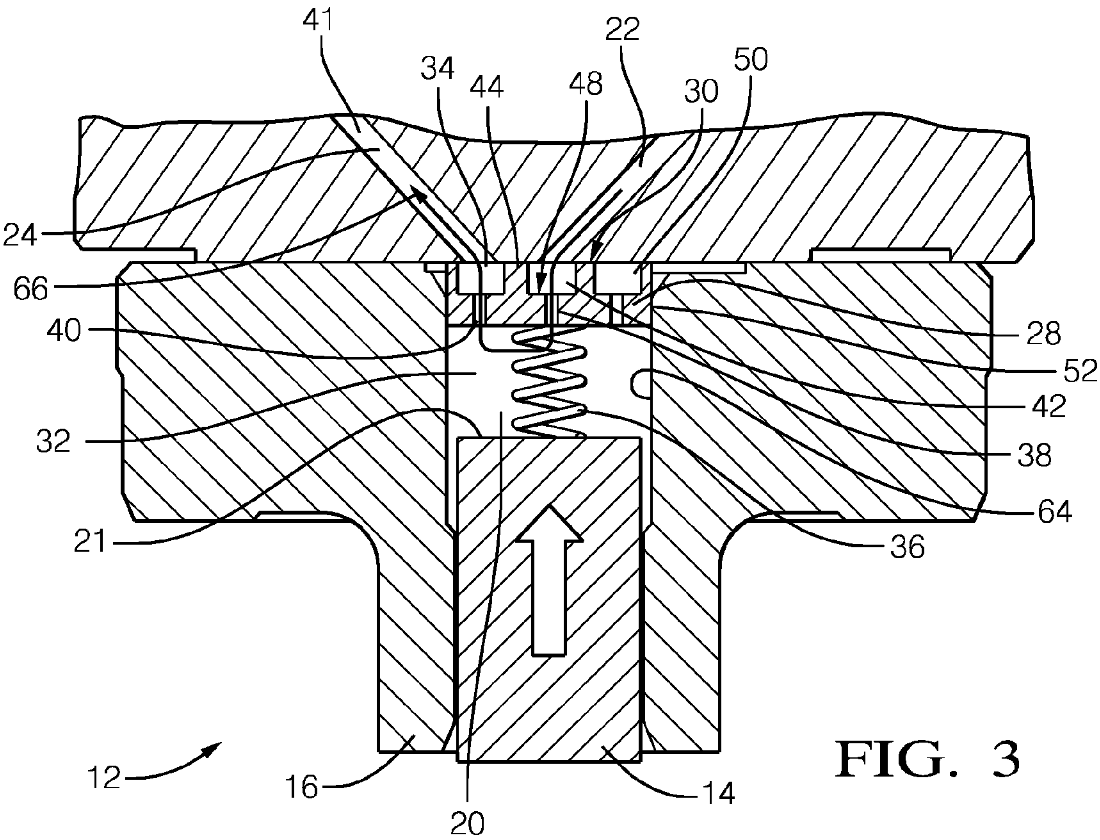
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FIG. 3

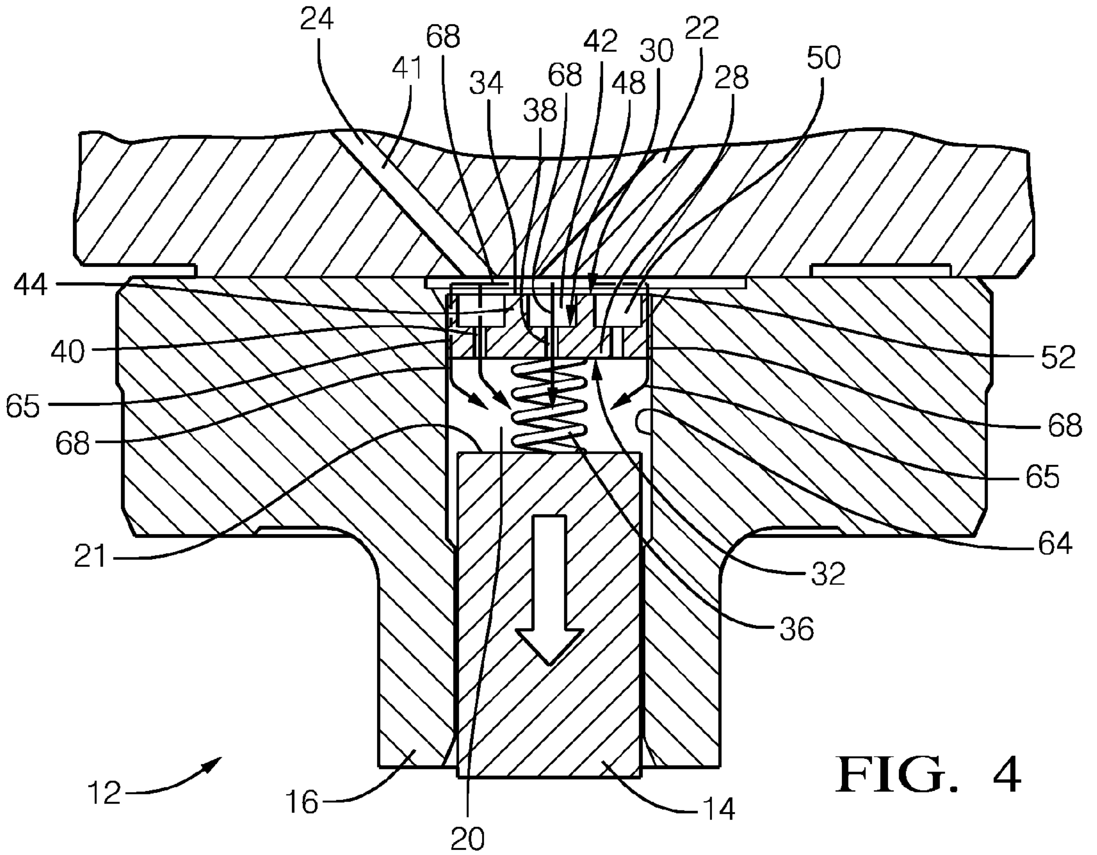
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FIG. 4

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EUROPEAN SEARCH REPORT

Application Number
EP 16 19 0307

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1

Place of search	Date of completion of the search	Examiner
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