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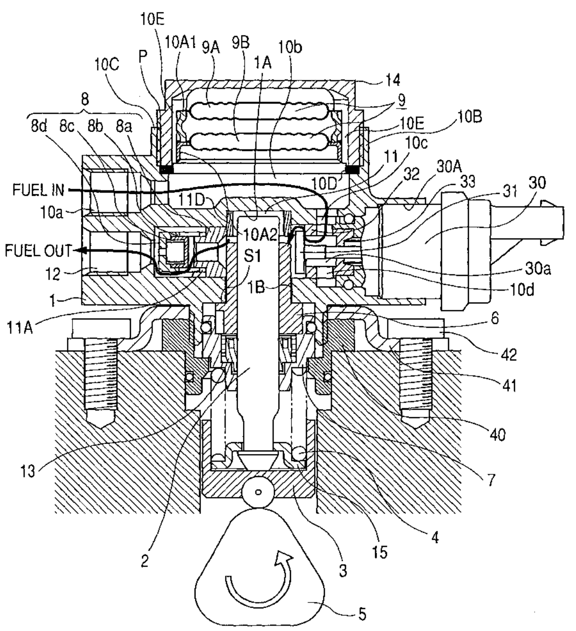
(54) **High-pressure fuel supply pump**

(57) A high-pressure fuel supply pump having a fuel relief path for connecting a high-pressure fuel path downstream of a discharge valve (8) for discharging fuel pressurized in a pressurizing chamber (11) to a low-pressure fuel path upstream of an inlet valve (30) or the pressurizing chamber, a check valve being provided in the fuel relief path as a relief valve for allowing the fuel to flow only to the low-pressure fuel path or the pressurizing chamber (11), wherein an energy attenuating mechanism is provided in a discharge path on a side facing the discharge valve (8) upstream of the relief valve in the fuel relief path so as to prevent an instantaneous pressure rise caused in the discharge path from propagating to the relief valve.

FIG. 1



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Description

BACKGROUND OF THE INVENTION

[Field of the Invention]

[0001] The present invention relates to a high-pressure fuel supply pump used to pressurize fuel supplied from a feed pump and then supply the pressurized fuel to a fuel injection valve and, more particularly, to a high-pressure fuel supply pump used in cylinder direct fuel injection type of internal combustion engine.

[0002] More particularly, the present invention relates to a high-pressure fuel supply pump in which a relief valve mechanism is incorporated in a pump housing as a safety valve to eliminate an excessive pressure rise of the fuel in a fuel path on a high pressure side.

[Prior Art]

[0003] In conventional high-pressure fuel supply pumps of this type, a fuel relief path is provided in the pump housing in the high-pressure fuel supply pump, the fuel relief path connecting a high-pressure fuel path downstream of an discharge valve (outlet valve) to a low-pressure fuel path upstream of an inlet valve, and a check valve is provided in the fuel relief path as a relief valve that passes fuel only from the high-pressure fuel path to the low-pressure fuel path, as disclosed in Japanese Patent Application Laid-open Publication No. 2003-343395.

[0004] If the pressure in the high-pressure fuel discharge path is excessively raised, the relief valve structured as the check valve opens and part of the high-pressure fuel is released to the low-pressure path, eliminating the excessively high pressure.

[0005] Patent Document 1: Japanese Patent Application Laid-open Publication No. 2003-343395

SUMMARY OF THE INVENTION

[0006] However, a high-pressure fuel supply pump structured as described above causes a state in which the pressure of the fuel to be discharged exceeds a pressure to open the relief valve in momentary in a transient state in which the discharge valve is opened and the fuel is being pressurized by the high-pressure fuel pump.

[0007] This momentary high-pressure state is not abnormal as a system state, so the relief valve does not need to operate; if anything, it is not desired for the relief valve to operate.

[0008] When the relief valve opens in this situation, the amount of fuel discharged by the high-pressure fuel supply pump is reduced and the energy efficiency is lowered.

[0009] The present invention addresses this problem with the object of preventing the relief valve from opening even when the pressure of the fuel to be discharged is raised in momentary in the transient state in which the discharge valve is opened and the fuel is being pressurized by the high-pressure fuel pump.

[0010] The above object is achieved by providing, in an discharge path disposed upstream of the relief valve in a relief path (that is, on the discharge valve side), a mechanism that prevents a momentary pressure rise caused in the discharge path from being transmitted to the relief valve.

[0011] Specifically, the above object is achieved by providing, in the relief path, an energy attenuating mechanism that prevents energy acting on the relief valve on the basis of a pressure rise caused in a short period on the discharge path side while the high-pressure fuel supply pump is performing a valve open operation.

[0012] Preferably, the energy attenuating mechanism can be structured with a plate that is disposed near the relief valve on the high-pressure path side (a discharge port side) and has at least one orifice.

[0013] Preferably, the energy attenuating mechanism can be structured with a discharge valve in an open state that narrows or shuts down a fuel relief path near upstream of the relief valve.

[0014] According to the present invention structured as described above, a high-pressure fuel supply pump can be provided which has a high compression ratio, that is, a high energy coefficient with the effect that when an excessive (abnormal) high-pressure is generated due to a fuel injection valve failure or the like, The fuel pressurerized to the excessiv (abnormal) high-pressure is released through the relief valve and high-pressure side piping and other high-pressure side devices are not damaged by the excessive (abnormal) high-pressure.

[0015] The fuel released through the relief valve can be expelled not only to the low-pressure path but also to a pressurizing chamber.

BRIEF DESCRIPTION OF THE DRAWINGS

[0016] FIG. 1 is the vertical cross section drawing to show an entire high-pressure fuel supply pump in first and second embodiments of the present invention.

[0017] FIG. 2 is the horizontal cross section drawing to show an entire high-pressure fuel supply pump in the first embodiment of the present invention.

[0018] FIG. 3 is the drawing to show a fuel supply system which uses the high-pressure fuel supply pump in the first embodiment of the present invention.

[0019] FIG. 4 is the drawing to show pressure waveforms in individual parts and a common rail in the high-pressure fuel supply pump in the first and second embodiments of the present invention.

[0020] FIG. 5 is the drawing to show an orifice plate in the first embodiment of the present invention.

[0021] FIG. 6 is the drawing to show other orifice plates in the first embodiment of the present invention.

[0022] FIG. 7 is the drawng to show the relation between the pressure in the common rail and the amount of fuel discharged in high-pressure by the high-pressure fuel supply pump in the first embodiment of the present invention.

[0023] FIG. 8 is the drawing to show the structure of a relief valve mechanism in the second embodiment of the present invention.

[0024] FIG. 9 is the vertical cross section drawing to show the high-pressure fuel supply pump in the second embodiment of the present invention.

[0025] FIG. 10 is the horizontal cross section drawing to show a high-pressure fuel supply pump in the second embodiment of the present invention.

[0026] FIG. 11 is the drawing to show a fuel supply system which uses the high-pressure fuel supply pump in the second embodiment of the present invention.

[0027] FIG. 12 is the schematical drawing to show the operation of an discharge valve mechanism in the high-pressure fuel supply pump in the second embodiment of the present invention, and the high-pressure fuel supply pump is in an discharge process.

[0028] FIG. 13 is the schematic drawing to show the principle of operation of the discharge valve mechanism in the high-pressure fuel supply pump in the second embodiment of the present invention, and the high-pressure fuel supply pump is in the relief condition.

[0029] FIG. 14 is the assembly drawing of the discharge valve mechanism in the high-pressure fuel supply pump in the second embodiment of the present invention.

[0030] FIG. 15 is the drawing to show the structure of the discharge valve mechanism in the high-pressure fuel supply pump in the second embodiment of the present invention, and the high-pressure fuel supply pump is in the discharge process.

[0031] FIG. 16 is the drawing to show the structure of the discharge valve mechanism in the high-pressure fuel supply pump in the second embodiment of the present invention, and the high-pressure fuel supply pump is the intake and spill processes.

[0032] FIG. 17 is the vertical and horizontal cross section drawings to show the structure of the discharge valve mechanism in the high-pressure fuel supply pump in the second embodiment of the present invention, and the high-pressure fuel supply pump is in the discharge process.

[0033] FIG. 18 is the vertical and horizontal cross section drawing to show the structure of the discharge valve mechanism in the high-pressure fuel supply pump in the second embodiment of the present invention, and the high-pressure fuel supply pump is the intake and spill processes.

DETAILED DESCRIPTION OF THE INVENTION

[0034] Embodiments of the present invention will be specifically described with reference to the drawings.

[First embodiment]

[0035] A first embodiment of the present invention will be specifically described with reference to FIGs. 1 to 3. First, the structure and operation of a system will be described with reference to the entire system structure shown in FIG. 3.

[0036] A section enclosed by broken lines is a pump housing 1 of the high-pressure fuel supply pump. The mechanisms and parts within the broken lines are included in the pump housing 1 in an integrated manner.

[0037] Fuel in a fuel tank 20 is drawn up by a feed pump 21 and delivered to an inlet port 10a in the pump housing 1 through an inlet pipe 28. Fuel drawn into the pump housing 1 is adjusted to a constant pressure by a pressure regulator 22.

[0038] The fuel, which has passed through the inlet port 10a, further passes through a pressure pulsation reducing mechanism 9 and inlet paths 10c and 10d, and then reaches an inlet port 30a in an electromagnetic inlet valve mechanism 30. The pressure pulsation reducing mechanism 9 will be described in detail later.

[0039] The electromagnetic inlet valve mechanism 30 has an electromagnetic coil 30b; while the electromagnetic coil 30b is energized, an electromagnetic plunger 30c is shifted to the right side in FIG. 3 and a spring 33 is kept compressed.

[0040] An inlet valve body 31 attached to an end of the electromagnetic plunger 30c then opens an inlet port 32 that communicates with a pressurizing chamber 11 of the high-pressure pump.

[0041] When the electromagnetic coil 30b is not energized and there is no difference in fluid pressure between the inlet path 10d (inlet port 30a) and the pressurizing chamber 11, the inlet valve body 31 is biased by a bias force of the spring 33 in the closing direction, keeping the inlet port 32 closed.

[0042] A specific operation will be described below.

[0043] When a plunger 2 is displaced downward in FIG. 1 due to the rotation of a cam described later and an intake process is brought, the volume of the pressurizing chamber 11 increases and thereby the fuel pressure in the pressurizing chamber 11 lowers. When the fuel pressure in the pressurizing chamber 11 falls below the pressure in the inlet path 10d (inlet port 30a) in this process, a differential fluid pressure of the fuel causes a valve opening force (a force to displace the inlet valve body 31 to the right in FIG. 1) in the inlet valve body 31.

[0044] The inlet valve body 31 is set so that when the valve opening force due to the differential fluid pressure becomes stronger than the bias force of the spring 33, the inlet valve body 31 opens and thus the inlet port 32 opens.

[0045] When, in this state, a control signal from an engine control unit (hereinafter referred to as ECU) 27 is applied to the electromagnetic inlet valve mechanism 30, current flows in the electromagnetic coil 30b of the electromagnetic inlet valve mechanism 30 and the electromagnetic plunger 30c is moved by the magnetic bias force to the right in FIG. 1, keeping the spring 33 compressed. As a result, the state in which the inlet valve body 31 opens the inlet port 32 is maintained.

[0046] When the plunger 2 completes the intake process and shifts to a compression process (the plunger 2 moves upward in FIG. 1) with the input voltage applied to the electromagnetic inlet valve mechanism 30, the magnetic bias force is maintained because the electromagnetic coil 30b is kept energized, so the inlet valve body 31 is kept open.

[0047] The volume of the pressurizing chamber 11 decreases as the plunger 2 is raised. In this state, however, the fuel intaked into the pressurizing chamber 11 is spilled to the inlet path 10d (inlet port 30a) through the inlet valve body 31 in the open state, so the pressure in the pressurizing chamber is not increased. This process is called a spill process.

[0048] When, in this state, the control signal from the ECU 27 is removed to deenergize the electromagnetic coil 30b, the magnetic bias force acting on the electromagnetic plunger 30c disappears after the elapse of a constant time (after magnetic and mechanical delay time). Since the bias force by the spring 33 is acting on the inlet valve body 31, the bias force by the spring 33 causes the inlet valve body 31 to close the inlet port 32 when the electromagnetic force acting on the electromagnetic plunger 30c disappears. When the inlet port 32 is closed, the fuel pressure in the pressurizing chamber 11 starts to rise as the plunger 2 moves upward.

[0049] When the fuel remaining in the pressurizing chamber 11 is pressurized and the fuel pressure in the pressurizing chamber 11 becomes equal to or more than the pressure at an discharge port 12, the fuel is discharged into a high-pressure pipe 29 through a discharge valve mechanism 8 and the discharge port 12, and then supplied to a common rail 23.

[0050] This process is called a discharge process. That is, the compression process (a rising process from the bottom dead center to the top dead center) of the plunger 2 comprises the spill process and the discharge process.

[0051] The amount of high-pressure fuel to be discharged can be controlled by controlling a timing at which the electromagnetic coil 30b in the electromagnetic inlet valve mechanism 30 is deenergized. When the electromagnetic coil 30b is deenergized early, the ratio of the spill process in the compression process is small and the ratio of the discharge process in the compression process is large.

[0052] That is, little fuel is returned (spilled) to the inlet path 10d (inlet port 30a), and much high-pressure fuel is discharged. When the timing at which the input voltage is turned off is delayed, the ratio of the spill process in the compression process is large and the ratio of the discharge process in the compression process is small.

[0053] That is, much fuel is returned (spilled) to the inlet path 10d, and little high-pressure fuel is discharged. When to deenergize the electromagnetic coil 30b is controlled by a command from the ECU.

[0054] The above structure enables a timing to deenergize the electromagnetic coil 30b to be controlled, and the amount of fuel to be highly pressurized and discharged can be thus controlled to an amount required by the internal combustion engine.

[0055] Accordingly, out of the fuel delivered to the fuel inlet port 10a, only a necessary amount of fuel is highly pressurized by the reciprocating motion of the plunger 2 in the pressurizing chamber 11 of the pump housing 1 and supplied under pressure from the discharge port 12 to the common rail 23.

[0056] Injectors 24 and a pressure sensor 26 are mounted on the common rail 23; the number of injectors 24 mounted matches the number of cylinders in the internal combustion engine. The injectors 24 inject fuel into the cylinders by being opened and closed by control signals from the ECU 27.

[0057] An orifice 25 provided at the entrance of the common rail 23, and as a result the spread of the pressure overshooting the common rail 23 is intercepted, and the injectors 24 can be supplied the steady (constant) pressure.

[0058] The pump housing 1 further includes relief paths 210 and 215 for enabling the downstream side of the discharge valve 8b to communicate with the inlet path 10c.

[0059] In the relief paths 210 and 215, a relief valve 202 is provided to restrict the fuel flow only to one way from the discharge (outlet) path 12b to the inlet path 10c. The concrete structure will be described with reference to FIG. 2.

[0060] A relief valve mechanism 200 comprises a relief valve seat 201, a relief valve 202, a relief retainer 203, a relief spring 204, and a relief spring adjuster 205.

[0061] The relief valve seat 201 is press-fitted into the pump housing 1 and fixed. An orifice plate 214 is fixed between the pump housing 1 and the relief valve seat 201. The relief valve 202 is seated against the relief valve seat 201 by a pressing force generated by the relief spring 204, the pressing force being transmitted through the relief retainer 203. The force to open the relief valve 202 is determined by the pressing force generated by the relief spring 204, and the pressing force is determined by engaging threads formed on the outer periphery of the relief spring adjuster 205 into threads formed on the pump housing 1 and adjusting an amount by which the relief spring 204 is compressed. An O-ring 213 prevents the fuel from leaking to the outside.

[0062] How the relief valve operates will be described below. The relief valve 202 is pressed against the relief valve seat 201 by the relief spring 204, which generates the pressing force. When the differential pressure between the inlet chamber and the relief path reaches or exceeds a prescribed pressure, the relief valve 202 is released from the relief valve seat 201, opening the relief valve 202. The orifice plate 214 is disposed at some midpoint in the relief path 210; the relief valve 202 is adapted so that it does not open sensitively in response to a rapid pressure change in the relief path 210.

[0063] If an excessively (abnormal) high pressure is generated in the common rail 23 or another place due to a failure in the injector 24 or the like, when the differential pressure between the relief path 210 and the inlet path 10c reaches or exceeds the valve opening pressure for the relief valve 202, the relief valve 202 opens and the fuel under excessively (abnormal) high pressure is spilled through the relief path 210 to the inlet path 10c, thereby protecting high-pressure pipes such as the common rail 23.

[0064] In the first embodiment, the discharge valve mechanism 8 and electromagnetic inlet valve mechanism 30 are disposed coaxially in series with the pressurizing chamber 11 positioned therebetween. The relief valve mechanism 200 is incorporated into relief valve mounting holes formed in the pump housing in parallel to mounting axis lines for the discharge valve mechanism 8 and electromagnetic inlet valve mechanism 30.

[0065] The structure and operation of the high-pressure fuel supply pump will be described in more detail with reference to FIGs. 1 and 2.

[0066] A concave 1A is formed as the pressurizing chamber 11 at the center of the pump housing 1. Another concave 11A is formed for mounting the discharge valve mechanism 8 between the discharge port 12 and the inner peripheral wall of the pressurizing chamber 11. In the outer wall of the pump housing, holes 30A are formed coaxially with the concave 11A for mounting the discharge valve mechanism, which supplies fuel to the pressurizing chamber 11, the hole 30A being used to mount the electromagnetic inlet valve mechanism 30.

[0067] The axis lines of the concave 11A for mounting the discharge valve mechanism 8 and the hole 30A for attaching the electromagnetic inlet valve mechanism 30 are formed so that they are orthogonal to the central axis line of the concave 1A formed as the pressurizing chamber 11.

[0068] The discharge valve mechanism 8 for discharging fuel from the pressurizing chamber 11 to the discharge path is disposed.

[0069] A cylinder 6 for guiding the reciprocating motion of the plunger 2 is attached in a way that it extends to the pressurizing chamber 11.

[0070] In the first embodiment, the concave 11A for mounting the discharge valve mechanism 8 and the hole 30A for attaching the electromagnetic inlet valve mechanism 30 are formed so that their axis lines are aligned. Accordingly, straight assembling is possible from the hole 30A for attaching the electromagnetic inlet valve mechanism 30 to the concave 11A for mounting the discharge valve mechanism 8. Alternatively, a force to press-fit the discharge valve mechanism 8 can be applied from the hole 30A for attaching the electromagnetic inlet valve mechanism 30. In this case, the smallest diameter of the hole 30A must be greater than the maximum outer diameter of the discharge valve mechanism 8.

[0071] However, it is also possible to shift the axis lines of the hole and concave part upward or downward.

[0072] In this case, the discharge valve mechanism 8 needs to be assembled from an opening 1B formed for attaching the cylinder 6.

[0073] The outer periphery of the cylinder 6 is held by a cylinder holder 7, and fixed to the pump housing 1 because the males threads formed on the outer periphery of the cylinder holder 7 are screwed into the female threads formed on the pump housing 1. The cylinder 6 slidably holds the plunger 2, which reciprocates in the pressurizing chamber 11, along the reciprocating motion.

[0074] In the first embodiment, the cylinder 6 is mounted in the opening 1B for mounting the cylinder 6 after the discharge valve mechanism 8 is mounted in the concave 11A.

[0075] An end of the cylinder 6 can be thus inserted up to a position at which the end faces the internal end of the discharge valve mechanism 8 mounted in the concave 11A. Accordingly, the volume to accommodate fuel in the pressurizing chamber 11 can be made small, increasing the fuel compression efficiency.

[0076] In the embodiment, a meal seal part is formed on a mating surface S1 between a flange-like annular surface part formed on the outer periphery of the cylinder 6 and the end surface of the opening 1B in the pump housing 1 so as to isolate the pressurizing chamber 11 from the ambient atmosphere. In general, there is a worry that the mating surface S1 erodes due to cavitation generated by variations in pressure in the pressurizing chamber 11. However, since the cylinder 6 is adapted to extend into the pressurizing chamber and thus the matching surface S1 for sealing can be positioned away from the generated cavitation, the possibility of erosion can be reduced.

[0077] In the first embodiment, an arrangement for preventing the discharge valve mechanism 8 from coming off is achieved by press-fitting a cylindrical member 11D into the internal periphery at the bottom (the upper end in FIG. 1) of the concave 1A after the discharge valve mechanism 8 is mounted.

[0078] The cylindrical member 11D also has a function for increasing the fuel compression efficiency by reducing the volume of the pressurizing chamber 11. When the cylindrical member 11D is not mounted, the cylinder 6 can be used to prevent the discharge valve mechanism 8 from coming off.

[0079] When the cylindrical member 11D is provided, the cylinder 6 does not need to be used as a retainer to prevent the discharge valve mechanism 8 from coming off. The cylinder 6 can be thus structured so that it does not reach the position of the discharge valve mechanism 8 by being shortened.

[0080] After the discharge valve mechanism 8 is press-fitted into the concave 11A, the discharge valve mechanism 8 itself can be used as the retainer by, for example, swaging the periphery on the pressurizing chamber 11 side to the internal wall of the pump housing. In this case, the cylindrical member 11D is not necessary. When the cylinder 6 is shortened so that it does not reach the position of the discharge valve mechanism 8, it is also possible to fix the cylinder 6 first and then mount the discharge valve mechanism 8 into the concave 11A.

[0081] Provided at the lower end of the plunger 2 is a tappet 3 that converts the rotational motion of a cam 5 attached to a cam shaft of the engine into vertical motion and transfers the vertical motion to the plunger 2. The plunger 2 is seated against the tappet 3 by a spring 4 through a retainer 15. Accordingly, the plunger 2 can advance and retract (reciprocate) as the cam 5 rotates.

[0082] A plunger seal 13 held at the bottom of the internal periphery of the cylinder holder 7 is provided in a state in which the plunger seal 13 is slidably in contact with the outer periphery of the plunger 2 at the bottom, shown in the drawing, of the cylinder 6, preventing fuel from leaking to the outside. It is also prevented that a lubricant (possibly engine oil) for lubricating a sliding part in the engine room enters the inside of the pump housing 1.

[0083] The pressure pulsation reducing mechanism 9, which reduces the propagation of pressure pulsation generated in the pump to the fuel pipe 28, is fixed to a damper cover 14.

[0084] The damper cover 14 is fixed to the pump housing 1. The inlet path as the low-pressure path comprises 10a, 10b, and 10c. The pressure pulsation reducing mechanism 9, which reduces the propagation of pressure pulsation generated in the pump to the fuel pipe 28 as a result of the reciprocating motion of the plunger 2, comprises two metal diaphragm assemblies 9A and 9B. In each of the metal diaphragm assemblies 9A and 9B, two metal diaphragms are welded along their outer peripheries; the interior is filled with an inert gas. The pump housing 1 includes a damper housing 10B, which is part of the inlet paths. The two metal diaphragm assemblies 9A and 9B are accommodated in the damper housing 10B. Supporting members 10A1 and 10A2 are provided on the periphery so that the two metal diaphragm assemblies 9A and 9B are disposed with a particular interval therebetween. The threads formed on the outer periphery of the damper cover 14 are screwed into the thread grooves 10C formed on the inner periphery of the damper housing 10B, and a seal member 10D is pressed so as to provide a seal, making the damper chamber hermetic. Accordingly, the damper chamber is defined in the inlet path 10, and the pressure pulsation reducing mechanism 9 is formed. Intaked fuel is also guided between the damper cover 14 and the metal diaphragm assembly 9A and between the metal diaphragm assemblies 9A and 9B through an inlet path 10E, basically causing the same pressure to act on the four diaphragms.

[0085] Although the damper cover 14 is fixed to the pump housing by being screwed in this embodiment, the damper cover 14 can also be fixed by, for example, welding the entire periphery at the P position. In this case, a seal is also provided by the welding, so the seal member 10D in the first embodiment can be eliminated.

[0086] In this case, the force to fix the metal diaphragm assemblies is also eliminated, so a process for fixing the metal diaphragm assemblies 9A and 9B is preferably provided separately from a process for fixing the damper cover 14.

[0087] It is also possible to perform welding after the damper cover 14 is screwed. In this case, the seal member can be eliminated and the metal diaphragm assemblies 9A and 9B can be fixed with the tightening torque for screwing as in this embodiment.

[0088] The discharge port (pipe connection part on the discharge side) 12 is formed in the pump housing 1. The pressurizing chamber 11 for pressurizing fuel is formed at some point on the fuel path from the inlet port 10a to the discharge port 12. The electromagnetic inlet valve mechanism 30 is formed at the entrance of the pressurizing chamber 11. The inlet valve spring 33 disposed in the electromagnetic inlet valve mechanism 30 generates a biased force in the direction to close the inlet port; the biased force is applied to the inlet valve body 31. The electromagnetic inlet valve mechanism 30 thus functions as the check valve for limiting the direction in which the fuel flows. The specific structure and operation have been described above.

[0089] The discharge valve mechanism 8 is provided at the exit of the pressurizing chamber 11. The discharge valve mechanism 8 comprises a seat member 8a, an discharge valve 8b, an discharge valve spring 8c, a holding member 8d used as an discharge valve stopper. When there is no differential pressure between the pressurizing chamber 11 and the discharge port 12, the discharge valve 8b is seated against the seat member 8a by the biased force of the discharge valve spring 8c and thus placed in the closed state. Only when the fuel pressure in the pressurizing chamber 11 is higher than the fuel pressure at the discharge port 12 by a predetermined value, the discharge valve 8b opens against the discharge valve spring 8c, discharging the fuel in the pressurizing chamber 11 to the common rail 23 through the discharge port 12.

[0090] After being opened, the discharge valve 8b comes into contact with the holding member 8d and its operation is restricted. Accordingly, the stroke of the discharge valve 8b is appropriately determined by the holding member 8d. If the stroke is too large, the closing of the discharge valve 8b is delayed and the fuel discharged to the discharge port 12 spills to the pressurizing chamber 11, lowering the efficiency of the high pressure pump. While the discharge valve 8b repeats valve opening and closing motions, the holding member 8d guides the discharge valve 8b so that the discharge valve 8b moves only in the stroke direction. This arrangement enables the discharge valve mechanism 8 to function as the check valve for limiting the fuel flow direction.

[0091] During the spill process, pressure pulsation is generated in the inlet path 10 by the fuel returned (spilled) to the inlet path 10d. The pressure pulsation is absorbed and reduced when the metal diaphragm assemblies 9A and 9B expand and contract. Only a small amount of fuel is returned (spilled) from the inlet port 10a through the inlet pipe 28 during the spill process. Most of the amount of fuel is absorbed by changes in volumes of the metal diaphragm assemblies 9A and 9B.

[0092] The relief path 215 is connected to the inlet path 10c as shown again in FIG. 2. Accordingly, the exit of the relief valve 202 is connected between the pressure pulsation reducing mechanism 9 and the inlet valve 31.

[0093] The orifice plate 214 has one or two or more orifices as shown in FIGs. 5 and 6.

[0094] Next, a case in which fuel is normally supplied under high pressure to the common rail 23 by the high-pressure fuel supply pump will be described.

[0095] While in the pressurizing process, that is, the plunger 2 is rising, a pressure overshoot is generated in the pressurizing chamber 11 in a period from an instant when a shift occurs from the spill process to the pressurizing process to a time immediately after the shift. The pressure overshoot generated in the pressurizing chamber 11 propagates from the discharge port 12 through the relief path 210 to the orifice plate 214. The orifice 214a or the orifices 214b or 214c prevent the pressure overshoot that has propagated up to the orifice plate 214 from further propagating to a relief path 211, so the pressure overshoot in the relief path 211 does not exceed the pressure to open the relief valve seat 201. The differential pressure between the entrance and exit of the relief valve does not therefore exceed the pressure to open the relief valve, so malfunction of the relief valve is eliminated and the amount of fuel discharged under high pressure is not reduced.

[0096] It can be thought that orifices (214a, 214b, 214c) of the orifice plate 214 is an attenuating mechanism that attenuates the energy of the pressure overshoot of he discharged fuel because it explained above.

[0097] In the structure described above, the holding member 8d used as the discharg valve stopper is fitted to the seat member 8a by being slightly press-fitted with the discharge valve 8b and discharge valve spring 8c disposed, and assembled to the pump housing 1 as the discharge valve mechanism 8 by being press-fitted from the pressurizing chamber 11 side.

[0098] Accordingly, the ease of assembling can be improved. When a fuel path to the relief valve is connected between the discharge valve mechanism 8 and the discharge port 12, the relief valve can be easily incorporated in the pump.

[0099] A stopper part of the discharge valve mechanism 8 is provided in the pump housing 1; the cylinder 6 disposed in the pressurizing chamber 11 has a part for preventing the seat member 8a from coming off; a clearance smaller than a length by which the seat member 8a is press-fitted to the pump housing 1 is provided between the seat member 8a and the cylinder 6.

[0100] Accordingly, even when the force to press-fit the seat member to the pump housing is small (that is, the difference between the outer diameter of the seat member and the inner diameter of the pump housing before press-fitting is small), the seat member does not come off, so the press-fitting force (the difference) does not need to be large. This prevents the seat part from being deformed during press-fitting and thus prevents the valve seat capability from being lowered. Accordingly, tolerance ranges for press-fitting forces (the differences) can be roughly managed, making inexpensive machining possible.

[0101] Since there is a clearance between the seat member 8a and the cylinder 6, incorrect positioning due to dimensional tolerances allowed for the assembling of individual parts can be corrected by the clearance. Even if the seat member 8a moves by the amount equal to the clearance when the pump operates, a press-fitted part can be obtained, maintaining the seal capability of the press-fitted part. In this embodiment, the inner diameter of the discharge port 12 into which a joint for piping on the discharging side is screwed can also be made equal to or smaller than the outer diameter of the seat member 8a having the largest outer diameter in the discharge valve mechanism 8. Accordingly, it is also possible to reduce the area of the sealed part between the discharge port and the joint and thereby to reduce the area of the sealed part at which a pressure is received.

[0102] The outer periphery of the cylinder 6 is held by the cylinder holder 7. When the threads formed on the inner periphery of a flange holder 40 are screwed into the threads formed on the pump housing 1, the cylinder holder 7 obtains a thrust, fixing the cylinder 6 to pump housing 1. The cylinder 6 holds the plunger 2, which is the pressurizing member, while allowing the plunger 2 to slide upward and downward.

[0103] The high-pressure fuel supply pump is fixed to the engine through the flange holder 40 and flange 41. The flange holder 40 is pressed against and fixed to the engine with setscrews 42 through the flange 41. Since the flange holder 40 is fixed to the pump housing 1 by the threads formed on the inner periphery, the pump housing is thus fixed to the engine.

[0104] The relief path 215 is connected through the inlet path 10c to the inlet path 10b in which the pressure pulsation reducing mechanism 9 is disposed. The exit of the relief valve 202 is thus connected between the pressure pulsation reducing mechanism 9 and the inlet valve 31.

[0105] The orifice plate 214 has one or two or more orifices. FIGs. 5 and 6 show examples of the orifice plate 214. The example in FIG. 5 has one orifice 214a; one example in FIG. 6 has four orifices 214b, and the other example has many orifices 214c. In this case, when a plurality of orifices are formed, each of the orifices is adapted to have a such a small diameter that the viscosity of the fuel to causes an effect. The function of the orifice will be described below.

[0106] First, a case in which fuel is normally supplied under high pressure by the high-pressure fuel supply pump to the common rail 23 will be described.

[0107] While the high-pressure fuel supply pump is in the discharge process, a pressure overshoot is generated in the pressurizing chamber 11. The pressure overshoot generated in the pressurizing chamber 11 propagates from the discharge port 12 through the relief path 210 to the orifice plate 214. The orifice 214a (214b or 214c) as an energy attenuating mechanism prevents the pressure overshoot that has propagated up to the orifice plate 214 from further propagating to the relief path 211, so the pressure overshoot in the relief path 211 can be reduced. Accordingly, malfunction of the relief valve is eliminated and a drop in the amount of fuel discharged under high pressure can also be reduced. That is, the efficiency as the high-pressure fuel supply pump can be maintained at a high level.

[0108] It can be thought that orifices (214a, 214b, 214c) of the orifice plate 214 is an attenuating mechanism that attenuates the energy of the pressure overshoot of he discharged fuel because it explained above.

[0109] The pressure overshoot generated in the pressurizing chamber 11 also propagates from the discharge port 12 through the high-pressure pipe 29 to the common rail 23. An orifice 25 provided at the entrance of the common rail 23 blocks the propagation of the pressure overshoot to the common rail 23, achieving fuel supply to the injector 24 under stable pressure.

[0110] Described next is a case in which an excessively high pressure is generated in the common rail 23 or another part under high pressure due to a failure in the injector 24 or the like.

[0111] FIG. 7 indicates the relation between the amount of fuel discharged under high pressure from the high-pressure fuel supply pump and the pressure in the common rail 23. In general, as the amount of fuel discharged under high pressure increases, the fuel pressure in the common rail 23 always increases even when the pressure to open the relief valve 202 is the same.

[0112] When an orifice is provided at the entrance of the relief valve 202 by using the orifice plate 214 or the like as shown in FIG. 2, the malfunction of the relief valve 202 due to the pressure overshoot propagated from compression chamber 11 to the relief path 210 as described above can be reduced. However, to block the propagation of the pressure overshoot to the relief valve 202, the orifice 214a must be very small. If an excessively high pressure is generated, the high-pressure fuel passes through the orifice 214a and is spilled through the relief path 215 to the inlet path 10b. However, a pressure drop is generated at the orifice 214a. As a result, the fuel pressure in the common rail 23 or the like is much higher than the pressure to open the relief valve 202, which is problematic in terms of the durability of the high-pressure part and costs.

[0113] When a plurality of orifices 214b or 214c, which are small enough for the viscosity of the fuel to cause an effect, are provided as shown in FIG. 6, the propagation of the pressure overshoot to the relief valve 202 can be blocked. In addition, when an excessively high pressure is generated, a pressure rise in the common rail 23 or the like can be suppressed. This is because although the path area of each of the orifices 214b and the orifices 214c is small, a total path area of these orifices can be made sufficiently large and thus a pressure loss is not generated at the orifice 214b, 214c. Accordingly, the problems with the durability of the high-pressure pipe part and costs can be avoided.

[0114] When the fuel under excessively high pressure is released to the inlet path 10b, the fuel pressure is rapidly lowered, causing large pressure pulsation in the inlet path 10b. However, the pressure pulsation reducing mechanism 9 disposed in the inlet path 10b can sufficiently reduce this pressure pulsation, preventing the pressure pulsation from propagating to the low-pressure pipe 28 and thereby preventing the pipe from being broken.

[0115] The use of sintered metal with mesh structure or the like instead of the orifice plate 214 provides the same effect.

[0116] In this embodiment described above, the exit of the relief path is connected to the inlet (low-pressure) path. However, the relief valve can be disposed at a position near the pressurizing chamber, preferably in the pressurizing chamber. If only the compression efficiency is not lowered, the exit of the relief path can be connected to the pressurizing chamber so as to spill the fuel to the pressurizing chamber at the occurrence of an excessively high pressure.

[Second embodiment]

[0117] A second embodiment of the present invention will be described with reference to FIG. 1 and FIGs. 8 to 18.

[0118] First, the structure of a relief valve mechanism B200 will be specifically described with reference to FIGs. 8 to 10.

[0119] The relief valve mechanism B200 comprises a relief valve housing B206, which is integrally formed with a relief valve seat B201, as well as a relief valve B202, a relief valve retainer B203, a relief spring B204, and a relief valve adjuster B205. The relief valve mechanism B200 is assembled as a sub-assembly outside the pump housing 1, and then fixed to the pump housing 1 by being press-fitted.

[0120] The relief valve B202, relief valve retainer B203, and relief spring B204 are inserted in succession into a relief valve housing B206 in that order. The relief spring adjuster B205 is then fixed to the relief valve housing B206 by being press-fitted. According to the position at which the relief spring adjuster B205 is fixed, a load set by the relief spring B204 is determined. A pressure to open the relief valve B202 is determined by the load set by the relief spring B204. The relief valve mechanism B200 structured in this way is fixed to the pump housing 1 by being press-fitted. In the second embodiment, the relief path 211 is integrally formed to the pump housing 1, in parallel to the cylinder 6.

[0121] Next, the function of the discharge valve mechanism 8 will be described with reference to FIGs. 11, 12, and 13. The discharge valve mechanism 8 is disposed at the exit of the pressurizing chamber 11. The discharge valve mechanism 8 comprises an discharge valve seat 8a, an discharge valve 8b, an discharge valve spring 8c, and an discharge valve holder 8d. The discharge valve 8b is slidably held by the discharge valve holder 8d, and guided by the discharge valve holder 8d so that the discharge valve 8b moves only in the stroke direction when the discharge valve 8b repeats open and close motions. When the discharge valve 8b opens and comes into contact with a contact part 8d3 of the discharge valve holder 8d, the operation of the discharge valve 8b is restricted. Accordingly, it is prevented that fuel discharged to the discharge port 12 under high pressure is spilled to the pressurizing chamber 11 due to a delay of the discharge valve 8b being closed and thus the efficiency as a high pump is lowered.

[0122] Discharge ports 8d1, relief ports 8d2, and a spill port 8d4 are formed in the discharge valve holder 8d. The relief ports 8d2 communicate with the relief path 211. While the high-pressure fuel supply pump is in the discharge process, the discharge valve 8b is in the open state as shown in FIG. 12. The discharge valve 8b comes in contact with the discharge valve holder 8d at the contact part 8d3, at which fuel is sealed, so the discharge path 12b is blocked from the relief path 211 and thus communication therebetween is disabled.

[0123] While the high-pressure fuel supply pump is in the intake and spill processes, the discharge valve 8b is in the closed state as shown in FIG. 13. The discharge valve 8b blocks the discharge path 12b from the pressurizing chamber 11 at a seat part 8a3 on the discharge valve seat 8a. Accordingly, even when the pressure in the pressurizing chamber 11 is reduced due the motion of the plunger 2, the fuel under high pressure in the discharge path 12b does not spill to the pressurizing chamber 11. A clearance is formed between the discharge valve 8b and the discharge valve holder 8d at the contact part 8d3 by the amount equal to the stroke of the discharge valve 8b. The discharge port 12 communicates with the relief path 211 through this clearance. That is, while in the discharge process, there is no communication between the discharge path 12b and the relief path 211; while in the intake and spill processes, there is communication between the discharge port 12 and the relief path 211.

[0124] Next, a case in which fuel is normally supplied under high pressure to the common rail 23 by the high-pressure fuel supply pump will be described.

[0125] While in the discharge process, the fuel highly pressurized in the pressurizing chamber 11 is supplied from the discharge port 12 through the high-pressure pipe 29 to the common rail 23, as shown in FIG. 12.

[0126] A pressure overshoot is generated in the pressurizing chamber 11 at this time. The pressure overshoot generated in pressurizing chamber 11 propagates to the discharge port 12, but the discharge valve 8b is in the open state. That is, there is no communication between the discharge port 12 and relief path 211 as described above, so the pressure overshoot does not propagate to the relief path 211.

[0127] Even when a pressure overshoot is generated in the pressurizing chamber 11, therefore, the relief valve B202 does not malfunction. This means that the amount of fuel discharged from the high-pressure fuel supply pump to the common rail 23 is not reduced.

[0128] It can be thought that contact part 8d3 for sealing fuel is the path switching mechanism that makes a switchover to enable or disable communication between the relief path and the discharge path because it explained above.

[0129] While in the intake and spill processes, there is communication between the discharge path 12b and relief path 211. Since there is no pressure overshoot, however, the relief valve B202 does not malfunction. That is, the amount of fuel discharged from the high-pressure fuel supply pump to the common rail 23 is not reduced.

[0130] Furthermore, a case in which an excessively (abnormal) high pressure is generated in a high-pressure part such as the common rail 23 due to a failure of the injector 24 or the like will be described.

[0131] While in the discharge process, there is no communication between the discharge path 12b and relief path 211 as described above, so the fuel under excessively high pressure cannot reach the relief valve B202.

[0132] While in the intake and spill processes, there is communication between the discharge port 12 and relief path 211 as described above.

[0133] Accordingly, the fuel under excessively (abnormal) high pressure flows from the discharge path 12b through the relief path 211, and reaches the relief valve B202. The fuel that passes through the relief valve B202 further passes through a relief path B205a formed in the relief spring adjuster B205, and is released to the inlet path 10b, which is a low-pressure part. The high-pressure parts such as the common rail 23 are thus protected.

[0134] When the fuel under excessively (abnormal) high pressure is released to the inlet path 10b, the fuel pressure is rapidly lowered, causing large pressure pulsation in the inlet path 10b. However, the pressure pulsation reducing mechanism 9 disposed further upstream in the inlet path 10b can sufficiently reduce this pressure pulsation, preventing the pressure pulsation from propagating to the low-pressure pipe 28 and thereby preventing the pipe from being broken.

[0135] Next, the structure of the discharge valve mechanism 8 having the function as described above will be described with reference to FIGs. 14, 15, 16, 17, and 18.

[0136] The discharge valve mechanism 8 is assembled outside the pump housing 1 as a sub-assembly before being incorporated into the pump housing 1. The discharge valve spring 8c, discharge valve 8b, and discharge valve seat 8a are inserted in succession into the discharge valve holder 8d in that order. The discharge valve seat 8a is then fixed to the discharge valve holder 8d at a press-fitted part 8a1 by being press-fitted.

[0137] The discharge valve mechanism 8 structured in this way is fixed to the pump housing by being press-fitted. Places in which press-fitting is performed are a press-fitted part 8a2, which is a side part of the discharge valve seat 8a, and press-fitted parts 8d5, which are sides of the discharge valve holder 8d. Other sides of the discharge valve holder 8d have a shape formed by cutting two planes 8d6 parallel on its cylindrical shape. That is, the sides of the discharge valve holder 8d comprise the press-fitted parts 8d5, which are cylindrical, and the planes 8d6.

[0138] The two discharge ports 8d1 are machined so that connection to the two planes 8d6 is established. The two relief parts 8d2 are machined so that connection to the cylindrical press-fitted parts 8d5 is established. When the discharge valve mechanism 8 is press-fitted to the pump housing 1, the relief ports 8d2 machined in the discharge valve holder 8d overlap the relief path 211 machined in the pump housing 1. The press-fitted part of the pump housing is machined in a cylindrical shape.

[0139] While in the discharge process, the fuel pressurized in the pressurizing chamber 11 is delivered from the discharge ports 8d1, flows along the planes 8d6 machined on the sides of the discharge valve holder 8d, and are discharged to the discharge path 12b through the clearance in the pump housing 1, as shown in FIGs. 15 and 17. At that time, the relief path 211 is blocked from the discharge path 12b by the contact part 8d3 on the discharge valve holder 8d, so there is no communication therebetween. Accordingly, the pressure overshoot generated in the pressurizing chamber 11 does not propagate to the relief valve B202.

[0140] When an excessively (abnormal) high pressure is generated in a high-pressure part such as the common rail 23 due to a failure of the injector 24 or the like, a clearance is formed at the contact part 8d3 between the discharge valve 8b and the discharge valve holder 8d by the amount equal to the stroke of the discharge valve 8b, as shown in FIGs. 16 and 18. This clearance is used for the discharge port 12 to communicate with the relief path 211 through the communicating port 8d4 and relief ports 8d2 formed in the discharge valve holder 8d.

[0141] Accordingly, the fuel under excessively (abnormal) high pressure can reach the relief valve B202, passes through a relief path B205a formed in the relief spring adjuster B205, and is released to the inlet path 10b, which is a low-pressure part.

[0142] The discharge valve mechanism 8 assembled outside the pump housing 1 is press-fitted to the pump housing 1 at the press-fitted parts 8d5 of the discharge valve holder 8d and an discharge valve seat 8a3. Particularly, the press-fitted part between 8d5 and the pump housing 1 is structured so that the press-fitted part serves as a blockade between the discharge path 12b and the relief path 211.

[0143] The clearance between the press-fitted parts 8d5 and the pump housing 1 may be such a minute clearance that the viscosity of the fuel causes an effect. Accordingly, the same effect as described above is obtained, and the load to press-fit the discharge valve mechanism 8 to the pump housing 1 can be reduced, improving the ease of assembling the high-pressure fuel supply pump.

[0144] The present invention is applied to high-pressure fuel supply pumps used in cylinder injection types of internal combustion engines. High-pressure fuel supply pumps having only one pressurizing chamber, that is, so-called single-cylinder types of high-pressure fuel supply pumps have been described in the embodiments, but the present invention can also be used for high-pressure fuel supply pumps having a plurality of pressurizing chambers, that is, so-called multicylinder types of high-pressure fuel supply pumps.

[0145] Features, components and specific details of the structures of the above-described embodiments may be exchanged or combined to form further embodiments optimized for the respective application. As far as those modifications are readily apparent for an expert skilled in the art they shall be disclosed implicitly by the above description without specifying explicitly every possible combination, for the sake of conciseness of the present description.

Claims

1. A high-pressure fuel supply pump having a fuel relief path for connecting a high-pressure fuel path downstream of a discharge valve (8) for discharging fuel pressurized in a pressurizing chamber (11) to a low-pressure fuel path upstream of an inlet valve (30) or the pressurizing chamber (11), a check valve being provided in the fuel relief path as a relief valve for allowing the fuel to flow only to the low-pressure fuel path or the pressurizing chamber (11), wherein an energy attenuating mechanism is provided in a discharge path on a side facing the discharge valve (8) upstream of the relief valve in the fuel relief path so as to prevent an instantaneous pressure rise caused in the discharge path from propagating to the relief valve.

2. The high-pressure fuel supply pump according to claim 1, wherein an energy attenuating mechanism for reducing energy based on a pressure rise in the discharge path is provided in the relief path, the energy attenuating mechanism acting on the relief valve in a direction to open the relief valve while the discharge valve (8) is in an open operation.

3. The high-pressure fuel supply pump according to claim 1 or 2, the energy attenuating mechanism is structured by including a plate having at least one orifice, the plate being disposed on a high-pressure fuel path side near the relief valve.

4. The high-pressure fuel supply pump according to at least one of claims 1 to 3, wherein the energy attenuating mechanism is structured by including the discharge valve (8); the discharge valve (8) narrows or blocks the high-pressure path near the relief valve while the discharge valve (8) is in the open operation.

5. A high-pressure fuel supply pump having a low-pressure inlet path for intaking fuel into a pressurizing chamber (11), a discharge path for discharging the fuel from the pressurizing chamber (11), an inlet valve disposed in the inlet path, a discharge valve (8) disposed in the discharge path, a relief path for connecting a side downstream of the discharge valve (8) in the discharge path to a side upstream of the inlet valve in the inlet path or connecting the side downstream of the discharge valve (8) to the pressurizing chamber (11), the discharge path side being the upstream side and the inlet path side being the downstream side or the discharge path side being the upstream side and the pressurizing chamber (11) side being the downstream side, and a relief valve, disposed in the relief path, for limiting a flow of the fuel to only one direction, from the upstream side to the downstream side, the relief valve being structured so that the relief valve is opened when a differential pressure between an entrance and an exit thereof is raised to or above a predetermined valve opening pressure, wherein an energy attenuating mechanism is provided upstream of the relief valve in the relief path so as to prevent a pressure pulsation caused in the discharge path from acting on the relief valve or reduce the pressure pulsation.

6. The high-pressure fuel supply pump according to claim 5, wherein an orifice is provided near the relief valve in the relief path, as the energy attenuating mechanism.

7. The high-pressure fuel supply pump according to claims 5 or 6, wherein a plurality of orifices are provided in parallel near the relief valve in the relief path, as the energy attenuating mechanism.

8. The high-pressure fuel supply pump according to at least one of claims 5 to 7, wherein a member having a mesh structure is provided near the relief valve in the relief path, as the energy attenuating mechanism.

9. The high-pressure fuel supply pump according to at least one of claims 5 to 8, wherein a path switching mechanism is provided near the relief valve in the relief path, as the energy attenuating mechanism; the path switching mechanism makes a switchover to enable or disable communication between the relief path and the discharge path.

10. The high-pressure fuel supply pump according to at least one of claims 5 to 9, wherein the path switching mechanism is structured by including a switching mechanism for disabling the communication between the relief path and the discharge path while the high-pressure fuel supply pump is in a process to discharge high-pressure fuel and enabling the communications in other processes.

11. The high-pressure fuel supply pump according to at least one of claims 5 to 10, wherein the discharge valve (8) is used as the switching mechanism; the discharge valve (8) narrows or blocks a connection part between the discharge path and the relief path while the discharge valve is in the open operation.

12. The high-pressure fuel supply pump according to at least one of claims 5 to 11, wherein a connection opening between the relief path and the discharge path is formed on a side of a cylindrical holding part that guides reciprocating motion of the discharge valve (8); the discharge valve narrows or blocks the connection opening when the discharge valve (8) is open.

13. The high-pressure fuel supply pump according to at least one of claims 5 to 12, wherein a guiding path is provided on a side of the cylindrical holding part so as to guide the fuel in the pressurizing chamber (11) to the discharge path while the discharge valve (8) in the open operation.

14. The high-pressure fuel supply pump according to at least one of claims 5 to 13, wherein the cylindrical holding part is fixed to a discharge opening part in the pressurizing chamber (11); a seat member for the discharge valve (8) is fixed to an end on the pressurizing chamber (11) side of the cylindrical holding part; the discharge valve (8) is pressed against the seat member by a spring held in the cylindrical holding part.

FIG. 1

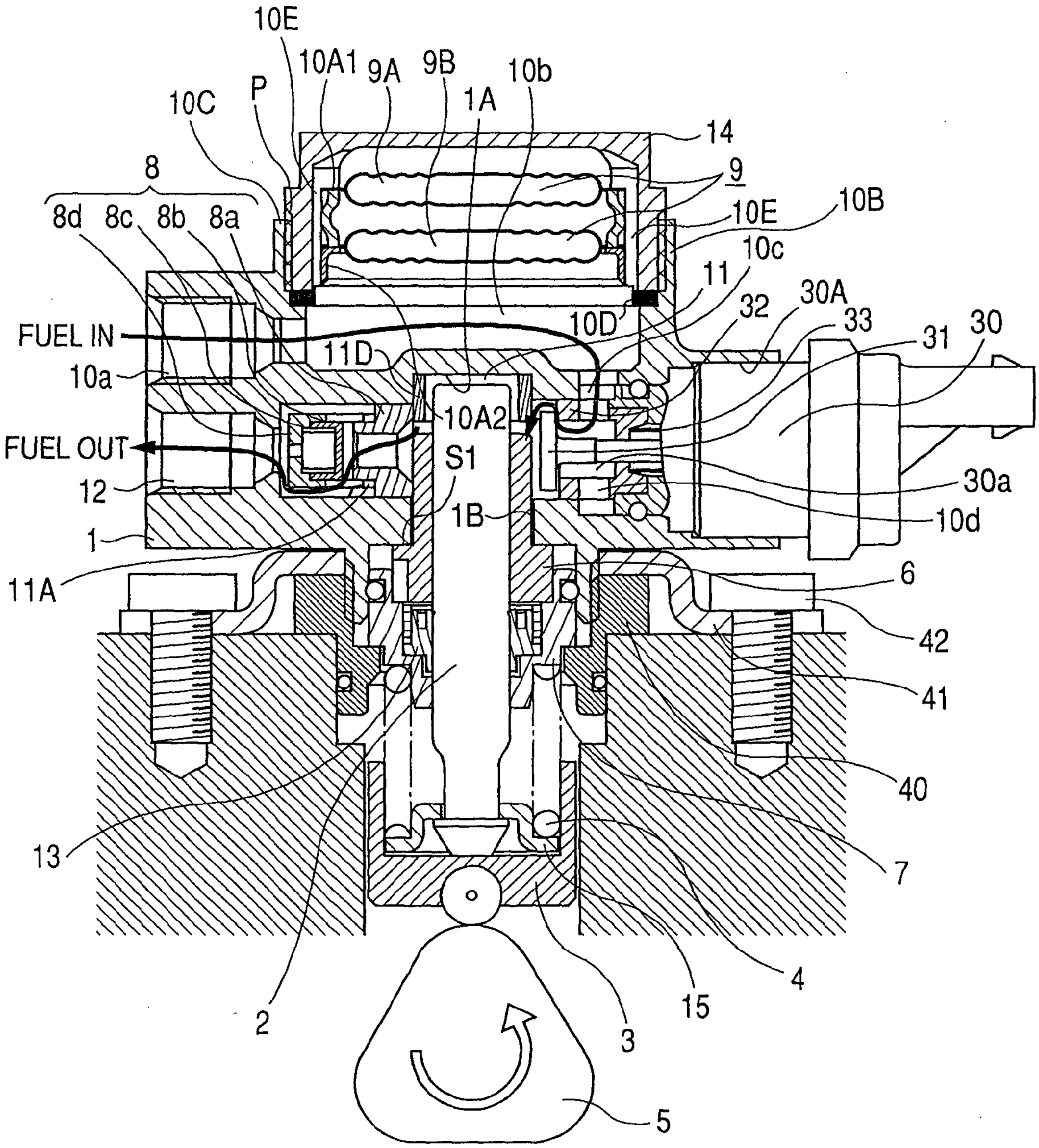
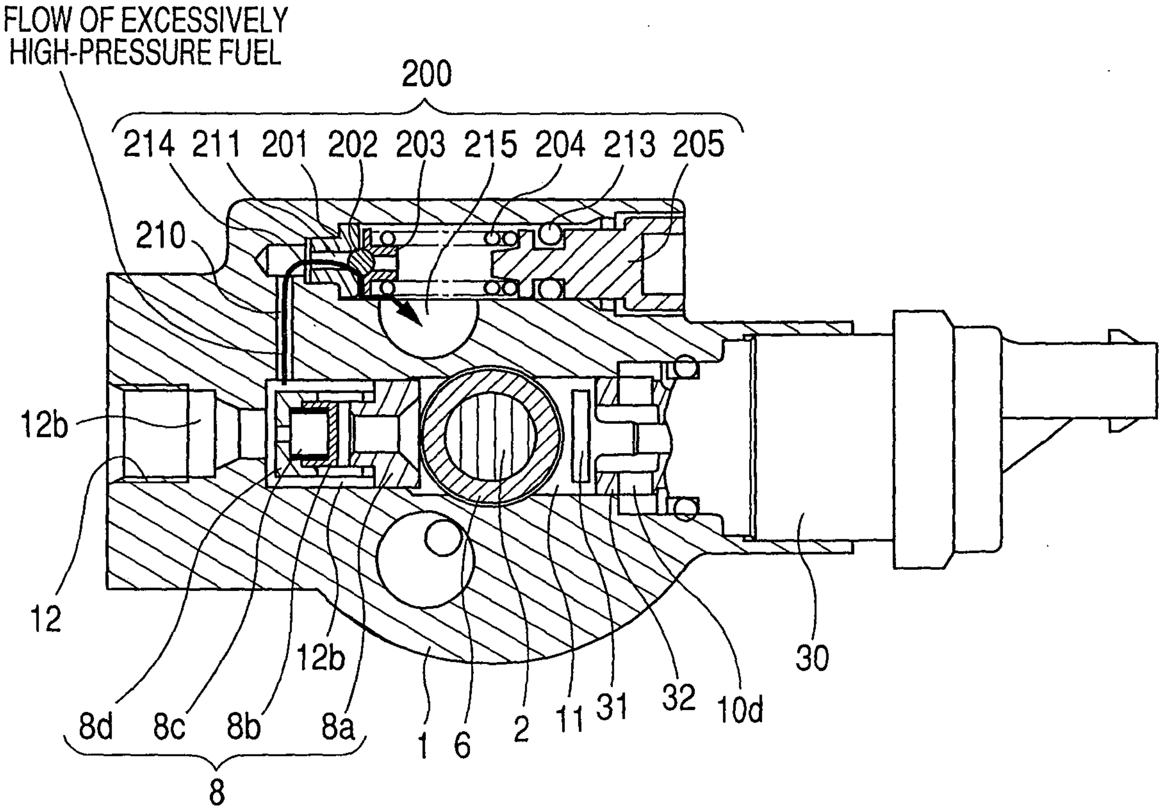

10E
10A1
9A
9B
10b
1A
10C
P
14
8
9
8d 8c 8b 8a
10E
10B
10c
11
32
30A
FUEL IN
10D
33
31
30
11D
10a
10A2
FUEL OUT
S1
30a
12
1B
10d
1
11A
6
42
41
40
13
7
4
15
3
2
5

FIG. 2



FLOW OF EXCESSIVELY HIGH-PRESSURE FUEL
200
214
211
201
202
203
215
204
213
205
210
12b
12
12b
8d
8c
8b
8a
8
1
6
2
11
31
32
10d
30

FIG. 3

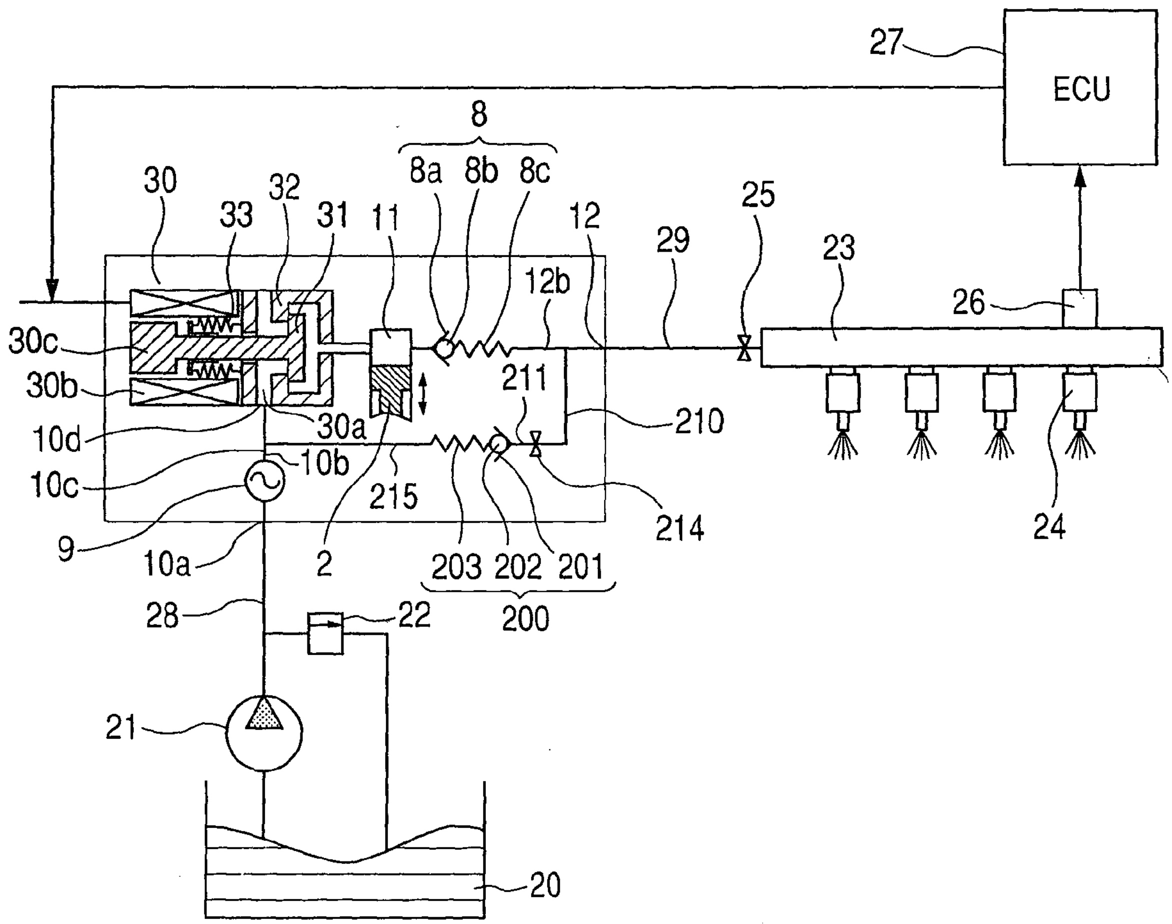

27
ECU
8
8a
8b
8c
30
33
32
31
11
12
12b
29
25
23
26
30c
30b
211
210
30a
10d
10b
10c
215
214
9
10a
2
203
202
201
24
200
28
22
21
20

FIG. 4

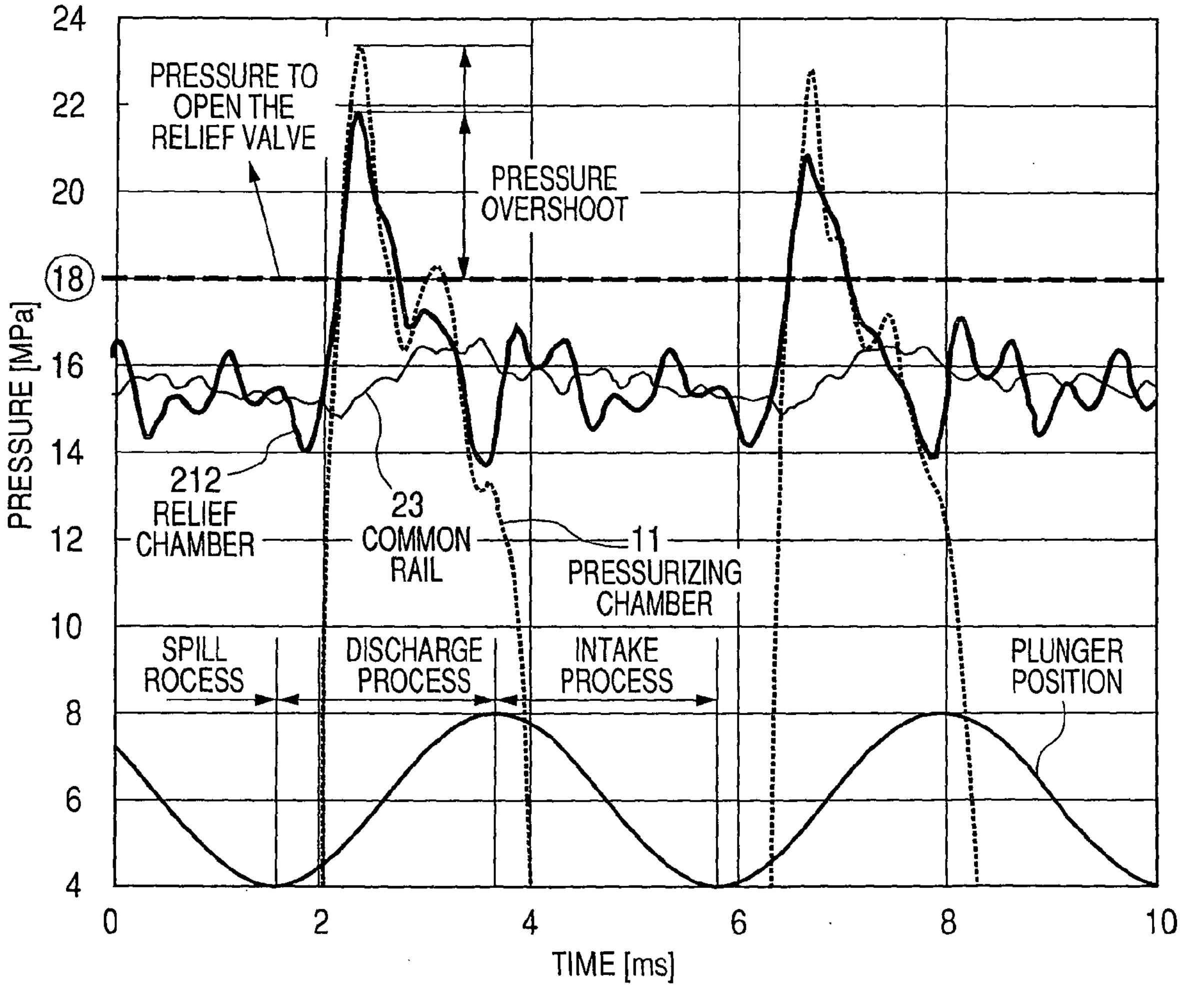

24
22
20
(18)
16
14
12
10
8
6
4
PRESSURE [MPa]
PRESSURE TO OPEN THE RELIEF VALVE
PRESSURE OVERSHOOT
212 RELIEF CHAMBER
23 COMMON RAIL
11 PRESSURIZING CHAMBER
SPILL ROCESS
DISCHARGE PROCESS
INTAKE PROCESS
PLUNGER POSITION
0
2
4
6
8
10
TIME [ms]

FIG. 5

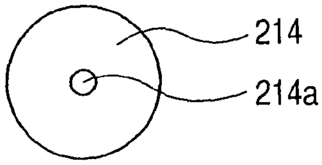

214
214a

FIG. 6

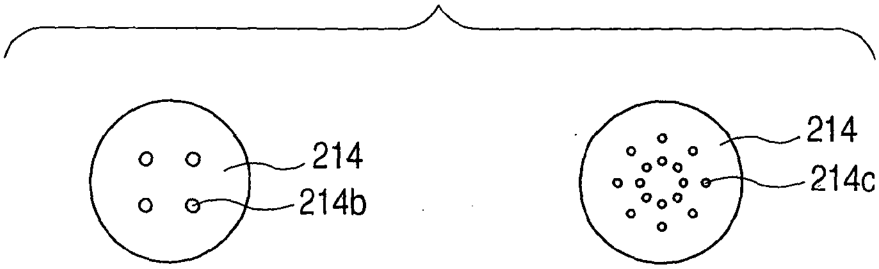

214
214b
214
214c

FIG. 7

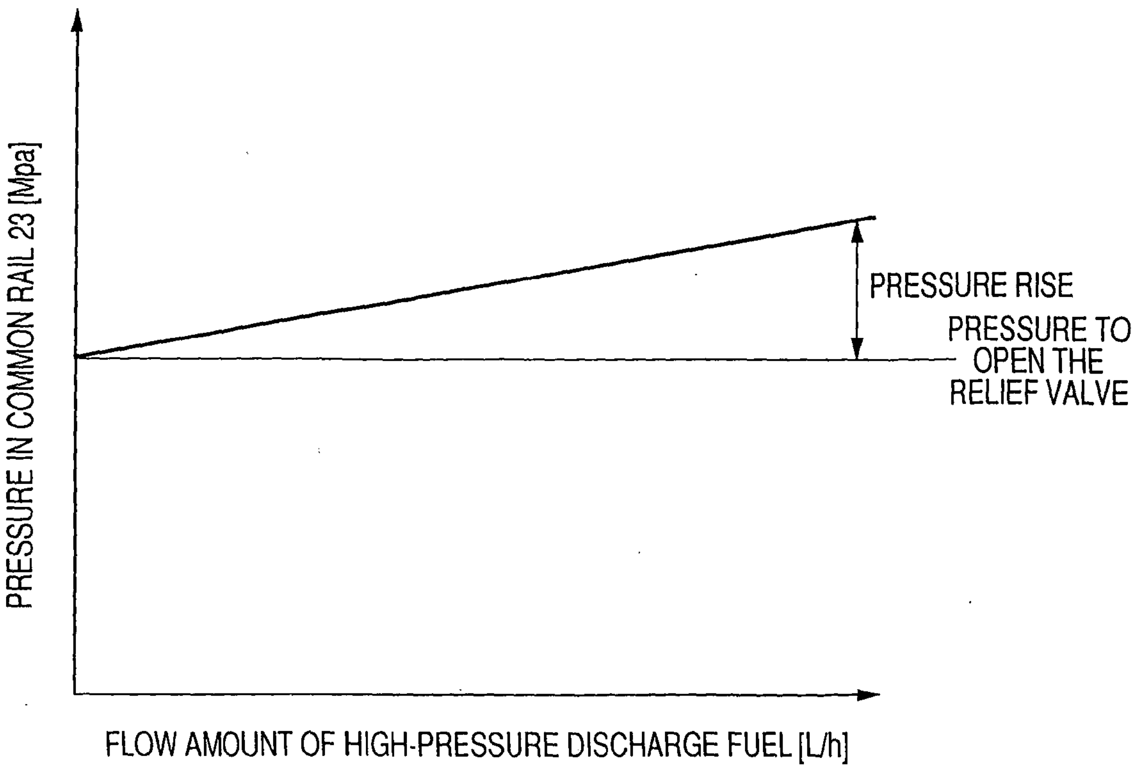

PRESSURE IN COMMON RAIL 23 [Mpa]
PRESSURE RISE
PRESSURE TO OPEN THE RELIEF VALVE
FLOW AMOUNT OF HIGH-PRESSURE DISCHARGE FUEL [L/h]

FIG. 8

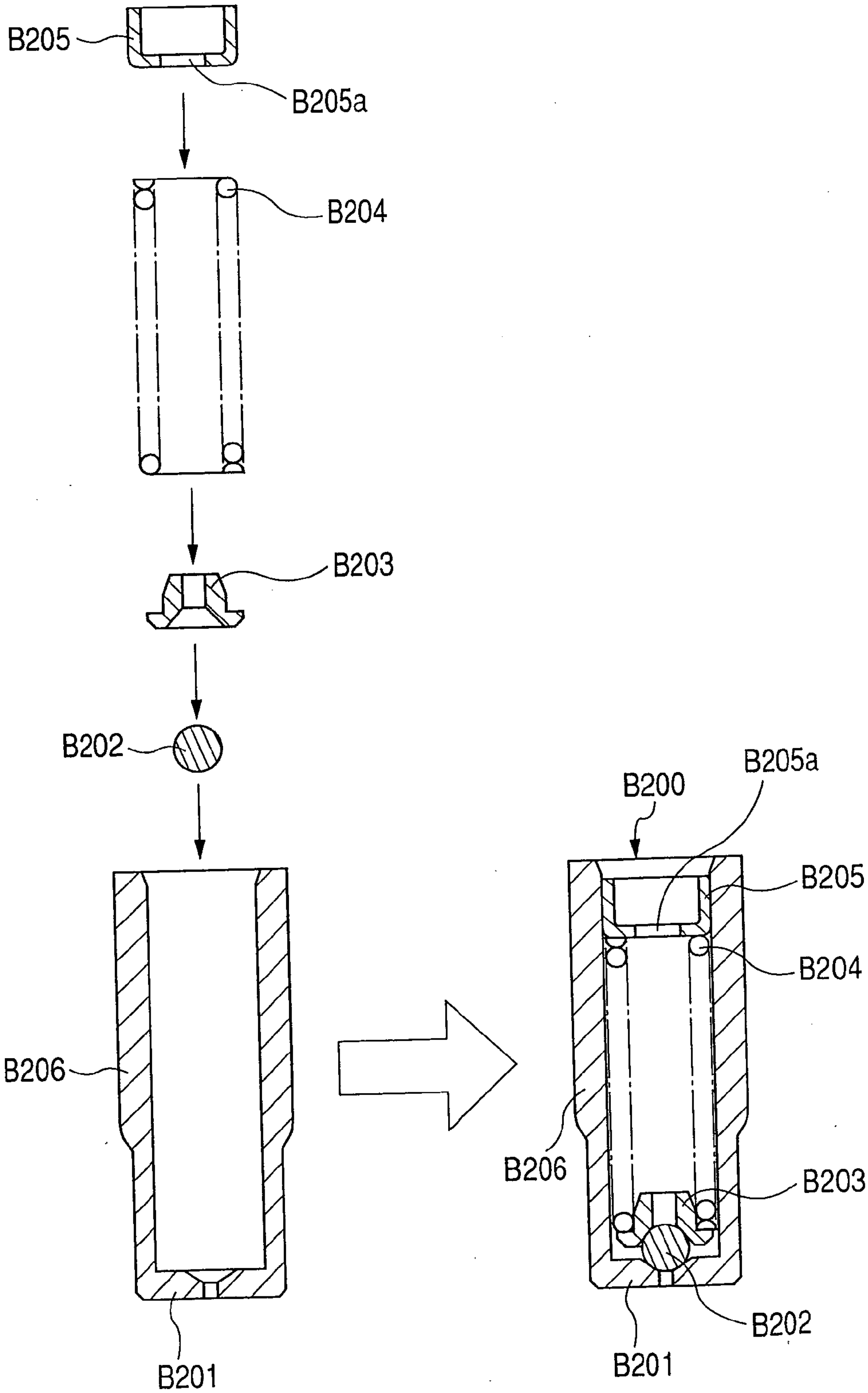

B205
B205a
B204
B203
B202
B206
B201
B200
B205a
B205
B204
B206
B203
B202
B201

FIG. 9

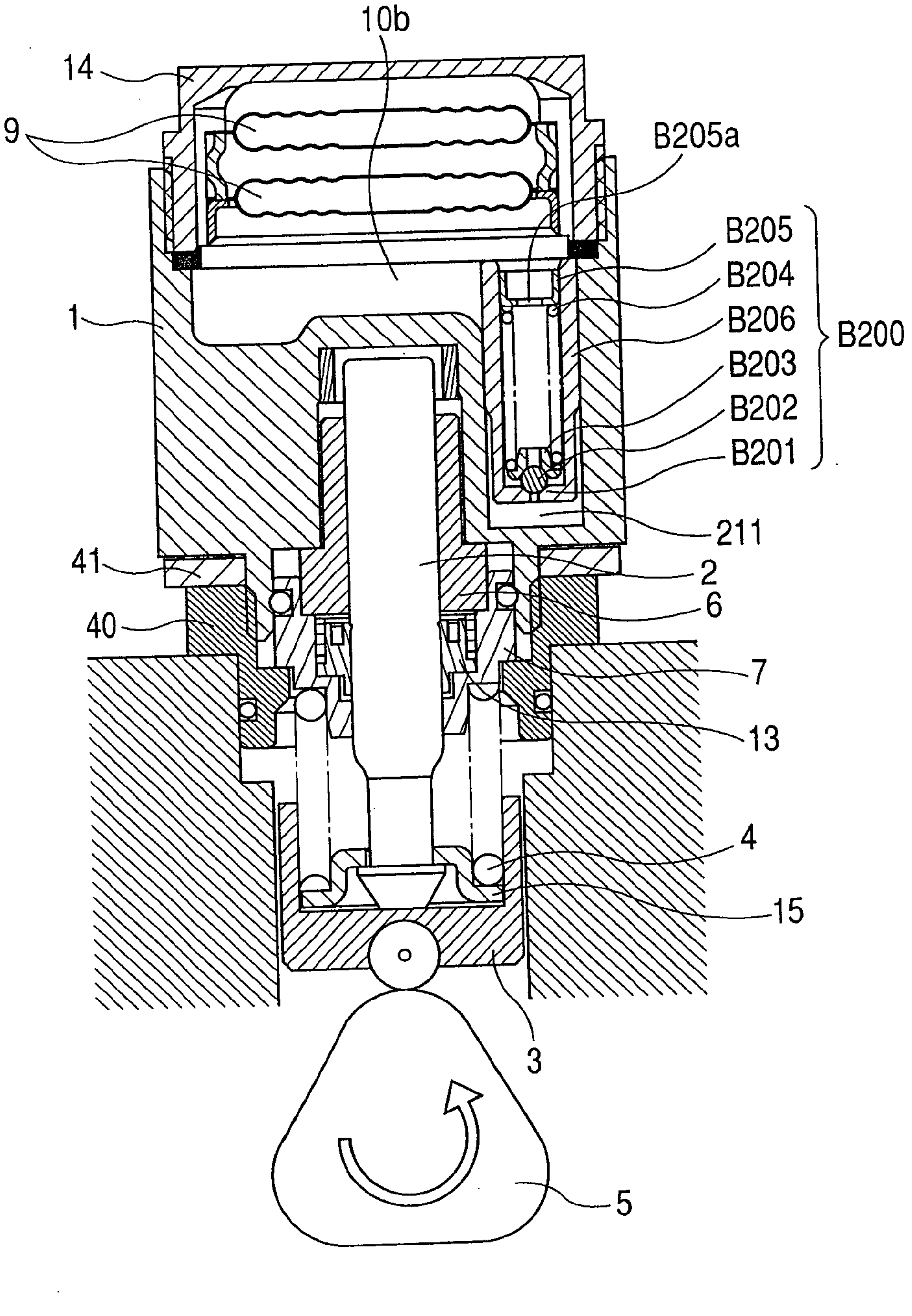

10b
14
9
B205a
B205
B204
B206
B203
B202
B201
B200
1
211
41
2
6
40
7
13
4
15
3
5

FIG. 10

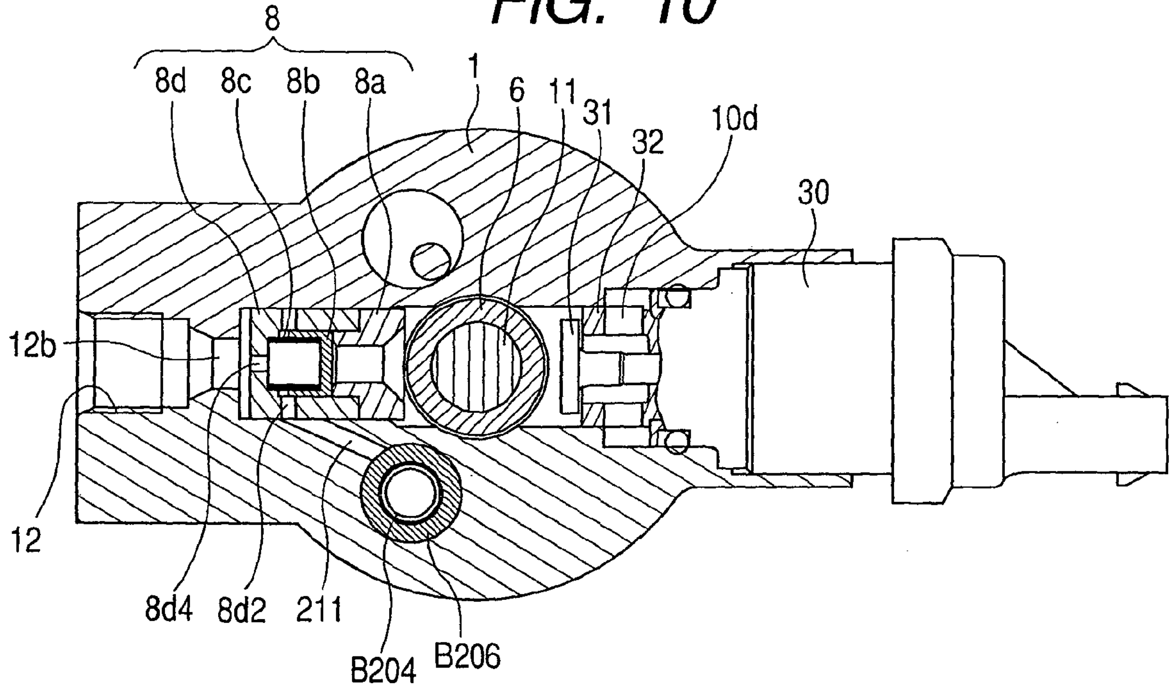

8
8d
8c
8b
8a
1
6
11
31
32
10d
30
12b
12
8d4
8d2
211
B204
B206

FIG. 11

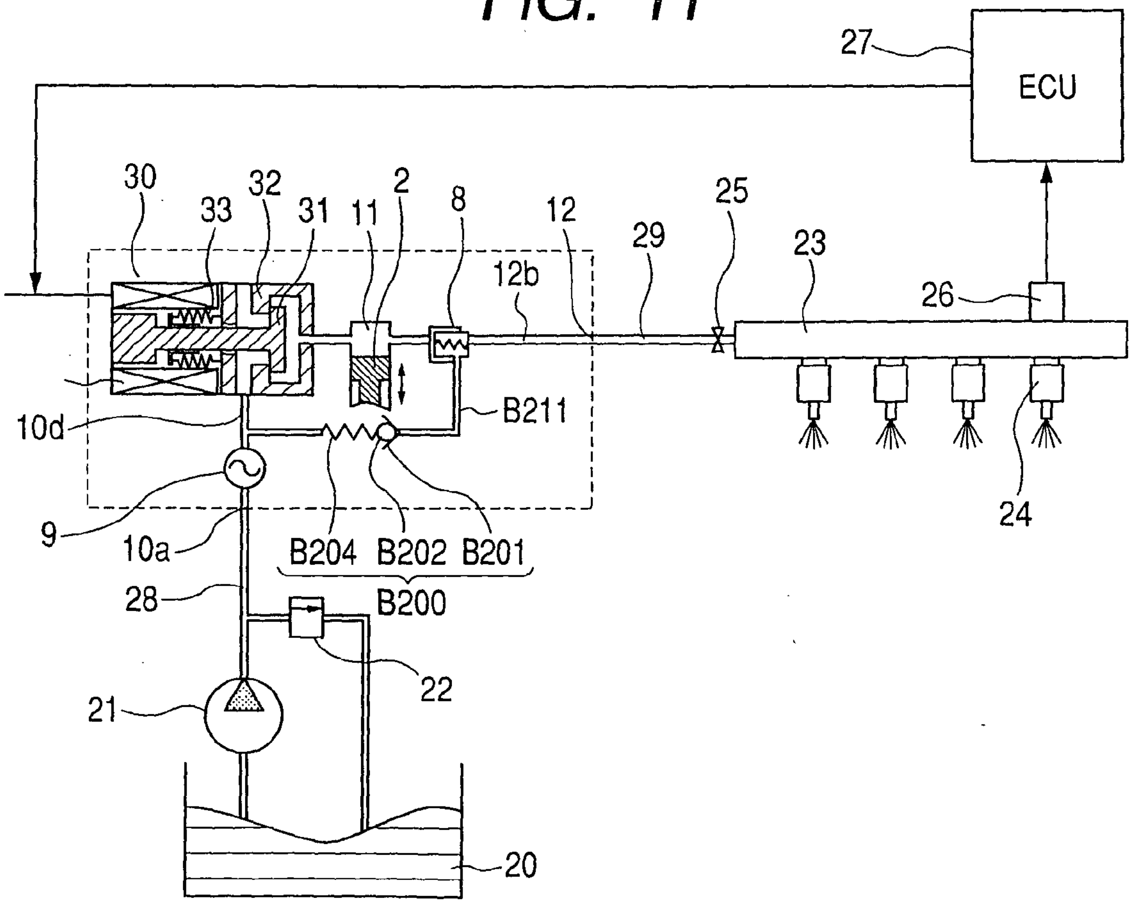

27
ECU
30
33
32
31
11
2
8
12
29
25
23
12b
26
10d
B211
24
9
10a
B204
B202
B201
28
B200
22
21
20

FIG. 12

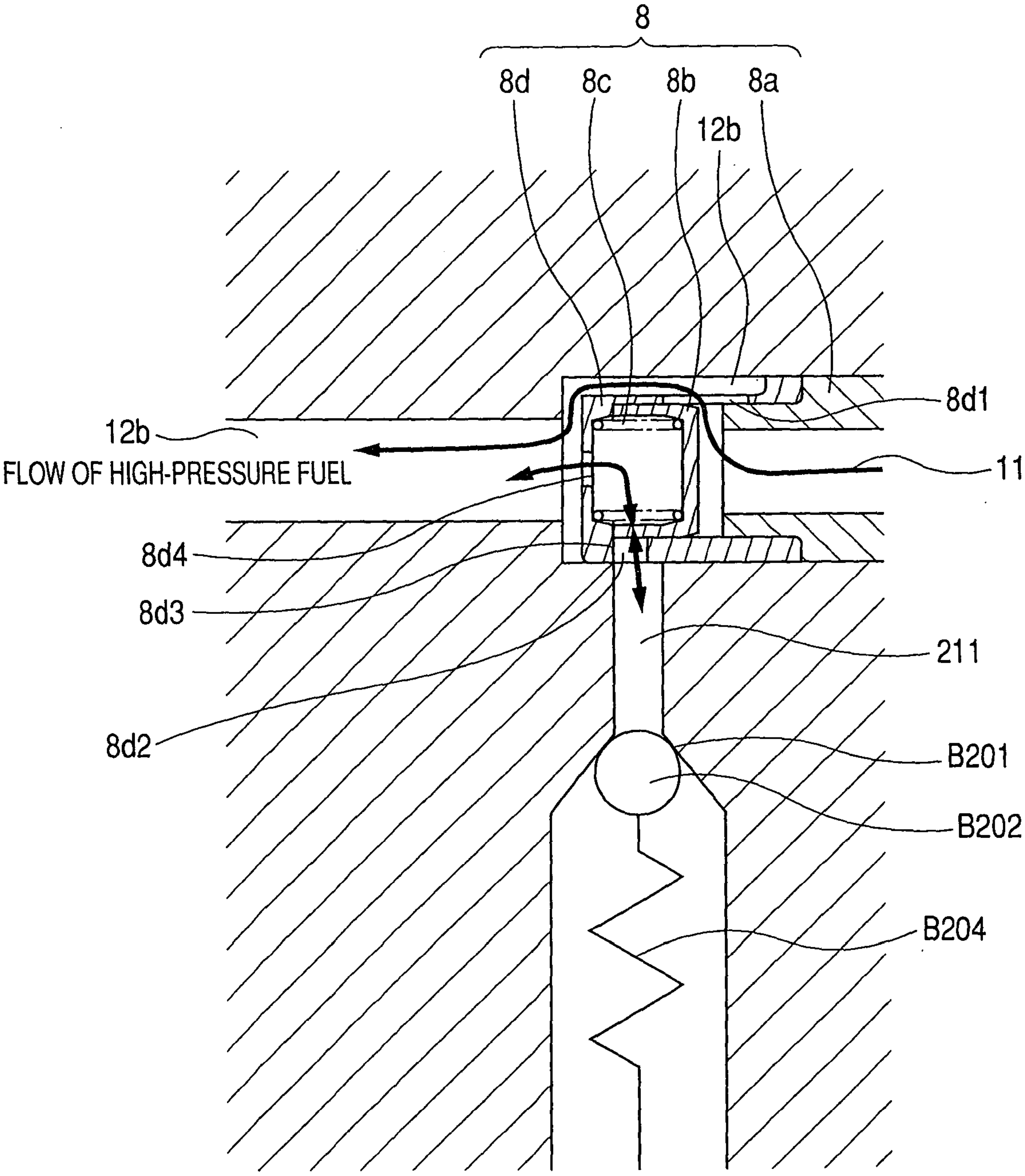

8
8d
8c
8b
8a
12b
8d1
12b
FLOW OF HIGH-PRESSURE FUEL
11
8d4
8d3
211
8d2
B201
B202
B204

FIG. 13

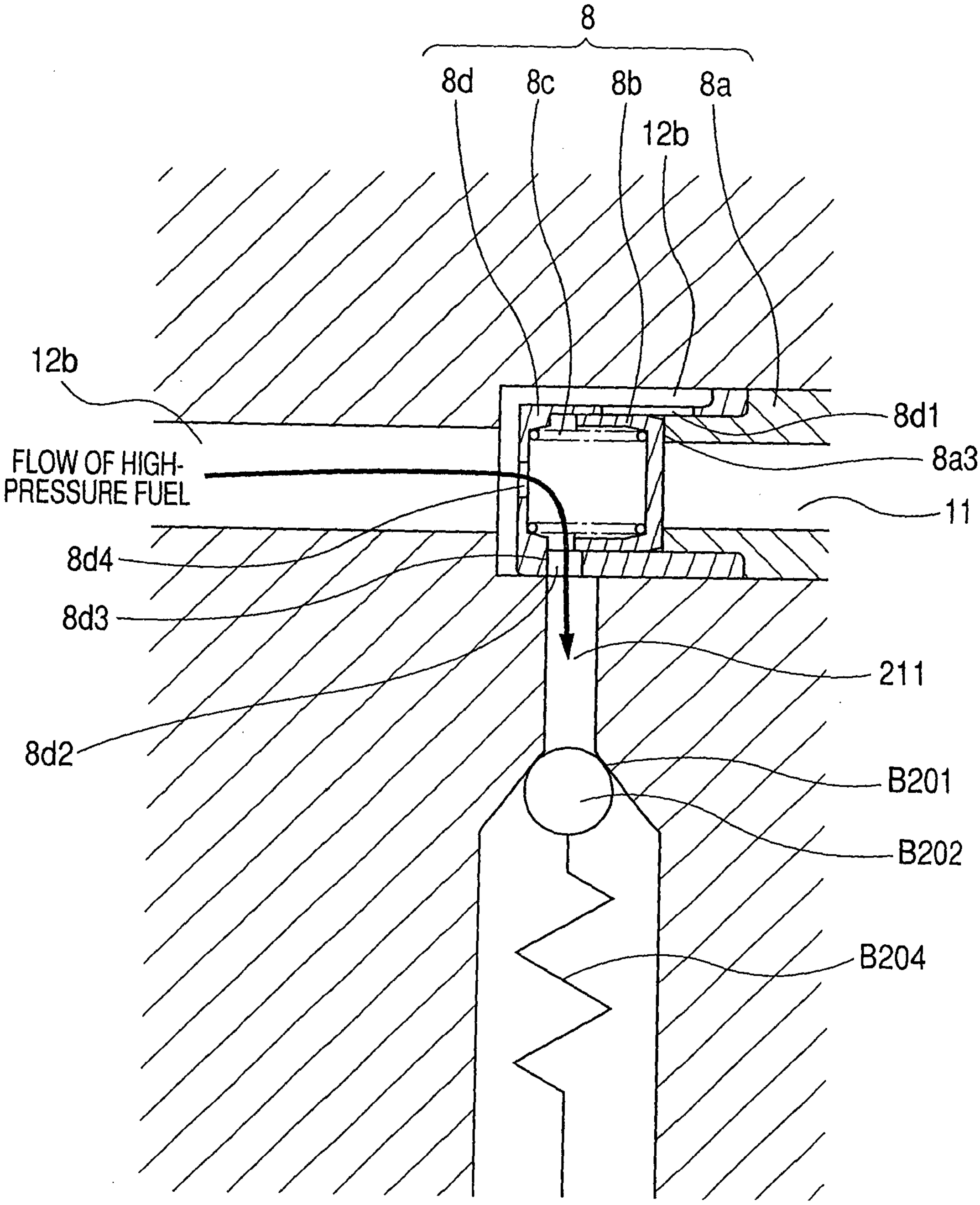

8
8d
8c
8b
8a
12b
12b
8d1
8a3
FLOW OF HIGH-PRESSURE FUEL
11
8d4
8d3
211
8d2
B201
B202
B204

FIG. 14

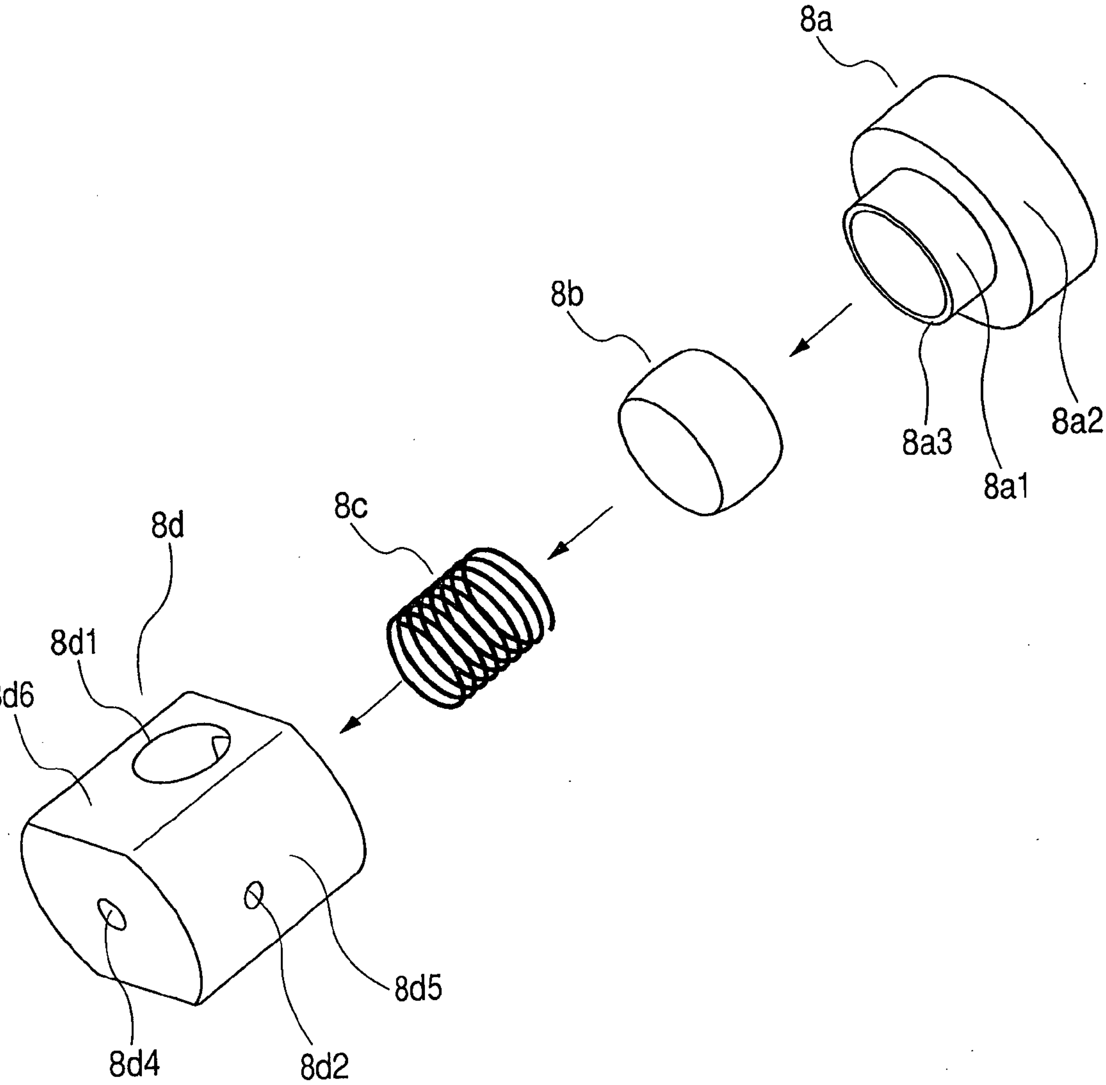


FIG. 15

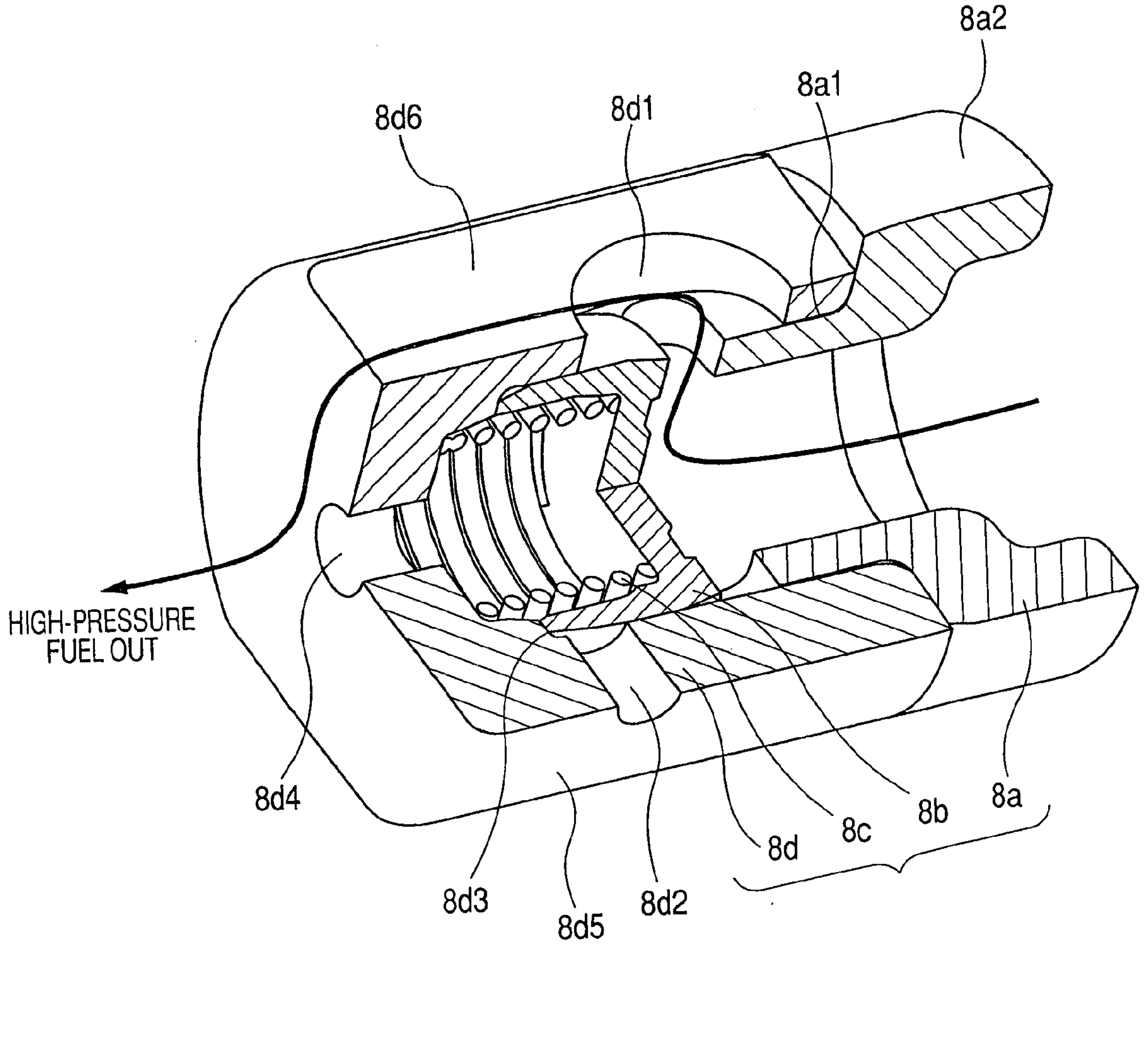

8a2
8d6
8d1
8a1
HIGH-PRESSURE
FUEL OUT
8d4
8d3
8d5
8d2
8d
8c
8b
8a

FIG. 16

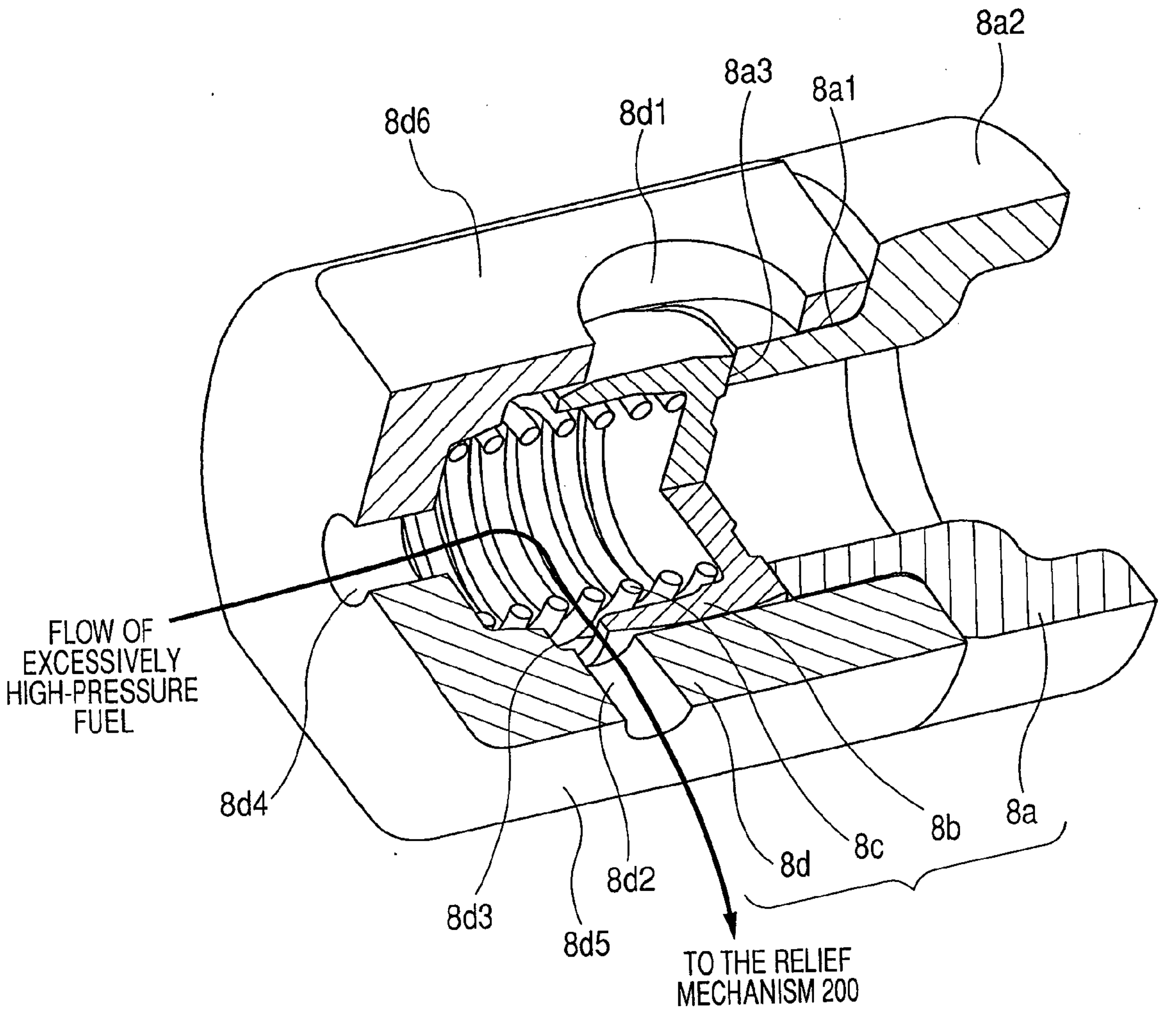

8a2
8a3
8a1
8d6
8d1
FLOW OF EXCESSIVELY HIGH-PRESSURE FUEL
8d4
8d3
8d5
8d2
8d
8c
8b
8a
TO THE RELIEF MECHANISM 200

FIG. 17

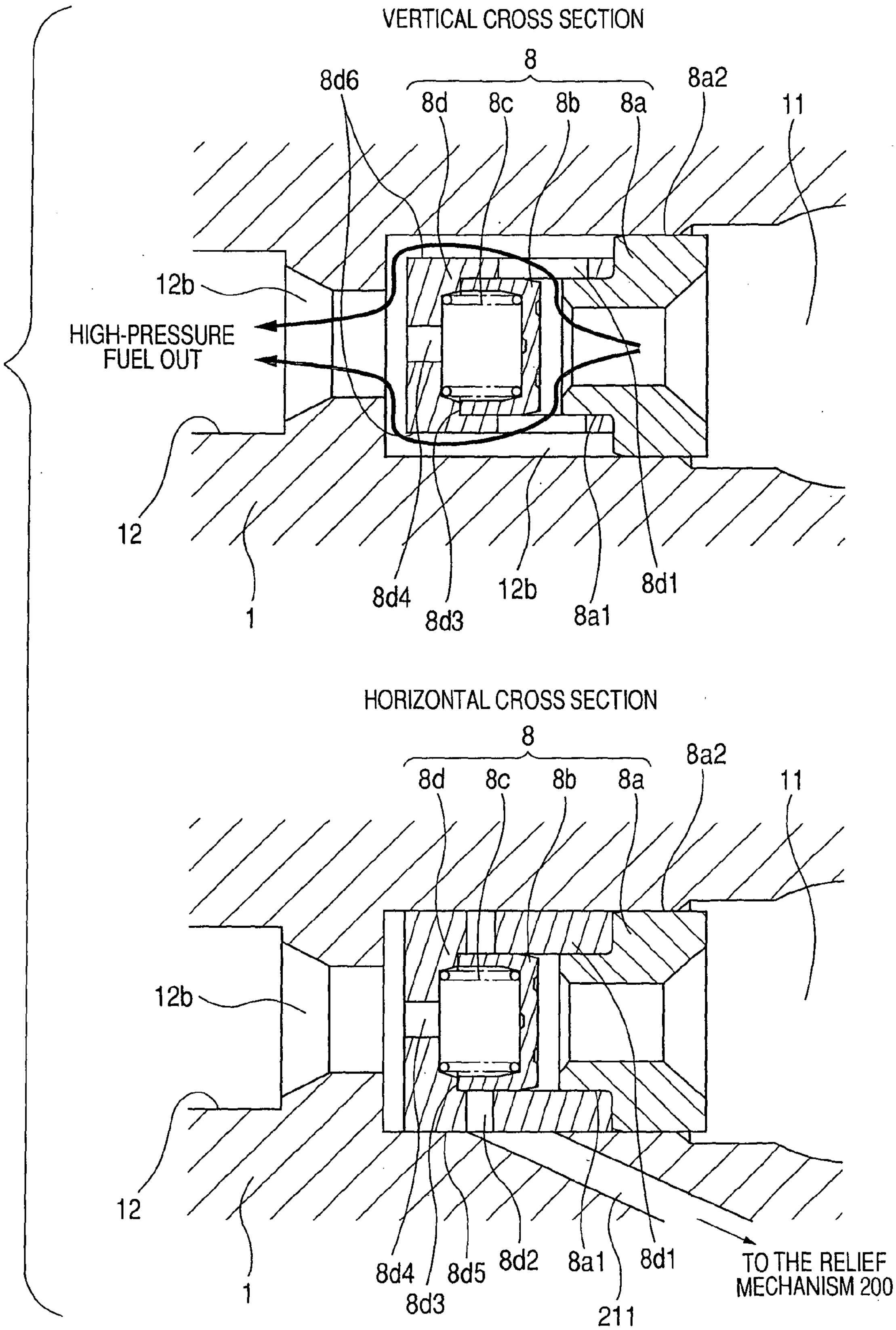
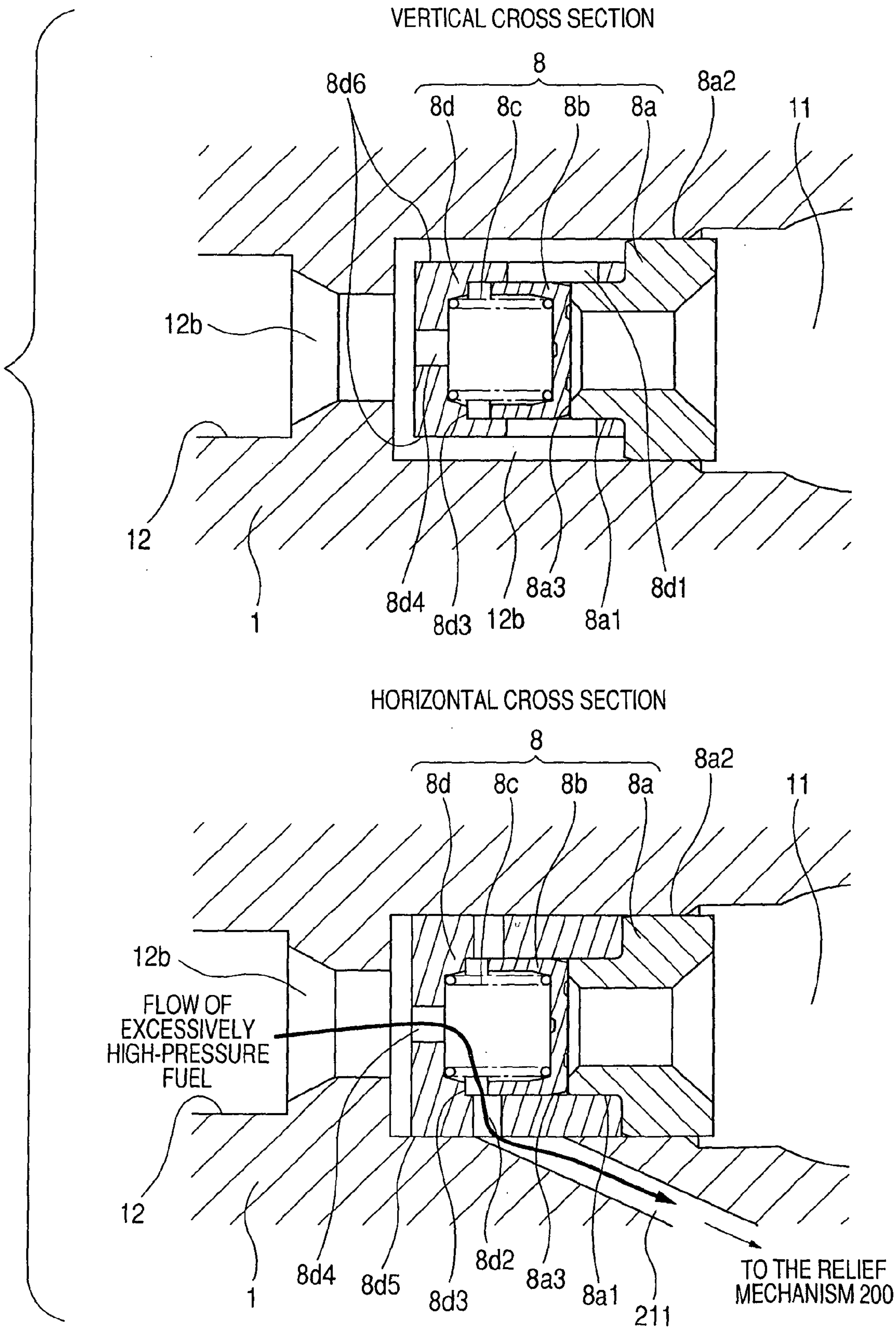

VERTICAL CROSS SECTION
8
8d6
8d
8c
8b
8a
8a2
11
12b
HIGH-PRESSURE FUEL OUT
12
1
8d4
8d3
12b
8a1
8d1
HORIZONTAL CROSS SECTION
8
8d
8c
8b
8a
8a2
11
12b
12
1
8d4
8d3
8d5
8d2
8a1
8d1
211
TO THE RELIEF MECHANISM 200

FIG. 18


VERTICAL CROSS SECTION
8
8d6
8d
8c
8b
8a
8a2
11
12b
12
1
8d4
8d3
12b
8a3
8a1
8d1
HORIZONTAL CROSS SECTION
8
8d
8c
8b
8a
8a2
11
12b
FLOW OF EXCESSIVELY HIGH-PRESSURE FUEL
12
1
8d4
8d5
8d3
8d2
8a3
8a1
211
TO THE RELIEF MECHANISM 200

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EUROPEAN SEARCH REPORT

Application Number
EP 07 01 5699

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Place of search	Date of completion of the search	Examiner
Munich	11 January 2008	Etschmann, Georg

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