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

(11) **EP 4 155 529 A1**

(12) # EUROPEAN PATENT APPLICATION
published in accordance with Art. 153(4) EPC

(43) Date of publication:
29.03.2023 Bulletin 2023/13

(21) Application number: **21809678.2**

(22) Date of filing: **05.02.2021**

(51) International Patent Classification (IPC):
F02M 59/46 *(2006.01)* ***F04B 53/10*** *(2006.01)*

(52) Cooperative Patent Classification (CPC):
F02M 59/46; F04B 53/10

(86) International application number:
PCT/JP2021/004252

(87) International publication number:
WO 2021/235019 (25.11.2021 Gazette 2021/47)

(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:
KH MA MD TN

(30) Priority: **21.05.2020 JP 2020088872**

(71) Applicant: **Hitachi Astemo, Ltd.**
Ibaraki 312-8503 (JP)

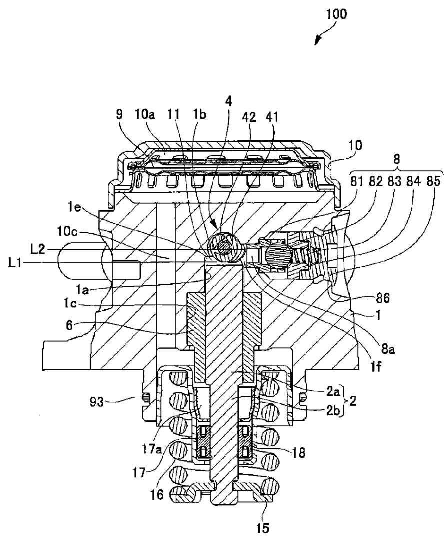
(72) Inventors:
- **HASHIDA, Minoru**
Hitachinaka-shi, Ibaraki 312-8503 (JP)
- **YAMADA, Hiroyuki**
Hitachinaka-shi, Ibaraki 312-8503 (JP)
- **OGURA, Kiyotaka**
Hitachinaka-shi, Ibaraki 312-8503 (JP)
- **TAMURA, Shingo**
Hitachinaka-shi, Ibaraki 312-8503 (JP)
- **USUI, Satoshi**
Hitachinaka-shi, Ibaraki 312-8503 (JP)
- **SAITO, Atsuji**
Hitachinaka-shi, Ibaraki 312-8503 (JP)

(74) Representative: **Strehl Schübel-Hopf & Partner**
Maximilianstrasse 54
80538 München (DE)

(54) **FUEL PUMP**

(57) Provided is a fuel pump capable of improving volumetric efficiency. The fuel pump of the present invention includes: a pump body 1 in which a pressurizing chamber 11 is formed; a plunger 2 that reciprocates in the pressurizing chamber 11; a discharge valve mechanism 8 that discharges fuel in the pressurizing chamber 11 to a discharge chamber 87; and a relief valve mechanism 4. The relief valve mechanism 4 opens when a difference between a pressure of the fuel in the discharge chamber 87 and a pressure of the fuel in the pressurizing chamber 11 exceeds a set value, and returns the fuel in the discharge chamber 87 to the pressurizing chamber 11. As viewed from a first direction along which the plunger 2 reciprocates, the discharge valve mechanism 8 and the relief valve mechanism 4 are disposed in a direction where the moving directions of the respective valve elements 82, 43 intersect with each other. The relief valve mechanism 4 is disposed at a position that overlaps with the pressurizing chamber 11 in the first direction and in a second direction that is a moving direction of the valve element 43 of the relief valve mechanism 4.

FIG. 3



EP 4 155 529 A1

Description

Technical Field

[0001] The present invention relates to a fuel pump that supplies fuel to an engine after pressurizing the fuel to a high pressure.

Background Art

[0002] As a fuel pump, there has been known a fuel pump described in PTL 1, for example. The high-pressure fuel supply pump described in PTL 1 includes a housing, an intake valve, a discharge valve, and a relief valve.

[0003] The housing has a cylinder in which a stepped cylindrical space is formed where a cylinder liner that slidably holds a plunger is accommodated and a pressurizing chamber is formed The intake valve is opened in a state where a current is not supplied to an electromagnetic solenoid, and when the current is supplied to the electromagnetic solenoid, the intake valve is opened so that a fuel is sucked into the pressurizing chamber.

[0004] The discharge valve is assembled to a discharge valve accommodating portion of the housing, and the discharge valve accommodating portion communicates with a pressurizing chamber through a fuel discharge hole. The high-pressure fuel obtained by pressurizing fuel in the pressurizing chamber is supplied to the discharge valve. The discharge valve is opened when the pressure of the supplied fuel becomes equal to or higher than a predetermined pressure, and the fuel that has passed through the discharge valve is pressure-fed to an accumulator.

[0005] A relief valve is assembled in a relief valve accommodating portion of the housing. The relief valve accommodating portion communicates with a high-pressure region on a downstream side of the discharge valve, and communicates with the pressurizing chamber through a communication passage. The relief valve is opened when the pressure of the fuel in the high-pressure region becomes equal to or higher than a specific pressure, and returns the high-pressure fuel to the pressurizing chamber.

Citation List

Patent Literature

[0006] PTL 1: JP 2018-523778 A

Summary of Invention

Technical Problem

[0007] However, in the high-pressure fuel supply pump described in PTL 1, a communication passage for making the discharge valve and the pressurizing chamber communicate with each other and a communication passage for making the relief valve and the pressurizing chamber communicate with each other are independently provided. As a result, in the high-pressure fuel supply pump described in PTL 1, a dead volume when the pressurizing chamber is filled with the fuel is increased and hence, volumetric efficiency of the pump is lowered.

[0008] The present invention has been made in view of the above-mentioned problems, and it is an object of the present invention to provide a fuel pump capable of enhancing volumetric efficiency.

Solution to Problem

[0009] In order to solve the above problems and to achieve the object of the present invention, a fuel pump of the present invention includes: a pump body in which a pressurizing chamber is formed; a plunger that reciprocates in the pressurizing chamber; a discharge valve mechanism that discharges fuel in the pressurizing chamber to a discharge chamber; and a relief valve mechanism. The relief valve mechanism opens when a difference between a pressure of the fuel in the discharge chamber and a pressure of the fuel in the pressurizing chamber exceeds a set value, and returns the fuel in the discharge chamber to the pressurizing chamber. As viewed from an axial direction of the plunger, the discharge valve mechanism and the relief valve mechanism are disposed in a direction where moving directions of the valves intersect with each other. The relief valve mechanism is disposed at a position where the relief valve overlaps with the pressurizing chamber in the axial direction of the plunger.

Advantageous Effects of Invention

[0010] According to the fuel pump having the above configuration, volumetric efficiency can be improved.

[0011] Problems, configurations, and advantageous effects other than those described above will be clarified by the following description of embodiments.

Brief Description of Drawings

[0012]

[FIG. 1] FIG. 1 is a view illustrating an overall configuration of a fuel supply system that uses a high-pressure fuel supply pump according to a first embodiment of the present invention.

[FIG. 2] FIG. 2 is a longitudinal cross-sectional view (part 1) of the high-pressure fuel supply pump according to the first embodiment of the present invention.

[FIG. 3] FIG. 3 is a longitudinal cross-sectional view (part 2) of the high-pressure fuel supply pump according to the first embodiment of the present invention.

[FIG. 4] FIG. 4 is a horizontal cross-sectional view of the high-pressure fuel supply pump according to the first embodiment of the present invention as viewed from above.

[FIG. 5] FIG. 5 is a perspective cross-sectional view with a part broken away of the high-pressure fuel supply pump according to the first embodiment of the present invention.

[FIG. 6] FIG. 6 is a longitudinal cross-sectional view of a high-pressure fuel supply pump according to a second embodiment of the present invention.

[FIG. 7] FIG. 7 is a perspective cross-sectional view with a part broken away of the high-pressure fuel supply pump according to the second embodiment of the present invention.

Description of Embodiments

1. First embodiment

[0013] A high-pressure fuel supply pump according to a first embodiment of the present invention is described hereinafter. In the respective drawings, the identical members are denoted by the same reference numerals.

[Fuel supply system]

[0014] A fuel supply system that uses a high-pressure fuel supply pump (fuel pump) according to a first embodiment will be described with reference to FIG. 1.

[0015] FIG. 1 is a view illustrating an overall configuration of the fuel supply system that uses the high-pressure fuel supply pump according to the first embodiment of the present invention.

[0016] As illustrated in FIG. 1, the fuel supply system includes a high-pressure fuel supply pump (fuel pump) 100, an engine control unit (ECU) 101, a fuel tank 103, a common rail 106, and a plurality of injectors 107. Components of the high-pressure fuel supply pump 100 are integrally incorporated in the pump body 1.

[0017] Fuel in the fuel tank 103 is pumped up by a feed pump 102 that is driven in response to a signal from the ECU 101. The pumped-up fuel is pressurized to an appropriate pressure by a pressure regulator (not illustrated) and is supplied to a low-pressure fuel intake port 51 of the high-pressure fuel supply pump 100 through a low-pressure pipe 104.

[0018] The high-pressure fuel supply pump 100 pressurizes the fuel supplied from the fuel tank 103, and pressure-feeds the fuel to the common rail 106. A plurality of injectors 107 and a fuel pressure sensor 105 are mounted on the common rail 106. The plurality of injectors 107 are mounted corresponding to the number of cylinders (combustion chambers), and inject fuel in response to a drive current outputted from the ECU 101. The fuel supply system of the present embodiment is a so-called direct injection engine system where each injector 107 directly injects fuel into each cylinder of the engine.

[0019] The fuel pressure sensor 105 outputs detected pressure data to the ECU 101. The ECU 101 calculates an appropriate injection fuel amount (target injection fuel length), an appropriate fuel pressure (target fuel pressure), and the like based on quantities of states of the engine (for example, a crank rotation angle, a throttle opening, an engine rotational speed, a fuel pressure, and the like) obtained from various sensors.

[0020] In addition, the ECU 101 controls driving of the high-pressure fuel supply pump 100 and driving of the plurality of injectors 107 on the basis of a calculation result of a fuel pressure (target fuel pressure) and the like. That is, the ECU 101 includes: a pump control unit that controls the high-pressure fuel supply pump 100; and an injector control unit that controls the injector 107.

[0021] The high-pressure fuel supply pump 100 includes a pressure pulsation reduction mechanism 9, an electromagnetic intake valve mechanism 3 that is a variable capacity mechanism, a relief valve mechanism 4 (see FIG. 2), and a discharge valve mechanism 8. The fuel that flows from the low-pressure fuel intake port 51 reaches an intake port 31b of the electromagnetic intake valve mechanism 3 through the pressure pulsation reduction mechanism 9 and the intake passage 10b.

[0022] The fuel that flows into the electromagnetic intake valve mechanism 3 passes through a valve element 32, flows through an intake passage 1d formed in the pump body 1, and then flows into a pressurizing chamber 11. A plunger 2 is inserted into the pressurizing chamber 11 in a reciprocating manner. Power is transmitted to the plunger 2 by way of a cam (not illustrated) of the engine, and the plunger 2 reciprocates.

[0023] In the pressurizing chamber 11, fuel is sucked from the electromagnetic intake valve mechanism 3 in a downward stroke of the plunger 2, and the fuel is pressurized in an upward stroke. When the fuel pressure in the pressurizing chamber 11 exceeds a predetermined value, the discharge valve mechanism 8 is opened, and the high-pressure fuel is pressure-fed to the common rail 106 through a discharge passage 12a. The discharge of the fuel by the high-pressure fuel supply pump 100 is operated by opening and closing the electromagnetic intake valve mechanism 3. The opening and closing of the electromagnetic intake valve mechanism 3 is controlled by the ECU 101.

[High-pressure fuel supply pump]

[0024] Next, the configuration of the high-pressure fuel supply pump 100 will be described with reference to FIG. 2 to FIG. 5.

[0025] FIG. 2 is a longitudinal cross-sectional view (part 1) of the high-pressure fuel supply pump 100 as viewed in cross section orthogonal to the horizontal direction. FIG. 3 is a longitudinal cross-sectional view (part 2) of the high-pressure fuel supply pump 100 as viewed in cross section orthogonal to the horizontal direction. FIG. 4 is a horizontal-direction cross-sectional view of the high-pressure fuel supply pump 100 as viewed in cross section orthogonal to a vertical direction of the high-pressure fuel supply pump 100. FIG. 5 is a perspective cross-sectional view with a part broken away of the high-pressure fuel supply pump 100.

[0026] As illustrated in FIG. 2 to FIG. 5, a pump body 1 of the high-pressure fuel supply pump 100 is formed in a substantially circular columnar shape. As illustrated in FIG. 2 and FIG. 3, the pump body 1 includes a first chamber 1a, a second chamber 1b, a third chamber 1c, and an intake passage 1d.

[0027] The first chamber 1a is a circular columnar space portion formed in the pump body 1. A center line 1A of the first chamber 1a agrees with a center line of the pump body 1. One end portion of the plunger 2 is inserted into the first chamber 1a. The plunger 2 reciprocates in the first chamber 1a. The first chamber 1a and one end of the plunger 2 form a pressurizing chamber 11.

[0028] The second chamber 1b is a circular columnar space portion formed in the pump body 1, and a center line of the second chamber 1b is orthogonal to the center line of the pump body 1 (first chamber 1a). The relief valve mechanism 4 is disposed in the second chamber 1b. Therefore, the second chamber 1b illustrates a specific example of a relief chamber according to the present invention. A diameter of the second chamber 1b is smaller than a diameter of the first chamber 1a.

[0029] The first chamber 1a and the second chamber 1b communicate with each other through a circular communication hole 1e. A diameter of the communication hole 1e is equal to the diameter of the first chamber 1a. The communication hole 1e is formed by extending one end of the first chamber 1a. A diameter of the communication hole 1e is larger than an outer diameter of the plunger 2. A center line 1A of the communication hole 1e agrees with the center line of the pump body 1. The center line of the communication hole 1e is orthogonal to the center line of the second chamber 1b. As illustrated in FIG. 3, a diameter of the communication hole 1e is larger than a diameter of the second chamber 1b.

[0030] A third chamber 1c is a circular columnar space portion formed in the pump body 1. The third chamber 1c is continuously formed with the other end of the first chamber 1a. A center line 1A of the third chamber 1c agrees with the center line 1A of the first chamber 1a and the center line of the pump body 1. A diameter of the third chamber 1c is larger than the diameter of the first chamber 1a. A cylinder 6 that guides the reciprocation of the plunger 2 is disposed in the third chamber 1c.

[0031] The cylinder 6 is formed in a cylindrical shape, and an outer peripheral side of the cylinder 6 is press-fitted into the third chamber 1c of the pump body 1. One end of the cylinder 6 is brought into contact with a top surface of the third chamber 1c (step portion formed between the first chamber 1a and the third chamber 1c). The plunger 2 is in brought into contact with an inner peripheral surface of the cylinder 6 in a slidable manner. The plunger 2 is guided by the cylinder 6 and reciprocates in the axial direction.

[0032] An O-ring 93 that illustrates a specific example of a seat member is interposed between a fuel pump mounting portion (not shown) and the pump body 1. The O-ring 93 prevents engine oil from leaking to the outside of an engine (internal combustion engine) through between the fuel pump mounting portion and the pump body 1.

[0033] A tappet (not illustrated) is mounted on a lower end of the plunger 2. The tappet converts a rotational motion of a cam mounted on a cam shaft of the engine into a vertical motion and transmits the vertical motion to the plunger 2. The plunger 2 is biased toward a cam (not illustrated) side by a spring 16 by way of a retainer 15. The tappet reciprocates due to the rotation of the cam. The plunger 2 reciprocates together with the tappet. As a result of the reciprocation of the plunger, a volume of the pressurizing chamber 11 changes.

[0034] A seal holder 17 is disposed between the cylinder 6 and the retainer 15. The seal holder 17 is formed in a cylindrical shape so as to allow the insertion of the plunger 2 into the seal holder 17. An auxiliary chamber 17a is formed in an upper end portion of the seal holder 17 on a cylinder 6 side. In addition, the seal holder 17 holds a plunger seal 18 at a lower end portion of the seal holder 17 on a retainer 15 side.

[0035] The plunger seal 18 is brought into contact with an outer periphery of the plunger 2 in a slidable manner. The plunger seal 18 seals fuel in the auxiliary chamber 17a. With such a configuration, when the plunger 2 reciprocates, it is possible to prevent the fuel in the auxiliary chamber 17a from flowing into the engine. In addition, the plunger seal 18 also prevents lubricating oil (including engine oil) that lubricates sliding portions in the engine from flowing into the pump body 1.

[0036] In FIG. 2 and FIG. 3, the plunger 2 reciprocates in the vertical direction. When the plunger 2 descends, the volume of the pressurizing chamber 11 is increased, and when the plunger 2 ascends, the volume of the pressurizing chamber 11 is decreased. That is, the plunger 2 is disposed so as to reciprocate in directions of enlarging and reducing the volume of the pressurizing chamber 11.

[0037] The plunger 2 has a large diameter portion 2a and a small diameter portion 2b. When the plunger 2 reciprocates, the large diameter portion 2a and the small diameter portion 2b are positioned in the auxiliary chamber 17a. Accordingly, the volume in the auxiliary chamber 17a is increased or decreased by the reciprocation of the plunger 2.

[0038] The auxiliary chamber 17a communicates with a low-pressure fuel chamber 10 through a fuel passage 10c (see FIG. 3). When the plunger 2 descends, fuel flows from the auxiliary chamber 17a to the low-pressure fuel chamber 10, and when the plunger 2 ascends, fuel flows from the low-pressure fuel chamber 10 to the auxiliary chamber 17a. As a result, in an intake stroke or a return stroke of the high-pressure fuel supply pump 100, a flow rate of fuel into and out of the pump can be reduced and hence, the pressure pulsation generated in the high-pressure fuel supply pump 100 can be reduced.

[0039] As illustrated in FIG. 4, an intake joint 5 is mounted on a side surface portion of the pump body 1. The intake joint 5 is connected to the low-pressure pipe 104 through which fuel supplied from the fuel tank 103 (see FIG. 1) passes. The fuel in the fuel tank 103 is supplied from the intake joint 5 to the inside of the pump body 1.

[0040] The intake joint 5 includes: the low-pressure fuel intake port 51 that is connected to the low-pressure pipe 104; and an intake flow passage 52 that communicates with the low-pressure fuel intake port 51. The fuel that has passed through the intake flow passage 52 passes through an intake filter 53 disposed in the pump body 1 and is supplied to the low-pressure fuel chamber 10. The intake filter 53 removes foreign substances present in the fuel thus preventing the foreign substances from entering the high-pressure fuel supply pump 100.

[0041] As illustrated in FIG. 2 and FIG. 3, the low-pressure fuel chamber 10 is formed on an upper portion of the pump body 1 of the high-pressure fuel supply pump 100. The low-pressure fuel chamber 10 includes a low-pressure fuel flow passage 10a and an intake passage 10b (see FIG. 2). The low-pressure fuel flow passage 10a includes the pressure pulsation reduction mechanism 9. When the fuel that flows into the pressurizing chamber 11 is again returned to the intake passage 10b through the electromagnetic intake valve mechanism 3 in a valve open state, the pressure pulsation occurs in the low-pressure fuel chamber 10. The pressure pulsation reduction mechanism 9 reduces the propagation of the pressure pulsation generated in the high-pressure fuel supply pump 100 to the low-pressure pipe 104.

[0042] The pressure pulsation reduction mechanism 9 is formed of a metal diaphragm damper in which an inert gas such as argon is filled. The metal diaphragm damper is formed by laminating outer peripheries of two corrugated disk-shaped metal plates to each other. The metal diaphragm damper of the pressure pulsation reduction mechanism 9 expands and contracts so as to absorb or reduce the pressure pulsation.

[0043] The intake passage 10b communicates with the intake port 31b (see FIG. 2) of the electromagnetic intake valve mechanism 3, and fuel that passes through the low-pressure fuel flow passage 10a reaches the intake port 31b of the electromagnetic intake valve mechanism 3 through the intake passage 10b.

[0044] As illustrated in FIG. 2 and FIG. 4, the electromagnetic intake valve mechanism 3 is inserted into a lateral hole formed in the pump body 1. The electromagnetic intake valve mechanism 3 includes: an intake valve seat 31 that is press-fitted into a lateral hole formed in the pump body 1; a valve element 32; a rod 33; a rod biasing spring 34; an electromagnetic coil 35; and an anchor 36.

[0045] The intake valve seat 31 is formed in a cylindrical shape, and a seating portion 31a is formed on an inner peripheral portion. An intake port 31b that reaches an inner peripheral portion from an outer peripheral portion is also formed in the intake valve seat 31. The intake port 31b communicates with the intake passage 10b in the low-pressure fuel chamber 10 described above.

[0046] A stopper 37 that faces the seating portion 31a of the intake valve seat 31 is disposed in the lateral hole formed in the pump body 1. The valve element 32 is disposed between the stopper 37 and the seating portion 31a. A valve biasing spring 38 is interposed between the stopper 37 and the valve element 32. The valve biasing spring 38 biases the valve element 32 toward a seating portion 31a side.

[0047] When the valve element 32 is brought into contact with the seating portion 31a, the valve element 32 closes a communicating portion formed between the intake port 31b and the pressurizing chamber 11. As a result, the electromagnetic intake valve mechanism 3 assumes a valve closing state. On the other hand, when the valve element 32 is brought into contact with the stopper 37, the valve element 32 opens the communicating portion formed between the intake port 31b and the pressurizing chamber 11. As a result, the electromagnetic intake valve mechanism 3 assumes a valve open state.

[0048] The rod 33 penetrates a cylinder hole of the intake valve seat 31. One end of the rod 33 is brought into contact with the valve element 32. The rod biasing spring 34 biases the valve element 32 in the valve opening direction which is a stopper 37 side by way of the rod 33. One end of the rod biasing spring 34 engages with the other end of the rod 33. The other end of the rod biasing spring 34 engages with a magnetic core 39 disposed so as to surround the rod biasing spring 34.

[0049] The anchor 36 faces an end surface of the magnetic core 39. The anchor 36 also engages with a flange mounted on an intermediate portion of the rod 33. The electromagnetic coil 35 is disposed around the whole circumference of the magnetic core 39. A terminal member 40 is electrically connected to the electromagnetic coil 35, and a current flows to the electromagnetic coil 35 through the terminal member 40.

[0050] In a non-energized state where a current is not supplied to the electromagnetic coil 35, the rod 33 is biased in a valve opening direction by a biasing force of the rod biasing spring 34. As a result, the rod 33 pushes the valve element 32 in the valve opening direction. As a result, the valve element 32 is separated from the seating portion 31a and is brought into contact with the stopper 37 and hence, the electromagnetic intake valve mechanism 3 assumes a valve open state. That is, the electromagnetic intake valve mechanism 3 is a normally open type valve that opens in a non-energized state.

[0051] When the electromagnetic intake valve mechanism 3 is in a valve open state, fuel in the intake port 31b passes between the valve element 32 and the seating portion 31a, and flows into the pressurizing chamber 11 passing through a plurality of fuel passing holes (not illustrated) formed in the stopper 37 and the intake passage 1d. In the valve open state of the electromagnetic intake valve mechanism 3, the valve element 32 comes into contact with the stopper 37, so that the position of the valve element 32 in the valve opening direction is restricted. In a valve open state of the electromagnetic intake valve mechanism 3, a gap existing between the valve element 32 and the seating portion 31a is a movable range of the valve element 32. That is, in a valve open state of the electromagnetic intake valve mechanism 3, the gap existing between the valve element 32 and the seating portion 31a is a valve opening stroke.

[0052] When a current is supplied to the electromagnetic coil 35, the anchor 36 is attracted in a valve closing direction by a magnetic attractive force of the magnetic core 39. As a result, the anchor 36 moves against a biasing force of the rod biasing spring 34, and is brought into contact with the magnetic core 39. When the anchor 36 moves in the valve closing direction on a magnetic core 39 side, the rod 33 moves together with the anchor 36. As a result, the valve element 32 is released from a biasing force in the valve opening direction, and moves in the valve closing direction by a biasing force of the valve biasing spring 38.

[0053] Then, when the valve element 32 is brought into contact with the seating portion 31a of the intake valve seat 31, the electromagnetic intake valve mechanism 3 assumes a valve closing state.

[0054] As illustrated in FIG. 3 and FIG. 4, the discharge valve mechanism 8 is connected to an outlet side (downstream side) of the pressurizing chamber 11. The discharge valve mechanism 8 includes: a discharge valve seat 81 that communicates with the pressurizing chamber 11, a valve element 82 that is brought into contact with and is separable from the discharge valve seat 81; a discharge valve spring 83 that biases the valve element 82 toward a discharge valve seat 81 side; and a discharge valve stopper 84 that determines a stroke (moving distance) of the valve element 82.

[0055] The discharge valve seat 81 is formed in a substantially cylindrical shape. The discharge valve seat 81 has a seat passage 8a which is a shaft hole. The seat passage 8a forms a passage on a pressurizing chamber 11 side in the discharge valve mechanism 8. A discharge valve inlet passage 1f that allows the pressurizing chamber 11 and the seat passage 8a to communicate with each other is formed in the pump body 1. The discharge valve inlet passage 1f also communicates with the second chamber 1b (relief chamber) besides the pressurizing chamber 11.

[0056] The valve element 82 faces an end surface of the discharge valve seat 81 on a side opposite to a pressurizing chamber 11 side.

[0057] The valve element 82 is biased toward a discharge valve seat 81 side and is pressed against the discharge valve seat 81 by the discharge valve spring 83. When the valve element 82 is separated from the discharge valve seat 81, fuel in the pressurizing chamber 11 can pass through between the valve element 82 and the discharge valve seat 81. As a result, the discharge valve mechanism 8 assumes a valve open state.

[0058] The discharge valve mechanism 8 includes a plug 85 that blocks leakage of fuel to the outside. The discharge valve stopper 84 is press-fitted into the plug 85. The plug 85 is joined to the pump body 1 by welding at a welded portion 86. As illustrated in FIG. 4, the discharge valve mechanism 8 communicates with a discharge chamber 87 that is opened and closed by the valve element 82. The discharge chamber 87 is formed in the pump body 1.

[0059] A lateral hole that communicates with the second chamber 1b (see FIG. 2) is formed in the pump body 1, and a discharge joint 12 is inserted into the lateral hole. The discharge joint 12 includes: the above discharge passage 12a that communicates with the lateral hole formed in the pump body 1 and the discharge chamber 87; and a fuel discharge port 12b that forms one end of the discharge passage 12a. The fuel discharge port 12b of the discharge joint 12 communicates with the common rail 106. The discharge joint 12 is fixed to the pump body 1 by welding by a welded portion 12c.

[0060] In a state where there is no difference in fuel pressure (fuel differential pressure) between the pressurizing chamber 11 and the discharge chamber 87, the valve element 82 is brought into pressure contact with the discharge valve seat 81 by a biasing force of the discharge valve spring 83. As a result, the discharge valve mechanism 8 assumes a valve closing state. When the fuel pressure in the pressurizing chamber 11 becomes larger than the fuel pressure in the discharge chamber 87, the valve element 82 moves against the biasing force of the discharge valve spring 83. As a result, the discharge valve mechanism 8 assumes a valve open state.

[0061] The moving direction of the valve element 82 in the discharge valve mechanism 8 is orthogonal to the direction that the plunger 2 reciprocates. The direction that the plunger 2 reciprocates corresponds to the first direction according to the present invention. The moving direction of the valve element 82 in the discharge valve mechanism 8 corresponds to the third direction according to the present invention.

[0062] When the discharge valve mechanism 8 is brought into a valve closed state, the (high-pressure) fuel in the pressurizing chamber 11 passes through the discharge valve mechanism 8, and reaches the discharge chamber 87. Then, the fuel that has reached the discharge chamber 87 is discharged to the common rail 106 (see FIG. 1) through the fuel discharge port 12b of the discharge joint 12. With the above configuration, the discharge valve mechanism 8 functions as a check valve that restricts the flowing direction of the fuel.

[0063] When any problem occurs in the common rail 106 or a member succeeding to the common rail 106 so that the pressure in the common rail 106 becomes higher than a predetermined pressure, the relief valve mechanism 4 illustrated in FIG. 2 is operated so as to return the fuel in the discharge passage 12a to the pressurizing chamber 11. As described in FIG. 5, the relief valve mechanism 4 is disposed at the position higher than the discharge valve mechanism 8 (see FIG. 5) in the direction (vertical direction) that the plunger 2 reciprocates.

[0064] As illustrated in FIG. 2, the relief valve mechanism 4 includes a relief spring 41, a relief valve holder 42, a valve element 43, and a seat member 44. The relief valve mechanism 4 is inserted into the pump body 1 from the discharge joint 12 and is disposed in the second chamber 1b. One end portion of the relief spring 41 is brought into contact with the pump body 1 (one end of the second chamber 1b), and the other end portion of the relief valve 41 is brought into contact with the relief valve holder 42.

[0065] The relief valve holder 42 engages with the valve element 43. A biasing force of the relief spring 41 acts on the valve element 43 by way of the relief valve holder 42.

[0066] The valve element 43 is pressed by the biasing force of the relief spring 41 so that the valve element 43 closes the fuel passage in the seat member 44. The moving direction of the valve element 43 (relief valve holder 42) is orthogonal to the direction that the plunger 2 reciprocates. The center line of the relief valve mechanism 4 (the center line of the relief valve holder 42) is orthogonal to the center line of the plunger 2. The moving direction of the valve element 43 in the relief valve mechanism 4 corresponds to the second direction according to the present invention.

[0067] The seat member 44 has a fuel passage that faces the valve element 43. A portion of the fuel passage formed in the seat member 44 on a side opposite to the valve element 43 communicates with the discharge passage 12a. The valve element 43 is brought into contact (close contact) with the seat member 44 so as to close the fuel passage. With such a configuration, the movement of fuel between the pressurizing chamber 11 (upstream side) and the seat member 44 (downstream side) is blocked.

[0068] When the pressure in the common rail 106 or a member succeeding to the common rail 106 is increased, a difference between a pressure of the fuel on a seat member 44 side (discharge chamber 87) and a pressure of the fuel in the pressurizing chamber 11 exceeds a set value. Accordingly, the fuel on the seat member 44 side presses the valve element 43, and moves the valve element 43 against a biasing force of the relief spring 41. As a result, the relief valve mechanism 4 is opened so that the fuel in the discharge chamber 87 and the discharge passage 12a returns to the pressurizing chamber 11 through the fuel passage formed in the seat member 44. In this manner, the pressure for opening the valve element 43 is determined based on a biasing force of the relief spring 41.

[Positional relationship among relief valve mechanism, discharge valve mechanism, and pressurizing chamber]

[0069] Next, the positional relationship among the relief valve mechanism 4, the discharge valve mechanism 8, and the pressurizing chamber 11 will be described.

[0070] As illustrated in FIG. 4 and FIG. 5, as viewed from the direction that the plunger 2 reciprocates, the moving direction of the valve element 43 (see FIG. 5) in the relief valve mechanism 4 differs from the moving direction of the valve element 82 in the discharge valve mechanism 8. That is, as viewed from the direction that the plunger 2 reciprocates, the moving direction of the valve element 43 in the relief valve mechanism 4 intersects with the moving direction of the valve element 82 in the discharge valve mechanism 8. As a result, the discharge valve mechanism 8 and the relief valve mechanism 4 can be disposed at positions that do not overlap with each other in the direction that the plunger 2 reciprocates. Accordingly, downsizing of the pump body 1 can be realized by effectively making use of the space in the pump body 1.

[0071] As illustrated in FIG. 4, the moving direction of the valve element 82 in the discharge valve mechanism 8 is the first radial direction of the pump body 1, and the moving direction of the valve element 43 in the relief valve mechanism 4 is the second radial direction that differs from the first radial direction of the pump body 1. An angle at which the first radial direction and the second radial direction illustrated in FIG. 4 intersect with each other is smaller than 90 degrees. However, the angle at which the first radial direction and the second radial direction intersect with each other may be approximately 90 degrees. As viewed from the direction along which the plunger 2 reciprocates, the discharge valve mechanism 8 and the relief valve mechanism 4 are disposed in a direction where the moving direction of the valve element 82 and the moving direction of the valve element 43 intersect with each other.

[0072] As illustrated in FIG. 2 and FIG. 4, the relief valve mechanism 4 is disposed at the position that overlaps with the pressurizing chamber 11 in the reciprocating direction of the plunger 2 and the moving direction of the valve element 43 of the relief valve mechanism 4. With such a configuration, it is unnecessary to form a passage for making the relief valve mechanism 4 and the pressurizing chamber 11 communicate with each other. As a result, a dead volume of the pressurizing chamber 11 can be reduced compared with a case where it is necessary to form a passage for making the relief valve mechanism 4 and the pressurizing chamber 11 communicate with each other. Accordingly, the volumetric efficiency of the pressurizing chamber 11 can be improved.

[0073] The volumetric efficiency is a ratio of a discharge amount of fuel discharged from the discharge valve mechanism 8 with respect to a moving distance from a bottom dead center of the plunger 2 where a volume of the pressurizing chamber 11 becomes the largest to a top dead center of the plunger 2 where the volume of the pressurizing chamber 11 becomes the smallest. The bottom dead center of the plunger 2 is the position where the plunger 2 is at the lowermost end (cam side of the engine). The top dead center of the plunger is the position where the plunger 2 is at the uppermost end.

[0074] As illustrated in FIG. 2, as viewed from the direction that the plunger 2 reciprocates and the direction that is orthogonal to the moving direction of the valve element 43 of the relief valve mechanism 4, the relief valve mechanism 4 overlaps with the entire region of the pressurizing chamber 11 parallel to the moving direction of the valve element 43 of the relief valve mechanism 4. With such a configuration, fuel that passes through the relief valve mechanism 4 can be efficiently returned to the pressurizing chamber 11.

[0075] As illustrated in FIG. 3 and FIG. 5, the discharge valve mechanism 8 is disposed at the position that overlaps with the relief valve mechanism 4 as viewed in the moving direction of the valve element 82 of the discharge valve mechanism 8. With such a configuration, a length of the pump body 1 in the direction that the plunger 2 reciprocates (a length of the pump body 1 in the axial direction) can be shortened. Accordingly, downsizing of the pump body 1 can be realized.

[0076] Further, a lower end L1 of the second chamber 1b (relief chamber) in which the relief valve mechanism 4 is disposed is arranged at a position closer to the plunger 2 in the reciprocating direction of the plunger 2 than the upper end L2 of the seat passage 8a in the discharge valve mechanism 8. Further, an upper end of the seat passage 8a in the discharge valve mechanism 8 is higher than an upper surface of the plunger 2 (see FIG. 6) that is positioned at the top dead center.

[0077] As illustrated in FIG. 5, an upper end of the relief valve mechanism 4 is disposed at a position remoter from the plunger 2 than an upper end of the discharge valve mechanism 8 in the reciprocating direction of the plunger 2. Further, as illustrated in FIG. 3, the relief valve mechanism 4 is disposed at the position that overlaps with the discharge valve mechanism 8 as viewed in the horizontal direction orthogonal to the reciprocating direction of the plunger 2. With such a configuration, a length of the pump body 1 in the direction that the plunger 2 reciprocates (a length of the pump body 1 in the axial direction) can be shortened. Accordingly, downsizing of the pump body 1 can be realized.

[0078] In the present embodiment, the first chamber 1a and the second chamber 1b formed in the pump body 1 partially overlap with each other. The discharge valve inlet passage 8a directly communicates with the first chamber 1a and the second chamber 1b. As a result, the dead volume of the pressurizing chamber 11 can be reduced, and the downsizing of the pump body 1 can be realized.

[0079] Conventionally, the discharge valve inlet passage communicates only with the first chamber. In this case, if the plunger that is positioned at the top dead center blocks the discharge valve inlet passage, a sufficient amount of fuel does not flow into the discharge valve mechanism. Therefore, conventionally, it is necessary to secure a space in the pump body in the direction that the plunger reciprocates, and to dispose the discharge valve inlet passage at the position where the discharge valve inlet passage is not closed by the plunger located at the top dead center.

[0080] On the other hand, in the high-pressure fuel supply pump 100 according to the present embodiment, the discharge valve inlet passage 8a communicates with not only the first chamber 1a but also the second chamber 1b. Accordingly, even if a space is not secured in the direction that the plunger 2 reciprocates in the pump body 1, it is possible to allow a sufficient amount of fuel to flow into the discharge valve mechanism. In addition, the configuration of the passage that communicates with the first chamber 1a can be simplified and hence, a working cost can be reduced. Furthermore, the discharge valve inlet passage 8a can be formed with a large diameter, a pressure loss is reduced. Accordingly, this configuration can also contribute to the enhancement of performance.

[0081] When holes such as the first chamber 1a, the second chamber 1b, the communication hole 1e and the like are formed in the pump body 1 by working, undesired protrusions (burrs) are formed on worked surfaces. If the protrusions (burrs) are left as it is, a dimensional error occurs with respect to the holes and hence, adverse effects such as a defect that a component cannot be mounted or an operator is injured when the operator touches the protrusion (burr). Therefore, it is necessary to remove the protrusions (burrs). In the above-described embodiment, the diameter of the communication hole 1e is equal to the diameter of the first chamber 1a. Therefore, the working of the communication hole 1e can be performed easily, and the protrusions (burrs) can be easily removed. In addition, it is possible to prevent the shape of the pump body 1 from becoming complicated. Therefore, the productivity of the pump body 1 and the high-pressure fuel supply pump 100 can be improved, and a cost can be reduced. By increasing the diameter of the discharge valve inlet passage 8a, the hole (passage) can be easily worked and, at the same time, the burrs can be easily removed. As a result, the quality of the high-pressure fuel supply pump 100 can be improved.

[0082] The diameter of the communication hole 1e is equal to the diameter of the first chamber 1a. Accordingly, it is possible to allow the fuel to easily flow from the relief valve 4 into the pressurizing chamber 11 and hence, the relief performance can be improved. Furthermore, the relief valve is directly incorporated in the second chamber 1b formed in the pump body 1. Accordingly, a housing (seat member) for housing components that form the relief valve can be omitted and hence, the number of components can be reduced whereby a cost can be reduced.

[Manner of operation of high-pressure fuel pump]

[0083] Next, the manner of operation of the high-pressure fuel pump according to the present embodiment will be described with reference to FIG. 2 and FIG. 4.

[0084] In FIG. 2, when the plunger 2 descends and the electromagnetic intake valve mechanism 3 is opened, the fuel flows from the intake passage 1d into the pressurizing chamber 11. Hereinafter, a stroke in which the plunger 2 descends is referred to as an intake stroke. On the other hand, when the plunger 2 ascends and the electromagnetic intake valve mechanism 3 is closed, the fuel in the pressurizing chamber 11 is pressurized, passes through the discharge valve mechanism 8, and is pressure-fed to the common rail 106 (see FIG. 1). Hereinafter, a stroke in which the plunger 2 ascends is referred to as a rising stroke.

[0085] As described above, when the electromagnetic intake valve mechanism 3 is closed during the rising stroke, the fuel sucked into the pressurizing chamber 11 is pressurized during the intake stroke. As a result, the discharge valve mechanism 8 is opened, and the fuel in the pressurizing chamber 11 is discharged to a common rail 106 side. On the other hand, when the electromagnetic intake valve mechanism 3 is opened during the rising stroke, the fuel in the pressurizing chamber 11 is pushed back toward an intake passage 1d side. Therefore, the fuel in the pressurizing chamber 11 is not discharged to the common rail 106 side. In this manner, the discharge of the fuel by the high-pressure fuel supply pump 100 is operated by opening and closing the electromagnetic intake valve mechanism 3. The opening and closing of the electromagnetic intake valve mechanism 3 is controlled by the ECU 101.

[0086] In the intake stroke, the volume of the pressurizing chamber 11 is increased, and the fuel pressure in the pressurizing chamber 11 is decreased. As a result, a fluid differential pressure between the intake port 31b and the pressurizing chamber 11 (hereinafter, referred to as a "fluid differential pressure before and after the valve element 32") is decreased. When the biasing force of the rod biasing spring 34 becomes larger than the fluid differential pressure before and after the valve element 32, the rod 33 moves in the valve opening direction. Then, the valve element 32 is separated from the seating portion 31a of the intake valve seat 31, and the electromagnetic intake valve mechanism 3 assumes a valve open state.

[0087] When the electromagnetic intake valve mechanism 3 assumes a valve open state, fuel in the intake port 31b passes between the valve element 32 and the seating portion 31a, and flows into the pressurizing chamber 11 after passing through a plurality of fuel passing holes (not illustrated) formed in the stopper 37. In a valve open state of the electromagnetic intake valve mechanism 3, the valve element 32 is brought into contact with the stopper 37 and hence, the position of the valve element 32 in the valve opening direction is restricted. A gap existing between the valve element 32 and the seating portion 31a in a valve open state of the electromagnetic intake valve mechanism 3 is a movable range of the valve element 32. This movable range is referred to as a valve open stroke.

[0088] After the intake stroke is completed, the process proceeds to the rising stroke. At this stage of the operation, the electromagnetic coil 35 remains in a non-energized state and hence, a magnetic attractive force does not act between the anchor 36 and the magnetic core 39. To the valve element 32, a biasing force in the valve opening direction corresponding to a difference in biasing force between the rod biasing spring 34 and the valve biasing spring 38, and a pressing force in the valve closing direction by a fluid force generated when the fuel flows back from the pressurizing chamber 11 to the low-pressure fuel flow passage 10a act.

[0089] In this state, in order to allow the electromagnetic intake valve mechanism 3 to maintain a valve open state, the difference between the biasing force of the rod biasing spring 34 and the biasing force of the valve biasing spring 38 is set larger than the fluid force. The volume of the pressurizing chamber 11 decreases as the plunger 2 ascends. Therefore, the fuel sucked into the pressurizing chamber 11 passes again between the valve element 32 and the seating portion 31a and is returned to the intake port 31b. Accordingly, there is no possibility that the pressure in the pressurizing chamber 11 is increased. This stroke is referred to as a return stroke.

[0090] In the return stroke, when a control signal from the ECU 101 (see FIG. 1) is applied to the electromagnetic intake valve mechanism 3, a current flows into the electromagnetic coil 35 via the terminal member 40. When a current flows into the electromagnetic coil 35, a magnetic attractive force acts between the magnetic core 39 and the anchor 36, and the anchor 36 (rod 33) is attracted to the magnetic core 39. As a result, the anchor 36 (rod 33) moves in the valve closing direction (direction away from the valve element 32) against a biasing force of the rod biasing spring 34.

[0091] When the anchor 36 (rod 33) moves in the valve closing direction, the valve element 32 is released from a biasing force in the valve opening direction. As a result, the valve element 32 moves in the valve closing direction by a biasing force of the valve biasing spring 38 and a fluid force generated by the fuel that flows into the intake passage 10b. Then, when the valve element 32 is brought into contact with the seating portion 31a of the intake valve seat 31 (when the valve element 32 is seated on the seating portion 31a), the electromagnetic intake valve mechanism 3 assumes a valve closing state.

[0092] After the electromagnetic intake valve mechanism 3 assumes a valve closing state, the fuel in the pressurizing chamber 11 is pressurized as the plunger 2 ascends. When the fuel in the pressurizing chamber 11 reaches or exceeds a predetermined pressure, the fuel passes through the discharge valve mechanism 8 and is discharged to the common rail 106 (see FIG. 1). This stroke is referred to as a discharge stroke. That is, the upward stroke from the bottom dead center to the top dead center of the plunger 2 includes a return stroke and a discharge stroke. By controlling the timing of energizing the electromagnetic coil 35 of the electromagnetic intake valve mechanism 3, an amount of high-pressure fuel to be discharged can be controlled.

[0093] If the timing of energizing the electromagnetic coil 35 is made earlier, the ratio of the return stroke during the rising stroke becomes smaller, and the ratio of the discharge stroke becomes larger. As a result, an amount of fuel returned to the intake passage 10b is decreased, and an amount of fuel discharged at a high pressure is increased. On the other hand, if the timing of energizing the electromagnetic coil 35 is delayed, a ratio of the return stroke during the rising stroke is increased, and a ratio of the discharge stroke is decreased. As a result, an amount of fuel that is returned to the intake passage 10b is increased, and an amount of fuel discharged at a high pressure is decreased. By controlling the timing of energizing the electromagnetic coil 35, an amount of fuel to be discharged at a high pressure can be controlled to an amount that an engine (internal combustion engine) requires.

2. Second embodiment

[0094] A high-pressure fuel supply pump according to a second embodiment of the present invention is described hereinafter. A point that makes the high-pressure fuel supply pump according to the second embodiment differ from the high-pressure fuel supply pump 100 according to the first embodiment is the position at which a discharge valve mechanism 8 is disposed. Therefore, in the description made hereinafter, the position of the discharge valve mechanism 8 is described, and the description of the configurations and the manner of operation common to the high-pressure fuel supply pump 100 according to the first embodiment is omitted.

[Positional relationship among relief valve mechanism, discharge valve mechanism, and pressurizing chamber]

[0095] Next, the positional relationship among a relief valve mechanism 4, a discharge valve mechanism 8, and a pressurizing chamber 11 is described with reference to FIG. 6 and FIG. 7. FIG. 6 is a longitudinal cross-sectional view of the high-pressure fuel supply pump according to the second embodiment as viewed in cross section orthogonal to the horizontal direction. FIG. 7 is a perspective cross-sectional view with a part broken away of the high-pressure fuel supply pump according to the second embodiment.

[0096] The high-pressure fuel supply pump 200 according to the second embodiment has the same configuration as the high-pressure fuel supply pump 100 according to the first embodiment. As illustrated in FIG. 7, as viewed from the direction that a plunger 2 reciprocates, the moving direction of a valve element 43 in a relief valve mechanism 4 differs from the moving direction of a valve element 82 in a discharge valve mechanism 8. That is, as viewed from the direction that the plunger 2 reciprocates, the moving direction of the valve element 43 in the relief valve mechanism 4 intersects with the moving direction of the valve element 82 in the discharge valve mechanism 8.

[0097] As illustrated in FIG. 7, the relief valve mechanism 4 is disposed at the position that overlaps with the pressurizing chamber 11 in the reciprocating direction of the plunger 2 and the moving direction of the valve element 43 of the relief valve mechanism 4. As illustrated in FIG. 6 and FIG. 7, the discharge valve mechanism 8 is disposed at the position that overlaps with the relief valve mechanism 4 as viewed in the moving direction of the valve element 82 of the discharge valve mechanism 8.

[0098] Further, a lower end L1 of the second chamber 1b (relief chamber) in which the relief valve mechanism 4 is disposed is arranged at a position closer to the plunger 2 in the reciprocating direction of the plunger 2 than the upper end L2 of the seat passage 8a in the discharge valve mechanism 8. Further, an upper end of the seat passage 8a in the discharge valve mechanism 8 is higher than an upper surface of the plunger 2 (see FIG. 6) that is positioned at the top dead center.

[0099] As illustrated in FIG. 7, an upper end of the relief valve mechanism 4 and an upper end of the discharge valve mechanism 8 are set substantially at the same height in the reciprocating direction of the plunger 2. Further, as illustrated in FIG. 6, the relief valve mechanism 4 is disposed at the position that overlaps with the discharge valve mechanism 8 as viewed in the horizontal direction orthogonal to the reciprocating direction of the plunger 2.

[0100] Further, as viewed from the moving direction of the valve element 43 of the relief valve mechanism 4, the discharge valve mechanism 8 overlaps with an entire region of the relief valve mechanism 4 in a direction that the plunger 2 reciprocates. With such a configuration, a length of the pump body 1 in the direction that the plunger 2 reciprocates (a length of the pump body 1 in the axial direction) can be more shortened than the length of the pump body 1 in the first embodiment. Accordingly, downsizing of the pump body 1 can be realized.

3. Summary

[0101] As described above, the high-pressure fuel supply pump (fuel pump) according to the above-described embodiments includes: the pump body 1 (pump body) that has the pressurizing chamber 11 (pressurizing chamber) and the discharge chamber 87 (discharge chamber); the plunger 2 (plunger) that reciprocates in the pressurizing chamber 11; and the discharge valve mechanism 8 (discharge valve mechanism) that discharges the fuel in the pressurizing chamber 11 to the discharge chamber 87. Further, the high-pressure fuel supply pump includes a relief valve mechanism 4 (relief valve mechanism) that opens when a difference between a pressure of fuel in the discharge chamber 87 and a pressure of fuel in the pressurizing chamber 11 exceeds a predetermined value, and returns the fuel in the discharge chamber 87 to the pressurizing chamber 11. As viewed from the first direction along which the plunger 2 reciprocates, the discharge valve mechanism 8 and the relief valve mechanism 4 are disposed in a direction where the moving directions of the respective valve elements 82, 43 (valves) intersect with each other.

[0102] The relief valve mechanism 4 is disposed at the position that overlaps with the pressurizing chamber 11 in the first direction and in the second direction that is the moving direction of the valve element 43 of the relief valve mechanism 4.

[0103] As a result, the discharge valve mechanism 8 and the relief valve mechanism 4 can be disposed at positions that do not overlap with each other in the first direction. As a result, the space in the pump body 1 can be effectively used, and the downsizing of the pump body 1 can be realized. Further, it is unnecessary to form a passage for making the relief valve mechanism 4 and the pressurizing chamber 11 communicate with each other. As a result, a dead volume of the pressurizing chamber 11 can be reduced compared with a case where a passage for making the relief valve mechanism 4 and the pressurizing chamber 11 communicate with each other is provided. Accordingly, the volumetric efficiency of the pressurizing chamber 11 can be improved.

[0104] In the high-pressure fuel supply pumps (fuel pumps) according to the above-described embodiments, the discharge valve mechanism 8 is disposed at the position that overlaps with the relief valve mechanism 4 (relief valve mechanism) as viewed from the third direction that is the moving direction of the valve element 82 (valve) in the discharge valve mechanism 8 (discharge valve mechanism). With such a configuration, a length of the pump body 1 (pump body) in the first direction (a length of the pump body 1 in the axial direction) can be shortened. Accordingly, downsizing of the pump body 1 can be realized.

[0105] In the high-pressure fuel supply pump (fuel pump) according to the above-described embodiment, the lower end L1 of the second chamber 1b (relief chamber) in which the relief valve mechanism 4 (relief valve mechanism) is disposed is disposed at the position closer to the plunger 2 (plunger) in the first direction than the upper end L2 of the seat passage 8a (passage on the pressurizing chamber side) in the discharge valve mechanism 8 (discharge valve mechanism). With such a configuration, a length of the pump body 1 (pump body) in the first direction (a length of the pump body 1 in the axial direction) can be shortened. Accordingly, downsizing of the pump body 1 can be realized.

[0106] In the high-pressure fuel supply pump (fuel pumps) according to the above-described embodiments, the discharge valve mechanism 8 (discharge valve mechanism) and the relief valve mechanism 4 (relief valve mechanism) may be disposed such that the moving directions of the respective valve elements 82, 43 (valves) are disposed approximately orthogonal to each other as viewed from the first direction. As a result, the discharge valve mechanism 8 and the relief valve mechanism 4 can be disposed in a spaced-apart manner from each other thus preventing the interference between the discharge valve mechanism 8 and the relief valve mechanism 4 As a result, the space in the pump body 1 can be effectively used and hence, the downsizing of the pump body 1 can be realized.

[0107] In the high-pressure fuel supply pumps (fuel pumps) according to the above-described embodiments, the relief valve mechanism 4 (relief valve mechanism) is disposed at the position that overlaps with the discharge valve mechanism 8 (discharge valve mechanism) as viewed from the horizontal direction orthogonal to the first direction. With such a configuration, a length of the pump body 1 (pump body) in the first direction (a length of the pump body 1 in the axial direction) can be shortened. Accordingly, downsizing of the pump body 1 can be realized.

[0108] In the high-pressure fuel supply pump (fuel pump) according to the above-described second embodiment, the discharge valve mechanism 8 (discharge valve mechanism) overlaps with the entire region of the relief valve mechanism 4 (relief valve mechanism) in the first direction as viewed from the second direction. With such a configuration, a length of the pump body 1 in the first direction (a length of the pump body 1 in the axial direction) can be more shortened than the length of the pump body 1 in the first embodiment. Accordingly, downsizing of the pump body 1 can be realized.

[0109] In the high-pressure fuel supply pump (fuel pump) according to the above-described first embodiment, the upper end of the relief valve mechanism 4 (relief valve mechanism) is disposed remoter from the plunger (2) (plunger) than the upper end of the discharge valve mechanism 8 (discharge valve mechanism) in the first direction. As a result, the discharge valve mechanism 8 is disposed closer to the plunger 2 side in the first direction than the relief valve mechanism 4. It is necessary to set the relief valve mechanism 4 at the position higher than the top dead center of the plunger 2 in order to avoid the interference between the relief valve mechanism 4 and the plunger 2. Therefore, by disposing the discharge valve mechanism 8 on the plunger 2 side in the first direction than the relief valve mechanism 4, it is possible to suppress the pump body 1 from becoming elongated in the first direction.

[0110] In the high-pressure fuel supply pumps (fuel pumps) according to the above-described embodiments, the relief valve mechanism 4 (relief valve mechanism) overlaps with the entire region of the pressurizing chamber 11 (pressurizing chamber) in the second direction as viewed from the direction orthogonal to the first direction and the second direction. With such a configuration, fuel that passes through the relief valve mechanism 4 can be efficiently returned to the pressurizing chamber 11.

[0111] In the high-pressure fuel supply pump (fuel pump) according to the above-described embodiment, the upper end of the seat passage 8a (passage on the pressurizing chamber side) in the discharge valve mechanism 8 (discharge valve mechanism) is higher than the upper surface of the plunger 2 positioned at the top dead center. With such a configuration, it is possible to prevent the plunger 2 positioned at the top dead center from clogging the seat passage 8a. As a result, it is possible to prevent the plunger 2 from blocking the discharge of the fuel by the discharge valve mechanism 8.

[0112] The embodiments of the fuel pump of the present invention have been described above including the manners of operation and the advantageous effects. However, the fuel pump of the present invention is not limited to the above-described embodiments, and various modifications can be made without departing from the gist of the invention described in the claims. Further, the above-described embodiments have been described in detail for facilitating the understanding of the present invention. However, the embodiments are not necessarily limited to the fuel pump that includes all configurations described above.

[0113] For example, in the above-described embodiment, the moving direction of the valve element 32 in the electromagnetic intake valve mechanism 3 is set to the second radial direction that is equal to the moving direction of the valve element 43 in the relief valve mechanism 4 (see FIG. 2). However, the moving direction of the valve element in the relief valve according to the present invention may be different from the moving direction of the valve element in the electromagnetic intake valve. For example, in the fuel pump according to the present invention, the moving direction of the valve element in the relief valve, the moving direction of the valve element in the electromagnetic intake valve, and the moving direction of the valve element in the discharge valve may all be set different from each other.

[0114] In the embodiment described above, the valve elements 82 of the discharge valve mechanism 8 and the valve element 43 of the relief valve mechanism 4 move in directions perpendicular to the direction (first direction) that the plunger 2 reciprocates. However, the directions that the valve of the discharge valve mechanism and the valve of the relief valve mechanism according to the present invention move may be inclined with respect to the directions perpendicular to the direction (first direction) that the plunger 2 reciprocates. That is, the discharge valve mechanism and the relief valve mechanism may be obliquely connected to the pressurizing chamber.

Reference Signs List

[0115]

1	pump body
1a	first chamber
1b	second chamber (relief chamber)
1c	third chamber
1d	intake passage
1e	communication hole
If	discharge valve inlet passage
2	plunger
3	electromagnetic intake valve mechanism
4	relief valve mechanism
5	intake joint
6	cylinder
8	discharge valve mechanism
8a	seat passage
9	pressure pulsation reduction mechanism
10	low-pressure fuel chamber
11	pressurizing chamber
12	discharge joint
41	relief spring
42	relief valve holder
43	valve element
44	seat member
81	discharge valve seat
82	valve element
83	discharge valve spring
84	discharge valve stopper
85	plug
87	discharge chamber
100, 200	high-pressure fuel supply pump
101	ECU
102	feed pump
103	fuel tank
104	low-pressure pipe
105	fuel pressure sensor
106	common rail
107	Injector

Claims

1. A fuel pump comprising:

a pump body including a pressurizing chamber and a discharge chamber;
a plunger that reciprocates in the pressurizing chamber;
a discharge valve mechanism that discharges fuel in the pressurizing chamber to the discharge chamber; and
a relief valve mechanism that opens and returns fuel in the discharge chamber to the pressurizing chamber when a difference between a pressure of the fuel in the discharge chamber and a pressure of the fuel in the pressurizing chamber exceeds a set value, wherein
the discharge valve mechanism and the relief valve mechanism are arranged in a direction that moving directions of a valve of the discharge

valve mechanism and a valve of the relief valve mechanism intersect with each other as viewed from a first direction that is a direction in which the plunger reciprocates, and

the relief valve mechanism is disposed at a position that overlaps with the pressurizing chamber in the first direction and in a second direction that is a moving direction of the valve in the relief valve mechanism.

2. The fuel pump according to claim 1, wherein
the discharge valve mechanism is disposed at a position that overlaps with the relief valve mechanism as viewed from a third direction that is a moving direction of the valve in the discharge valve mechanism.

3. The fuel pump according to claim 1, wherein
a lower end of a relief chamber in which the relief valve mechanism is disposed is disposed at a position closer to the plunger in the first direction than an upper end of a passage in the discharge valve mechanism on a pressurizing chamber side.

4. The fuel pump according to claim 1, wherein
the discharge valve mechanism and the relief valve mechanism are disposed such that moving directions of the respective valves are approximately orthogonal to each other as viewed from the first direction.

5. The fuel pump according to claim 1, wherein
the relief valve mechanism is disposed at a position that overlaps with the discharge valve mechanism as viewed from a horizontal direction orthogonal to the first direction.

6. The fuel pump according to claim 5, wherein
the discharge valve mechanism overlaps with an entire region of the relief valve mechanism in the first direction as viewed from the second direction.

7. The fuel pump according to claim 1, wherein
an upper end of the relief valve mechanism is disposed at a position remoter from the plunger in the first direction than an upper end of the discharge valve mechanism.

8. The fuel pump according to claim 1, wherein
the relief valve mechanism overlaps with an entire region of the pressurizing chamber parallel to the second direction as viewed from a direction orthogonal to the first direction and the second direction.

9. The fuel pump according to claim 1, wherein
an upper end of a passage of the discharge valve mechanism on a pressurizing chamber side is set higher than an upper surface of the plunger positioned at a top dead center.

FIG. 1

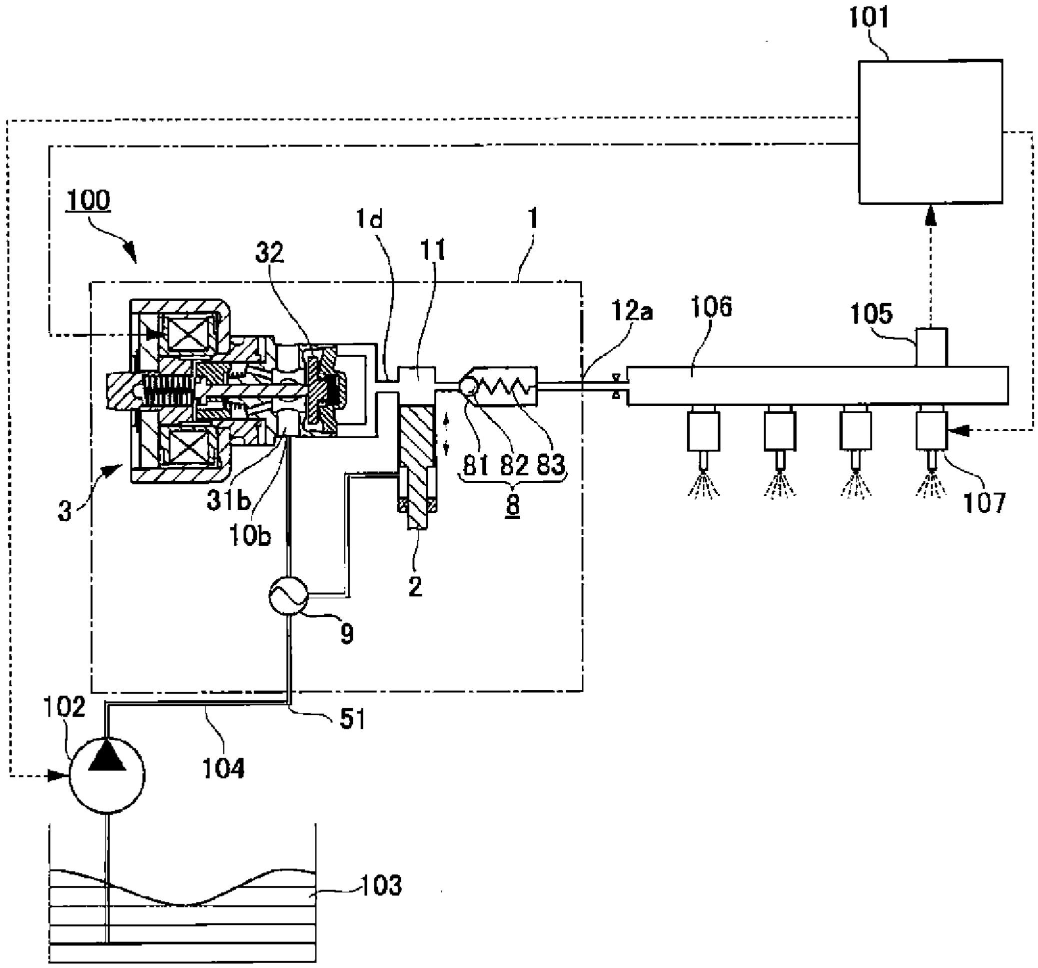

101
100
1d
11
1
32
12a
106
105
81 82 83
8
3
31b
10b
107
2
9
102
51
104
103

FIG. 2

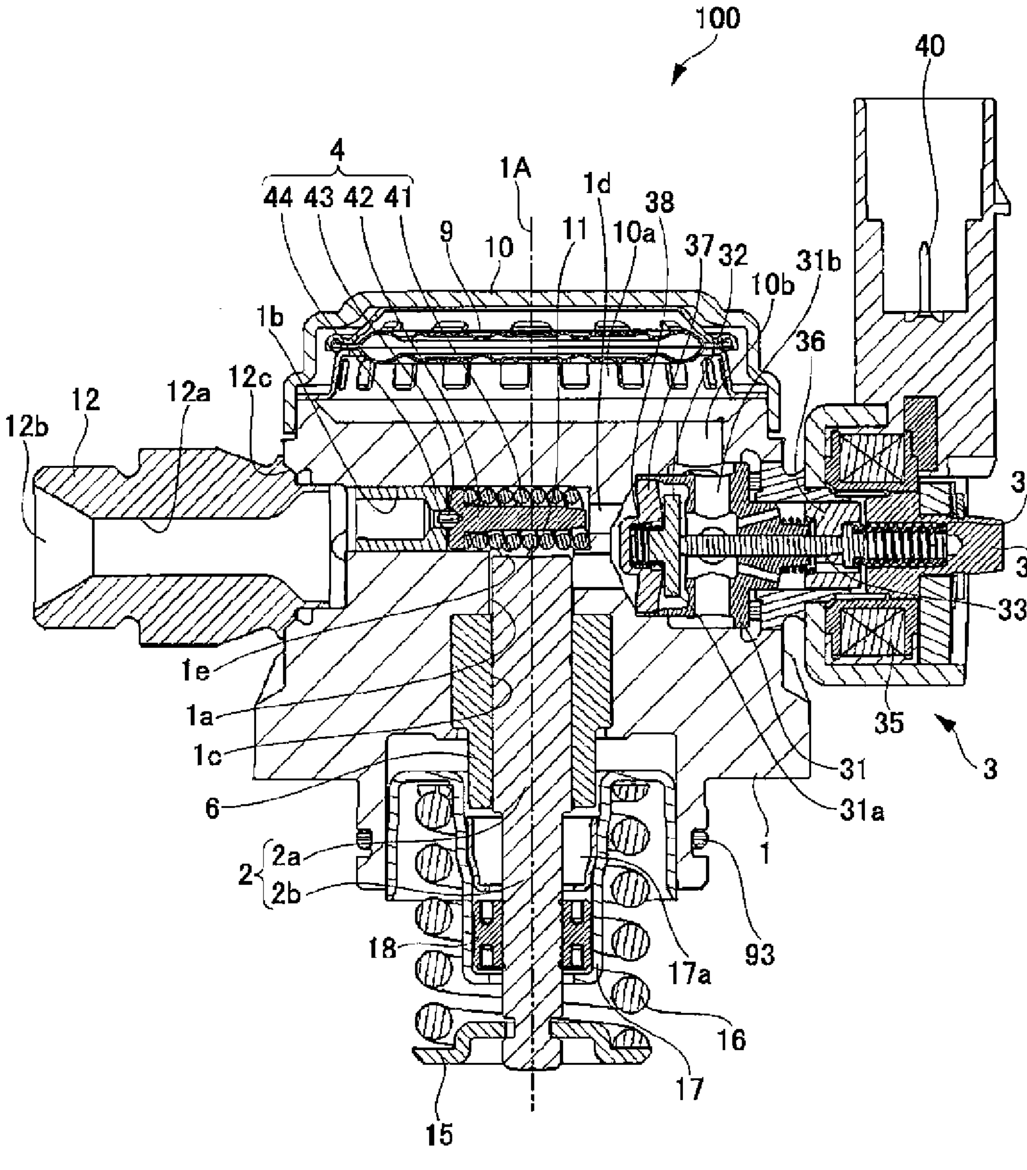

100
40
4
44 43 42 41
1A
1d
38
9
10
11
10a
37
32
10b
31b
1b
36
12b
12
12a
12c
34
39
33
1e
1a
35
1c
3
31
6
31a
2a
2
2b
1
93
17a
18
16
17
15

FIG. 3

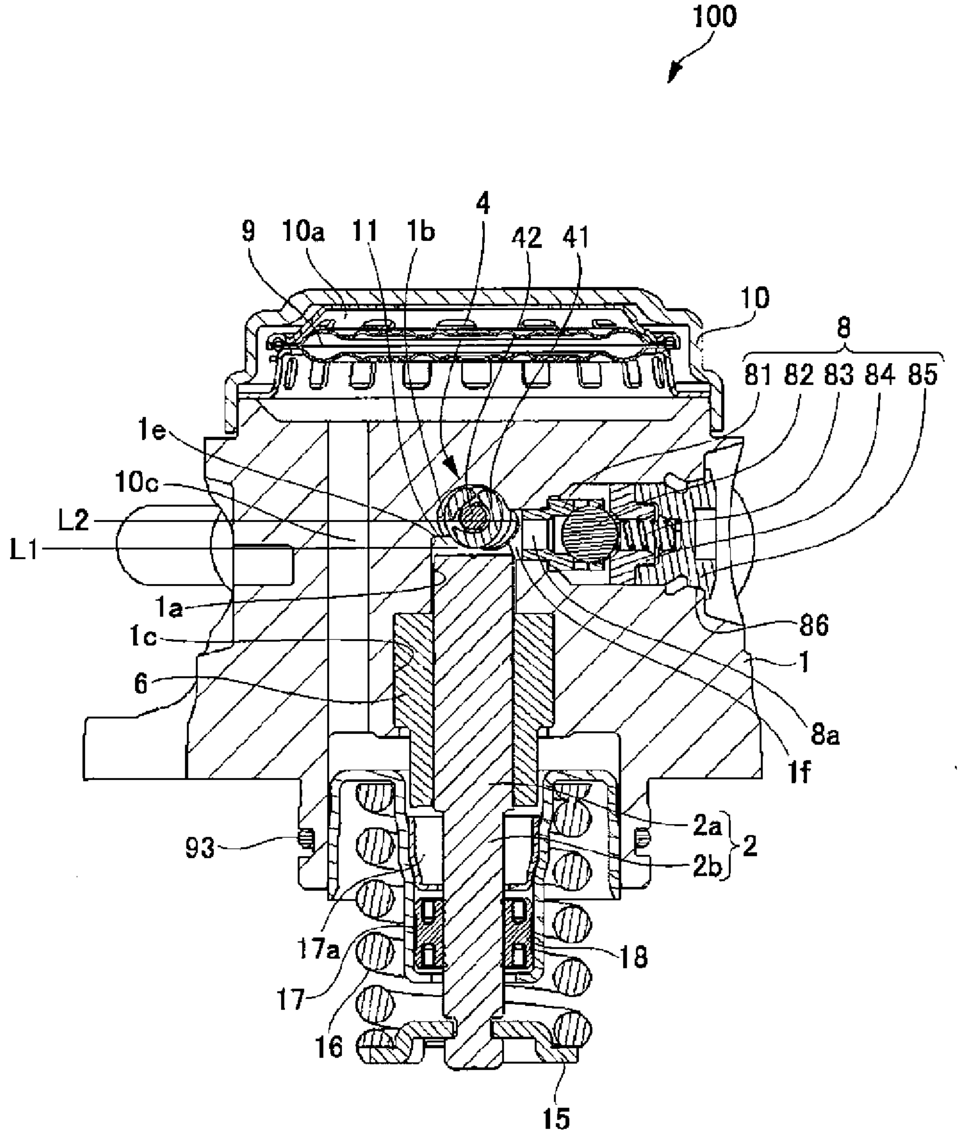

100
4
9
10a
11
1b
42
41
10
8
81 82 83 84 85
1e
10c
L2
L1
1a
1c
6
86
1
8a
1f
93
2a
2b
2
17a
18
17
16
15

FIG. 4

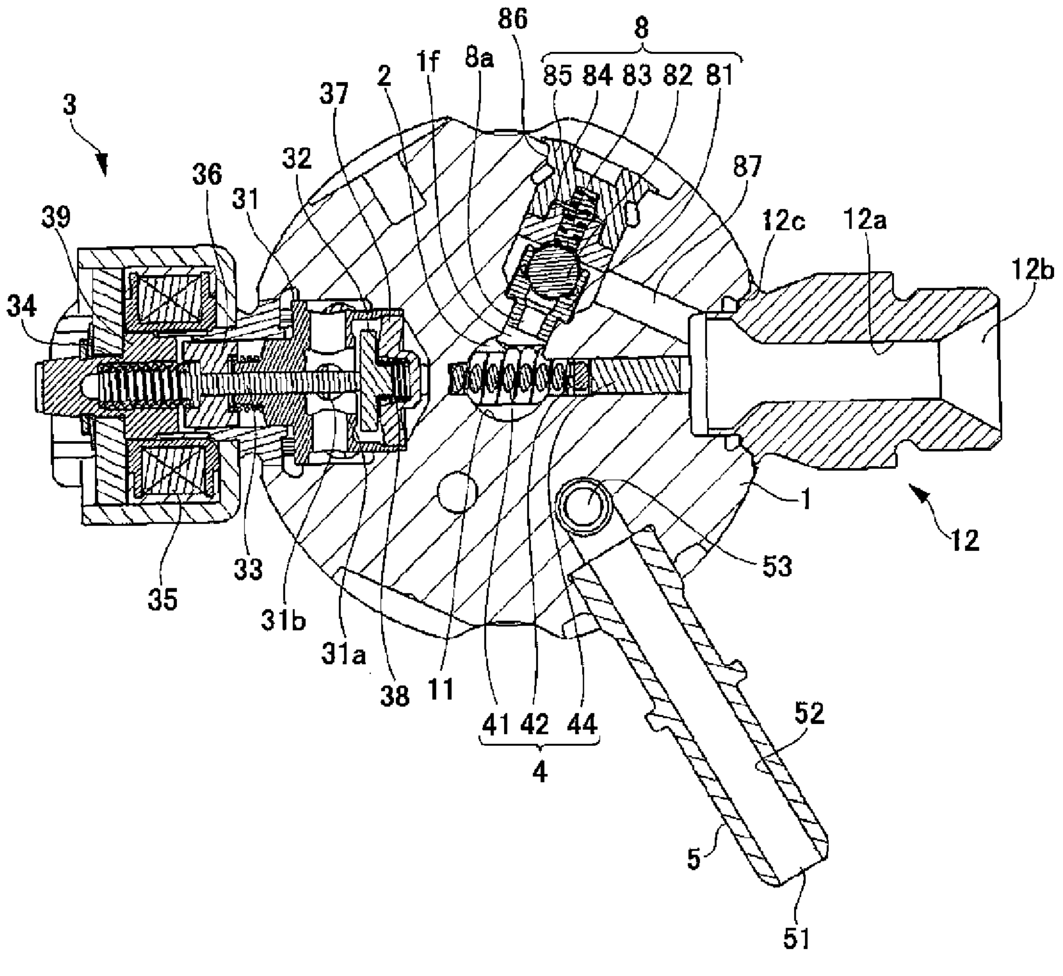

3
39
34
36
31
32
37
2
1f
8a
86
8
85 84 83 82 81
87
12c
12a
12b
1
12
53
52
5
51
35
33
31b
31a
38
11
41 42 44
4

FIG. 5

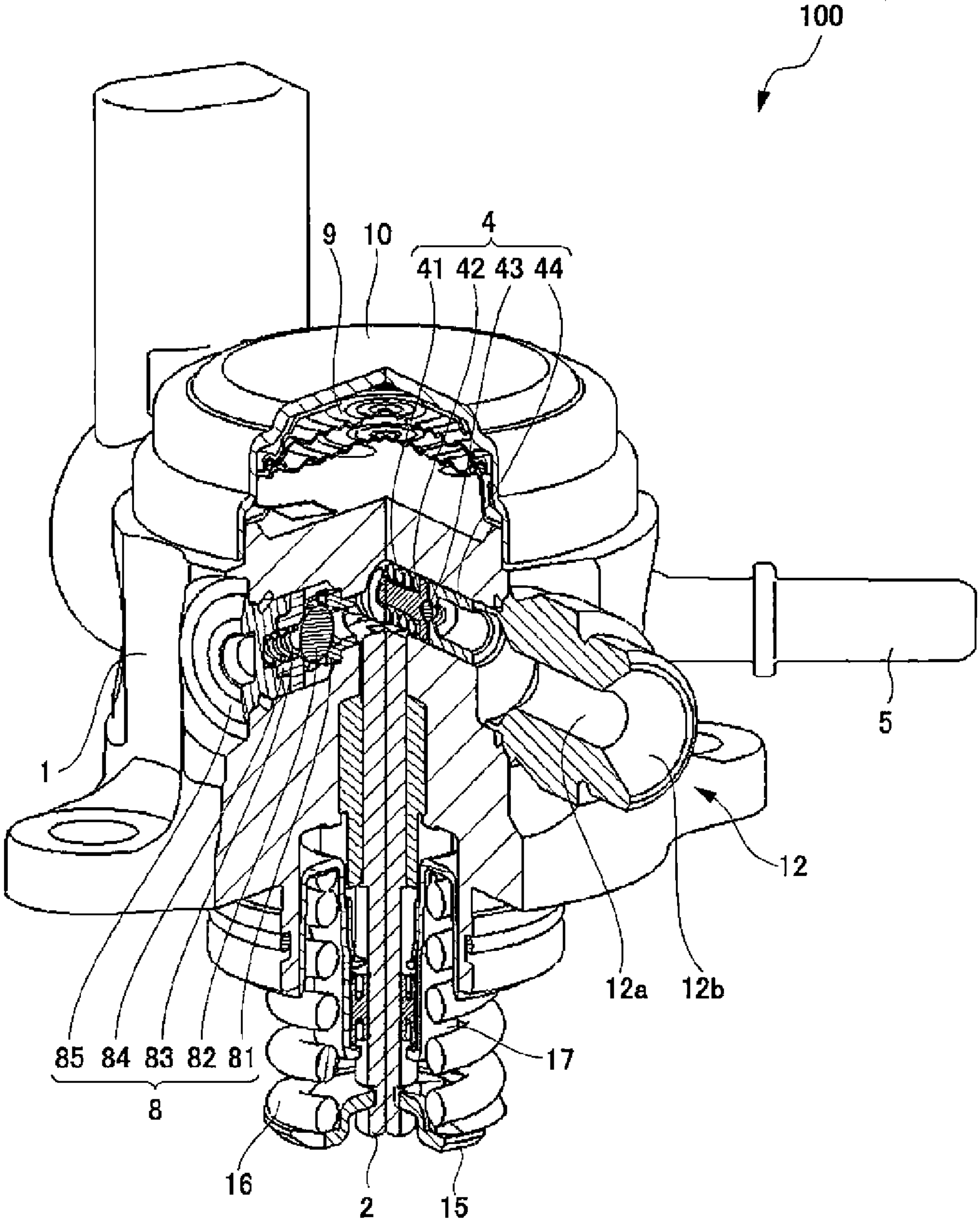


FIG. 6

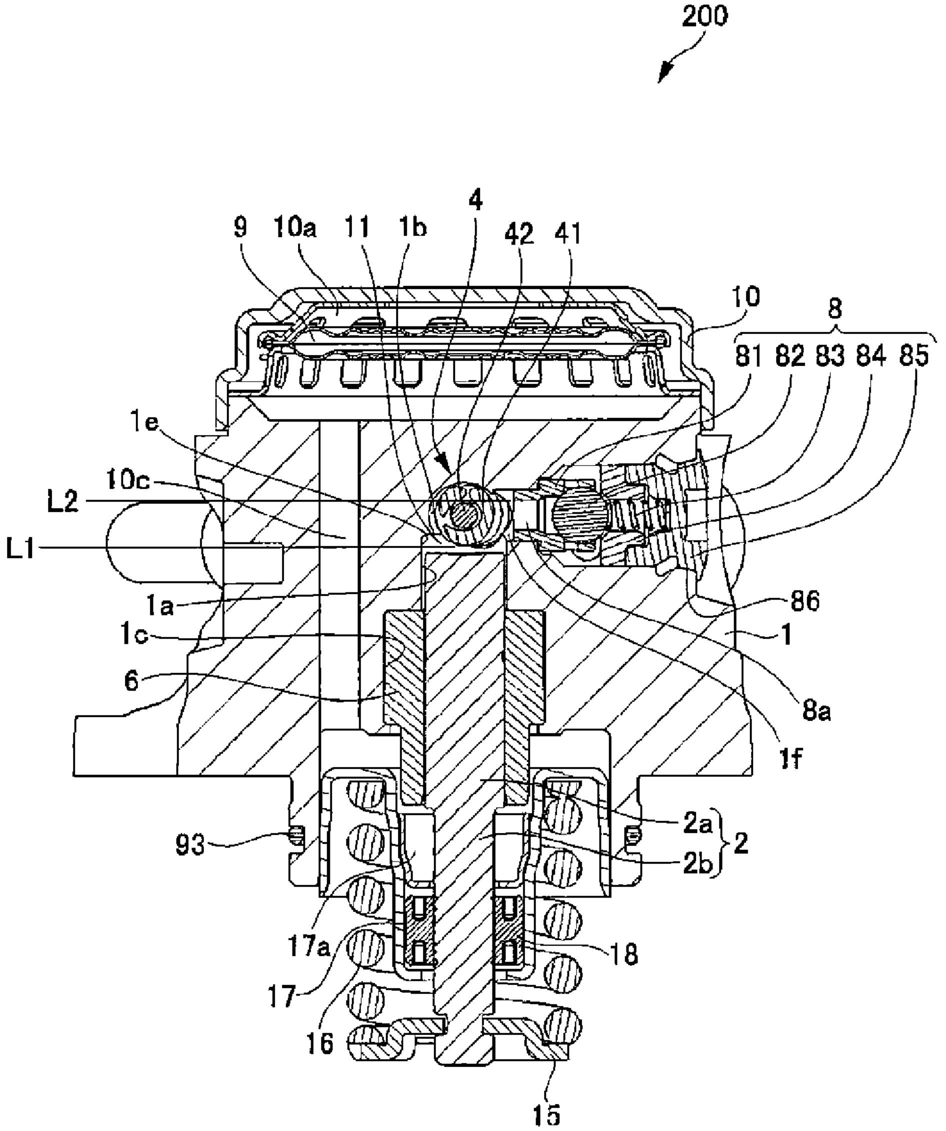
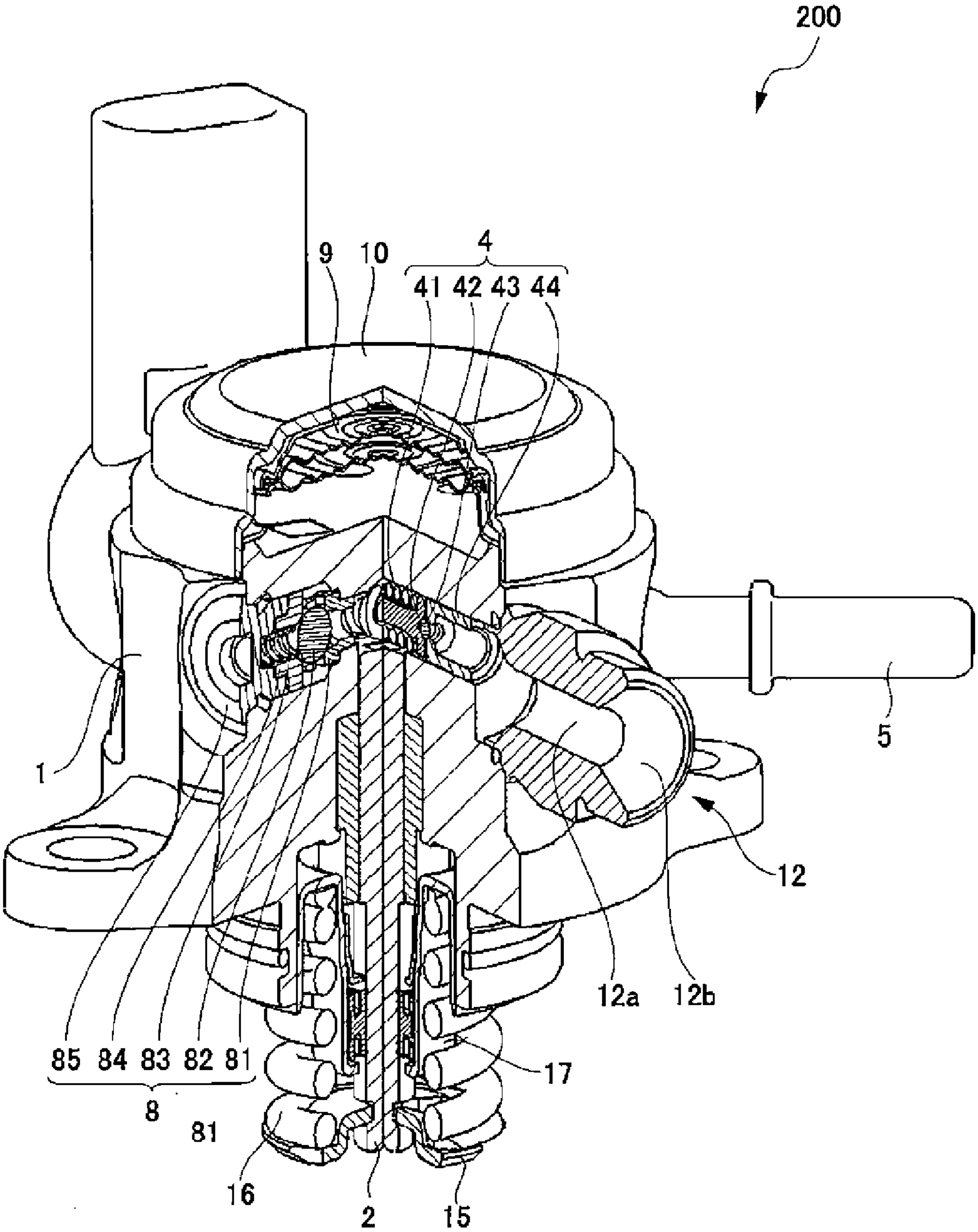

200
4
9
10a
11
1b
42
41
10
8
81
82
83
84
85
1e
10c
L2
L1
1a
1c
6
86
1
8a
1f
93
2a
2
2b
17a
18
17
16
15

FIG. 7



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2021/004252

A. CLASSIFICATION OF SUBJECT MATTER

Int. Cl. F02M59/46(2006.01)i, F04B53/10(2006.01)i
FI: F02M59/46 Y, F02M59/46 T, F04B53/10 H

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
Int. Cl. F02M39/00-71/04, F04B53/10

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Published examined utility model applications of Japan	1922-1996
Published unexamined utility model applications of Japan	1971-2021
Registered utility model specifications of Japan	1996-2021
Published registered utility model applications of Japan	1994-2021

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	JP 2018-150911 A (HITACHI AUTOMOTIVE SYSTEMS, LTD.) 27 September 2018, paragraphs [0013]-[0038], fig. 1-3	1-9
A	JP 5800020 B2 (TOYOTA MOTOR CORP.) 28 October 2015, entire text, all drawings	1-9
A	JP 2019-520519 A (ROBERT BOSCH GMBH) 18 July 2019, entire text, all drawings	1-9
A	US 2014/0255219 A1 (STANADYNE CORPORATION) 11 September 2014, entire text, all drawings	1-9
A	JP 2019-100268 A (HITACHI AUTOMOTIVE SYSTEMS, LTD.) 24 June 2019, entire text, all drawings	1-9

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
30.03.2021	13.04.2021

Name and mailing address of the ISA/	Authorized officer
Japan Patent Office 3-4-3, Kasumigaseki, Chiyoda-ku, Tokyo 100-8915, Japan	Telephone No.

Form PCT/ISA/210 (second sheet) (January 2015)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/JP2021/004252

Patent Documents referred to in the Report	Publication Date	Patent Family	Publication Date
JP 2018-150911 A	27.09.2018	(Family: none)	
JP 5800020 B2	28.10.2015	US 2014/0199194 A1 entire text, all drawings WO 2013/018129 A1 DE 112011105490 B4 CN 103717873 A	
JP 2019-520519 A	18.07.2019	US 2019/0301415 A1 entire text, all drawings WO 2018/007055 A1 EP 3482060 A1 DE 102016212458 A1 CN 109416009 A KR 10-2019-0026745 A	
US 2014/0255219 A1	11.09.2014	US 2016/0010607 A1 WO 2014/137900 A1 EP 2964949 A1 CN 105008709 A	
JP 2019-100268 A	24.06.2019	(Family: none)	

Form PCT/ISA/210 (patent family annex) (January 2015)

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- JP 2018523778 A **[0006]**