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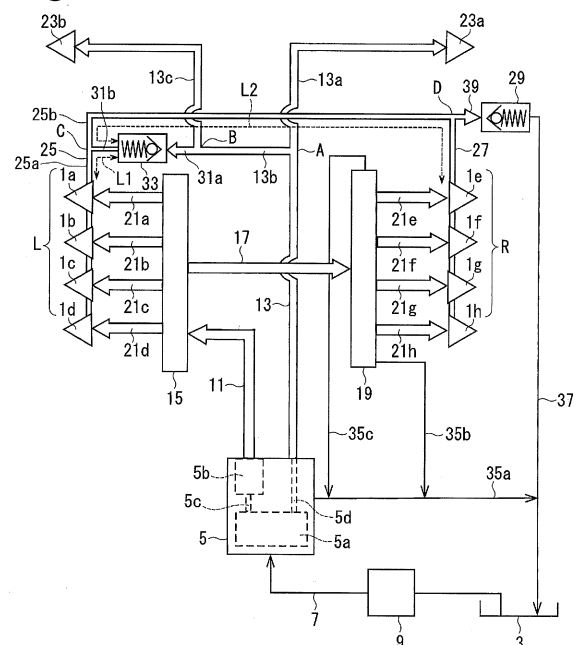
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(54) **FUEL SUPPLY DEVICE**

(57) A fuel supply device comprises a return flow channel (39) for merging a first return flow channel (25) with a second return flow channel (27) at a merging point (D) and returning the flow channel to a fuel tank (3). A back pressure valve (29) is provided to the return flow channel (39), and back pressure is imparted to first injectors (1a-1d) and second injectors (1e-1h). Communicating flow channels (31a, 31 b) connect an intermediate pressure flow channel (13) to either the first return flow channel (25), the second return flow channel (27), or a portion upstream of the back pressure valve (29). A non-return valve (33) has lower open valve pressure than the back pressure, the non-return valve (33) is provided to the communicating flow channels (31a, 31b), and the non-return valve (33) allows fuel to be supplied from the intermediate pressure flow channel (13) to the first return flow channel (25) and the second return flow channel (27) and prevents the fuel from flowing the opposite direction.

Fig. 1



Description

TECHNICAL FIELD

[0001] The present invention relates to a fuel supply device, and more particularly, to a fuel supply device applied to a multicylinder diesel engine.

BACKGROUND ART

[0002] Japanese Laid-Open Patent Publication No. 2009-102990 discloses an example of a typical fuel supply device. The fuel supply device of the document is connected to a plurality of first injectors, which inject fuel into each first combustion chamber of a first cylinder group, and a plurality of second injectors, which inject fuel into each second combustion chamber of a second cylinder group, in a multicylinder diesel engine. The fuel supply device of the document supplies fuel from a fuel tank to each first injector and each second injector. Each first injector and each second injector may be a piezo-injector, which employs a piezo element as an actuator that opens and closes an injection hole.

[0003] The fuel supply device in the document includes a medium pressure pump, which is described as a feed pump in the document, and a high pressure pump. The medium pressure pump adjusts the fuel from the fuel tank to a medium pressure and delivers the medium-pressure fuel to a medium pressure passage. The high pressure pump adjusts the fuel, which is delivered through the medium pressure passage, to a high pressure, which is higher than the medium pressure, and delivers the high-pressure fuel to a high pressure passage. The high pressure passage is connected to a common rail. A first high pressure passage connects the common rail to each first injector. A second high pressure passage connects the common rail to each second injector.

[0004] A first return passage, which is connected to each first injector, is capable of transporting surplus fuel from each first injector. A second return passage, which is connected to each second injector, is capable of transporting surplus fuel from each second injector. A first connection passage and a first recovery passage branch from the first return passage at a first branching point. The first connection passage is connected to the medium pressure passage. The first recovery passage is connected to the fuel tank. A second connection passage and a second recovery passage branch from the second return passage at a second branching point. The second connection passage, like the first connection passage, is connected to the medium pressure passage. The second recovery passage, like the first recovery passage, is connected to the fuel tank.

[0005] A first back pressure valve is arranged in the first recovery passage, and a second back pressure valve is arranged in the second recovery passage. The first back pressure valve is capable of applying back pressure to the first injectors, and the second back pressure valve

is capable of applying back pressure to the second injectors. Additionally, a first check valve is arranged in the first connection passage, and a second check valve is arranged in the second connection passage. The first check valve permits the supply of fuel from the medium pressure passage to the first return passage and impedes the supply of fuel from the first return passage to the medium pressure passage. The second check valve permits the supply of fuel from the medium pressure passage to the second return passage and impedes the supply of fuel from the second return passage to the medium pressure passage. A valve opening pressure of the first check valve is set to be lower than the back pressure of the first back pressure valve. A valve opening pressure of the second check valve is set to be lower than the back pressure of the second back pressure valve.

[0006] In the fuel supply device of the document, fuel is drawn from the fuel tank by the medium pressure pump and delivered to the high pressure pump. Then, the fuel, which is delivered to the medium pressure passage, is adjusted to a higher pressure than the medium pressure by the high pressure pump and delivered to the common rail through the high pressure passage. The high-pressure fuel, which is accumulated in the common rail, is injected from the first injectors into the first combustion chambers of the first cylinder group in the engine and from the second injectors into the second combustion chambers of the second cylinder group in the engine.

[0007] The surplus fuel in each first injector is transported to the fuel tank through the first return passage and the first recovery passage. The surplus fuel in each second injector is transported to the fuel tank through the second return passage and the second recovery passage.

[0008] Under this situation, the pressure of the first return passage side acts against the pressure of the fuel tank side at the first back pressure valve, and the pressure of the second return passage side acts against the pressure of the fuel tank side at the second back pressure valve. The first back pressure valve opens when the pressure difference between the pressure of the first return passage side and the pressure of the fuel tank side becomes larger than the back pressure that is set by an urging force of a spring of the first back pressure valve. The second back pressure valve opens when the pressure difference between the pressure of the second return passage side and the pressure of the fuel tank side becomes larger than the back pressure that is set by an urging force of a spring of the second back pressure valve. In this manner, the surplus fuel, which is exposed to the atmospheric pressure through the first back pressure valve and the second back pressure valve, is returned to the fuel tank.

[0009] During operation of the engine, when the fuel tank becomes empty, that is, when fuel runs out, bubbles enter the first return passage of the first injectors, which are piezo-injectors, and the second return passage of the second injectors, which are piezo-injectors. This de-

creases the pressures of the first return passage and the second return passage. In this condition, when the tank is refilled with fuel and the engine is restarted, the first injectors and the second injectors cannot inject fuel.

[0010] Therefore, in the fuel supply device of the document, when the fuel tank is refilled with fuel and the engine is restarted, the medium pressure pump supplies fuel to the first return passage through the first connection passage and supplies fuel to the second return passage through the second connection passage. In the first check valve, the pressure of the medium pressure pump side in the first connection passage acts against the pressure of the first return passage side. In the second check valve, the pressure of the medium pressure pump side in the second connection passage acts against the pressure of the second return passage side. Then, when the pressure difference between the pressure of the medium pressure pump side and the pressure of the first return passage side becomes larger than the valve opening pressure that is set by the urging force of the spring of the first check valve, the first check valve opens. When the pressure difference between the pressure of the medium pressure pump side and the pressure of the second return passage side becomes larger than the valve opening pressure that is set by the urging force of the spring of the second check valve, the second check valve opens. In this manner, the fresh fuel is supplied to the first return passage under a pressure that is higher than the valve opening pressure of the first check valve, and supplied to the second return passage under a pressure that is higher than the valve opening pressure of the second check valve.

[0011] The valve opening pressure of the first check valve is set to be lower than the back pressure of the first back pressure valve, and the valve opening pressure of the second check valve is set to be lower than the back pressure of the second back pressure valve. Therefore, the back pressure of the first back pressure valve acts on the fuel in the first return passage, and the back pressure of the second back pressure valve acts on the fuel in the second return passage. This obtains the pressure of the first return passage, which is needed for fuel injection from the first injector, and the pressure of the second return passage, which is needed for fuel injection from the second injector. However, when the engine is restarted after fuel replenishment, high-pressure fuel, which is supplied by the high pressure pump, exists in the common rail, the first high pressure passage, and the second high pressure passage. Thus, the fuel supply device of the document enables the first injectors and the second injectors to inject fuel again.

PRIOR ART DOCUMENT

PATENT DOCUMENT

[0012] Patent Document 1: Japanese Laid-Open Patent Publication No. 2009-102990

SUMMARY OF THE INVENTION

PROBLEMS THAT ARE TO BE SOLVED BY THE INVENTION

[0013] The fuel supply device in Japanese Laid-Open Patent Publication No. 2009-102990 includes the first return passage, which connects the first cylinder group to the fuel tank, and the second return passage, which connects the second cylinder group to the fuel tank. Further, the first back pressure valve and the first check valve are provided for the first return passage, and the second back pressure valve and the second check valve are provided for the second return passage.

[0014] Thus, in the above fuel supply device, a volume difference and a pressure loss difference are easily produced between the first return passage and the second return passage. A valve opening pressure difference and a flow characteristic difference are easily produced between the first check valve and the second check valve. A back pressure difference and a flow characteristic difference are easily produced between the first back pressure valve and the second pressure valve. Consequently, in the above fuel supply device, an injection time difference and an injection amount difference are easily produced between the first injector and the second injector. This may influence the engine starting performance, fuel efficiency, output, an emission performance, and so on. To avoid such situations, a control may be executed so that priority for injection is given to one of the first injector and the second injector over the other one. Alternatively, a control may be executed to correct the difference in the injection amount between the first injectors and the second injectors. Further, the tolerance of components may be decreased. However, these actions would raise the manufacturing costs. In the fuel supply device of document 1, fuel injection is controlled so that the first injectors have priority over the second injectors by setting the valve opening pressure of the first check valve, which is arranged in the first connection passage, to be lower than the valve opening pressure of the second check valve, which is arranged in the second connection passage. As a result, injection always needs to be started from the first cylinder group.

[0015] The above fuel supply device includes a large number of components. This increases the fuel supply device in size and weight, and raises component costs and management costs. Further, an increase in the number of assembling steps raises the manufacturing costs. It is thus difficult to install the fuel supply device in a vehicle or the like.

MEANS FOR SOLVING THE PROBLEM

[0016] It is an object of the present disclosure to provide a fuel supply device capable of starting an engine with high quality while lowering the manufacturing costs and obtaining superior properties for installation in a ve-

hicle or the like.

[0017] In one aspect of the present disclosure, a fuel supply device is connected to a plurality of first injectors and a plurality of second injectors. The fuel supply device supplies fuel from a fuel tank to each of the first injectors and each of the second injectors. The first injectors inject the fuel into a first fuel chamber of a first cylinder group of an engine. The second injectors inject the fuel into a second fuel chamber of a second cylinder group of the engine. Each of the first injectors and each of the second injectors are piezo-injectors. The fuel supply device includes a medium pressure pump, a high pressure pump, a high pressure passage, a first return passage, a second return passage, a recovery passage, a back pressure valve, a medium pressure passage, a connection passage, and a check valve. The medium pressure pump is capable of adjusting the fuel from the fuel tank to a medium pressure and delivering the medium-pressure fuel. The high pressure pump is capable of adjusting the fuel to a high pressure, which is higher than the medium pressure, and delivering the high-pressure fuel. The high pressure passage connects the high pressure pump to each of the first injectors and each of the second injectors. The first return passage is connected to each of the first injectors and capable of transporting surplus fuel from each of the first injectors. The second return passage is connected to each of the second injectors and capable of transporting surplus fuel from each of the second injectors. The recovery passage joins the first return passage and the second return passage at a junction and returns the surplus fuel to the fuel tank. The back pressure valve is arranged in the recovery passage and capable of applying a back pressure to each of the first injectors and each of the second injectors. The medium pressure passage is connected to the medium pressure pump. The connection passage connects the medium pressure passage to one of the first return passage, the second return passage, and a portion of the recovery passage upstream from the back pressure valve. The check valve is arranged in the connection passage and has a lower opening valve pressure than the back pressure. The check valve permits the supply of fuel from the medium pressure passage to the first return passage and the second return passage and impedes the opposite.

[0018] The fuel supply device of this aspect employs the recovery passage that joins the first return passage and the second return passage at the junction, and returns the surplus fuel to the fuel tank through the recovery passage. Therefore, even if a volume difference and a pressure loss difference exists between the first return passage and the second return passage, a volume difference and a pressure loss difference do not exist in the first recovery passage. That is, in this aspect, the influence of the return passages on the recovery passage is smaller than that in document 1.

[0019] In this aspect, the back pressure valve is arranged in the recovery passage that joins the first return passage and the second return passage at the junction.

As a comparative example, if different back pressure valves are arranged in the first return passage and the second return passage, a back pressure difference and a flow characteristic difference may be produced between the two back pressure valves. In contrast, in the fuel supply device of the present disclosure, such a back pressure difference and a flow characteristic difference do not exist.

[0020] In this aspect, the check valve, which has a lower opening valve pressure than the back pressure, is arranged in the connection passage, which is connected to the medium pressure passage. The medium pressure passage is connected, through the connection passage, to one of the first return passage, the second return passage, and the portion of the recovery passage upstream from the back pressure valve. In document 1, different check valves are arranged in two return passages. In contrast, the fuel supply device of the present disclosure includes only one return passage with the single check valve. Therefore, an opening valve pressure difference and a flow characteristic difference that are produced when a plurality of check valves are used do not exist in this aspect.

[0021] This limits the injection time difference and the injection amount difference of the first injector and the second injector. Therefore, the engine easily achieves superior starting capability, fuel efficiency, output, emission properties, and so on. In the fuel supply device of the present disclosure, there is no need for a complicated control of the injectors. This allows for a relatively moderate tolerance for components. Thus, the manufacturing costs may be reduced.

[0022] In this aspect, the fuel supply device includes a small number of components. This allows for the fuel supply device to be reduced in size and weight. In addition to decreasing component costs and management costs, a decrease in the number of assembling steps lowers the manufacturing costs. This realizes a fuel supply device having superior properties for installation in a vehicle or the like.

[0023] Therefore, in the fuel supply device of this aspect, the engine may be started with high quality while lowering the manufacturing costs and obtaining superior properties for installation in a vehicle or the like.

[0024] In the present disclosure, in addition to a diesel engine, a gasoline engine may be used as a multicylinder engine. When the fuel supply device in this aspect is used in a diesel engine, a common rail may be arranged between the high pressure pump and each first injector and between the high pressure pump and each second injector.

[0025] In one aspect of the present disclosure, the engine includes an addition valve that adds the fuel to raise the exhaust temperature of the engine. The medium pressure passage connects the medium pressure pump to the addition valve. A filter in an exhaust gas purification catalyst may collect particulate matter, which is emitted by the engine. In this situation, when a certain amount

of particulate matter is deposited in the filter, the addition valve adds fuel to the exhaust gas to raise the temperature of the filter. This burns the deposited particulate matter and regenerates the filter. In this aspect, the medium pressure pump is connected to the addition valve through the medium pressure passage. This eliminates the need for a special medium pressure passage that connects the medium pressure pump to the addition valve, and allows for a smaller fuel supply device to be realized.

[0026] In one aspect of the present disclosure, one of the first return passage and the second return passage includes a first portion, which extends from the check valve toward each of the first injectors, and a second portion, which extends from the check valve toward each of the second injectors. The longer one of the first portion and the second portion has a larger cross-sectional passage area than the other one of the first portion and the second portion.

[0027] In one aspect of the present disclosure, one of the first return passage and the second return passage is connected to the connection passage at a connecting point. The first portion extends from the connecting point toward each of the first injectors, and the second portion extends from the connecting point toward each of the second injectors. When the first portion is longer than the second portion, the cross-sectional passage area of the first portion is larger than that of the second portion. When the second portion is longer than the first portion, the cross-sectional passage area of the second portion is larger than that of the first portion.

[0028] In one aspect of the present invention, the cross-sectional passage area of the connection passage is larger than that of the shorter one of the first portion and the second portion. In these aspects, in addition to the advantages that the above fuel supply device obtains, the volume difference and the pressure loss difference between the first return passage and the second return passage may be further reduced from that in document 1.

[0029] In one aspect of the present invention, the first return passage and the second return passage are configured so that the length from the check valve to each of the first injectors and the length from the check valve to each of the second injectors are the same. In this aspect, the volume difference and the pressure loss difference between the first return passage and the second return passage may be further reduced from that in document 1. This allows for a smaller fuel supply device to be realized.

BRIEF DESCRIPTION OF THE DRAWINGS

[0030]

Fig. 1 is a schematic diagram showing the structure of a fuel supply device of a first embodiment.

Fig. 2 is a schematic diagram showing the structure of a fuel supply device of a second embodiment.

Fig. 3 is a schematic diagram showing the structure of a fuel supply device of a third embodiment.

EMBODIMENTS OF THE INVENTION

[0031] First to third embodiments of the present disclosure will now be described with reference to the drawings.

10 First Embodiment

[0032] As shown in Fig. 1, a fuel supply device of a first embodiment is connected to four first injectors 1a to 1d and a plurality of second injectors 1e to 1h. The first injectors 1a to 1d inject fuel into each first combustion chamber of a first cylinder group L in a multicylinder diesel engine. The second injectors 1e to 1h inject fuel into each second combustion chamber of a second cylinder group R in the diesel engine. The fuel supply device of the first embodiment supplies fuel from a fuel tank 3 to the first injectors 1a to 1d and the second injectors 1e to 1h. Each of the first injectors 1a to 1d and the second injectors 1e to 1h is a piezo-injector, which employs a piezo element, and functions as an actuator that opens and closes an injection hole.

[0033] In the fuel supply device of the first embodiment, the fuel tank 3 is connected to a supply pump 5 through a supply pipe 7. A fuel filter 9 is arranged in the supply pipe 7. The supply pump 5 incorporates a medium pressure pump 5a and a high pressure pump 5b.

[0034] The medium pressure pump 5a adjusts the fuel from the fuel tank 3 to a medium pressure of a few megapascals, and delivers the fuel to medium pressure pump pipes 5c and 5d. The high pressure pump 5b is connected to the medium pressure pump 5a through the medium pressure pump pipe 5c. The high pressure pump 5b is capable of adjusting the fuel, which is delivered through the medium pressure pump pipe 5c, to a high pressure of a few hundred megapascals. A primary high pressure pipe 11 is in communication with a discharge unit of the high pressure pump 5b. A medium pressure pipe 13 is connected to the medium pressure pump 5a through the medium pressure pump pipe 5d.

[0035] A first common rail 15 is connected to the high pressure pump 5b through the primary high pressure pipe 11. A second common rail 19 is connected to the first common rail 15 through a secondary high pressure pipe 17. The first common rail 15 is connected to the first injectors 1a to 1d through the first high pressure pipes 21a to 21d, respectively. The second common rail 19 is connected to the second injectors 1e to 1h through the second high pressure pipes 21e to 21h, respectively. The primary high pressure pipe 11, the first common rail 15, and the first high pressure pipes 21a to 21d correspond to a first high pressure passage. The primary high pressure pipe 11, the first common rail 15, the secondary high pressure pipe 17, the second common rail 19, and the second high pressure pipes 21e to 21h correspond to a

second high pressure passage. The first high pressure passage and the second high pressure passage correspond to a high pressure passage through which fuel flows under a high pressure.

[0036] A first medium pressure pipe 13a and a connection pipe 13b branch from the medium pressure pipe 13 at a first branching point A. A second medium pressure pipe 13c and a first connection pipe 31a branch from the connection pipe 13b at a second branching point B. A first addition injector 23a, which serves as a first addition valve, is connected to the first medium pressure pipe 13a. A second addition injector 23b, which serves as a second addition valve, is connected to the second medium pressure pipe 13c. The first addition injector 23a and the second addition injector 23b are each arranged at the upstream side of a diesel particulate filter (DPF) in an exhaust gas purification catalyst. The medium pressure pump pipes 5c and 5d, the medium pressure pipe 13, the first medium pressure pipe 13a, the second medium pressure pipe 13c, and the connection pipe 13b correspond to a medium pressure passage through which fuel flows under a medium pressure.

[0037] Each of the first injectors 1a to 1d is connected to a first return pipe 25 that defines a first return passage. Each of the second injectors 1e to 1h is connected to a second return pipe 27 that defines a second return passage. The first return pipe 25 is connected to a second connection pipe 31b at a connecting point C. The first return pipe 25 is connected to the second return pipe 27 and a first recovery pipe 39 at a junction D, which is downstream of the connecting point C. The first recovery pipe 39 extends from the junction D to a back pressure valve 29. The first return pipe 25, the second return pipe 27, and the first recovery pipe 39 form a return passage, which transports fuel.

[0038] The first connection pipe 31a and the second connection pipe 31b form a connection passage, which connects the medium pressure passage to the return passage. A check valve 33 is arranged between the first connection pipe 31a and the second connection pipe 31b. The check valve 33 permits the supply of fuel from the first connection pipe 31a to the second connection pipe 31b and impedes the supply of fuel from the second connection pipe 31b to the first connection pipe 31a. The opening valve pressure of the check valve 33 is set to be lower than the pressure of the return passage.

[0039] The first return pipe 25 is capable of transporting surplus fuel from the first injectors 1a to 1d. Also, the second return pipe 27 is capable of transporting surplus fuel from the second injectors 1e to 1h. The back pressure valve 29 is capable of applying a back pressure, which is used to operate the first injectors 1a to 1d and the second injectors 1e to 1h. The downstream side of the back pressure valve 29 is connected to the second recovery pipe 37. The first recovery pipe 39 and the second recovery pipe 37 form a recovery passage, which returns fuel to the fuel tank 3. The supply pump 5 is connected to the second recovery pipe 37 through a drain

pipe 35a. The drain pipe 35a is connected to the fuel tank 3 through a portion of the second recovery pipe 37. Drain pipes 35b and 35c are connected to the second common rail 19. The second common rail 19 is connected to the drain pipe 35a through the drain pipe 35b, and also connected to the drain pipe 35a through the drain pipe 35c.

[0040] In the fuel supply device of the first embodiment, fuel from the fuel tank 3 is drawn through the supply pipe 7 into the medium pressure pump 5a of the supply pump 5. During this process, foreign matter is removed from the fuel by the fuel filter 9. The fuel, which is drawn by the medium pressure pump 5a, is delivered to the high pressure pump 5b of the supply pump 5 and adjusted to a high pressure. The high-pressure fuel is delivered into the first common rail 15 through the primary high pressure pipe 11. The fuel from the first common rail 15 is delivered into the second common rail 19 through the secondary high pressure pipe 17.

[0041] The high-pressure fuel, which is accumulated in the first common rail 15, is injected into the first combustion chambers of the first cylinder group L in the engine by the first injectors 1a to 1d. The high-pressure fuel, which is accumulated in the second common rail 19, is injected into the second combustion chambers of the second cylinder group R in the engine by the second injectors 1e to 1h.

[0042] The surplus fuel in the first injectors 1a to 1d is transported to the fuel tank 3 after passing through the first return pipe 25, the first recovery pipe 39, the back pressure valve 29, and the second recovery pipe 37. The surplus fuel in the second injectors 1e to 1h is transported to the fuel tank 3 after passing through the second return pipe 27, the first recovery pipe 39, the back pressure valve 29, and the second recovery pipe 37.

[0043] Under this situation, in the back pressure valve 29, the pressure at the side of the first recovery pipe 39 acts against the pressure at the side of the fuel tank 3. The back pressure valve 29 opens when the pressure difference between side of the first recovery pipe 39 and the side of the fuel tank 3 becomes larger than the pressure used to operate the first injectors 1a to 1d and the second injectors 1e to 1h. In this manner, the surplus fuel is exposed to the atmospheric pressure through the back pressure valve 29 and returned to the fuel tank 3.

[0044] During operation of the engine, when the fuel tank becomes empty, that is, when fuel runs out, bubbles enter the first return passage, which is connected to the first injectors 1a to 1d, and the second return passage, which is connected to the second injectors 1e to 1h. The first injectors 1a to 1d and the second injectors 1e to 1h are piezo-injectors. This decreases the pressures of the first return passage and the second return passage. In this condition, when the tank is refilled with fuel and the engine is restarted, the first injectors 1a to 1d and the second injectors 1e to 1h cannot inject fuel.

[0045] Therefore, in the fuel supply device of the first embodiment, when the fuel tank is refilled with fuel and the engine is restarted, the medium pressure pump 5a

supplies fuel to the first return pipe 25 through the connection pipe 13b, the first connection pipe 31a, and the second connection pipe 31 b. The fuel, which is supplied to the first return pipe 25, is also supplied to the second return pipe 27 from the junction D.

[0046] Under this situation, in the check valve 33, the pressure at the side of the first connection pipe 31 a connected to the medium pressure pump 5a acts against the pressure at the side of the second connection pipe 31b connected to the first return pipe 25. The check valve 33 opens when the pressure at the side of the medium pressure pump 5a, that is, the side of the first connection pipe 31a, becomes larger than a force obtained by adding the pressure at the side of the first return pipe 25, that is, the side of the second connection pipe 31 b, to the spring force of the check valve 33. In this manner, the fresh fuel from the fuel tank 3 is supplied to the first return pipe 25 and the second return pipe 27 under a pressure that is higher than the valve opening pressure of the check valve 33.

[0047] The advantages of this embodiment will now be described below.

(1) The opening valve pressure of the check valve 33 is set to be lower than the back pressure of the back pressure valve 29, that is, the pressure that opens the back pressure valve 29. Thus, the back pressure of the back pressure valve 29 acts on the fuel in the first return pipe 25 and the fuel in the second return pipe 27. This obtains the pressure of the first return passage 25, which is used for fuel injection from the first injectors 1a to 1d, and the pressure of the second return passage 27, which is used for fuel injection from the second injectors 1 e to 1 h.

(2) When the fuel tank 3 is refilled with fuel and the engine is restarted, the high pressure pump 5b supplies high-pressure fuel to the first common rail 15, the second common rail 19, the first high pressure pipes 21a to 21d, and the second high pressure pipes 21e to 21h. Thus, the fuel supply device of the first embodiment enables the first injectors 1a to 1d and the second injectors e to 1h to inject fuel again.

(3) During this process, the fuel supply device of the first embodiment returns the surplus fuel from the first injectors 1a to 1d and the second injectors 1e to 1h to the fuel tank 3 through the first recovery pipe 39 and the second recovery pipe 37. The pipe length L2 from the check valve 33 to the second injectors 1e to 1h is greater than the pipe length L1 from the check valve 33 to the first injectors 1a to 1d. The length L1 is the total of the length of the second connection pipe 31b and the length of the upstream portion of the first return pipe 25 from the connecting point C. The length L2 is the total of the length of the second connection pipe 31 b, the length of the downstream portion of the first return pipe 25 from the

connecting point C, and the length of the second return pipe 27. In the first embodiment, the first return passage 25 includes a first portion 25a, which extends from the check valve 33 to the first injectors 1a to 1d, and a second portion 25b, which extends from the check valve 33 to the second injectors 1 e to 1h. Specifically, the first portion 25a extends from the connecting point C toward the first injectors 1a to 1 d, and the length L1 is the total of the length of the second connection pipe 31b and the length of the first portion 25a. The second portion 25b extends from the connecting point C toward the second injectors 1 e to 1 h, and the length L2 is the total of the length of the second connection pipe 31 b, the length of the second portion 25b, and the second return pipe 27. In document 1, a different recovery passage is connected to each return passage. In contrast, in the first embodiment, the first return pipe 25 and the second return pipe 27 joined into the single first recovery pipe 39 at junction D. Therefore, even if a volume difference and a pressure loss difference exist between the first return pipe 25 and the second return pipe 27, the volume difference and the pressure loss difference do not exist in the first recovery pipe 39. That is, in the first embodiment, influence of the return passage on the recovery passage is smaller than that in document 1.

(4) In the fuel supply device of the first embodiment, the back pressure valve 29 is arranged at the downstream side of the first recovery pipe 39, that is, the side of the fuel tank 3. As a comparative example, if different back pressure valves are arranged in the first return passage and the second return passage, a back pressure difference and a flow characteristic difference may be produced between the two back pressure valves. In contrast, in the first embodiment, only a single back pressure valve 29 is arranged in the first recovery pipe 39 that is a portion of a single recovery passage. Therefore, since the first embodiment employs only a single back pressure valve 29, a back pressure difference and a flow characteristic difference do not exist.

(5) Further, in the fuel supply device of the first embodiment, the check valve 33, which has a lower opening valve pressure than the back pressure of the back pressure valve 29, is arranged between the first connection pipe 31a and the second connection pipe 31 b. Document 1 uses two return passages, each of which includes a check valve. However, the first embodiment uses only the single return passage, which includes the single check valve 33. Therefore, in the first embodiment, a valve opening pressure difference and a flow characteristic difference, which are produced when a plurality of check valves are employed, do not exist.

(6) In this manner, the fuel supply device of the first embodiment includes the single check valve 33 and the single back pressure valve 29. This limits the injection time difference and the injection amount difference of the first injectors 1a to 1d and the second injectors 1e to 1h. Therefore, the engine easily achieves superior starting capability, fuel efficiency, output, emission properties, and so on. Consequently, in the fuel supply device of the first embodiment, there is no need for a complicated control of the injectors. This allows for a relatively moderate tolerance for components. Thus, the manufacturing costs may be reduced.

(7) The fuel supply device of the first embodiment includes a small number of components. This allows for the fuel supply device to be reduced in size and weight. In addition to decreasing component costs and management costs, a decrease in the number of assembling steps lowers the manufacturing costs. This realizes a fuel supply device having superior properties for installation in a vehicle or the like. Consequently, according to the fuel supply device of the first embodiment, the engine may be started with high quality while lowering the manufacturing costs and obtaining superior properties for installation in a vehicle or the like.

(8) The fuel supply device of the first embodiment connects the first addition injector 23a to the first medium pressure pipe 13a, and the second addition injector 23b to the second medium pressure pipe 13c. Thus, without using a special medium pressure passage, when a certain amount of particulate matter is deposited in a DPF, the first addition injector 23a and the second addition injector 23b add fuel to the exhaust gas to raise the temperature of the DPF. In other words, in the first embodiment, the medium pressure pump 5a is connected to the addition valves, that is, the first addition injector 23a and the second addition injector 23b, through the medium pressure passage. This eliminates the need for a special medium pressure passage that connects the medium pressure pump 5a to the addition valves. Thus, the first embodiment realizes a smaller fuel supply device.

Second Embodiment

[0048] As shown in Fig. 2, in the fuel supply device of the second embodiment, like the first embodiment, the pipe length L2 from the check valve 33 to the second injectors 1e to 1h is greater than the pipe length L1 from the check valve 33 to the first injectors 1a to 1d.

[0049] However, in the fuel supply device of the second embodiment, a cross-sectional passage area of the second portion 25b of the first return pipe 25, which is located closer to the first recovery pipe 39 than the connecting

point C, and a cross-sectional passage area of the second return pipe 27a are larger than a cross-sectional passage area of the first portion 25a of the first return pipe 25 between the connecting point C and the first injectors 1a to 1d. Additionally, the cross-sectional passage area of the second connection pipe 31c and the cross-sectional passage area of the first recovery pipe 39a are the largest among the first return pipe 25, the second return pipe 27a, the first recovery pipe 39a, and the second connection pipe 31c. Otherwise, the structure of the second embodiment is to the same as the first embodiment. **[0050]** (9) Thus, in addition to the advantages of the fuel supply device of the first embodiment, the fuel supply device of the second embodiment allows for further reduction in the volume difference and the pressure loss difference between the first return pipe 25 and the second return pipe 27a as compared with document 1.

Third Embodiment

[0051] As shown in Fig. 3, in the fuel supply device of the third embodiment, the second connection pipe 31d is connected to the first return pipe 25 at a connecting point E. The first return pipe 25 and the second return pipe 27 are configured so that a length L3 from the check valve 33 to the first injectors 1a to 1d and a length L4 from the check valve 33 to the second injectors 1e to 1h are the same. Otherwise, the structure of the third embodiment is the same as the first embodiment.

[0052] (10) Thus, the fuel supply device of the third embodiment allows for further reduction in the volume difference and the pressure loss difference between the first return pipe 25 and the second return pipe 27a as compared with document 1.

[0053] The present disclosure is described through the first to third embodiments. However, the present disclosure is not restricted to the first to third embodiments. The present disclosure may be modified within the scope and equivalence of the appended claims.

[0054] For example, the connection passage does not have to be connected to the first return pipe 25. Instead, the connection passage may be connected to the second return pipe 27 and the first recovery pipes 39 and 39a.

[0055] The present disclosure has industrial applicability and may be applied to a vehicle or the like that includes a diesel engine.

DESCRIPTION OF REFERENCE SYMBOLS

[0056]

L: First Cylinder Group
1a to 1d: First Injector
R: Second Cylinder Group
1 e to 1 h: Second Injector
3: Fuel Tank
5a: Medium Pressure Pump
5b: High Pressure Pump

11, 15, 17, 19, 21a to 21d, 21e to 21h: High Pressure Passage (11: Primary High Pressure Pipe, 15: First Common Rail, 17: Secondary High Pressure Pipe, 19: Second Common Rail, 21a to 21d: First High Pressure Pipe, 21e to 21h: Second High Pressure Pipe) 5
 25: First Return Passage (First Return Pipe)
 27: Second Return Passage (Second Return Pipe)
 D: Junction
 37, 39: Recovery Passage (37: Second Recovery Pipe, 39: First Recovery Pipe) 10
 29: Back Pressure Valve
 5c, 5d, 13, 13a, 13c, 13b: Medium Pressure Passage (5c, 5d: Medium Pressure Pump Pipe, 13a: First Medium Pressure Pipe, 13c: Second Medium Pressure Pipe, 13b: Connection Pipe) 15
 31a, 31b: Connection Passage (First Connection Pipe, Second Connection Pipe)
 33: Check Valve
 23a: First Addition Valve (First Addition Injector) 20
 23b: Second Addition Valve (Second Addition Injector)

Claims

1. A fuel supply device connected to a plurality of first injectors and a plurality of second injectors, wherein the fuel supply device supplies fuel from a fuel tank to each of the first injectors and each of the second injectors, the first injectors inject the fuel into a first fuel chamber of a first cylinder group of an engine, the second injectors inject the fuel into a second fuel chamber of a second cylinder group of the engine, and each of the first injectors and each of the second injectors are piezo-injectors, the fuel supply device comprising:
 - a medium pressure pump capable of adjusting the fuel from the fuel tank to a medium pressure and delivering the medium-pressure fuel;
 - a high pressure pump capable of adjusting the fuel to a high pressure, which is higher than the medium pressure, and delivering the high-pressure fuel;
 - a high pressure passage that connects the high pressure pump to each of the first injectors and each of the second injectors;
 - a first return passage connected to each of the first injectors, wherein the first return passage is capable of transporting surplus fuel from each of the first injectors;
 - a second return passage connected to each of the second injectors, wherein the second return passage is capable of transporting surplus fuel from each of the second injectors;
 - a recovery passage that joins the first return pas-
- sage and the second return passage at a junction, wherein the recovery passage returns the surplus fuel to the fuel tank;
- a back pressure valve arranged in the recovery passage, wherein the back pressure valve is capable of applying a back pressure to each of the first injectors and each of the second injectors;
- a medium pressure passage connected to the medium pressure pump;
- a connection passage that connects the medium pressure passage to one of the first return passage, the second return passage, and a portion of the recovery passage upstream from the back pressure valve; and
- a check valve having a lower opening valve pressure than the back pressure and arranged in the connection passage, wherein the check valve permits the supply of fuel from the medium pressure passage to the first return passage and the second return passage and impedes the opposite.
2. The fuel supply device according to claim 1, wherein the engine includes an addition valve that adds the fuel to raise the exhaust temperature of the engine, and the medium pressure passage connects the medium pressure pump to the addition valve.
3. The fuel supply device according to claim 1 or 2, wherein one of the first return passage and the second return passage includes a first portion that extends from the check valve toward each of the first injectors and a second portion that extends from the check valve toward each of the second injectors, and the longer one of the first portion and the second portion has a larger cross-sectional passage area than the other one of the first portion and the second portion.
4. The fuel supply device according to claim 3, wherein one of the first return passage and the second return passage is connected to the connection passage at a connecting point, the first portion extends from the connecting point toward each of the first injectors, and the second portion extends from the connecting point toward each of the second injectors, when the first portion is longer than the second portion, the cross-sectional passage area of the first portion is larger than that of the second portion, and when the second portion is longer than the first portion, the cross-sectional passage area of the second portion is larger than that of the first portion.
5. The fuel supply device according to claim 3 or 4, wherein the cross-sectional passage area of the con-

nection passage is larger than that of the shorter one of the first portion and the second portion.

6. The fuel supply device according to claim 1 or 2, wherein the first return passage and the second return passage are configured so that the length from the check valve to each of the first injectors and the length from the check valve to each of the second injectors are the same.

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Fig. 1

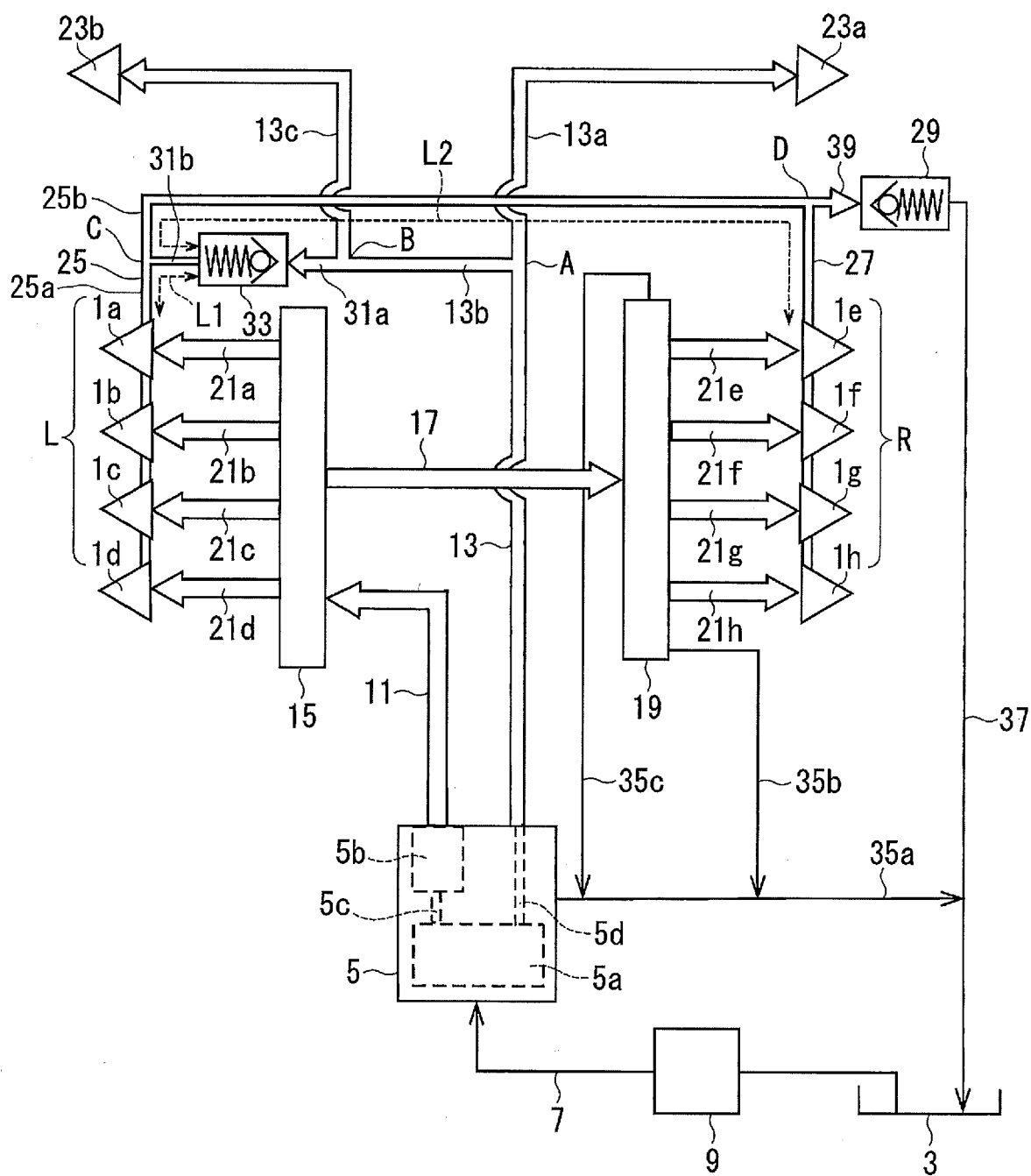


Fig. 2

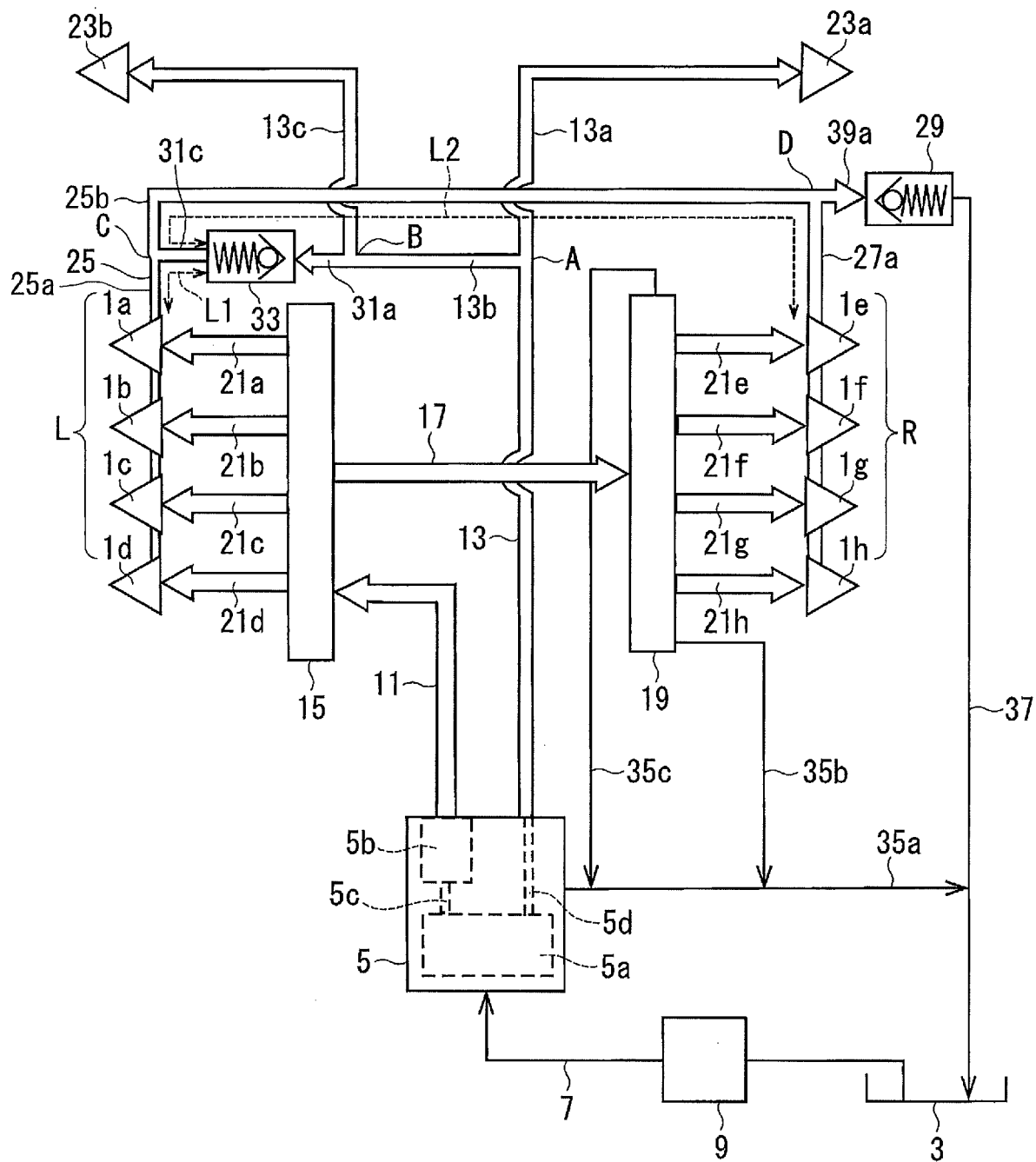
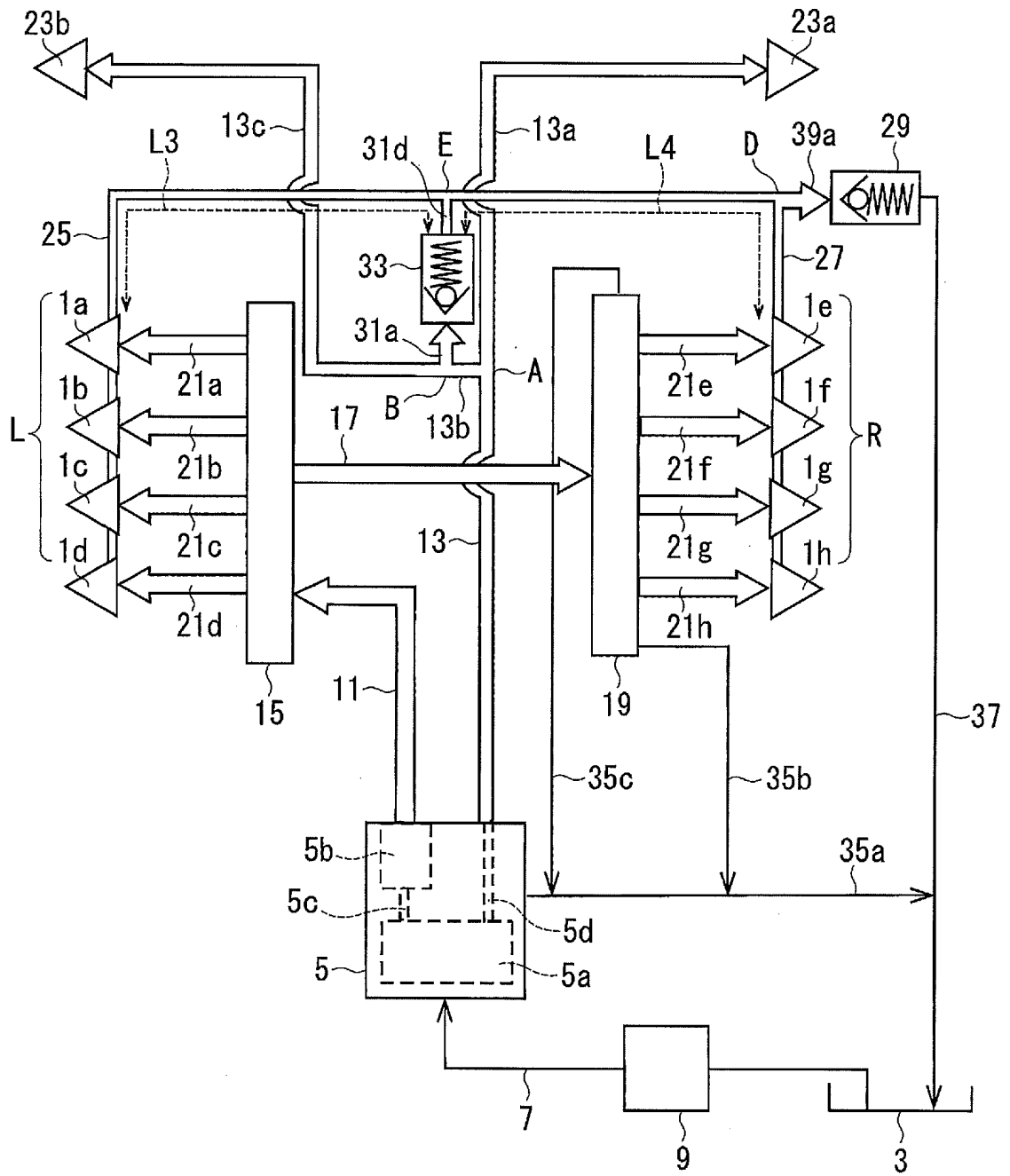


Fig. 3



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2012/081348

A. CLASSIFICATION OF SUBJECT MATTER

F02M55/00 (2006.01) i, F02M37/00 (2006.01) i, F02M55/02 (2006.01) i

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)

F02M55/00, F02M37/00, F02M55/02

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

Jitsuyo Shinan Koho	1922-1996	Jitsuyo Shinan Toroku Koho	1996-2013
Kokai Jitsuyo Shinan Koho	1971-2013	Toroku Jitsuyo Shinan Koho	1994-2013

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.
Y	JP 2009-293541 A (Bosch Corp.), 17 December 2009 (17.12.2009), paragraphs [0048] to [0054]; fig. 4 (Family: none)	1-6
Y	JP 7-293394 A (Robert Bosch GmbH), 07 November 1995 (07.11.1995), paragraphs [0013] to [0014]; fig. 1 & US 5577479 A & EP 678668 A2 & DE 4414242 A1	1-6
Y	JP 2010-38139 A (Denso Corp.), 18 February 2010 (18.02.2010), paragraph [0027]; fig. 1 & DE 102009036364 A1	2-6

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

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"&" document member of the same patent family

Date of the actual completion of the international search
08 February, 2013 (08.02.13)Date of mailing of the international search report
19 February, 2013 (19.02.13)Name and mailing address of the ISA/
Japanese Patent Office

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2012/081348

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2009-257215 A (Toyota Motor Corp.), 05 November 2009 (05.11.2009), entire text; all drawings (Family: none)	1-6
A	JP 2007-205330 A (Denso Corp.), 16 August 2007 (16.08.2007), entire text; all drawings & DE 102007000072 A1	1-6

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2009102990 A [0002] [0012] [0013]