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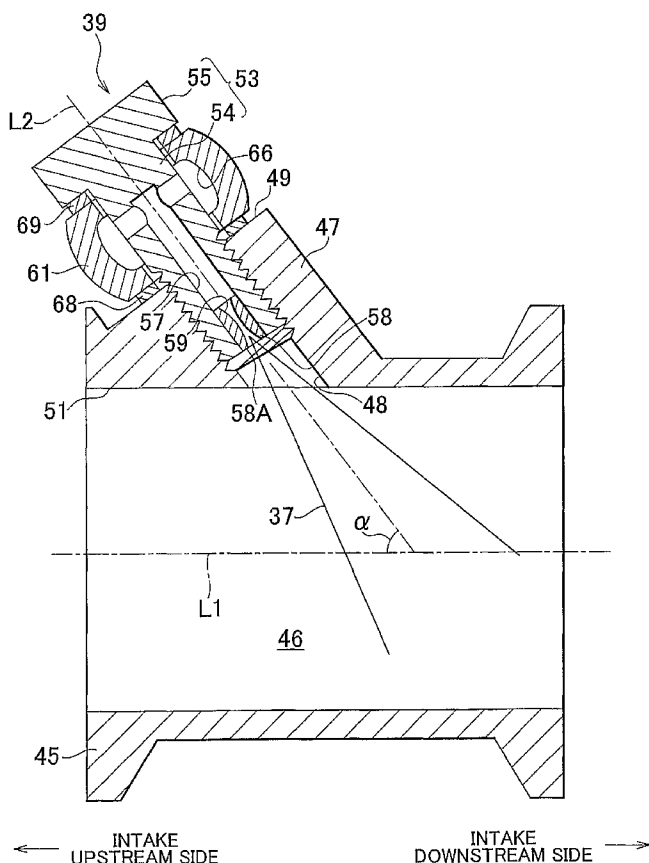
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(54) Title: FUEL INJECTION DEVICE



(57) Abstract: A joint bolt (53) is mounted in a mounting hole (48) formed in a delivery spacer (45) defining a fuel injection space (46). The mounting hole (48) opens in both the inner wall surface (51) and the outer wall surface (49) of the delivery spacer (45). The joint bolt (53) is attachable and detachable through the opening on the outer wall surface side (49) of the delivery spacer (45). A jet nozzle (58) is disposed in a portion of the mounting hole (48) recessed from the inner wall surface (51) of the delivery spacer (45). Fuel (37) is supplied from outside the delivery spacer (45) and introduced into the mounting hole (48) through a fuel passage (57) formed in the joint bolt (53), thereby injected from a constantly open injection hole (59) of the jet nozzle (58). The jet nozzle (58) is fixed to a shaft (54) of the joint bolt (53) by press-fitting, with the injection hole (59) in communication with the fuel passage (57).

FUEL INJECTION DEVICE

BACKGROUND OF THE INVENTION

5 1. Field of the Invention

[0001] The present invention relates to a fuel injection device that injects fuel to an internal combustion engine.

2. Description of the Related Art

10 [0002] Internal combustion engines using alcohol and/or gasoline have recently been put into practical use. This type of internal combustion engine is operable on any one of alcohol alone, gasoline alone, and blend of alcohol and gasoline.

[0003] Alcohol is less volatile than gasoline, and is not easily vaporized at low temperatures. Thus, the low-temperature startability of the internal combustion engine is reduced as the concentration of alcohol in fuel increases, for example in the case where
15 the fuel consists only of highly-concentrated alcohol or in the case where the proportion of alcohol in a blended fuel is higher than the proportion of gasoline.

[0004] Japanese Patent Application Publication No. 2-149757 describes a technique to inject auxiliary fuel that has higher gasoline concentration than the main fuel, which has higher alcohol concentration, at low-temperature start of an internal
20 combustion engine. This technique provides a fuel injection device that injects auxiliary fuel at low-temperature start of the internal combustion engine, in addition to an electromagnetic fuel injection valve for injecting main fuel during engine operation other than low-temperature start of the internal combustion engine (that is, during normal operation). An auxiliary fuel tank for storing the auxiliary fuel is disposed in an engine
25 room. The auxiliary fuel in the auxiliary fuel tank is supplied by an auxiliary fuel pump through auxiliary fuel piping to the fuel injection device, and injected into an intake passage.

[0005] The fuel injection device is mounted in a mounting hole formed in an intake pipe. The mounting hole is formed through a wall of the intake pipe, and opens

in both an inner wall surface and an outer wall surface of the intake pipe. Such a fuel injection device may be constructed similarly to the electromagnetic fuel injection valve mentioned above. At low-temperature start, however, the required precision of the fuel injection amount is not as high as that during normal operation. Therefore, although a fuel injection device is constructed more simply than the electromagnetic fuel injection valve, the fuel injection device may be used to meet the required precision.

[0006] An example of the fuel injection device constructed differently from the electromagnetic fuel injection valve may include a fuel injection body and a jet nozzle. A portion of the fuel injection body is disposed toward the outer wall surface of the intake pipe, and the jet nozzle is disposed toward the inner wall surface of the intake pipe (i.e., toward the intake passage) as compared to the fuel injection body. A fuel passage is provided on the fuel injection body, and fuel piping in communication with the fuel passage is fastened to the intake pipe through the fuel injection body. An injection hole is provided in the jet nozzle, and a flow area in the injection hole may be smaller locally than a flow area in the fuel passage. No member or mechanism is provided for opening and closing the injection hole of the jet nozzle. In the fuel injection device, at low-temperature start of the internal combustion engine, auxiliary fuel supplied through the fuel piping is introduced into the mounting hole through the fuel passage of the fuel injection body, and injected into the intake passage from the injection hole of the jet nozzle that is opened constantly. In this way, at low-temperature start of the internal combustion engine, auxiliary fuel that is higher in gasoline concentration than fuel during the normal operation is injected into the internal combustion to improve the engine startability.

[0007] The jet nozzle and the fuel injection body in the above fuel injection device are mounted in the mounting hole. The jet nozzle is, however, mounted to a more recessed position in the mounting hole from the opening on the outer wall surface of the intake pipe than the fuel injection body. Thus, when maintenance or replacement of the jet nozzle is required to made, the fuel injection body is first removed from the mounting hole, and the jet nozzle is then removed from the inside of the mounting hole.

Then, the jet nozzle after the maintenance such as washing, or a new jet nozzle after the replacement, is mounted to the recessed position in the mounting hole again, and the fuel injection body is then mounted into the mounting hole from the outer wall surface of the intake pipe.

5 **[0008]** However, because the jet nozzle used in the fuel injection device has a small dimension and is mounted to the recessed position in the mounting hole as described above, installation and removal of the jet nozzle may require a specific tool, and the jet nozzle once removed from the mounting hole may be dropped and lost, resulting in a low workability of maintenance and replacement.

10

SUMMARY OF THE INVENTION

[0009] The present invention provides a fuel injection device that may improve the workability of maintenance and replacement of a jet nozzle.

15 **[0010]** A first aspect of the present invention relates to a fuel injection device including: a fuel injection body mounted in a mounting hole formed in a mounting member defining a fuel injection space therein, the mounting hole opening in both an inner wall surface and an outer wall surface of the mounting member, and the fuel injection body being removably attached through the opening on the outer wall surface
20 side; and a jet nozzle disposed in a portion of the mounting hole recessed from the opening on the outer wall surface toward the fuel injection space, fuel for an internal combustion engine supplied from outside the mounting member being introduced into the mounting hole through a fuel passage formed in the fuel injection body, and being injected from an injection hole. More particularly, with the injection hole in
25 communication with the fuel passage, the jet nozzle is fixed to the fuel injection body so as to be removably attached to the mounting hole together with the fuel injection body.

[0011] The fuel injection body may be a joint bolt in which a shaft of the joint bolt is threaded into the mounting hole, and the fuel passage may be formed in the shaft to which fuel piping is fastened. Also, the jet nozzle may be fixed to the shaft.

[0012] A fuel supply-connecting portion may be provided at a downstream end of the fuel piping, and the fuel supply-connecting portion may be in communication with the fuel passage of the shaft.

[0013] The fuel supply-connecting portion may be formed with a through-hole that opens in both axial end surfaces thereof, and a recess may be formed around the through hole.

[0014] The mounting member may constitute a segment of the intake pipe of the internal combustion engine, and the fuel injection space may constitute a segment of the intake passage. Also, the jet nozzle may be disposed in a portion of the mounting hole recessed from the inner wall surface of the mounting member.

[0015] The jet nozzle may be press-fitted into the fuel injection body, with the injection hole in communication with the fuel passage.

[0016] A counter bored portion may be provided at one end of the fuel injection body, and the jet nozzle may be press-fitted into the counter bored portion of the fuel injection body.

[0017] The jet nozzle may be screwed into the fuel injection body with the injection hole in communication with the fuel passage.

[0018] The injection hole of the jet nozzle may narrow at an intermediate portion in an axial direction of the jet nozzle.

[0019] The injection hole of the jet nozzle may narrow to a uniform diameter from an intermediate portion to an end in an axial direction of the jet nozzle.

[0020] The internal combustion engine may be operable on fuel blended with at least alcohol as a main fuel. Also, the fuel injection device may inject an auxiliary fuel, which has a higher concentration of gasoline than the main fuel, at low-temperature start of the internal combustion engine.

BRIEF DESCRIPTION OF THE DRAWINGS

[0021] The foregoing and further objects, features and advantages of the

invention will become apparent from the following description of example embodiments with reference to the accompanying drawings, wherein like numerals are used to represent like elements and wherein:

FIG. 1 is a schematic diagram showing an internal combustion engine for an FFV incorporating an auxiliary fuel injection device according to an example embodiment of the present invention;

FIG. 2 is a cross sectional view showing the auxiliary fuel injection device of FIG. 1 and the vicinity thereof;

FIG. 3A is a partial cross sectional view showing the auxiliary fuel injection device before being attached to a delivery spacer;

FIG. 3B is a partial cross sectional view showing an eye-shaped joint of FIG. 3A and auxiliary fuel piping as viewed from a different direction;

FIG. 4 is a cross sectional view showing the auxiliary fuel injection device before a jet nozzle is fixed in a joint bolt by press-fitting;

FIG. 5A is a partial cross sectional view showing a modified example of the attachment structure of the jet nozzle; and

FIG. 5B is a partial cross sectional view showing a modified example of the shape of an injection hole in the jet nozzle.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0022] Hereinafter, an auxiliary fuel injection device for an internal combustion engine mounted on a flexible fuel vehicle (hereinafter simply referred to as "FFV") will be described as an example embodiment of a fuel injection device in the present invention with reference to FIGs. 1 to 4. The internal combustion engine may run on any one of alcohol alone, gasoline alone, and a blend of alcohol and gasoline mixed in any proportion.

[0023] As shown in FIG. 1, the internal combustion engine 11 includes a cylinder block 13 having a plurality of cylinders 12, and a cylinder head 14 mounted on

top of the cylinder block 13. Pistons 15 housed in each cylinder 12 with reciprocal motion are connected to a crankshaft 17, which is an output shaft of the internal combustion engine 11, via a connecting rod 16.

[0024] An intake passage 19 is connected to the combustion chamber 18 of each cylinder 12, to introduce air outside the internal combustion engine 11 into the combustion chamber 18. An intake port 21 formed in the cylinder head 14 and a passage 23 inside an intake manifold 22 formed upstream (left side in FIG. 1) of intake air constitute a segment of the intake passage 19. The upstream end of the intake port 21 opens toward a sidewall on one side of the cylinder head 14 (left side in FIG. 1) while the downstream end of the intake port 21 opens downward the cylinder head 14. The intake manifold 22 distributes the intake air to the intake port 21 of each cylinder 12. An exhaust passage 24 is connected to the combustion chamber 18 of each cylinder 12 to discharge combustion gas outward the internal combustion engine 11. An exhaust port 25 is provided in the cylinder head 14, and constitutes a segment of the exhaust passage 24. The upstream end of the exhaust port 25 opens downward the cylinder head 14 while the downstream end of the exhaust port 25 opens toward a sidewall on the other side (right side in FIG. 1) of the cylinder head 14.

[0025] An intake valve 26 and an exhaust valve 27 are provided in the cylinder head 14 with respect to each cylinder 12. An intake camshaft 28 that is driven to rotate by the crankshaft 17 pushes down the intake valve 26, which opens the intake port 21. Likewise, an exhaust camshaft 28 that is also driven to rotate by the crankshaft 17 pushes down the exhaust valve 27, which opens the exhaust port 25.

[0026] An electromagnetic main fuel injection valve 31 with respect to each cylinder 12 is mounted in the cylinder head 14, to inject fuel for internal combustion engines toward the downstream side of the intake air in intake port 21. The main fuel injection valve 31 is connected to a main fuel tank 34 via main fuel piping 32 and a main fuel pump 33. The main fuel tank 34 stores a blended fuel of alcohol and gasoline mixed in any proportion. The blended fuel in the main fuel tank 34 is delivered to the main fuel injection valve 31 through the main fuel piping 32 by the main fuel pump 33.

When a solenoid coil of the main fuel injection valve 31 is energized, a core in the main fuel injection valve 31 is pulled and a needle valve integral with the core is moved apart from a nozzle. Then, an injection hole of the nozzle is opened so that the blended fuel is injected toward the intake downstream of the intake port 21. The injected fuel is mixed
5 with intake air flowing in the intake passage 19 to form an air-fuel mixture, which flows into the combustion chamber 18. The air-fuel mixture is ignited by a spark discharge of a spark plug 35, and combusted. Combustion gas at high temperature and high pressure is generated at this time, and causes the pistons 15 to reciprocate. The reciprocating motions of the pistons 15 are transmitted to the crankshaft 17 via the connecting rod 16 to
10 rotate the crankshaft 17. In this way, the internal combustion engine 11 produces a driving force (torque).

[0027] Alcohol used for the internal combustion engine 11 is less volatile than gasoline, and is not easily vaporized at low temperatures. Thus, the low-temperature startability of the internal combustion engine 11 is reduced as the concentration of
15 alcohol in the fuel increases, for example when the fuel consists only of highly concentrated alcohol or when the proportion of alcohol in a blended fuel is higher than the proportion of gasoline.

[0028] Accordingly, according to the example embodiment in the present invention, fuel that has a higher concentration of gasoline than alcohol is injected at
20 low-temperature start. This fuel contains gasoline in a predetermined proportion or higher. Here, in order to differentiate between the two types of fuel, the fuel having a higher alcohol concentration is referred to as "main fuel 36", while the fuel having a higher gasoline concentration is referred to as "auxiliary fuel 37". At low-temperature start, the main fuel injection valve 31 is temporarily closed to stop the injection of the
25 main fuel 36, instead of which the auxiliary fuel 37 is injected.

[0029] The auxiliary fuel 37 contains gasoline in such a minimum proportion or higher to ensure engine start even at low temperatures where engine start with the main fuel 36 would be difficult. For example, the auxiliary fuel 37 for engine starting may be blended fuel of alcohol and gasoline containing gasoline in the above minimum

proportion or higher (for example, containing 50% or higher gasoline). As a matter of course, fuel containing 100% gasoline may be used as the auxiliary fuel 37.

[0030] According to the example embodiment, an auxiliary fuel injection device 39 for injecting the auxiliary fuel 37 at low-temperature engine start is provided for each cylinder 12 in order to inject the auxiliary fuel 37, in addition to the main fuel injection valve 31 for injecting the main fuel 36 during normal operation of the engine except for low-temperature engine start. The auxiliary fuel injection device 39 is provided on the intake upstream of the main fuel injection valve 31. An auxiliary fuel tank 38 for storing the auxiliary fuel 37 may be disposed in an engine room. The auxiliary fuel injection device 39 is connected to the auxiliary fuel tank 38 via such as auxiliary fuel piping 41, a control valve 42 and an auxiliary fuel pump 44. The auxiliary fuel pump 44 delivers the auxiliary fuel 37 in the auxiliary fuel tank 38 via the auxiliary fuel piping 41 to each auxiliary fuel injection device 39. The control valve 42 may be an electromagnetic valve, a solenoid valve, etc., and adjusts the flow rate of the auxiliary fuel 37 to be delivered to each auxiliary fuel injection device 39 through the auxiliary fuel piping 41 by adjusting the flow area of the auxiliary fuel piping 41.

[0031] Thus, the internal combustion engine 11 at a low temperature may be started by injecting an auxiliary fuel 37 that contains more gasoline, which is more volatile and provides excellent ignition quality. This improves the low-temperature startability of the internal combustion engine 11 which can operate on alcohol or blended fuel. Once the internal combustion engine is started and the temperature has sufficiently increased, the control valve 42 reduces the flow area of the auxiliary fuel piping 41 to block or restrict the communication of the auxiliary fuel 37. Therefore, the fuel injection from the auxiliary fuel injection device 39 is stopped or nearly stopped, and the main fuel injection valve 31 injects the main fuel 36.

[0032] Now, the auxiliary fuel injection device 39 and the attachment structure thereof will be described. A delivery spacer 45 as a mounting member [mounted member??] is interposed between the cylinder head 14 and the intake manifold 22. The delivery spacer 45 with the intake manifold 22 constitutes a segment of the intake pipe.

The delivery spacer 45 defines therein the same number of fuel injection spaces 46 as that of the cylinders 12. Each fuel injection space 46 constitutes a segment of the intake passage 19, and introduces the intake air distributed by the intake manifold 22 into the intake port 21 of the corresponding cylinder 12.

5 **[0033]** Here, the fuel injection space 46 is set as a reference in order to refer to each part of the delivery spacer 45. The term “inner” is used to refer to a direction of moving radially closer to the fuel injection space 46, while the term “outer” is used to refer to a direction of moving radially away from the fuel injection space 46.

[0034] As shown in at least one of FIG. 2 and FIG. 3A, an outward projection
10 47 is provided in an outer wall surface 49 of the delivery spacer 45, specifically in a respective position corresponding to each fuel injection space 46. A mounting hole 48 is formed in each outward projection 47 of the delivery spacer 45. The mounting hole 48 is inclined with respect to an axis L1 of the fuel injection space 46 by a predetermined angle α . Due to this inclination, the outer end of the mounting hole 48 opens in the
15 outer wall surface 49 of the corresponding projection 47, while the inner end of the mounting hole 48 opens in a cylindrical inner wall surface 51 of the delivery spacer 45, specifically on the intake downstream relative to the outer end of the mounting hole 48. Female threads 52 are formed on the inner peripheral surface of the mounting hole 48. Each auxiliary fuel injection device 39 is mounted to the delivery spacer 45 at the
20 mounting hole 48 having the female threads 52.

[0035] Each auxiliary fuel injection device 39 includes a fuel injection body that can be inserted into or pull out of the mounting hole 48 through the opening on the outer wall surface 49, and a jet nozzle 58 that is disposed in a portion of the mounting hole 48 recessed from the opening on the outer wall surface 49 to the fuel injection space
25 46 side.

[0036] A joint bolt 53 is used as the fuel injection body. . The joint bolt 53 in this example embodiment has a similar construction to a joint bolt used to tighten fuel piping in some internal combustion engines such as diesel engines. As shown in FIG. 3A and FIG. 4, the joint bolt 53 includes a shaft 54 and a hexagonal head 55 that is

integrally provided at one end of the shaft 54. Here, the head 55 is set as a reference in order to refer to each part of the shaft 54. Along an axis L2 (axial direction) of the shaft 54, the term "base" is used to refer to a direction of moving closer to the head 55, while the term "distal" is used to refer to a direction of moving away from the head 55. For example, an axial end of the shaft 54 where the head 55 is provided is referred to as "base end", while an axial end of the shaft 54 where the head 55 is not provided is referred to as "distal end".

[0037] Male threads 56 that can be screwed into the female threads 52 of the mounting hole 48 are formed on an outer peripheral surface 54B of the shaft 54 from an axially intermediate portion to the distal end of the shaft 54. Also, the shaft 54 is formed with a fuel passage 57 through which the auxiliary fuel 37 is passed. The end of the fuel passage 57 at the base end opens in the outer peripheral surface 54B of the shaft 54, while the other end of the fuel passage 57 on the distal end opens in a distal end surface 54A of the shaft 54. The flow area of the fuel passage 57 is uniform at any position.

[0038] The jet nozzle 58 is generally cylindrical, and an outer diameter R2 of the jet nozzle 58 is slightly larger than an inner diameter R1 of the fuel passage 57. The jet nozzle 58 is formed with an injection hole 59 opening in both the axial end surfaces thereof. The injection hole 59 narrows at an intermediate portion in the axial direction of the jet nozzle 58. The intermediate portion of the injection hole 59 is smaller in flow area than the fuel passage 57. Such a narrowed portion restricts the flow rate, and determines the injection amount, of the auxiliary fuel 37. Thus, the injection amount of the auxiliary fuel 37 may be changed by changing the flow area at the narrowed portion.

[0039] The jet nozzle 58, shaped as described above, is fixed to the distal end of the shaft 54 by press-fitting, with the injection hole 59 in communication with the fuel passage 57. An end surface 58A on the distal end of the fixed jet nozzle 58 and the distal end surface 54A of the shaft 54 are on the same plane, as shown in FIG. 3A.

[0040] The auxiliary fuel injection device 39, including the joint bolt 53 and the jet nozzle 58, is constructed as described above. Unlike the electromagnetic main

fuel injection valve 31 described above, the auxiliary fuel injection device 39 is not provided with a movable member, mechanism for opening and closing the injection hole 59 (such as solenoid coil, core, needle valve, etc.). The injection hole 59 is constantly open.

5 [0041] As shown in at least one of FIG. 2, FIG. 3A and FIG. 3B, the auxiliary fuel injection device 39 is detachably mounted to the delivery spacer 45 at the mounting hole 48, with the auxiliary fuel piping 41 tightened to the auxiliary fuel injection device 39.

10 [0042] To be specific, an eye-shaped joint 61 is fixed to the downstream end of the auxiliary fuel piping 41. The eye-shaped joint 61 includes a generally cylindrical joint body 62 and a tubular connection part 63 that projects radially outward from the outer peripheral surface of the joint body 62. The joint body 62 is formed with a through-hole 64 opening in both the axial end surfaces thereof (i.e., both the upper and lower surfaces in FIG. 3B). The inner diameter of the through-hole 64 is slightly larger than the outer diameter of the shaft 54 of the joint bolt 53, allowing insertion of the shaft 54 therethrough. Also, a recess 65 is formed around the entire periphery of the through-hole 64 at an axially intermediate portion of the union body 62. With the shaft 54 inserted through the through-hole 64, an annular space 66 is defined by the recess 65 around the shaft 54, as shown in FIG. 2. The inner space of the connection part 63 and 20 the annular space 66 are in communication with each other through a communication hole 67 formed in the joint body 62. The downstream end of the auxiliary fuel piping 41 is inserted into the connection part 63, and fixed by means of such as welding. Here, the eye-shaped joint 61 may be regarded as the fuel supply-connecting portion of the present invention.

25 [0043] A gasket 68, the eye-shaped joint 61 and a gasket 69 are overlaid in sequence on the outer wall surface 49 of the delivery spacer 45 at the projection 47. Thus, in the auxiliary fuel injection device 39, the shaft 54 of the joint bolt 53 is inserted through the gasket 69, the through-hole 64 of the eye-shaped joint 61, and the gasket 68 in sequence. Then, the male threads 56 of the shaft 54 are screwed into the female

threads 52 of the mounting hole 48. As the joint bolt 53 is tightened, the gasket 68 is tightly sandwiched between the eye-shaped joint 61 and the outer wall surface 49 of the projection 47, and the gasket 69 is tightly sandwiched between the head 55 of the joint bolt 53 and the eye-shaped joint 61. In this way, the pair of gaskets 68 and 69 and the eye-shaped joint 61 are tightened together to the delivery spacer 45 by the joint bolt 53. With the joint bolt 53 tightened, a base end of the fuel passage 57 of the joint bolt 53 corresponds in position to the annular space 66. Thus, the auxiliary fuel 37 delivered through the auxiliary fuel piping 41 may flow into the fuel passage 57 in the joint bolt 53 by way of the annular space 66 in the eye-shaped joint 61. In addition, the sealing function of the gaskets 68 and 69 increases the liquid tightness of the annular space 66, preventing the auxiliary fuel 37 from leaking out of the annular space 66.

[0044] Also, with the joint bolt 53 tightened, the end surface 58A of the jet nozzle 58 is positioned in the mounting hole 48 outward (i.e., toward the outer wall surface 49) from the inner wall surface 51 (i.e., fuel injection space 46) of the delivery spacer 45.

[0045] In an internal combustion engine 11 equipped with the auxiliary fuel injection device 39 constructed as described above, the control valve 42 is controlled to increase the flow area in the auxiliary fuel piping 41 at low-temperature start of the internal combustion engine 11, so that a larger amount of the auxiliary fuel 37 is delivered to each auxiliary fuel injection device 39 through the auxiliary fuel piping 41. The auxiliary fuel 37 flows into the fuel passage 57 of each joint bolt 53 as described above, and then is injected from the injection hole 59 of the jet nozzle 58 toward the fuel injection space 46.

[0046] The injected auxiliary fuel 37 is mixed with intake air flowing in the intake passage 19 to form an air-fuel mixture, which is supplied to the internal combustion engine 11. In this way, at low-temperature start, the auxiliary fuel 37 is injected to the internal combustion engine 11, thereby improving the startability of the internal combustion engine.

[0047] If the jet nozzle 58 projects from the inner wall surface 51 of the

delivery spacer 45 into the fuel injection space 46 (i.e., intake passage 19), the jet nozzle 58 would disrupt the flow of intake air, which might disturb the airflow. Also, if a backfire or the like occurred in the internal combustion engine 11, the jet nozzle 58 would be exposed to the backfire, which might cause a combustion product to adhere to and around the injection hole 59, thereby forming a deposit thereon. Here, the term “backfire” refers to a phenomenon in which a part of an air-fuel mixture is left unburned in an expansion stroke of the internal combustion engine 11 and remains as an ignition source inside the combustion chamber 18 after an exhaust stroke, and a new air-fuel mixture is ignited by the ignition source and combusted when the intake valve 26 is opened.

[0048] In the example embodiment described above, the jet nozzle 58 is disposed in the mounting hole 48 outward (toward the outer wall surface 49) recessed from the inner wall surface 51 of the delivery spacer 45. Therefore, the jet nozzle 58 does not obstruct the airflow. In addition, a backfire does not easily reach the jet nozzle 58, thereby preventing a deposit from forming on the jet nozzle 58.

[0049] In the above auxiliary fuel injection device 39, blocking substances may adhere to the inside of and around the injection hole 59 and be deposited thereon over time, thereby clogging the injection hole 59. In this case, it is necessary to clean the jet nozzle 58 of the blocking substances, or to replace the jet nozzle 58 with an unclogged one. Also, it is important to regularly check the jet nozzle 58 in order to prevent the jet nozzle 58 from becoming clogged. Performing any such work requires the jet nozzle 58 to be removed from the delivery spacer 45.

[0050] In this case, a hexagonal tool is used to loosen the joint bolt 53, which is threaded into the mounting hole 48. The jet nozzle 58, which is fixed to the shaft 54 of the joint bolt 53, rotates together with the joint bolt 53 in the same direction. The rotation causes the joint bolt 53 to move in the direction of getting out of the mounting hole 48 through the opening on the outer wall surface 49 of the delivery spacer 45. Accordingly, the jet nozzle 58, which is fixed to the joint bolt 53, is also moved together with the joint bolt 53 in the same direction.

[0051] Also, loosening the joint bolt 53 as described above increases the distance between the head 55 and the projection 47. This releases the tightening of the eye-shaped joint 61 and the gaskets 68 and 69 between the head 55 and the projection 47, that is, the tightening of the auxiliary fuel piping 41 to the delivery spacer 45 by the joint
5 bolt 53.

[0052] By removing the shaft 54 from the mounting hole 48, the jet nozzle 58 is taken out of the delivery spacer 45. With the auxiliary fuel injection device 39 mounted to the delivery spacer 45 as shown in FIG. 2, the jet nozzle 58 is disposed in a portion of the mounting hole 48 recessed from the opening on the outer wall surface 49 to
10 the fuel injection space 46. However, just by removing the joint bolt 53 from the mounting hole 48, the jet nozzle 58 may be taken out of the recessed position in the mounting hole 48 to the outside of the delivery spacer 45.

[0053] In addition, by removing the joint bolt 53 from the mounting hole 48 as described above, the eye-shaped joint 61 and the gaskets 68, 69 are removed from the
15 projection 47. Once the joint bolt 53 and the jet nozzle 58 are removed from the delivery spacer 45, it is possible to perform maintenance work, such as washing the jet nozzle 58 to remove the blocking substances, in a larger space. In washing the jet nozzle 58, blowing compressed air into the fuel passage 57 of the joint bolt 53, for example, may remove the blocking substances that have adhered to and around or have
20 been deposited on the injection hole 59 of the jet nozzle 58. In this respect, this example embodiment is superior to the case where the joint bolt 53 and the jet nozzle 58 are separately mounted to the mounting hole 48. In a comparative example, the jet nozzle 58 is washed by blowing compressed air, for example, with only the joint bolt 53 removed from the mounting hole 48. In this case, the washing work is difficult because
25 the jet nozzle 58 is mounted in a recessed and narrow portion of the mounting hole 48.

[0054] In addition, the jet nozzle 58 removed from the delivery spacer 45 is fixed to the joint bolt 53. Thus, because the jet nozzle 58 is integral with the joint bolt 53 that is larger than the jet nozzle 58, the jet nozzle 58 is easy to handle, even if the jet nozzle 58 is difficult to handle due to a small dimension, by holding the joint bolt 53 to

indirectly hold the jet nozzle 58. Thus, according to this example embodiment, the possibility that the jet nozzle 58 may be dropped and lost is low compared to the case where the jet nozzle 58 and the joint bolt 53 are separate.

[0055] In mounting the jet nozzle 58 after maintenance such as washing, or a new jet nozzle 58 to the delivery spacer 45, the shaft 54 of the joint bolt 53, to which the jet nozzle 58 is fixed, is inserted through the gasket 69, the eye-shaped joint 61 and the gasket 68, and then mounted from the opening on the outer wall surface 49 of the delivery spacer 45, with the jet nozzle 58 at the head. An end of the male threads 56 on the joint bolt 53 is positioned at an end of the female threads 52 on the mounting hole 48, and the joint bolt 53 is tightened. The tightening causes the male threads 56 to gradually engage with the female threads 52, and the jet nozzle 58 and the shaft 54 to be gradually inserted into the mounting hole 48.

[0056] Once the joint bolt 53 is tightened until the gasket 68 is tightly sandwiched between the eye-shaped joint 61 and the projection 47 and the gasket 69 is tightly sandwiched between the head 55 of the joint bolt 53 and the eye-shaped joint 61, the joint bolt 53 is now completely mounted in the mounting hole 48. Instead of being directly mounted in the mounting hole 48, the jet nozzle 58 is indirectly mounted in the mounting hole 48 via the shaft 54 of the joint bolt 53, disposed in a specified portion of the mounting hole 48.

[0057] According to the example embodiment described in detail above, the jet nozzle 58 is fixed to the shaft 54 of the joint bolt 53, with the injection hole 59 in communication with the fuel passage 57, so that the jet nozzle 58 is inserted into or pulled out of the mounting hole 48 together with the joint bolt 53.

[0058] Thus, just by loosening the joint bolt 53 to remove it from the mounting hole 48, the jet nozzle 58 together may be taken out of the recessed portion of the mounting hole 48 to the outside of the delivery spacer 45. This requires only removing the joint bolt 53, and there is no need, in addition, to remove the jet nozzle 58 or for a special tool for removing the jet nozzle 58 (for example, a tiny flathead screwdriver, etc.). Maintenance such as washing and replacement of the jet nozzle 58 may be performed in a

large workspace, improving the workability.

[0059] Also, the jet nozzle 58 removed from the delivery spacer 45 is fixed to the joint bolt 53. Thus, the possibility that the jet nozzle 58 may be dropped and lost is low compared to the case where it is separate from the joint bolt 53.

5 [0060] In addition, by simply tightening the joint bolt 53 to mount it in the mounting hole 48, the jet nozzle 58 may be mounted to a specified portion of the mounting hole 48 via the joint bolt 53. This requires only mounting the joint bolt 53, and there is no need, in addition, to mount the jet nozzle 58 or for a special tool for mounting the jet nozzle 58.

10 [0061] In this way, according to this example embodiment, the workability of maintenance and replacement of the jet nozzle 58 is improved. The joint bolt 53 is used as the fuel injection body to which the jet nozzle 58 is fixed.

[0062] Thus, just by tightening the joint bolt 53, the joint bolt 53 is allowed to fulfill its primary function, that is, to tighten the auxiliary fuel piping 41 (eye-shaped joint 15 61) to the delivery spacer 45. Along with the tightening, the auxiliary fuel injection device 39 may be mounted in the mounting hole 48.

[0063] In addition, just by loosening the joint bolt 53, the auxiliary fuel piping 41 may be unfastened from the delivery spacer 45. Along with the unfastening, the auxiliary fuel injection device 39 may be detached from the mounting hole 48.

20 [0064] According to this example embodiment, the jet nozzle 58 is disposed in the portion of the mounting hole 48 outward (toward the outer wall surface 49) recessed from the inner wall surface 51 of the delivery spacer 45. Thus, it is possible to avoid obstructing the flow of intake air, which may occur if the jet nozzle 58 projects into the fuel injection space 46. In addition, a backfire is not permitted to easily reach the jet 25 nozzle 58, preventing a deposit from being produced.

[0065] Also, according to this example embodiment, the jet nozzle 58 is fixed to the joint bolt 53 by "press-fitting". Thus, the jet nozzle 58 may be fixed to the joint bolt 53 by just performing a small number of simple operations, which include press-fitting the jet nozzle 58 into the shaft 54 of the joint bolt 53 with the injection hole

59 of the jet nozzle 58 in communication with the fuel passage 57.

[0066] Next, a modified example of the present invention will be described. The present invention is not limited to the construction adopted in the above example embodiment where the jet nozzle 58 is press-fitted into the fuel passage 57. As shown in FIG. 5A, a cylindrical counter bore 71 that is in communication with the fuel passage 57 and that has an inner diameter R3, which is larger than the inner diameter R1 of the fuel passage 57, may be formed at the distal portion of the shaft 54. The jet nozzle 58 may be press-fitted into the counter bore 71 with the injection hole 59 in communication with the fuel passage 57.

[0067] In this case, the following effects may be obtained, in addition to the similar functions and effects as those of the above example embodiment. The fuel passage 57 may have an inner diameter R1 and the counter bore 71, into which the jet nozzle 58 is press-fitted, may have an inner diameter R3 that is different from the inner diameter R1 of the fuel passage 57. Because the counter bore 71 is where the jet nozzle 58 is press-fitted while the fuel passage 57 is where the auxiliary fuel 37 flows, the machining precisions required of both are different from each other. That is, the counter bore 71 requires a high machining precision in order for the jet nozzle 58 to be securely press-fitted thereinto, while the fuel passage 57 does not require as high a machining precision as that of the counter bore 71. Thus, it is not necessary to machine the fuel passage 57 with a high precision, which facilitates machining compared to the above example embodiment.

[0068] Further, the shape of the injection hole 59 of the jet nozzle 58 may be made different from that in the above example embodiment. For example, as shown in FIG. 5B, the injection hole 59 may narrow to a uniform diameter from an intermediate portion to the distal end in the axial direction of the jet nozzle 58. Alternatively, the injection hole 59 may have a smallest diameter at the distal end in the axial direction of the jet nozzle 58, although not shown. Still alternatively, the injection hole 59 may have a uniform diameter at any axial position.

[0069] In the above example embodiment, the end surface 58A of the jet

nozzle 58 is not necessary to be positioned on the same plane with the distal end surface 54A of the shaft 54. For example, the end surface 58A may be positioned on the base end side (which is opposite to the fuel injection space 46 side) with respect to the distal end surface 54A. Alternatively, the end surface 58A may be positioned on the distal end side (the fuel injection space 46 side) with respect to the distal end surface 54A. In this case, a part of the jet nozzle 58 is exposed from the shaft 54 toward the fuel injection space 46 in the mounting hole 48.

[0070] The jet nozzle 58 may be fixed to the fuel injection body (joint bolt 53) by means different from press-fitting described above. For example, the outer peripheral surface of the jet nozzle 58 and the inner wall surface of the fuel passage 57 may be formed with male threads and female threads, respectively, which can be screwed together.

[0071] A fuel injection body may be provided separately from the joint bolt 53. In this case, the fuel injection body may be mounted to the mounting member by means other than a screw. A member different from the delivery spacer 45 may be used as the mounting member, and may be formed with a mounting hole for mounting the fuel injection device in a removable manner.

[0072] The above internal combustion engine mounted on an FFV may be operable on fuel containing components other than those in the above example embodiment. The present invention may be applied to a fuel injection device for an internal combustion engine of a different type from the internal combustion engine mounted on an FFV described above. In addition, the present invention may be applied to a fuel injection device for injecting main fuel, instead of an auxiliary fuel injection device for injecting auxiliary fuel.

[0073] While the invention has been described with reference to example embodiments thereof, it is to be understood that the invention is not limited to the described embodiments or constructions. To the contrary, the invention is intended to cover various modifications and equivalent arrangements. In addition, while the various elements of the example embodiments are shown in various combinations and

configurations, other combinations and configurations, including more, less or only a single element, are also within the spirit and scope of the invention.

CLAIMS

1. A fuel injection device that includes a fuel injection body mounted in a mounting hole formed in a mounting member that defines a fuel injection space therein, the mounting hole opening in both an inner wall surface and an outer wall surface of the mounting member, and the fuel injection body being removably attached through the opening on the outer wall surface side; and a jet nozzle disposed in a portion of the mounting hole recessed from the opening on the outer wall surface toward the fuel injection space, fuel for an internal combustion engine that is supplied from outside the mounting member being introduced into the mounting hole through a fuel passage formed in the fuel injection body, and being injected from an injection hole, the fuel injection device characterized in that:

the jet nozzle is fixed to the fuel injection body with the injection hole in communication with the fuel passage so as to be removably attached to the mounting hole together with the fuel injection body.

2. The fuel injection device according to claim 1, wherein

the fuel injection body is a joint bolt in which a shaft of the joint bolt is threaded into the mounting hole, the fuel passage being formed in the shaft to which fuel piping is fastened, and

the jet nozzle is fixed to the shaft.

3. The fuel injection device according to claim 2, wherein

a fuel supply-connecting portion is provided at a downstream end of the fuel piping, the fuel supply-connecting portion being in communication with the fuel passage of the shaft.

4. The fuel injection device according to claim 3, wherein

the fuel supply-connecting portion is formed with a through-hole that opens in both axial end surfaces thereof, and

a recess is formed around the through hole.

5. The fuel injection device according to any one of claims 1 to 4, wherein ,

the mounting member constitutes a segment of the intake pipe of the internal
5 combustion engine, and the fuel injection space constitutes a segment of the intake
passage, and

the jet nozzle is disposed in a portion of the mounting hole recessed from the
inner wall surface of the mounting member.

10 6. The fuel injection device according to any one of claims 1 to 5, wherein

the jet nozzle is press-fitted into the fuel injection body with the injection hole in
communication with the fuel passage.

7. The fuel injection device according to any one of claims 1 to 5, wherein

15 a counter bored portion is provided at one end of the fuel injection body, and
the jet nozzle is press-fitted into the counter bored portion of the fuel injection
body.

8. The fuel injection device according to any one of claims 1 to 5, wherein .

20 the jet nozzle is screwed into the fuel injection body with the injection hole in
communication with the fuel passage.

9. The fuel injection device according to any one of claims 1 to 8, wherein

25 the injection hole of the jet nozzle narrows at an intermediate portion in an axial
direction of the jet nozzle.

10. The fuel injection device according to any one of claims 1 to 8, wherein

the injection hole of the jet nozzle narrows to a uniform diameter from an
intermediate portion to an end in an axial direction of the jet nozzle.

11. The fuel injection device according to any one of claims 1 to 10, wherein

the internal combustion engine is operable on fuel blended with at least alcohol as a main fuel, and

5 the fuel injection device injects an auxiliary fuel, which has a higher concentration of gasoline than the main fuel, at low-temperature start of the internal combustion engine.

FIG. 2

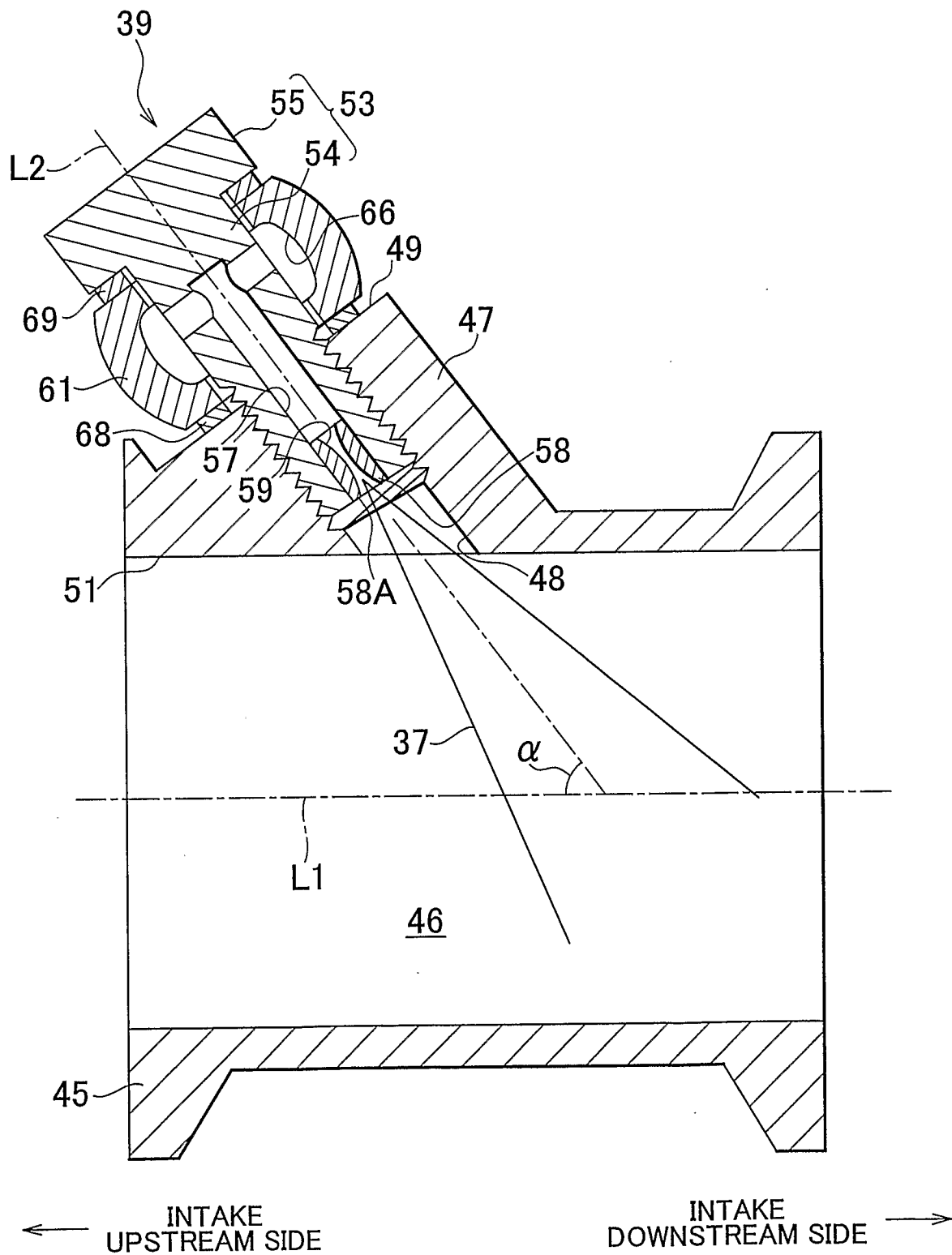


FIG. 3A

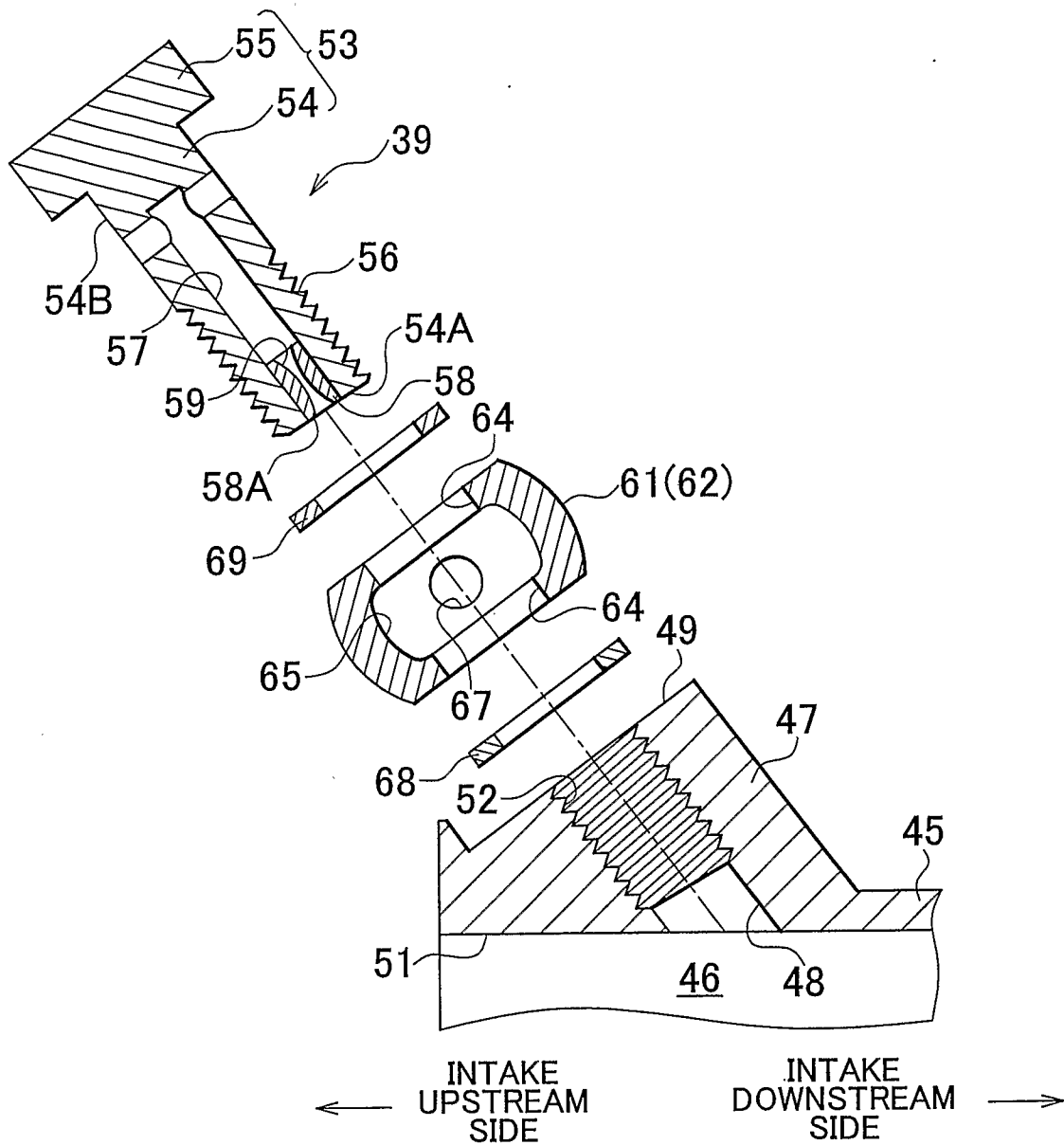


FIG. 3B

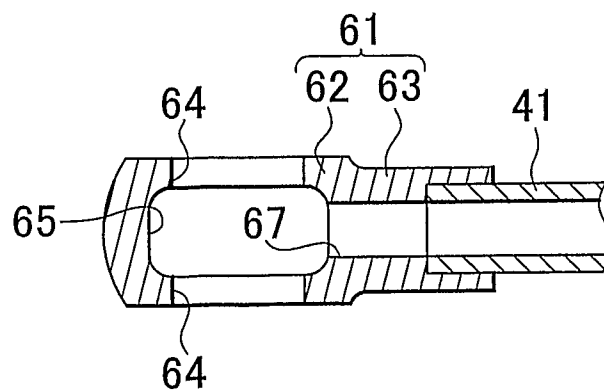


FIG. 4

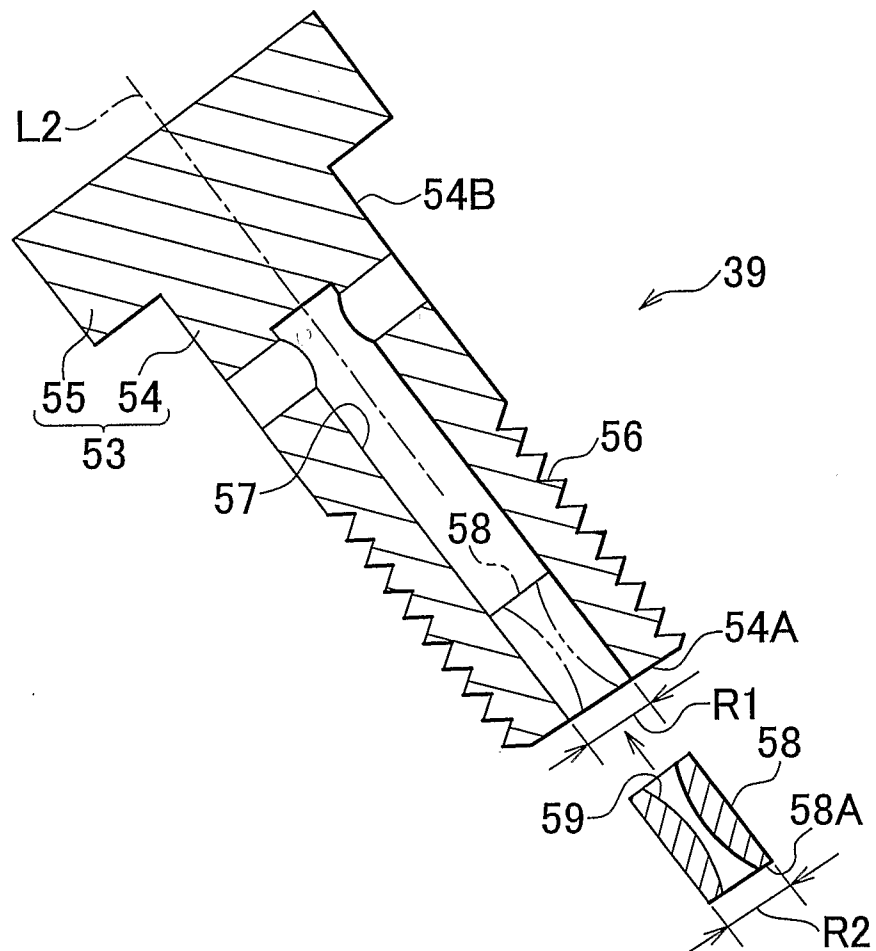


FIG. 5A

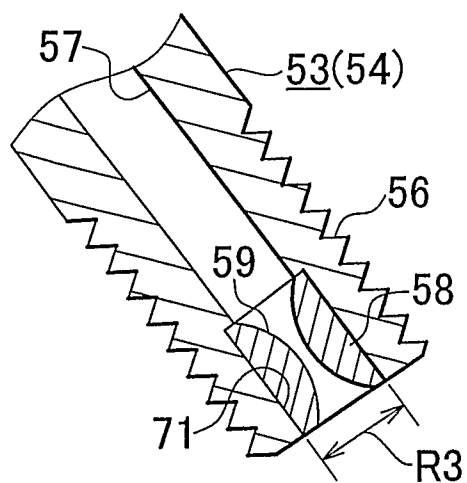


FIG. 5B

