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(54) **Fuel supply system for engine**

(57) To provide a fuel supply system for an engine that can enhance the assembling workability even though each fuel injector has an attaching angle different from one another, fuel injectors 57-60 are divided into a plurality of injector groups including a first injector group 65 and a second injector group 66. A first fuel supply rail 72 and a second injector group 66. A first fuel supply rail 72

is connected to the fuel injectors 57, 58 of the first injector group 65, and the second fuel supply rail 73 is connected to the fuel injectors 59, 60 of the second injector group 66. The first fuel supply rail 72 and the second fuel supply rail 73 are connected to each other through a connecting unit 75.

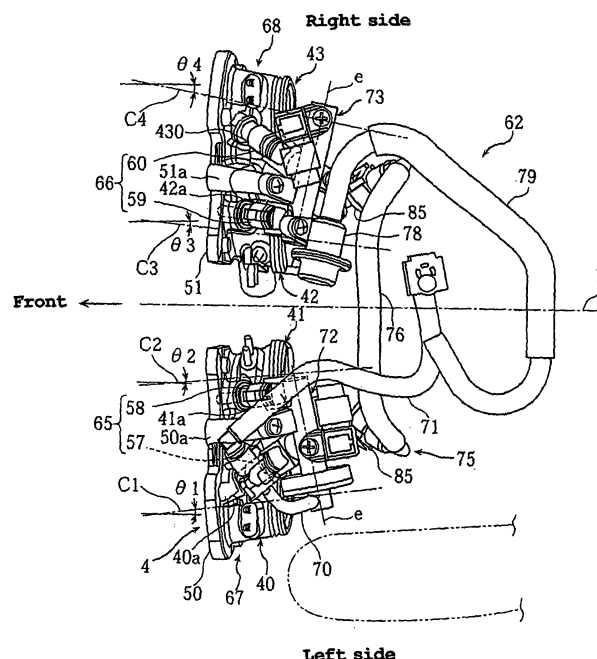


FIG. 7

Description

BACKGROUND

[0001] The present invention relates to a fuel supply system for an engine including fuel injectors installed in respective intake passages of an engine which has a plurality of cylinders, and a fuel supply rail supplying fuel to the fuel injectors.

[0002] For example, in a fuel supply system for a multiple cylinder engine mounted to a motorcycle, generally, intake passages for the respective cylinders are connected to a rear wall of a cylinder head in such a manner that the intake passages extend parallel to each other, fuel injectors are installed in the respective intake passages at downstream of locations throttle valves of the respective intake passages in such a manner that the fuel injectors extend parallel to each other, and a fuel supply rail which is common to the respective fuel injectors is connected to the fuel injectors (see, for example, see JP-A-2002-256895).

[0003] In the meantime, if attaching angles of the respective fuel injectors are different from each other in the conventional fuel supply system, it may be difficult to simultaneously attach the common fuel supply rail to the respective fuel injectors. Hence, it can be proposed that each fuel injector has its own fuel supply rail. However, if this arrangement is employed, the assembling workability may deteriorate.

[0004] The present invention seeks to provide a fuel supply system for an engine that can enhance the workability in assembling a fuel supply rail even though each fuel injector has an attaching angle different from one another.

SUMMARY

[0005] The invention is defined in the claims.

[0006] An embodiment of the present invention provides a fuel supply system for an engine having a plurality of cylinders, intake passages connected to intake ports of the respective cylinders of the engine, fuel injectors installed in the respective intake passages, and a fuel supply rail connected to the fuel injectors. The fuel supply rail includes a first fuel supply rail and a second fuel supply rail. The fuel injectors are divided into a plurality of injector groups including a first injector group and a second injector group. The first fuel supply rail is connected to the fuel injectors of the first injector group, and the second fuel supply rail is connected to the fuel injectors of the second injector group. The first fuel supply rail and the second fuel supply rail are connected to each other through a connecting unit.

[0007] In an embodiment of a fuel supply system according to the present invention, the fuel injectors are divided into the first and second injector groups, the first fuel supply rail is connected to the first injector group, and the second fuel supply rail is connected to the second

injector group. Therefore, for example, even though each fuel injector has an attaching angle different from one another, the differences between the attaching angles of the respective fuel injectors can be small because of the division of the fuel injectors into the plurality of injector groups, in comparison with a situation in which the fuel injectors are not divided. The assembling workability of the fuel supply rail is enhanced, accordingly.

[0008] Also, in such an embodiment, as the first and second fuel supply rails are connected to each other through the connecting unit, those rails can be joined together without any problem, even though axial directions of the first and second fuel supply rails are consistent with the first and second injector groups, respectively. Assembling and attaching work of the fuel supply rail thus can be easily done.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] Embodiments of the invention are described by way of example with reference to the accompanying drawings.

FIG. 1 is a side elevational view of a motorcycle incorporating a fuel supply system for an engine, constructed in accordance with one embodiment of the present invention.

FIG. 2 is a top plan view of the fuel supply system.

FIG. 3 is a left side elevational view of the fuel supply system.

FIG. 4 is a right side elevational view of the fuel supply system.

FIG. 5 is a rear elevational view of the fuel supply system.

FIG. 6 is a cross sectional and side elevational view of the fuel supply system (VI-VI line cross sectional view of FIG. 2).

FIG. 7 is a top plan view of respective fuel injectors installed in intake passages of the fuel supply system.

FIG. 8 is a rear view of the respective fuel injectors installed in the intake passages.

FIG. 9 is a bottom plan view of a cylinder head of the engine.

FIG. 10 is a cross sectional view of a coupling member of the fuel supply system.

FIG. 11 is an assembling and attaching view of a detachable connector of the fuel supply system.

DETAILED DESCRIPTION

[0010] With reference to drawings, embodiments of the present invention will be described below. FIGs. 1 through 11 are illustrations for depicting a fuel supply system for an engine constructed in accordance with one embodiment of the present invention. Herein, the terms "front," "rear," "right" and "left" mean front, rear, right and left positions or portions which the rider sitting on a seat

perceives.

[0011] In the illustrations, reference numeral 1 indicates a motorcycle. The motorcycle 1 has a vehicle frame 2 which is a double cradle type, an engine 3 mounted inside the cradle configuration of the vehicle frame 2, an intake system 4 connected to the engine 3, an exhaust system 5, and a fuel supply system 62 supplying fuel to the engine 3.

[0012] A head pipe 6 positioned at a front end of the vehicle frame 2 supports a front fork unit 7 for right and left steering movement. A lower end portion of the front fork unit 7 has a front wheel 8, while a top end portion of the front fork unit 7 has steering handle bars 9.

[0013] A rear portion of the vehicle frame 2 supports a rear arm via a pivot shaft 12 for up and down swing movement. A rear end portion of the rear arm 10 has a rear wheel.

[0014] A fuel tank 14 is disposed at a portion of the vehicle frame 2 above the engine 3. A straddle type seat 15 is disposed in the rear of the fuel tank 14.

[0015] The vehicle frame 2 includes right and left upper tubes 16, 16 having tank rail sections 16a, 16a which extend slightly downward rearward from a top portion of the head pipe 6 and a rear arm support sections 16b, 16b extending obliquely downward rearward from rear ends of the tank rail sections 16a, and right and left down tubes 17, 17 having inclining sections 17a, 17a extending obliquely downward rearward from a bottom portion of the head pipe 6 and horizontal sections 17b, 17b extending generally horizontally rearward from bottom ends of the inclining sections 17a.

[0016] The vehicle frame 2 also includes right and left seat rails 18, 18 extending obliquely upward rearward from top ends of the right and left rear arm support sections 16b, and right and left seat stays 19, 19 coupling middle portions of the seat rails 18 in a fore to aft direction and lower portions of the rear arm support sections 16b.

[0017] The engine 3 is an air-cooled, four-stroke, in-line, four-cylinder engine. The engine 3 is mounted with a cylinder axis inclining forward and is suspended and supported by the right and left upper tubes 16 and the right and left down tubes 17.

[0018] The engine 3 has a structure in which a cylinder block 23 and a cylinder head 24 both having cooling fins 23c, 24c which extend therefrom are piled up on a top mating surface of a crankcase 22 accommodating a crankshaft 21 which extends horizontally in a vehicle width direction, a head cover 25 is attached to the cylinder head 24, and a transmission case 22a accommodating a transmission mechanism (not shown) is unitarily coupled with a rear portion of the crankcase 22. The cylinder block 23 has four cylinders 23' disposed parallel to each other in a crankshaft direction. Although not shown, pistons inserted into and disposed in the respective cylinders 23' are coupled with the crankshaft 21 through connecting rods.

[0019] As shown in FIGs. 6 and 9, portions of a bottom mating surface 24a' of the cylinder head 24 correspond-

ing to the first through fourth cylinders form combustion recesses 24d defining combustion chambers. A rear portion of each combustion recess 24d which is one of the portions that interpose the cylinder axis therebetween has two intake valve openings 24e, 24e which are allotted every cylinder, and a front portion thereof has two exhaust valve openings 24f, 24f.

[0020] The intake valve opening 24e and the exhaust valve opening 24f each has a circular valve seat 31, 32 fitted thereto to seal up a space between an intake valve 33 and the intake valve opening 24e or a space between an exhaust valve 34 and the exhaust valve opening 24f, the intake and exhaust valves 33, 34 being described later.

[0021] Exhaust branch ports 24g, 24g extending from the respective exhaust valve openings 24f, 24f merge together to form a single exhaust merger port 24g' The respective single exhaust merger ports 24g' thus open at a front wall 24a of the cylinder head 24.

[0022] Intake ports 24H extending from the respective intake valve openings 24e, 24e open at a rear wall 24b of the cylinder head 24. Each intake port 24H communicates with the respective intake valve opening 24e, and includes an outer intake branch port 24h' positioned close to a shaft end of the crankshaft, i.e., outside in an engine width direction, an inner intake branch port 24h" positioned opposite to the shaft end of the crankshaft, i.e., close to a center thereof in the engine width direction, and a merger port 24h into which the outer and inner intake branch ports merge together. An externally connecting opening 24b' of each merger port 24h opens at the rear wall 24b.

[0023] In this regard, the outer and inner intake branch ports 24h' , 24h" and the merger port 24h are formed in such a manner that a merger axis (axis of the intake port H) f1' extending through a center of branch axes f1o, f1i which extend from centers of the respective intake valve openings 24e to a center of the externally connecting opening 24b' inclines. That is, the merger axis f1' inclines so that an upstream portion flu of the merger axis f1' corresponding to the merger port 24h is positioned at a location opposite to the shaft end of the crankshaft, i.e., at a location close to the center b in the engine width direction, more than a downstream portion f1d corresponding to the branch ports 24h' , 24h".

[0024] In this connection, an angle $\theta 1'$ made between the merger axis f1' of each merger port 24h of the first and fourth cylinders positioned outside in the vehicle width direction (crankshaft direction) and a straight line b' extending parallel to an engine center line b which extends normal to the crankshaft is set to be an inclining angle larger than an angle $\theta 2'$ made between the merger axis f2' of each merger port 24h of the second and third cylinders positioned inside in the vehicle width direction and a straight line b" extending parallel to the engine center line b (see FIG. 9).

[0025] Further, an inclining angle $\theta 1o$ of a branch axis flo of each outer branch port 24h' of the first and fourth

cylinders relative to the straight line b' extending parallel to the engine center line b is set to be larger than an inclining angle θ_{1i} of an axis f1i of each inner branch port 24h" relative to the straight line b'. Similarly, with the second and third cylinders, an inclining angle θ_{2o} of a branch axis f2o of each outer branch port 24h' relative to the straight line b" is set to be larger than an inclining angle θ_{2i} of an axis f2i of each inner branch port 24h" relative to the straight line b".

[0026] Additionally, in FIG. 9, reference symbols C1 and C2 indicate center lines of intake conduits connected to the externally connecting opening 24b'. Inclining angles θ_1 , θ_2 relative to the straight lines b', b" of the center lines C1, C2 are smaller than the inclining angles θ_1' , θ_2' , respectively.

[0027] The cylinder head 24 has the intake valves 33 and the exhaust valves 34 that open and close the intake openings 24e and the exhaust openings 24f, respectively. Each of the intake valves 33 and exhaust valves 34 is urged to its closed position by a valve spring 36, 36 and includes a valve plate 33a, 34a abutting a valve seat 31, 32 and a valve stem 33b, 34b unitarily formed with the valve plate 33a, 34a. Each valve stem 33b, 34b wears, at its top end, a valve lifter 35, 35 slidably supporting the associated intake valve 33 or exhaust valve 34.

[0028] The intake valves 33 and the exhaust valves 34 are driven between open and closed positions by an intake camshaft 37 and an exhaust camshaft 38, respectively, which are arranged to press the valve lifters 35. The intake camshaft 37 and the exhaust camshaft 38 extend parallel to the crankshaft 22 and are rotated by the crankshaft 22 via a cam chain 39.

[0029] The cam chain 39 extends between the second and third cylinders, more specifically, extends through the center of the crankshaft 22 in its axial direction to be generally consistent with the engine center line b that extends normal to the crankshaft 22, in the plan view (see FIG. 9).

[0030] The exhaust system 5 is coupled with the front wall 24a of the cylinder head 24 to communicate with the respective exhaust ports 24g. The exhaust system 5 includes four exhaust conduits 26 extending downward from the front wall 24a and then rearward below the engine 3, a left side manifold 27a into which two exhaust conduits 26, 26 placed on the left side in the vehicle width direction merge together and a right side manifold 27b into which two exhaust conduits 26, 26 placed on the right side in the vehicle width direction merge together, a main manifold 28 into which the left and right side manifolds 27a, 27b merge together, and a single muffler 29 connected to the main manifold 28 (see FIG. 1).

[0031] The intake system 4 is coupled with the rear wall 24b of the cylinder head 24 to communicate with the respective intake merger ports 24h. The intake system 4 includes, viewed in the camshaft direction, first through fourth downstream intake conduits 40-43 extending rearward from the rear wall 24b and generally normal to the

cylinder axis a, first through fourth upstream intake conduits 45-48 continuously extending rearward from the respective downstream intake conduits 40-43, and a common air cleaner 49 connected to the first through fourth upstream intake conduits 45-48 via a joint 55.

[0032] Each of the first through fourth upstream intake conduits 45-48 has a butterfly type main throttle valve 44a and a sub throttle valve 44b disposed inside thereof. The respective main throttle valves 44a are coupled together by a common valve shaft 44c to move between open and closed positions, while the respective sub throttle valves 44b are coupled together by another common valve shaft 44d to move between open and closed positions.

[0033] The first through fourth downstream intake conduits 40-43 and the first through fourth upstream intake conduits 45-48 define intake passages. The first through fourth downstream and upstream intake conduits 40-43, 45 ~ 48 are arranged to make straight lines together with each other counterpart.

[0034] The first through fourth downstream intake conduits 40-43 and the first through fourth upstream intake conduits 45-48 are connected to each other counterpart via joints 53 made of rubber and are fixed by bands 54 which are attached to the respective joints 53.

[0035] The first through fourth downstream and upstream intake conduits 40-43, 45-48 are symmetrically arranged on both sides interposing the engine center line b therebetween.

[0036] The first and second downstream intake conduits 40, 41 are unitarily formed together with an attaching base 50, while the third and fourth downstream intake conduits 42, 43 are unitarily formed together with another attaching base 51. The respective bases 50, 51 are fixed to the rear wall 24b by bolts. Additionally, reference numeral 52 indicates a heat insulating plate. The heat insulating plates 52 are attached to the engine rear wall 24b together with the attaching bases 50, 51.

[0037] As shown in FIG. 7, the first through fourth downstream intake conduits 40-43 and the first through fourth upstream intake conduits 45-48 are arranged, when viewed in the direction of the cylinder axis a, i.e., from a location thereabove, to form obliquely extending axes C1-C4 whereby upstream portions of the axes of the respective intake conduits 40-43, 45-48 are positioned inside in the crankshaft direction more than downstream portions thereof.

[0038] In this regard, the angles θ_1 , θ_4 of the obliquely extending axes C1-C4 of the first and fourth downstream intake conduits 40, 43 positioned outside in the vehicle width direction relative to the engine center line b is set to be larger than the angles θ_2 , θ_3 of the obliquely extending axes C2, C3 of the second and third downstream intake conduits 41, 42 positioned inside more than the first and fourth downstream intake conduits 40, 43. That is, the intake conduits 40, 43 positioned outside incline more than the intake conduits 41, 42 positioned inside to contribute to narrowing the engine width.

[0039] More specifically, each of the angles θ_1 , θ_4 of the obliquely extending axes C1, C4 of the first and fourth downstream intake conduits 40, 43 relative to the engine center line b is approximately ten degrees. On the other hand, each of the angles θ_2 , θ_3 of the obliquely extending axes C2, C3 of the second and third downstream intake conduits 41, 42 relative to the engine center line b is approximately five degrees. Each of the first through fourth upstream intake conduits 45-48 has the same angle as the counterpart of the first through fourth downstream intake conduits.

[0040] The inclining angles θ_1 , θ_2 of the axes C1, C2 of the intake conduits are set to be smaller than the inclining angles θ_1' , θ_2' of the merger axes f_1' , f_2' of the merger ports 24h on the intake side. Accordingly, the inclining angle of each intake conduit 40, 41 is gentler than the inclining angle of each merger ports 24h, 24h.

[0041] Bosses 40a-43a defining injector holes 40b-43b therein swell out at upper wall portions of the respective first through fourth downstream conduits 40-43 to extend along the axes C1-C4.

[0042] First through fourth fuel injectors 57-60 are mounted to the respective bosses 40a-43a. When viewed in the direction of the cylinder axis, the respective first through fourth fuel injectors 57-60 are arranged to extend between the joints 53, which are disposed at the mating surfaces of the downstream intake conduits 40-43 and the upstream intake conduits 45-48, and the attaching bases 50, 51 of the downstream intake conduits 40-43.

[0043] The first and fourth fuel injectors 57, 60 positioned outside in the vehicle width direction are arranged to extend generally along the axes C1, C4 of the first and fourth downstream intake conduits 40, 43 and the axes f_1' , f_1' of the intake merger ports 24h, and also to be positioned inside more than the axes C1, C4, f_1' , f_1' in the vehicle width direction.

[0044] The second and third fuel injectors 58, 59 positioned inside in the vehicle width direction are arranged to extend generally along the obliquely extending axes C2, C3 of the second and third downstream intake conduits 41, 42 and the obliquely extending axes f_2' , f_2' of the intake merger ports 24h, and also to be positioned outside more than the axes C2, C3, f_2' , f_2' in the vehicle width direction.

[0045] The first and second fuel injectors 57, 58 are arranged to extend in directions in which axis angles thereof are different from each other, while the third and fourth fuel injectors 59, 60 are arranged to extend in directions in which axis angles thereof are different from each other. Specifically, in the plan view, the first and fourth fuel injectors 57, 60 are arranged in such a manner that the axes thereof cross the obliquely extending C1, C4 of the first and fourth downstream intake conduits 40, 43 and the axes f_1' , f_1' of the intake merger ports from inside locations to outside locations in the vehicle width direction. Also, the second and third fuel injectors 58, 59 are arranged in such a manner that the axes thereof ex-

tend parallel to the axes f_2' , f_2' of the second and third intake merger ports and slightly cross the axes f_2' , f_2' from outside locations to inside locations in the vehicle width direction.

[0046] In the construction described above, fuel injected from fuel injection nozzles 57a-60a of the first and fourth fuel injectors 57-60 are injected toward rear sides of the respective valve plates 33a of the right and left intake valves 33 through the inside of the intake branch ports 24h, 24h. In this regard, in FIG. 9, hatched sections A where the hatching, which looks like a mesh, indicate impingement areas of the fuel injected into the exhaust ports 24H. The fuel, after impinging these areas, moves toward the valve plates of the respective intake valves.

[0047] The fuel supply system 62 is connected to the first through fourth fuel injectors 57-60. The fuel supply system 62 has the following construction.

[0048] As shown in FIG. 7, the first through fourth fuel injectors 57-60 are divided into a first fuel injector group 65 including the first fuel injector 57 positioned outside on the left side in the vehicle width direction (crankshaft direction) and the second fuel injector 58 positioned inside more than the first fuel injector 57, and a second fuel injector group 66 including the fourth fuel injector 60 positioned outside on the right side in the vehicle width direction and the third fuel injector 59 positioned inside more than the fourth fuel injector 57.

[0049] The first through fourth downstream intake conduits 40-43 are divided into a first intake passage group 67 including the first downstream intake conduit 40 positioned outside on the left side in the vehicle width direction and the second downstream intake conduit 41 positioned inside more than the first downstream intake conduit 40, and a second intake passage group 68 including the fourth downstream intake conduit 43 positioned outside on the right side in the vehicle width direction and the third downstream intake conduit 42 positioned inside more than the fourth downstream intake conduit 43.

[0050] The first injector group 65 is allotted to the first intake passage group 67, while the second injector group 66 is allotted to the second intake passage group 68. The first intake passage group 67 and the second intake passage group 68 are symmetrically arranged on both sides of the engine center line b (see FIG. 7).

[0051] A first fuel supply rail 72 made of an aluminum alloy casting is connected to the first and second fuel injectors 57, 58 of the first injector group 65, while a second fuel supply rail 73 made of an aluminum alloy casting is connected to the third and fourth fuel injectors 59, 60 of the second injector group 66.

[0052] The first injector group 65, the first intake passage group 67 and the first fuel supply rail 72 are previously assembled together as an assembly to be mounted to the engine 3. Similarly, the second injector group 66, the second intake passage group 68 and the second fuel supply rail 73 are previously assembled together as another assembly to be mounted to the engine 3. Because,

as thus described, the respective components are divided into right and left assemblies and the components are mounted as such individual assemblies, easiness in assembling and attaching work to the engine 3 can be improved, and also accuracy in assembling and attaching work of the respective components can be enhanced.

[0053] The first and second fuel supply rails 72, 73 are arranged to extend in the vehicle width direction in such a manner that each axis e thereof slightly inclines rearward relative to a straight line extending normal to the engine center line b. The first and second fuel supply rails 72, 73 are attached to attaching bosses 50a, 51a which are formed at the respective attaching bases 50, 51 to rise up rearward.

[0054] The inclining angles of the first and second fuel supply rails 72, 73 are set to correspond to the different attaching angles between the first and second fuel injectors 57, 58 and the third and fourth fuel injectors 59, 60. More specifically, the first and second fuel supply rails 72, 73 are arranged to incline in such a manner that their outside portions in the vehicle width direction are positioned rearward in the vehicle more than their inside portions and are also positioned lower than the inside portions.

[0055] A fuel supply conduit 70 is connected to an outer end of the first fuel supply rail 72 in the vehicle width direction. A fuel supply hose 71 is connected to the fuel supply conduit 70 to supply fuel in the fuel tank 14 thereto through a fuel pump (not shown).

[0056] A regulator 78 adjusting fuel pressure is connected to an inner end of the second fuel supply rail 73 in its axial direction. The regulator 78 is connected to the fuel tank 14 through a fuel return hose 79. In this connection, reference numeral 80 indicates a boost hose and a reference numeral 81 indicates a breather hose connected to a breather tank 82, respectively.

[0057] The first fuel supply rail 72 and the second fuel supply rail 73 are connected to each other through a connecting unit 75. The connecting unit 75 includes one flexible connecting hose 76 and right and left coupling members 77, 77 coupling the connecting hose 76 and the first and second fuel supply rails 72, 73.

[0058] Each of the right and left coupling members 77 includes a flange section 77a detachably attached to a boss section 72a, 73a, which is unitarily formed with the first or second fuel supply rail 72, 73, by bolts 83, 83, a cylindrical section 77b formed to be coupled with the flange section 77a, and a joint section 77c formed to project from the cylindrical section 77b. Each boss section 72a, 73a is formed to extend in a direction in which the boss section 72a, 73a normally crosses the axis e of the first or second fuel supply rail 72, 73.

[0059] Each of the right and left flange sections 77a is, similarly to each of the boss sections 72a, 73a, formed to extend in the direction in which the flange section 77a crosses the axis e of the first or second fuel supply rail 72, 73 at right angles. Also, each of the right and left joint sections 77c is formed to extend obliquely upward to

cross a line connecting the respective bolts 83 of the flange section 77a to each other, and is also formed to face the outside in the crankshaft direction, i.e., to face the outside in the vehicle width direction.

[0060] The right and left joint sections 77c are detachably coupled with the connecting hose 76 through detachable connectors 85, 85.

[0061] As shown in FIG. 11, each of the right and left detachable connectors 85 includes an insertion section 85a inserted into one of the ends of the connecting hose 76, a housing section 85b extending from the insertion section 85 and bending so that its axis turns at a right angle, and a clamping member 86 attached to the housing section 85b.

[0062] An engaging hook 85c with which a brim 77d formed at the joint section 77c engages is formed by being notched so as to be resiliently deformable. Also, the clamping member 86 has stoppers 86a that can contact with an outer circumferential surface of the joint section 77c.

[0063] The housing section 85b is putted onto the joint section 77c from a rear location (see FIG. 11 (a)) and is pushed until the brim 77d of the joint section 77c engages with the engaging hook 85c (see FIG. 11 (b)). Further, the clamping member 86 is pushed until the stoppers 86a contact with the joint section 77c (see FIG. 11(b), (c)). Disassembling them requires that the clamping member 86 is pulled up outward under a resiliently deformed condition. According to the fuel supply system in this embodiment, because the fuel injectors are divided into the first fuel injector group 65 including the first and second fuel injectors 57, 58 and the second fuel injector group 66 including the third and fourth fuel injectors 59, 60, the first supply rail 72 is connected to the fuel injectors 59, 60 of the first fuel injector group, and the second fuel supply rail 73 is connected to the fuel injectors 59, 60 of the second fuel injector group 66, the fuel injectors 57-60 having different attaching angles are divided into two groups. Thereby, in view of whole the fuel injectors, the differences between the attaching angles of the respective fuel injectors can be moderated in comparison with a situation in which the fuel injectors are not divided. The fuel supply rails 72, 73 can be easily assembled and attached, accordingly. Incidentally, even if a single common straight fuel supply rail is attempted to be connected without the fuel injectors 57-60 being divided, it is impossible to make the fuel supply rail extend straightly in view of its construction. However, in the situation such that the fuel injectors are divided into the two injector groups as described with the embodiment, the common fuel rails for each group can be connected to each other even though the attaching angles of the injectors of the respective groups are different.

[0064] In this embodiment because the first and second fuel supply rails 72, 73 are connected to each other through the flexible connecting hose 76, the first and second injector groups 65, 66 can be easily and surely connected to each other even though the axial directions of

the respective supply rails 72, 72 are greatly different from each other. The assembling workability can be improved, accordingly.

[0065] In this embodiment, in order to couple the connecting hose 76 and the first and second fuel supply rails 72, 73 with each other through the coupling members 77, 77, the flange section 77a of each coupling member 77 is formed to extend normal to the axis e of the fuel supply rail 72, 73. Each boss section 72a, 73a for connecting the associated flange section 77a to the fuel supply rail 72, 73 thus can be the minimum size. Incidentally, if the flange section 77a inclines obliquely relative to the axis e, bolt hole intervals of the flange section 77a need to be large because the attaching bolts holes are positioned outside more than fuel holes of the fuel supply rails 72, 73. As a result, the coupling members 77 can be upsizing.

[0066] Because each joint section 77c protrudes in the direction in which the joint section 77c crosses the flange section 77a, the joint section 77c does not interfere with a tool for fastening the bolts 83 when the flange section 77a is attached to the associated boss section 72a, 73a by the bolts 83. The assembling workability thus can be improved.

[0067] In this embodiment, because the right and left joint sections 77c and the connecting hose 76 are connected to each other through the detachable connectors 85, the connecting hose 76 can be attached to the joint sections 77c in a one-touch work. The workability can be improved, accordingly.

[0068] On the other hand, when the right and left coupling members are connected using the detachable connectors 85, the distance between the right and left joint sections 77c, 77c needs to be relatively long because of structural problems of the detachable connectors 85 and in accordance with a magnitude of the flexibility of the connecting hose 76.

[0069] In this embodiment, because the joint sections 77c of the right and left coupling members 77 are formed to face the outside in the crankshaft direction, the substantial distance between the right and left joint sections 77c can be expanded. Therefore, the connecting unit 75 can be easily assembled and attached, and the distance necessary for using the detachable connectors 85 can be ensured.

[0070] In this embodiment, the intake passages are divided into the first intake passage group 67 including the first and second downstream intake conduits (outer intake passages) 40, 41 and where the first fuel injector group 65 is disposed, and the second intake passage group 68 including the third and fourth downstream intake conduits 42, 43 and where the second fuel injector group 66 is disposed. The easiness in assembling and attaching work to the engine 3 can thus be enhanced, and also accuracy in assembling and attaching work of the respective fuel injectors 57-60, etc. can be enhanced.

[0071] In this embodiment, the first through fourth downstream and upstream intake conduits 40-43, 45-48

are formed to define the obliquely extending axes C1-C4 along which the upstream portions of the respective intake conduits 40-43, 45-48 are offset toward the inside in the crankshaft direction more than the downstream portions thereof. Therefore, the widths of the first through fourth downstream and upstream intake conduits 40-43, 45-48 in the crankshaft direction can be small, and, to the extent, the entire size of the engine 3 in the vehicle width direction can be reduced. Thereby, the knees (see the chain double-dashed line of FIG. 7) of the rider can be prevented from interfering with the intake passages when the rider sits on the seat 15 to make the knee-grip. The riding position thus can be stabilized.

[0072] In this embodiment, the first through fourth fuel injectors 57-60 are arranged in the direction in which the fuel injectors 57-60 extend generally along the obliquely extending intake merger axes C1-C4 of the first through fourth downstream intake conduits 40-43 and the intake merger axes f1', f2' of the intake merger ports and are also directed toward the rear sides of the valve plates 33a of the respective intake valves 33. Therefore, fuel can be injected and supplied in such a manner that the fuel impinges the rear surfaces of the valve plates of the intake valves 33, while the respective intake conduits 40-43 and the intake ports 24H are inclined inside. Thereby, cooling ability of the valve seats 31 that seal the intake valves 33 can be ensured. Wear of the valve seats 31 can be reduced, accordingly.

[0073] Particularly, in the air-cooled engine 3, due to its structural conditions, the temperature of the valve seat 31 portions may not be sufficiently lowered in some situations relating to arrangement positions of the respective fuel injectors 57-60. In this embodiment, however, because of the construction described above, the temperature of the valve seat 31 portions can be lowered by the fuel injected and supplied from the respective fuel injectors 57-60, and the wear of the valve seats 31 can be reduced.

[0074] In this embodiment, the angles $\theta 1$, $\theta 4$ of the obliquely extending axes C1, C4 of the first and fourth downstream intake conduits 40, 43 and upstream intake conduits 45, 48 positioned outside in the crankshaft direction are set to be larger than the angles $\theta 2$, $\theta 3$ of the respective second and third intake conduits 41, 42 and 46, 47 positioned inside. The engine width thus can be made small.

DESCRIPTION OF REFERENCE NUMERALS

[0075]

1: motorcycle

3: engine

23': cylinder

24e: intake valve opening (combustion chamber side opening)

24H: intake port

40-43: downstream intake conduit (first intake pas-

sage, downstream portion of axis of intake passage)
 40, 45: outer intake passage
 41, 46: inner intake passage
 44a: throttle valve (first opening/ closing valve)
 44b: throttle valve (second opening/ closing valve) 5
 45-48: upstream intake conduit (second intake pas-
 sage, upstream portion of axis of intake passage)
 57, 60: outer fuel injector
 58, 59: inner fuel injector
 62: fuel supply system 10
 65: first fuel injector group
 66: second fuel injector group
 67: outer intake passage
 68: inner intake passage
 72: first fuel supply rail 15
 72a: boss section
 73: second fuel supply rail
 73a: attaching boss section
 75: connecting unit
 76: connecting hose 20
 77: coupling member
 77a: flange section
 77c: joint section
 85: detachable connector 25
 a: cylinder axis
 b: engine center line
 C1-C4: axis of intake passage
 e: axis of fuel supply rail
 01: inclining angle of axis of outer intake passage
 02: inclining angle of axis of inner intake passage 30

Claims

1. A fuel supply system for an engine, comprising: an engine having a plurality of cylinders; intake passages connected to intake ports of the respective cylinders of the engine; fuel injectors installed in the respective intake passages; and a fuel supply rail connected to the fuel injectors, wherein the fuel supply rail includes a first fuel supply rail and a second fuel supply rail, the fuel injectors include a first fuel injector group and a second fuel injector group, the first fuel supply rail is connected to the first fuel injector group, and the second fuel supply rail is connected to the second fuel injector group, and the first fuel supply rail and the second fuel supply rail are connected to each other through a connecting unit. 35
2. The fuel supply system for an engine according to Claim 1, wherein the connecting unit includes a flexible connecting hose, and a coupling member disposed between the connecting hose and the fuel supply rail. 40
3. The fuel supply system for an engine according to Claim 2, wherein the coupling member has a flange section detachably attached to an attaching boss section formed in the fuel supply rail, and the flange section is formed to extend generally normal to an axis of the fuel supply rail. 45
4. The fuel supply system for an engine according to Claim 3, wherein the coupling member has a joint section to which the connecting hose is jointed, and the joint section extends in a direction in which the joint section crosses the flange section. 50
5. The fuel supply system for an engine according to Claim 3, wherein a crankshaft of the engine extends horizontally, the coupling member has a joint section to which the connecting hose is jointed, and the joint section is formed to extend toward a shaft end of the crankshaft. 55
6. The fuel supply system for an engine according to Claim 3, wherein the coupling member has a joint section to which the connecting hose is jointed, and the joint section and the connecting hose are detachably connected to each other through a detachable connector. 60
7. The fuel supply system for an engine according to any preceding Claim, wherein each one of the intake passages is formed in such a manner that an upstream portion of an axis of the intake passage is positioned opposite to a shaft end of a crankshaft more than a downstream portion of the axis of the intake passage, when viewed from a combustion chamber of the associated intake passage. 65
8. The fuel supply system for an engine according to Claim 7, wherein each one of the fuel injectors is positioned to inject fuel generally along the downstream portion of the axis of the associated intake passage and toward a combustion chamber side opening of the associated intake port. 70
9. The fuel supply system for an engine according to Claim 7 or Claim 8, wherein each one of the intake passages includes an outer intake passage positioned close to the shaft end of the crankshaft and an inner intake passage positioned opposite to the shaft end of the crankshaft, and an inclining angle of the axis of the outer intake passage relative to an engine center line extending normal to the crankshaft is larger than an inclining angle of the axis of the inner intake passage relative to the engine center line extending normal to the crankshaft. 75
10. The fuel supply system for an engine according to Claim 9, wherein the fuel injectors include an outer fuel injector positioned at the outer intake passage and an inner fuel injector positioned at the inner in-

take passage, an angle of the inner fuel injector relative to the associated inner intake passage is different from an angle of the outer fuel injector relative to the associated outer intake passage, and the outer fuel injector and the inner fuel injector are connected through the fuel supply rail. 5

11. The fuel supply system for an engine according to Claim 7, wherein each one of the intake passages includes a first intake passage portion at which the fuel injector is disposed and a second intake passage portion at which a first opening/ closing valve and a second opening/ closing valve are disposed. 10

12. The fuel supply system for an engine according to Claim 11, wherein the first fuel supply rail is positioned on one side of an engine center line extending normal to the crankshaft and the second fuel supply rail is positioned on the other side of the engine center line so that the first and second fuel supply rails are symmetrical to each other. 15 20

13. A motorcycle to which a fuel supply system for an engine is mounted, the fuel supply system including intake passages connected to intake ports of respective cylinders of an engine, fuel injectors installed in the respective intake passages, and a fuel supply rail connected to the fuel injectors, wherein the fuel rail includes a first fuel supply rail and a second fuel supply rail, 25 30
the fuel injectors include a first fuel injector group and a second fuel injector group, the first fuel supply rail is connected to the first fuel injector group, the second fuel supply rail is connected to the second fuel injector group, and the first fuel supply rail and the second fuel supply rail are connected to each other through a connecting unit. 35

14. The motorcycle according to Claim 13, wherein the first fuel supply rail is positioned on one side of an engine center line and the second fuel supply rail is positioned on the other side of an engine center line so that the first and second fuel supply rails are symmetrical to each other. 40 45

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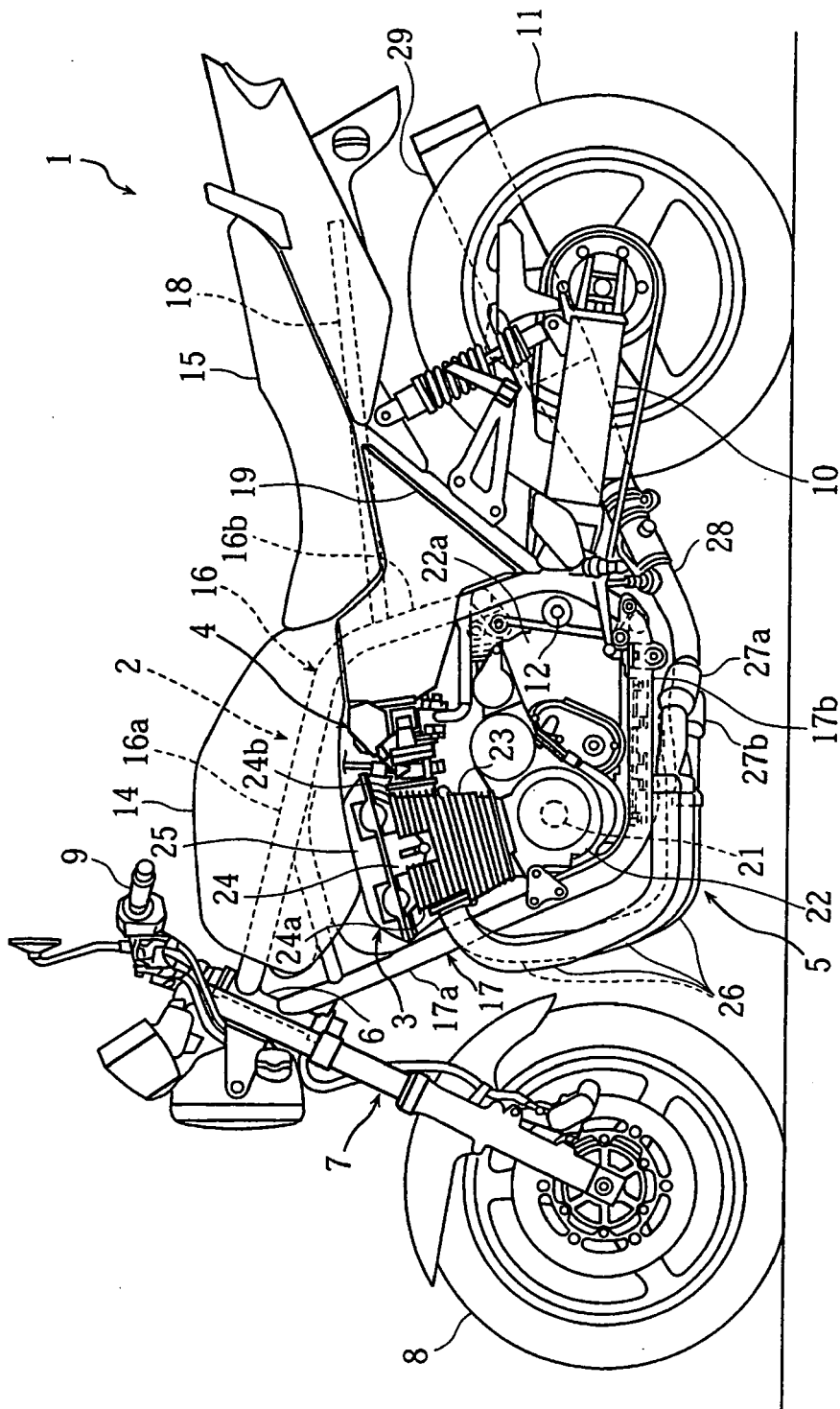


FIG. 1

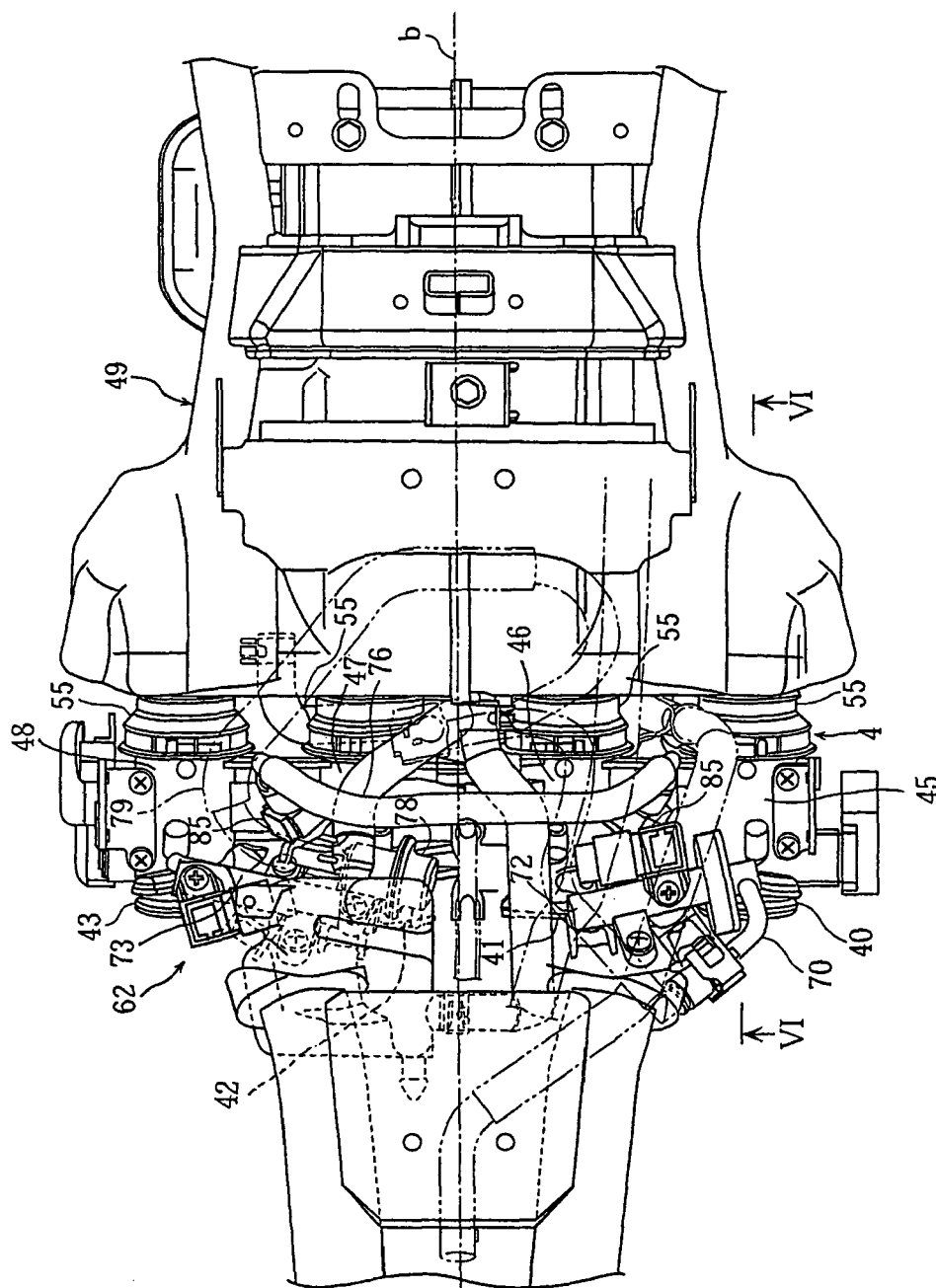


FIG. 2

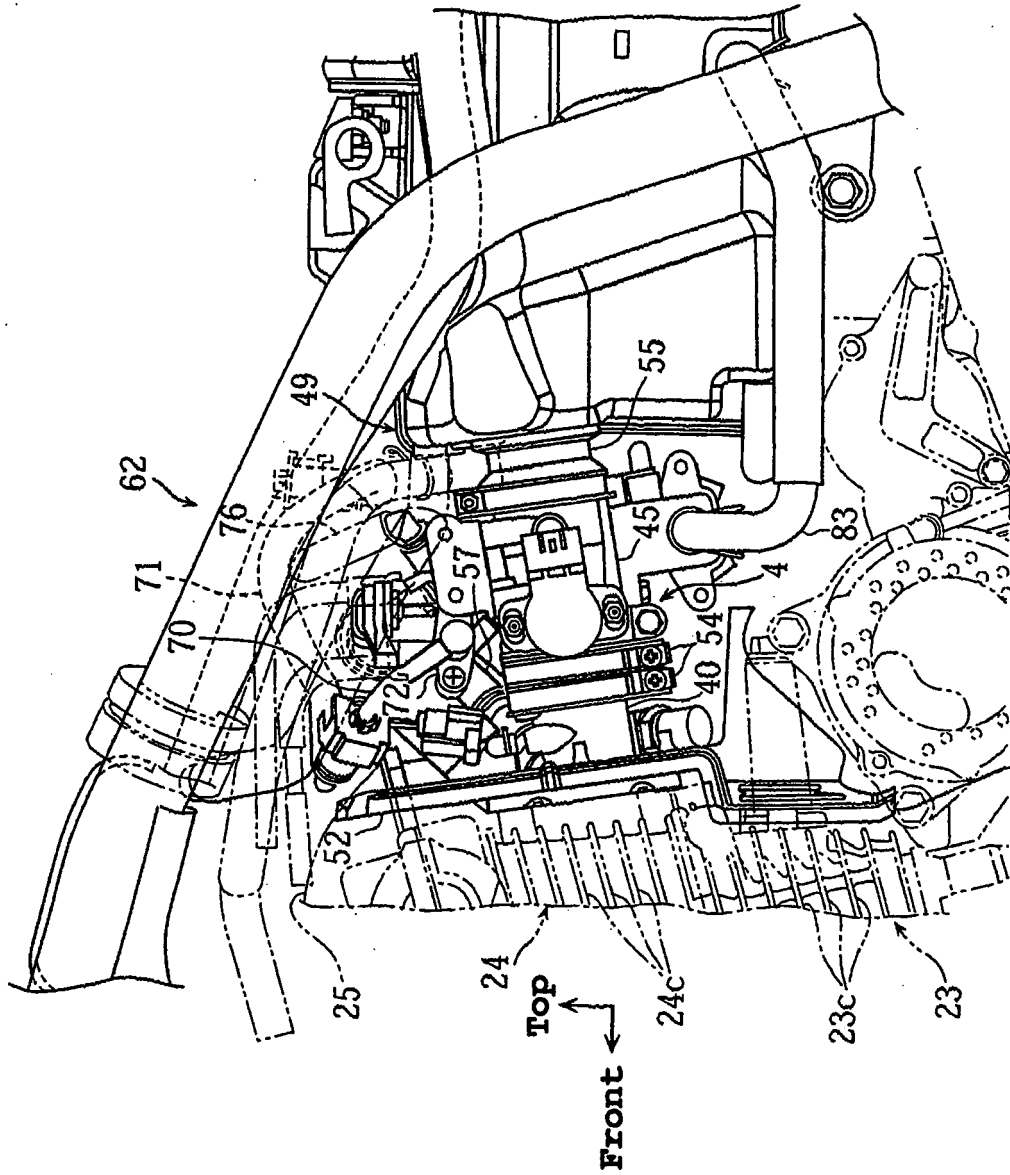


FIG. 3

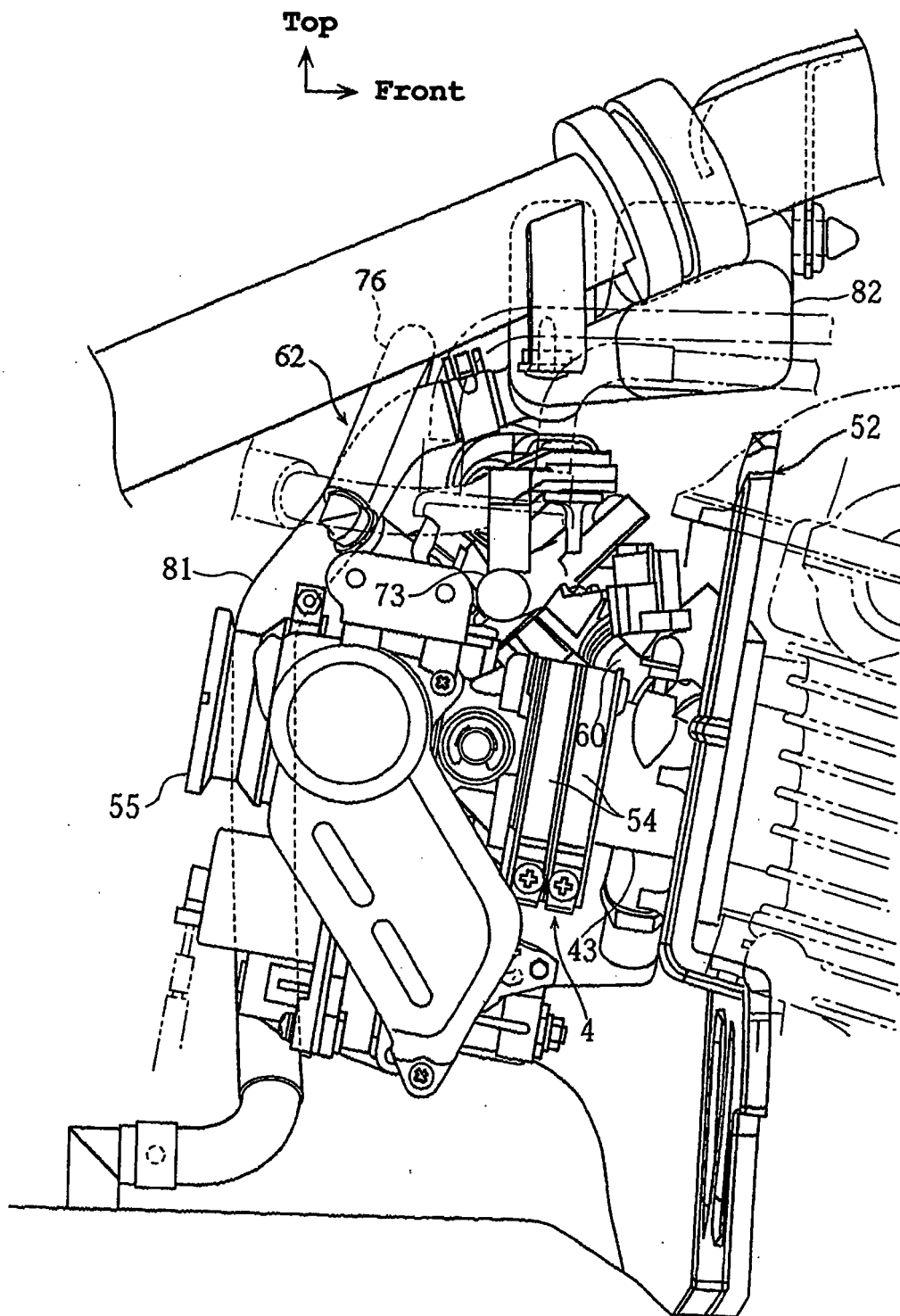


FIG. 4

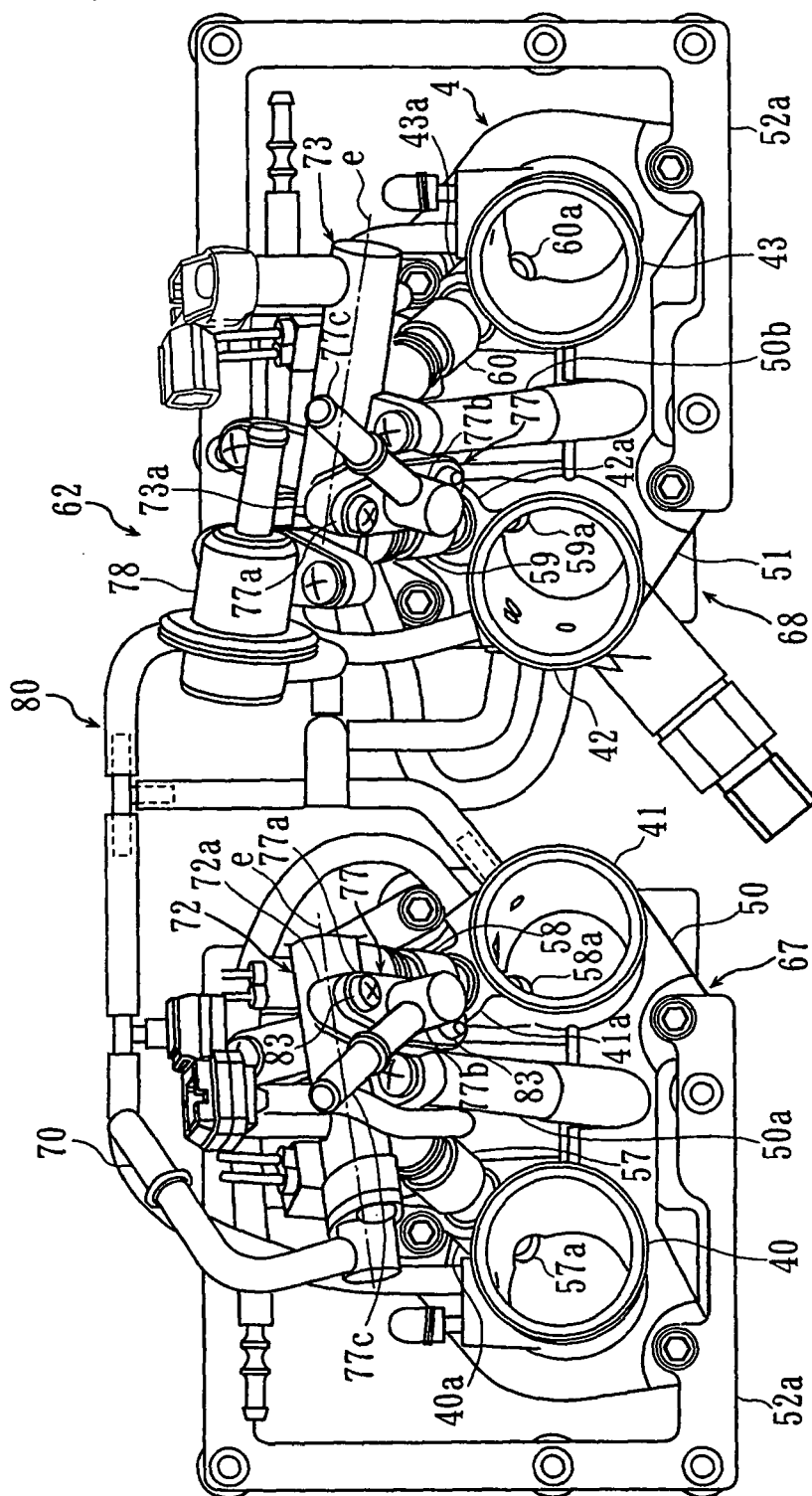


FIG. 5

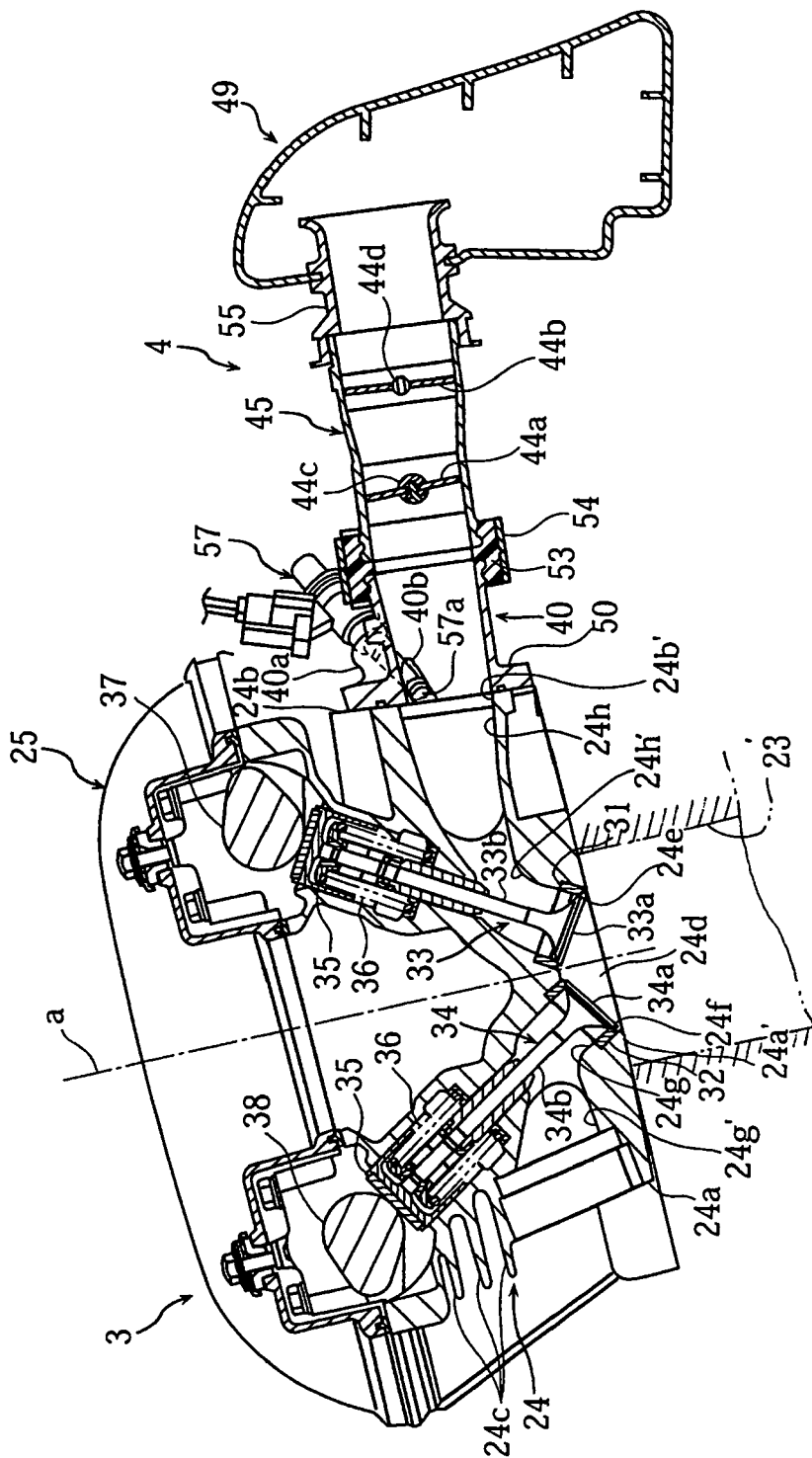


FIG. 6

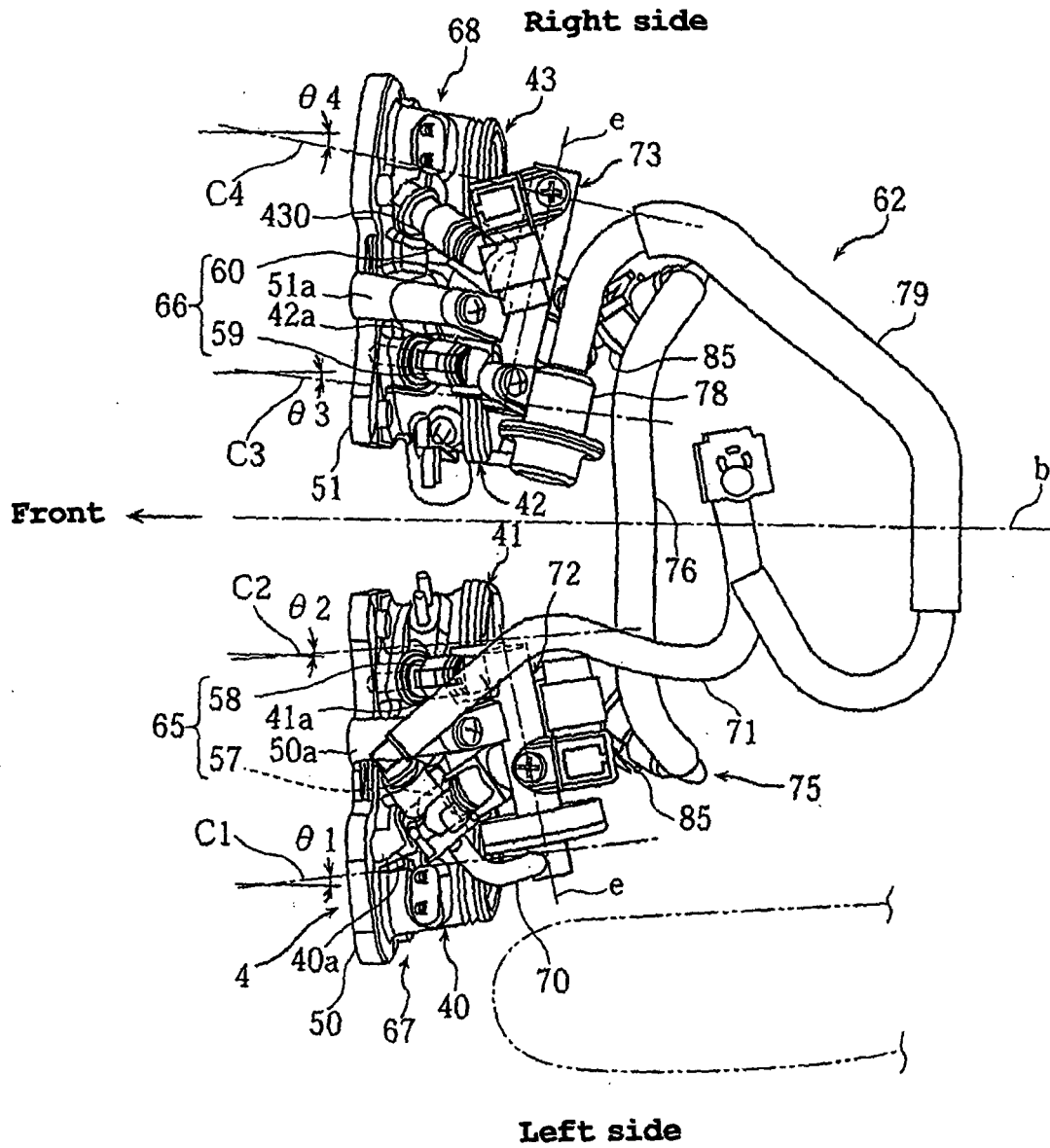


FIG. 7

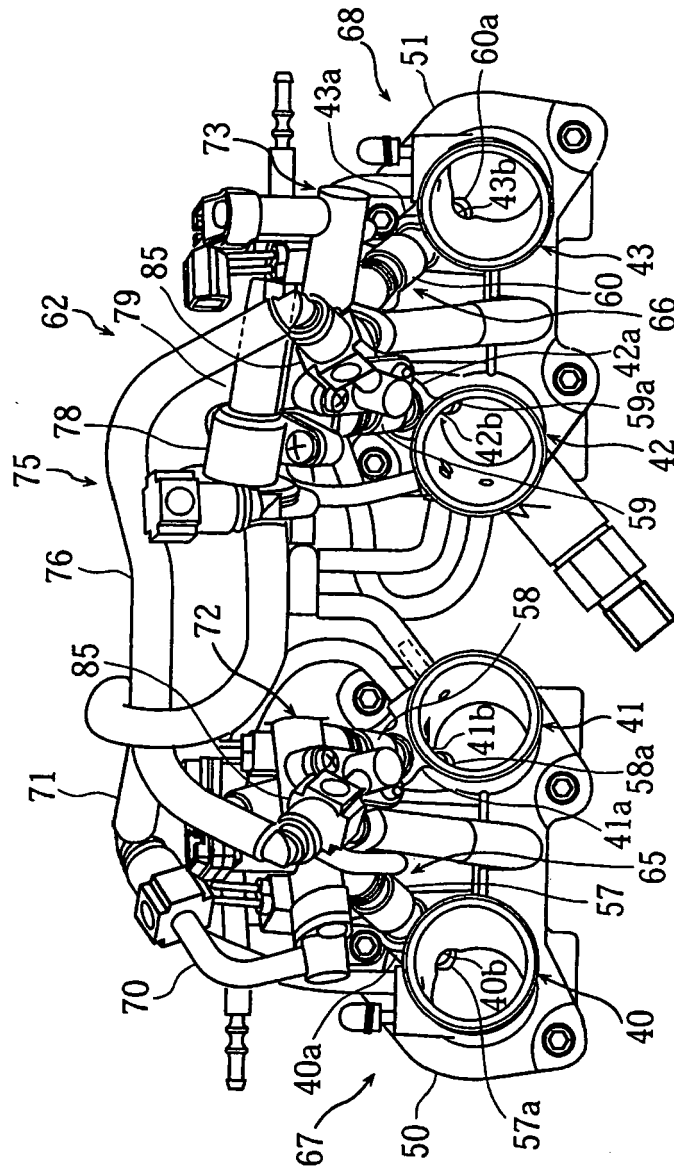


FIG. 8

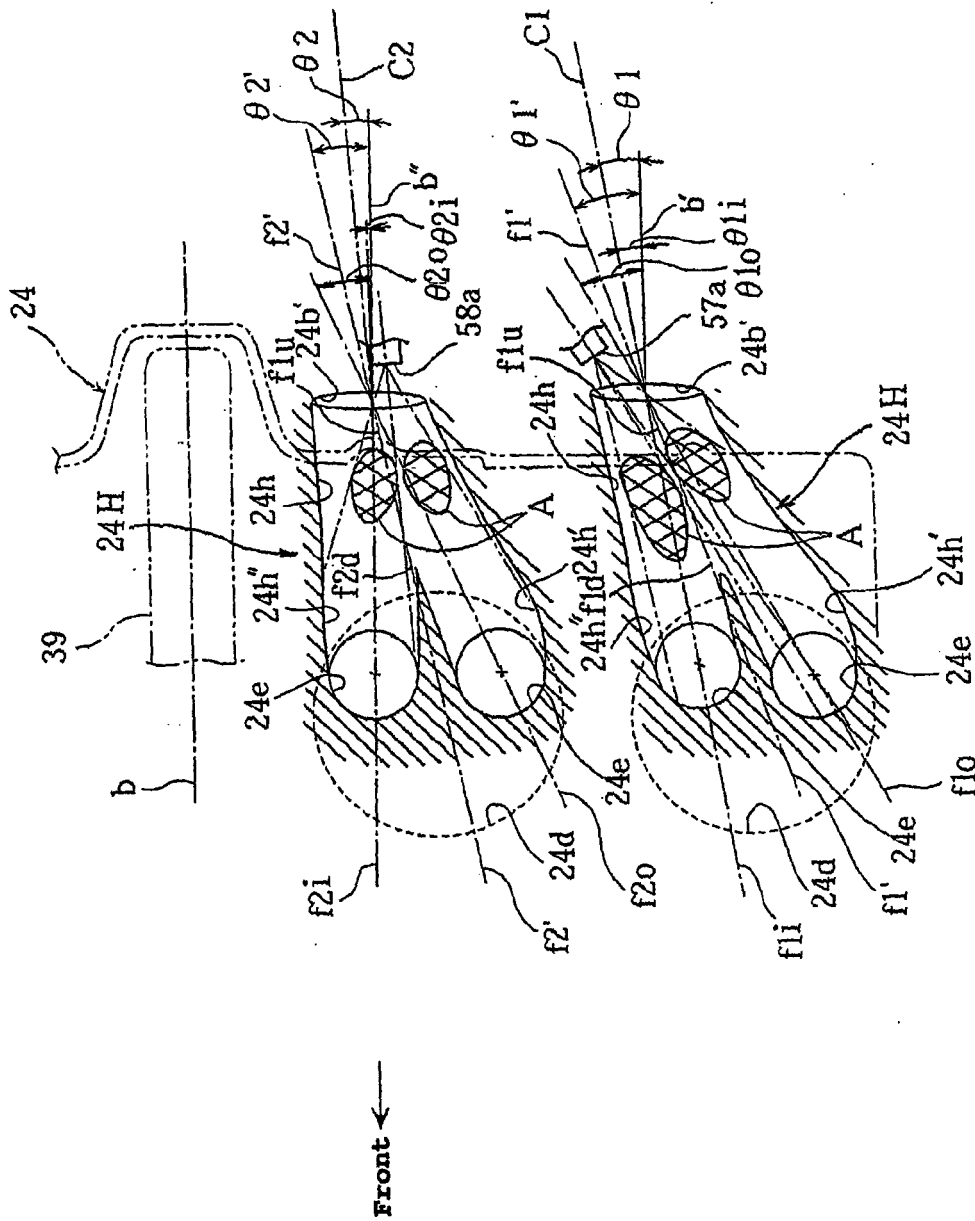


FIG. 9

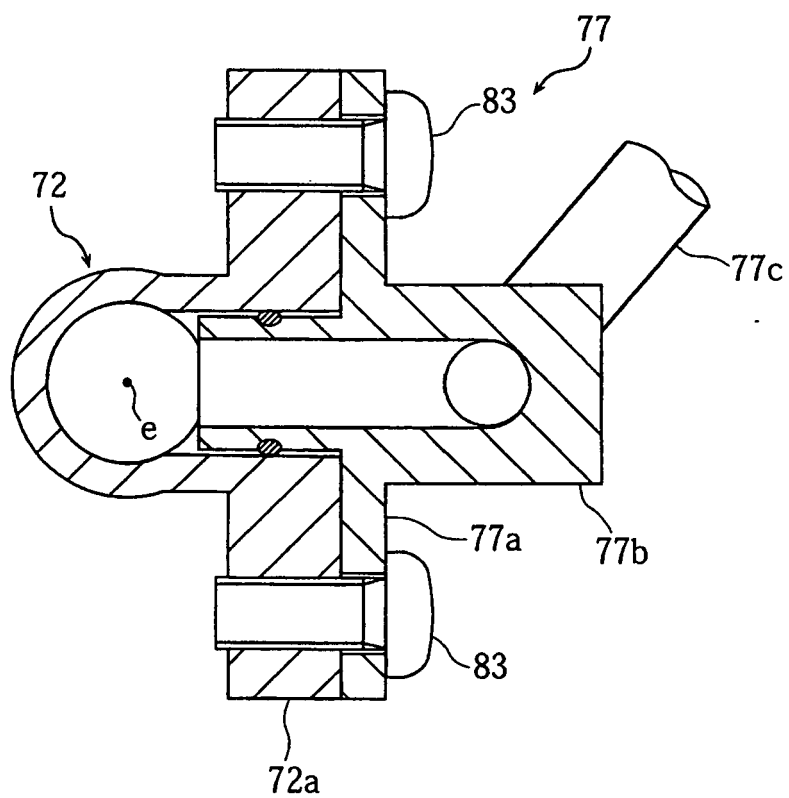


FIG. 10

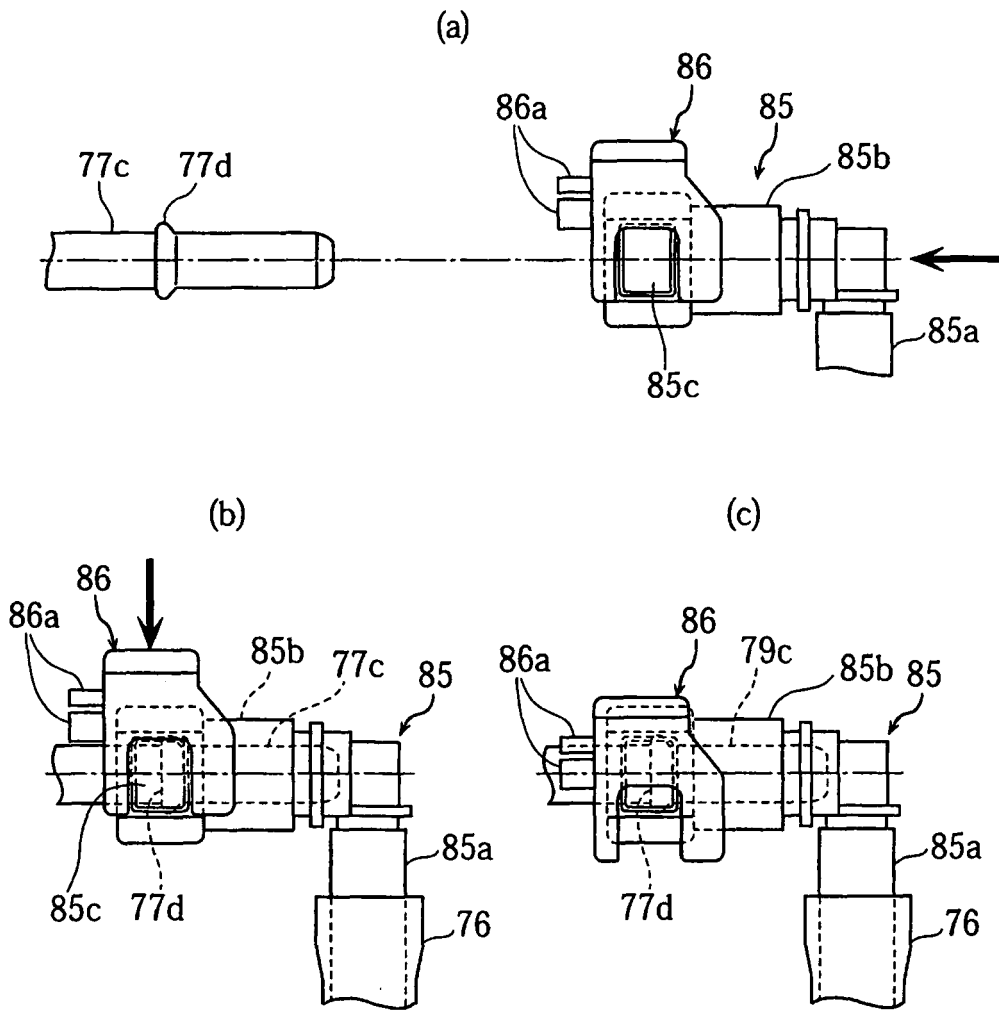


FIG. 11

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

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