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

(11) EP 3 546 739 A1

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
02.10.2019 Bulletin 2019/40

(51) Int Cl.:
F02M 35/16 *(2006.01)* ***F02M 61/14*** *(2006.01)*

(21) Application number: **19166044.8**

(22) Date of filing: **29.03.2019**

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
KH MA MD TN

(30) Priority: **30.03.2018 JP 2018067320**

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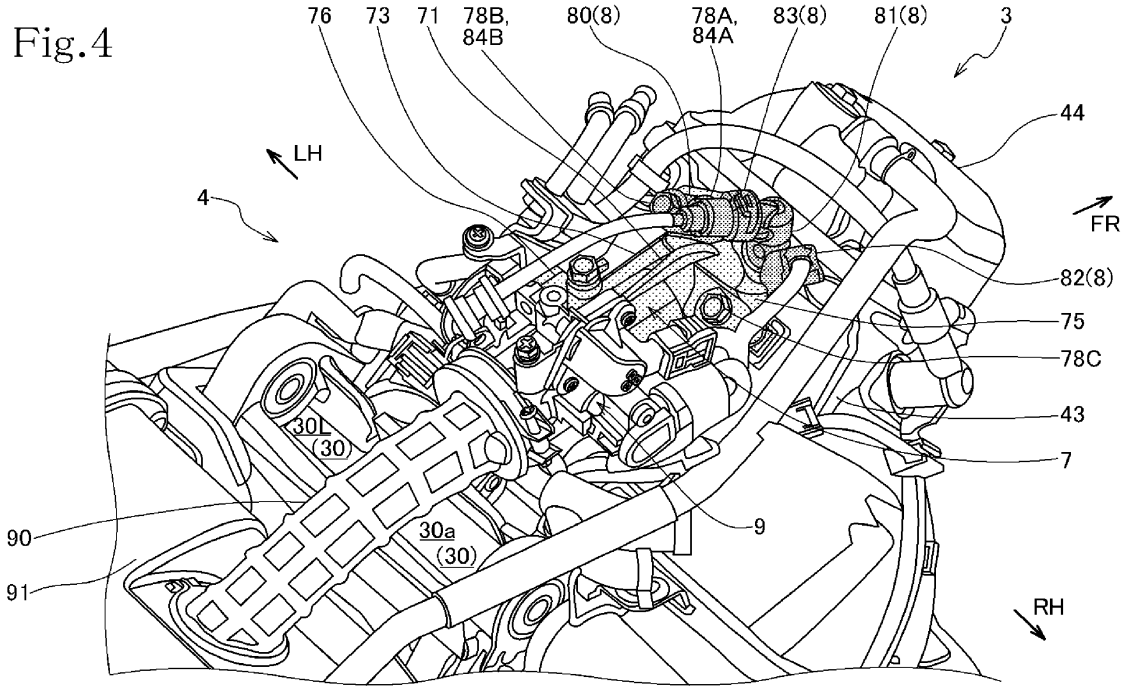
(54) INTAKE STRUCTURE FOR INTERNAL COMBUSTION ENGINES FOR USE ON SADDLE-TYPE VEHICLES

(57) An intake structure for an internal combustion engine 4 for use on a saddle-type vehicle, includes upper, lower, left, and right ribs 71, 72, 73, 74 erected respectively on upper, lower, left, and right surfaces of an intake pipe 7, in which an injector 81 is disposed between the upper rib 71 and one of the left rib 73 and the right rib 74. The upper rib, the lower rib, the left rib, and the right rib of the intake pipe increase the rigidity and mechanical strength of the intake pipe against vibrations produced by the vehicle and vibrations produced in the intake pipe, thereby increasing the vibration control capability of the intake pipe, and the injector can be placed out of physical interference with the ribs even with the upper rib 71 being disposed on the intake pipe.

Fig.4



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Description

[Technical Field]

[0001] The present invention relates to an intake structure for internal combustion engines for use on saddle-type vehicles which includes an intake pipe that has a high vibration control capability and that is less detrimental to the installation of a fuel injection device.

[Background Art]

[0002] Some internal combustion engines for use on motorcycles such as light motorcycles (LMCs) have a cylinder axis slightly inclined forward from the vertical. Such an internal combustion engine includes an intake pipe extending between a carburetor and a cylinder head and having a pair of upper and lower stiffener ribs extending longitudinally therealong and integrally projecting from respective left and right side surfaces thereof. The intake pipe also includes a pair of streamlining ribs extending longitudinally therealong on respective upper and lower surfaces thereof. One internal combustion engine of this type is disclosed in Patent Document 1 indicated below, for example.

[0003] Unlike a fuel supply process that supplies an air-fuel mixture into a combustion chamber using a carburetor, a process for supplying an air-fuel mixture to a combustion chamber with a fuel injection device requires that an injector be disposed in an intake pipe. If the latter process is employed in the internal combustion engine disclosed in Patent Document 1, then the injector disposed in the intake pipe tends to physically interfere with the ribs on the intake pipe.

[0004] Therefore, when the intake pipe has ribs thereon, there has been a demand for a structure in which an injector and an injector mount base are disposed out of physical interference with the ribs on the intake pipe.

[0005] There is known in the art a scooter-type motorcycle incorporating a swingable power unit whose cylinder axis is oriented in longitudinal directions of the motorcycle. The swingable power unit includes an intake pipe extending from a junction between itself and a cylinder head and curved in a rearward direction of the motorcycle, and a throttle body disposed upstream of the intake pipe. Since the intake pipe is caused to vibrate when the swingable power unit swings, the intake pipe has been required to incorporate a structure that increases the vibration control capability of the intake pipe.

[Prior Art Document]

[Patent Document]

[0006] Patent Document 1: JP 2010-190083 A (FIGS. 2, 3, 7, 8)

[Summary of the Invention]

[Underlying Problem to be solved by the Invention]

[0007] The present invention has been made in view of the above prior art. It is an object of the present invention to provide an intake structure for internal combustion engines for use on saddle-type vehicles which increases the vibration control capability of an intake pipe and which is not detrimental to the installation of an injector, etc. of a fuel injection device from a viewpoint of physical interference with a vibration control means for the intake pipe.

[Means to solve the Problem]

[0008] To achieve the above object, there is provided in accordance with the present invention an intake structure for an internal combustion engine for use on a saddle-type vehicle, having upper, lower, left, and right ribs erected respectively on upper, lower, left, and right surfaces of an intake pipe, in which an injector is disposed between the upper rib and one of the left rib and the right rib.

[0009] With the above arrangement, the upper rib, the lower rib, the left rib, and the right rib of the intake pipe increase the rigidity and mechanical strength of the intake pipe against vibrations produced by the vehicle and vibrations produced in the intake pipe, thereby increasing the vibration control capability of the intake pipe, and the injector is placed out of physical interference with the ribs even with the upper rib being disposed on the intake pipe.

[0010] In the above arrangement, the internal combustion engine may be included in a swingable power unit mounted on a vehicle body frame for swinging movement with a rear wheel, and the intake pipe may be bent and extend rearward of the vehicle from a junction between the intake pipe and a cylinder head.

[0011] With this arrangement, in the swingable power unit where the intake pipe is curved and extends rearward from the junction between the intake pipe and the cylinder head, even if the distance between the cylinder head and the throttle body is larger than a predetermined value, the upper rib, the lower rib, the left rib, and the right rib of the intake pipe are effective to increase the rigidity and mechanical strength of the intake pipe against vibrations produced by the vehicle and vibrations produced in the intake pipe, thereby increasing the vibration control capability of the intake pipe, and the injector is placed on the intake pipe out of physical interference with the ribs even with the upper rib being disposed on the intake pipe.

[0012] In the above arrangement, injector-side installation holes may be disposed between the upper rib and the other of the left rib and the right rib, and the injector and the injector-side installation holes may be disposed respectively on left and right sides of the upper rib.

[0013] With this arrangement, the ribs for dealing with vibrations of the vehicle may be mounted on the intake pipe out of physical interference with the injector and the

injection-side installation holes.

[0014] In the above arrangement, a throttle body may be disposed upstream of the intake pipe, and at least the lower rib, the left rib, and the right rib may have respective rib heights that are progressively larger toward a downstream side along the direction in which air flows through the intake pipe.

[0015] With the above arrangement, even with the throttle body being connected to an upstream end of the intake pipe, the intake pipe is stably supported on the internal combustion engine.

[0016] In the above arrangement, the intake pipe may have a downstream portion which is connected to the cylinder head and has a connection area that is larger than a connection area of an upstream portion thereof connected to the throttle body.

[0017] With this arrangement, since the connection area of the downstream portion of the intake pipe that is connected to the cylinder head is larger than the connection area of the upstream portion of the intake pipe that is connected to the throttle body, even with throttle body being connected to the upstream portion of the intake pipe, the intake pipe is stably supported on the swingable power unit.

[0018] In the above arrangement, the upper rib and the lower rib may have respective rib heights such that the larger the curvature of the intake pipe is, the larger the rib heights are, except for a peripheral area around an insertion hole in which the injector is inserted.

[0019] With this arrangement, the swingable power unit where the intake pipe is curved can have a higher vibration control capability for the intake pipe by increasing the rib heights depending on the curvature of the intake pipe.

[Effects of the Invention]

[0020] With the intake structure for the internal combustion engine for use on the saddle-type vehicle according to the present invention, the upper rib, the lower rib, the left rib, and the right rib of the intake pipe increase the rigidity and mechanical strength of the intake pipe against vibrations produced by the vehicle and vibrations produced in the intake pipe, thereby increasing the vibration control capability of the intake pipe, and the injector is placed out of physical interference with the ribs even with the upper rib being disposed on the intake pipe.

[Brief Description of Drawings]

[0021]

FIG. 1 is a right-hand side elevational view of a motorcycle incorporating therein an intake structure for internal combustion engines for use on saddle-type vehicles according to an embodiment of the present invention;

FIG. 2 is a sectional side elevational view of an internal combustion engine in a front part of a power unit illustrated in FIG. 1, taken generally along a cylinder axis with the internal combustion engine being illustrated in the same orientation as in FIG. 1;

FIG. 3 is a plan view of the internal combustion engine in the front part of the power unit;

FIG. 4 is a perspective view of the internal combustion engine in the front part of the power unit, as viewed from a point slightly obliquely rightward behind the internal combustion engine;

FIG. 5 is a sectional view of a cylinder head and a cylinder-head-side flange of an intake pipe, including axes of injector-side installation holes, as viewed along line V - V of FIG. 3;

FIG. 6 is a vertical sectional view of the intake pipe illustrated in FIG. 2, the intake pipe being illustrated in the same orientation as in FIG. 2;

FIG. 7 is a plan view of the intake pipe mounted on the motorcycle, as viewed along line VII - VII of FIG. 6; and

FIG. 8 is a bottom view of the intake pipe mounted on the motorcycle, as viewed along line VIII - VIII of FIG. 6.

[Mode for carrying out the Invention]

[0022] An intake structure for internal combustion engines for use on saddle-type vehicles according to an embodiment of the present invention will be described below with the drawings.

[0023] In the present description and claims, directions such as forward, rearward, leftward, rightward, upward, and downward directions and other directional expressions are in accord with those with respect to a vehicle that incorporates therein the intake structure according to the present embodiment. A saddle-type vehicle in the present embodiment specifically refers to a scooter-type motorcycle (hereinafter simply referred to as "motorcycle").

[0024] In the drawings, the reference characters FR represent a forward direction, LH a leftward direction, RH a rightward direction, and UP an upward direction, of the vehicle.

[0025] FIGS. 1 through 8 deal with the embodiment of the present invention. FIG. 1 is a right-hand side elevational view of the motorcycle 1 incorporating therein the intake structure for internal combustion engines for use on saddle-type vehicles according to the present embodiment.

[0026] The motorcycle 1 incorporating the present embodiment includes a front vehicle body portion 1A and a rear vehicle body portion 1B that are interconnected by a low floor portion 1C. The motorcycle 1 has a vehicle body frame 2 serving as a vehicle body skeleton that generally includes a down frame 21 and a pair of left and right main frames 22.

[0027] The down frame 21 extends downwardly from a head pipe 20 of the front vehicle body portion 1A. The

left and right main frames 22 include respective lower frames 22a extend substantially horizontally rearwardly from and are connected to the lower end of the down frame 21. The left and right main frames 22 also include a pair of left and right slanted portions 22b extending obliquely rearward and upward from the rear ends of the lower frames 22a. The slanted portions 22b have upper portions bent and extend rearward into a pair of left and right horizontal portions 22c that extend substantially horizontally.

[0028] A storage box, not depicted, is supported on the slanted portions 22b and the horizontal portions 22c of the main frames 22, and is covered with a rider's seat 11 disposed thereon.

[0029] In the front vehicle body portion 1A, a handle 12 is pivotally supported by the head pipe 20 and disposed above the head pipe 20. A front fork 13 extends downward from the head pipe 20. A front wheel 14 is rotatably supported on the lower end of the front fork 13.

[0030] A power unit support bracket 23 projects rearward from the slanted portions 22b of the main frames 22. A swingable power unit (hereinafter simply referred to as "power unit") 3 together with a rear wheel 15 operatively coupled thereto is vertically swingably connected to and supported on the power unit support bracket 23 by a link 24.

[0031] The motorcycle 1 incorporates therein an upper link support structure for the power unit 3.

[0032] In the front vehicle body portion 1A, the head pipes 20 and the down frame 21 are covered with a front cover 10a and a leg shield 10b that are positioned forward and rearward, respectively, of the head pipes 20 and the down frame 21.

[0033] The floor portion 1C is provided by the lower frames 22a of the main frames 22. The lower frames 22a have upper surfaces covered with a floor cover 10c, left and right surfaces covered with respective longitudinal floor side covers 10d, and lower surfaces covered with an under cover 10e.

[0034] In the rear vehicle body portion 1B, a fuel tank 16 is mounted on the horizontal portions 22c of the main frames 22 below a rear portion of the rider's seat 11. The slanted portions 22b and the horizontal portions 22c of the main frames 22 have left and right portions and rear portions covered with a body cover 10f. A front fender 10g is disposed above the front wheel 14.

[0035] The covers 10a through 10f are made of a suitable material. The under cover 10e should preferably, but not necessarily, be made of a resin material.

[0036] The power unit 3 includes an internal combustion engine 4 and a power transmitting assembly 5 extending rearward from the internal combustion engine 4 and including a belt-type continuously variable transmission 51. The rear wheel 15 is mounted on a rear axle 52a that is an output shaft of a speed reducer gear mechanism 52 disposed in a rear portion of the power transmitting assembly 5.

[0037] A rear cushion, not depicted, is interposed between the rear portion of the power transmitting assembly 5 and the horizontal portions 22c, i.e., rear portions, of the main frames 22.

[0038] The internal combustion engine 4 includes a crankshaft 41 extending transversely, i.e., in leftward and rightward directions, of the motorcycle 1 and rotatably supported by a power unit case 30. The internal combustion engine 4 has a cylinder block 42, a cylinder head 43, and a cylinder head cover 44 that are successively stacked and fastened together. The cylinder block 42 has a cylinder axis C inclined forward to such an extent that it lies nearly horizontally.

[0039] The power unit case 30 is of a structure that can be divided into left and right case members. The left case member extends integrally rearward as part of the power transmitting assembly 5.

[0040] As shown in FIG. 2, in an upper portion of the power unit 3, an intake pipe 7 is connected to the inlet of an intake port 45 defined in an upper portion of the cylinder head 43 that is inclined forward through a large angle. The intake pipe 7 is bent and extends rearward from a junction 7a thereof that is joined to the cylinder head 43.

[0041] An exhaust pipe 6 is connected to the outlet of an exhaust port 46 defined in a lower portion of the cylinder head 43. The exhaust pipe 6 is connected to a catalytic converter 60 (FIG. 1) that is of a substantially tubular shape. The catalytic converter 60 houses therein a catalyst 61 such as a three-way catalyst or the like, for example, for purifying exhaust gases emitted from the internal combustion engine 4.

[0042] The exhaust pipe 6 includes a front exhaust pipe 6A (FIG. 1) and a rear exhaust pipe 6B. The front exhaust pipe 6A extends downward from the outlet of the exhaust port 46 and is connected to the catalytic converter 60 whose central axis is oriented in the transverse directions of the motorcycle 1. The rear exhaust pipe 6B that is connected to the catalytic converter 60 is bent rearward, extends rearward along a right side of the motorcycle 1, and is connected to a muffler 62 disposed on a right side of the rear wheel 15.

[0043] An air cleaner 91 is mounted on an upper portion of the power transmitting assembly 5. The intake pipe 7 is bent rearward from the inlet of the intake port 45 defined in the upper portion of the cylinder head 43 and is connected to a throttle body 9. The air cleaner 91 is disposed upstream of and connected to the throttle body 9 through a connecting tube 90.

[0044] FIG. 2 is a sectional side elevational view of the internal combustion engine 4 in the front part of the power unit 3 illustrated in FIG. 1, taken generally along the cylinder axis C.

[0045] In FIG. 2, the vertical surfaces of left halves of the cylinder block 42, the cylinder head 43, and the head cover 44 of the internal combustion engine 4 are illustrated in vertical section. The power unit case 30 has a right half case, not depicted, and a left half case 30L, and the mating surface of the left half case 30L that is to mate

to the mating surface of the right half case is illustrated in FIG. 2 so as to face the viewer of FIG. 2.

[0046] The power unit case 30 is made up of the right half case, not depicted, and the left half case 30L that are combined with each other. The right half case serves as a right half of a crankcase 30a. The left half case 30L has a front part serving as a left half of the crankcase 30a and extends rearward as part of the power transmitting assembly 5 that houses therein a power transmitting device including the belt-type continuously variable transmission 51, the speed reducer gear mechanism 52, and so on between the crankshaft 41 and the rear axle 52a on which the rear wheel 15 is mounted.

[0047] Rotational power from the crankshaft 41 that is rotatably supported on the crankcase 30a of the internal combustion engine 4 is transmitted through the belt-type continuously variable transmission 51 and the speed reducer gear mechanism 52 in the power transmitting assembly 5 to the rear wheel 15.

[0048] A piston 31 is reciprocably disposed in a cylinder bore 42a defined in the cylinder block 42. The piston 31 is coupled to a crankpin 41a on the crankshaft 41 in the crankcase 30a by a connecting rod 32.

[0049] A combustion chamber 49 is defined between the top surface of the piston 31 slidably fitted in the cylinder bore 42a defined in the cylinder block 42 and a combustion chamber ceiling surface 43a of the cylinder head 43 that faces the top surface of the piston 31.

[0050] According to the present embodiment, the internal combustion engine 4 incorporates an SOHC two-valve system including a valve operating mechanism 35 disposed in the cylinder head 43. The cylinder head cover 44 is disposed on the cylinder head 43 in covering relation to the valve operating mechanism 35.

[0051] In order to transmit power to the valve operating mechanism 35 in the cylinder head cover 44, an endless cam chain, not depicted, is disposed in a cam chain chamber, not depicted, defined in the crankcase 30a, the cylinder block 42, and the cylinder head 43 on one side thereof at one end of the crankshaft 41 and is trained around a camshaft 36 and the crankshaft 41. When power is transmitted from the crankshaft 41 to the camshaft 36 through the endless cam chain, the camshaft 36 rotates in synchronism with the crankshaft 41 at a speed that is one half of the crankshaft 41.

[0052] A spark ignition plug, not depicted, is fitted in the cylinder head 43 and inserted into the combustion chamber 49 on the other side of the cylinder head 43 at the other end of the crankshaft 41.

[0053] The intake port 45 and the exhaust port 46 are defined in the cylinder head 43 on the cylinder block 42 whose cylinder axis C is inclined forward so as to lie nearly horizontally. The intake port 45 and the exhaust port 46 have ends open at the combustion chamber ceiling surface 43a and are curved and extend in directions vertically away from each other.

[0054] The intake port 45 has an upstream end that is open upward of the cylinder head 43 and is connected to the intake pipe 7, making up a continuous intake channel 70. The throttle body 9 is connected to an upstream end of the intake pipe 7 that is bent and extends rearward.

[0055] The exhaust port 46 has a downstream end that is open downward of the cylinder head 43 and is connected to the exhaust pipe 6 (see FIG. 1).

[0056] A tubular intake valve guide 37i is fitted in a curved outer wall 45a of the cylinder head 43 that defines the intake port 45 therein. An intake valve 38i is slidably supported by the tubular intake valve guide 37i to open and close an intake valve opening 47 defined in the cylinder head 43 and through which the intake port 45 communicates with the combustion chamber 49.

[0057] A tubular exhaust valve guide 37e is fitted in a curved outer wall 46a of the cylinder head 43 that defines the exhaust port 46 therein. An exhaust valve 38e is slidably supported by the tubular exhaust valve guide 37e to open and close an exhaust valve opening 48 defined in the cylinder head 43 and through which the exhaust port 46 communicates with the combustion chamber 49.

[0058] The intake valve 38i and the exhaust valve 38e are normally urged to move upward by valve springs 34 such that their valve heads close the intake valve opening 47 and the exhaust valve opening 48, respectively. As illustrated in FIG. 2, when the intake valve 38i and the exhaust valve 38e have their stem ends depressed respectively by an intake rocker arm 39i and an exhaust rocker arm 39e that are held in abutment against an intake cam 36i and an exhaust cam 36e on the camshaft 36 and are caused to swing, the intake valve 38i and the exhaust valve 38e are axially moved to open the intake valve opening 47 and the exhaust valve opening 48, respectively, at predetermined timings, bringing the intake port 45 and the exhaust port 46 into fluid communication with the combustion chamber 49 to introduce an air-fuel mixture into the combustion chamber 49 and discharge combustion gases from the combustion chamber 49 at predetermined timings.

[0059] According to the present embodiment, as illustrated in FIG. 2, the throttle body 9 which is made of metal is fastened to the upstream end of the intake pipe 7 that is connected to the intake port 45 in the cylinder head 43.

[0060] The throttle body 9 has an upstream end connected to the air cleaner 91 through the connecting tube 90 that is made of a resin material. When the power unit 3 swings and vibrates, the intake pipe 7 tends to be subject to upward, downward, leftward, and rightward vibrational loads, particularly upward, downward, leftward, and rightward bending moments, including loads due to the weight of the throttle body 9 fastened to the intake pipe 7.

[0061] In view of those vibrational loads, as illustrated in FIG. 2, the intake pipe 7 includes a stiffening upper rib 71 and a stiffening lower rib 72 erected respectively on upper and lower surfaces thereof and extending along the direction in which intake air flows through the intake pipe 7.

[0062] As illustrated in FIGS. 3 and 4, the intake pipe

7 further includes a stiffening left rib 73 and a stiffening right rib 74 erected respectively on left and right surfaces thereof and extending along the direction in which intake air flows through the intake pipe 7.

[0063] As illustrated in FIG. 2, the intake pipe 7 includes a cylinder-head-side flange 75 on a downstream end thereof that serves as a junction 7a connected to the inlet of the intake port 45 in the cylinder head 43 and a throttle-body-side flange 76 on an upstream end thereof that serves as a junction connected to the throttle body 9. As will be noted from FIGS. 6 through 8, the intake pipe 7 is curved rearward from the cylinder-head-side flange 75 toward the throttle-body-side flange 76.

[0064] The internal combustion engine 4 incorporating the present embodiment further includes a fuel injection device 8 having an injector 81 on an upper portion of the intake pipe 7. The fuel injection device 8 injects fuel into the intake port 45.

[0065] As illustrated in FIGS. 3 and 4, the fuel injection device 8 includes the injector 81, an injector mount base 80 by which the injector 81 is mounted on the intake pipe 7, and a control terminal 82 and a fuel connector 83 that are mounted on the injector 81.

[0066] FIG. 5 is a sectional view of the cylinder head 43 and the cylinder-head-side flange 75 of the intake pipe 7, including axes x1 and x2 of injector-side installation holes 84A and 84B, as viewed along line V - V of FIG. 3.

[0067] In FIGS. 2 through 5, the fuel injection device 8 is depicted densely stippled, whereas the intake pipe 7 is depicted coarsely stippled, so that they can easily be visually distinguished from each other.

[0068] As illustrated in FIG. 5, the injector 81 that is mounted on the intake pipe 7 by the injector mount base 80 is fitted and inserted in an injector insertion hole 77 defined in the cylinder-head-side flange 75 of the intake pipe 7 between the right rib 74 and the upper rib 71. The injector 81 is fastened to the intake pipe 7 by bolts 78A and 78B inserted respectively through injection-side mount holes 84A and 84B defined in a leftward extension of the injector mount base 80. The bolt 78A is threaded into an intake-pipe-side fastening hole 79A defined in the cylinder-head-side flange 75 of the intake pipe 7 between the upper rib 71 and the left rib 73. The bolt 78B is inserted through an intake-pipe-side fastening hole 79B defined in the cylinder-head-side flange 75 of the intake pipe 7 between the upper rib 71 and the left rib 73.

[0069] The intake-pipe-side fastening hole 79A is an internally threaded hole. The injector mount base 80 is fastened to the intake pipe 7 by the bolt 78A that is inserted in the injection-side mount hole 84A and threaded into the intake-pipe-side fastening hole 79A.

[0070] The intake-pipe-side fastening hole 79B is a through hole doubling as a hole through which the intake pipe 7 is fastened to the cylinder head 43. The bolt 78B that is inserted through the injection-side mount hole 84B is inserted through the intake-pipe-side fastening hole 79B and threaded into an intake pipe fixing internally threaded hole 43B defined in the cylinder head 43. The injector mount base 80 of the fuel injection device 8 and the intake pipe 7 are thus fastened together to the cylinder head 43 by the bolt 78B.

[0071] The intake pipe 7 is further fastened to the cylinder head 43 by a bolt 78C inserted through an intake-pipe-side fastening hole 79C (see FIG. 7) defined in the cylinder-head-side flange 75 and threaded into an internally threaded hole 43C defined in the cylinder head 43.

[0072] According to the present embodiment, the upper rib 71, the lower rib 72, the left rib 73, and the right rib 74 of the intake pipe 7 increase the rigidity and mechanical strength of the intake pipe 7 against vibrations produced by the motorcycle 1 and vibrations produced in the intake pipe 7, thereby increasing the vibration control capability of the intake pipe 7. Since the injector 81 is disposed at a position between the upper rib 71 and the right rib 74, the injector 81 is placed out of physical interference with the upper rib 71 and the left and right ribs 73, 74 even with the upper rib 71 being disposed on the intake pipe 7

[0073] As the injector-side installation holes 84A and 84B are disposed between the upper rib 71 and the left rib 73, the injector 81 and the injector-side installation holes 84A and 84B are positioned respectively on the left and right sides of the upper rib 71. Consequently, the ribs 71 through 74 for making the intake pipe 7 resistant to vibrations from the motorcycle 1 are disposed on the intake pipe 7 out of physical interference with the injector 81 and the injector-side installation holes 84A and 84B.

[0074] The injector 81 may alternatively be positioned between the upper rib 71 and the left rib 73, with the injector-side installation holes 84A and 84B positioned between the upper rib 71 and the right rib 74.

[0075] FIG. 6 is a vertical sectional view of the intake pipe 7 illustrated in FIG. 2, the intake pipe 7 being illustrated in the same orientation as in FIG. 2.

[0076] FIG. 7 is a plan view of the intake pipe 7 mounted on the motorcycle 1, as viewed along line VII - VII of FIG. 6. FIG. 8 is a bottom view of the intake pipe 7 mounted on the motorcycle 1, as viewed along line VIII - VIII of FIG. 6.

[0077] The upward, forward, rightward, and leftward directions of the motorcycle 1 are illustrated in FIGS. 6 through 8.

[0078] As illustrated in FIGS. 2, 6, and 7, the throttle body 9 is disposed upstream of the intake pipe 7, and the lower rib 72, the left rib 73, and the right rib 74 have respective rib heights h72, h73, and h74 that are progressively larger toward the downstream side along the direction in which air flows through the intake pipe 7.

[0079] Even when loads due to the weight of the throttle body 9 made of metal and vibrations thereof are applied to the intake pipe 7 from the throttle body 9 connected to the upstream end of the intake pipe 7, since the rib heights are progressively higher toward the downstream side where the load moments are higher, the resistance and mechanical strength of the intake pipe 7 against the load moments are increased toward the downstream

side, allowing the intake pipe 7 to be stably supported on the internal combustion engine 4.

[0080] According to the present embodiment, inasmuch as the injector 81 of the fuel injection device 8 and the injector-side installation holes 84A and 84B in the injector mount base 80 are disposed on both sides of the upper rib 71, the upper rib 71 has a rib height h71 that is relatively limited. However, the rib height h1 as a whole is progressively larger toward the downstream side along the direction in which air flows through the intake pipe 7, contributing to an increase in the resistance and mechanical strength of the intake pipe 7 against the load moments on the downstream side.

[0081] As illustrated in FIG. 7, the fastening hole 79C is formed in the cylinder-head-side flange 75 for fastening the intake pipe 7 to the cylinder head 43. The bolt 78C is inserted through the fastening hole 79C and directly threaded, not via an injector-side installation hole, into the internally threaded hole 43C defined in the cylinder head 43, fastening intake pipe 7 to the cylinder head 43 (see FIG. 5).

[0082] Effects that are obtained from the layout and shape of the ribs 71 through 74 on the intake pipe 7, and the layout of the injector 81 of the fuel injection device 8 and the injector-side installation holes 84A and 84B in the injector mount base 80 are not restricted only to the internal combustion engine 4 of the swingable power unit 3 whose cylinder axis C is inclined forward nearly horizontally, for use on the scooter-type motorcycle 1.

[0083] The same effects are also applicable to internal combustion engines whose cylinder axis is inclined slightly forward from the vertical, for use on motorcycles that incorporate a power unit fixedly mounted on a vehicle body frame, e.g., LMCs (light motorcycles).

[0084] In those alternative applications, the power unit is not swingably mounted on the vehicle body frame. However, the effects obtained according to the above embodiment are also applicable because saddle-type vehicles are swingable and vibratable themselves.

[0085] Specifically, the upper rib 71, the lower rib 72, the left rib 73, and the right rib 74 of the intake pipe 7 increase the rigidity and mechanical strength of the intake pipe 7 against vibrations produced by the vehicle and vibrations produced in the intake pipe 7, thereby increasing the vibration control capability of the intake pipe 7. Since the injector 81 is disposed at a position between the upper rib 71 and the right rib 74 or between the upper rib 71 and the left rib 73, the injector 81 is placed out of physical interference with the upper rib 71 and the left and right ribs 73, 74 even with the upper rib 71 being disposed on the intake pipe 7.

[0086] Nevertheless, the present invention is particularly useful when applied to the internal combustion engine 4 of the swingable power unit 3 on the scooter-type motorcycle 1, as exemplified by the above embodiment. In that case, the internal combustion engine 4 is included in the swingable power unit 3 that is mounted on the vehicle body frame 2 such that the internal combustion engine 4 is vertically swingable together with the rear wheel 15, with the cylinder axis C being oriented longitudinally of the motorcycle 1 and the intake pipe 7 being curved and extending rearward from the junction 7a between the intake pipe 7 and the cylinder head 43.

[0087] In the swingable power unit 3 where the intake pipe 7 is curved and extends rearward from the junction 7a between the intake pipe 7 and the cylinder head 43, even if the distance between the cylinder head 43 and the throttle body 9 is larger than a predetermined value for increasing the power output of the internal combustion engine 4 in low and medium rotational speed ranges, the upper rib 71, the lower rib 72, the left rib 73, and the right rib 74 of the intake pipe 7 are effective to increase the rigidity and mechanical strength of the intake pipe 7 against vibrations produced by the motorcycle 1 and vibrations produced in the intake pipe 7, thereby increasing the vibration control capability of the intake pipe 7, and the injector 81 is placed on the intake pipe 7 out of physical interference with the ribs 71 through 74 even with the upper rib 71 being disposed on the intake pipe 7.

[0088] As illustrated in FIG. 8, the cylinder-head-side flange 75 of the intake pipe 7 that is positioned downstream and connected to the cylinder head 43 has a connection area Sa that is larger than a connection area Sb of a throttle-body-side flange 76 that is positioned upstream and connected to the throttle body 9.

[0089] Therefore, even if the throttle body 9 connected to the upstream end of the intake pipe 7 is relatively heavy, the intake pipe 7 is stably supported on the swingable power unit 3.

[0090] As illustrated in FIGS. 2, 6, and 7, the larger the curvature of the intake pipe 7 is, the larger the rib heights h71 and h72 of the upper and lower ribs 71 and 72 are, except for a peripheral area 77a around the injector insertion hole 77 in which the injector 81 is inserted.

[0091] In other words, the swingable power unit 3 where the intake pipe 7 is curved can have a higher vibration control capability for the intake pipe 7 by increasing the rib heights h71 and h72 depending on the curvature of the intake pipe 7.

[0092] While the preferred embodiment of the present invention has been described above, the present invention is not limited to the illustrated embodiment, but various changes and modifications may be made in the embodiment within the scope of the present invention. For example, the power unit and the internal combustion engine according to the present invention are not limited to those on motorcycles, but are widely applicable to those on other kinds of saddle-type vehicles.

[0093] The layout of various parts in the leftward and rightward directions has been described in accordance with the illustrated embodiment for illustrative purposes. However, the parts may be arranged according to a reversed layout in the leftward and rightward directions.

[Reference Signs List]

[0094] 1···Motorcycle, 2···Vehicle body frame, 3···Power unit or swingable power unit, 4···Internal combustion engine, 5···Power transmitting assembly, 7···Intake pipe, 7a···Junction, 8···Fuel injection device, 9···Throttle body, 15···Rear wheel, 22···Main frame, 22a···Lower frame, 22b···Slanted portion, 22C···Horizontal portion, 23···Power unit support bracket, 24···Link, 30···Power unit case, 30a···Crankcase, 30L···Left half case, 41···Crankshaft, 42···Cylinder block, 42a···Cylinder bore, 43···Cylinder head, 43a···Combustion chamber ceiling surface, 43B···Intake pipe fixing internally threaded hole, 45···Intake port, 47···Intake valve opening, 49···Combustion chamber, 51···Belt-type continuously variable transmission, 52···Speed reducer gear mechanism, 70···Intake channel, 71···Upper rib, 72···Lower rib, 73···Left rib, 74···Right rib, 75···Cylinder-head-side flange, 76···Throttle-body-side flange, 77···Injector insertion hole, 77a···Peripheral area around insertion hole, 78A···Bolt, 78B···Bolt, 78C···Bolt, 79A···Intake-pipe-side fastening hole, 79B···Intake-pipe-side fastening hole, 79C···Intake-pipe-side fastening hole, 80···Injector mount base, 81···Injector, 82···Control terminal, 83···Fuel connector, 84A···Injector-side installation hole, 84B···Injector-side installation hole, 90···Connecting tube, 91···Air cleaner, C···Cylinder axis, h71···Rib height (of the upper rib 71), h72···Rib height (of the lower rib 72), h73···Rib height (of the left rib 73), h74···Rib height (of the right rib 74), Sa···Connection area of the cylinder-head-side flange 75, Sb···Connection area of the throttle-body-side flange 76

Claims

1. An intake structure for an internal combustion engine for use on a saddle-type vehicle, having upper, lower, left, and right ribs (71, 72, 73, 74) erected respectively on upper, lower, left, and right surfaces of an intake pipe (7) of the engine (4), wherein:
   an injector (81) is disposed between the upper rib (71) and one of the left rib (73) and the right rib (74).

2. The intake structure for an internal combustion engine for use on a saddle-type vehicle as claimed in claim 1, wherein:

   the internal combustion engine (4) is included in a swingable power unit (3) mounted on a vehicle body frame (2) for swinging movement with a rear wheel (15), with a cylinder axis (C) of the engine (4) being oriented longitudinally of the vehicle; and
   the intake pipe (7) is bent and extends rearward of the vehicle from a junction (7a) between the intake pipe (7) and a cylinder head (43) of the engine (4).

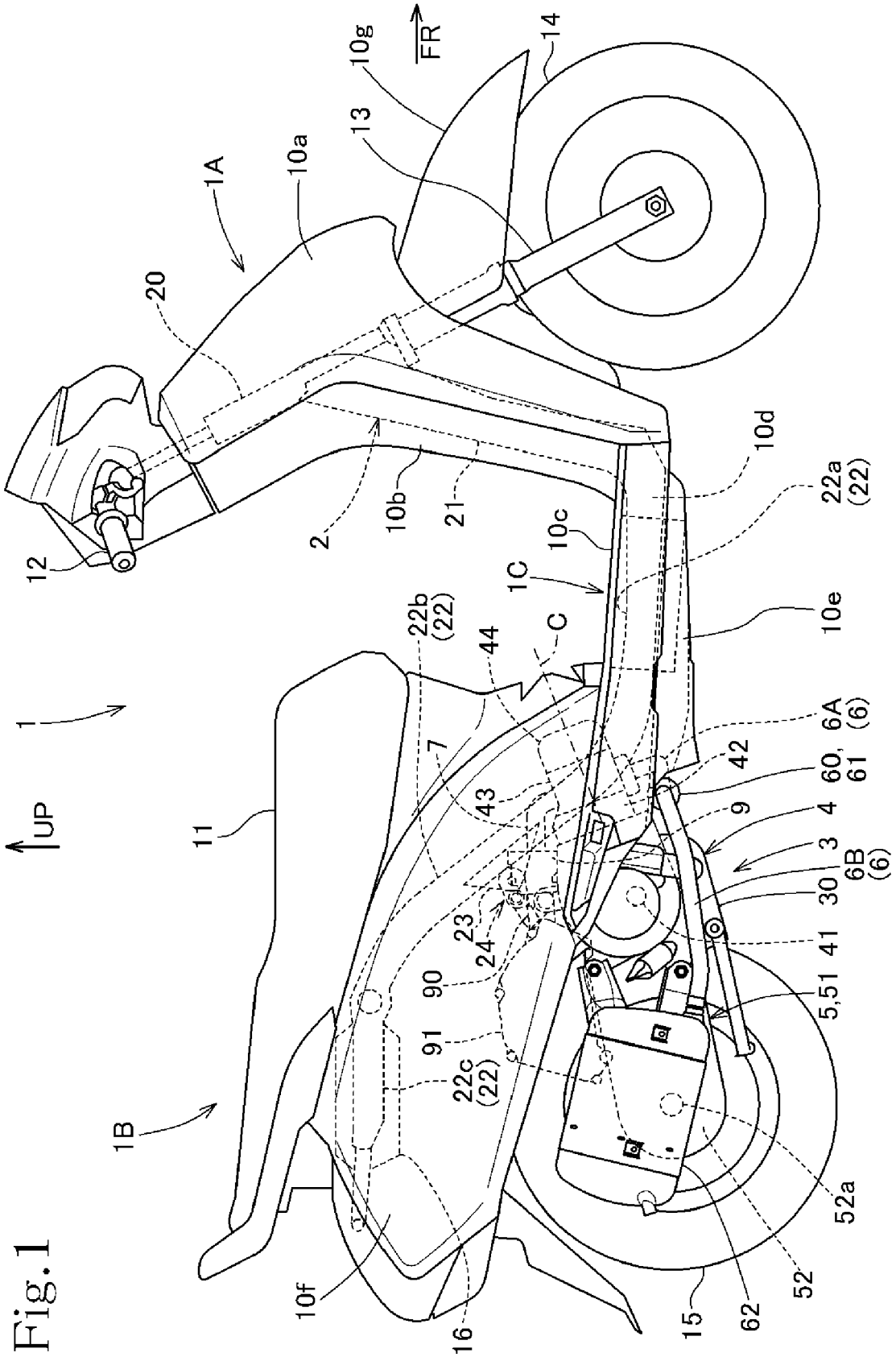
3. The intake structure for an internal combustion engine for use on a saddle-type vehicle as claimed in claim 1 or 2, wherein:
   injector-side installation holes (84A, 84B) are disposed between the upper rib (71) and the other of the left rib (73) and the right rib (74), and the injector (81) and the injector-side installation holes (84A, 84B) are disposed respectively on left and right sides of the upper rib (71).

4. The intake structure for an internal combustion engine for use on a saddle-type vehicle as claimed in any one of claims 1 through 3, wherein:

   a throttle body (9) is disposed upstream of the intake pipe (7); and
   at least the lower rib (72), the left rib (73), and the right rib (74) have respective rib heights (h72, h73, h74) which are progressively larger toward a downstream side along a direction in which air flows through the intake pipe (7).

5. The intake structure for an internal combustion engine for use on a saddle-type vehicle as claimed in claim 4, wherein:
   the intake pipe (7) has a downstream portion which is connected to a cylinder head (43) and has a connection area (Sa) larger than a connection area (Sb) of an upstream portion thereof which is connected to the throttle body (9).

6. The intake structure for an internal combustion engine for use on a saddle-type vehicle as claimed in claim 4 or 5, wherein:
   the upper rib (71) and the lower rib (72) have respective rib heights (h71, h72) such that the larger the curvature of the intake pipe (7) is, the larger the rib heights (h71, h72) are, except for a peripheral area (77a) around an insertion hole in which the injector (81) is inserted.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1B
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10b
10c
10d
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10f
10g
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12
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14
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21
22a (22)
22b (22)
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44
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52a
60, 61
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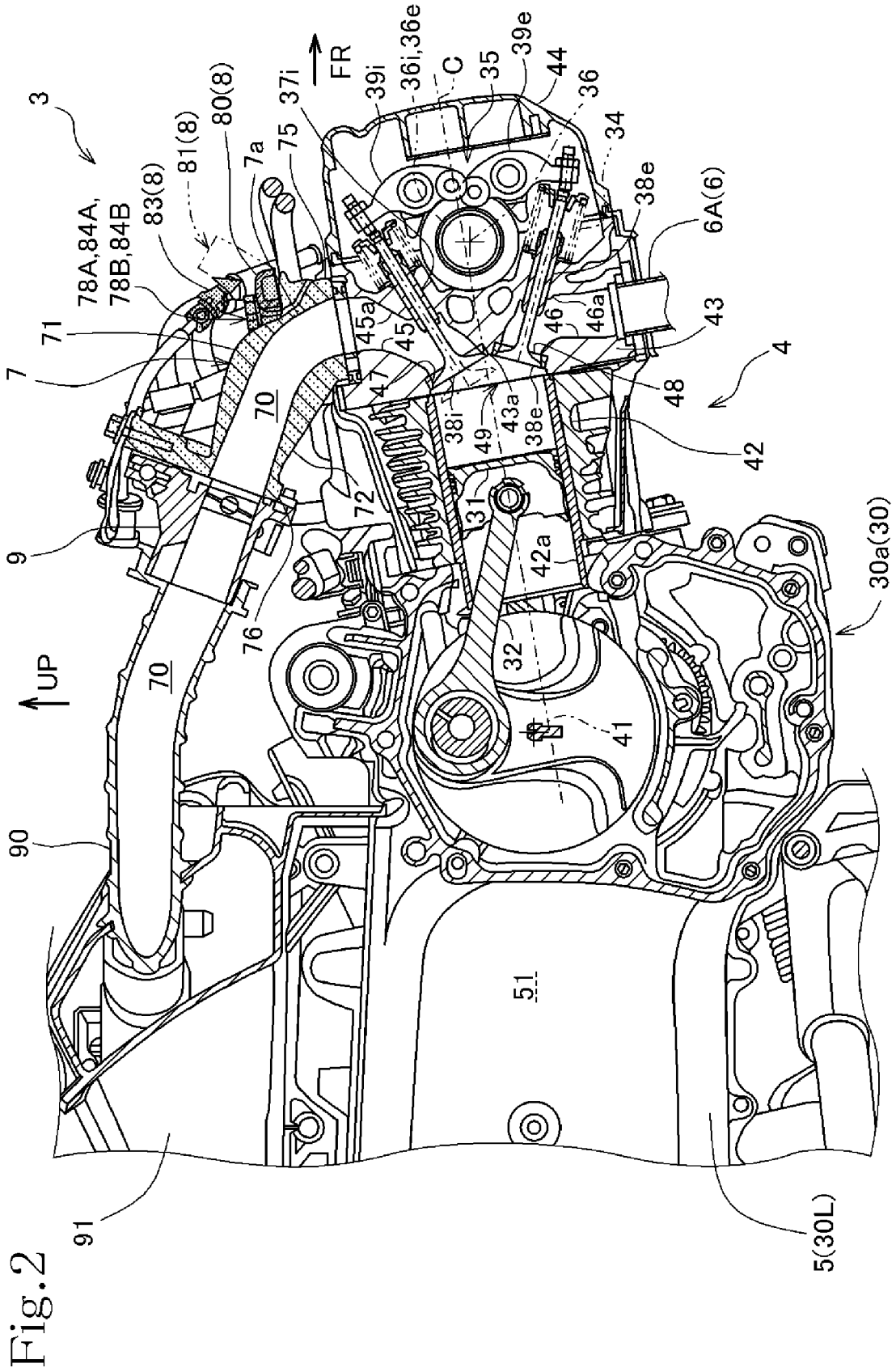
90
91
C

Fig.1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36
34
38e
6A(6)
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7
70
45a
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46a
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38i
49
43a
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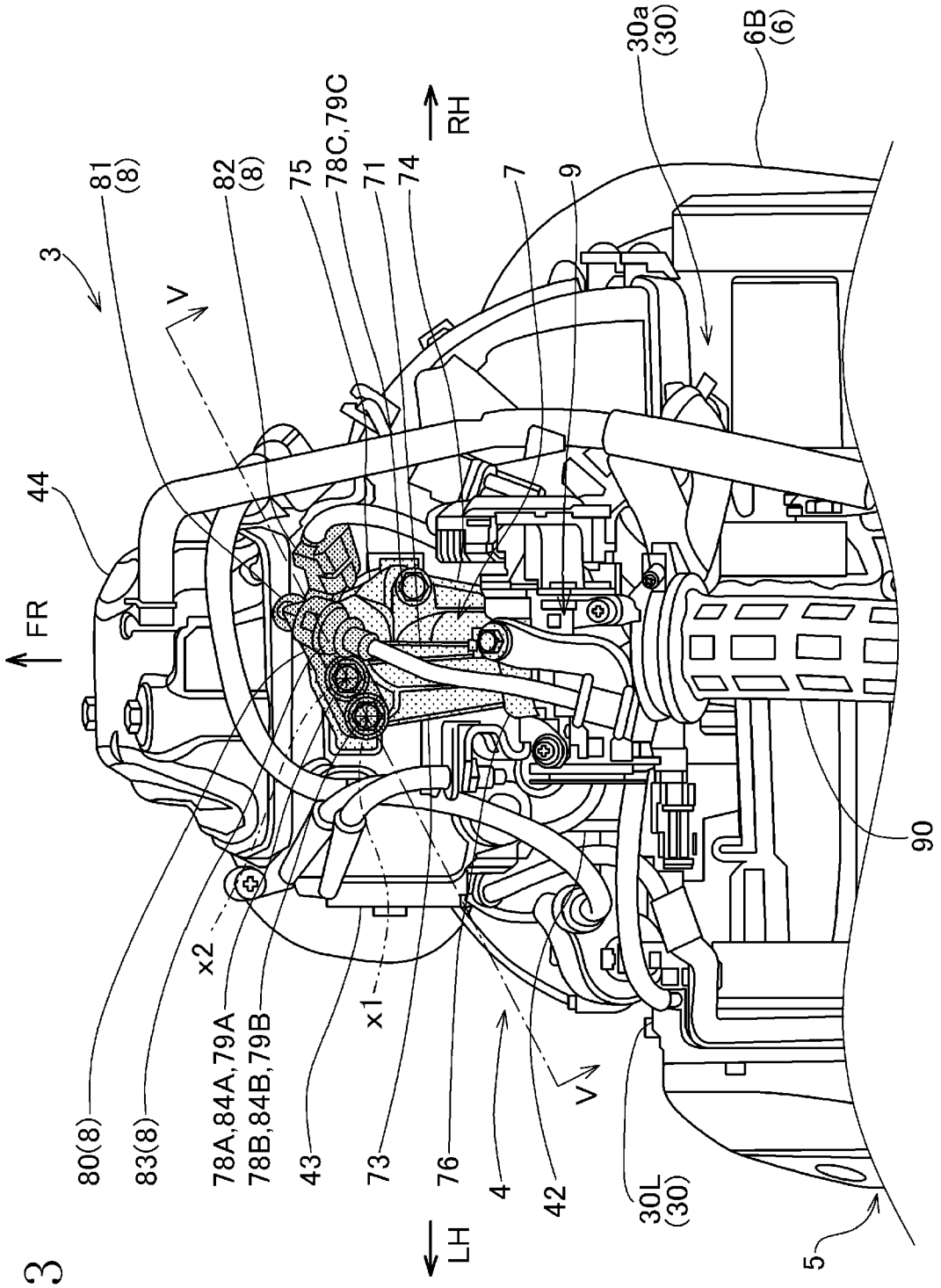
91
5(30L)

Fig.2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74
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V
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x2
x1
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78B,84B,79B
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73
76
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30L (30)
5
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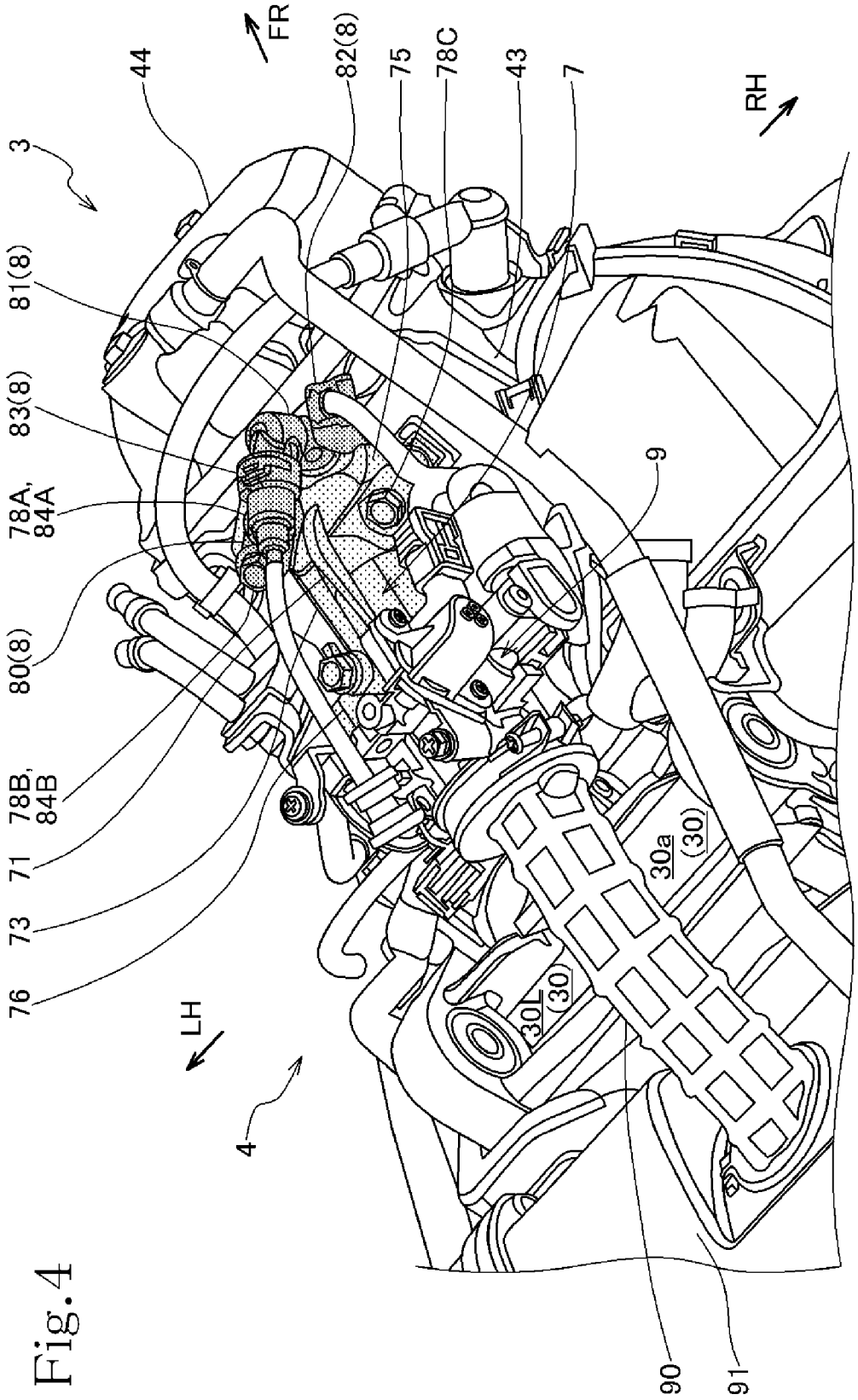
80(8)
83(8)
LH

Fig.3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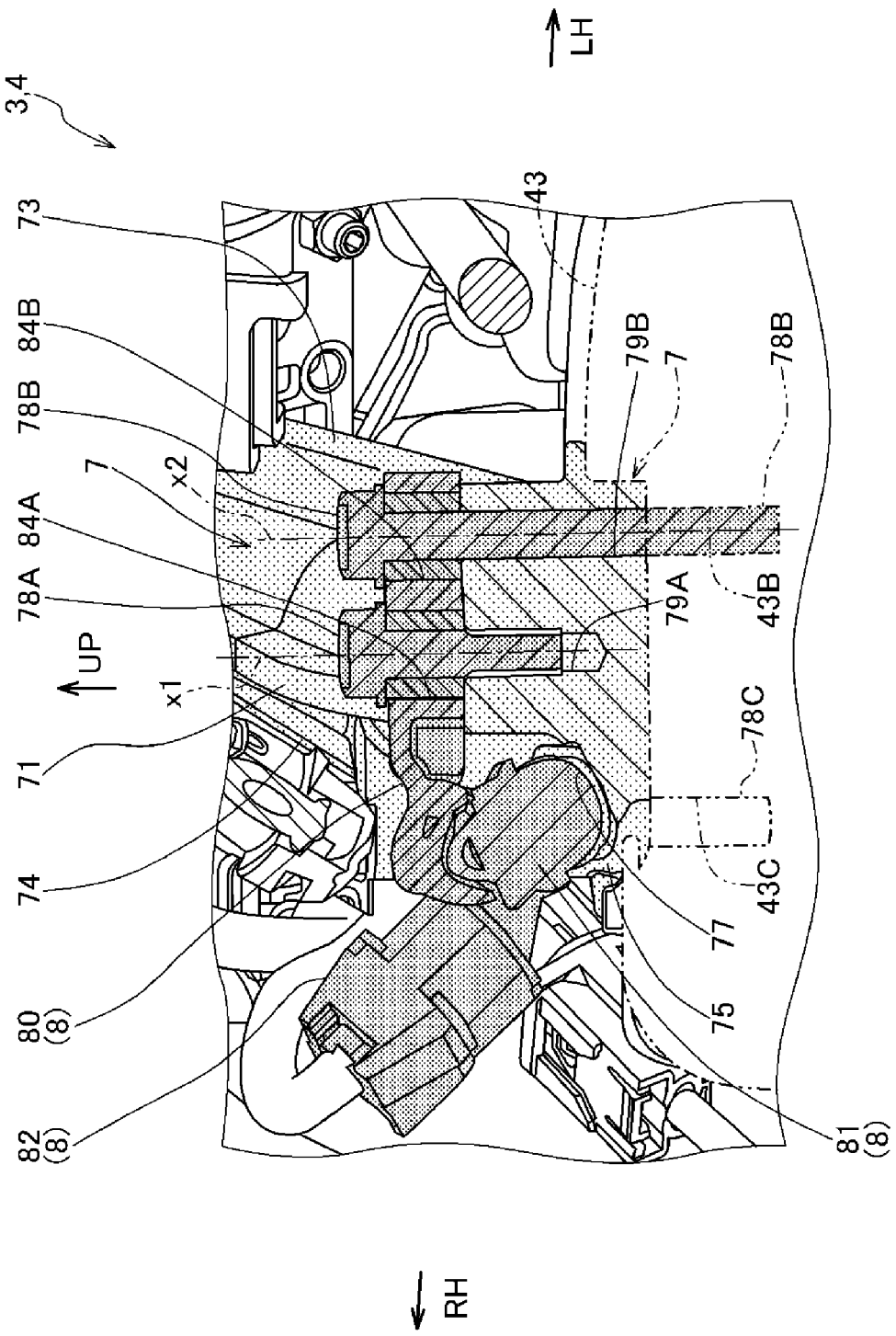
(30)
30L
(30)
4
90
91

Fig.4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RH
UP
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84B
78B
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74
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(8)
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43B
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43C
77
75
81
(8)

Fig.5

Fig.6

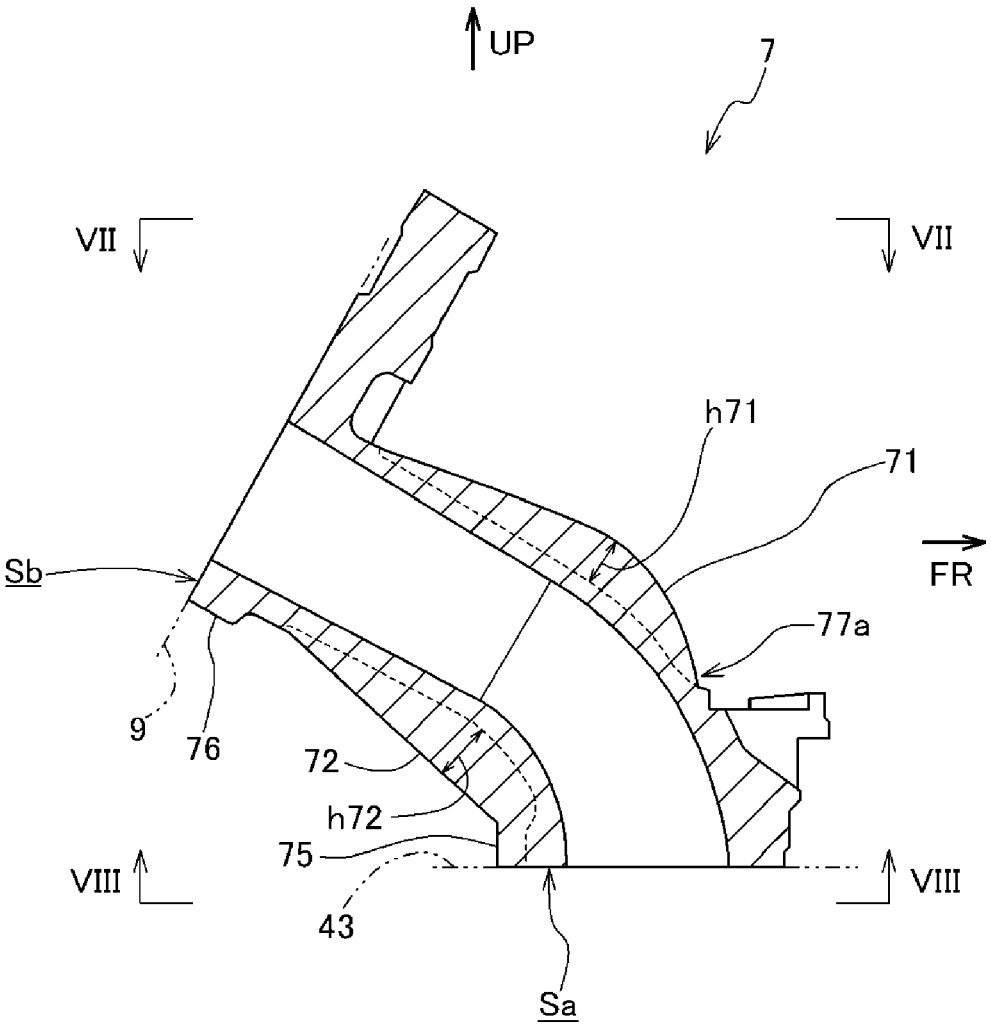


Fig.7

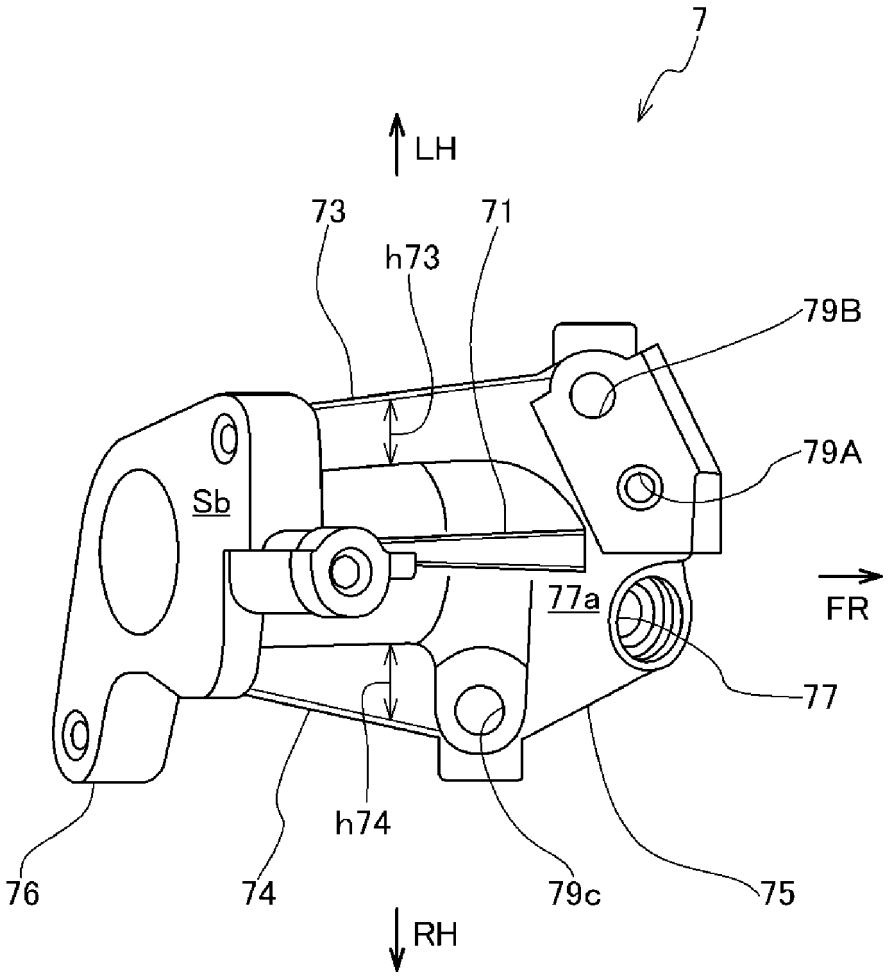
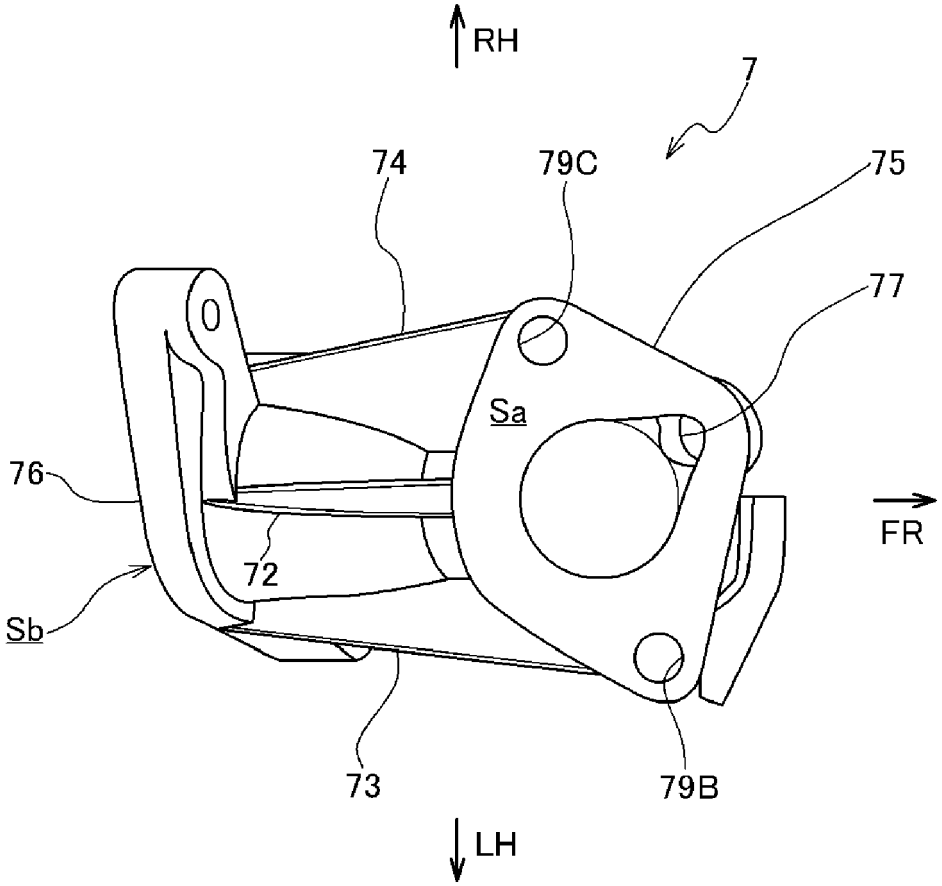


Fig.8



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Application Number
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F02M

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	7 August 2019	Kolodziejczyk, Piotr

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