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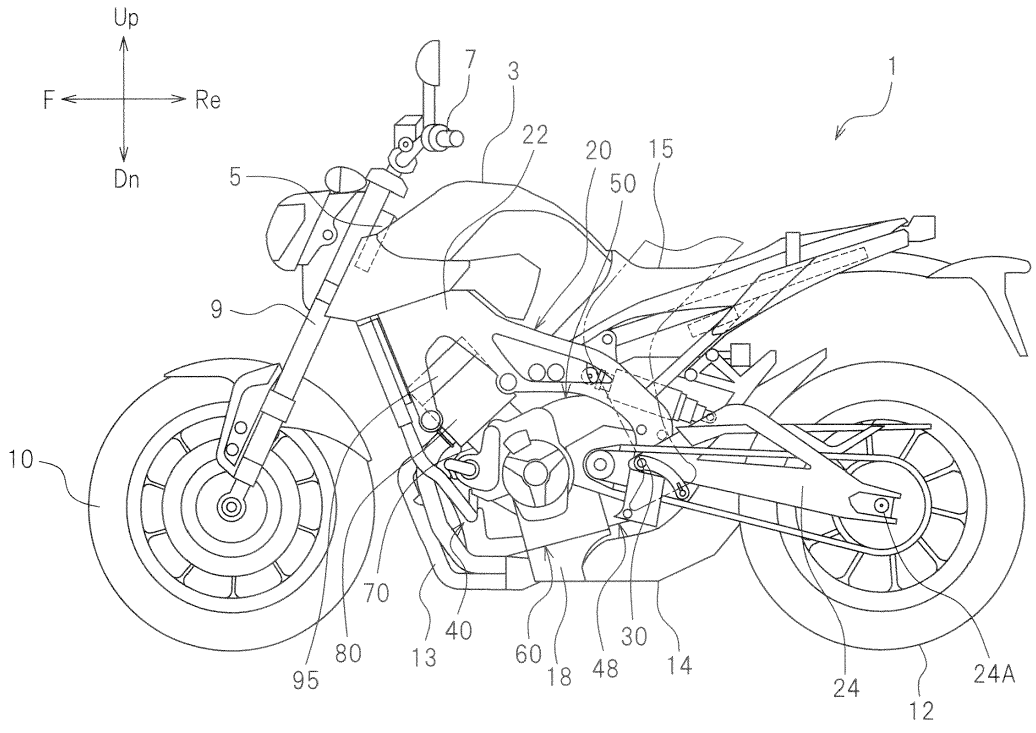
(54) Motorcycle

(57) A motorcycle includes a body frame, and an internal combustion engine having a crankshaft, a drive shaft, an upper crankcase disposed above the crankshaft and the drive shaft, a lower crankcase (60) disposed below the crankshaft and the drive shaft, and a cylinder body disposed above the upper crankcase and having a plurality of cylinders arranged transversely. The lower crankcase (60) has a left boss portion (130) and a right boss portion (134) respectively having holes (132), (136) for receiving a rod-shaped fastener extending transversely, and secured to the body frame by the fastener. The lower crankcase (60) includes an oil passage (160) through which oil to be supplied to the drive shaft flows, the oil passage (160) formed integrally with the lower crankcase (60).

FIG.1



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Description

[0001] The present invention relates to motorcycles.

[0002] Conventionally, in an internal combustion engine for motorcycles and the like, oil is circulated through oil passages formed in a crankcase for accommodating a crankshaft as well as in a cylinder body and a cylinder head, which are disposed above the crankcase. In the crankcase, a drive shaft to which the torque of the crankshaft is transmitted is disposed. The drive shaft needs to be lubricated and cooled by circulating the oil. Patent Literatures 1 and 2 disclose a technique for supplying oil from the oil passage formed in the crankcase to the drive shaft.

[0003] However, a crankcase that comprises an upper crankcase and a lower crankcase, as described in JP 2008-151275 A, has considerable constraints on component layout within the crankcase, and it is difficult to form an oil passage extending in the transverse direction within the crankcase. For that reason, oil is supplied to the drive shaft and the like by using an oil pipe, which is a separate component from the crankcase. However, this may result in an extra cost due to the provision of the separate part. On the other hand, with a crankcase comprising a left crankcase and a right crankcase, as described in JP 2010-007847 A, an oil passage extending in the transverse direction can be formed by combining the left crankcase and the right crankcase. Nevertheless, this technique cannot be applied to multi-cylinder in-line internal combustion engine having two or more cylinders, so it is impossible to achieve high revolution and high power.

[0004] The present invention has been accomplished in view of the foregoing and other problems, and it is an object of the invention to provide a motorcycle that prevents an increase in the number of parts of its internal combustion engine and at the same time achieves high-speed revolution and high power.

[0005] According to the present invention said object is solved by a motorcycle having the features of independent claim 1. Preferred embodiments are laid down in the dependent claims.

[0006] Accordingly, it is provided a motorcycle comprising: a body frame; an internal combustion engine, the internal combustion engine comprising a crankshaft, a drive shaft to which torque of the crankshaft is transmitted, an upper crankcase disposed above the crankshaft and the drive shaft, a lower crankcase disposed below the crankshaft and the drive shaft and joined to the upper crankcase, and a cylinder body disposed above the upper crankcase and having a plurality of cylinders arranged transversely, wherein: at least one of the upper crankcase and the lower crankcase has a boss portion, having a hole for receiving a rod-shaped fastener extending transversely, and being secured to the body frame by the fastener; and the at least one of the upper crankcase and the lower crankcase has an oil passage for flowing oil supplied to the drive shaft, the oil passage integrally formed with the upper crankcase and/or the lower crankcase and extending in a transverse direction.

[0007] In the motorcycle according to the present teaching, the oil passage through which the oil to be supplied to the drive shaft flows is integrally formed with the upper crankcase or the lower crankcase, which is positioned below the cylinder body. Thus, the oil passage does not need to be formed as an independent member. Therefore, cost reduction and weight reduction are achieved because of the reduction of the parts count. Moreover, because the cylinder body has the plurality of cylinders arranged transversely, high revolution and high power can be achieved.

[0008] In another preferred embodiment, the upper crankcase having the oil passage or the lower crankcase having the oil passage includes a rib having the boss portion and protruding outward from an outer wall of the upper crankcase or from an outer wall of the lower crankcase.

[0009] Provision of the rib in this way can prevent twist of the boss portion.

[0010] In another preferred embodiment, the oil passage is disposed so that a portion of the oil passage and a portion of the rib overlap each other, as viewed from the rear of the motorcycle.

[0011] This can prevent the vertical size of the internal combustion engine from increasing.

[0012] In another preferred embodiment, the motorcycle further comprises a head pipe. The body frame has a left main frame extending rearward and obliquely downward from the head pipe, and a right main frame extending rearward and obliquely downward from the head pipe and being positioned to the right of the left main frame. At least one of the upper crankcase and the lower crankcase has a left boss portion disposed between the left main frame and the right main frame and secured to the left main frame by the fastener, and a right boss portion disposed between the left main frame and the right main frame and secured to the right main frame by the fastener. At least a portion of the oil passage is positioned between the left boss portion and the right boss portion, as viewed from the rear of the motorcycle.

[0013] This increases the strength of the rib on which the left boss portion is formed and the rib on which the right boss portion is formed.

[0014] In another preferred embodiment, the oil passage includes a first outer wall forming a portion of an outer surface of the upper crankcase or a portion of an outer surface of the lower crankcase.

[0015] Thus, the first outer wall of the oil passage and a portion of the outer surface of the upper crankcase or of the lower crankcase are formed of the same component. Therefore, the volumetric space within the upper crankcase or the lower crankcase is greater than in the case that these components are formed of different components. This offers more freedom in component layout.

[0016] In another preferred embodiment, the upper crankcase and the lower crankcase includes a crank

chamber accommodating the crankshaft, and a drive chamber accommodating the drive shaft, and the oil passage includes a second outer wall being positioned inward of the upper crankcase or the lower crankcase and forming a portion of the drive chamber.

[0017] Thus, the second outer wall of the oil passage and a portion of the drive chamber are formed of the same component. Therefore, the volumetric space within the upper crankcase or the lower crankcase is greater than in the case that these components are formed of different components. This offers more freedom in component layout.

[0018] In another preferred embodiment, the transverse length of the drive chamber is shorter than the transverse length of the crank chamber; and the second outer wall of the oil passage forms a portion of the drive chamber of the lower crankcase.

[0019] Thereby, the oil passage can be made more compact in size.

[0020] In another preferred embodiment, the drive chamber has a front wall, a left wall extending rearward from the front wall, a right wall extending rearward from the front wall, and a rear wall connecting the left wall and the right wall to each other; the rear wall has the rib extending rearward and in a vertical direction from the rear wall and including the boss portion; and the oil passage intersects the rib.

[0021] Since the rib including the boss portion intersects the oil passage, the strength of the rib is enhanced. As a result, the boss portion has high rigidity.

[0022] In another preferred embodiment, the oil passage is disposed so that, as viewed from one side of the motorcycle, the distance between the center of the boss portion and the center of the oil passage is shorter than the distance between the center of the boss portion and the center of the drive shaft.

[0023] Because the oil passage is disposed compactly within a limited space in the upper crankcase or the lower crankcase in this way, the internal combustion engine is prevented from increasing in size.

[0024] In another preferred embodiment, the oil passage is disposed so that, as viewed from one side of the motorcycle, the center of the oil passage is positioned more frontward than the center of the boss portion and more rearward than the center of the drive shaft.

[0025] Because the oil passage is disposed compactly within a limited space in the upper crankcase or the lower crankcase in this way, the internal combustion engine is prevented from increasing in size.

[0026] In another preferred embodiment, the motorcycle further comprises a first gear provided on the drive shaft, and the oil passage is disposed so as to overlap at least one of the drive shaft and the first gear, as viewed in plan of the motorcycle.

[0027] This prevents the internal combustion engine from increasing in size and also offers more freedom in layout of the components except for the oil passage. Moreover, because it is unnecessary to provide an oil passage formed by a separate component between the crankshaft and the drive shaft, the distance between the crankshaft and the drive shaft can be shortened.

[0028] In another preferred embodiment, a main shaft disposed more rearward than the crankshaft and more frontward than the drive shaft; and a second gear provided on the main shaft and meshing with the first gear, and wherein the oil passage does not overlap the first gear or the second gear, as viewed from one side of the motorcycle.

[0029] This allows the oil passage to be disposed desirably irrespective of the shapes of the first gear and the second gear, and therefore offers more freedom in layout of the oil passage.

[0030] In another preferred embodiment, the oil passage is disposed so that a portion of the oil passage and a portion of the boss portion overlap each other, as viewed in plan of the motorcycle.

[0031] This prevents the internal combustion engine from increasing in size.

[0032] In another preferred embodiment, the upper crankcase and the lower crankcase include a drive shaft supporting surface for supporting the drive shaft, the drive shaft supporting surface includes an oil groove through which oil flows, and the at least one of the upper crankcase and the lower crankcase includes a communication passage integrally formed with the upper crankcase and/or the lower crankcase and configured to allow communication between the oil passage and the oil groove.

[0033] Because the oil groove can be formed in the drive shaft supporting surface, the amount of oil supplied can be adjusted easily by providing a narrower portion for the oil groove.

[0034] In another preferred embodiment, the oil passage is integrally formed with the lower crankcase and is disposed so that, as viewed from one side of the motorcycle, the center of the oil passage is positioned higher than the center of the boss portion and lower than the center of the drive shaft.

[0035] Because the boss portion is positioned lower than the drive shaft and the oil passage, the stability of the lower crankcase on the body frame is improved.

ADVANTAGEOUS EFFECTS OF INVENTION

[0036] As described above, the present teaching makes it possible to provide a motorcycle that prevents an increase in the number of parts of its internal combustion engine and at the same time achieves high-speed revolution and high power.

BRIEF DESCRIPTION OF DRAWINGS

[0037]

Fig. 1 is a left side view illustrating a motorcycle according to one embodiment;

Fig. 2 is a left side view illustrating a left main frame and an internal combustion engine according to one embodiment;
Fig. 3 is a cross-sectional view taken along line III-III in Fig. 2;
Fig. 4 is a cross-sectional view taken along line IV-IV in Fig. 2;
Fig. 5 is a cross-sectional view illustrating an internal combustion engine according to one embodiment;
Fig. 6 is a left side view of a crankcase according to one embodiment;
Fig. 7 is a bottom view of an upper crankcase according to one embodiment;
Fig. 8 is a plan view of a lower crankcase according to one embodiment;
Fig. 9 is a cross-sectional view illustrating a portion of the internal combustion engine according to one embodiment;
Fig. 10 is a cross-sectional view illustrating a portion of the internal combustion engine according to one embodiment;
Fig. 11 is a bottom view of a cylinder head according to one embodiment;
Fig. 12 is a plan view of the cylinder head according to one embodiment;
Fig. 13 is a right side view illustrating a cam chain chamber of the internal combustion engine according to one embodiment;
Fig. 14 is a right side view of the crankcase according to one embodiment;
Fig. 15 is a perspective view of the crankcase according to one embodiment;
Fig. 16 is a cross-sectional view taken along line XVI-XVI in Fig. 14;
Fig. 17 is a cross-sectional view taken along line XVII-XVII in Fig. 6;
Fig. 18 is a schematic view illustrating a flow of oil in a region surrounding the cylinder head according to one embodiment;
Fig. 19 is a plan view illustrating a mounting surface of a cylinder body according to one embodiment;
Fig. 20 is a front view of the crankcase according to one embodiment;
Fig. 21 is a cross-sectional view taken along line XXI-XXI in Fig. 19;
Fig. 22 is a cross-sectional view taken along line XXII-XXII in Fig. 19;
Fig. 23 is a perspective view of the upper crankcase according to one embodiment;
Fig. 24 is a perspective view of the lower crankcase according to one embodiment;
Fig. 25 is a rear view of the crankcase according to one embodiment; and
Fig. 26 is a perspective view of the lower crankcase according to one embodiment.

DESCRIPTION OF EMBODIMENTS

[0038] Hereinbelow, preferred embodiments will be described. As illustrated in Fig. 1, a motorcycle 1 according to the present preferred embodiment is an on-road type motorcycle 1. It should be noted, however, that the motorcycle according to the present teaching is not limited to the on-road type motorcycle 1. The motorcycle according to the present teaching may be any other type of motorcycle, such as a moped type motorcycle, an off-road type motorcycle, or a scooter type motorcycle.

[0039] In the following description, the terms "front," "rear," "left," "right," "up," and "down" respectively refer to front, rear, left, right, up, and down as defined based on the perspective of the rider seated on the seat of the motorcycle 1, unless specifically indicated otherwise. The terms "above/up" and "below/down" respectively mean the relative vertical positions above/up and below/down as used when the motorcycle 1 is stationary on a horizontal plane. Reference characters F, Re, L, R, Up, and Dn in the drawings indicate front, rear, left, right, up, and down, respectively.

[0040] As illustrated in Fig. 1, the motorcycle 1 has a head pipe 5 and a body frame 20 secured to the head pipe 5. A steering shaft (not shown) is supported on the head pipe 5, and a handlebar 7 is provided on an upper portion of the steering shaft. A front fork 9 is provided on a lower portion of the steering shaft. A front wheel 10 is supported rotatably at the lower end of the front fork 9. A fuel tank 3 is disposed behind the head pipe 5, and a seat 15 is disposed at the rear of the fuel tank 3. The fuel tank 3 and the seat 15 are supported by the body frame 20.

[0041] The body frame 20 has a left main frame 22 extending rearward and obliquely downward from the head pipe 5, and a right main frame 32 (see Fig. 3) extending rearward and obliquely downward from the head pipe 5 and being positioned to the right of the left main frame 22. The body frame 20 has a left rear arm 24 disposed at the rear of the left main frame 22 and linked to the body frame 20 via a pivot shaft 30, and a right rear arm (not shown) disposed at the rear of the right main frame 32 and linked to the body frame 20 via the pivot shaft 30. A rear wheel 12 is rotatably supported at a rear end portion 24A of the left rear arm 24 and a rear end portion of the right rear arm.

[0042] The motorcycle 1 has an internal combustion engine 40. The internal combustion engine 40 is disposed under the left main frame 22 and the right main frame 32. The internal combustion engine 40 is supported non-swingably by the left main frame 22 and the right main frame 32. More specifically, as illustrated in Fig. 2, each of the left main frame 22 and the right main frame 32 has a first connecting portion 22A, a second connecting portion 22B positioned more rearward than the first connecting portion 22A, a third connecting portion 22C positioned more rearward than the second connecting portion 22B, and a fourth connecting portion 22D posi-

tioned lower than the third connecting portion 22C. At the first connecting portion 22A, each of the left main frame 22 and the right main frame 32 is linked to a connecting portion 80A (see Fig. 13) of a later-described cylinder head 80. At the second connecting portion 22B, each of the left main frame 22 and the right main frame 32 is linked to a connecting portion 80B (see Fig. 18) of the cylinder head 80. At the third connecting portion 22C, each of the left main frame 22 and the right main frame 32 is linked to a boss portion 120 (see Fig. 3) of an upper crankcase 50. At the fourth connecting portion 22D, the left main frame 22 and the right main frame 32 are linked to a left boss portion 130 (see Fig. 4) and a right boss portion 134 (see Fig. 4) of a later-described lower crankcase 60.

[0043] As illustrated in Fig. 5, the internal combustion engine 40 is a multi-cylinder engine. The internal combustion engine 40 has a crankshaft 42 extending in a transverse direction, a balancer shaft 38 positioned more frontward than the crankshaft 42, a main shaft 108 positioned more rearward than the crankshaft 42, a drive shaft 118 positioned more rearward than the main shaft 108, a clutch 100 to which torque of the crankshaft 42 is transmitted, a transmission 110, and a crankcase 48 (see Fig. 1) for accommodating these components. The crankcase 48 comprises the upper crankcase 50 and the lower crankcase 60. As illustrated in Fig. 6, the upper crankcase 50 is disposed above the crankshaft 42, the balancer shaft 38, and the drive shaft 118. The lower crankcase 60 is disposed below the crankshaft 42, the balancer shaft 38, and the drive shaft 118, and is joined to the upper crankcase 50. The axial center 42C of the crankshaft 42, the axial center 38C of the balancer shaft 38, and the axial center 118C of the drive shaft 118 are disposed on the same linear line W. The main shaft 108 is disposed higher than the balancer shaft 38, the crankshaft 42, and the drive shaft 118. An oil pan 18 (see Fig. 1) for recovering the oil having been circulated through the inside of the internal combustion engine 40 is disposed below the lower crankcase 60. The lower crankcase 60 and the oil pan 18 are joined to each other. As illustrated in Fig. 5, the crankshaft 42 extends in a transverse direction (in a vehicle width direction). A sprocket 42S is formed at a right end portion of the crankshaft 42. A crank gear 42G is fixed to a portion of the crankshaft 42 that is more leftward than the sprocket 42S.

[0044] A gear 38G is fixed to a right end portion of the balancer shaft 38. The gear 38G meshes with a crank gear 42G that is fixed to the crankshaft 42. Thus, the balancer shaft 38 is linked to the crankshaft 42. The balancer shaft 38 is driven by the crankshaft 42.

[0045] The clutch 100 has a clutch housing 102 and a clutch boss 104. The clutch housing 102 is linked to a gear 106. The gear 106 meshes with the crank gear 42G, which is fixed to the crankshaft 42. Thus, the clutch housing 102 of the clutch 100 is linked to the crankshaft 42. The main shaft 108 is fixed to the clutch boss 104. The main shaft 108 is provided with a plurality of gears 108G, and the drive shaft 118 is provided with a plurality of gears 118G. The transmission 110 has a shift drum 112 and a shift fork 114. The shift fork 114 moves at least either one of the gears 108G or the gears 118G so as to change a combination of the gears 108G and the gears 118G that mesh with each other. Thereby, the transmission gear ratio is changed. A sprocket 116 is fitted to a left end portion of the drive shaft 118. The sprocket 116 and the rear wheel 12 (see Fig. 1) are linked to each other by a chain 117. The torque of the crankshaft 42 is transmitted to the rear wheel 12 through the chain 117. The mechanism for transmitting mechanical power from the drive shaft 118 to the rear wheel 12 is not limited to the chain 117, but may be another type of mechanism, such as a transmission belt, a drive shaft, or a gear mechanism.

[0046] As illustrated in Figs. 7 and 8, the upper crankcase 50 and the lower crankcase 60 together form a crank chamber 45 accommodating the crankshaft 42, a clutch chamber 105 accommodating the clutch 100, a transmission chamber 115 accommodating the transmission 110, and a cam chain chamber 46 accommodating a later-described cam chain 47. The transmission chamber 115 accommodates the main shaft 108 and the drive shaft 118. The crank chamber 45 and the clutch chamber 105 are in communication with each other. The crank chamber 45 and the clutch chamber 105 are in communication with each other at the rear of a third cylinder 73. The clutch chamber 105 is positioned to the right of the transmission chamber 115. The left-to-right length H1 of the transmission chamber 115 is shorter than the left-to-right length H2 of the crank chamber 45. The term "left-to-right length" herein means the transverse length. The just-mentioned length H1 represents the length of the transversely longest portion of the transmission chamber 115, and the just-mentioned length H2 represents the length of the transversely longest portion of the crank chamber 45.

[0047] As illustrated in Fig. 1, the internal combustion engine 40 has a cylinder body 70, a cylinder head 80, and a cylinder head cover 95. The cylinder body 70 extends frontward and obliquely upward from the upper crankcase 50. The cylinder head 80 is disposed above the cylinder body 70 and joined to the cylinder body 70. The cylinder head cover 95 is disposed above the cylinder head 80 and joined to an end portion of the cylinder head 80. In the present preferred embodiment, the cylinder body 70 and the upper crankcase 50 are integrally formed with each other. However, the cylinder body 70 and the upper crankcase 50 may be formed of separate parts. It is possible that a gasket may be disposed between the cylinder head 80 and the cylinder body 70.

[0048] As illustrated in Fig. 9, a first cylinder 71, a second cylinder 72, and a third cylinder 73 are formed inside the cylinder body 70. The internal combustion engine 40 is a three-cylinder engine. The first cylinder 71, the second cylinder 72, and the third cylinder 73 are disposed from left to right in that order. The first cylinder 71, the

second cylinder 72, and the third cylinder 73 accommodate pistons 43. Each of the pistons 43 is connected to the crankshaft 42 via a connecting rod 44. The internal combustion engine 40 of the present preferred embodiment is a three-cylinder engine having three cylinders 71 to 73. However, it may be a single-cylinder engine having one cylinder, or may be a multi-cylinder engine that has two cylinders, or four or more cylinders. It is preferable that the internal combustion engine 40 be a multi-cylinder engine having two or more cylinders.

[0049] The internal combustion engine 40 has three combustion chambers 82 that are lined up in a vehicle width direction. The combustion chamber 82 is formed by the top face of the piston 43, the inner circumferential wall of each of the cylinders 71 to 73, and a recessed portion 81 formed in the cylinder head 80. The combustion chamber 82 is provided with an ignition device 17 (see Fig. 10) for igniting the fuel in the combustion chambers 82. As illustrated in Fig. 10, a plurality of intake ports 83 and a plurality of exhaust ports 85, which are in communication with the combustion chambers 82, are formed in the cylinder head 80. The internal combustion engine 40 has an intake valve 84 for opening/closing the passage between the combustion chamber 82 and the intake port 82, and an exhaust valve 86 for opening/closing the passage between the combustion chamber 82 and the exhaust port 85. The intake port 83 constitutes part of an intake passage 28. The intake passage 28 is connected to an air cleaner, which is not shown in the drawings. The exhaust port 85 constitutes part of an exhaust passage 29. The exhaust passage 29 includes an exhaust pipe 13 (see Fig. 1), which is fitted to the cylinder head 80, and a silencer 14 (see Fig. 1). As illustrated in Fig. 11, in the present preferred embodiment, each one of the combustion chambers 82 is provided with two intake ports 83 and two exhaust ports 85. The intake valve 84 is disposed for each of the intake ports 83, and the exhaust valve 86 is disposed for each of the exhaust ports 85. It is possible, however, that each one of the combustion chambers 82 may be provided with one intake port 82 and one exhaust port 85. It is also possible that each one of the combustion chambers 82 may be provided with different numbers of intake ports 82 and exhaust ports 85 from each other.

[0050] As illustrated in Fig. 10, an intake camshaft 84A and an exhaust camshaft 86A extending in a transverse direction are disposed between the cylinder head 80 and the cylinder head cover 95. The intake camshaft 84A has intake cams 84B (see Fig. 12) each of which comes into contact with an upper end 84t of the intake valve 84 to operate the intake valve 84. The exhaust camshaft 85A has exhaust cams 86B (see Fig. 12) each of which comes into contact with an upper end 86t of the exhaust valve 86 to operate the exhaust valve 86. As illustrated in Fig. 12, a cam chain sprocket 84S is fitted to a right end portion of the intake camshaft 84A. A cam chain sprocket 86S is fitted to a right end portion of the exhaust camshaft 86A. As illustrated in Fig. 13, the cam chain 47 is looped over the cam chain sprockets 84S and 86S and the sprocket 42S. The cam chain 47 interlocks with the crankshaft 42.

[0051] The internal combustion engine 40 has the cam chain chamber 46 for accommodating the cam chain 47. The cam chain chamber 46 of the present preferred embodiment is formed over the entirety of the cylinder head cover 95, the cylinder head 80, the cylinder body 70, the upper crankcase 50, and the lower crankcase 60. As illustrated in Fig. 8, the cam chain chamber 46 is positioned to the right of the crank chamber 45. The clutch chamber 105 is positioned behind the cam chain chamber 46.

[0052] As illustrated in Fig. 14, the upper crankcase 50 has a first upper partition wall 51 and a second upper partition wall 52. As illustrated in Fig. 7, the first upper partition wall 51 separates the cam chain chamber 46 and the crank chamber 45 from each other. The first upper partition wall 52 has a bottom face 52A and separates the cam chain chamber 46 and the crank chamber 105 from each other. A first passage 53, formed of a groove extending in a front-to-rear direction, is formed in the bottom face 52A of the second upper partition wall 52. The first passage 53 allows communication between the cam chain chamber 46 and the clutch chamber 105. As illustrated in Fig. 14, a second passage 54 allowing communication between the cam chain chamber 46 and the crank chamber 45 is formed in the first upper partition wall 51 of the upper crankcase 50. The second passage 54 is positioned below the cylinder body 70. The second passage 54 is positioned more frontward than the axial center 42C of the crankshaft 42. The second passage 54 is positioned more rearward than the axial center 38C of the balancer shaft 38.

[0053] The lower crankcase 60 has a first lower partition wall 61 and a second lower partition wall 62. As illustrated in Fig. 8, the first lower partition wall 61 separates the cam chain chamber 46 and the crank chamber 45 from each other. The first lower partition wall 61 is in contact with the first upper partition wall 51. The second lower partition wall 62 separates the cam chain chamber 46 and the clutch chamber 105 from each other. The second lower partition wall 62 has a top face 62A that is in contact with the bottom face 52A of the second upper partition wall 52. A first passage 63, formed of a groove extending in a front-to-rear direction, is formed in the top face 62A of the second lower partition wall 62. The first passage 63 allows communication between the cam chain chamber 46 and the clutch chamber 105. As illustrated in Fig. 14, an oil passage 64 that allows communication between the cam chain chamber 46 and the crank chamber 45 is formed in the first lower partition wall 61. The oil in the cam chain chamber 46 passes through the oil passage 64 and flows into the crank chamber 45, and the oil is recovered in the oil pan 18 positioned below the crank chamber 45. The bottom face 52A of the second upper partition wall 52 and the top face 62A of the second lower partition wall 62 may be indirectly in contact with each other, by interposing a gasket or the

like between the bottom face 52A and the top face 62A.

[0054] As illustrated in Fig. 15, the first passages 53 and 63 allow communication between the cam chain chamber 46 and the clutch chamber 105. As illustrated in Fig. 16, the vertical length of the first passage 53 is longer than the vertical length of the first passage 63. The left-to-right length of the first passage 53 is substantially the same as the left-to-right length of the first passage 63. The vertical lengths of the first passages 53 and 63 may be equal to each other, or the vertical length of the first passage 63 may be longer than that of the first passage 53. The left-to-right lengths of the first passages 53 and 63 may be different from each other. The first passages 53 and 63 may be disposed so as to be staggered from each other in a transverse direction. In the present preferred embodiment, the first passages 53 and 63 are formed respectively in the bottom face 52A of the second upper partition wall 52 and the top face 62A of the second lower partition wall 62. However, it is sufficient that the first passage be formed in at least one of the bottom face 52A and the top face 62A. The first passage may be such as to penetrate through at least one of the second upper partition wall 52 and the second lower partition wall 62 so as to allow communication between the cam chain chamber 46 and the clutch chamber 105.

[0055] As illustrated in Fig. 7, the upper crankcase 50 has a first bolt insertion hole 55A and a second bolt insertion hole 55B at the respective opposite sides of the first passage 53. The first bolt insertion hole 55A is positioned more leftward than the second bolt insertion hole 55B. The diameter of the first bolt insertion hole 55A is greater than the diameter of the second bolt insertion hole 55B. As illustrated in Fig. 8, the lower crankcase 60 has a first bolt insertion hole 65A and a second bolt insertion hole 65B at the respective opposite sides of the first passage 63. The first bolt insertion hole 65A is positioned more leftward than the second bolt insertion hole 65B. The diameter of the first bolt insertion hole 65A is greater than the diameter of the second bolt insertion hole 65B. As illustrated in Fig. 16, the upper crankcase 50 and the lower crankcase 60 are secured to each other by bolts 56A and 56B.

[0056] As illustrated in Fig. 5, the sprocket 42S, which is fitted to the right end portion of the crankshaft 42, is accommodated in the cam chain chamber 46. The crank gear 42G of the crankshaft 42 is accommodated in the crank chamber 45. When the crankshaft 42 is rotating, the crank gear 42G and the oil passage 64 may overlap, as viewed from side. A gap P1 between the crank gear 42G and the first lower partition wall 61 is smaller than a gap P2 between the sprocket 42S and the first lower partition wall 61. More specifically, the gaps P1 and P2 are the gap between the first lower partition wall 61 and the crank gear 42G that is at the axial center 42C of the crankshaft 42 and the gap between the first lower partition wall 61 and the sprocket 42S that is at the axial center 42C of the crankshaft 42, respectively.

[0057] As illustrated in Fig. 9, the internal combustion engine 40 has an alternator 67. The alternator 67 is fitted to a left end portion of the crankshaft 42. As illustrated in Fig. 6, the upper crankcase 50 and the lower crankcase 60 together form an alternator chamber 68 for accommodating the alternator 67. As illustrated in Fig. 5, the alternator chamber 68 is positioned to the left of the crank chamber 45. A plastic gear 66 for driving a water pump 16 is disposed in the alternator chamber 68. A gear 38H is fixed to a left end portion of the balancer shaft 38. The gear 38H meshes with the plastic gear 66. Therefore, the water pump 16 interlocks with the balancer shaft 38. As illustrated in Fig. 6, the upper crankcase 50 has a third upper partition wall 69A. As illustrated in Fig. 7, the third upper partition wall 69A separates the alternator chamber 68 and the crank chamber 45 from each other. The lower crankcase 60 has a third lower partition wall 69B. As illustrated in Fig. 8, the third lower partition wall 69B separates the alternator chamber 68 and the crank chamber 45 from each other. As illustrated in Fig. 6, the third upper partition wall 69A has an outlet 77E of a later-described first communication port 77. The outlet 77E is disposed above the plastic gear 66. The outlet 77E is disposed more frontward than the center 66C of the plastic gear 66. An oil passage 69P that allows communication between the alternator chamber 68 and the crank chamber 45 is formed in the third lower partition wall 69B. The oil that has flowed from the cylinder body 70 through the first communication port 77 and the outlet 77E into the alternator chamber 68 is supplied to the plastic gear 66. Thereafter, the oil flows through the oil passage 69P into the crank chamber 45 and is recovered into the oil pan 18, which is positioned below the crank chamber 45. As illustrated in Fig. 17, a rib 69R extending from the third lower partition wall 69B is formed below the crankshaft 42. As a result, without being affected by the rotation of the crankshaft 42, the oil in the alternator chamber 68 flows in the direction indicated by the arrow X in Fig. 17 in a desirable manner, and is recovered in the oil pan 18.

[0058] As illustrated in Fig. 18, the internal combustion engine 40 has the cylinder body 70, the cylinder head 80 positioned above the cylinder body 70, and a first cylindrical dowel pin 87 and a second cylindrical dowel pin 88 for positioning the cylinder body 70 and the cylinder head 80. The first dowel pin 87 may be a tapered pin. The second dowel pin 88 may be a tapered pin.

[0059] As illustrated in Fig. 19, the cylinder body 70 has a mounting surface 76 to be fitted to the cylinder head 80. The cylinder body 70 has the first cylinder 71, the second cylinder 72, and the third cylinder 73, which are lined up in a transverse direction. The cam chain chamber 46 is disposed to the right of the third cylinder 73, which is the rightmost one of the cylinders. The cylinder body 70 has a coolant passage 74 that surrounds the cylinders 71 to 73 and through which coolant flows. The cylinder body 70 has a plurality of bolt insertion holes 75 formed around the coolant passage 74. The cylinder body 70 has a first communication port 77 and a second communication port 78. The cylinders 71 to 73, the cool-

ant passage 74, the bolt insertion holes 75, the first communication port 77, and the second communication port 78 are open in the mounting surface 76.

[0060] In the mounting surface 76 of the cylinder body 70, a linear line passing through the axial center 71C of the first cylinder 71, the axial center 72C of the second cylinder 72, and the axial center 73C of the third cylinder 73 is defined as a first linear line L1, and a linear line passing through the axial center 72C of the second cylinder 72 and being orthogonal to the first linear line L1 is defined as a second linear line L2. Note that the second linear line L2 should pass the midpoint between the axial center 71C of the first cylinder 71, which is the leftmost one of the cylinders, and the axial center 73C of the third cylinder 73, which is the rightmost one of the cylinders. In the present preferred embodiment, the just-mentioned midpoint is in agreement with the axial center 72C of the second cylinder 72. A region that is in front of the first linear line L1 and to the left of the second linear line L2 is defined as a front left region. A region that is behind the first linear line L1 and to the left of the second linear line L2 is defined as a rear left region. A region that is in front of the first linear line L1 and to the right of the second linear line L2 is defined as a front right region. A region that is behind the first linear line L1 and to the right of the second linear line L2 is defined as a rear right region. Then, the first communication port 77 is disposed in the front left region, and the second communication port 78 is disposed in the rear right region.

[0061] The first communication port 77 and the second communication port 78 are formed at positions further away from the first linear line L1 than the bolt insertion holes 75, in terms of the front-to-rear positional relationship in the cylinder body 70. The first communication port 77 is positioned more frontward than the bolt insertion holes 75. It is preferable that the first communication port 77 be disposed more leftward than the axial center 71 C of the first cylinder 71, which is the leftmost one of the cylinders. It is preferable that the first communication port 77 be disposed in front of the first cylinder 71, which is the leftmost one of the cylinders. The second communication port 78 is positioned more rearward than the bolt insertion holes 75. It is preferable that the second communication port 78 be disposed more rightward than the axial center 73C of the third cylinder 73, which is the rightmost one of the cylinders. It is preferable that the second communication port 78 be disposed behind the third cylinder 73, which is the rightmost one of the cylinders. In the mounting surface 76 of the cylinder body 70, the diameter A1 of the first communication port 77 (the inner diameter A1 of a later-described first main communication port 77A) and the diameter B1 of the second communication port 78 (the inner diameter B1 of a later-described second main communication port 78A) are greater than the diameter C1 of the bolt insertion holes 75. In the mounting surface 76 of the cylinder body 70, the diameter A1 of the first communication port 77 and the diameter B1 of the second communication port 78 are greater than the groove width of the coolant passage 74. The just-mentioned groove width is, for example, the groove width D1 of a portion of the coolant passage 74 that overlaps the first linear line L1 and/or the second linear line L2. As illustrated in Fig. 20, the upper end 77T of the first communication port 77 is disposed lower than the upper end 78T of the second communication port 78. In the present preferred embodiment, the first communication port 77 is disposed more leftward than the axial center 71C of the first cylinder 71. However, because it is sufficient that the first communication port 77 be disposed in the above-described front left region, the first communication port 77 may be disposed, for example, between the axial center 71C of the first cylinder 71 and the axial center 72C of the second cylinder 72. Likewise, in the present preferred embodiment, the second communication port 78 is disposed more rightward than the axial center 73C of the third cylinder 73. However, because it is sufficient that the second communication port 78 be disposed in the above-described rear right region, the second communication port 78 may be disposed, for example, between the axial center 73C of the third cylinder 73 and the axial center 72C of the second cylinder 72. In the case of a multi-cylinder engine having four or more cylinders, it is preferable that at least either one of the first communication port or the second communication port be disposed between cylinders.

[0062] As illustrated in Fig. 21, the first communication port 77 has a first main communication port 77A and a first sub-communication port 77B, which has the inner diameter A2 greater than the inner diameter A1 of the first main communication port 77A. The first dowel pin 87 is fitted into the first sub-communication port 77B. The outer diameter A3 of the first dowel pin 87 is greater than the inner diameter A1 of the first main communication port 77A. The outer diameter A3 of the first dowel pin 87 is less than or equal to the inner diameter A2 of the first sub-communication port 77B. It is preferable that the axial center 77C of the first communication port 77 and the axial center 87C of the first dowel pin 87 be in agreement with each other. It is preferable that the inner diameter A4 of the first dowel pin 87 be equal to the inner diameter A1 of the first main communication port 77A.

[0063] As illustrated in Fig. 22, the second communication port 78 has a second main communication port 78A and a second sub-communication port 78B, which has the inner diameter B2 greater than the inner diameter B1 of the second main communication port 78A. The second dowel pin 88 is fitted into the second sub-communication port 78B. The outer diameter B3 of the second dowel pin 88 is greater than the inner diameter B1 of the second main communication port 78A. The outer diameter B3 of the second dowel pin 88 is less than or equal to the inner diameter B2 of the second sub-communication port 78B. It is preferable that the axial center 78C of the second communication port 78 and the axial center 88C of the second dowel pin 88 be in agreement with each other. It is preferable that the inner diameter B4 of

the second dowel pin 88 be equal to the inner diameter B1 of the second main communication port 78A.

[0064] As illustrated in Fig. 19, an oil supply port 79 is formed in the cylinder body 70. The oil in the oil pan 18 is supplied through the oil supply port 79 to the cylinder head 80. The oil supply port 79 is positioned more rearward than the first communication port 77 and more frontward than the second communication port 78. The oil supply port 79 is positioned more rearward than the first linear line L1. The oil supply port 79 is positioned more rightward than the second communication port 78.

[0065] As illustrated in Fig. 11, the cylinder head 80 has a mounting surface 92 to be fitted to the cylinder body 70, a first passage 93, and a second passage 94. The first passage 93 and the second passage 94 are open in the mounting surface 92. The first passage 93 is in communication with the first communication port 77 of the cylinder body 70. The second passage 94 is in communication with the second communication port 78 of the cylinder body 70. At least either oil or air flows through the first passage 93 and the second passage 94. In the present preferred embodiment, mainly oil flows through the first passage 93, and mainly air flows through the second passage 94.

[0066] The cylinder head 80 has a plurality of coolant passages 90 that are in communication with the coolant passage 74 of the cylinder body 70. The cylinder head 80 has a plurality of bolt insertion holes 91 formed around the coolant passages 90. The coolant passages 90 and the bolt insertion holes 91 are open in the mounting surface 92. The cylinder head 80 is secured to the cylinder body 70 by bolts (not shown) inserted into the plurality of bolt insertion holes 91. The cam chain chamber 46 is disposed to the right of the second passage 94. An oil supply port 89 is formed in the cylinder head 80. The oil supply port 89 is in communication with the oil supply port 79 of the cylinder body 70. The oil supply port 89 is positioned more rearward than the first passage 93 and more frontward than the second passage 94. The oil supply port 89 is positioned more rearward than the intake port 83. The oil supply port 89 is positioned to the right of the second communication port 94.

[0067] As illustrated in Fig. 18, the first dowel pin 87 is fitted into the first communication port 77 and the first passage 93. The first communication port 77 and the first passage 93 are in communication with each other through the first dowel pin 87. The second dowel pin 88 is fitted into the second communication port 78 and the second passage 94. The second communication port 78 and the second passage 94 are in communication with each other through the second dowel pin 88. The first dowel pin 87 disposed lower than the second dowel pin 88. The dowel pins for positioning the cylinder body 70 and the cylinder head 80 are the first dowel pin 87 and the second dowel pin 88 only.

[0068] The upper end of the second communication port 78 is open in the mounting surface 76 of the cylinder body 70, and the lower end of the second communication port 78 is open in the crank chamber 45. The second communication port 78 allows communication between the crank chamber 45 and the interior of the cylinder head 80. The air in the crank chamber 45 passes through the second communication port 78, the second dowel pin 88, and the second passage 94 and flows into the cylinder head 80, as indicated by the arrow Y in Fig. 18.

[0069] The oil reserved in the oil pan 18 (see Fig. 1) is supplied to the crankshaft 42, as indicated by the arrow Z1 in Fig. 18, by an oil pump, which is not shown in the drawings. A portion of the oil supplied to the crankshaft 42 is supplied to the balancer shaft 38, as indicated by the arrow Z2 in Fig. 18. Another portion of the oil supplied to the crankshaft 42 is supplied to the upper crankcase 50, the oil supply port 79 of the cylinder body 70, and the oil supply port 89 of the cylinder head 80, as indicated by the arrow Z3 in Fig. 18. As indicated by the arrows Z4 and Z5 in Fig. 18, the oil supplied to the oil supply port 89 is then supplied to the intake camshaft 84A and the exhaust camshaft 86A through a cam cap (not shown) and an oil passage 95P. A portion of the oil supplied to the intake camshaft 84A and the exhaust camshaft 86A circulates in the cylinder body 70, and flows into the first passage 93, as indicated by the arrow Z6 in Fig. 18. The oil having flowed into the first passage 93 flows through the first dowel pin 87 and the first communication port 77 and then flows into the alternator chamber 68 (see Fig. 6), as indicated by the arrow Z7 in Fig. 18, and the oil is recovered in the oil pan 18. Another portion of the oil supplied to the intake camshaft 84A and the exhaust camshaft 86A flows into the cam chain chamber 46 (see Fig. 13). The oil in the cam chain chamber 46 passes through the oil passage 64 and flows into the crank chamber 45, and the oil is recovered in the oil pan 18 positioned below the crank chamber 45.

[0070] In the present preferred embodiment, the upper crankcase 50 and the cylinder body 70 are integrally formed with each other. However, if the upper crankcase and the cylinder body 70 are separate parts, the internal combustion engine 40 may have two cylindrical dowel pins between the upper crankcase 50 and the cylinder body 70, for positioning the upper crankcase 50 and the cylinder body 70. One of the dowel pins is fitted into the first communication port 77, and other one of the dowel pins is fitted into the second communication port 78.

[0071] As illustrated in Fig. 23, the upper crankcase 50 has a boss portion 120 extending transversely. The boss portion 120 has a hole 122 extending in a transverse direction. As illustrated in Fig. 3, the boss portion 120 is disposed between the left main frame 22 and the right main frame 32. A rod-shaped fastener 140 extending in a transverse direction is inserted through a first left insertion hole 23A formed in the left main frame 22, a first right insertion hole 33A formed in the right main frame 32, and the hole 122 of the boss portion 120. By the fastener 140, the boss portion 120 of the upper crankcase 50 is secured to the left main frame 22 and the right main frame 32. As illustrated in Fig. 14, the boss 120 is dis-

posed more rearward than the clutch chamber 105.

[0072] As illustrated in Fig. 24, the lower crankcase 60 has a left boss portion 130 extending transversely direction and a right boss portion 134 extending transversely. The left boss portion 130 has a hole 132 extending in a transverse direction. The right boss portion 134 has a hole 136 extending in a transverse direction. As illustrated in Fig. 4, the left boss portion 130 is disposed between the left main frame 22 and the right main frame 32. The right boss portion 134 is disposed between the left main frame 22 and the right main frame 32 and to the right of the left boss portion 130. A rod-shaped fastener 150 extending transversely is inserted through a second left insertion hole 23B formed in the left main frame 22, a second right insertion hole 33B formed in the right main frame 32, and the hole 132 of the left boss portion 130, and the hole 136 of the right boss portion 134. By the fastener 150, the left boss portion 130 of the lower crankcase 60 is secured to the left main frame 22, and the right boss portion 134 is secured to the right main frame 32. In the present preferred embodiment, the upper crankcase 50 has the boss portion 120, and the lower crankcase 60 has the left boss portion 130 and the right boss portion 134. However, it is sufficient that at least one of the upper crankcase 50 and the lower crankcase 60 should have a boss portion. Moreover, the upper crankcase 50 may have the right and left boss portions, as with the lower crankcase 60, and the lower crankcase 60 may have only one boss portion, as with the upper crankcase 50.

[0073] As illustrated in Fig. 25, the lower crankcase 60 has an oil passage 160 extending in a transverse direction. The oil passage 160 is integrally formed with the lower crankcase 60. The oil to be supplied to the drive shaft 118 flows through the oil passage 160. In the present preferred embodiment, the left end 160L of the oil passage 160 is positioned more leftward than the left boss portion 130. The right end 160R of the oil passage 160 is positioned more rightward than the right boss portion 134. That said, it is sufficient that at least a portion of the oil passage 160 should be positioned between the left boss portion 130 and the right boss portion 134, as viewed from the rear of the motorcycle. For example, it is possible that the left end 160L of the oil passage 160 may be positioned more rightward than the left boss portion 130 and the right end 160R of the oil passage 160 may be positioned more leftward than the right boss portion 134. Alternatively, the left end 160L of the oil passage 160 may be linked to the left boss portion 130, and the right end 160R of the oil passage 160 may be linked to the right boss portion 134. As illustrated in Fig. 6, the oil passage 160 is disposed lower than the drive shaft 118 and higher than the left boss portion 130. As viewed from one side of the motorcycle, the oil passage 160 is disposed so that the center 160C of the oil passage 160 is positioned higher than the center 130C of the left boss portion 130 and lower than the center (axial center) 118C of the drive shaft 118. The oil passage 160 is disposed so that, as viewed from one side of the motorcycle, the distance T1 between the center 130C of the left boss portion 130 and the center 160C of the oil passage 160 is shorter than the distance T2 between the center 130C of the left boss portion 130 and the center 118C of the drive shaft 118. As viewed from one side of the motorcycle, the oil passage 160 does not overlap the gears 108G of the main shaft 108 and the gears 118G of the drive shaft 118. In the present preferred embodiment, the oil passage 160 is disposed so that, as viewed from one side of the motorcycle, the center 160C of the oil passage 160 is positioned more frontward than the center 130C of the left boss portion 130 and more rearward than the center 118C of the drive shaft 118. That said, the oil passage 160 may be disposed so that, as viewed from one side of the motorcycle, the center 160C of the oil passage 160 and the center 130C of the left boss portion 130 overlap each other. Alternatively, the oil passage 160 may be disposed so that, as viewed from one side of the motorcycle, the center 160C of the oil passage 160 overlaps the hole 132 of the left boss portion 130.

[0074] As illustrated in Fig. 8, the oil passage 160 is disposed so as to overlap the drive shaft 118, as viewed in plan of the motorcycle. The oil passage 160 is disposed so that, as viewed in plan of the motorcycle, a portion of the oil passage 160 overlaps a portion of the left boss portion 130 and a portion of the right boss portion 134. As illustrated in Fig. 25, the oil passage 160 is disposed so that, as viewed from the rear of the motorcycle, a portion of the oil passage 160 overlaps a portion of a first rib 133 and a portion of a second rib 137. In the present preferred embodiment, the oil passage 160 disposed higher than the left boss portion 130 and the right boss portion 134, as illustrated in Fig.25, and as viewed from the rear of the motorcycle, the oil passage 160 does not overlap the left boss portion 130 and the right boss portion 134. However, it is possible that the oil passage 160 may overlap the left boss portion 130 and the right boss portion 134, as viewed from the rear of the motorcycle.

[0075] As illustrated in Fig. 8, the transmission chamber 115 has a front wall 115A, a left wall 115B, a right wall 115C, and a rear wall 115D. The left wall 115B extends rearward from the front wall 115A. The right wall 115C is positioned to the right of the left wall 115B and extends rearward from the front wall 115A. The rear wall 115D connects a rear end portion of the left wall 115B and a rear end portion of the right wall 115C. As illustrated in Fig. 24, the first rib 133 provided with the left boss portion 130 and the second rib 137 provided with the right boss portion 134 are formed on the rear wall 115D. The first ribs 133 and the second ribs 137 extend rearward and in a vertical direction, from the rear wall 115D. The oil passage 160 intersects the first ribs 133 and the second ribs 137. As illustrated in Fig. 6, the front end portion 133A of each of the first ribs 133 is disposed more frontward than the oil passage 160.

[0076] As illustrated in Fig. 24, the oil passage 160 has a first outer wall 162, which constitutes a portion of the outer surface of the lower crankcase 60. In the present

preferred embodiment, the first outer wall 162 constitutes a portion of the outer surface of the rear wall 115D of the transmission chamber 115. As illustrated in Fig. 8, the oil passage 160 has a second outer wall 164, which is positioned inward of the lower crankcase 60 and which constitutes a portion of the outer surface of the lower crankcase 60. In the present preferred embodiment, the second outer wall 164 constitutes a portion of the rear wall 115D of the transmission chamber 115.

[0077] As illustrated in Fig. 26, the lower crankcase 60 has drive shaft supporting surfaces 170 and 174 for supporting the drive shaft 118 (see Fig. 5). An oil groove 172 through which oil flows is formed in the drive shaft supporting surface 170. An oil groove 176 through which oil flows is formed in the drive shaft supporting surface 174. As illustrated in Fig. 25, the lower crankcase 60 has a first communication passage 173 that allows communication between the oil passage 160 and the oil groove 172, and a second communication passage 177 that allows communication between the oil passage 160 and the oil groove 176. As illustrated in Fig. 7, the upper crankcase 50 has drive shaft supporting surfaces 180 and 184 for supporting the drive shaft 118 (see Fig. 5). An oil groove 182 through which oil flows is formed in the drive shaft supporting surface 180.

[0078] As illustrated in Fig. 5, oil is supplied to the first communication passage 173 through the oil groove 172 (see Fig. 26), which is formed in the drive shaft supporting surface 170, by an oil pump, which is not shown in the drawings. The oil having been supplied to the first communication passage 173 flows through the oil passage 160, the second communication passage 177, and the oil groove 176 (see Fig. 26), as indicated by the arrow K in Fig. 5. A portion of the oil having been supplied to the oil groove 176 flows through the inside of the drive shaft 118, and is supplied to each of the gears 118G on the drive shaft 118.

[0079] In the present preferred embodiment, the oil passage 160 through which the oil to be supplied to the drive shaft 118 is formed only in the lower crankcase 60. However, the oil passage 160 may be formed only in the upper crankcase 50, and it may be formed in both of the upper crankcase 50 and the lower crankcase 60.

[0080] As described above, in the motorcycle 1 according to the present preferred embodiment, the oil passage 160 through which the oil to be supplied to the drive shaft 118 flows is integrally formed with the lower crankcase 60, which is positioned below the cylinder body 70. Thus, the oil passage 160 does not need to be formed as an independent member, so it is possible to achieve cost reduction and weight reduction because of the reduction of the parts count. Moreover, because the cylinder body 70 has the plurality of cylinders 71 to 73 arranged transversely, high revolution and high power can be achieved.

[0081] In the present preferred embodiment, as illustrated in Fig. 24, the lower crankcase 60, which is provided with the oil passage 160, has the first rib 133 formed with the left boss portion 130 and the second rib 137 formed with the right boss portion 134 is formed, both the first rib 133 and the second rib 137 protruding outward from the outer wall 115D of the lower crankcase 60. Provision of the first rib 133 and the second rib 137 in this way prevents twist of the left boss portion 130 and the right boss portion 134.

[0082] In the present embodiment, as illustrated in Fig. 25, the oil passage 160 is disposed so that a portion of the oil passage 160 overlaps a portion of a first rib 133 and a portion of a second rib 137, as viewed from the rear of the motorcycle. This can prevent the vertical size of the internal combustion engine 40 from increasing.

[0083] In the present preferred embodiment, as illustrated in Figs. 4 and 25, the lower crankcase 60 has the left boss portion 130, which is disposed between the left main frame 22 and the right main frame 32 and secured to the left main frame 22 by the fastener 150, and the right boss portion 134, which is disposed between the left main frame 22 and the right main frame 32 and secured to the right main frame 32 by the fastener 150. In addition, at least a portion of the oil passage 160 is positioned between the left boss portion 130 and the right boss portion 134, as viewed from the rear of the motorcycle. This increases the strength of the first rib 133, on which the left boss portion 130 is formed, and the second rib 137, on which the right boss portion 134 is formed.

[0084] In the present embodiment, as illustrated in Fig. 26, the oil passage 160 has the first outer wall 162, which forms a portion of the outer surface of the lower crankcase 60. Thus, the first outer wall 162 of the oil passage 160 and a portion of the outer surface of the lower crankcase 60 are formed of the same component. Therefore, the volumetric space within the lower crankcase 60 is greater than in the case that these components are formed of different components. This offers more freedom in component layout.

[0085] In the present preferred embodiment, as illustrated in Figs. 7 and 8, the upper crankcase 50 and the lower crankcase 60 together form the crank chamber 45 accommodating the crankshaft 42, and the transmission chamber 115 accommodating the drive shaft 118. The oil passage 160 has the second outer wall 164, which is positioned inward of the lower crankcase 60 and forms a portion of the transmission chamber 115. Thus, the second outer wall 164 of the oil passage 160 and a portion of the transmission chamber 115 are formed of the same component. Therefore, the volumetric space within the lower crankcase 60 is greater than in the case that these components are formed of different components. This offers more freedom in component layout.

[0086] In the present preferred embodiment, as illustrated in Fig. 8, the transverse length H1 of the transmission chamber 115 is shorter than the transverse length H2 of the crank chamber 45, and the second outer wall 164 of the oil passage 160 forms a portion of the transmission chamber 115 of the lower crankcase 60. Thereby, the oil passage 160 can be made compact in size.

[0087] In the present preferred embodiment, as illus-

trated in Fig. 26, the transmission chamber 115 has the front wall 115A, the left wall 115B extending rearward from the front wall 115A, the right wall 115C extending rearward from the front wall 115A, and the rear wall 115D connecting the left wall 115B and the right wall 115C to each other. The rear wall 115D has the first rib 133 and the second rib 137, extending rearward and in a vertical direction from the rear wall 115D and respectively having the left boss portion 130 and the right boss portion 134. The oil passage 160 intersects the first ribs 133 and the second ribs 137. Because the first rib 133 having the left boss portion 130 and the second rib 137 having the right boss portion 134 intersect the oil passage 160, the strength of the first rib 133 and the second rib 137 is enhanced. As a result, the left boss portion 130 and the right boss portion 134 have high rigidity.

[0088] In the present preferred embodiment, as illustrated in Fig. 6, the oil passage 160 is disposed so that, as viewed from one side of the motorcycle, the distance T1 between the center 130C of the left boss portion 130 and the center 160C of the oil passage 160 is shorter than the distance T2 between the center 130C of the left boss portion 130 and the center 118C of the drive shaft 118. Because the oil passage 160 is disposed compactly within a limited space in the lower crankcase 60 in this way, the internal combustion engine 40 is prevented from increasing in size.

[0089] In the present preferred embodiment, as illustrated in Fig. 6, the oil passage 160 is disposed so that, as viewed from one side of the motorcycle, the center 160C of the oil passage 160 is positioned more frontward than the center 130C of the left boss portion 130 and more rearward than the center 118C of the drive shaft 118. Because the oil passage 160 is disposed compactly within a limited space in the lower crankcase 60 in this way, the internal combustion engine 40 is prevented from increasing in size.

[0090] In the present preferred embodiment, the internal combustion engine 40 further includes the first gear 118G provided on the drive shaft 118, and the oil passage 160 is disposed so as to overlap at least one of the drive shaft 118 and the first gear 118G, as viewed in plan of the motorcycle. This prevents the internal combustion engine 40 from increasing in size and also offers more freedom in layout of the components except for the oil passage 160.

[0091] In the present preferred embodiment, as illustrated in Fig. 6, the motorcycle further includes the main shaft 108 disposed more rearward than the crankshaft 42 and more frontward than the drive shaft 118, and the gear 108G provided on the main shaft 108 and meshing with the gear 118G. The oil passage 160 does not overlap the gear 108G or the gear 118G, as viewed from one side of the motorcycle. This allows the oil passage 160 to be disposed desirably irrespective of the shapes of the gear 108G and the gear 118G, and therefore offers more freedom in layout of the oil passage 160.

[0092] In the present preferred embodiment, as illustrated in Fig. 8, the oil passage 160 is disposed so that, as viewed in plan of the motorcycle, a portion of the oil passage 160 overlaps a portion of the left boss portion 130 and a portion of the right boss portion 134. This prevents the internal combustion engine 40 from increasing in size.

[0093] In the present preferred embodiment, as illustrated in Figs. 7 and 8, the upper crankcase 50 has the drive shaft supporting surfaces 180 and 184 for supporting the drive shaft 118. The oil groove 182 through which oil flows is formed in the drive shaft supporting surface 180. The lower crankcase 60 has the drive shaft supporting surfaces 170 and 174 for supporting the drive shaft 118. The oil groove 172 through which oil flows is formed in the drive shaft supporting surfaces 170 and 174. The lower crankcase has the first communication passage 173 that allows communication between the oil passage 160 and the oil groove 172, and the second communication passage 177 that allows communication between the oil passage 160 and the oil groove 176. Because the oil grooves 172 and 176 can be formed in the drive shaft supporting surfaces 170 and 174 respectively, the amount of oil supplied can be adjusted easily by providing an orifice for the oil grooves 172 and 176.

[0094] In the present preferred embodiment, as illustrated in Fig. 6, the oil passage 160 is integrally formed with the lower crankcase 60, and the oil passage 160 is disposed so that, as viewed from one side of the motorcycle, the center 160C of the oil passage 160 is positioned higher than the center 130C of the left boss portion 130 and lower than the center 118C of the drive shaft 118. Because the left boss portion 130 is positioned lower than the drive shaft 118 and the oil passage 160, the stability of the lower crankcase 60 on the left main frame 22 and the right main frame 32 is improved.

REFERENCE SIGNS LIST

[0095]

40 -- Internal combustion engine
42 -- Crankshaft
45 -- Crank chamber
50 -- Upper crankcase
60 -- Lower crankcase
70 -- Cylinder body
108 -- Main shaft
115 -- Transmission chamber
115 -- Rear wall of transmission chamber
118 -- Drive shaft
130 -- Left boss portion
133 -- First rib
134 -- Right boss portion
137 -- Second rib
150 -- Fastener
160 -- Oil passage
172 -- Oil groove
173 -- First communication passage

177 -- Second communication passage

Claims

1. A motorcycle comprising:

a body frame (20); and
an internal combustion engine (40), the internal combustion engine (40) comprising a crankshaft (42), a drive shaft (118) to which torque of the crankshaft (42) is transmitted, an upper crankcase (50) disposed above the crankshaft (42) and the drive shaft (118), a lower crankcase (60) disposed below the crankshaft (42) and the drive shaft (118) and joined to the upper crankcase (50), and a cylinder body (70) disposed above the upper crankcase (50) and including a plurality of cylinders (71,72,73) arranged transversely, wherein:

at least one of the upper crankcase (50) and the lower crankcase (60) includes a boss portion (120,130,134), having a hole (122,132,136) for receiving a rod-shaped fastener (150) extending transversely, and being secured to the body frame (20) by the fastener (150); and
the at least one of the upper crankcase (50) and the lower crankcase (60) includes an oil passage (160) through which oil to be supplied to the drive shaft (118) flows, the oil passage (160) integrally formed with the upper crankcase (50) and/or the lower crankcase (60) and extending in a transverse direction.

2. A motorcycle according to claim 1, wherein the upper crankcase (50) having the oil passage or the lower crankcase (60) having the oil passage (160) includes a rib (133,137) having the boss portion (130,134) and protruding outward from an outer wall of the upper crankcase (50) or from an outer wall (115D) of the lower crankcase (60).

3. A motorcycle according to claim 2, wherein the oil passage (160) is disposed so that a portion of the oil passage (160) and a portion of the rib (133,137) overlap each other, as viewed from the rear of the motorcycle.

4. A motorcycle according to claim 2 or 3, further comprising:

a head pipe (5); and wherein:

the body frame (20) includes a left main frame (22) extending rearward and obliquely downward from the head pipe (5), and a right main frame (32) extending rearward and
obliquely downward from the head pipe (5) and being positioned to the right of the left main frame (22);
at least one of the upper crankcase (50) and the lower crankcase (60) includes a left boss portion (130) disposed between the left main frame (22) and the right main frame (32) and secured to the left main frame (22) by the fastener (150), and a right boss portion (134) disposed between the left main frame (22) and the right main frame (32) and secured to the right main frame (32) by the fastener (150); and
at least a portion of the oil passage (160) is positioned between the left boss portion (130) and the right boss portion (134), as viewed from the rear of the motorcycle.

5. A motorcycle according to any one of claims 2 to 4, wherein the oil passage (160) includes a first outer wall (162) forming a portion of an outer surface of the upper crankcase (50) or a portion of an outer surface of the lower crankcase (60).

6. A motorcycle according to any one of claims 2 to 5, wherein:

the upper crankcase (50) and the lower crankcase (60) includes a crank chamber (45) accommodating the crankshaft (42), and a drive chamber (115) accommodating the drive shaft (118); and
the oil passage (160) includes a second outer wall (164) being positioned inward of the upper crankcase (50) or the lower crankcase (60) and forming a portion of the drive chamber (115).

7. A motorcycle according to claim 6, wherein:

the transverse length of the drive chamber (115) is shorter than the transverse length of the crank chamber (45); and
the second outer wall (164) of the oil passage (160) forms a portion of the drive chamber (115) of the lower crankcase (60).

8. A motorcycle according to claim 6 or 7, wherein:

the drive chamber (115) has a front wall (115A), a left wall (115B) extending rearward from the front wall (115A), a right wall (115C) extending rearward from the front wall (115A), and a rear wall (115D) connecting the left wall (115B) and the right wall (115C) to each other;
the rear wall (115D) has the rib (133,137) ex-

tending rearward and in a vertical direction from the rear wall (115D) and including the boss portion (130,134); and
the oil passage (160) intersects the rib (133,137).

9. A motorcycle according to any one of claims 1 to 8, wherein the oil passage (160) is disposed so that, as viewed from one side of the motorcycle, the distance between the center (130C) of the boss portion (130) and the center (160C) of the oil passage (160) is shorter than the distance between the center (130C) of the boss portion (130) and the center (118C) of the drive shaft (118).

10. A motorcycle according to any one of claims 1 to 9, wherein the oil passage (160) is disposed so that, as viewed from one side of the motorcycle, the center (160C) of the oil passage (160) is positioned more frontward than the center (130C) of the boss portion (130) and more rearward than the center (118C) of the drive shaft (118).

11. A motorcycle according to any one of claims 1 to 10, further comprising:

a first gear (118G) provided on the drive shaft (118), and wherein
the oil passage (160) is disposed so as to overlap at least one of the drive shaft (118) and
the first gear (118G), as viewed in plan of the motorcycle.

12. A motorcycle according to claim 11, further comprising:

a main shaft (108) disposed more rearward than the crankshaft (42) and more frontward than the drive shaft (118); and a second gear (108G) provided on the main shaft (108) and
meshing with the first gear (118G), and wherein the oil passage (160) does not overlap the first gear (118G) or the second gear (108G), as viewed from one side of the motorcycle.

13. A motorcycle according to any one of claims 1 to 12, wherein the oil passage (160) is disposed so that a portion of the oil passage (160) and a portion of the boss portion (130,134) overlap each other, as viewed in plan of the motorcycle.

14. A motorcycle according to any one of claims 1 to 13, wherein:

the upper crankcase (50) and the lower crankcase (60) include a drive shaft supporting surface (170,174,180,184) for supporting the drive shaft (118);
the drive shaft supporting surface (170,174,180,184) includes an oil groove (172,176,182) through which oil flows; and
the at least one of the upper crankcase (50) and the lower crankcase (60) includes a communication passage (173,177) integrally formed with the upper crankcase (50) and/or
the lower crankcase (60) and configured to allow communication between the oil passage (160) and the oil groove (172,176,182).

15. A motorcycle according to any one of claims 1 to 14, wherein the oil passage (160) is integrally formed with the lower crankcase (60) and is disposed so that, as viewed from one side of the motorcycle, the center (160C) of the oil passage (160) is positioned higher than the center (130C) of the boss portion (130) and lower than the center (118C) of the drive shaft (118).

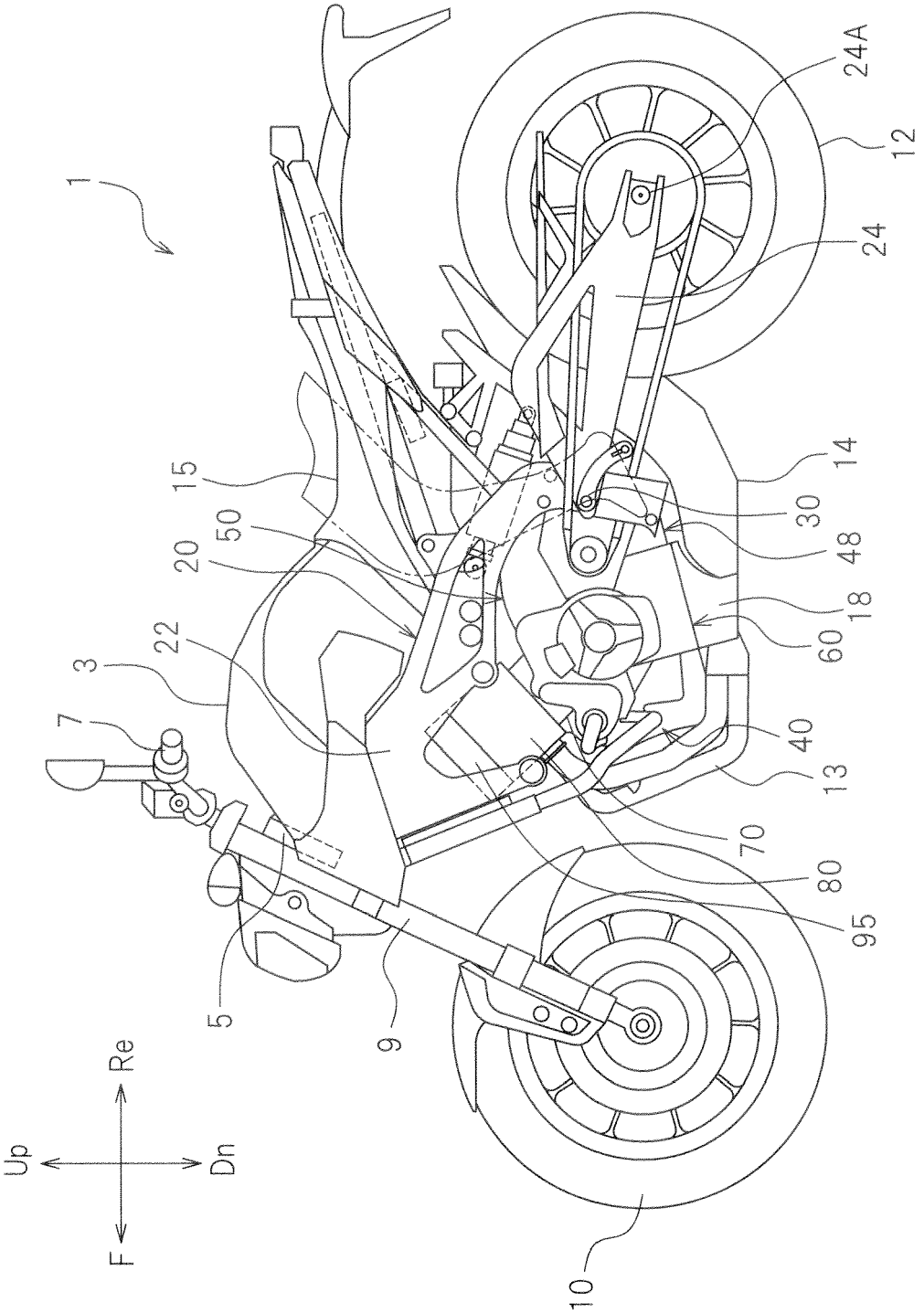


FIG.1

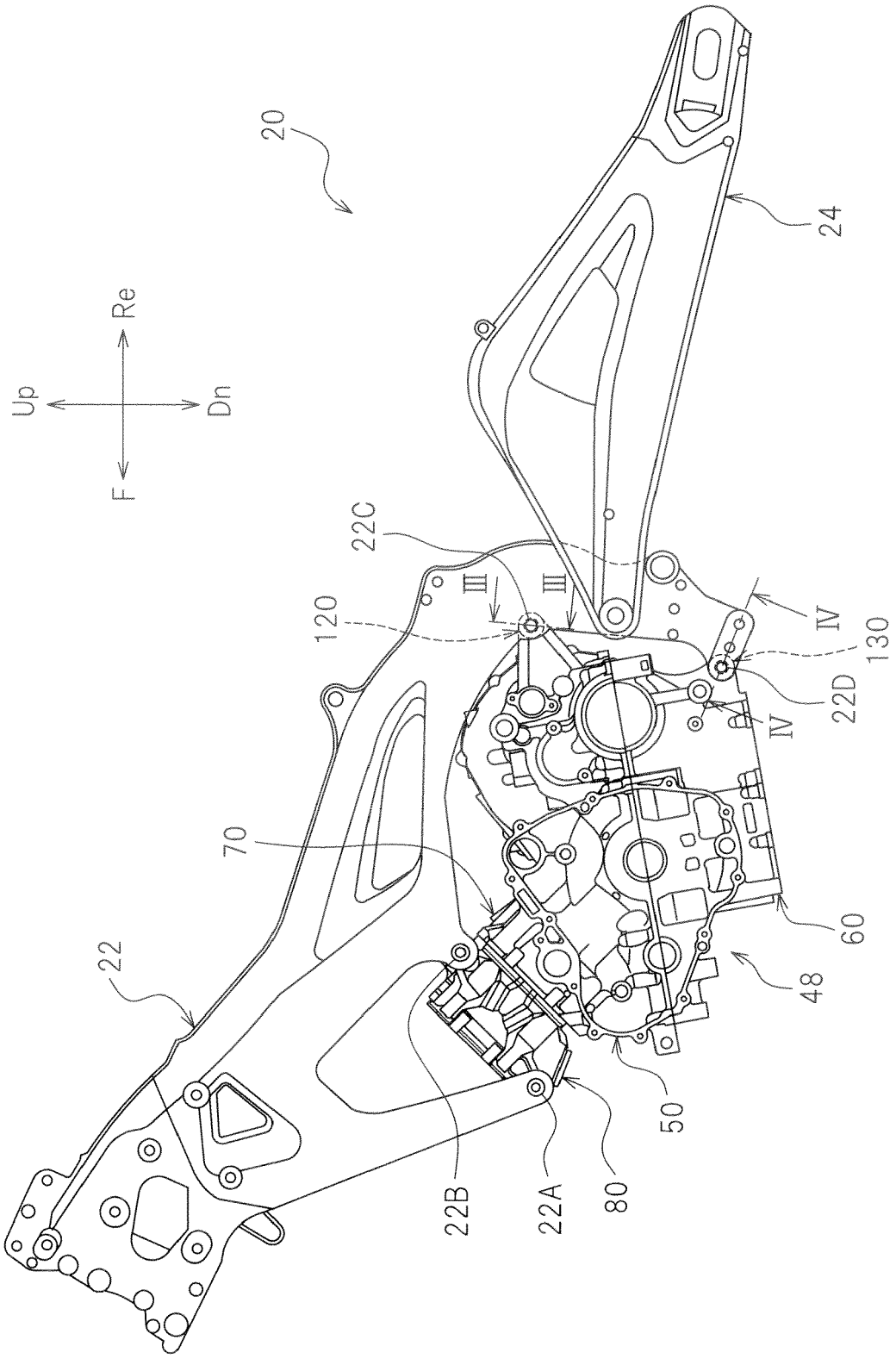

20
24
Re
Up
Dn
F
22C
III
III
120
IV
130
22D
IV
70
60
22
48
50
22B
22A
80

FIG.2

FIG.3

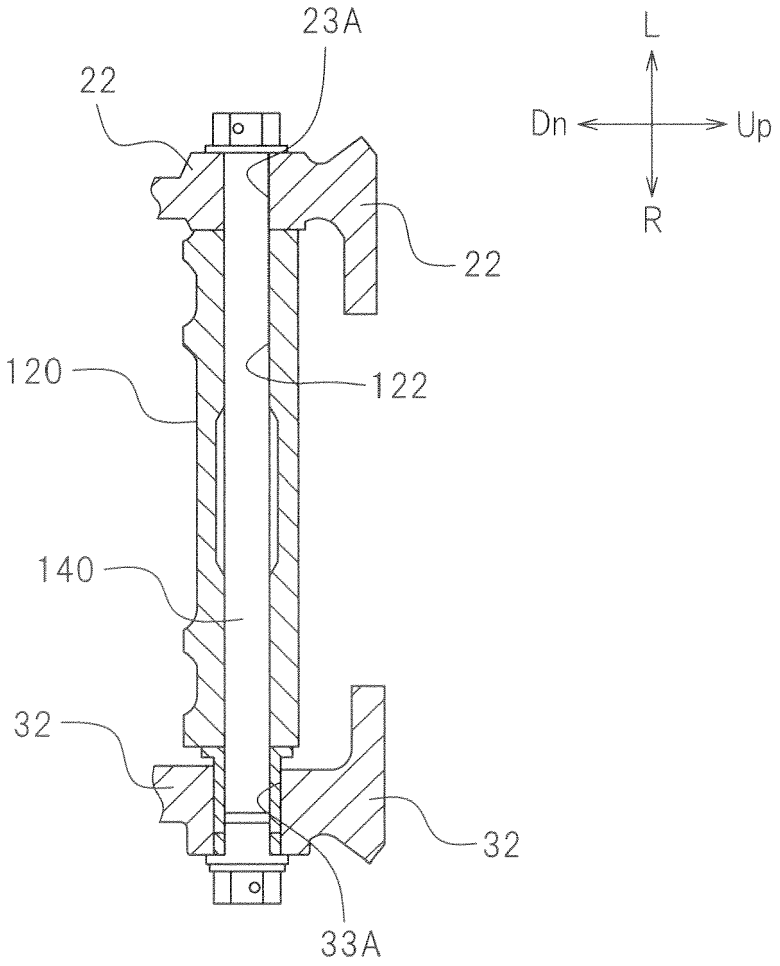


FIG.4

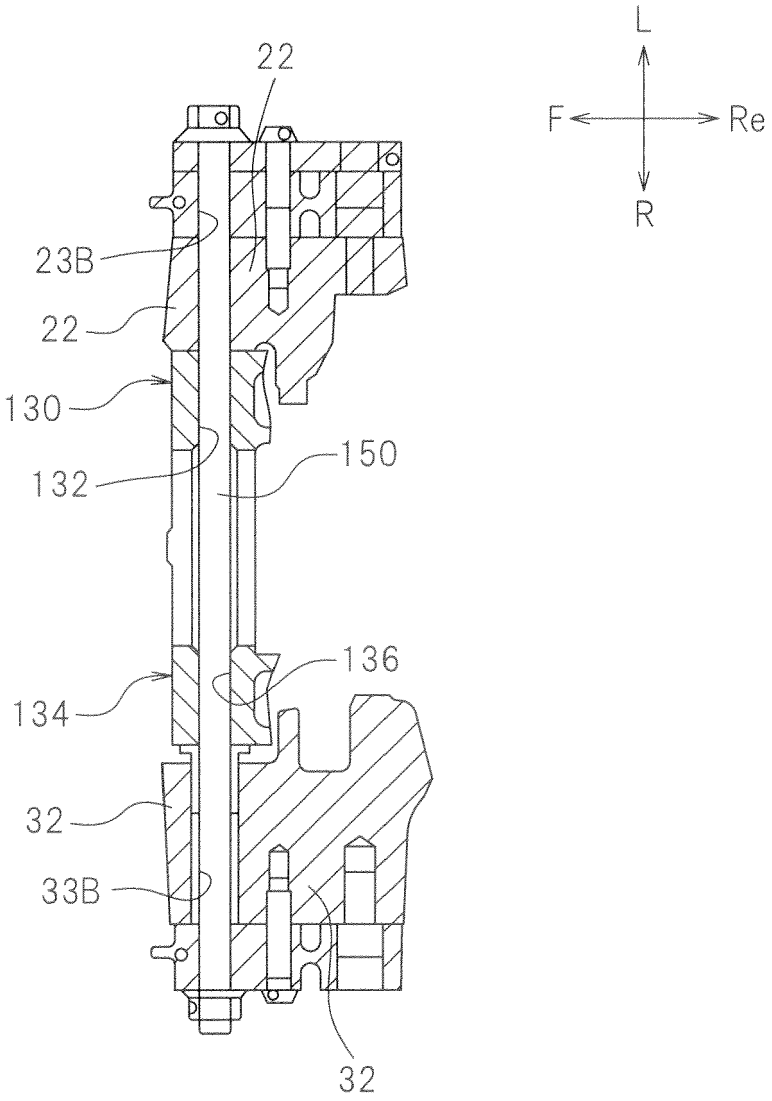
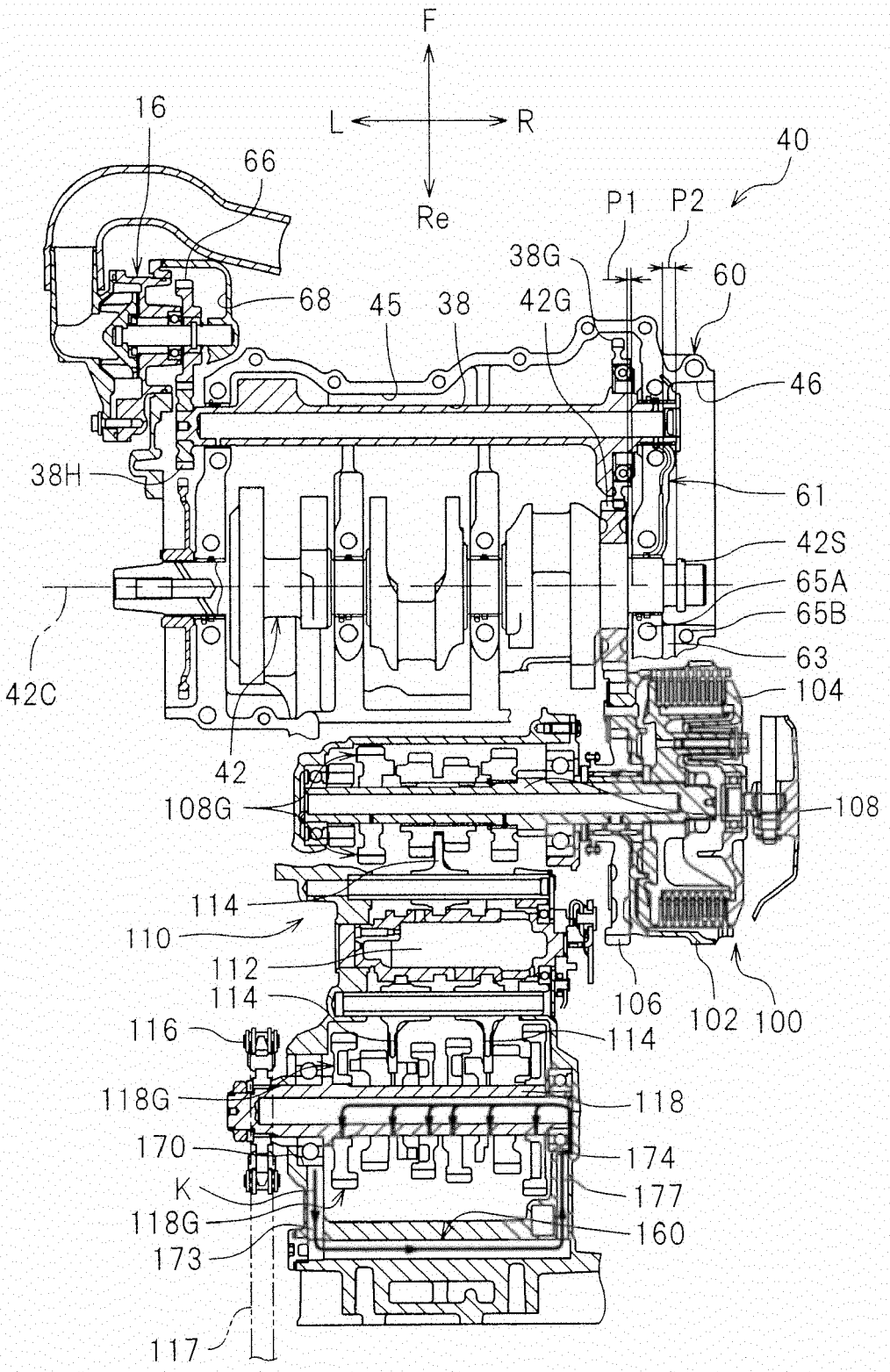


FIG.5


F
L
R
Re
16
66
40
P1
P2
38G
60
68
45
38
42G
46
38H
61
42S
65A
65B
63
104
42C
42
108G
108
114
110
112
114
106
102
100
116
114
118G
118
170
174
K
177
118G
160
173
117

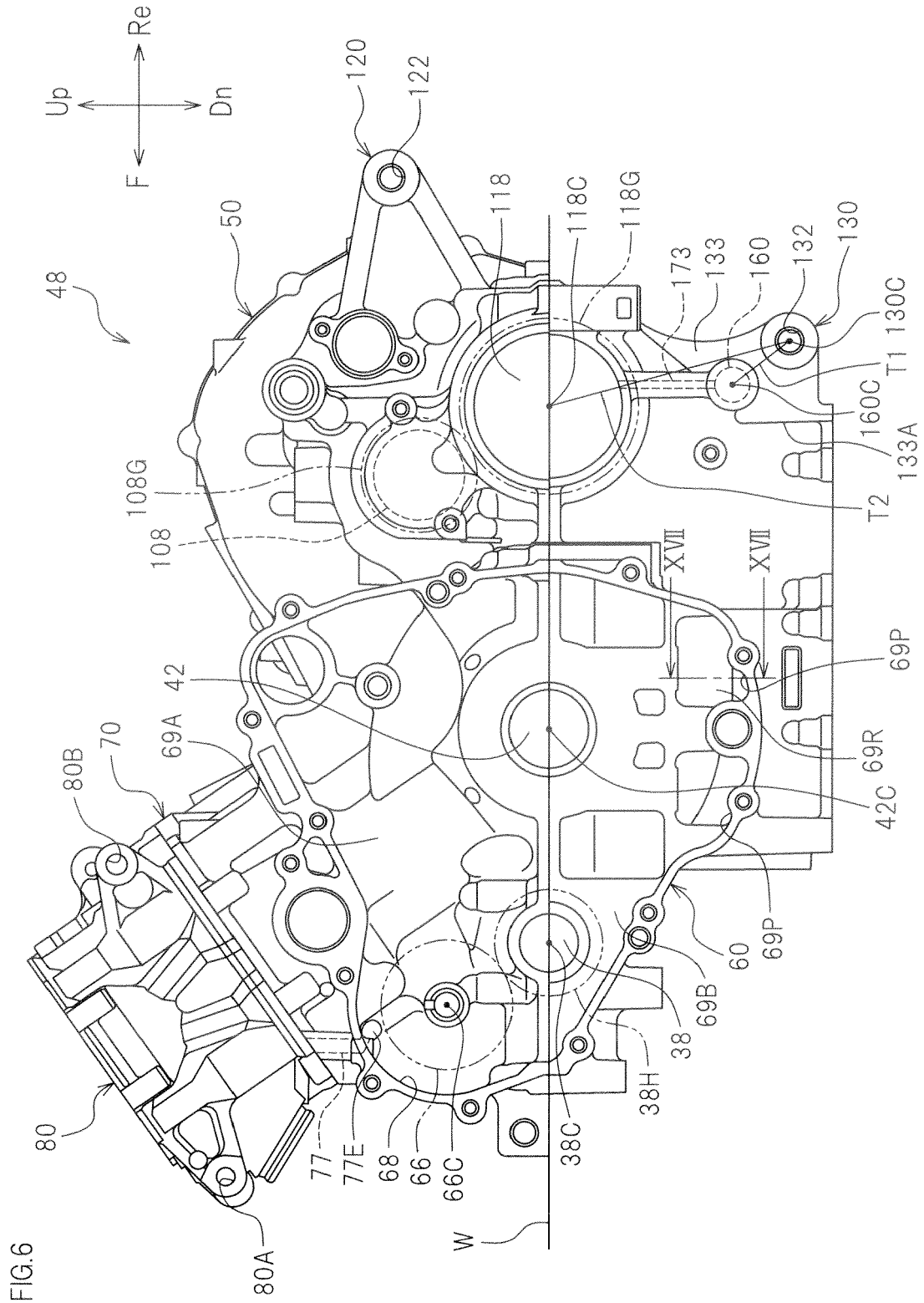

Up
Re
Dn
F
120
122
118
118C
118G
173
133
160
132
130
130C
T1
160C
133A
T2
50
48
108G
108
XVII
XVII
69P
42
69A
70
80B
69R
42C
69P
60
69B
38
38H
38C
80
77
77E
68
66
66C
W
80A

FIG.6

FIG.7

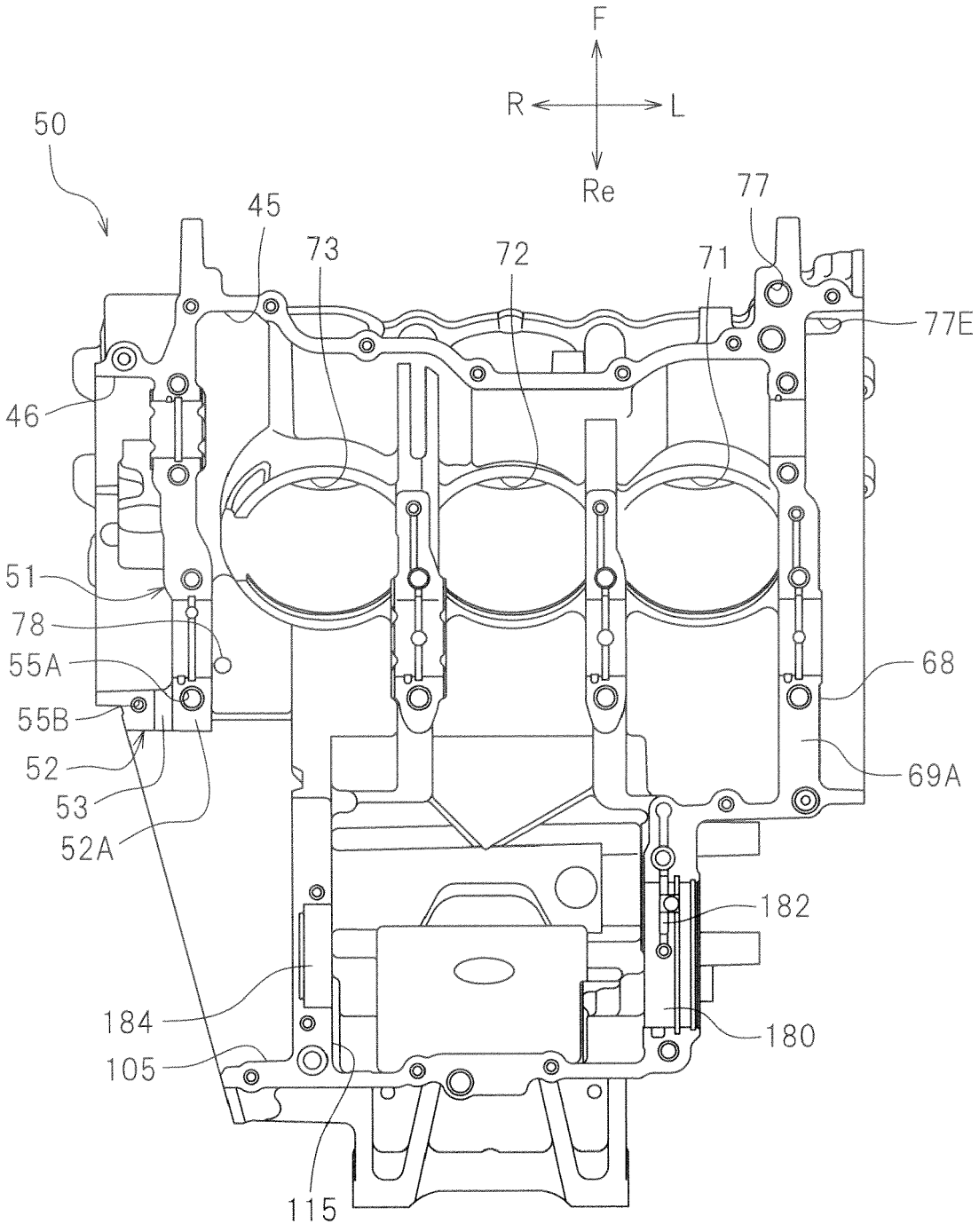

F
R
L
Re
50
45
73
72
71
77
77E
46
51
78
55A
55B
52
53
52A
68
69A
182
184
105
180
115

FIG.8

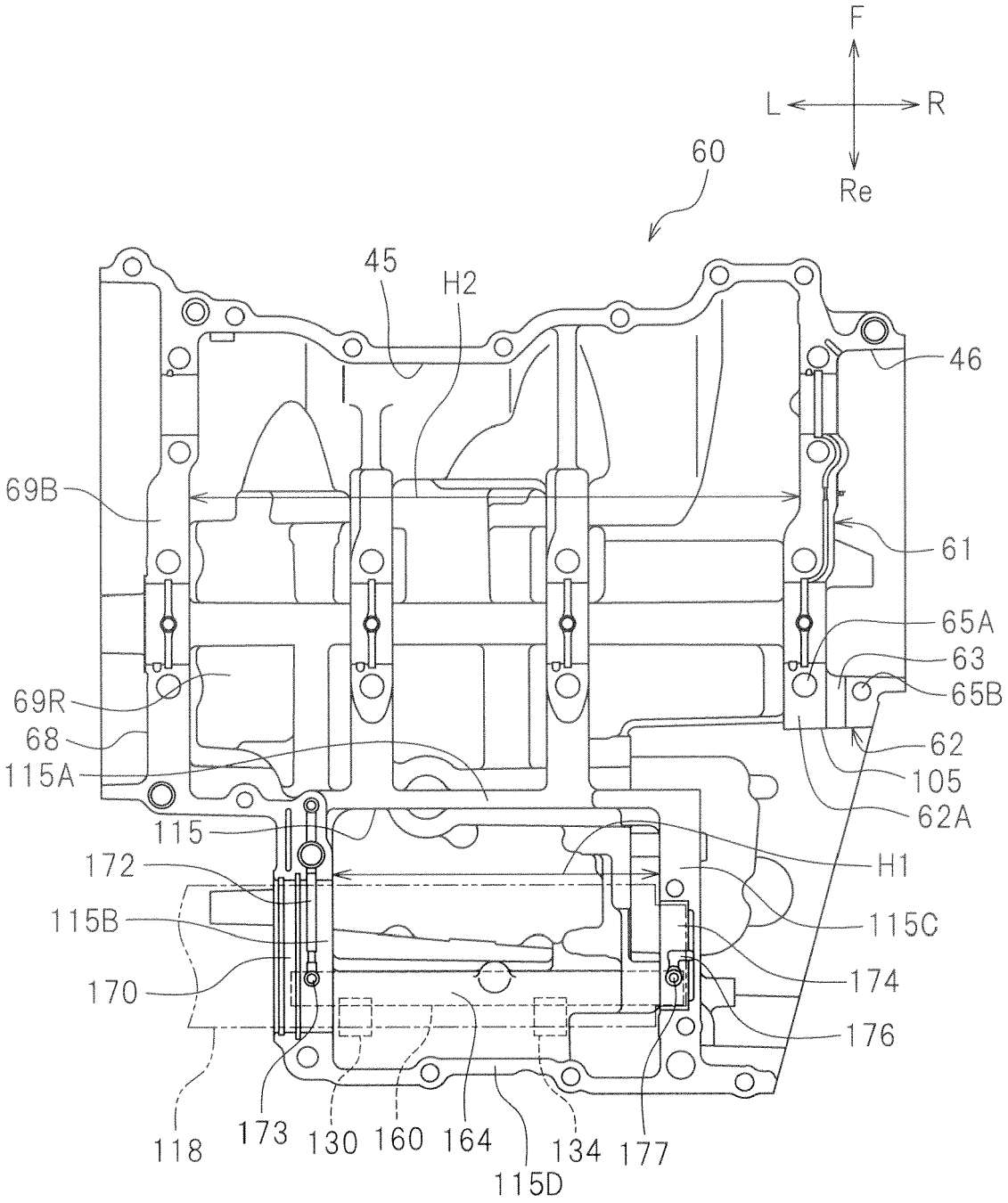

F
L
R
Re
60
45
H2
46
69B
61
65A
63
65B
69R
68
115A
62
105
62A
115
172
H1
115B
115C
170
174
176
118
173
130
160
164
134
177
115D

FIG.9

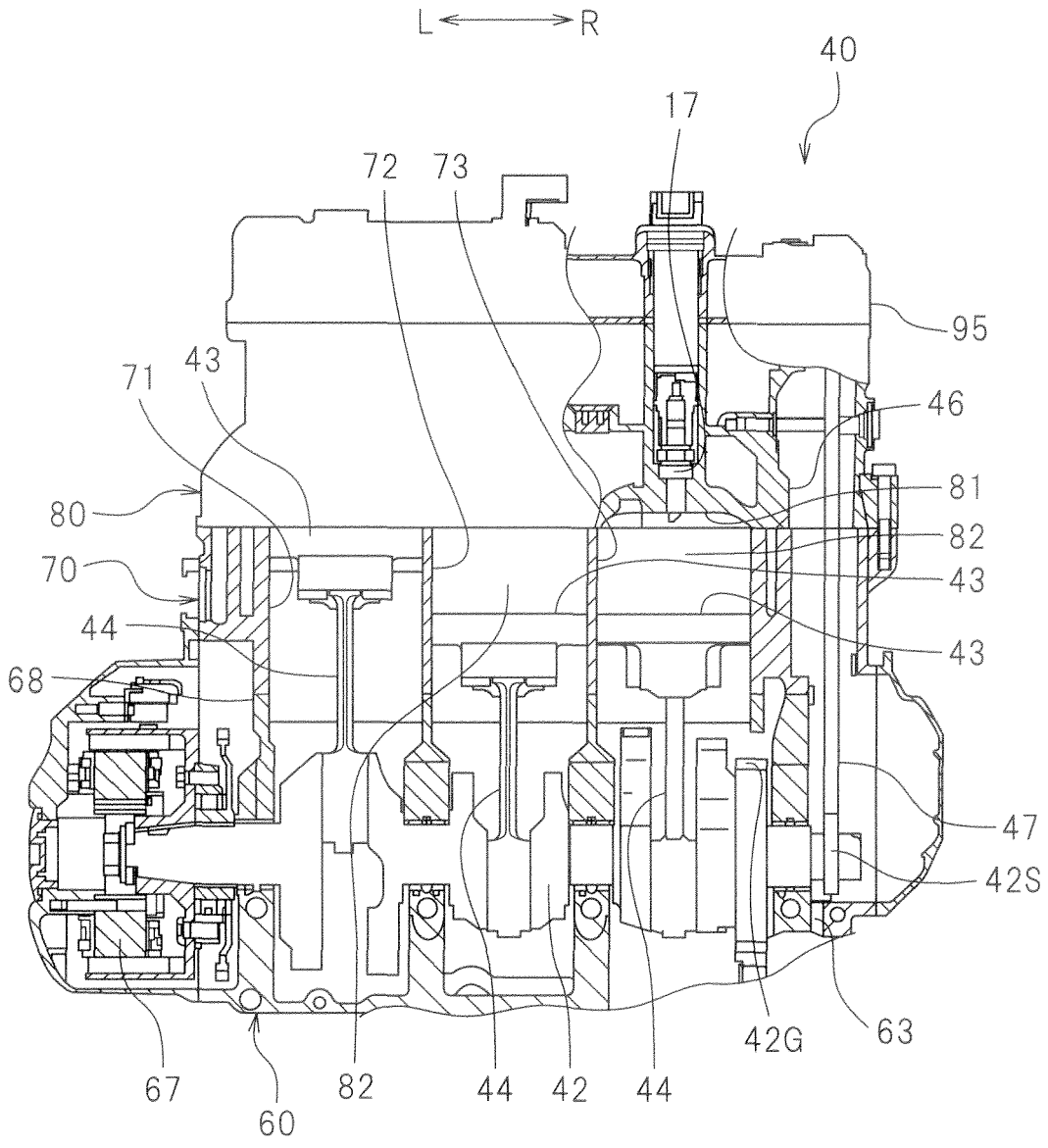
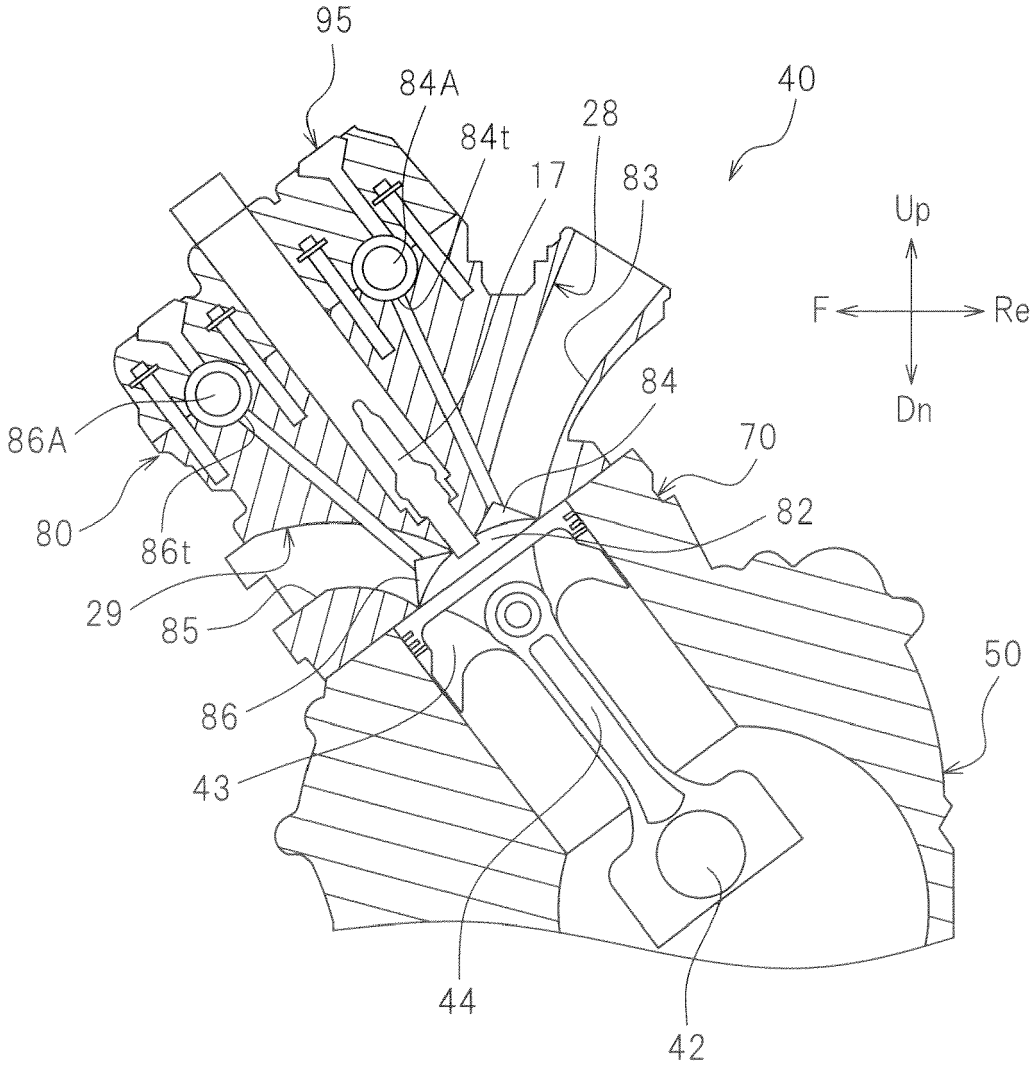
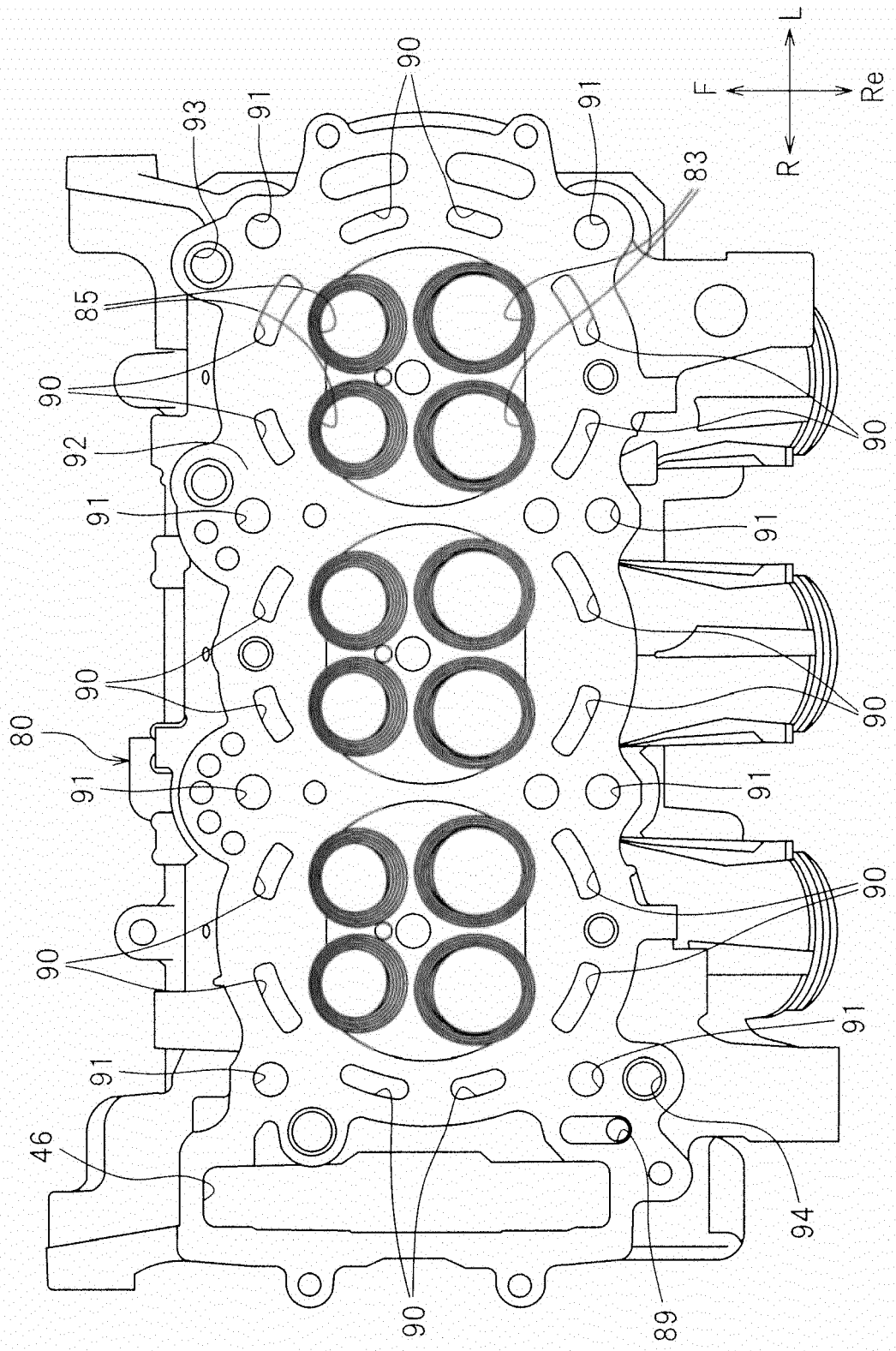

L
R
40
17
72
73
95
71
43
46
80
81
82
70
43
44
43
68
47
42S
42G
63
67
60
82
44
42
44

FIG.10


95
84A
84t
28
40
17
83
Up
F
Re
Dn
84
86A
70
82
80
86t
29
85
50
86
43
44
42


L
F
Re
R
90
93
91
91
83
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91
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90
90
80
91
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90
90
91
91
46
94
90
89

FIG.11

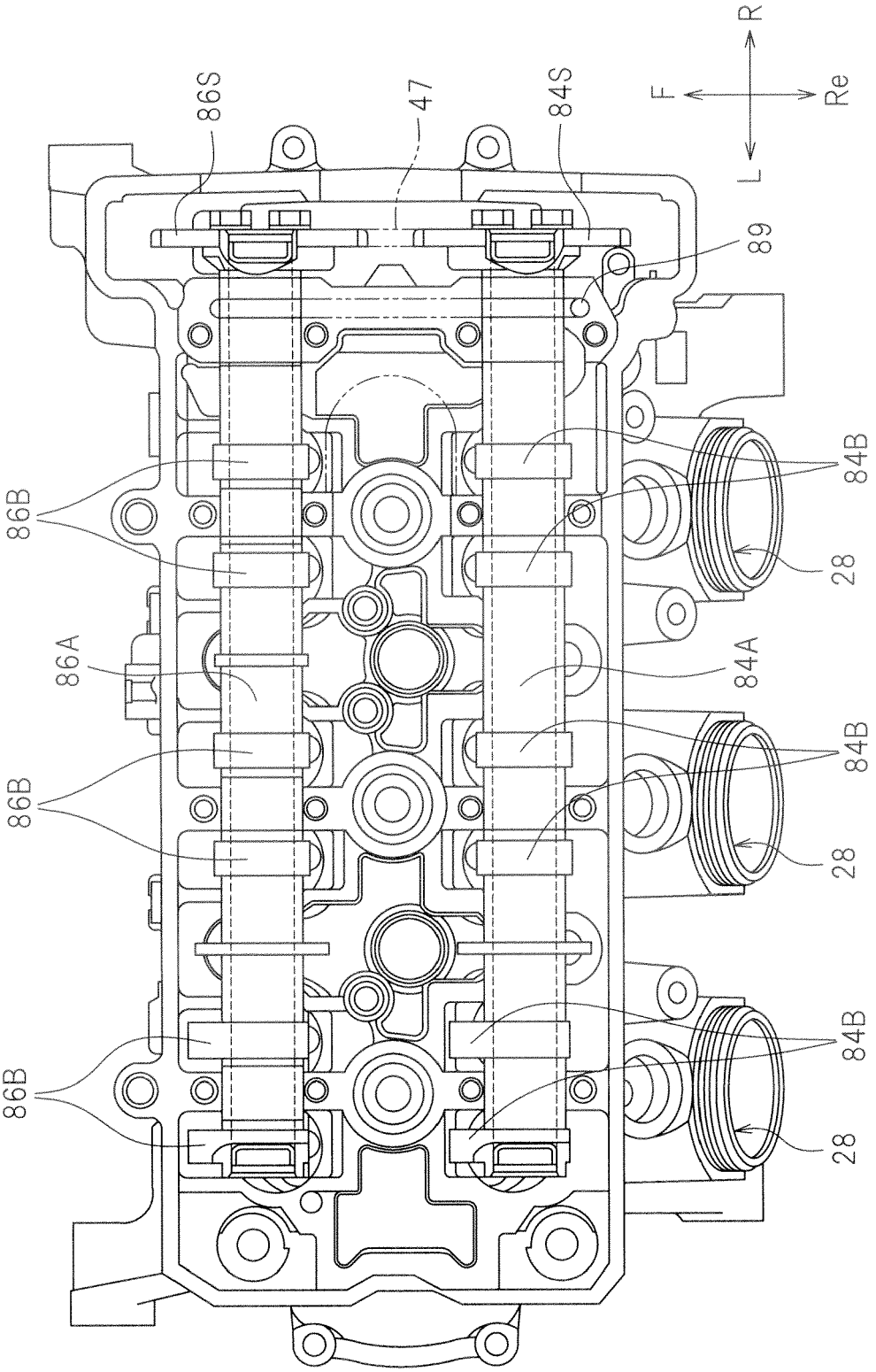
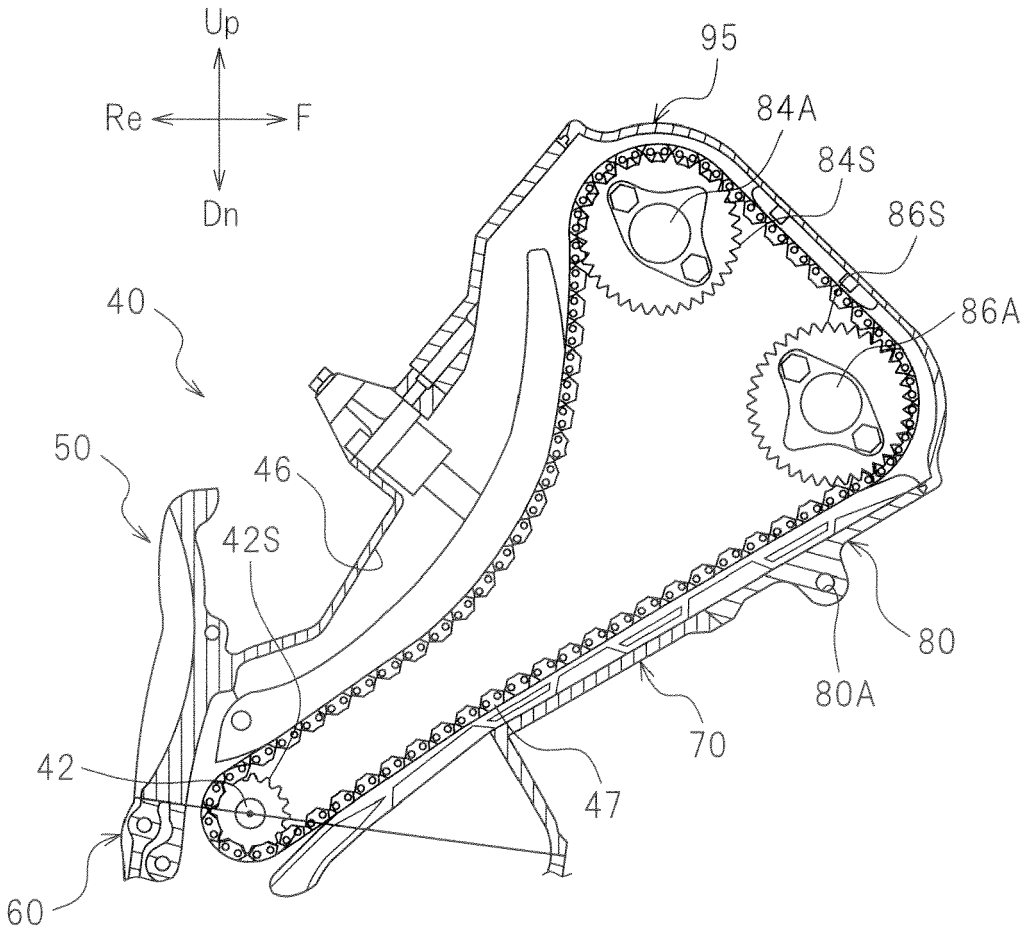


FIG.12

FIG.13



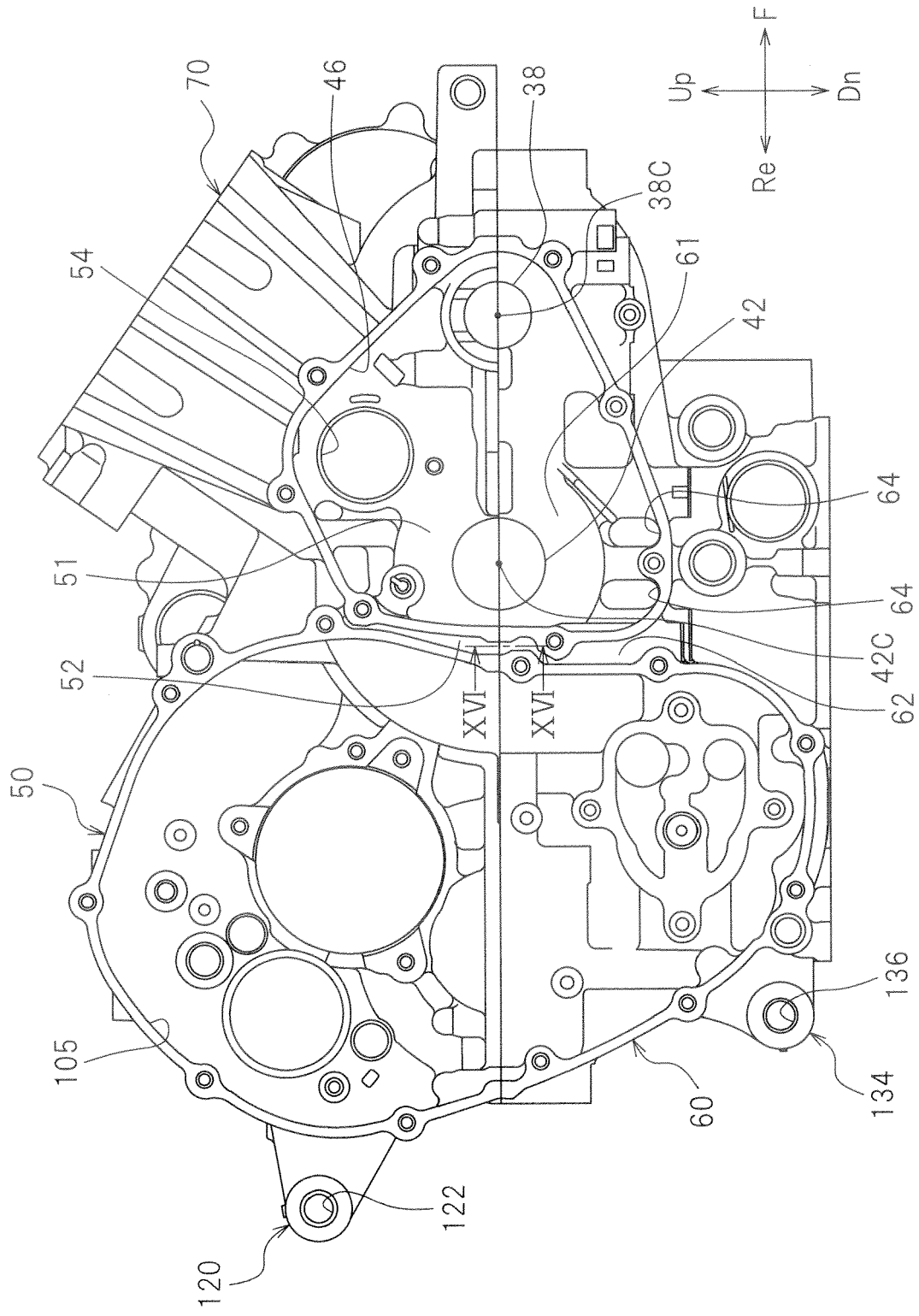

F
Up
Dn
Re
70
46
38
38C
61
42
54
64
51
64
42C
52
62
XVI
XVI
50
136
105
60
134
122
120

FIG.14

FIG.15

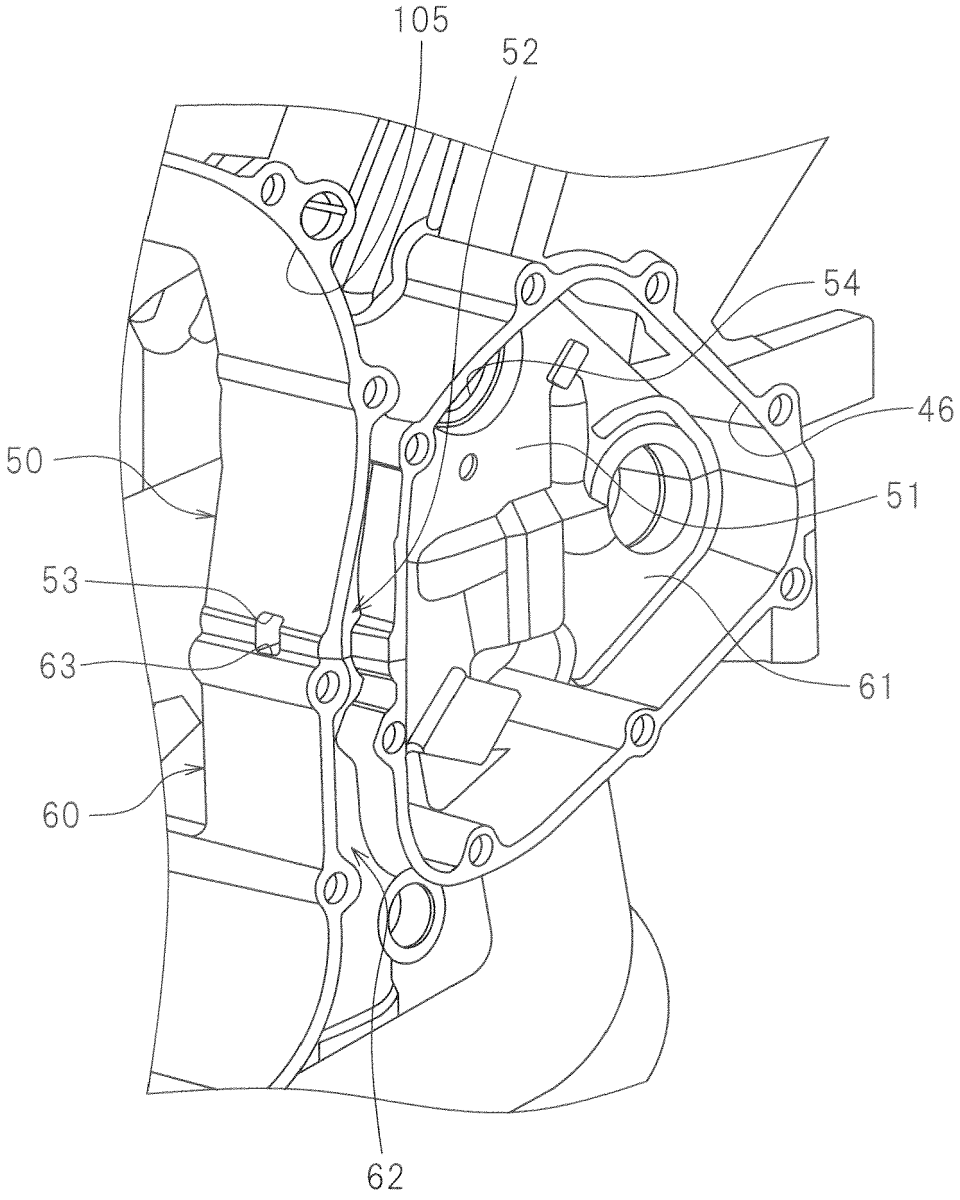


FIG.16

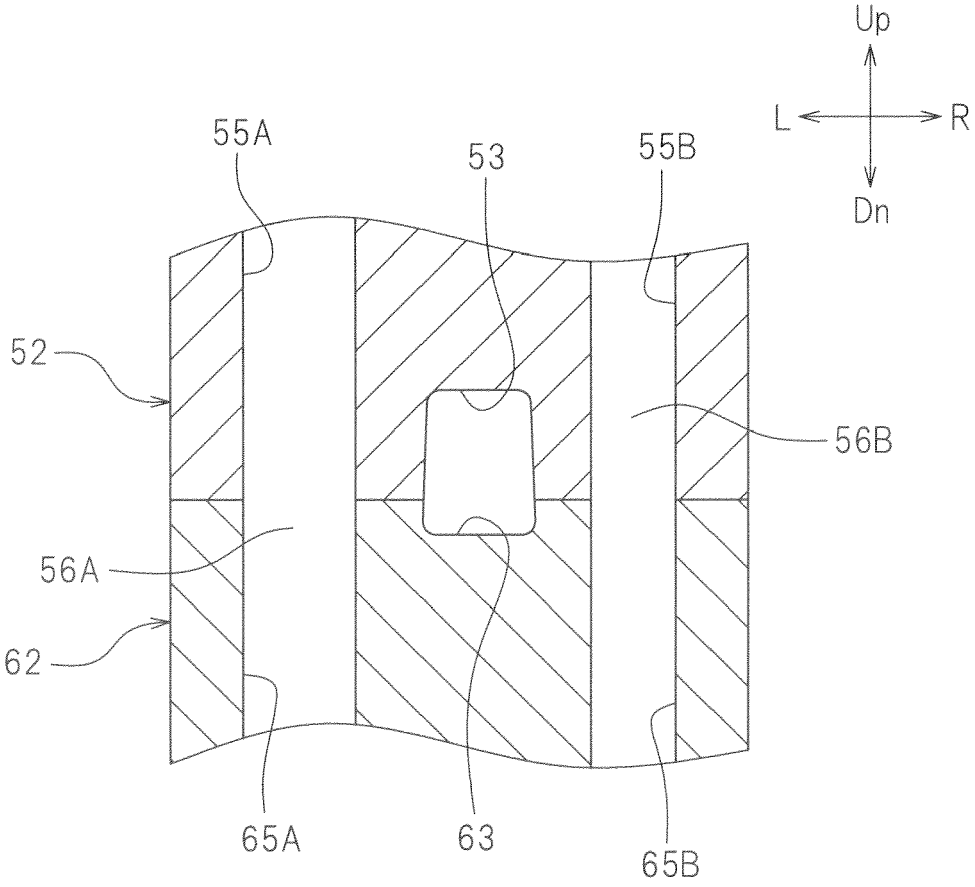


FIG.17

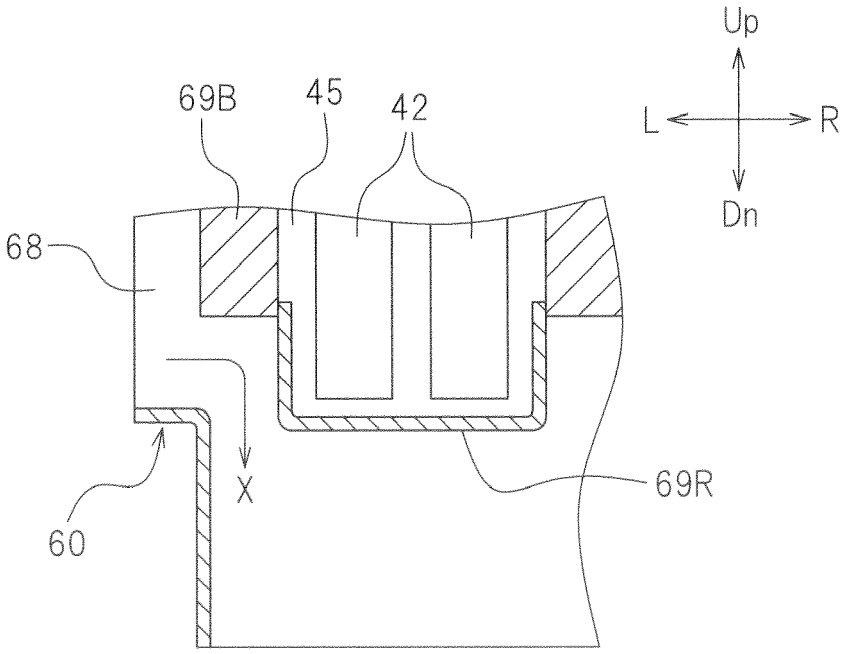
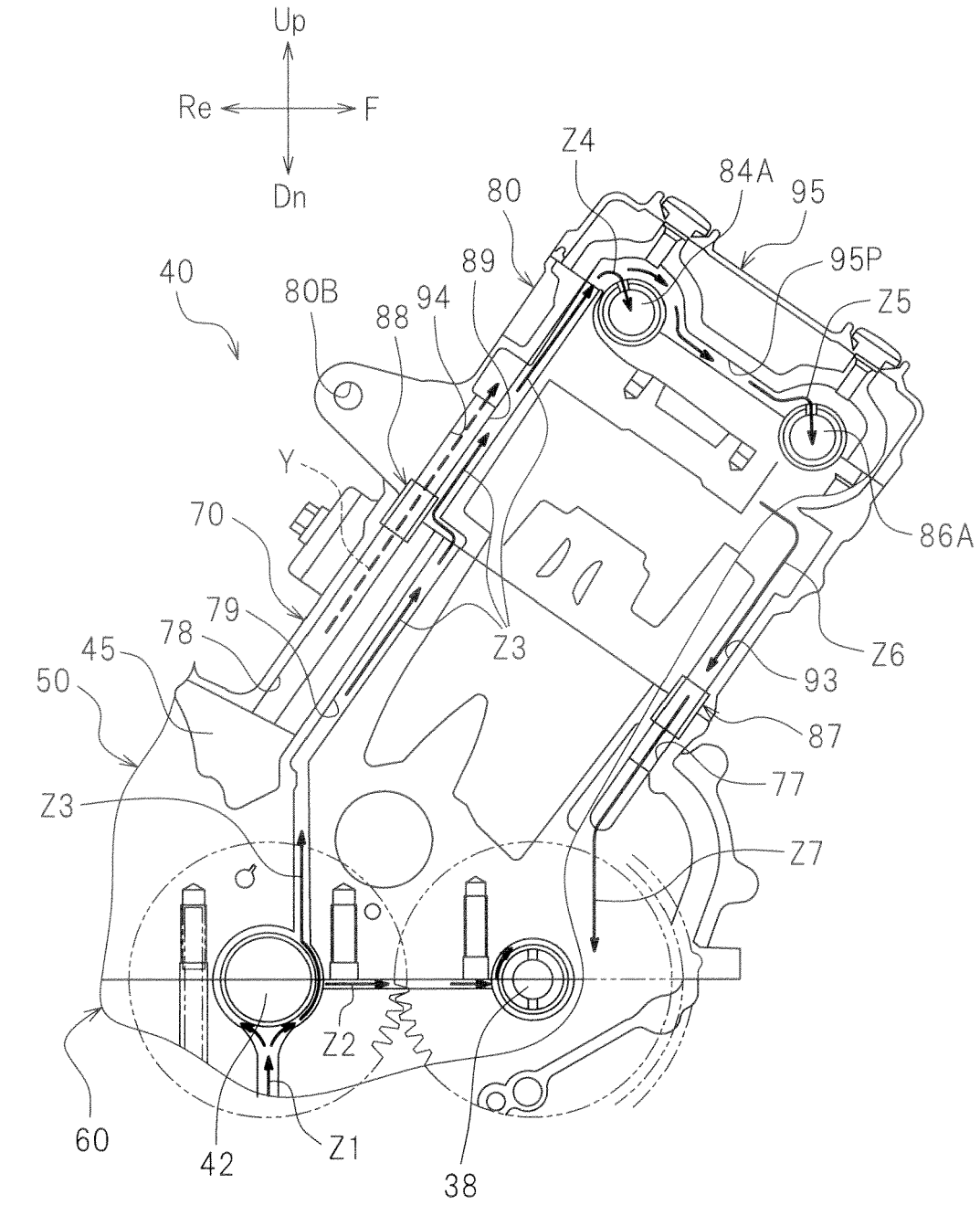


FIG.18


Up
Re
F
Dn
Z4
84A
95
80
89
95P
40
80B
88
94
Z5
Y
70
86A
79
78
Z3
45
Z6
50
93
87
Z3
77
Z7
Z2
60
42
Z1
38

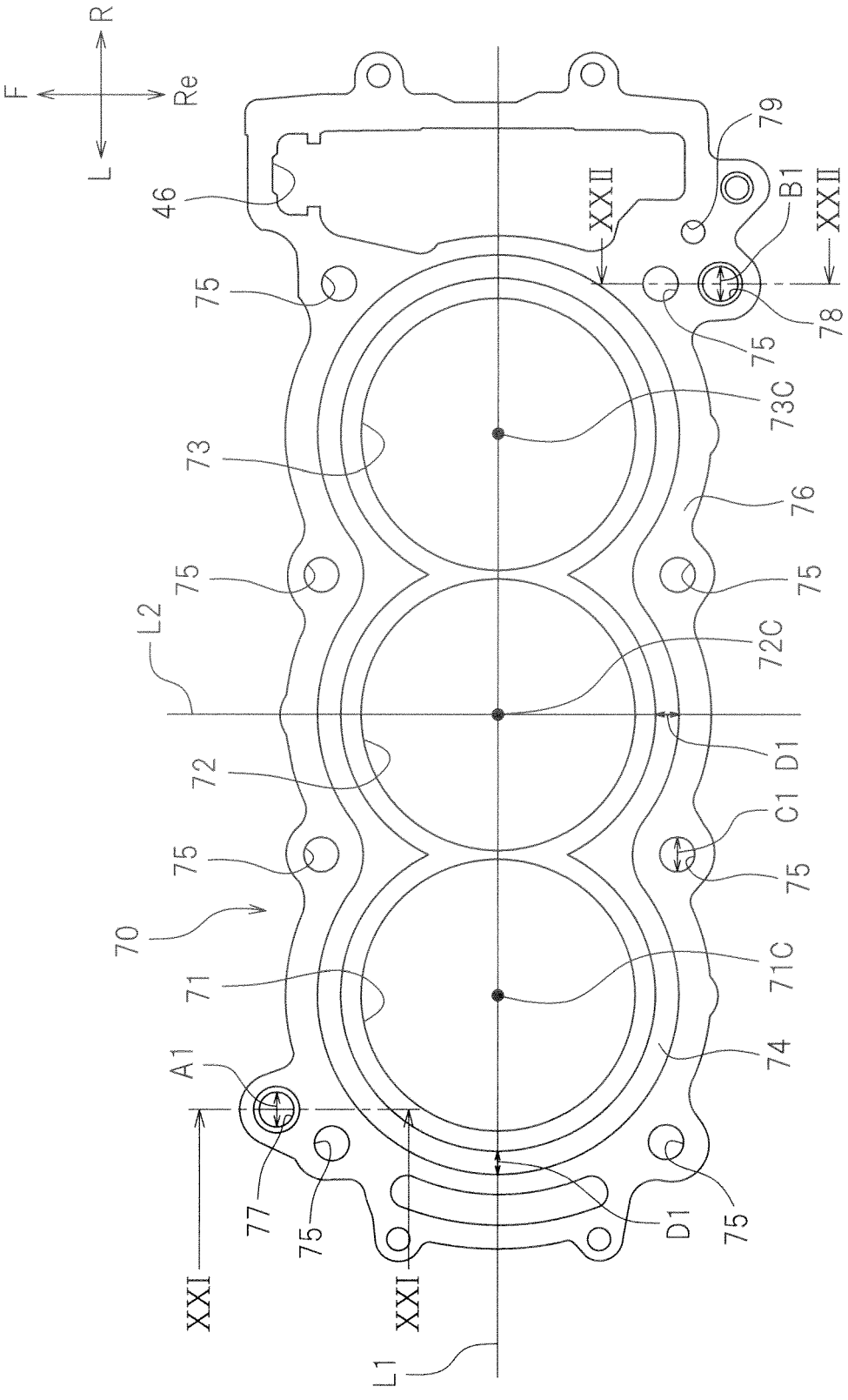

F
R
Re
L
46
79
B1
XXII
XXII
75
78
75
73C
73
76
75
75
L2
72C
72
D1
C1
75
75
70
71
71C
74
A1
77
75
D1
75
XXI
XXI
L1

FIG.19

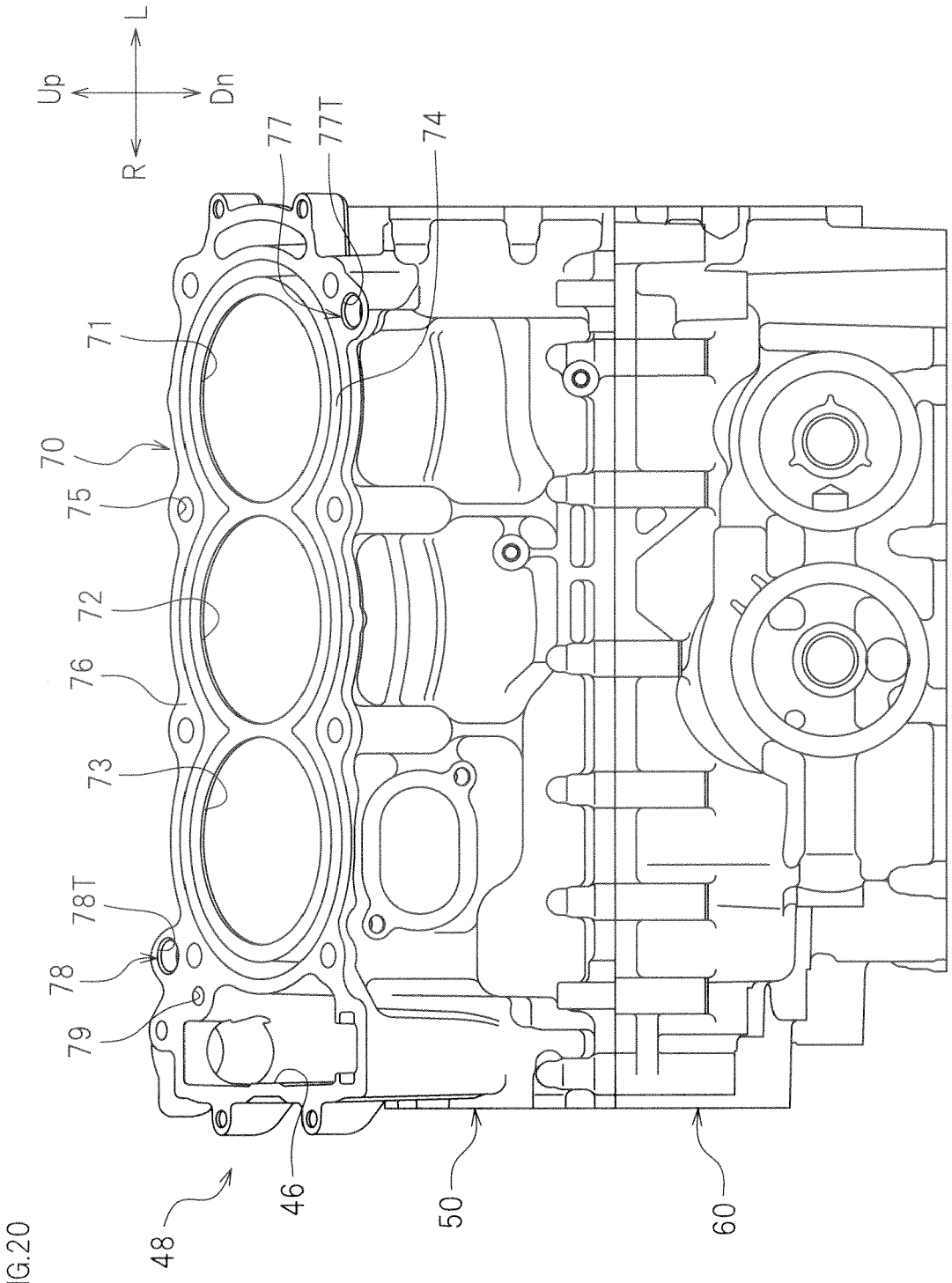


FIG.20

FIG.21

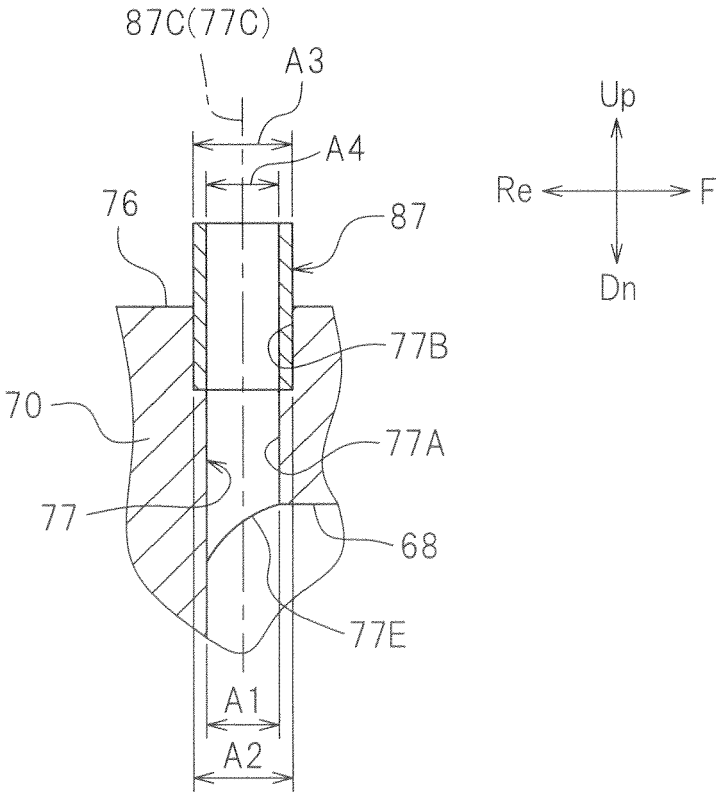
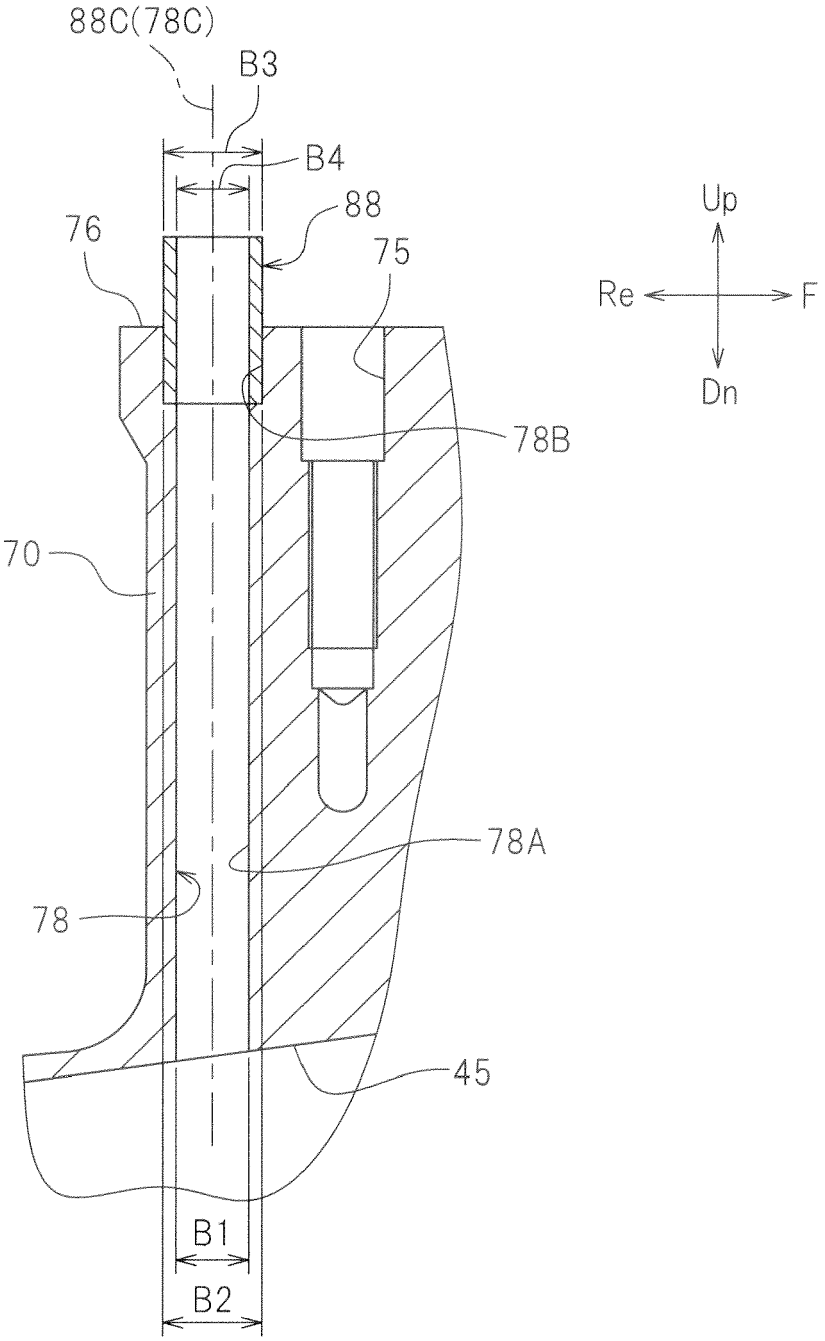


FIG.22



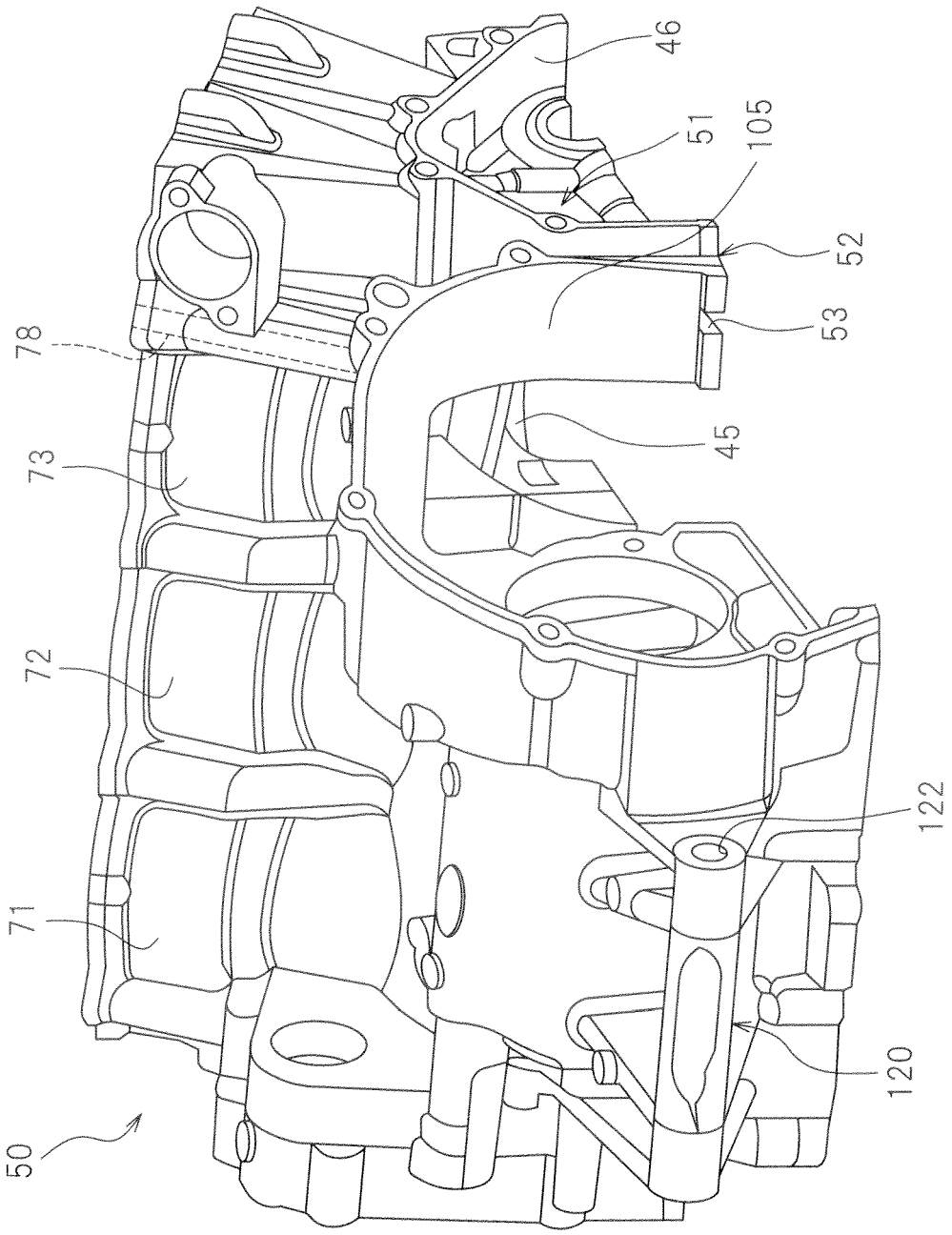


FIG.23

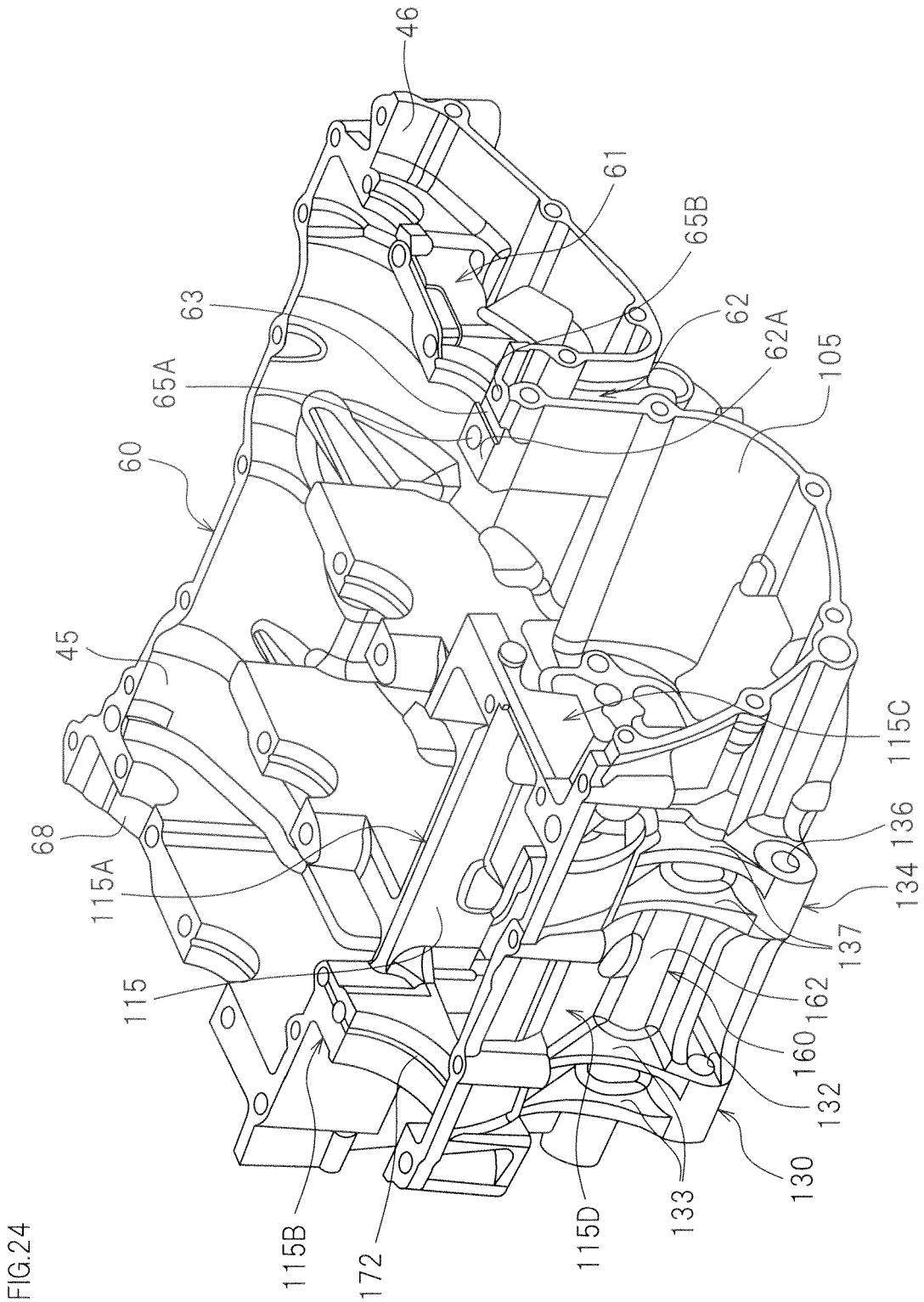
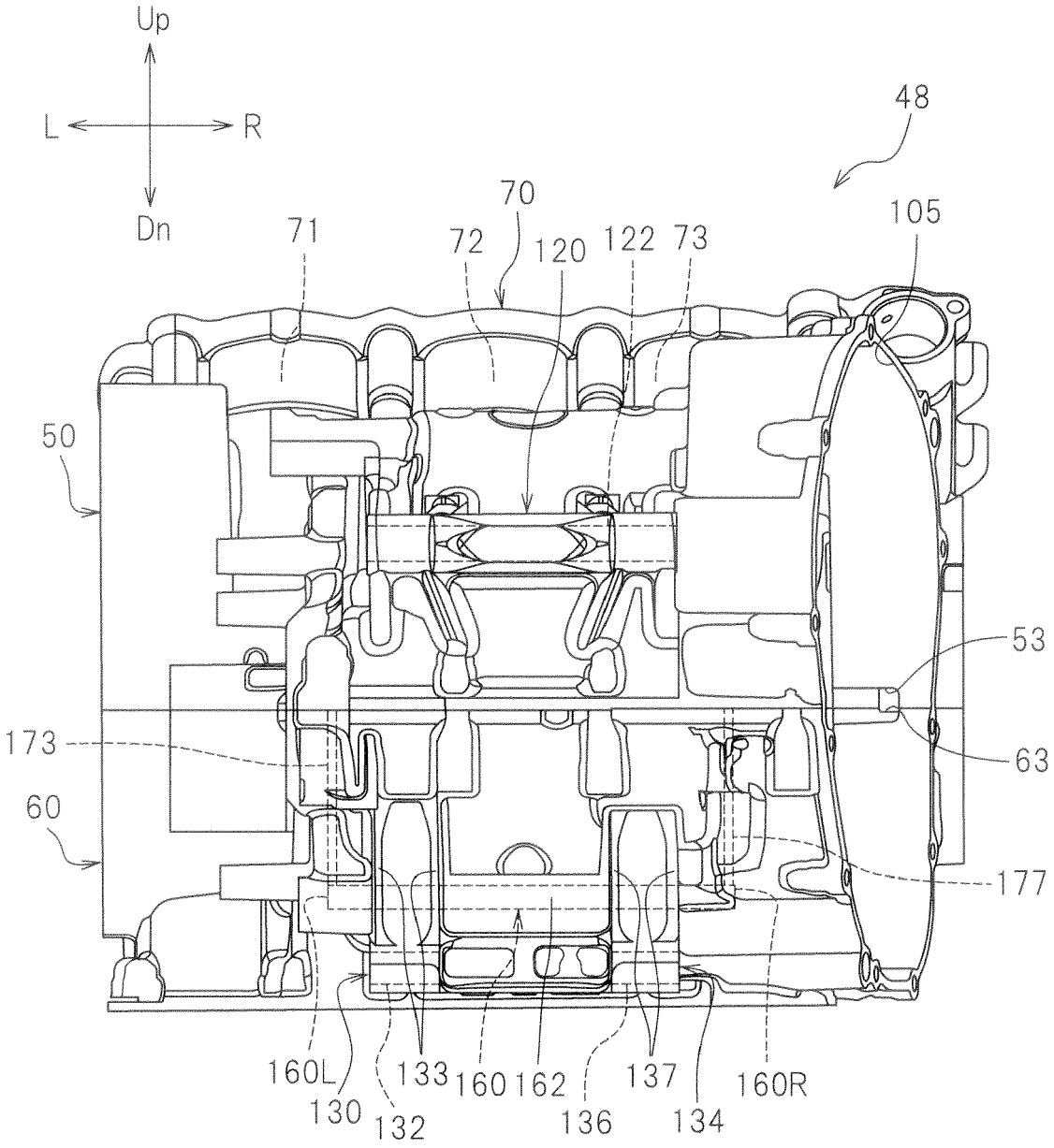

46
61
65B
63
62
62A
105
65A
60
45
115C
68
136
115A
134
137
115
162
160
132
130
133
115D
115B
172

FIG.24

FIG.25


Up
L
R
Dn
48
70
71
72
120
122
73
105
50
53
173
63
60
177
160L
130
133
132
160
162
136
137
134
160R

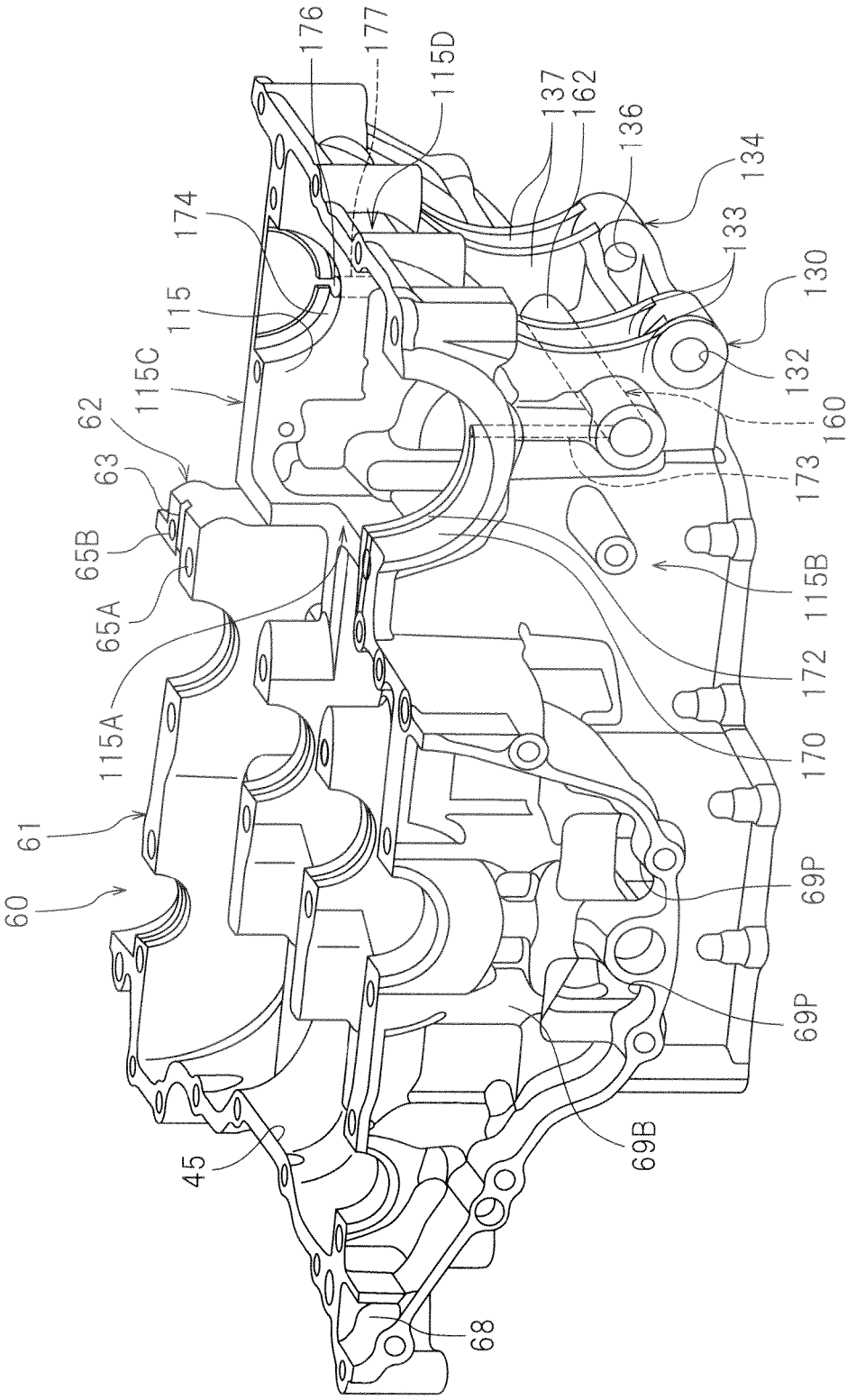

176
177
115D
137
162
136
134
174
133
130
115
132
115C
160
62
63
173
65B
115B
65A
172
115A
170
61
69P
60
69P
69B
45
68

FIG.26

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2008151275 A **[0003]**
- JP 2010007847 A **[0003]**