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(71) Applicant: **HONDA MOTOR CO., LTD.**
Tokyo (JP)

(72) Inventors:
- **ISHIKAWA, Eiichi**
  SAITAMA (JP)
- **HOJO, Atsuo**
  SAITAMA (JP)
- **KUROKAWA, Masaya**
  SAITAMA (JP)

(74) Representative: **Poulin, Gérard**
BREVALEX
3, rue du Docteur Lancereaux
75008 Paris (FR)

(54) Water-cooled type engine

(57) In a water-cooled engine, to enable a reduction in the size of the engine at or around a cylinder head and to ensure that a cooling water lead-out pipe portion for leading out cooling water from a cooling jacket can be disposed in the cylinder head, while obviating the interference with a valve-operating chamber and securing maintainability of a spark plug.

Valve-operating chamber forming walls 33a, 34a are provided with a recessed portion 158 at a portion thereof corresponding to the other end portion of a camshaft 141 whose one end portion fronts on a chain chamber 151, a spark plug 159 with its rear end portion disposed at the recessed portion 158 is attached to a cylinder head 33 in an inclined state so as to be spaced farther from the chain chamber 151 as one goes away from a combustion chamber 117, and a cooling water lead-out pipe portion 161 disposed on the outer side of the valve-operating chamber forming walls 33a, 34a and deviated from the recessed portion 158 toward the side of either intake valves or exhaust valves is provided in the cylinder head 33 so as to extend substantially in parallel to the cylinder axis C.

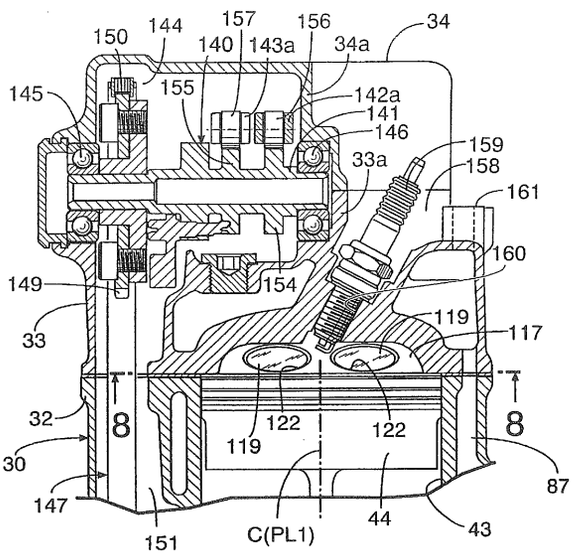

FIG. 7

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Description

[0001] The present invention relates to a water-cooled type engine, and particularly to an improvement in a water-cooled type engine in which a cylinder head in which an intake valve and an exhaust valve are openably and closably disposed with their operating axes intersecting in a roughly V shape is provided with a cooling jacket for passing cooling water therethrough and a cooling water lead-out pipe portion for leading out the cooling water from the cooling jacket, and the cylinder head is provided with a chain chamber on which one end portion of a camshaft disposed between the intake valve and the exhaust valve fronts.

[0002] A water-cooled type engine in which a cylinder head is provided with a cooling water lead-out pipe portion for leading out cooling water from a cooling jacket provided at a cylinder block and the cylinder head has been known, as described in, for example,

Japanese Patent Laid-open No. 2001-263066.

[0003] In the above-mentioned conventional water-cooled type engine, however, the cooling water lead-out pipe portion is provided in the cylinder head so as to project to the outer side, and a cooling water hose connected to the cooling water lead-out pipe portion is also projected largely to the outer side from the cylinder head, so that the engine is enlarged in size at or around the cylinder head.

[0004] In order to solve this problem, it may be contemplated to provide the cooling water lead-out pipe portion at an upper portion of the cylinder head so as to be parallel to the axis of a cylinder bore. However, since a valve-operating chamber for containing a valve-operating device for opening and closing an intake valve and an exhaust valve is provided between the cylinder head and a head cover and a spark plug is also attached to the upper portion of the cylinder head, it is necessary to dispose the cooling water lead-out pipe portion so as to obviate interference thereof with the valve-operating chamber and so as not to hamper the maintenance of the spark plug.

[0005] The present invention has been made in consideration of the above-mentioned circumstances. Accordingly, it is an object of the present invention to provide a water-cooled type engine in which a cooling water lead-out pipe portion for leading out cooling water from a cooling jacket can be disposed in a cylinder head while obviating the interference thereof with a valve-operating chamber, securing maintainability of a spark plug, and enabling a reduction in the size of the engine at or around the cylinder head.

[0006] In order to attain the above object, the invention as set forth in claim 1 resides in a water-cooled type engine including a cylinder head in which an intake valve and an exhaust valve are openably and closably disposed with their operating axes intersecting in a roughly V shape, the cylinder head being provided with a cooling jacket for passing cooling water therethrough and a cooling water lead-out pipe portion for leading out the cooling water from the cooling jacket, and the cylinder head being provided with a chain chamber on which one end portion of a camshaft disposed between the intake valve and the exhaust valve fronts, characterized in that the camshaft is disposed at a position deviated toward the side of the chain chamber with its other end portion corresponding substantially to a central portion of a combustion chamber, a portion corresponding to the other end portion of the camshaft, of valve-operating chamber forming walls provided in the cylinder head and a head cover coupled to the cylinder head so as to form a circumferential wall of a valve-operating chamber containing a valve-operating device including the camshaft, is provided with a recessed portion, a spark plug with its tip end portion fronting on a roughly central portion of the combustion chamber and with its rear end portion disposed at the recessed portion is attached to the cylinder head in an inclined state so that its rear end side is spaced away from the chain chamber, and the cooling water lead-out pipe portion disposed on the opposite side of the chain chamber and on the outer side of the valve-operating chamber forming walls and deviated from the recessed portion toward the side of either one of the intake valve and the exhaust valve is provided in the cylinder head so as to extend substantially in parallel to the cylinder axis.

[0007] In addition, the invention as set forth in claim 2 is characterized, in addition to the constitution of the invention as set forth in claim 1, in that the angle formed between the operating axis of one valve, closer to the cooling water lead-out pipe portion, of the intake valve and the exhaust valve and the cylinder axis on a projection onto a plane containing the cylinder axis is set smaller than the angle formed between the operating axis of the other valve of the intake valve and the exhaust valve and said cylinder axis on the projection, and an opening portion, opening into the combustion chamber, of a plug mount hole provided in the cylinder head for mounting the spark plug is disposed to be deviated from the cylinder axis toward the side of the other valve.

[0008] The invention as set forth in claim 3 is characterized, in addition to the constitution of the invention as set forth in claim 2, in that the axis of the camshaft is disposed to be deviated toward the opposite side of the cooling water lead-out pipe portion relative to a plane being parallel to the camshaft and containing the cylinder axis.

[0009] Furthermore, in order to attain the above object, the invention as set forth in claim 4 resides in a water-cooled type engine including a cylinder head in which an intake valve and an exhaust valve are openably and closably disposed with their operating axes intersecting in a roughly V shape, the cylinder head being provided with a cooling jacket for passing cooling water therethrough and a cooling water lead-out pipe portion for leading out the cooling water from the cooling jacket, and the cylinder head being provided with a chain cham-

ber on which one end portion of a camshaft disposed between the intake valve and said exhaust valve fronts, characterized in that the camshaft is disposed at a position deviated toward the side of the chain chamber with its other end portion corresponding substantially to a central portion of a combustion chamber, a portion corresponding to the other end portion of the camshaft, of valve-operating chamber forming walls provided in the cylinder head and a head cover coupled to the cylinder head so as to form a circumferential wall of a valve-operating chamber for containing a valve-operating device including the camshaft, is provided with a recessed portion, a spark plug with its tip end portion fronting on a roughly central portion of the combustion chamber and with its rear end portion disposed at the recessed portion is attached to the cylinder head in an inclined state so that its rear end side is spaced away from the chain chamber, the cooling water lead-out pipe portion disposed on the opposite side of the chain chamber and on the outer side of the valve-operating chamber forming walls and deviated from the recessed portion toward the side of a plurality of the exhaust valves is provided in the cylinder head so as to extend substantially in parallel to the cylinder axis, the angle formed between the operating axes of the exhaust valves and the cylinder axis on a projection onto a plane containing the cylinder axis is set smaller than the angle formed between the operating axes of the intake valves and the cylinder axis on the projection, and the distance between an opening portion, opening into the combustion chamber, of a plug mount hole provided in the cylinder head for mounting the spark plug and a plurality of intake valve ports provided in the cylinder head in the state of fronting on the combustion chamber so as to open and close each of the intake valves is set smaller than the distance between a plurality of exhaust valve ports provided in the cylinder head in the state of fronting on the combustion chamber so as to open and close each of the exhaust valves and the opening portion of the plug mount hole.

[0010] According to the invention as set forth in claim 1, the camshaft is disposed at a position deviated toward the side of the chain chamber, the valve-operating chamber forming walls are provided with the recessed portion corresponding to a free space generated by the deviation of the camshaft, the spark plug inclined so that its rear end side is spaced away from the chain chamber is attached to the cylinder head so that its rear end portion is disposed at the recessed portion, and the cylinder head is provided with the cooling water lead-out pipe portion disposed at a position deviated from the recessed portion toward the side of either one of the intake valve and the exhaust valve on the outer side of the valve-operating chamber forming walls on the opposite side of the chain chamber. Therefore, the cooling water lead-out pipe portion extending substantially in parallel to the cylinder axis can be provided in the cylinder head while obviating the interference thereof with the valve-operating chamber, securing maintainability of the spark plug, and enabling a reduction in the size of the engine at or around the cylinder head.

[0011] In addition, according to the invention as set forth in claim 2, the area of a cooling passage of the cooling jacket can be set comparatively large between the valve axis of one valve, closer to the cooling water lead-out pipe portion, of the intake valve and the exhaust valve and the spark plug, and it is therefore possible to contrive enhancement of the cooling performance for the cylinder head in the surroundings of the one valve, closer to the cooling water lead-out pipe portion, of the intake valve and the exhaust valve.

[0012] According to the invention as set forth in claim 3, the angle formed between the operating axis of the valve, closer to the cooling water lead-out pipe portion, of the intake valve and the exhaust valve and the cylinder axis can set smaller so as to obviate the interference thereof with the camshaft, whereby it is possible to further enhance the cooling performance for the valve closer to the cooling water lead-out pipe portion.

[0013] Furthermore, according to the invention as set forth in claim 4, the camshaft is disposed at a position deviated toward the side of the chain chamber, the valve-operating chamber forming walls are provided with the recessed portion corresponding to a free space generated due to the deviation of the camshaft, the spark plug inclined so that its rear end side is spaced away from the chain chamber is attached to the cylinder head so that its rear end portion is disposed at the recessed portion, and the cylinder head is provided with the cooling water lead-out pipe portion which is disposed to be deviated from the recessed portion toward the side of the exhaust valve on the outer side of the valve-operating chamber forming walls on the opposite side of the chain chamber. Therefore, the cooling water lead-out portion extending substantially in parallel to the cylinder axis can be provided in the cylinder head while obviating the interference thereof with the valve-operating chamber, securing maintainability of the spark plug, and enabling a reduction in the size of the engine at or around the cylinder head. Moreover, since the cooling water is led out from the cooling jacket on the side closer to the exhaust valve, the distance between a plurality of exhaust valve ports and the opening portion of the plug mount hole can be set comparatively large, whereby the area of a cooling passage of the cooling jacket can be set comparatively large between the valve axis of the exhaust valve and the spark plug, and the flow rate of the cooling water can therefore be set comparatively large. As a result of these points, it is possible to contrive enhancement of cooling performance for the cylinder head in the surroundings of the exhaust valve.

[0014] Now, a mode for carrying out the present invention will be described below, based on one embodiment of the present invention shown in the accompanying drawings:

Fig. 1 is a side view of a small-type motorcycle.

Fig. 2 is a view along arrow 2 of Fig. 1, omitting a fuel tank and a rider's seat.
Fig. 3 is a side view of a lower portion of an engine.
Fig. 4 is a sectional view along line 4-4 of Fig. 3.
Fig. 5 is a vertical sectional view of an upper portion of the engine.
Fig. 6 is a partly cut-out plan view along arrow 6 of Fig. 5, in the condition where a head cover is omitted.
Fig. 7 is a sectional view along line 7-7 of Fig. 6.
Fig. 8 is a bottom view of an essential part of a cylinder head, along line 8-8 of Fig. 7.

[0015] Figs. 1 to 8 illustrate one embodiment of the present invention, in which Fig. 1 is a side view of a small-type motorcycle, Fig. 2 is a view along arrow 2 of Fig. 1, omitting a fuel tank and a rider's seat, Fig. 3 is a side view of a lower portion of an engine, Fig. 4 is a sectional view along line 4-4 of Fig. 3, Fig. 5 is a vertical sectional view of an upper portion of the engine, Fig. 6 is a partly cut-out plan view along arrow 6 of Fig. 5 ±n the condition where a head cover is omitted, Fig. 7 is a sectional view along line 7-7 of Fig. 6, and Fig. 8 is a bottom view of an essential part of a cylinder head, along line 8-8 of Fig. 7.

[0016] First, in Figs. 1 and 2, a vehicle body frame 11 of a small-type motorcycle used for trial contests includes a head pipe 12, a left-right pair of main frames 13, 13 extending rearwardly downwards from the head pipe 12, a left-right pair of down tubes 14 extending downwards from front portions of the main frames 13..., a left-right pair of center frames 15 integral with and extending downwards from the rear ends of both the main frames 13..., an intermediate cross member 16 for connection between intermediate portions of both the main frames 13..., a rear cross member 17 for connection between rear portions of both the main frames 13..., and a lower cross member 18 for connection between lower portions of both the center frames 15....

[0017] A front fork 19 for supporting a front wheel WF is steerably borne on the head pipe 12 at the front end of the vehicle body frame 11, and a bar-like steering handle 20 is coupled to the front fork 19. A front end portion 17 of a rear fork 21 for shaft-supporting a rear wheel WR On its front end portion is vertically oscillatably mounted on the left-right pair of center frames 15...through a pivot shaft 22. A link mechanism 23 is provided between the lower cross member 18 and the rear fork 21, and a rear cushion 24 is provided between the link mechanism 23 and the rear cross member 17.

[0018] A fuel tank 25 is mounted between front portions of the left-right pair of main frames 13..., a rider's seat 26 disposed on the rear side of the fuel tank 25 is supported by the intermediate cross member 16 and the rear cross member 17, and a rear fender 27 is provided in continuity with the rear end of the rider's seat 26.

[0019] A power unit P including a single-cylinder four-cycle engine E of the water-cooled type and the fuel injection type and a normally meshed type transmission M is disposed between the front wheel WF and the rear wheel WR. An engine main body 30 of the engine E is supported by lower end portions of the left-right pair of down tubes 14..., a hanger plate 28 extended downwards from intermediate portions of the main frames 13..., and the lower cross member 18. On the lower side of the engine main body 30, a skid plate 29 is disposed, with a spacing between itself and a lower portion of the engine main body 30. The skid plate 29 is attached to lower end portions of the down tubes 14...and to the lower cross member 18.

[0020] In Figs. 3 to 5, the engine main body 30 of the engine E includes a crankcase 31..., a cylinder block 32 coupled to the crankcase 31..., a cylinder head 33 coupled to the cylinder block 32, and a head cover 34 coupled to the cylinder head 33.

[0021] The crankcase 31... for rotatably bearing a crankshaft 36 thereon has a structure in which a right case half 37 disposed an the right side at the time of mounting on the motorcycle and a left case half 38 disposed on the left side at the time of mounting on the motorcycle are coupled to each other at a mating surface 39 along a plane orthogonal to the axis of the crankshaft 36. Moreover, the crankcase 31...is provided therein with a crank chamber 40 for containing an essential part of the crankshaft 36 and a transmission chamber 41 for containing the transmission M, the chambers being partitioned from each other by a partition wall 42.

[0022] An essential part of the crankshaft 36 is contained in the crank chamber 40, and a large end portion of a connecting rod 45 connected to a piston 44 slidably fitted in a cylinder bore 43 provided in the cylinder black 32 is coupled to the crankshaft 36 through a crank pin 46.

[0023] One end portion of the crankshaft 36 rotatably penetrates through the right case half 37, while the other end portion of the crankshaft 36 rotatably penetrates through the left case half 38.
A ball bearing 47 is interposed between the right case half 37 and the crankshaft 36, whereas a roller bearing 48 is interposed between the left case half 38 and the crankshaft 36.

[0024] The transmission M includes a main shaft 52 having an axis parallel to the crankshaft 36 and being rotatably borne on the right and left case halves 37, 38 through ball bearings 51 · · ·, and a counter shaft 53 having an axis parallel to the main shaft 52 and being rotatably borne on both the case halves 37, 38 through ball bearings 54 · · · . A drive gear group 55 · · · for a plurality of speed change stages is mounted on the main shaft 52, while a driven gear group 56 · · · corresponding to the drive gear group 55 · · · is mounted on the counter shaft 53. By selectively establishing a corresponding pair of gears among the drive gear group 55 · · · and the driven gear group 56 · · ·, the output of the engine E is transmitted to the counter shaft 53 through a plurality of

stages of speed change.

[0025] Again in Fig. 1, a drive sprocket 57 is attached to an end portion of the counter shaft 53 projecting from the left case half 38 on the front side relative to the pivot shaft 22, and an endless chain 59 is wrapped around a driven sprocket 58 attached to the rear wheel WR and the drive sprocket 57.

[0026] A speed change switching clutch 60 for switching ON and OFF the transmission of power between the crankshaft 36 and the main shaft 52 is mounted to one end portion of the main shaft 52 projecting from the right case half 37, and an input member 61 possessed by the speed change switching clutch 60 is relatively rotatably borne on the main shaft 52.

[0027] A power transmission gear train 62 is provided between the input member 61 of the speed change switching clutch 60 and the crankshaft 36. The power transmission gear train 62 is comprised of a first drive gear 63 fixed to one end portion of the crankshaft 36, and a clutch gear 64 meshed with the first drive gear 63. The clutch gear 64 is coupled to the input member 61 through a damper 65, and is rotated together with the input member 61.

[0028] A second drive gear 67 constituting a part of an accessory driving power transmission gear train 66 and the first drive gear 63 are mounted to one end portion of the crankshaft 36 so as to be non-rotatable relative to the crankshaft 36 by spline fit or the like, while making contact with each other. The second drive gear 67 is integrally provided with a cylinder portion 67a making contact with the outside surface of an inner ring of the ball bearing 47 interposed between the crankshaft 36 and the crankcase 31 · · · on the axially inner side relative to the second drive gear 67. A bolt 68 having a radially enlarged head portion 68a for making contact and engagement with the outer end of the first drive gear 63 is screw-engaged with one end portion of the crankshaft 36.

[0029] Namely, the cylinder portion 67a of the second drive gear 67 is clamped between the first drive gear 63 and the ball bearing 47, and an annular oil seal 69 is interposed between the cylinder portion 67a and the right case half 37.

[0030] The accessory driving power transmission gear train 66 is provided between the crankshaft 36 and a balancer shaft 75 rotatably borne on the right case half 37 and the left case half 38 on the front side of the crankshaft 36 through a ball bearing 73 and a roller bearing 74, and includes the second drive gear 67 fixed to the crankshaft 36, and a first driven gear 76 fixed to one end portion of the balancer shaft 75 and meshed with the second drive gear 67.

[0031] In addition, on the upper side of the balancer shaft 75, there is disposed a water pump 80 of which a pump housing 79 is composed of a right cover 77 coupled to the right case half 37 from the outside and a pump cover 78 fastened to the outside surface of the right cover 77. The water pump 80 has a pump shaft 81 parallel to the balancer shaft 75.

[0032] The pump shaft 81 penetrates the right cover 77 of the pump housing 79 in a liquid-tight and rotatable manner. Rotary vanes 82 are coaxially attached to one end portion of the pump shaft 81 projecting into the pump housing 79, and the other end portion of the pump shaft 81 is rotatably borne on the right case half 37.

[0033] A power transmission gear train 83 is provided between one end portion of the balancer shaft 75 and the pump shaft 81, and, as a result, the power transmitted from the crankshaft 36 to the balancer shaft 75 through the accessory driving power transmission gear train 66 is transmitted through the power transmission gear train 83 to the pump shaft 81.

[0034] The pump cover 78 of the pump housing 79 of the water pump 80 is provided with a water return pipe 84, and a hose 85 (see Fig. 1) for leading water from a radiator 86 disposed on the front side of the engine main body 30 and supported by both the down tubes 14 · · · is connected to the return pipe 84. Besides, water discharged from the water pump 80 is supplied through the crankcase 31 into cooling jackets 87 provided for the cylinder block 32 and the cylinder head 33 in a mutually communicated state.

[0035] An oil collecting in the crankcase 31 is pumped up by an oil pump 90. The oil pump 90, of the trochoid type, comprises an inner rotor 92 fixed to the inner end of a pump shaft 91, and an outer rotor 93 meshed with the inner rotor 92.

[0036] A pump chamber 94 for containing the inner rotor 92 and the outer rotor 93 therein is formed between the right case half 37 and the left case half 38 on both sides of the mating surface 39, and is composed of a containing recessed portion 95 provided in the left case half 38 so as to front on the mating surface 39, and the right case half 37.

[0037] The pump shaft 91 is borne on a support cylinder portion 96 provided in the right case half 38 in a liquid-tight and rotatable manner, and a second driven gear 97 is fixed to an outer end portion of the pump shaft 91 projecting from the support cylinder portion 96. On the other hand, a third drive gear 98 is fixed to the other end portion of the balancer shaft 75, and the third drive gear 98 is meshed with the second driven gear 97, whereby the pump shaft 91 is driven to rotate.

[0038] At a portion, fronting on the mating surface 39, of the right case half 37, there are provided a discharge-side recessed portion 99 communicated with the pump chamber 94 and a suction-side recessed portion 100 communicated with the pump chamber 94 so that an inner end portion of the pump shaft 91 is received by the right case half 37 between both of the recessed portions 99 and 100.

[0039] On the other hand, the left case half 38 is provided with an oil discharge passage 101 having one end opened at the mating surface 39 for communication with the discharge-side recessed portion 99, so as to supply the oil to individual lubrication portions of the engine.

[0040] In addition, the suction-side recessed portion 100 and a lower portion of the crankcase 31 are connected to each other through an oil suction passage 102. A passage groove 103 for forming the oil suction passage 102 between the right and left case halves 37 and 38 on both sides of the mating surface 39 is provided in at least one of the case halves 37 and 38, in this embodiment, in the left case half 38.

[0041] A starting operating force according to a kick operation can be inputted to the clutch gear 64 through a kick starting gear train 105. The kick starting gear train 105 includes a fourth drive gear 107 mounted to a kick shaft 106 rotatably borne on the crankcase 31, an idle gear 108 fixed to the counter shaft 53 and meshed with the fourth drive gear 107, and a third driven gear 109 relatively rotatably borne on the main shaft 52 and meshed with the idle gear 108. The input member 61 of the speed change switching clutch 60 is relatively non-rotatably mounted to the third driven gear 109.

[0042] The fourth drive gear 107 is borne on the kick shaft 106 so as to be rotatable but not relatively movable in the axial direction. A one-way clutch mechanism 110 for coupling the kick shaft 106 and the fourth drive gear 107 to each other at the time of normal rotation of the kick shaft 106 is provided between the kick shaft 106 and the fourth drive gear 107.

[0043] The one-way clutch mechanism 110 includes a clutch body 111 fitted over the kick shaft 106 so as to be relatively movable in the axial direction but relatively non-rotatable, and a friction spring 112 for applying a frictional resistance against the rotation of the clutch body 111. The opposed surfaces of the fourth drive gear 107 and the clutch body 111 are provided respectively with ratchet teeth 113 and 114 which transmit only the normal rotation of the clutch member 111, or the kick shaft 106, to the fourth drive gear 107 when meshed.

[0044] In addition, kick return springs 115, 115 composed of torsion coil springs are provided in an inner-outer double form between the right case half 37 and the kick shaft 106, and the kick shaft 106 is biased toward the return side by these kick return springs 115, 115.

[0045] Referring further to Fig. 6 and 7 also, a combustion chamber 117 on which a top portion of the piston 44 fronts is provided between the cylinder block 32 and the cylinder head 33. Pluralities of (in this embodiment, one each) intake valves 118 · · · and exhaust valves 119 · · · are openably and closably disposed in the cylinder head 33 with their operating axes intersect in a roughly V shape on a projection onto a first plane PL1 (a plane parallel to Fig. 5) containing the axis of the cylinder bore 43, i.e., the cylinder axis C.

[0046] The cylinder head 33 is provided with a pair of intake valve ports 120 · · · fronting on the combustion chamber 117 so as to be opened and closed respectively with each of the intake valves 118 · · · , a single intake port 121 communicated in common with both the intake valve ports 120 · · · and opened at a rear side wall of the cylinder head 33, a pair of exhaust valve ports 122 · · · fronting on the combustion chamber 117 so as to be opened and closed respectively with each of the exhaust valves 119· · ·, and a single exhaust port 123 communicated in common with the exhaust valve ports 122 · · · and opened at a front side wall of the cylinder head 33.

[0047] Besides, the cylinder head 33 is provided with a pair of intake-side guide cylinder 124 · · · in which to slidably fit both the intake valves 118 · · · so as to guide the opening and closing operations of both the intake valves 118 · · ·, and a pair of exhaust-side guide cylinders 125 · · · in which to slidably fit both the exhaust valves 119· · · so as to guide the opening and closing operations of both the exhaust valves 119 · · ·. Valve springs 126 · · · for biasing the intake valves 118 · · · in the valve-closing directions are interposed between upper end portions of both the intake valves 118 · · · projecting from the intake-side guide cylinders 124 · · · and the cylinder head 33, while valve springs 127 · · · for biasing both the exhaust valves 119· · · in the valve-closing directions are interposed between upper end portions of both the exhaust valves 119 · · · projecting from the exhaust-side guide cylinders 125· · · and the cylinder head 33.

[0048] A connection cylinder portion 138 projecting to the outer side relative to the coupling portion of the cylinder head 33 and the head cover 34 to form an inlet portion 121a of the intake port 121 is integrally provided at a rear side wall of the cylinder head 33 so that the axis of the inlet portion 121a is disposed in a second plane PL2 substantially orthogonal to the cylinder axis C.

[0049] An insulator 128 and a throttle body 129 are connected to the connection cylinder portion 138. The insulator 128 has a structure in which a flange 128b is burned onto the downstream end of its cylinder portion 128a formed of a rubber, and the flange 128b is joined to the connection cylinder portion 138. The throttle body 129 connected to an upstream end portion of the insulator 128 has a structure in which a body 131 having an intake passage 130 communicated with the intake port 121 is provided, and a throttle valve 132 capable of controlling the flow area of the intake passage 130 is openably and closably disposed in the body 131.

[0050] Moreover, the cylinder portion 128a of the insulator 128 is so formed as to be bent in the second plane PL2, and the throttle body 129 is connected to the upstream end portion of the insulator 128 so that the intake passage 130 thereof is disposed in the second plane PL2. In addition, the throttle body 129 includes a throttle drum 133 which is disposed on the outer side of the body 131 so as to rotate as one body with the throttle valve 132 and around and to which a throttle wire 134 is wrapped and connected. The throttle body 129 is connected to the cylinder head 33 through the insulator 128 in such a posture that the throttle drum 133 is disposed on the opposite side of the cylinder head 33.

[0051] Meanwhile, a fuel injection valve 135 for injecting a fuel toward the intake port 121 is attached to the cylinder head 33. The connection cylinder portion 138 of the cylinder head 33 is provided with a mount hole 136 in which to fit a tip end portion of the fuel injection valve 135 in a liquid-tight manner, and a rear end portion of the fuel injection valve 135 with its tip end portion fitted liquid-tight in the mount hole 136 is fitted in a holder 137 fastened to the cylinder head 33. In other words, the fuel injection valve 135 is attached to the cylinder head 33 in the manner of being clamped between the cylinder head 33 and the holder 137, and the fuel is supplied to the fuel injection valve 135 via the holder 137.

[0052] Meanwhile, a valve-operating device 140 for opening and closing the pair of intake valves 118 · · · and the pair of exhaust valves 119 · · · includes a camshaft 141 disposed between both the intake valves 118 · · · and both the exhaust valves 119 · · · with its axis substantially parallel to the axis of the inlet portion 121a of the intake port 121, an intake-side rocker arm 142 oscillated according to the rotation of the camshaft 141 to open and close both the intake valves 118 · · · , and an exhaust-side rocker arm 143 oscillated according to the rotation of the camshaft 141 to open and close both the exhaust valves 119 · · ·, and is contained in a valve-operating chamber 144 formed between the cylinder head 33 and the head cover 34 coupled to the cylinder head 33.

[0053] Both end portions of the camshaft 141 are rotatably borne on the coupling surfaces of the cylinder head 33 and the head cover 34 through ball bearings 145, 146, and the rotating power of the crankshaft 36 is transmitted to one end portion of the camshaft 141 through a timing power transmission device 147.

[0054] The timing power transmission device 147 includes a drive sprocket 148 (see Fig. 4) formed integrally with a portion, projecting from the left case half 38 of the crankcase 31 · · ·, of the crankshaft 36, a driven sprocket 149 fixed to one end portion of the camshaft 141, and a cam chain 150 wrapped around the drive sprocket 148 and the driven sprocket 149. A chain chamber 151 for containing the cam chain 150 so that the cam chain 150 can be moved is formed in the area ranging from the crankcase 31 through the cylinder block 32 to the cylinder head 33.

[0055] On both sides of the cam shaft 141, an intake-side rocker shaft 152 and an exhaust-side rocker shaft 153 are disposed with their axes parallel to the camshaft 141. Both end portions of both the rocker shafts 152, 153 are fixedly supported by being clamped between the cylinder head 33 and the head cover 34.

[0056] The intake-side rocker arm 142 is oscillatably borne on the intake-side rocker shaft 152, and integrally includes an arm 142a for shaft-supporting a roller 156 making rolling contact with an intake-side cam 154 provided on the camshaft 141, and arms 142b, 142c having tip end portions abutted on upper end portions of both the intake valves 118· · ·. Similarly, the exhaust-side rocker arm 143 is oscillatably borne on the exhaust-side rocker shaft 153, and integrally includes an arm 143a for shaft-supporting a roller 157 making rolling contact with an exhaust-side cam 155 provided on the camshaft 141, and arms 143b, 143c having tip end portions abutted on upper end portions of both the exhaust valves 119 · · ·.

[0057] The cam shaft 141 is disposed at a position deviated toward the side of the chain chamber 151 so that its other end portion, i.e., its portion borne on the cylinder head 33 and the head cover 34 through the ball bearing 146 corresponds substantially to a central portion of the combustion chamber 117. In addition, the circumferential wall of the valve-operating chamber 144 is composed of valve-operating chamber forming walls 33a, 34a provided in the cylinder head 33 and the head cover 34. Of the valve-operating chamber forming walls 33a, 34a, the portion corresponding to the other end portion of the camshaft 141 is provided with a recessed portion 158.

[0058] On the other hand, a spark plug 159 with its tip end portion fronting on a roughly central portion of the combustion chamber 117 and with its rear end portion disposed at the recessed portion 158 is attached to the cylinder head 33 in an inclined state so that its rear end side is spaced away from the chain chamber 151. The cylinder head 33 is provided with a plug mount hole 160 for mounting the spark plug 159.

[0059] Meanwhile, the cylinder head 33 is provided with a cooling water lead-out pipe portion 161 for leading out cooling water from the cooling jacket 87, and the cooling water lead-out pipe portion 161 is connected to the radiator 86 through a hose 162 (see Fig. 1).

[0060] Moreover, the cooling water lead-out pipe portion 161 is disposed on the opposite side of the chain chamber 151 and on the outer side of the valve-operating chamber forming walls 33a, 34a, and is provided in the cylinder head 33 so as to extend substantially in parallel to the cylinder axis C at a position deviated from the recessed portion 158 toward the side of either the intake valves 118 · · · or the exhaust valves 119 · · ·, in this embodiment, toward the side of the exhaust valves 119 · · ·.

[0061] In addition, the angle $\alpha 1$ formed between the operating axes of the exhaust valves 119 · · · , which are closer to the cooling water lead-out pipe portion 161, of the intake valves 118 · · · and the exhaust valves 119 · · · , and the cylinder axis C on a projection onto the first plane PL1 is set smaller than the angle $\alpha 2$ formed between the operating axes of the intake valves 118· · ·, which are the other valves, and the cylinder axis C on the projection.

[0062] Moreover, as shown in Fig. 8, an opening portion, opening into the combustion chamber 117, of the plug mount hole 160 is disposed to be deviated from the cylinder axis C toward the side of the intake valves 118 · · · . The distance between the opening portion, opening into the combustion chamber 117, of the plug mount

hole 160 and intake valve ports 120 ··· provided in the cylinder head 33 so as to front on the combustion chamber 117 is set smaller than the distance between exhaust valve ports 122··· provided in the cylinder head 33 so as to front on the combustion chamber 117 and the opening portion of the plug mount hole 160.

[0063] In addition, the axis of the camshaft 141 in the valve-operating device 140 is disposed to be deviated toward the opposite side of the cooling water lead-out pipe portion 161, relative to a third plane PL3 being parallel to the camshaft 141 and containing the cylinder axis C.

[0064] Meanwhile, the throttle body 129 is connected to an air cleaner 165 disposed on the rear side of the throttle body 129 and supported on the vehicle body frame 11. The cylinder head 33, the fuel injection valve 135, and the throttle body 129 in the engine E configured to be of the SOHC type as above-described are disposed between the left-right pair of main frames 13, 13 possessed by the vehicle body frame 11.

[0065] In addition, an exhaust pipe 166 with its upstream end connected to the exhaust port 123 in the cylinder head 33 is extended rearwards on the right side of the engine main body 30, and the downstream end of the exhaust pipe 166 is connected to an exhaust muffler 167 disposed on the right upper side of the rear wheel WR.

[0066] Next, functions of the present embodiment will be described. The pair of intake valves 118 · · · and the pair of exhaust valves 119 · · · are openably and closably disposed in the cylinder head 33 with their operating axes intersect in a roughly V shape on the projection onto the first plane PL1 containing the cylinder axis C. The valve-operating device 140 for opening and closing both of the intake valves 118 · · · and both of the exhaust valves 119 · · · includes the camshaft 141 which is disposed between both of the intake valves 118 · · · and both of the exhaust valves 119 · · ·, with its axis orthogonal to the first plane PL1, and to one end portion of which the rotational power is inputted from the crankshaft 36 through the timing power transmission device 147. In this case, the camshaft 141 is disposed at a position deviated toward the side of the chain chamber 151 containing the cam chain 150 in a movable state therein so that its other end portion corresponds substantially to a central portion of the combustion chamber 117. Moreover, of the valve-operating chamber forming walls 33a, 34a provided in the cylinder head 33 and the head cover 34 so as to form the circumferential wall of the valve-operating chamber 144 containing the valve-operating device 140 therein, the portion corresponding to the other end portion of the camshaft 141 is provided with the recessed portion 158, and the spark plug 159 with its tip end portion fronting on a roughly central portion of the combustion chamber 117 and with its rear end portion disposed at the recessed portion 158 is attached to the cylinder head 33 in an inclined state so that its rear end side is spaced away from the chain chamber 151.

[0067] Therefore, the spark plug 159 can be disposed at the recessed portion 158 formed in the valve-operating chamber forming walls 33a, 34a correspondingly to a free space generated due to the deviation of the camshaft 141 toward the side of the chain chamber 151, while obviating the interference thereof with the valve-operating chamber 144. In addition, the cylinder head 33 is provided with the cooling water lead-out pipe portion 161 for leading out the cooling water from the cooling jacket 87. In this case, the cooling water lead-out pipe portion 161 disposed on the opposite side of the chain chamber 151 and on the outer side of the valve-operating chamber forming walls 33a, 34a and deviated from the recessed portion 158 toward the side of either the intake valves 118 · · · or the exhaust valves 119 · · ·, in this embodiment, toward the side of the exhaust valves 119 · · ·, is provided in the cylinder head 33 so as to extend substantially in parallel to the cylinder axis C.

[0068] Therefore, the cooling water lead-out pipe portion 161 extending substantially in parallel to the cylinder axis C can be provided in the cylinder head 33 while securing maintainability of the spark plug 159 and enabling a reduction in the size of the engine at or around the cylinder head 33.

[0069] In addition, the angle $\alpha 1$ formed between the operating axes of the exhaust valves 119 · · · , which are closer to the cooling water lead-out pipe portion 161, of the intake valves 118 · · · and the exhaust valves 119 · · · , and the cylinder axis C on the projection onto the first plane PL1 is set smaller than the angle $\alpha 2$ formed between the operating axes of the intake valves 118 · · · and the cylinder axis C on the projection, and the opening portion, opening into the combustion chamber 117, of the plug mount hole 160 provided in the cylinder head 33 for mounting the spark plug 159 is disposed to be deviated from the cylinder axis C toward the side of the intake valves 118 · · ·. In other words, the distance between the opening portion, opening into the combustion chamber 117, of the plug mount hole 160 and the plurality of intake valve ports 120 · · · provided in the cylinder head 33 in the state of fronting on the combustion chamber 117 so as to open and close each of the intake valves 118 · · · is set smaller than the distance between the plurality of exhaust valve ports 122 · · · provided in the cylinder head 33 in the state of fronting on the combustion chamber 117 so as to open and close each of the exhaust valves 119 · · · and the opening portion of the plug mount hole 160. Therefore, the area of the cooling passage in the cooling jacket 87 can be set comparatively large between the valve axes of the exhaust valves 119 · · · , which are closer to the cooling water lead-out pipe portion 161, of the intake valves 118 · · · and the exhaust valves 119 · · · , and the spark plug 159. In addition, the cooling water is led out from the cooling jacket 87 on the side closer to the exhaust valves 119 · · · , so that the flow rate of the cooling water is higher in the surroundings of the exhaust valves 119 · · · . As a

result of these points, it is possible to contrive enhancement of the cooling performance for the cylinder head 33 in the surroundings of the exhaust valves 119· · ·.

[0070] Besides, the axis of the camshaft 141 is disposed to be deviated toward the opposite side of the cooling water lead-out pipe portion 161, relative to the third plane PL3 being parallel to the camshaft 141 and containing the cylinder axis C. Thus, the angle formed between the operating axes of the exhaust valves 119 · · · , which are the valves closer to the cooling water lead-out pipe portion 161, and the cylinder axis C can be set so smaller as to obviate the interference with the camshaft 141, whereby it is possible to further enhance the cooling performance for the exhaust valves 119 · · · which are the valves closer to the cooling water lead-out pipe portion 161.

[0071] Furthermore, the cylinder head 33 is integrally provided with the connection cylinder portion 138 projecting to the outer side relative to the coupling portion of the cylinder head 33 and the head cover 34 so as to form the inlet portion 121a of the intake port 121 so that the axis of the inlet portion 121a is disposed in the second plane PL2 substantially orthogonal to the cylinder axis C. The connection cylinder portion 138 is provided with a mount hole 136 in which to fit liquid-tight the tip end portion of the fuel injection valve 135 attached to the cylinder head 33 so as to inject the fuel toward the intake port 121, and the throttle body 129 is connected to the connection cylinder portion 138 through the insulator 128 so that the axis of the intake passage 130 is disposed in the second plane PL2.

[0072] According to such a mount structure of the fuel injection valve 135 as above, most part, exclusive of the tip end portion, of the fuel injection valve 135 can be exposed to the exterior of the cylinder head 33 while disposing the throttle body 129 close to the cylinder head 33, and the fuel injection valve 135 can be effectively cooled while enabling a reduction in the overall size of the engine E including the throttle body 129.

[0073] In addition, the insulator 128 is so formed as to be bent in the second plane PL2, and the throttle drum 133 possessed by the throttle body 129 is disposed on the opposite side of the cylinder head 33. Therefore, the throttle body 129 can be disposed closer to the side of the cylinder head 33 due to the bending of the insulator 128, and the fuel injection valve 135 is prevented from constituting an obstacle in disposing the throttle wire 134 which is wrapped around the throttle drum 133.

[0074] Moreover, the engine E is configured to be of the SOHC type in which the intake valves 118 · · · and the exhaust valves 119 · · · are openably and closably disposed in the cylinder head 33, with their operating axes intersecting in a roughly V shape on the projection onto the first plane PL1 containing the cylinder axis C and the axis of the inlet portion 121a of the intake port 121, and the camshaft 141 with its axis substantially parallel to the axis of the inlet portion 121a of the intake port 121 is disposed between the intake valves 118 · · · and the exhaust valves 119· · ·. Therefore, it is possible to reduce as much as possible the width of an upper portion of the cylinder head 33, to thereby cause more part of the fuel injection valve 135 to project from the cylinder head 33, and to cool the fuel injection valve 135 more effectively.

[0075] Besides, the cylinder head 33, the fuel injection valve 135, and the throttle body 129 in the single-cylinder engine E are disposed between the left-right pair of main frames 13, 13 possessed by the vehicle body frame 11. Therefore, it is possible to dispose the fuel injection valve 135 and the throttle body 129 while reducing the spacing between the left-right pair of main frames 13, 13, which contributes to enhancement of the property for the rider to ride astride and of riding comfort.

[0076] While one embodiment of the present invention has been described above, the present invention is not limited to the above embodiment, and various design modifications are possible without departure from the present invention as defined by the claims.

Claims

1. A water-cooled type engine comprising

a cylinder head (33) in which an intake valve (118) and an exhaust valve (119) are openably and closably disposed with their operating axes intersecting in a roughly V shape, said cylinder head (33) being provided with a cooling jacket (87) for passing cooling water therethrough and a cooling water lead-out pipe portion (161) for leading out said cooling water from said cooling jacket (87), and said cylinder head (33) being provided with a chain chamber (151) on which one end portion of a camshaft (141) disposed between said intake valve (118) and said exhaust valve (119) fronts,

wherein said camshaft (141) is disposed at a position deviated toward the side of said chain chamber (151) with its other end portion corresponding substantially to a central portion of a combustion chamber (117), a portion corresponding to said other end portion of said camshaft (141), of valve-operating chamber forming walls (33a, 34a) provided in said cylinder head (33) and a head cover (34) coupled to said cylinder head (33) so as to form a circumferential wall of a valve-operating chamber (144) containing a valve-operating device (140) including said camshaft (141), is provided with a recessed portion (158), a spark plug (159) with its tip end portion fronting on a roughly central portion of said combustion chamber (117) and with its rear end portion disposed at said recessed portion (158) is attached to said cylinder head (33) in an inclined state so that its rear end side is spaced away from said chain chamber (151) , and said cooling water lead-out pipe portion (161) disposed on the opposite side of said chain chamber (151)

and on the outer side of said valve-operating chamber forming walls (33a, 34a) and deviated from said recessed portion (158) toward the side of either one of said intake valve (118) and said exhaust valve (119) is provided in said cylinder head (33) so as to extend substantially in parallel to the cylinder axis (C).

2. The water-cooled type engine as set forth in claim 1, wherein the angle (α1) formed between the operating axis of one valve, closer to said cooling water lead-out pipe portion (161), of said intake valve (118) and said exhaust valve (119) and said cylinder axis (C) on a projection onto a plane (PL1) containing said cylinder axis (C) is set smaller than the angle (α2) formed between the operating axis of the other valve of said intake valve (118) and said exhaust valve (119) and said cylinder axis (C) on said projection, and an opening portion, opening into said combustion chamber (117), of a plug mount hole (160) provided in said cylinder head (33) for mounting said spark plug (159) is disposed to be deviated from said cylinder axis (C) toward the side of said other valve.

3. The water-cooled type engine as set forth in claim 2, wherein the axis of said camshaft (141) is disposed to be deviated toward the opposite side of said cooling water lead-out pipe portion (161) relative to a plane (PL3) being parallel to said camshaft (141) and containing said cylinder axis (C).

4. A water-cooled type engine comprising

a cylinder head (33) in which an intake valve (118) and an exhaust valve (119) are openably and closably disposed with their operating axes intersecting in a roughly V shape, said cylinder head (33) being provided with a cooling jacket (87) for passing cooling water therethrough and a cooling water lead-out pipe portion (161) for leading out said cooling water from saidcooling jacket (87), and said cylinder head (33) being provided with a chain chamber (151) on which one end portion of a camshaft (141) disposed between said intake valve (118) and said exhaust valve (119) fronts,

wherein said camshaft (141) is disposed at a position deviated toward the side of said chain chamber (151) with its other end portion corresponding substantially to a central portion of a combustion chamber (117), a portion corresponding to said other end portion of said camshaft (141), of valve-operating chamber forming walls (33a, 34a) provided in said cylinder head (33) and a head cover (34) coupled to said cylinder head (33) so as to form a circumferential wall of a valve-operating chamber (144) for containing a valve-operating device (140) including said camshaft (141), is provided with a recessed portion (158), a spark plug (159) with its tip end portion fronting on a roughly central portion of said combustion chamber (117) and with its rear end portion disposed at said recessed portion (158) is attached to said cylinder head (33) in an inclined state so that its rear end side is spaced away from said chain chamber (151), said cooling water lead-out pipe portion (161) disposed on the opposite side of said chain chamber (151) and on the outer side of said valve-operating chamber forming walls (33a, 34a) and deviated from said recessed portion (158) toward the side of a plurality of said exhaust valves (119) is provided in said cylinder head (33) so as to extend substantially in parallel to the cylinder axis (C), the angle (α1) formed between the operating axes of said exhaust valves (119) and said cylinder axis (C) on a projection onto a plane (PL1) containing said cylinder axis (C) is set smaller than the angle (α2) formed between the operating axes of said intake valves (118) and said cylinder axis (C) on said projection, and the distance between an opening portion, opening into said combustion chamber (117), of a plug mount hole (160) provided in said cylinder head (33) for mounting said spark plug (159) and a plurality of intake valve ports (120) provided in said cylinder head (33) in the state of fronting on said combustion chamber (117) so as to open and close each said intake valve (118) is set smaller than the distance between a plurality of exhaust valve ports (122) provided in said cylinder head (33) in the state of fronting on said combustion chamber (117) so as to open and close each said exhaust valve (119) and said opening portion of said plug mount hole (160).

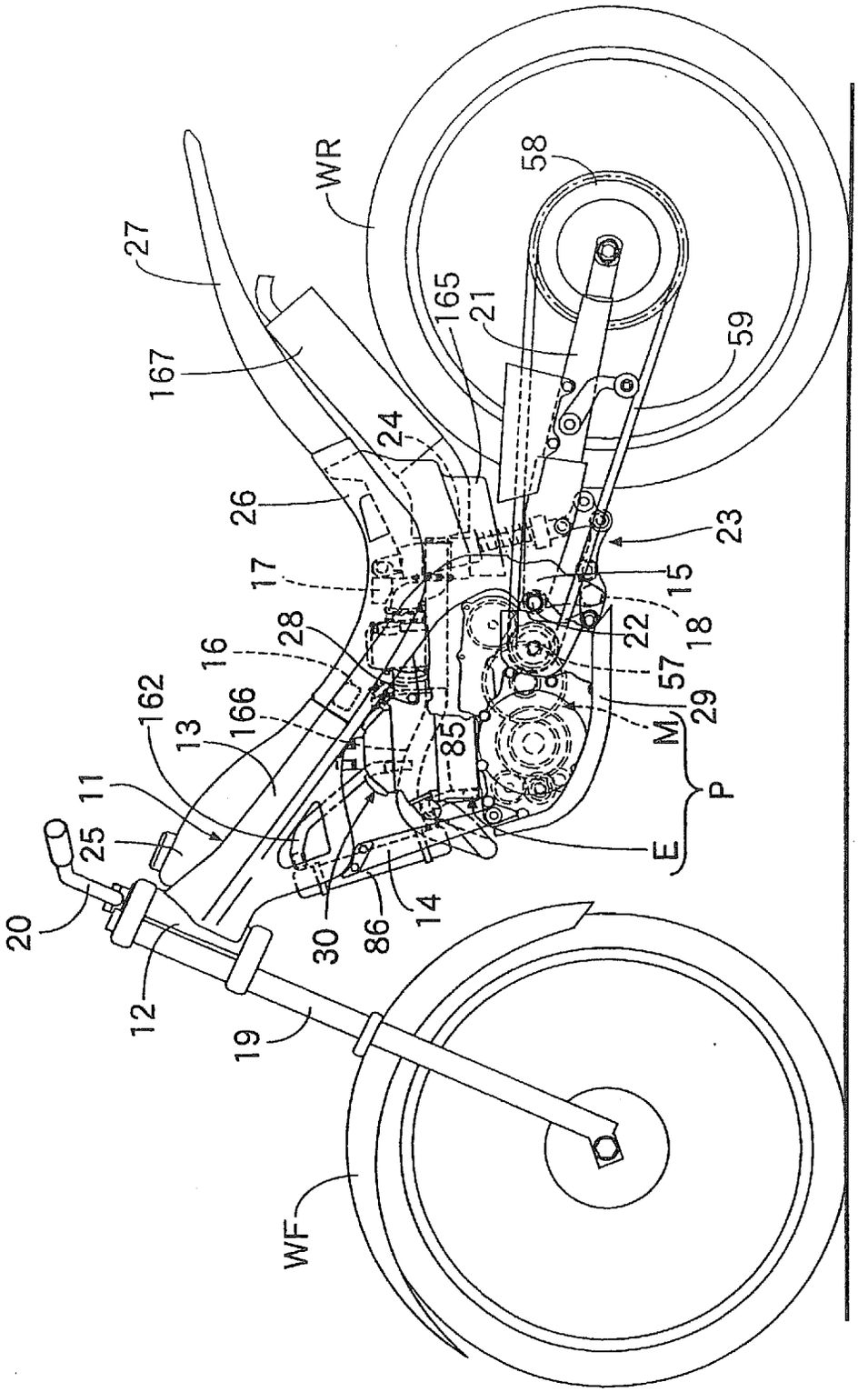

WR
58
27
165
21
59
167
24
26
23
17
15
22
18
28
16
57
162
29
13
166
M
85
11
P
25
E
20
30
86
14
12
19
WF

FIG. 1

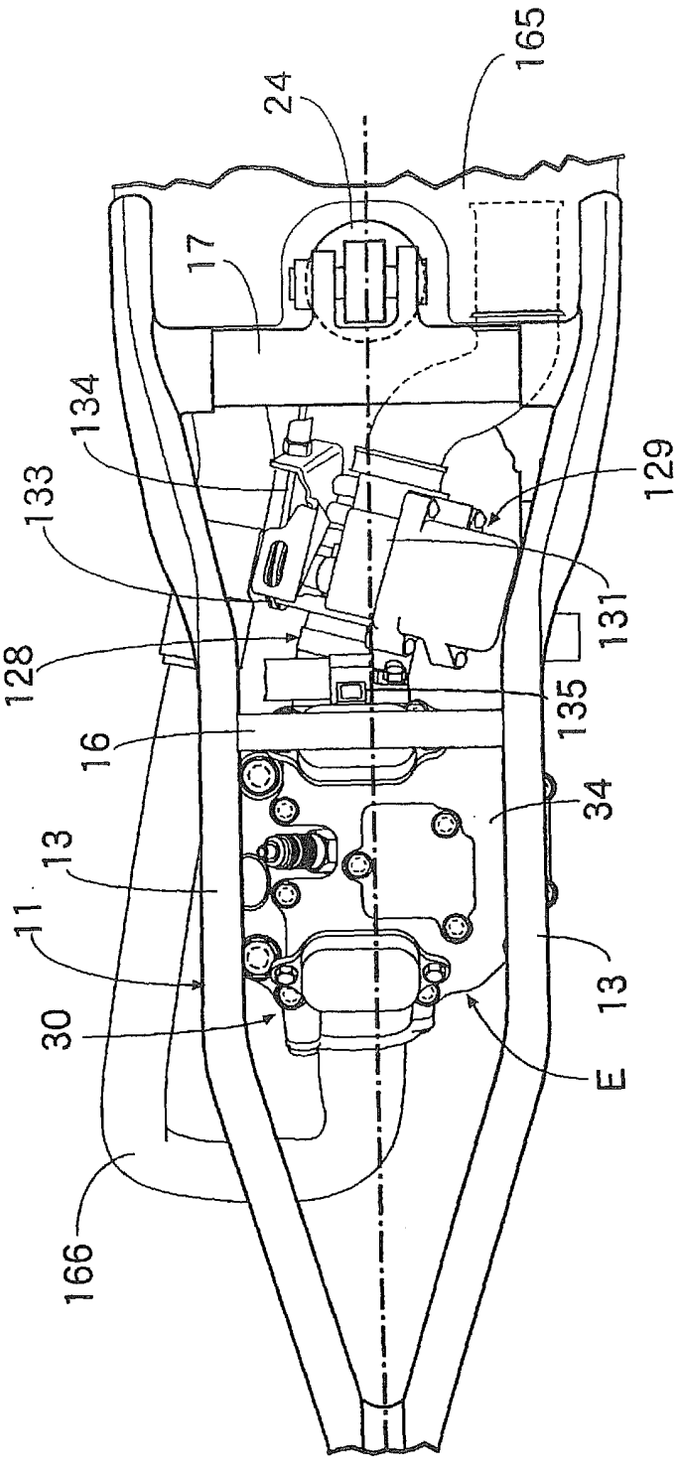


FIG. 2

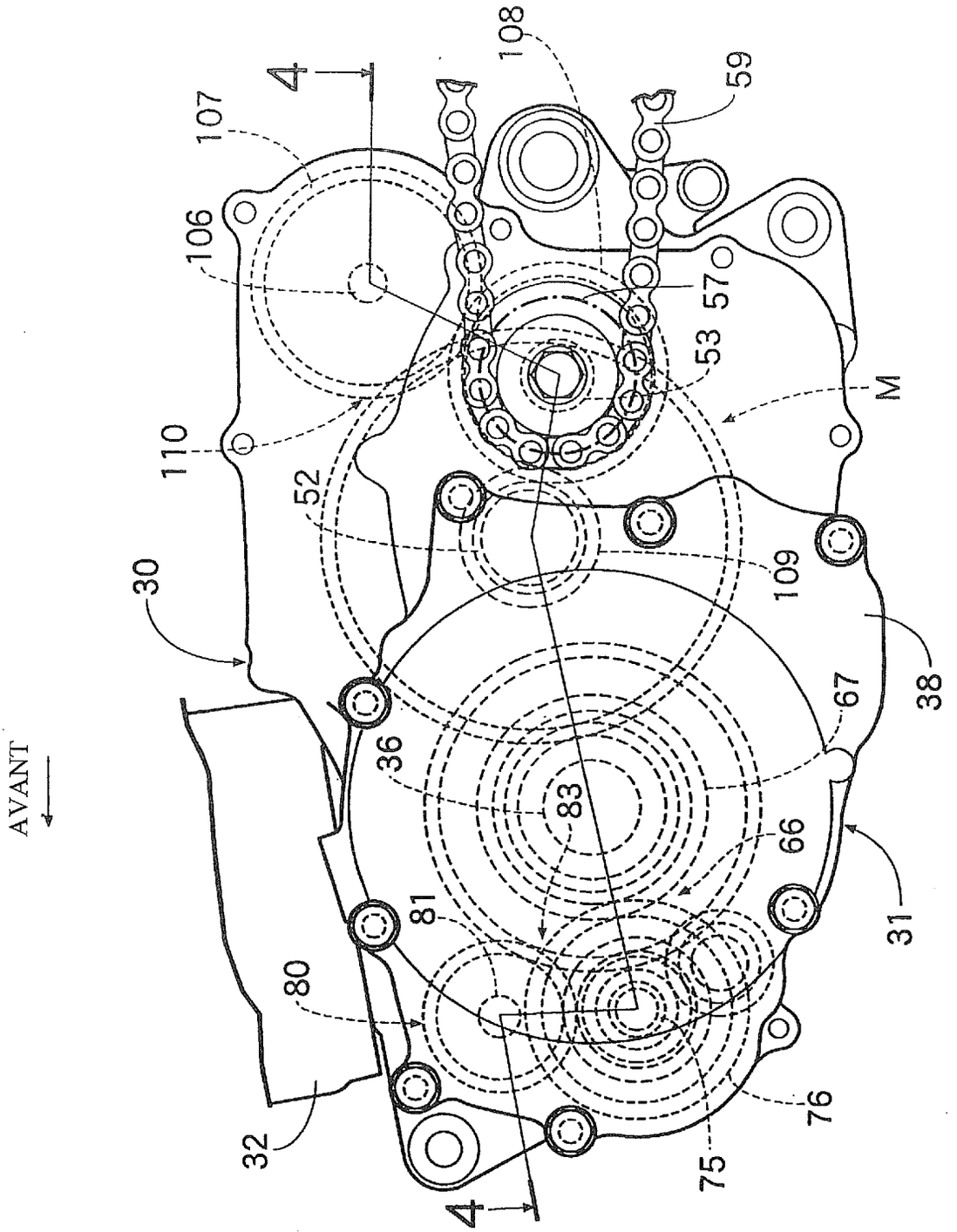
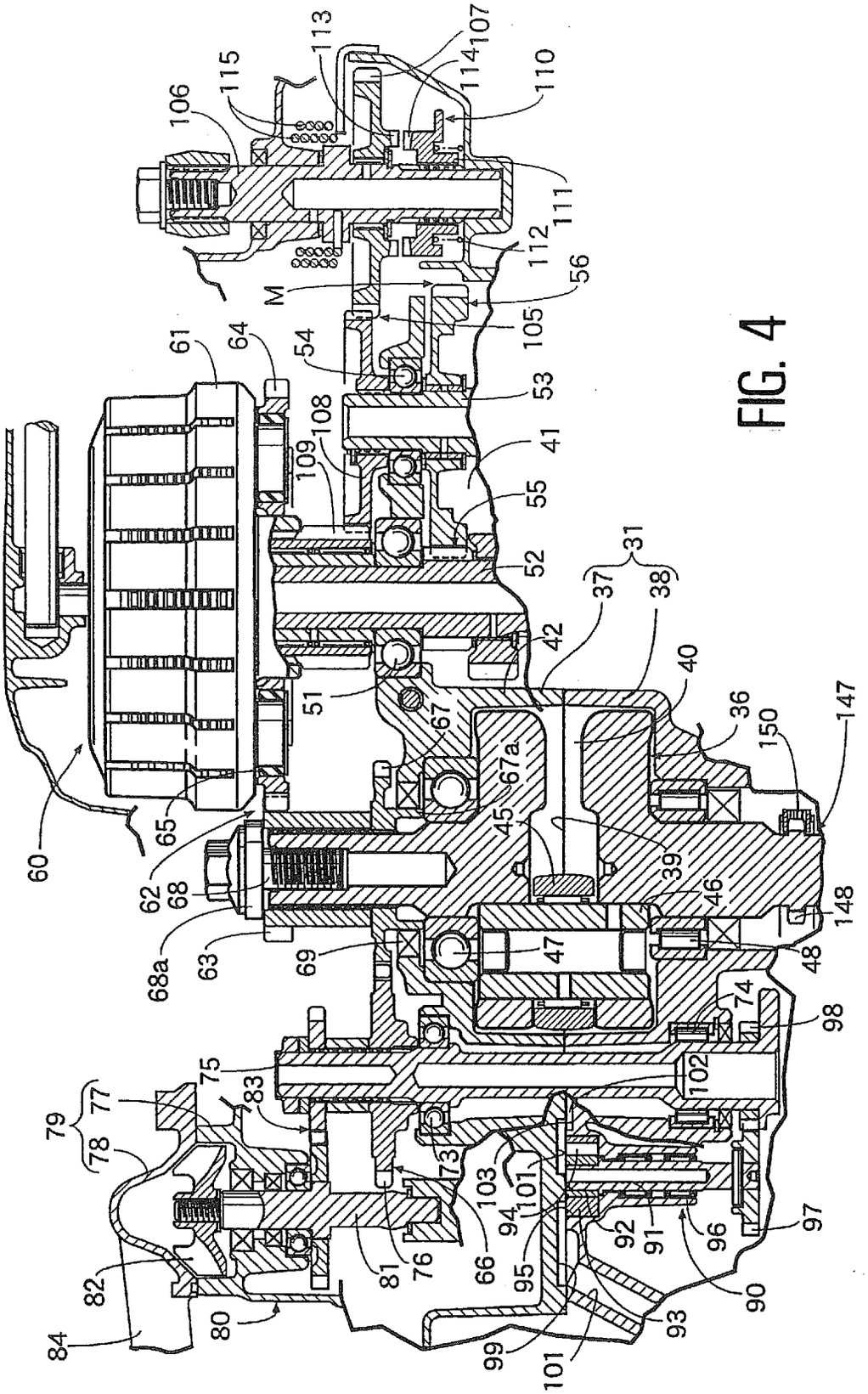

AVANT
4
4
107
106
110
30
32
80
81
36
52
108
59
57
53
M
109
38
67
66
83
31
76
75

FIG. 3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38
42
40
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67
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150
147
67a
45
39
46
148
62
68
68a
63
69
47
48
74
98
75
102
83
79
77
78
73
103
101
94
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66
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81
76
82
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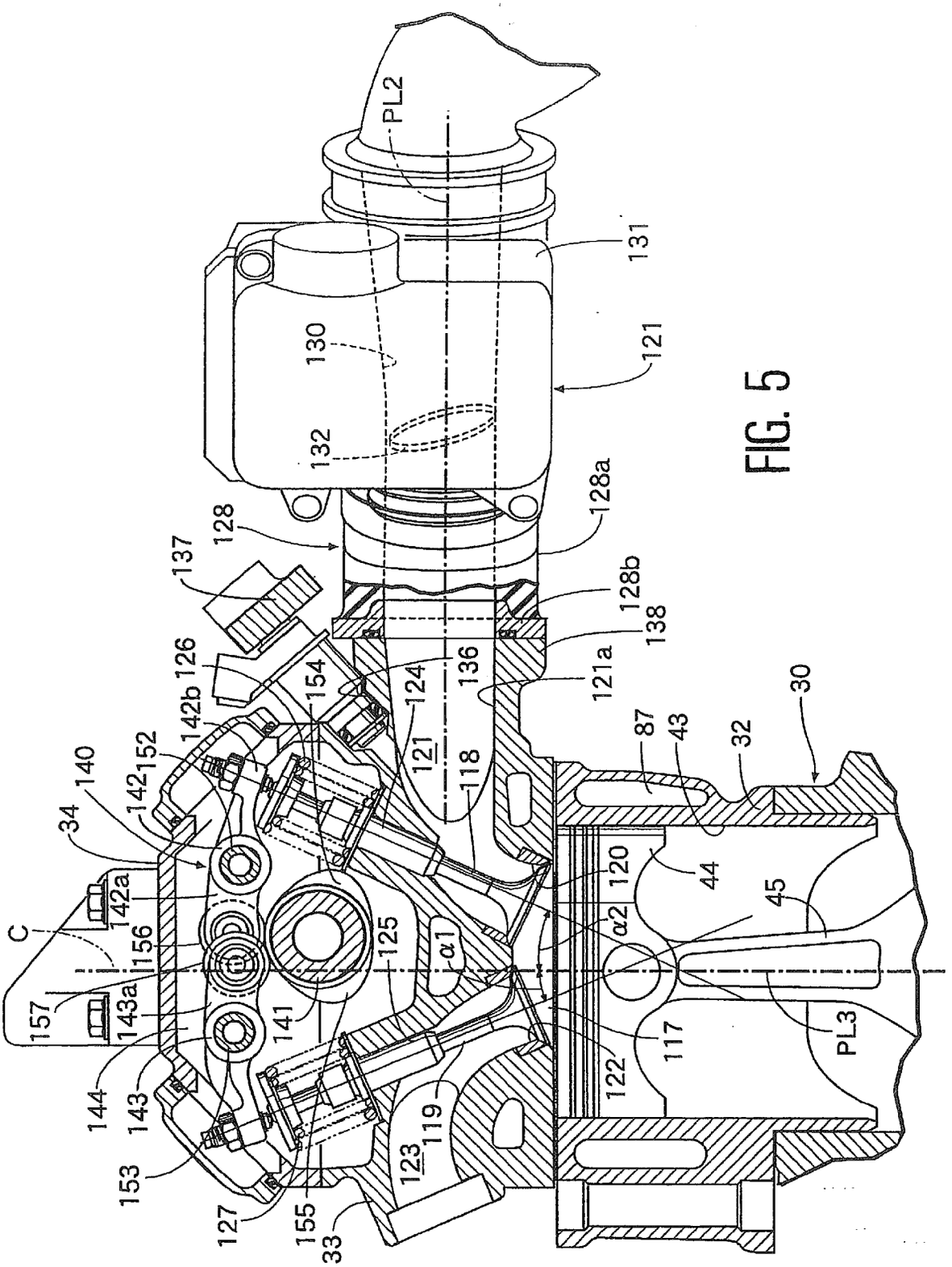
84
90
93
99
101
60
65

FIG. 4


PL2
131
130
121
132
128a
128
137
128b
138
126
121a
136
154
124
142b
152
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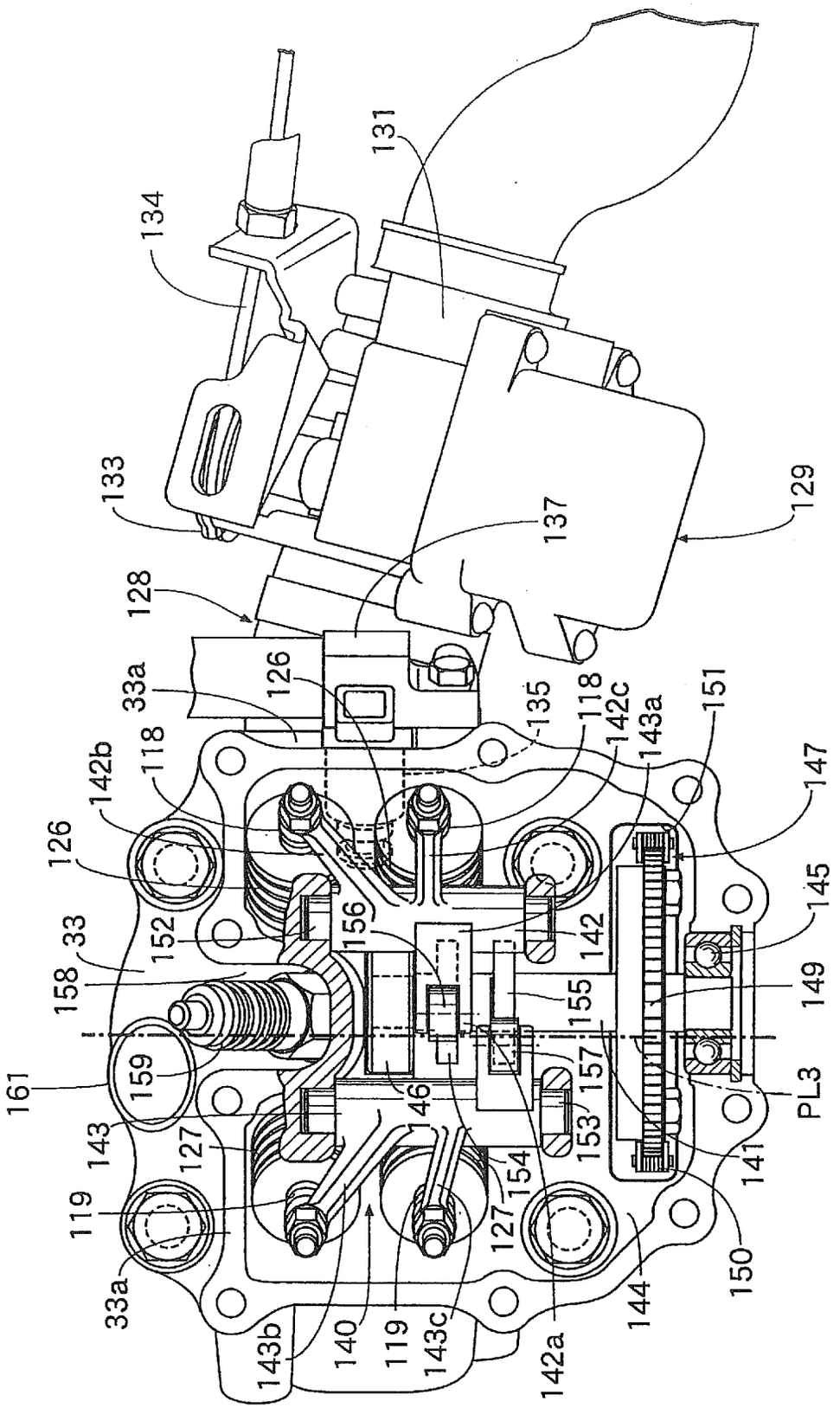
142
34
121
118
87
43
32
30
142a
120
44
45
C
156
125
α1
α2
143a
157
141
117
PL3
144
143
122
119
153
123
127
155
33

FIG. 5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134
133
129
137
128
33a
126
135
118
142c
143a
151
142b
118
147
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145
33
152
156
142
158
149
155
159
161
157
PL3
146
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127
154
141
119
127
150
33a
144
140
119
143c
142a
143b

FIG. 6

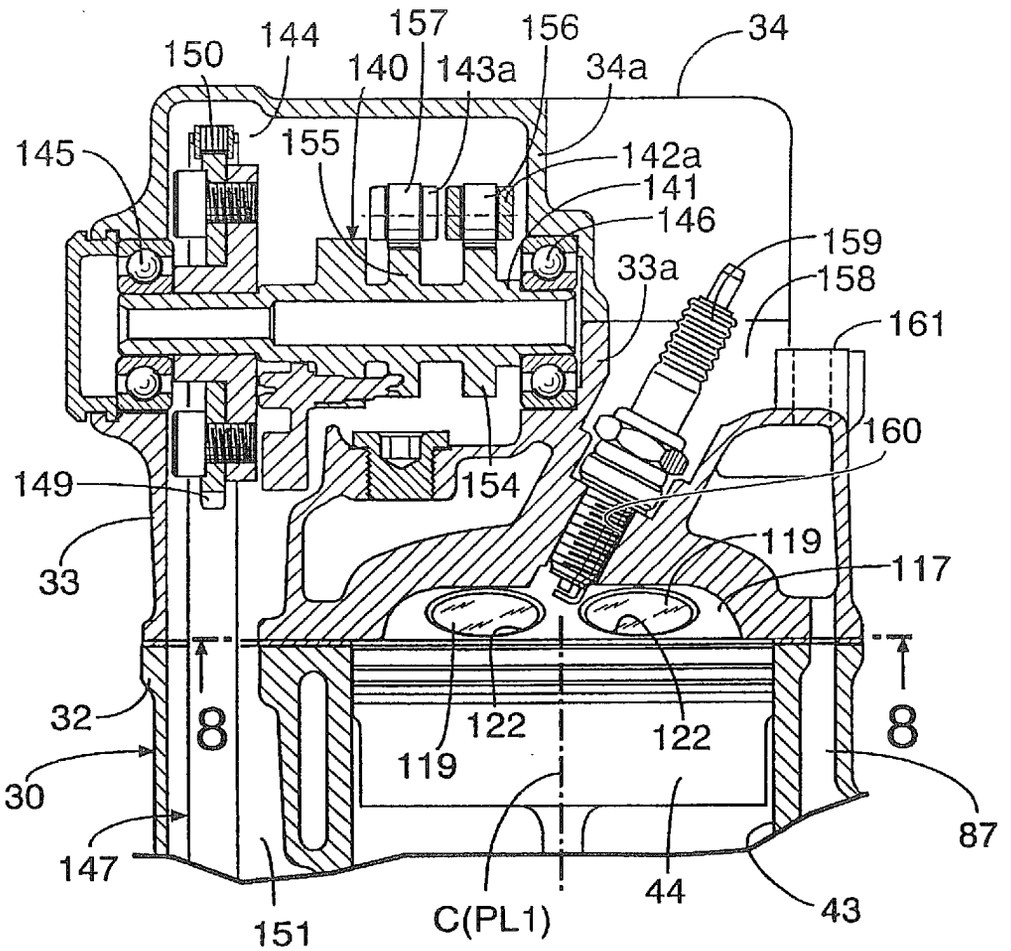
150
144
157
156
34
140
143a
34a
145
155
142a
141
146
159
33a
158
161
160
149
154
33
119
117
32
8
8
122
122
119
30
87
147
44
43
151
C(PL1)

FIG. 7

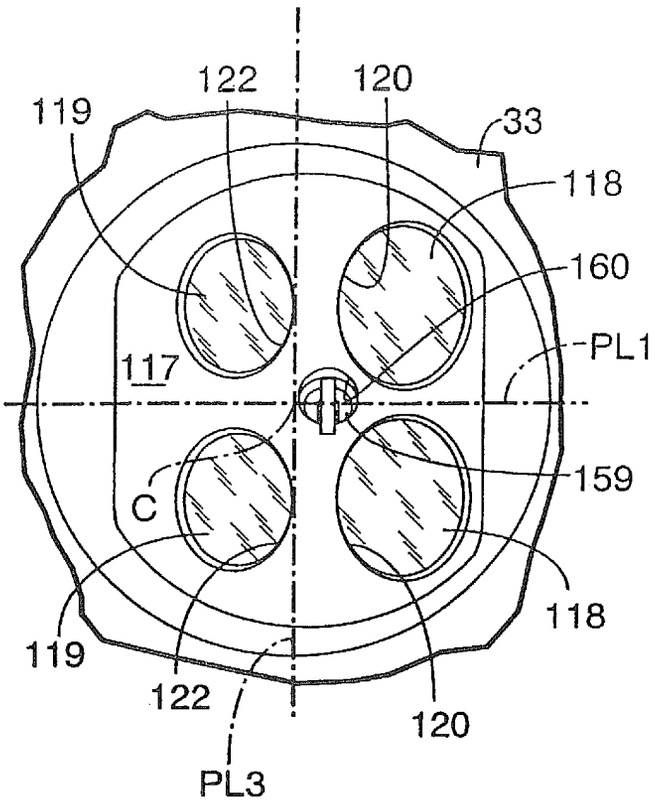

FIG. 8