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

(11) **EP 4 549 711 A1**

(12) **EUROPEAN PATENT APPLICATION**
published in accordance with Art. 153(4) EPC

(43) Date of publication:
07.05.2025 Bulletin 2025/19

(21) Application number: **23830763.1**

(22) Date of filing: **03.04.2023**

(51) International Patent Classification (IPC):
F01P 3/02 *(2006.01)* ***F01P 11/08*** *(2006.01)*
F02F 1/36 *(2006.01)*

(52) Cooperative Patent Classification (CPC):
F01P 3/02; F01P 11/08; F02F 1/36

(86) International application number:
PCT/JP2023/013794

(87) International publication number:
WO 2024/004309 (04.01.2024 Gazette 2024/01)

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

(30) Priority: **30.06.2022 JP 2022105600**

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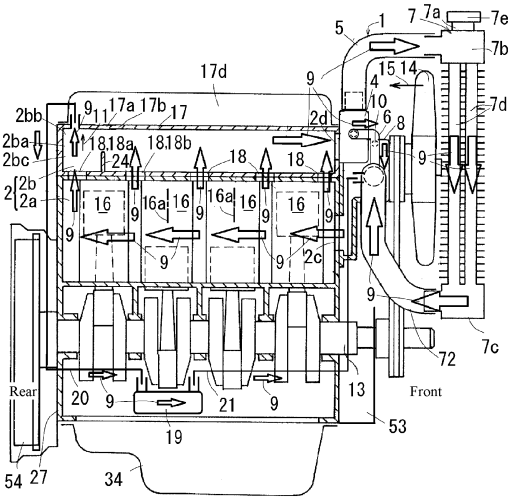
(54) WATER-COOLED ENGINE

(57) Provided is a water-cooled engine in which cooling performance of a rear end-side head portion 17a is improved. A plurality of water floating ports 18 opened on a peripheral side of each cylinder 16 is provided between a cylinder jacket 2a and a head jacket 2b. Engine cooling water 9 floats from the cylinder jacket 2a to the head jacket 2b via the plurality of water floating ports 18. The head jacket 2b includes a rear end-side jacket portion 2ba facing a rear end-side water floating port 18a in the rear end-side head portion 17a of a cylinder head 17 among the plurality of water floating ports 18. An oil cooler 19 that is cooled with water, a cooler water supply pipe 20 from the head jacket 2b to the oil cooler 19, and a cooler drain pipe 21 from the oil cooler 19 to a water pump 8 are provided. The cooler water supply pipe 20 is led out from the rear end-side jacket portion 2ba.

FIG. 2



EP 4 549 711 A1

Description

TECHNICAL FIELD

[0001] The present invention relates to a water-cooled engine, and particularly to a water-cooled engine in which cooling performance of a rear end-side head portion is improved.

BACKGROUND ART

[0002] Conventionally, there is a water-cooled engine provided with a cooling water circulation path of an engine by a water pump (see, for example, Patent Document 1).

PRIOR ART DOCUMENTS

PATENT DOCUMENTS

[0003] Patent Document 1: Japanese Patent Application Laid-open No. 2018-105277 (see Fig. 1)

SUMMARY OF THE INVENTION

PROBLEMS TO BE SOLVED BY THE INVENTION

[0004] <<Problems>> The cooling performance of a rear end-side head portion may be deteriorated.

[0005] In the engine of Patent Document 1, since a cooler water supply pipe of a water-cooled oil cooler is led out from a rear end side of a cylinder jacket, a floating amount of engine cooling water from the cylinder jacket to the rear end-side jacket portion of a head jacket is insufficient, and the cooling performance of the rear end-side head portion may be deteriorated.

[0006] An object of the present invention is to provide a water-cooled engine in which cooling performance of a rear end-side head portion is improved.

SOLUTIONS TO THE PROBLEMS

[0007] The main configuration of the present invention is as follows.

[0008] In a water-cooled engine, as exemplified in Figs. 3(A) and 3(B), a water jacket (2) includes a cylinder jacket (2a) around a cylinder (16) and a head jacket (2b) in a cylinder head (17), as exemplified in Fig. 3(A), the cylinder jacket (2a) includes a jacket inlet (2c) at a front end, as exemplified Fig. 3(B), the head jacket (2b) includes a jacket outlet (2d) at a front end, a plurality of water floating ports (18) opened on a peripheral side of each of the cylinder (16) is provided between the cylinder jacket (2a) and the head jacket (2b), engine cooling water (9) floats from the cylinder jacket (2a) to the head jacket (2b) via the plurality of water floating ports (18), the head jacket (2b) includes a rear end-side jacket portion (2ba) facing a rear end-side water floating port (18a) at a rear end-side head portion (17a) of the cylinder head (17) among the plurality of water floating ports (18), as exemplified in Fig. 2, the water-cooled engine includes an oil cooler (19) that is cooled with water, a cooler water supply pipe (20) from the head jacket (2b) to the oil cooler (19), and a cooler drain pipe (21) from the oil cooler (19) to a water pump (8), and the cooler water supply pipe (20) is led out from the rear end-side jacket portion (2ba).

EFFECTS OF THE INVENTION

[0009] The present invention has the following effects.

[0010] <<Effect>> The cooling performance of the rear end-side head portion (17a) is improved.

[0011] In this engine, since a water absorbing force of the water pump (8) is applied to the rear end-side jacket portion (2ba) via the cooler drain pipe (21), the oil cooler (19), and the cooler water supply pipe (20) in this order, a large amount of engine cooling water (9) is sucked up from the rear end-side water floating port (18a) to the rear end-side jacket portion (2ba), and the cooling performance of the rear end-side head portion (17a) where the engine cooling water (9) is originally difficult to float is improved.

[0012] <<Effect>> The cooling performance of the engine is enhanced.

[0013] In this engine, since a large amount of engine cooling water (9) floats up from the rear end-side water floating port (18a) to the rear end-side jacket portion (2ba), it is not necessary to reduce a passage sectional area of the other water floating port (18) for this purpose, and the passage resistance of a cooling water circulation path (1) can be reduced, and the cooling performance of the engine is enhanced.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014]

Fig. 1 is a front view of a cooling water circulation path of an engine used in a water-cooled engine according to an embodiment of the present invention.

Fig. 2 is a side view of the cooling water circulation path in Fig. 1.

Fig. 3(A) is a plan view of a cylinder block used in the cooling water circulation path of Fig. 1, Fig. 3(B) is a plan view of a cylinder head, and Fig. 3(C) is a sectional view taken along line C-C of Fig. 3(B).

Fig. 4(A) is a sectional view taken along line IVA-IVA of Fig. 3(A), Fig. 4(B) is a sectional view taken along line B-B of Fig. 4(A), Fig. 4(C) is a sectional view taken along line C-C of Fig. 4(A), and Fig. 4(D) is a sectional view taken along line D-D of Fig. 4(A).

Fig. 5 is a side view of a fuel supply device and a lubricating device used in the water-cooled engine according to the embodiment of the present invention.

Fig. 6(A) is a side view of a cylinder block used in the

water-cooled engine according to the embodiment of the present invention, Fig. 6(B) is a side view of an auxiliary machine attachment base, Fig. 6(C) is a sectional view taken along line C-C of Fig. 6(B), Fig. 6(D) is a sectional view taken along line D-D of Fig. 6(B), Fig. 6(E) is a sectional view taken along line E-E of Fig. 6(C), and Fig. 6(F) is a sectional view taken along line F-F of Fig. 6(D).

Fig. 7(A) is a side view of a modification of the auxiliary machine attachment base, Fig. 7(B) is a sectional view taken along line B-B of Fig. 7(A), Fig. 7(C) is a side view of the modification of an oil branch pipe, and Fig. 7 (D) is an enlarged sectional view of a portion D of Fig. 7(C).

Fig. 8 is a front view of the water-cooled engine according to the embodiment of the present invention.

Fig. 9 is a rear view of the water-cooled engine according to the embodiment of the present invention.

Fig. 10 is a side view of the water-cooled engine according to the embodiment of the present invention.

EMBODIMENTS OF THE INVENTION

[0015] Figs. 1 to 10 are diagrams for describing a water-cooled engine according to an embodiment of the present invention. In this embodiment, a vertical four-cycle in-line four-cylinder diesel engine will be described.

[0016] As illustrated in Fig. 10, the engine includes a cylinder block (27), a cylinder head (17) assembled to an upper portion of the cylinder block (27), a head cover (17d) assembled to an upper portion of the cylinder head (17), a crankshaft (13) housed in a crankcase (27c) of the cylinder block (27), a gear case (53) assembled to a front side of the cylinder block (27) with an installation direction of the crankshaft (13) as a front-rear direction, one side in a front-rear direction as a front, and the other side as a rear, an engine cooling fan (14) disposed on a front side of the gear case (53), and a flywheel (54) attached to the crankshaft (13) on a rear side of the cylinder block (27).

[0017] The engine cooling fan (14) blows engine cooling air (15) backward.

[0018] As illustrated in Fig. 3(B), when viewed in a direction parallel to a cylinder center axis (16a), a width direction of the cylinder head (17) orthogonal to the front-rear direction is defined as a lateral direction, and as illustrated in Figs. 8 and 9, an intake manifold (55) is provided on one side in the lateral direction of the cylinder head (17), and an exhaust manifold (56) is provided on the other side.

[0019] The engine includes an intake device, a fuel supply device, an exhaust device, a valve device, an interlocking shaft, a lubricating device, and a water cooling device.

[0020] As illustrated in Fig. 10, the intake device includes an air cleaner (57), an air compressor (49b) of a supercharger (49) attached to an upper portion of the exhaust manifold (56), a supercharging pipe (49c), and the intake manifold (55) illustrated in Fig. 5.

[0021] The air purified by the air cleaner (57) illustrated in Fig. 10 is compressed by the air compressor (49b) and supercharged from the supercharging pipe (49c) to the intake manifold (55) illustrated in Fig. 5.

[0022] As illustrated in Fig. 5, the fuel supply device includes a fuel tank (58), a fuel supply pump (59), a common rail (60), a fuel injector (61), and an engine ECU (62). An electromagnetic valve of the fuel injector (61) is electrically connected to the engine ECU (62). The electromagnetic valve is opened for a predetermined time at a predetermined timing by control of the engine ECU (62). A predetermined injection amount of fuel (73) is injected from the fuel injector (61) into each cylinder (16) at a predetermined injection timing. The fuel (73) is light oil.

[0023] ECU is an abbreviation of an electronic control unit and is a microcomputer.

[0024] The injection timing is set by a crank angle, and the crank angle is detected on the basis of a pulse signal accompanying engine rotation formed by an electromagnetic pickup (63) electrically connected to the engine ECU (62).

[0025] As illustrated in Fig. 10, the exhaust device includes the exhaust manifold (56), an exhaust turbine (49d) of the supercharger (49), and an exhaust treatment device (74), and exhaust gas discharged from the exhaust manifold (56) is treated by a DOC and a DPF (not illustrated) in the exhaust treatment device (74) after driving the exhaust turbine (49d).

[0026] DOC is an abbreviation of diesel oxidation catalyst, and DPF is an abbreviation of diesel particulate filter.

[0027] As illustrated in Figs. 8 and 9, the valve device includes a valve cam shaft (64) and an intake and exhaust valve (not illustrated) driven by the valve cam shaft (64).

[0028] The valve cam shaft (64) is interlocked with the crankshaft (13) via a timing transmission gear train (not illustrated).

[0029] The crankshaft (13) is also interlocked with a pair of left and right secondary balancer shafts (65) and (65) via a timing transmission gear train.

[0030] As illustrated in Fig. 5, the lubricating device includes an oil pan (34), an oil strainer (66), an oil pump (35), an auxiliary machine attachment base (36), a base oil supply path (38) that supplies an engine oil (37) from the oil pump (35) to the auxiliary machine attachment base (36), a crankshaft oil supply path (39) that supplies the engine oil (37) from the base oil supply path (38) to a bearing (13a) of the crankshaft (13). As illustrated in Fig. 8, the lubricating device includes a pair of balancer shaft oil supply path (67) and (67) that supplies the engine oil (37) to the respective bearings (65a) of the pair of left and right secondary balancer shafts (65) and (65) via the

crankshaft oil supply path (39), and a camshaft oil supply path (68) that supplies the engine oil (37) from the bearing (65a) of the secondary balancer shaft (65) on an exhaust end side to a bearing (64a) of the valve cam shaft (64).

[0031] The oil cooler (19) and an oil filter (44) are attached to the auxiliary machine attachment base (36). The oil cooler (19) is disposed at a position higher than the oil filter (44).

[0032] As illustrated in Fig. 1, the water cooling device includes a cooling water circulation path (1) of the engine.

[0033] The cooling water circulation path (1) of the engine includes a water jacket (2) in the engine, a valve housing case (4) housing a thermostat valve (3), a main water path (5), a radiator (7), a water pump (8), and a bypass water path (6).

[0034] During operation of the engine, when the thermostat valve (3) is closed, which occurs when the water temperature of the engine cooling water in the water jacket (2) is lower than a predetermined temperature, all of the engine cooling water (9) in the water jacket (2) bypasses the radiator (7) and returns to the water jacket (2) via the valve housing case (4), the bypass water path (6), and the water pump (8) in order.

[0035] During operation of the engine, when the thermostat valve (3) is opened, which occurs when the temperature of the engine cooling water (9) in the water jacket (2) is higher than a predetermined temperature, most of the engine cooling water (9) in the water jacket (2) returns to the water jacket (2) via the valve housing case (4), the main water path (5), the radiator (7), and the water pump (8) in order, and a part of the engine cooling water (9) in the water jacket (2) bypasses the radiator (7) and returns to the water jacket (2) via the valve housing case (4), the bypass water path (6), and the water pump (8) in order.

[0036] That is, as illustrated in Fig. 1, the engine is configured such that a predetermined amount of the engine cooling water (9) of the water jacket (2) bypasses the radiator (7) and returns to the water jacket (2) via the valve housing case (4), the bypass water path (6), and the water pump (8) in order by a pressure feeding force of the water pump (8) during operation of the engine.

[0037] As illustrated in Fig. 1, the engine includes an air vent passage (10) that is led out in a horizontal direction or a rising direction from an upper portion of an impeller chamber (8a) of the water pump (8) and reaches the bypass water path (6), and an air passage portion (3a) that allows air to pass from a valve upstream side to a valve downstream side of the thermostat valve (3).

[0038] During supply of the engine cooling water (9) from a water supply port (7a) of the radiator (7) while the engine is stopped, air (11) that tends to stay in the upper portion of the impeller chamber (8a) of the water pump (8) is pushed out from the upper portion of the impeller chamber (8a) to the bypass water path (6) through the air vent passage (10) due to a rise of the water level of the cooling water circulation path (1), and is pushed out from the water supply port (7a) of the radiator (7) via the air passage portion (3a) and the main water path (5) in order from the bypass water path (6).

[0039] In this engine, during the supply of the engine cooling water (9), due to a rise of the water level of the cooling water circulation path (1), the air (11) that tends to stay in the upper portion of the impeller chamber (8a) of the water pump (8) is pushed out from the water supply port (7a) of the radiator (7), and the air (11) hardly remains in the cooling water circulation path (1) of the engine. Therefore, a deterioration of the cooling performance due to the circulation of the air (11) in the cooling water circulation path (1) hardly occurs during the operation of the engine, and the cooling performance of the engine is enhanced.

[0040] In addition, in this engine, since the circulation of the air (11) in the cooling water circulation path (1) hardly occurs during the operation of the engine, the cooling water circulation path (1) is hardly damaged by cavitation.

[0041] As illustrated in Fig. 1, in this embodiment, the air vent passage (10) is formed by a drilled hole led out in the horizontal direction from the impeller chamber (8a) and reaching the bypass water path (6), and the air passage portion (3a) is formed in the thermostat valve (3). However, the present invention is not limited to this configuration, and the air vent passage (10) may be led out obliquely upward or vertically upward from the impeller chamber (8a), and the air passage portion (3a) may be provided in the valve housing case (4).

[0042] Note that a pump housing (8b) of the water pump (8), a terminal end of a water path wall (6a) of the bypass water path (6), and a passage wall (10a) of the air vent passage (10) bridged between the pump housing and the terminal end are integrally molded by a continuous metal material, and the air vent passage (10) of the drilled hole is formed in the passage wall (10a) of the air vent passage (10).

[0043] As illustrated in Fig. 1, the engine includes a reserve tank (12) connected to the water supply port (7a) of the radiator (7).

[0044] In this engine, since the air (11) hardly remains in the cooling water circulation path (1), the amount of the engine cooling water (9) in the reserve tank (12) replaced with the air (11) decreases, and the frequency of supplying the engine cooling water (9) to the reserve tank (12) can be reduced.

[0045] As illustrated in Fig. 1, the radiator (7) includes an upper tank (7b), a lower tank (7c), and radiation pipes (7d) arranged side by side in an upright direction between the upper tank (7b) and the lower tank (7c), the upper tank (7b) is linked to the valve housing case (4) via the main water path (5), and the lower tank (7c) is linked to the water pump (8) via a return water path (72).

[0046] The water supply port (7a) is provided in the upper tank (7b) and is covered with a radiator cap (7e).

[0047] As illustrated in Fig. 1, the radiator cap (7e) is provided with a valve mechanism (7f). During operation of the engine, when the volume of the engine cooling

water (9) in the cooling water circulation path (1) expands due to an increase in temperature and the internal pressure of the cooling water circulation path (1) increases, the main pressure valve of the valve mechanism (7f) opens, and a part of the engine cooling water (9) in the cooling water circulation path (1) overflows and accumulates in the reserve tank (12). After the engine is stopped, when the internal pressure of the cooling water circulation path (1) decreases due to a decrease in temperature, a negative pressure valve of the valve mechanism (7f) opens, and a part of the engine cooling water (9) accumulated in the reserve tank (12) is drawn back to the cooling water circulation path (1).

[0048] As illustrated in Figs. 3(A) and 3(B), the water jacket (2) includes a cylinder jacket (2a) around the cylinder (16) and a head jacket (2b) in the cylinder head (17). As illustrated in Fig. 3(A), the cylinder jacket (2a) includes a jacket inlet (2c) at a front end. As illustrated in Fig. 3(B), the head jacket (2b) includes a jacket outlet (2d) at a front end, a plurality of water floating ports (18) opened on a peripheral side of each cylinder (16) is provided between the cylinder jacket (2a) and the head jacket (2b), the engine cooling water (9) floats from the cylinder jacket (2a) to the head jacket (2b) via the plurality of water floating ports (18), the head jacket (2b) includes a rear end-side jacket portion (2ba) facing a rear end-side water floating port (18a) in a rear end-side head portion (17a) of the cylinder head (17) of the plurality of water floating ports (18).

[0049] As illustrated in Fig. 2, the engine includes the water-cooled oil cooler (19), a cooler water supply pipe (20) from the head jacket (2b) to the oil cooler (19), and a cooler drain pipe (21) from the oil cooler (19) to the water pump (8), and the cooler water supply pipe (20) is led out from the rear end-side jacket portion (2ba).

[0050] In this engine, since a water absorbing force of the water pump (8) is applied to the rear end-side jacket portion (2ba) via the cooler drain pipe (21), the oil cooler (19), and the cooler water supply pipe (20) in this order, a large amount of engine cooling water (9) is sucked up from the rear end-side water floating port (18a) to the rear end-side jacket portion (2ba), and the cooling performance of the rear end-side head portion (17a) where the engine cooling water (9) is originally difficult to float is improved.

[0051] In this engine, since a large amount of engine cooling water (9) floats up from the rear end-side water floating port (18a) to the rear end-side jacket portion (2ba), it is not necessary to reduce a passage sectional area of the other water floating port (18) for this purpose, and a passage resistance of the cooling water circulation path (1) can be reduced, and the cooling performance of the engine is enhanced.

[0052] As illustrated in Fig. 2, the cooler water supply pipe (20) is led out from an upper end portion (2bb) of the rear end-side jacket portion (2ba).

[0053] In this engine, when the engine is inclined forward and downward, the air (11) and water vapor that tend to accumulate in the upper end portion (2bb) of the rear end-side jacket portion (2ba) are sucked out through the cooler water supply pipe (20), and thus, the air (11) and water vapor are less likely to stagnate in the rear end-side jacket portion (2ba), and the cooling performance of the rear end-side head portion (17a) is enhanced.

[0054] As illustrated in Fig. 3(B), the cooler water supply pipe (20) is led out from an intake end-side portion (2bc) of the rear end-side jacket portion (2ba) with an inlet (22a) side of an intake port (22) as an intake end side and an outlet (32a) side of an exhaust port (32) as an exhaust end side of both lateral sides.

[0055] In this engine, since the engine cooling water (9) having a relatively low temperature in the intake end-side portion (2bc) of the rear end-side jacket portion (2ba) is supplied from the cooler water supply pipe (20) to the oil cooler (19), the cooling performance of the oil cooler (19) is enhanced.

[0056] As illustrated in Fig. 3(B), the head jacket (2b) includes a near-rear-end inter-bore water path (23a) near a rear end of the cylinder head (17) of a plurality of inter-bore water paths (23) located between cylinder bores, a near-rear-end water floating port (18b) that supplies the engine cooling water (9) to the near-rear-end inter-bore water path (23a) among the plurality of water floating ports (18), a near-rear-end jacket portion (2bd) facing the near-rear-end water floating port (18b), and a partition wall (24).

[0057] The near-rear-end jacket portion (2bd) is disposed in a front side of the rear end-side jacket portion (2ba), and the partition wall (24) is disposed between the near-rear-end jacket portion (2bd) and the rear end-side jacket portion (2ba).

[0058] In this engine, the engine cooling water (9) floated from the near-rear-end water floating port (18b) to the near-rear-end jacket portion (2bd) is blocked by the partition wall (24) and is supplied to the near-rear-end inter-bore water path (23a) without being sucked out by the cooler water supply pipe (20) led out from the rear end-side jacket portion (2ba). Therefore, the cooling performance of a near-rear-end head portion (17b) of the cylinder head (17) is enhanced.

[0059] As illustrated in Fig. 3(B), the near-rear-end inter-bore water path (23a) is located between the cylinder (16) on a rearmost end side and the cylinder (16) in front of the cylinder (16).

[0060] As illustrated in Fig. 3(C), in this engine, the partition wall (24) links a lower peripheral wall (22b) of the intake port (22) and a head bottom wall (17c) of a cylinder head (17).

[0061] In this engine, since heat of the head bottom wall (17c) is dissipated to the lower peripheral wall (22b) of the intake port (22) via the partition wall (24), the cooling performance of the head bottom wall (17c) is enhanced.

[0062] In this engine, the partition wall (24) enhances the rigidity of the head bottom wall (17c).

[0063] As illustrated in Fig. 3(B), the cylinder head (17)

includes the inter-bore water path (23) located between the cylinder bores, and as illustrated in Fig. 4(A), head bolt bosses (25) disposed on both sides of the inter-bore water path (23) in the lateral direction, the head bolt bosses (25) include head bolts (26) inserted into the head bolt bosses, and the cylinder head (17) and the cylinder block (27) are fastened with a head gasket (28) interposed therebetween by a fastening force of the head bolts (26).

[0064] The cylinder head (17) includes a reinforcing wall (29) along one head bolt boss (25) of a pair of head bolt bosses (25) and (25) disposed on both sides in the lateral direction of the inter-bore water path (23), and a reinforcing rib (30) along the other head bolt boss (25), a water path bottom wall (23b) of the inter-bore water path (23) and a jacket ceiling wall (2be) of the head jacket (2b) are linked by the reinforcing wall (29), and the reinforcing rib (30) rises from the water path bottom wall (23b) toward the jacket ceiling wall (2be).

[0065] In this engine, since heat of the water path bottom wall (23b) is radiated from the reinforcing wall (29) and the reinforcing rib (30) to the engine cooling water (9) passing through the inter-bore water path (23), the cooling performance of the water path bottom wall (23b) is enhanced.

[0066] In this engine, since the fastening force of the head bolt (26) is transmitted to the water path bottom wall (23b) via the reinforcing wall (29) and the reinforcing rib (30), the sealability of the head gasket (28) is enhanced.

[0067] In this engine, the reinforcing wall (29) and the reinforcing rib (30) enhance the rigidity of the water path bottom wall (23b).

[0068] As illustrated in Fig. 4(B), the reinforcing wall (29) is coupled to a peripheral wall (22c) of the intake port (22).

[0069] In this engine, since heat of the water path bottom wall (23b) is dissipated to the peripheral wall (22c) of the intake port (22) via the reinforcing wall (29), the cooling performance of the water path bottom wall (23b) is enhanced.

[0070] In this engine, the reinforcing wall (29) coupled to the peripheral wall (22c) of the intake port (22) enhances the rigidity of the water path bottom wall (23b).

[0071] As illustrated in Figs. 4(A) and 4(C), the reinforcing rib (30) is disposed on a water path bottom wall portion (23c) on an exhaust end side of the water path bottom wall (23b).

[0072] In this engine, since the heat of the water path bottom wall portion (23c) on the exhaust end side, which is likely to overheat, is conducted to the reinforcing rib (30) and dissipated to the engine cooling water (9) passing in a large amount above the reinforcing rib (30), the cooling performance of the water path bottom wall portion (23c) on the exhaust end side is enhanced.

[0073] As illustrated in Fig. 4(A), a raised end surface (30a) of the reinforcing rib (30) is inclined downward from the head bolt boss (25) along which the reinforcing rib (30) extends toward the reinforcing wall (29).

[0074] Therefore, the fastening force of the head bolt (26) is transmitted to the water path bottom wall portion (23c) on the exhaust end side via the reinforcing rib (30), and the heat of the water path bottom wall portion (23c) on the exhaust end side is dissipated from the inclined wide raised end surface (30a) of the reinforcing rib (30) to a large amount of engine cooling water (9) flowing above the reinforcing rib (30). Thus, the cooling performance of the water path bottom wall portion (23c) on the exhaust end side is enhanced.

[0075] As illustrated in Fig. 4(A), the engine includes a pair of water floating holes (31) and (31) that causes the engine cooling water (9) to float from the cylinder jacket (2a) to the head jacket (2b) on both lateral sides of the water path bottom wall (23b) of the inter-bore water path (23). The water floating hole (31) on the exhaust end side of the pair of water floating holes (31) and (31) is defined as an exhaust end-side water floating hole (31a), and the water floating hole (31) on an intake end side is defined as an intake end-side water floating hole (31b). As illustrated in Figs. 4(A) and 4(C), the exhaust end-side water floating hole (31a) is provided in the reinforcing rib (30). As illustrated in Figs. 4(A) and 4(B), the intake end-side water floating hole (31b) is provided in the reinforcing wall (29). As illustrated in Fig. 4(B), a water floating hole outlet (31ba) of the intake end-side water floating hole (31b) is directed to an exhaust port peripheral wall (32b).

[0076] As illustrated in Fig. 4(B), in this engine, since the engine cooling water (9) flowing out from the water floating hole outlet (31ba) of the intake end-side water floating hole (31b) is directed to the exhaust port peripheral wall (32b), the cooling performance of the exhaust port peripheral wall (32b) is enhanced.

[0077] As illustrated in Fig. 4(A), the cylinder jacket (2a) includes an inter-bore water path (33) provided between the adjacent cylinder bores, a jacket portion (2aa) on the intake end side, and a jacket portion (2ab) on the exhaust end side, and the engine cooling water (9) is sent from the jacket portion (2aa) on the intake end side to the jacket portion (2ab) on the exhaust end side via the inter-bore water path (33).

[0078] The inter-bore water path (33) includes a first transverse water path (33c) provided between an inter-bore ceiling wall (33a) and a first transverse wall (33b) immediately below the inter-bore ceiling wall (33a), and a second transverse water path (33e) provided between the first transverse wall (33b) and a second transverse wall (33d) immediately below the first transverse wall (33b).

[0079] An intake end-side wall portion (33ba) of the first transverse wall (33b) is inclined downward toward the jacket portion (2aa) on the intake end side, an inlet lower portion (33ca) of the first transverse water path (33c) is therefore inclined downward toward the jacket portion (2aa) on the intake end side, and an inlet upper portion (33ea) of the second transverse water path (33e) is inclined downward toward the jacket portion (2aa) on the intake end side.

[0080] In this engine, as illustrated in Fig. 3(A), the jacket inlet (2c) on a front end side of the cylinder jacket (2a) faces a laterally central portion of a front surface of the cylinder (16) on the front end side, and a passage sectional area of the jacket portion (2aa) on the intake end side is larger than a passage sectional area of the jacket portion (2ab) on the exhaust side. As illustrated in Fig. 3(B), the jacket outlet (2d) on the front end side of the head jacket (2b) is disposed closer to the exhaust end side. Therefore, the engine cooling water (9) is sent from the jacket portion (2aa) on the intake end side to the jacket portion (2ab) on the exhaust end side via the inter-bore water path (33).

[0081] In this engine, since the low-temperature engine cooling water (9) below the jacket portion (2aa) on the intake end side is introduced upward along the inclination of the inlet lower portion (33ca) of the first transverse water path (33c) and the inlet upper portion (33ea) of the second transverse water path (33e), the cooling performance between the cylinder bores is enhanced.

[0082] As illustrated in Fig. 4(A), the inter-bore water path (33) includes a third transverse water path (33g) provided between the second transverse wall (33d) and a third transverse wall (33f) immediately below the second transverse wall (33d).

[0083] An intake end-side wall portion (33da) of the second transverse wall (33d) is inclined downward toward the jacket portion (2aa) on the intake side, an inlet lower portion (33eb) of the second transverse water path (33e) is therefore inclined downward toward the jacket portion (2aa) on the intake end side, and an inlet upper portion (33ga) of the third transverse water path (33g) is inclined downward toward the jacket portion (2aa) on the intake end side.

[0084] In this engine, since the low-temperature engine cooling water (9) below the jacket portion (2aa) on the intake end side is introduced upward along the inclination of the inlet lower portion (33eb) of the second transverse water path (33e) and the inlet upper portion (33ga) of the third transverse water path (33g), the cooling performance between the cylinder bores is enhanced.

[0085] As illustrated in Fig. 4(A), in this engine, the exhaust end-side water floating hole (31a) is formed to have a larger minimum passage sectional area than the intake end-side water floating hole (31b).

[0086] In this engine, since the flow of the engine cooling water (9) introduced into the exhaust end-side water floating hole (31a) from the jacket portion (2aa) on the intake end side via the inter-bore water path (33) is promoted, the cooling performance between the cylinder bores is enhanced.

[0087] The inter-bore water path (33) includes a fourth transverse water path (33k) provided between the third transverse wall (33f) and a fourth transverse wall (33h) immediately below the third transverse wall (33f). The fourth transverse water path (33k) is formed in the horizontal direction.

[0088] As illustrated in Fig. 5, the engine includes the oil pan (34), the oil pump (35), the auxiliary machine attachment base (36) to which the oil cooler (19) is attached, the base oil supply path (38) that supplies the engine oil (37) of the oil pan (34) from the oil pump (35) to the auxiliary machine attachment base (36), and the crankshaft oil supply path (39) that supplies the engine oil (37) cooled by the oil cooler (19) from the auxiliary machine attachment base (36) to the bearing (13a) of the crankshaft (13).

[0089] As illustrated in Fig. 6(B), in this engine, the auxiliary machine attachment base (36) includes an oil cooler oil supply port (40), an oil cooler oil supply path (40a) led out from the oil cooler oil supply port (40), an oil cooler oil discharge port (41), and an oil cooler oil discharge path (41a) led out from the oil cooler oil discharge port (41).

[0090] Of the oil cooler oil supply port (40) and the oil cooler oil discharge port (41) having a height difference, a higher port is defined as a cooler higher port (42), a lower port is defined as a cooler lower port (43). Of the oil cooler oil supply path (40a) and the oil cooler oil discharge path (41a), a path led out from the cooler lower port (43) is defined as a cooler lower port oil path (43a). The cooler lower port oil path (43a) is led upward to a height equal to or higher than a height of a lower edge (42a) of the cooler higher port (42).

[0091] The height equal to or higher than the height of the lower edge (42a) of the cooler higher port (42) is equal to the height of the lower edge (42a) of the cooler higher port (42) or higher than the height of the lower edge (42a) of the cooler higher port (42).

[0092] In this engine, the engine oil (37) in the oil cooler (19) remains at least up to the height of the lower edge (42a) of the cooler higher port (42) while the engine is stopped, and the engine oil (37) is supplied to the bearing (13a) of the crankshaft (13) via the crankshaft oil supply path (39) in a short time when the engine restarts to prevent seizure.

[0093] As illustrated in Fig. 6(B), in this engine, one of the oil cooler oil supply path (40a) and the oil cooler oil discharge path (41a) that is led out from the cooler higher port (42) is defined as a cooler higher port oil path (42c), and when viewed in a direction parallel to the lateral direction, the cooler higher port oil path (42c) is led out downward from the cooler higher port (42). Since the engine oil (37) in the oil cooler (19) flows down from the cooler higher port (42) toward the oil pan (34) via the cooler higher port oil path (42c), a filter lower port oil path (48a), the oil filter (44), and the base oil supply path (38) in order while the engine is stopped, the engine oil (37) remains only up to the height of the lower edge (42a) of the cooler higher port (42).

[0094] When viewed in a direction parallel to the lateral direction, the cooler higher port oil path (42c) illustrated in Fig. 6(B) may be led out upward from the cooler higher port (42) and may be led out upward to a height equal to or

higher than the height of the cooler lower port oil path (43a) and the lower edge (42a) of the cooler higher port (42). In this case, while the engine is stopped, the engine oil (37) in the oil cooler (19) can remain up to the same height as the lower edge (42a) of the cooler higher port (42) or a height of the lower edge of an upward leading end of the cooler lower port oil path (43a) exceeding the height.

[0095] As illustrated in Figs. 6(B) and 6(C), the cooler higher port (42) is provided in a pipe base end (42ba) inserted into the auxiliary machine attachment base (36) of a horizontal pipe (42b) directed in the lateral direction.

[0096] As illustrated in Fig. 6(B), when viewed in a direction parallel to the lateral direction, the cooler lower port oil path (43a) is led out upward from the cooler lower port (43), and then led out downward to an oil path inlet (39a) of the crankshaft oil supply path (39).

[0097] As illustrated in Fig. 6(B), the oil cooler oil supply port (40) is defined as the cooler higher port (42), the oil cooler oil discharge port (41) is defined as the cooler lower port (43), and the oil cooler oil discharge path (41a) is defined as the cooler lower port oil path (43a).

[0098] Since the engine oil (37) passing through the oil cooler (19) by the pressure feeding force of the oil pump (35) smoothly descends in the oil cooler (19) during operation of the engine while increasing the specific gravity by cooling of the oil cooler (19), the burden of pressure feeding of the oil pump (35) can be reduced.

[0099] As illustrated in Figs. 6(C) to 6(F), the oil cooler (19) is configured by alternately overlapping an oil passage layer (19b) through which the engine oil (37) passes and a water passage layer (19c) through which the engine cooling water (9) passes. As illustrated in Fig. 6(E), the oil passage layer (19b) is provided with an oil partition wall (19ba), and as illustrated in Fig. 6 (F), the water passage layer (19c) is provided with a water partition wall (19ca).

[0100] In the oil passage layer (19b), the engine oil (37) introduced from the oil cooler oil supply port (40) on a rear upper side is reversed downward and backward on a front side of the oil partition wall (19ba), and is discharged from the oil cooler oil discharge port (41) on a rear lower side.

[0101] In the water passage layer (19c), the engine cooling water (9) introduced from the oil cooler water supply port (70) on a front lower side is reversed upward and forward on a rear side of the water partition wall (19ca), and is discharged from the oil cooler water discharge port (71) on a front upper side.

[0102] As illustrated in Fig. 5, the engine includes the oil filter (44) attached to the auxiliary machine attachment base (36), and the engine oil (37) supplied to the auxiliary machine attachment base (36) is purified by the oil filter (44) and supplied to the oil cooler (19).

[0103] As illustrated in Figs. 6(B) and 6(C), the auxiliary machine attachment base (36) includes an oil filter oil supply port (45), an oil filter oil supply path (45a) led out from the oil filter oil supply port (45), an oil filter oil discharge port (46), and an oil filter oil discharge path (46a) led out from the oil filter oil discharge port (46).

[0104] Of the oil filter oil supply port (45) and the oil filter oil discharge port (46) having a height difference, a higher port is defined as a filter higher port (47), a lower port is defined as a filter lower port (48). Of the oil filter oil supply path (45a) and the oil filter oil discharge path (46a), a path led out from the filter lower port (48) is defined as a filter lower port oil path (48a). The filter lower port oil path (48a) is led out upward to a height equal to or higher than a height of a lower edge (47a) of the filter higher port (47).

[0105] The height equal to or higher than the height of the lower edge (47a) of the filter higher port (47) is equal to the height of the lower edge (47a) of the filter higher port (47) or higher than the height of the lower edge (47a) of the filter higher port (47).

[0106] As illustrated in Fig. 6(C), in this engine, of the oil filter oil supply path (45a) and the oil filter oil discharge path (46a), a path led out from the filter higher port (47) is defined as a filter higher port oil path (47b). The filter higher port oil path (47b) is led out laterally in the horizontal direction from the filter higher port (47). While the engine is stopped, the engine oil (37) in the oil filter (44) flows down from the filter higher port (47) toward the oil pan (34) via the filter higher port oil path (47b) and the base oil supply path (38) in order, and remains only up to the height of the lower edge (47a) of the filter higher port (47).

[0107] The filter higher port oil path (47b) may be led out upward from the filter higher port (47) when viewed in a direction parallel to the lateral direction. **In** this case, while the engine is stopped, the engine oil (37) in the oil filter (44) can remain up to the height of the lower edge of an upward leading end of the filter higher port oil path (47b) equal to or higher than the height of the lower edge (47a) of the filter higher port (47).

[0108] As illustrated in Fig. 6(C), the filter higher port (47) is provided at an oil path outlet (47c) of the horizontal filter higher port oil path (47b) directed in the lateral direction of the auxiliary machine attachment base (36).

[0109] As illustrated in Fig. 6(C), the filter higher port oil path (47b) is connected to an oil path outlet (38a) of the base oil supply path (38).

[0110] As illustrated in Fig. 6(B), the filter lower port oil path (48a) is led out upward from the filter lower port (48) and then connected to the upward cooler higher port oil path (42c).

[0111] In this engine, the engine oil (37) in the oil filter (44) remains at least up to the height of the lower edge (47a) of the filter higher port (47) while the engine is stopped, and the engine oil (37) is supplied to the bearing (13a) of the crankshaft (13) via the crankshaft oil supply path (39) in a short time when the engine restarts to prevent seizure.

[0112] As illustrated in Fig. 6(B), the oil filter oil supply port (45) is defined as the filter higher port (47), the oil filter oil discharge port (46) is defined as the filter lower port (48), and the oil filter oil discharge path (46a) is defined as

the filter lower port oil path (48a).

[0113] In this engine, the engine oil (37) passing through the oil filter (44) by the pressure feeding force of the oil pump (35) descends in the oil filter (44) by the weight of the engine oil (37) during operation of the engine, so the burden of pressure feeding of the oil pump (35) can be reduced.

[0114] A modification of the auxiliary machine attachment base (36) illustrated in Figs. 7(A) and 7(B) is as follows.

[0115] The oil cooler oil supply path (40a) and the oil cooler oil discharge path (41a) of the auxiliary machine attachment base (36) are both led upward to a height equal to or higher than the height of an in-cooler uppermost portion (19a) of the oil cooler (19).

[0116] The height equal to or higher than the height of the in-cooler uppermost portion (19a) of the oil cooler (19) is equal to the height of the in-cooler uppermost portion (19a) of the oil cooler (19) or higher than the height of the in-cooler uppermost portion (19a) of the oil cooler (19).

[0117] In this engine, the engine oil (37) in the oil cooler (19) remains filled in the oil cooler (19) while the engine is stopped, and the engine oil (37) is supplied to the bearing (13a) of the crankshaft (13) via the crankshaft oil supply path (39) in a short time when the engine restarts to prevent seizure.

[0118] As illustrated in Figs. 7(A) and 7(B), both the oil filter oil supply path (45a) and the oil filter oil discharge path (46a) are led upward to a height equal to or higher than the height of an in-filter uppermost portion (44a) of the oil filter (44).

[0119] In this engine, the engine oil (37) in the oil filter (44) remains filled in the oil filter (44) while the engine is stopped, and the engine oil (37) is supplied to the bearing (13a) of the crankshaft (13) via the crankshaft oil supply path (39) in a short time when the engine restarts to prevent seizure.

[0120] Other configurations of the modification of the auxiliary machine attachment base (36) illustrated in Figs. 7(A) and 7(B) are the same as the configuration of the basic example of the auxiliary machine attachment base (36) illustrated in Figs. 6(A) to 6(F). In Figs. 7(A) and 7(B), the same elements as the elements in Figs. 6(A) to 6(F) are denoted by the same reference signs.

[0121] As illustrated in Fig. 5, in this engine, the auxiliary machine attachment base (36) is attached to near a rear side of an intake end side of the cylinder block (27). As illustrated in Fig. 9, the engine includes the oil branch pipe (50) led out from the rear side of the auxiliary machine attachment base (36), a rear end wall transverse oil path (27b) crossing the inside of a rear end wall (27a) of the cylinder block (27), and a supercharger oil supply pipe (51) that supplies the engine oil (37) to a bearing (49a) of the supercharger (49). The engine oil (37) of the auxiliary machine attachment base (36) is supplied to the bearing (49a) of the supercharger (49) via the oil branch pipe (50), the rear end wall transverse oil path (27b), and the supercharger oil supply pipe (51) in order.

[0122] In this engine, since the engine oil (37) is supplied from the auxiliary machine attachment base (36) to the bearing (49a) of the supercharger (49) in the shortest route, the engine oil (37) is supplied to the bearing (49a) of the supercharger (49) in a short time when the engine starts to prevent seizure.

[0123] In this engine, at a time of cold start of the engine in which the viscosity of the engine oil (37) increases, the engine oil (37) passing through the rear end wall transverse oil path (27b) crossing the inside of the rear end wall (27a) of the cylinder block (27) immediately after the start is heated by combustion heat of the engine and has a low viscosity, and the engine oil (37) is supplied to the bearing (49a) of the supercharger (49) without delay. Therefore, seizure of the bearing (49a) of the supercharger (49) is prevented even at the time of cold start.

[0124] As illustrated in Figs. 8 to 10, in this engine, a supercharger oil discharge pipe (69) is led out from the bearing (49a) of the supercharger (49), and the engine oil (37) that has lubricated the bearing (49a) of the supercharger (49) returns to the oil pan (34) via the supercharger oil discharge pipe (69).

[0125] The oil branch pipe (50), the supercharger oil supply pipe (51), and the supercharger oil discharge pipe (69) are all engine exterior pipes, and the rear end wall transverse oil path (27b) is an engine internal oil path.

[0126] As illustrated in Fig. 6(B), the engine oil (37) is branched from an oil cooler oil discharge path (41a) of the auxiliary machine attachment base (36) to the oil branch pipe (50).

[0127] In this engine, since the engine oil (37) cooled by the oil cooler (19) is supplied to the bearing (49a) of the supercharger (49), seizure of the bearing (49a) of the supercharger (49) is prevented even at high engine speed when the rotational speed of the supercharger (49) is high.

[0128] A structure of a modification of the oil branch pipe (50) illustrated in Fig. 7(C) is as follows.

[0129] A check valve (52) illustrated in Fig. 7(D) is attached to the oil branch pipe (50) illustrated in Fig. 7(C) to prevent backflow of the engine oil (37) from the oil branch pipe (50) to the auxiliary machine attachment base (36).

[0130] In this engine, the engine oil (37) in the oil branch pipe (50), the rear end wall transverse oil path (27b), and the supercharger oil supply pipe (51) illustrated in Fig. 9 does not fall off toward the auxiliary machine attachment base (36) while the engine is stopped. Therefore, the engine oil (37) is supplied to the bearing (49a) of the supercharger (49) in a short time when the engine restarts to prevent seizure of the bearing (49a) of the supercharger (49).

[0131] The oil branch pipe (50) illustrated in Fig. 9 is led out from the oil filter oil discharge port (46) on a flow path upstream side of the oil cooler (19).

[0132] The modification of the oil branch pipe (50) illustrated in Fig. 7(C) may be combined with the mod-

ification of the auxiliary machine attachment base (36) illustrated in Fig. 7(A) in addition to the basic example of the auxiliary machine attachment base (36) illustrated in Fig. 6(B).

DESCRIPTION OF REFERENCE SIGNS

[0133]

(1): Cooling water circulation path
(2): Water jacket
(2a): Cylinder jacket
(2b): Head jacket
(2ba): Rear end-side jacket portion
(2bb): Upper end portion
(2bc): Intake end-side portion
(2bd): Near-rear-end jacket portion
(2c): Jacket inlet
(2d): Jacket outlet
(7): Radiator
(7a): Water supply port
(8): Water pump
(9): Engine cooling water
(16): Cylinder
(16a): Cylinder center axis
(17): Cylinder head
(17a): Rear end-side head portion
(18): Water floating port
(18a): Rear end-side water floating port
(18b): Near-rear-end water floating port
(19): Oil cooler
(20): Cooler water supply pipe
(21): Cooler drain pipe
(22): Intake port
(22a): Inlet
(22b): Lower peripheral wall
(23): Inter-bore water path
(23a): Near-rear-end water floating port
(24): Partition wall
(32): Exhaust port
(32a): Outlet

Claims

1. A water-cooled engine comprising an engine, wherein

a cooling water circulation path (1) of the engine includes a water jacket (2) in the engine, a radiator (7), and a water pump (8),
engine cooling water (9) circulates between the water jacket (2) and the radiator (7) by a pressure feeding force of the water pump (8) during operation of the engine,
the engine is a vertical multi-cylinder straight engine,
a direction in which a crankshaft (13) is extended is defined as a front-rear direction, one side in the front-rear direction is defined as a front, and another side is defined as a rear,
the water jacket (2) includes a cylinder jacket (2a) around a cylinder (16) and a head jacket (2b) in a cylinder head (17), the cylinder jacket (2a) includes a jacket inlet (2c) at a front end, the head jacket (2b) includes a jacket outlet (2d) at a front end, a plurality of water floating ports (18) opened on a peripheral side of each of the cylinder (16) is provided between the cylinder jacket (2a) and the head jacket (2b), the engine cooling water (9) floats from the cylinder jacket (2a) to the head jacket (2b) via the plurality of water floating ports (18), the head jacket (2b) includes a rear end-side jacket portion (2ba) facing a rear end-side water floating port (18a) at a rear end-side head portion (17a) of the cylinder head (17) among the plurality of water floating ports (18),
the water-cooled engine includes an oil cooler (19) that is cooled with water, a cooler water supply pipe (20) from the head jacket (2b) to the oil cooler (19), and a cooler drain pipe (21) from the oil cooler (19) to the water pump (8), and
the cooler water supply pipe (20) is led out from the rear end-side jacket portion (2ba).

2. The water-cooled engine according to claim 1, wherein the cooler water supply pipe (20) is led out from the upper end portion (2bb) of the rear end-side jacket portion (2ba).

3. The water-cooled engine according to claim 1, wherein when viewed in a direction parallel to a cylinder center axis (16a), a width direction of the cylinder head (17) orthogonal to the front-rear direction is defined as a lateral direction, an inlet (22a) side of an intake port (22) is defined as an intake end side and an outlet (32a) side of an exhaust port (32) is defined as an exhaust end side of both sides in the lateral direction, and the cooler water supply pipe (20) is led out from an intake end-side portion (2bc) of the rear end-side jacket portion (2ba).

4. The water-cooled engine according to claim 1, wherein

the head jacket (2b) includes a near-rear-end inter-bore water path (23a) close to a rear end of the cylinder head (17) among a plurality of inter-bore water paths (23) located between cylinder bores, a near-rear-end water floating port (18b) that supplies the engine cooling water (9) to the near-rear-end inter-bore water path (23a) among the plurality of water floating ports (18), a near-rear-end jacket portion (2bd) facing the near-rear-end water floating port (18b), and

a partition wall (24), and
the near-rear-end jacket portion (2bd) is disposed in a front side of the rear end-side jacket portion (2ba), and the partition wall (24) is disposed between the near-rear-end jacket portion (2bd) and the rear end-side jacket portion (2ba).

5. The water-cooled engine according to claim 4, wherein the partition wall (24) connects a lower peripheral wall (22b) of an intake port (22) and a head bottom wall (17c) of the cylinder head (17).

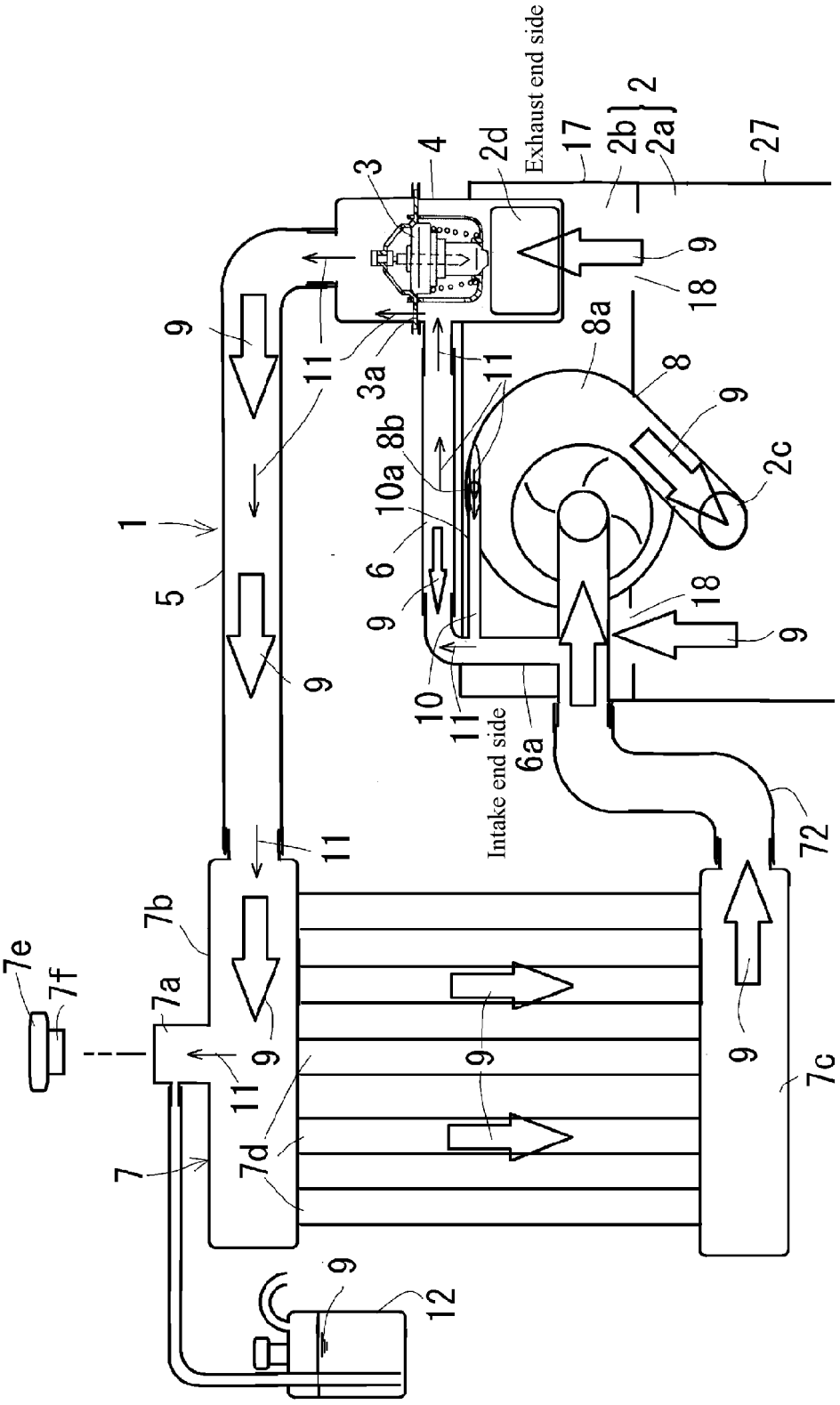

Exhaust end side
Intake end side
1
2
2a
2b
2c
2d
3
3a
4
5
6
6a
7
7a
7b
7c
7d
7e
7f
8
8a
8b
9
10
10a
11
12
17
18
27
72

FIG. 1

FIG. 2

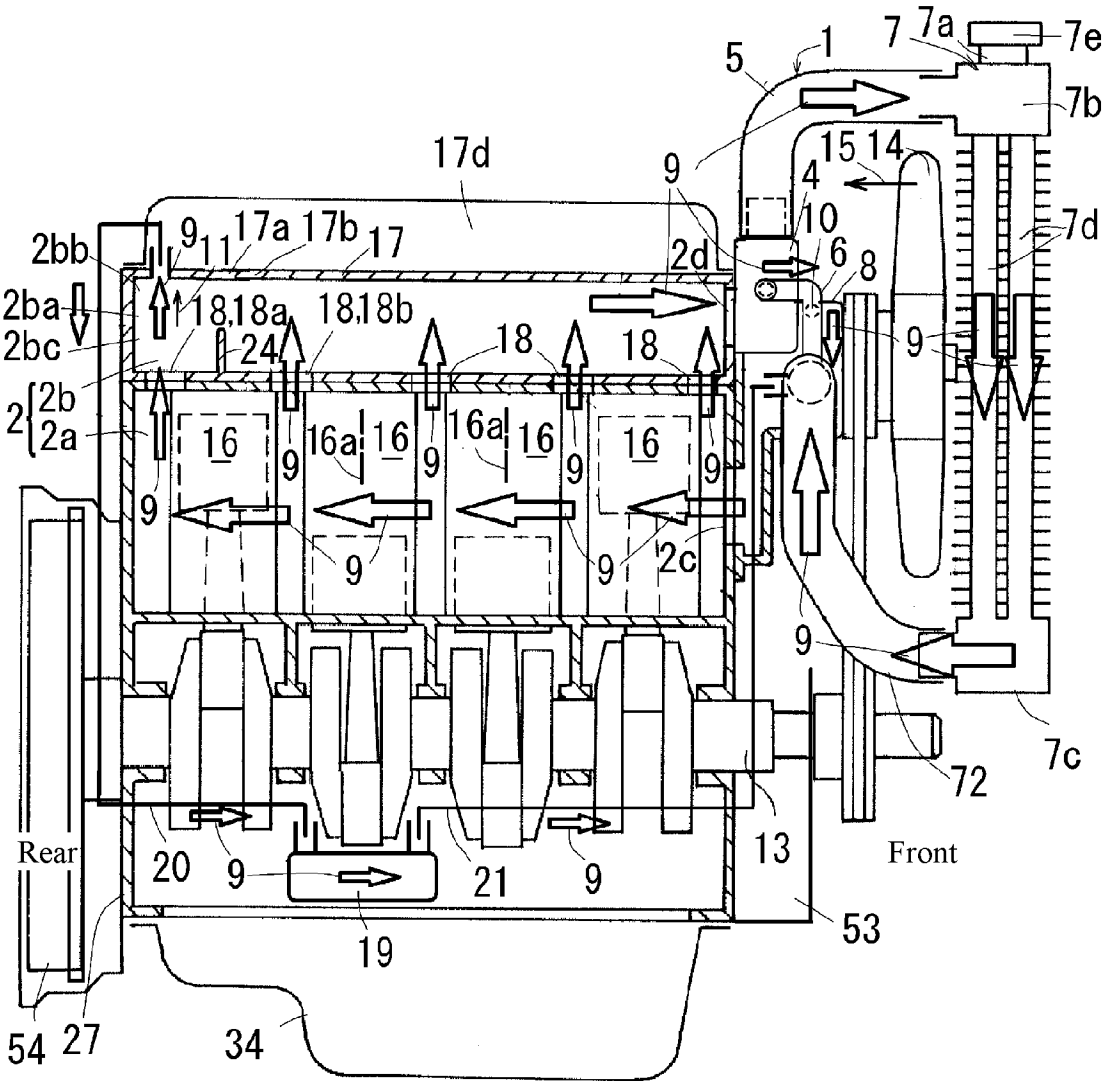

7
7a
7e
1
5
7b
17d
9
15
14
4
10
7d
2bb
9
11
17a
17b
17
2d
6
8
2ba
18,18a
18,18b
18
18
9
2bc
24
2
2b
2a
16
16a
16
16a
16
16
9
2c
7c
72
Rear
20
21
13
Front
19
53
54
27
34

FIG. 3

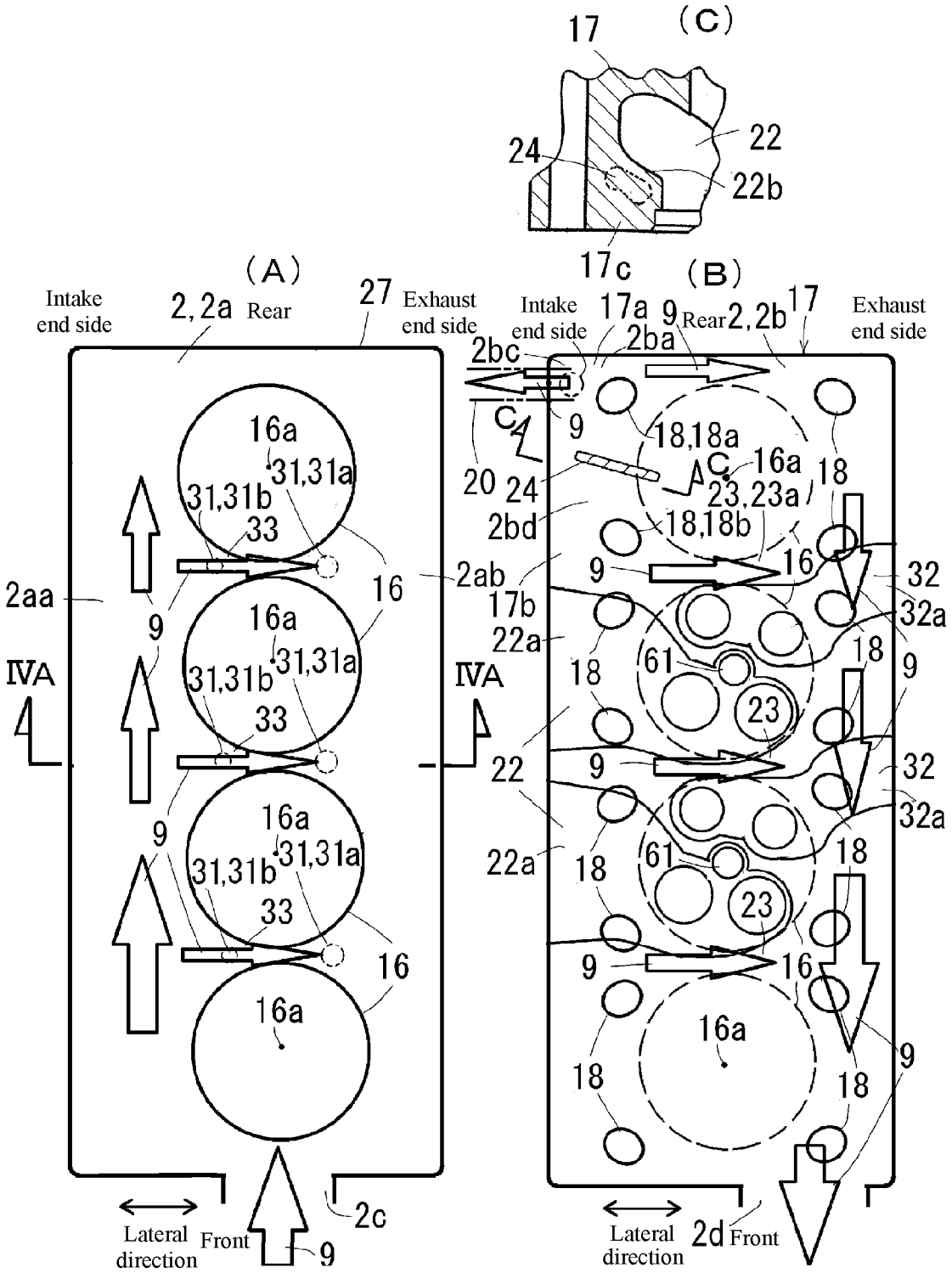

(A)
(B)
(C)
17
22
24
22b
17c
Intake end side
2, 2a
Rear
27
Exhaust end side
2aa
IVA
16a
31,31a
31,31b
33
16
9
2ab
2bc
2ba
17a
2, 2b
17
2bd
17b
22a
18,18a
18,18b
16a
23,23a
18
20
32
32a
61
23
22
2c
2d
Lateral direction
Front

FIG. 4

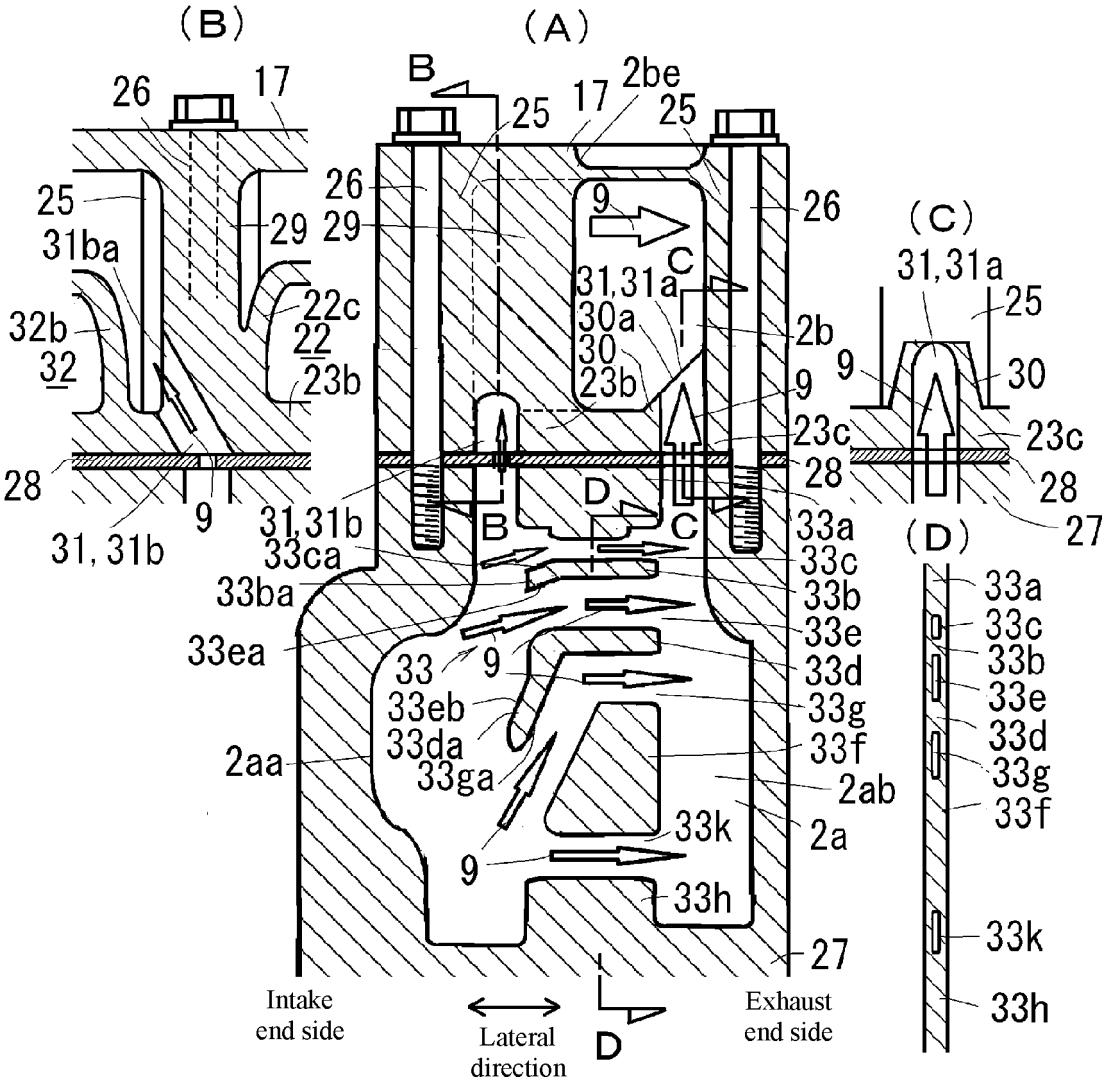

(B)
(A)
(C)
(D)
26
17
25
29
31ba
32b
32
22c
22
23b
28
9
31, 31b
B
2be
31,31a
30a
30
2b
C
23c
D
33ca
33ba
33ea
33
33eb
33da
33ga
2aa
33k
33h
27
2ab
2a
33a
33c
33b
33e
33d
33g
33f
Intake end side
Lateral direction
Exhaust end side

FIG. 5

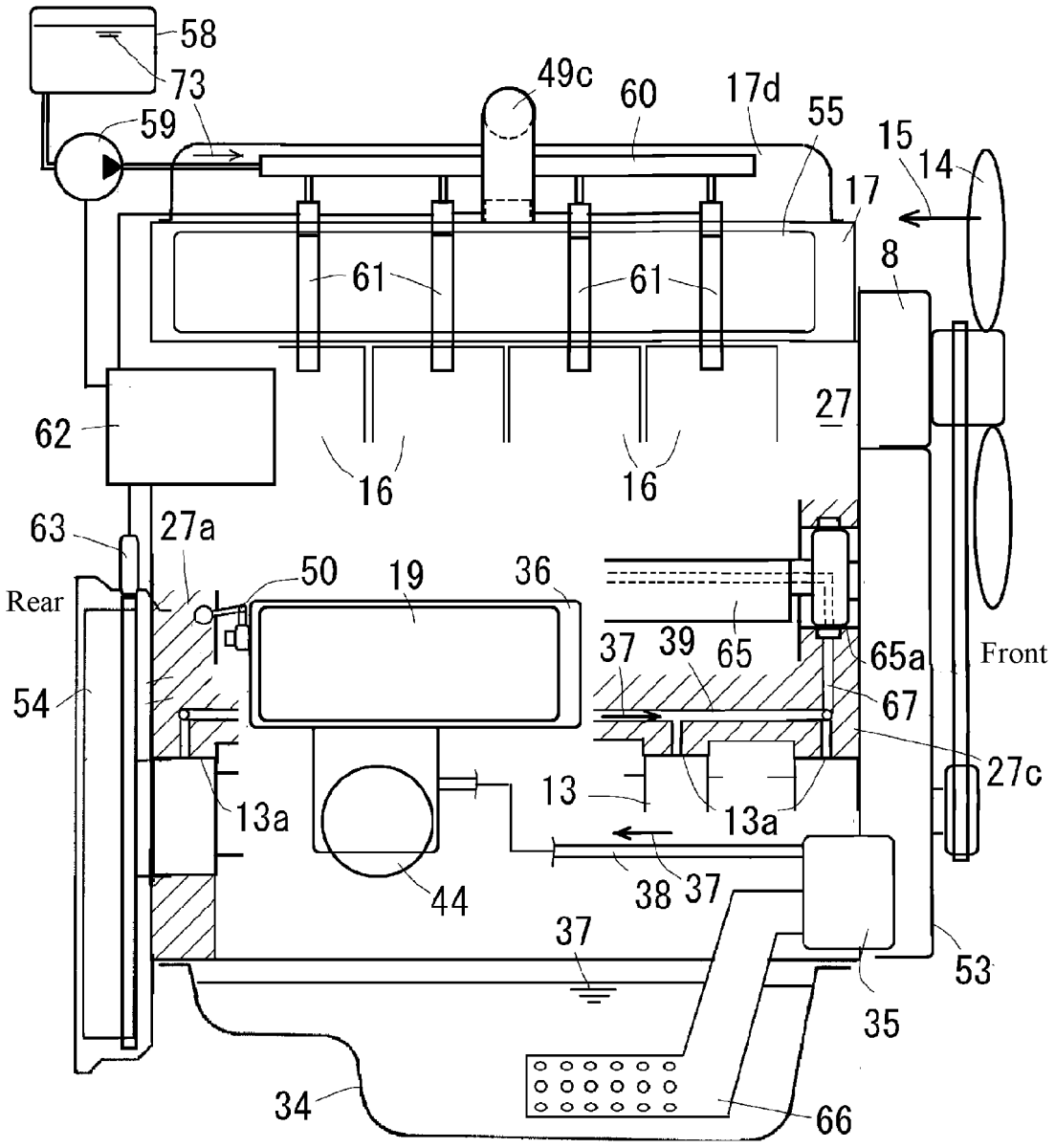

58
73
59
49c
60
17d
55
15
14
17
8
61
61
62
16
16
27
63
27a
50
19
36
Rear
54
37
39
65
65a
Front
67
27c
13a
13
13a
44
38
37
37
53
35
34
66

FIG. 6

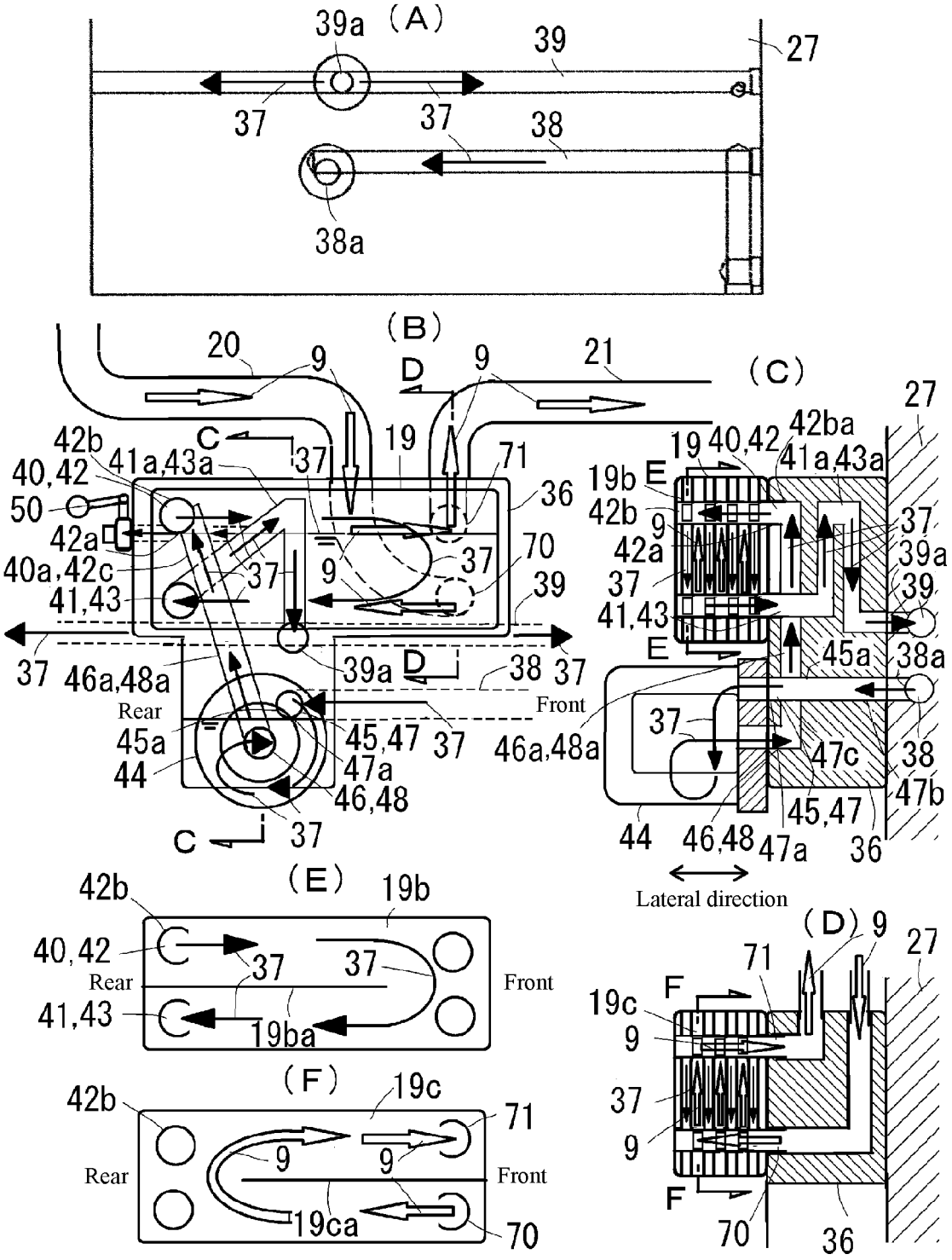

(A)
39a
39
27
37
37
38
38a
(B)
20
9
D
9
21
(C)
42b
C
37
19
71
36
40,42
41a,43a
50
42a
40a,42c
41,43
37
9
37
70
39
37
46a,48a
39a
D
38
37
Rear
Front
45a
44
45,47
37
47a
46,48
C
37
19
40,42
42ba
41a,43a
19b
E
42b
9
42a
37
41,43
37
39a
39
E
45a
38a
37
47c
38
47b
46a,48a
44
46,48
47a
45,47
36
Lateral direction
(E)
19b
42b
40,42
Rear
37
37
Front
41,43
19ba
(F)
19c
42b
71
9
9
Rear
Front
19ca
70
(D)
9
27
71
F
19c
9
37
9
F
70
36

FIG. 7

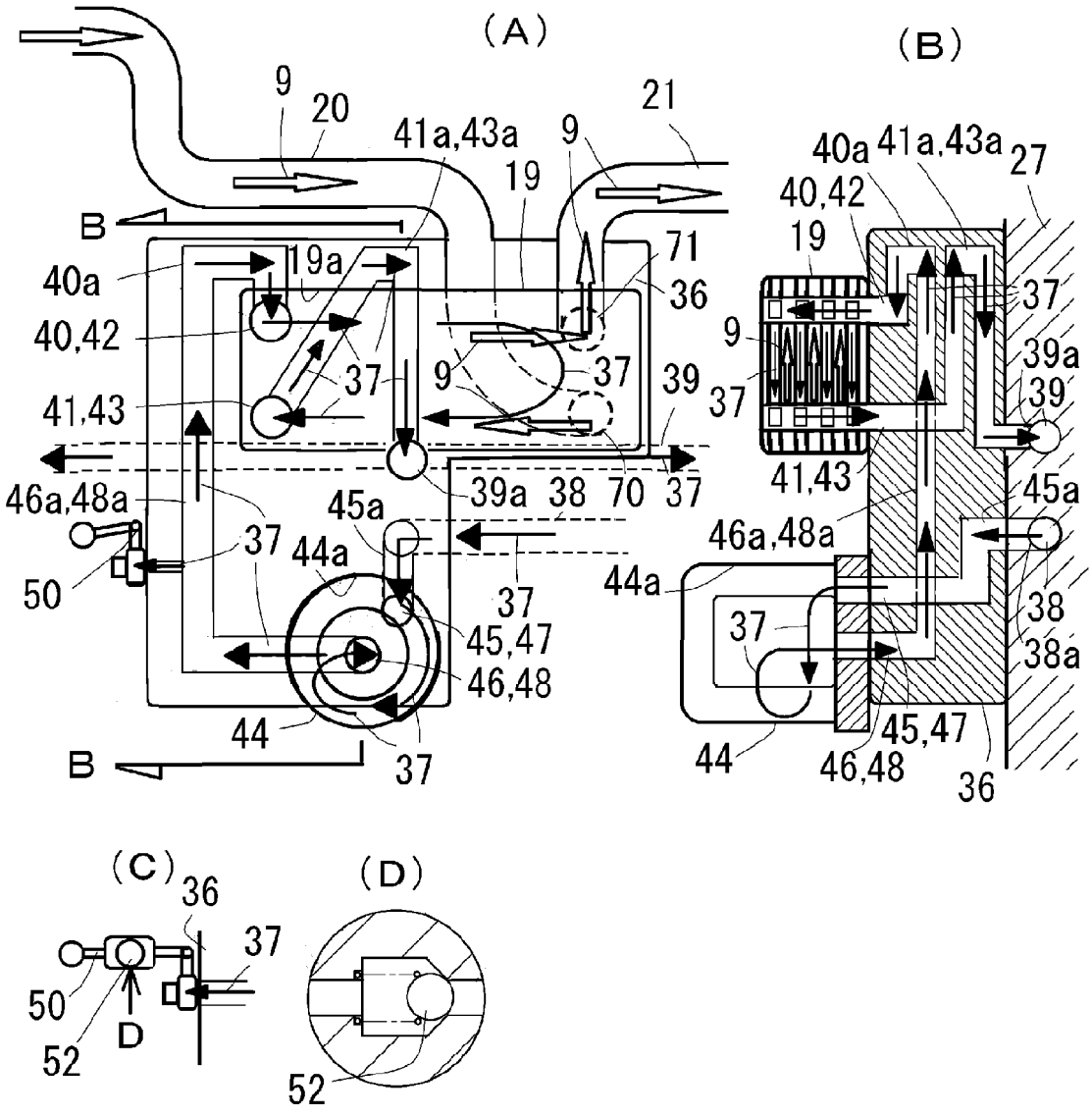

(A)
(B)
(C)
(D)
9
20
41a,43a
19
21
71
36
B
40a
19a
40,42
37
41,43
46a,48a
50
44a
45,47
46,48
44
39
39a
38
70
45a
27
38a
52
D

FIG. 8

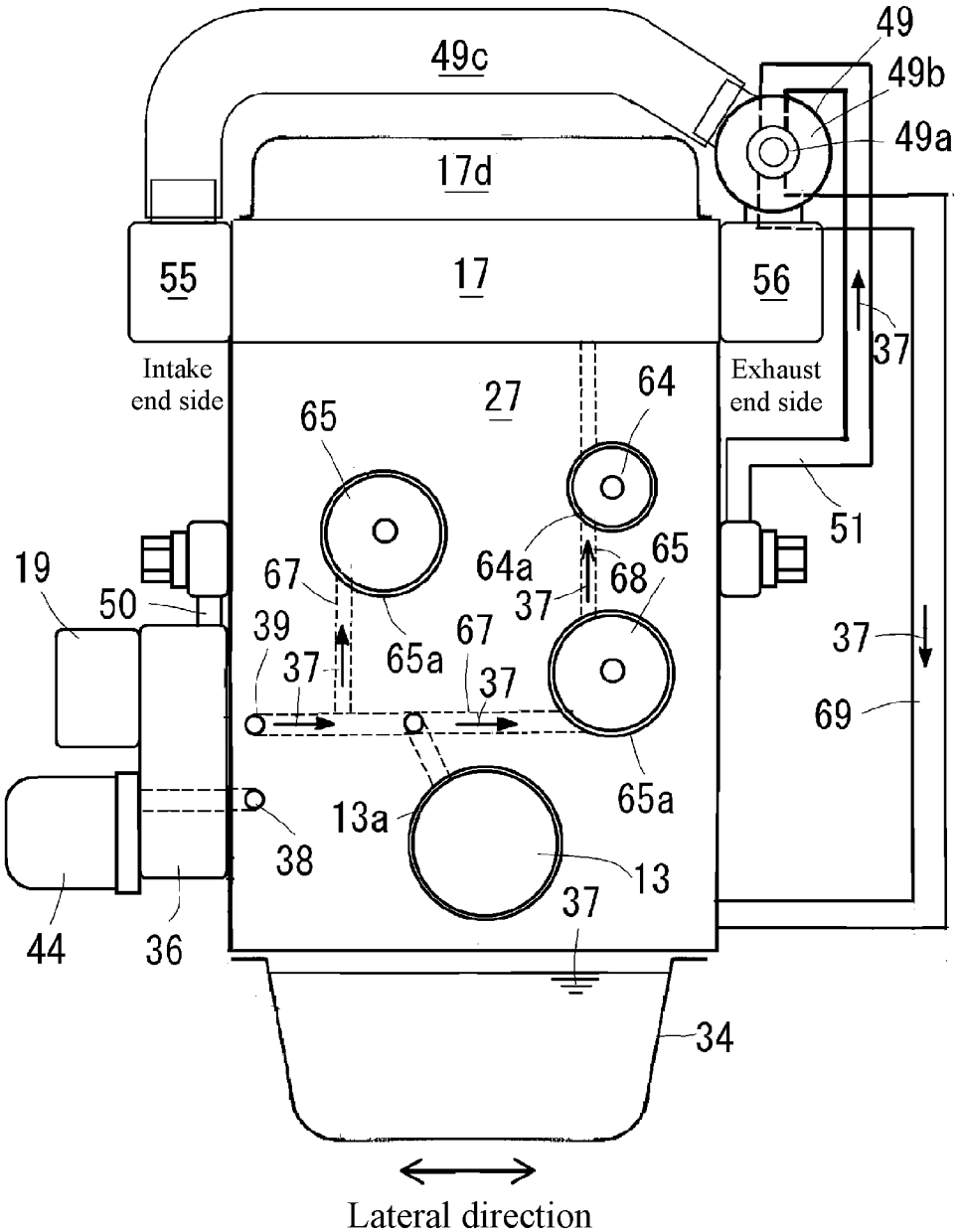

49
49c
49b
49a
17d
55
17
56
37
Intake
end side
27
64
Exhaust
end side
65
51
19
67
64a
68
65
50
37
37
39
67
37
65a
37
37
69
65a
13a
38
13
37
44
36
34
Lateral direction

FIG. 9

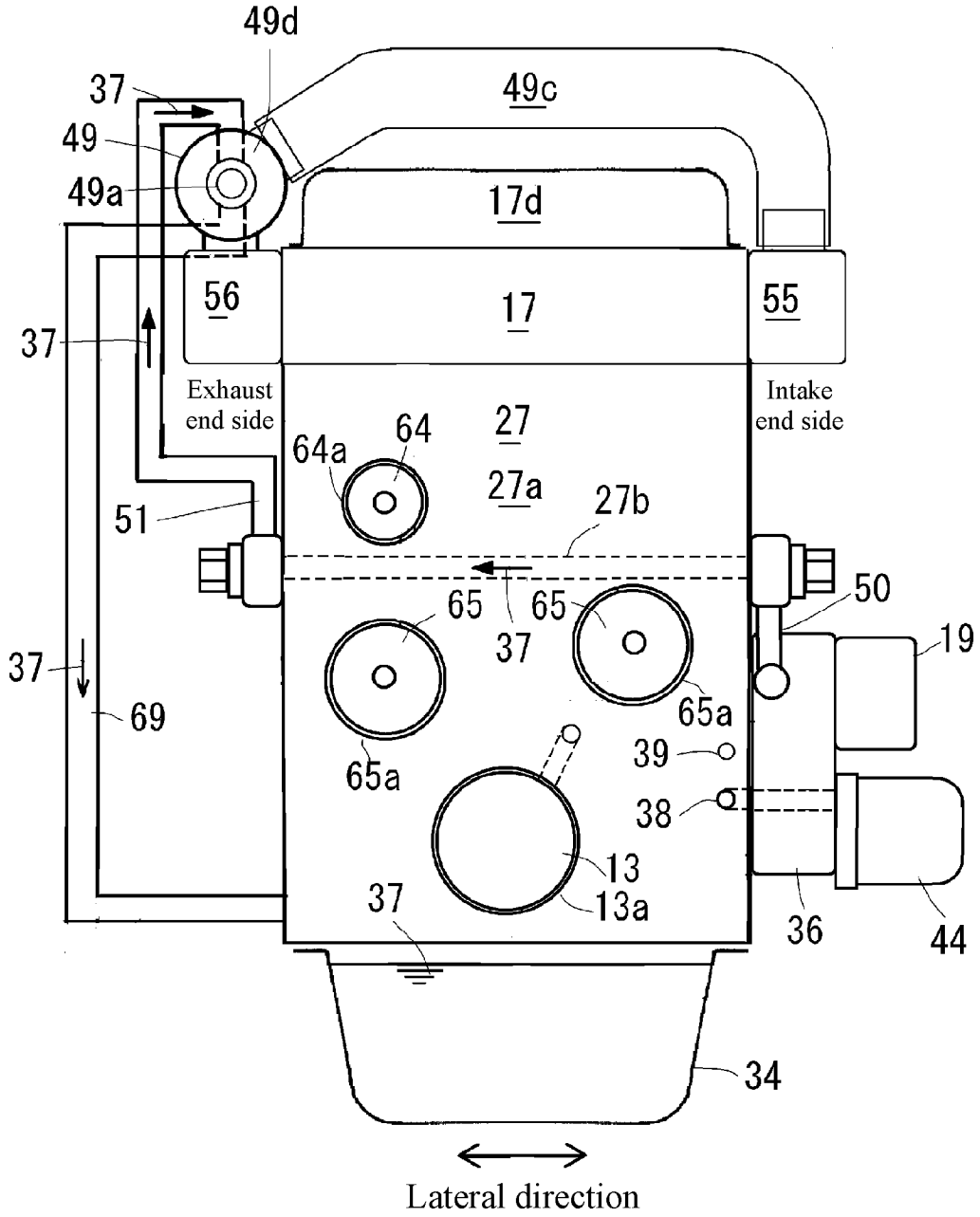
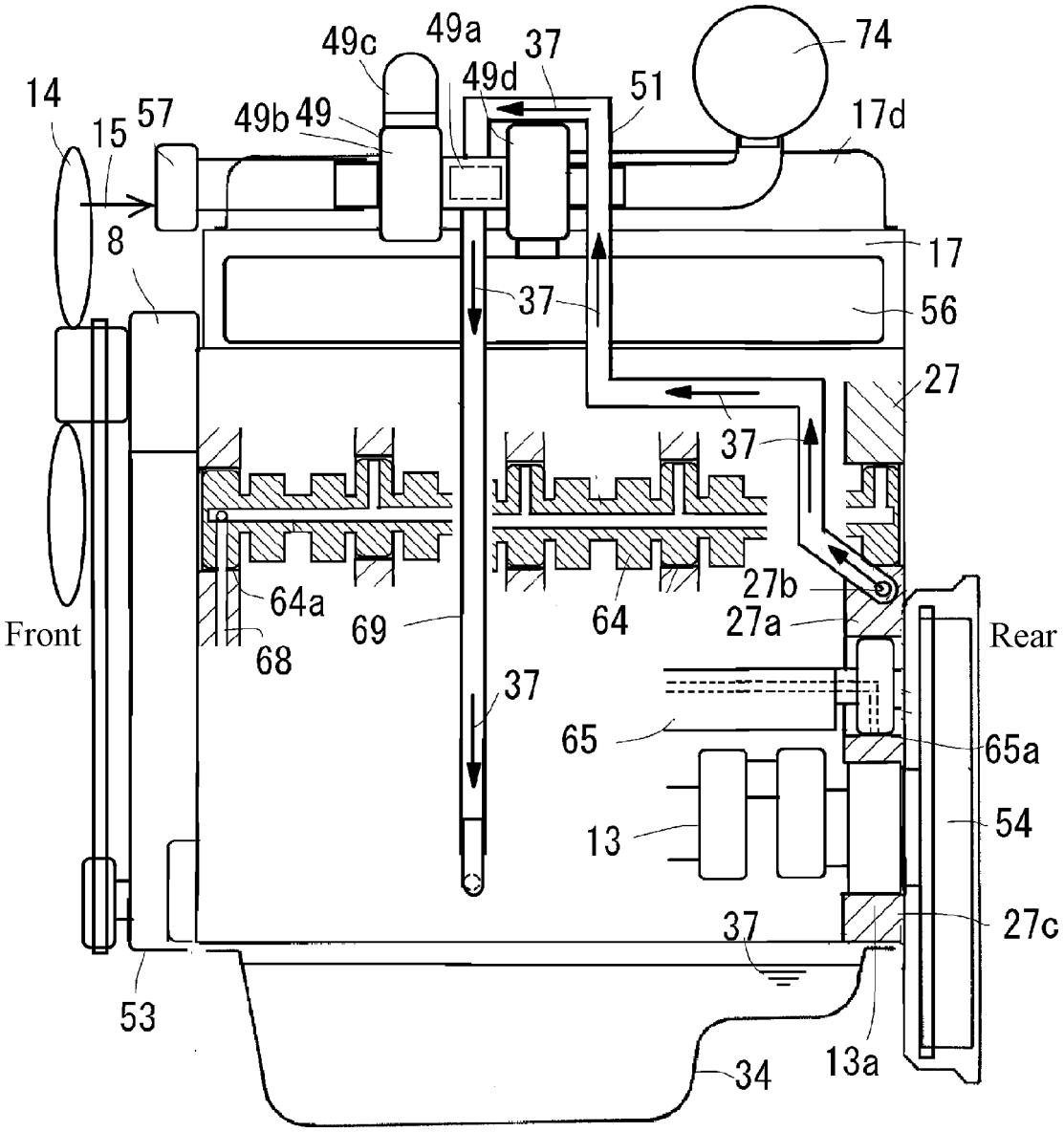

49d
37
49c
49
49a
17d
56
17
55
37
Exhaust end side
Intake end side
64a
64
27
27a
27b
51
50
65
65
37
19
37
69
65a
65a
39
38
13
13a
37
36
44
34
Lateral direction

FIG. 10


14
15
57
49b
49
49c
49a
37
49d
51
74
17d
8
17
37
56
27
37
64a
68
69
64
27b
27a
Front
Rear
37
65
65a
13
54
37
27c
53
34
13a

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2023/013794

A. CLASSIFICATION OF SUBJECT MATTER

F01P 3/02(2006.01)i; ***F01P 11/08***(2006.01)i; ***F02F 1/36***(2006.01)i
FI: F01P3/02 F; F01P11/08 B; F02F1/36 Z

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

F01P3/02; F01P11/08; F02F1/36; F01P7/14; F01M5/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Published examined utility model applications of Japan 1922-1996
Published unexamined utility model applications of Japan 1971-2023
Registered utility model specifications of Japan 1996-2023
Published registered utility model applications of Japan 1994-2023

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 2008-185002 A (AISIN SEIKI CO LTD) 14 August 2008 (2008-08-14) paragraphs [0013]-[0016], [0021], [0033], fig. 1	1-3
A		4-5
Y	JP 6-173676 A (KUBOTA CORP) 21 June 1994 (1994-06-21) paragraphs [0001], [0011]-[0017], fig. 1-2	1-3
A		4-5
Y	US 2017/0254252 A1 (HYUNDAI MOTOR COMPANY) 07 September 2017 (2017-09-07) paragraphs [0011], [0040]-[0046], fig. 2-3	3
A	JP 2008-75506 A (YAMAHA MOTOR CO LTD) 03 April 2008 (2008-04-03) paragraph [0046], fig. 9-10	4-5
A	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 158435/1980 (Laid-open No. 81424/1982) (NISSAN DIESEL MOTOR CO., LTD.) 20 May 1982 (1982-05-20), specification, p. 3, lines 2-7, fig. 1	4-5

☑ Further documents are listed in the continuation of Box C. ☑ See patent family annex.

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
12 May 2023	**30 May 2023**
Name and mailing address of the ISA/JP **Japan Patent Office (ISA/JP)** **3-4-3 Kasumigaseki, Chiyoda-ku, Tokyo 100-8915** **Japan**	Authorized officer Telephone No.

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2023/013794

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2018/0100463 A1 (HYUNDAI MOTOR COMPANY) 12 April 2018 (2018-04-12) paragraph [0030], fig. 2-3	4-5
A	DE 2810980 A1 (DAIMLER-BENZ AG) 27 September 1979 (1979-09-27) entire text, all drawings	1-5
A	JP 2011-169237 A (ISUZU MOTORS LTD) 01 September 2011 (2011-09-01) entire text, all drawings	1-5
A	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 24707/1982 (Laid-open No. 127122/1983) (TOYO KOGYO CO) 29 August 1983 (1983-08-29), entire text, all drawings	1-5
A	JP 2020-114995 A (MAZDA MOTOR CORPORATION) 30 July 2020 (2020-07-30) entire text, all drawings	3

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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/JP2023/013794

Patent document cited in search report	Publication date (day/month/year)	Patent family member(s)	Publication date (day/month/year)
JP 2008-185002 A	14 August 2008	(Family: none)	
JP 6-173676 A	21 June 1994	(Family: none)	
US 2017/0254252 A1	07 September 2017	CN 107152348 A	
JP 2008-75506 A	03 April 2008	(Family: none)	
JP 57-81424 U1	20 May 1982	(Family: none)	
US 2018/0100463 A1	12 April 2018	DE 102016224817 A1 KR 10-2018-0039777 A CN 107917012 A	
DE 2810980 A1	27 September 1979	(Family: none)	
JP 2011-169237 A	01 September 2011	(Family: none)	
JP 58-127122 U1	29 August 1983	(Family: none)	
JP 2020-114995 A	30 July 2020	US 2020/0232413 A1 entire text, all drawings EP 3683428 A1	

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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2018105277 A **[0003]**