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(54) INTERNAL COMBUSTION ENGINE

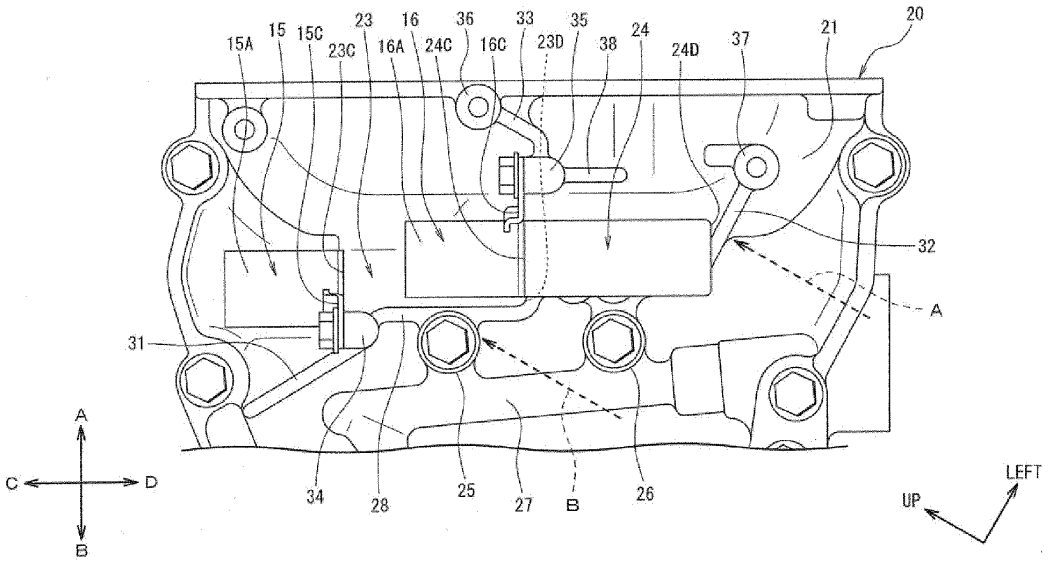
(57) [Object]

To provide an internal combustion engine capable of protecting a portion of a hydraulic control valve exposed to the outside from foreign matter such as flying stones flying from below.

[Solution]

An exhaust side cylinder portion (24) is adjacently formed below a bulging portion (21). Further, the other end portion (24D) of the exhaust side cylinder portion (24) in the axial direction is disposed below one end portion (24C) of the exhaust side cylinder portion (24) in the axial direction. Then, a chain casing (20) includes a connection rib (32) which is formed on the side of the other end portion (24D) of the exhaust side cylinder portion (24) in the axial direction to connect the other end portion (24D) of the exhaust side cylinder portion (24) in the axial direction to the bulging portion (21).

FIG. 4



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Description

[Technical Field]

[0001] This invention relates to an internal combustion engine.

[Background of the Invention]

[0002] JP 2006-118497 A describes an arrangement structure of a solenoid valve including a first solenoid valve which controls hydraulic oil supplied to an intake valve phase changing means for changing a rotation phase of an intake valve cam shaft and a second solenoid valve which controls hydraulic oil supplied to an exhaust valve phase changing means for changing a rotation phase of an exhaust valve cam shaft. In JP 2006-118497 A, the first solenoid valve and the second solenoid valve are provided in a timing chain cover disposed at an end portion of an engine.

[Prior Art]

[Patent Literature]

[0003] [Patent Literature 1] JP 2006-118497 A

[Summary of the Invention]

[Problem to be solved by the Invention]

[0004] However, in the technique described in Patent Literature 1, since the first solenoid valve and the second solenoid valve are arranged to protrude from an end portion of the timing chain cover to the outside, there is concern that a portion of the first solenoid valve or the second solenoid valve exposed to the outside may be damaged by collision with foreign matter such as flying stones flying from a road surface.

[0005] This invention has been made in view of the above-described circumstances and an object of this invention is to provide an internal combustion engine capable of protecting a portion of a hydraulic control valve exposed to the outside from foreign matter such as flying stones flying from below.

[Means to solve the problem]

[0006] According to aspects of this invention, there is provided an internal combustion engine including: a variable valve timing mechanism configured by winding a timing chain thereon; a hydraulic control valve controlling hydraulic oil supplied to the variable valve timing mechanism; and a chain casing fixed to a cylinder head to cover the timing chain and the variable valve timing mechanism, wherein the chain casing includes a bulging portion bulging in a crank shaft direction and covering the variable valve timing mechanism and a cylindrical cylinder portion attaching the hydraulic control valve thereto, wherein the hydraulic control valve includes a small diameter portion inserted from one end portion of the cylinder portion in an axial direction to the cylinder portion and a large diameter portion exposed from one end portion of the cylinder portion in the axial direction, wherein the internal combustion engine is mounted on a vehicle so that center lines of a plurality of cylinders are inclined with respect to an up to down direction of the vehicle, wherein the cylinder portion is adjacently formed below the bulging portion, wherein the other end portion of the cylinder portion in the axial direction is disposed below one end portion of the cylinder portion in the axial direction, and wherein the chain casing includes a connection rib formed on the side of the other end portion of the cylinder portion in the axial direction to connect the other end portion of the cylinder portion in the axial direction to the bulging portion.

[Effect of the Invention]

[0007] In this way, according to this invention, it is possible to provide an internal combustion engine capable of protecting a portion of a hydraulic control valve exposed to the outside from foreign matter such as flying stones flying from below.

[Brief description of figures]

[0008]

[Fig. 1] Fig. 1 is a front view of an internal combustion engine according to an embodiment of this invention.
[Fig. 2] Fig. 2 is a perspective view of a chain casing and a hydraulic control valve of the internal combustion engine according to an embodiment of this invention.
[Fig. 3] Fig. 3 is a perspective view of a chain casing of the internal combustion engine according to an embodiment of this invention.
[Fig. 4] Fig. 4 is a front view of the chain casing and the hydraulic control valve of the internal combustion engine according to an embodiment of this invention.

[Embodiment(s) of the Invention]

[0009] An internal combustion engine according to embodiments of this invention is an internal combustion engine including: a variable valve timing mechanism configured by winding a timing chain thereon; a hydraulic control valve controlling hydraulic oil supplied to the variable valve timing mechanism; and a chain casing fixed to a cylinder head to cover the timing chain and the variable valve timing mechanism, wherein the chain casing includes a bulging portion bulging in a crank shaft direction and covering the variable valve timing mechanism and a cylindrical cylinder portion attaching the hydraulic control valve thereto, wherein the hydraulic control valve

includes a small diameter portion inserted from one end portion of the cylinder portion in an axial direction to the cylinder portion and a large diameter portion exposed from one end portion of the cylinder portion in the axial direction, wherein the internal combustion engine is mounted on a vehicle so that center lines of a plurality of cylinders are inclined with respect to an up to down direction of the vehicle, wherein the cylinder portion is adjacently formed below the bulging portion, wherein the other end portion of the cylinder portion in the axial direction is disposed below one end portion of the cylinder portion in the axial direction, and wherein the chain casing includes a connection rib formed on the side of the other end portion of the cylinder portion in the axial direction to connect the other end portion of the cylinder portion in the axial direction to the bulging portion.

[0010] Accordingly, the internal combustion engine according to an embodiment of this invention can protect a portion exposed to the outside of the hydraulic control valve from foreign matter such as flying stones flying from below.

[Embodiments]

[0011] Hereinafter, an internal combustion engine according to an embodiment of this invention will be described with reference to the drawings. Figs. 1 to 4 are diagrams showing the internal combustion engine according to an embodiment of this invention.

[0012] In Figs. 1 to 4, the display in the up, down, front, rear, right, and left directions shows the up, down, front, rear, right, and left when mounted on the vehicle. Further, the display of the AB direction, the CD direction, and the EF direction is based on the case in which the internal combustion engine separated from the vehicle is upright so that the cylinder head is located right above the crank shaft. The AB direction, the CD direction, and the EF direction are directions orthogonal to each other and the EF direction coincides with the front to rear direction of the vehicle equipped with the internal combustion engine.

[0013] First, a configuration will be described. In Fig. 1, an internal combustion engine 1 mounted on the vehicle includes a cylinder block 2. The cylinder block 2 is provided with a crank shaft 2A and the crank shaft 2A extends in the EF direction.

[0014] The cylinder block 2 is provided with three cylinders (not shown) arranged in the EF direction and the cylinder extends in the AB direction. The internal combustion engine 1 of this embodiment is an FR (front engine-rear drive) type vertical engine. Additionally, the internal combustion engine 1 is not limited to an in-line engine and may be, for example, a V-type engine. Then, the number of cylinders is not limited to three.

[0015] A cylinder head 3 is provided at the end portion of the cylinder block 2 in the A direction. The cylinder head 3 includes an intake port (not shown) which takes air, an exhaust port 3B which discharges an exhaust gas, an intake valve, and an exhaust valve (not shown). The exhaust port 3B opens to a side wall of the cylinder head 3 in the D direction. The intake port opens to a side wall of the cylinder head 3 in the C direction.

[0016] A cylinder head cover 4 is installed at the end portion of the cylinder head 3 in the A direction. An oil pan 5 is installed at the end portion of the cylinder block 2 in the B direction and the oil pan 5 stores lubricating oil of the internal combustion engine 1.

[0017] The internal combustion engine 1 is installed below a floor panel of a driver seat on the front part of the vehicle (not shown). Thus, the vehicle equipped with the internal combustion engine 1 is a so-called cab-over type vehicle in which a driver seat is disposed above the internal combustion engine 1. The internal combustion engine 1 is installed in the vehicle so that the center line C of the cylinder is inclined in the left to right direction with respect to the up to down direction of the vehicle.

[0018] An undercover 1A is provided below the internal combustion engine 1. The undercover 1A extends in the horizontal direction and covers the internal combustion engine 1 from below. A bottom surface 5A of the oil pan 5 is located at the bottom portion of the internal combustion engine 1 in a vehicle mounted state. This bottom surface 5A is inclined with respect to the left to right direction of the internal combustion engine 1 itself to extend in parallel to the undercover lAin the vehicle mounted state.

[0019] In this way, the internal combustion engine 1 is mounted on the front part of the vehicle in a largely inclined posture. Therefore, in the vehicle mounted state, the side surface (intake side) of the internal combustion engine 1 in the C direction faces the upper side of the vehicle and the side surface (exhaust side) of the internal combustion engine 1 in the D direction faces the lower side of the vehicle.

[0020] The internal combustion engine 1 includes a variable valve timing mechanism 11 on which a timing chain 10 is wound and the cylinder head cover 4 which is connected to the cylinder head 3. Further, the internal combustion engine 1 includes an intake hydraulic control valve 15 and an exhaust hydraulic control valve 16 each having a cylindrical shape and serving as an intake hydraulic control valve controlling hydraulic oil supplied to the variable valve timing mechanism 11.

[0021] The internal combustion engine 1 includes a chain casing 20 and this chain casing 20 is fixed to the side surface of the cylinder head 3. The chain casing 20 covers the timing chain 10 and the variable valve timing mechanism 11. The variable valve timing mechanism 11 includes an intake side variable valve timing mechanism 12 which is disposed on the side of the intake port and an exhaust side variable valve timing mechanism 13 which is disposed on the side of the exhaust port 3B.

[0022] The internal combustion engine 1 includes an oil pan 5 which is provided on the side opposite to the cylinder head 3 with respect to the chain casing and is connected to the cylinder head 3 through the cylinder block 2, an intake port which is provided in the cylinder

head 3 and takes air, and an exhaust port 3B which is provided on the side opposite to the intake port with respect to the chain casing and discharges an exhaust gas.

[0023] The chain casing 20 is provided with a bulging portion 21 which covers the variable valve timing mechanism 11. The bulging portion 21 bulges in the crank shaft direction. Here the crank shaft direction is the axial direction of the crank shaft 2A. In this embodiment, the bulging portion 21 bulges toward the outside of the chain casing 20 (the front side in the vehicle mounted state). The bulging portion 21 is formed at the end portion on the side of the cylinder head cover 4 (the end portion in the A direction) of the chain casing 20. The intake hydraulic control valve 15 and the exhaust hydraulic control valve 16 are arranged closer to the oil pan 5 than the bulging portion 21 of the chain casing 20.

[0024] Further, the internal combustion engine 1 includes an oil pump 6 and the oil pump 6 pressure-feeds oil stored in the oil pan 5 to a lubrication required portion and the variable valve timing mechanism 11. The oil pump 6 is provided around the crank shaft 2A.

[0025] Here, in this embodiment, the direction of the cylinder head cover 4 with respect to the chain casing 20 and the direction of the oil pan 5 are defined as the AB direction, the direction of the intake port with respect to the chain casing 20 and the direction of the exhaust port 3B are defined as the CD direction, and the outward direction of the chain casing 20 (the front side in the vehicle mounted state) and the inward direction (the rear side in the vehicle mounted state) are defined as the EF direction.

[0026] The intake hydraulic control valve 15 is disposed on the side of the intake port in the CD direction. The exhaust hydraulic control valve 16 is disposed on the side of the exhaust port 3B in the CD direction.

[0027] In Figs. 2 and 4, the chain casing 20 is provided with a cylindrical intake side cylinder portion 23 to which the intake hydraulic control valve 15 is attached and a cylindrical exhaust side cylinder portion 24 to which the exhaust hydraulic control valve 16 is attached. The intake side cylinder portion 23 and the exhaust side cylinder portion 24 extend in the CD direction. The exhaust side cylinder portion 24 constitutes the cylinder portion and the first cylinder portion of this invention. The intake side cylinder portion 23 constitutes the second cylinder portion of this invention.

[0028] The intake side cylinder portion 23 and the exhaust side cylinder portion 24 are adjacently formed below the bulging portion 21. In a state in which the internal combustion engine 1 is mounted on the vehicle, the other end portion 23D (the end portion in the D direction. See Fig. 4) of the intake side cylinder portion 23 in the axial direction is disposed below one end portion 23C of the intake side cylinder portion 23 in the axial direction (the end portion in the C direction. See Fig. 4). Similarly, the other end portion 24D of the exhaust side cylinder portion 24 in the axial direction (the end portion in the D direction. See Fig. 4) is disposed below one end portion 24C of the exhaust side cylinder portion 24 in the axial direction (the end portion in the C direction. See Fig. 4).

[0029] In Figs. 1 and 4, the intake hydraulic control valve 15 includes a small diameter portion 15B (see Fig. 1) which is inserted from one end portion 23C of the intake side cylinder portion 23 in the axial direction (see Fig. 4) into the intake side cylinder portion 23 and a large diameter portion 15A (see Fig. 1) which is exposed from one end portion 23C of the intake side cylinder portion 23 in the axial direction (see Fig. 4). Similarly, the exhaust hydraulic control valve 16 includes a small diameter portion 16B (see Fig. 1) which is inserted from one end portion 24C of the exhaust side cylinder portion 24 in the axial direction (see Fig. 4) into the exhaust side cylinder portion 24 and a large diameter portion 16A (see Fig. 1) which is exposed from one end portion 24C of the exhaust side cylinder portion 24 in the axial direction (see Fig. 4).

[0030] In Fig. 3, the intake side cylinder portion 23 is provided with an accommodation hole 23A accommodating the small diameter portion 15B of the intake hydraulic control valve 15. The exhaust side cylinder portion 24 is provided with an accommodation hole 24A accommodating the small diameter portion 16B of the exhaust hydraulic control valve 16.

[0031] In Fig. 1, the chain casing 20 is provided with an oil pump accommodation portion 29 which accommodates the oil pump 6. The intake side cylinder portion 23, the exhaust side cylinder portion 24, and the oil pump accommodation portion 29 are integrally formed with each other.

[0032] The oil pump accommodation portion 29 is a flat portion which does not bulge in the direction of the crank shaft in the chain casing 20. The oil pump accommodation portion 29 is disposed below the bulging portion 21 and is continuous to the lower portion of the bulging portion 21.

[0033] Since the oil pump accommodation portion 29 has a flat shape rather than a bulging shape like the bulging portion 21, the rigidity thereof is inferior to that of the bulging portion 21 as it is. Here, in this embodiment, the rigidity of the portion provided with the intake side cylinder portion 23 and the exhaust side cylinder portion 24 of the oil pump accommodation portion 29 is improved. Further, since it is preferable to compactly arrange the intake side cylinder portion 23 and the exhaust side cylinder portion 24 in the AB direction, the intake side cylinder portion 23 and the exhaust side cylinder portion 24 are arranged to be offset in the CD direction and the EF direction.

[0034] A connector (not shown) for electrically controlling the intake hydraulic control valve 15 and the exhaust hydraulic control valve 16 is connected to the side of the intake port of the large diameter portions 15A and 16A in the CD direction. A connection port of each connector faces the outside (front side) of the chain casing 20 in the EF direction.

[0035] Here, since the internal combustion engine 1 of this embodiment is mounted on the vehicle in a largely inclined posture, the uppermost portions of the intake

hydraulic control valve 15 and the exhaust hydraulic control valve 16 in the up to down direction of the vehicle are located below the uppermost portion of the cylinder head cover 4 in the up to down direction of the vehicle in the vehicle mounted state. Further, a connector (not shown) of the end portion on the side of the intake port of the large diameter portion 16A of the exhaust hydraulic control valve 16 in the CD direction is disposed at a position which is on the lower side in the up to down direction of the vehicle and on the side of the cylinder head cover 4 with respect to a connector (not shown) of the end portion on the side of the intake port of the large diameter portion 15A of the intake hydraulic control valve 15 in the CD direction.

[0036] Accordingly, the connector of the large diameter portion 16A of the exhaust hydraulic control valve 16 is disposed between the connector of the large diameter portion 15A of the intake hydraulic control valve 15 and the cylinder head cover 4 and below the uppermost portions of both the intake hydraulic control valve 15 and the cylinder head cover 4 in the up to down direction of the vehicle. Therefore, it is possible to suppress foreign matter such as dust from settling and accumulating on the connector of the large diameter portion 16A of the exhaust hydraulic control valve 16 without disposing the exhaust hydraulic control valve 16 inside the cylinder head cover 4.

[0037] The intake hydraulic control valve 15 and the exhaust hydraulic control valve 16 are respectively inserted in the D direction from the end portions of the intake side cylinder portion 23 and the exhaust side cylinder portion 24 in the C direction (the upper side in the vehicle mounted state). Therefore, since the insertion directions of the intake hydraulic control valve 15 and the exhaust hydraulic control valve 16 are the same as each other, the insertion work can be facilitated.

[0038] Further, since the intake hydraulic control valve 15 is disposed above the intake side cylinder portion 23 and the exhaust hydraulic control valve 16 is disposed above the exhaust side cylinder portion 24 in the vehicle mounted state, it is possible to prevent a foreign mater from entering the intake hydraulic control valve 15 and the exhaust hydraulic control valve 16 even when the foreign matter or the like mixed with the hydraulic oil precipitates.

[0039] In Fig. 3, the edge portion of the chain casing 20 is provided with a plurality of cylinder head fastening portions 41 and 42 and the cylinder head fastening portions 41 and 42 respectively include fastening holes 41A and 42A for fastening the oil pump accommodation portion 29 to the cylinder head 3. The cylinder head fastening portions 41 and 42 are adjacent to each other in the AB direction. The portion provided with the cylinder head fastening portions 41 and 42 of the chain casing 20 is a portion having a large wall thickness and high strength.

[0040] In Figs. 3 and 4, the accommodation hole 23A of the intake side cylinder portion 23 and the accommodation hole 24A of the exhaust side cylinder portion 24 are arranged on either the side of the intake port or the side of the exhaust port 3B in the CD direction and open to either the side of the intake port or the side of the exhaust port 3B. That is, the accommodation hole 23A of the intake side cylinder portion 23 and the accommodation hole 24A of the exhaust side cylinder portion 24 are arranged in the same direction in the CD direction and open in the same direction. In this embodiment, the accommodation hole 23A of the intake side cylinder portion 23 and the accommodation hole 24A of the exhaust side cylinder portion 24 are arranged on the side of the intake port and open to the side of the intake port.

[0041] In Fig. 3, an axis 23R of the accommodation hole 23A of the intake side cylinder portion 23 and an axis 24R of the accommodation hole 24A of the exhaust side cylinder portion 24 are arranged at different positions in the EF direction.

[0042] Specifically, the axis 23R is disposed on the inside of the chain casing 20 in relation to the axis 24R in the EF direction. The axis 23R and the axis 24R are parallel to each other. Accordingly, since the casting pins forming the accommodation holes 23A and 24A can be extracted in the same direction, it is possible to manufacture the chain casing 20 from a simple mold structure and to further shorten the distance between the intake side cylinder portion 23 and the exhaust side cylinder portion 24 in the CD direction (the direction of the axes 23R and 24R).

[0043] In Fig. 1, at least a part of the intake side cylinder portion 23 and the exhaust side cylinder portion 24 overlaps in the AB direction.

[0044] In Fig. 3, the chain casing 20 includes a wall-shaped connection portion 43. The connection portion 43 extends in the EF direction and connects the end portion on the side of the exhaust port 3B (the other end portion 23D shown in Fig. 4) of the intake side cylinder portion 23 in the CD direction to the end portion on the side of the intake port (one end portion 24C shown in Fig. 4) of the exhaust side cylinder portion 24 in the CD direction. Additionally, the connection portion 43 also extends in the AB direction. Thus, the connection portion 43 connects the intake side cylinder portion 23 and the exhaust side cylinder portion 24 in the EF direction and the AB direction.

[0045] In Fig. 3, the chain casing 20 includes a cylindrical oil gallery portion 27 and an oil passage (not shown) through which hydraulic oil flows is formed inside the oil gallery portion 27.

[0046] The oil gallery portion 27 extends in the CD direction. The chain casing 20 includes a wall portion 21A extending in the EF direction and continuous to the oil pump accommodation portion 29 and this wall portion 21A is provided at the end portion on the side of the oil pan 5 in the bulging portion 21 in the AB direction. The intake side cylinder portion 23 and the exhaust side cylinder portion 24 are arranged between the oil gallery portion 27 and the wall portion 21A in the AB direction.

[0047] Additionally, in order to suppress the vibration

of an intake manifold (not shown) connected to the intake port of the cylinder head 3 from being transmitted to the chain casing 20, it is preferable to improve the rigidity of the portion in the vicinity of the intake manifold in the chain casing 20. Here, the intake port and the intake manifold connected to the intake port are arranged between the cylinder head fastening portion 41 and the cylinder head fastening portion 42 in the AB direction. Accordingly, since it is possible to set the distance between the cylinder head fastening portion 41 and the cylinder head fastening portion 42 to a minimum distance, it is possible to improve the rigidity of the portion in the vicinity of the cylinder head fastening portions 41 and 42 in the chain casing 20. Further, it is possible to suppress the vibration of the portion in the vicinity of the cylinder head fastening portions 41 and 42 in the chain casing 20.

[0048] The chain casing 20 includes an intake side fastening boss portion 25 and an exhaust side fastening boss portion 26 for attaching the chain casing 20 to the cylinder head 3. The intake side fastening boss portion 25 and the exhaust side fastening boss portion 26 are arranged in the vicinity of the bulging portion 21 in the B direction.

[0049] The end portion of the bulging portion 21 in the B direction is connected to the end portions of the intake side cylinder portion 23 and the exhaust side cylinder portion 24 in the A direction. The end portion of the intake side fastening boss portion 25 in the A direction is connected to the end portion of the intake side cylinder portion 23 in the B direction. The end portion of the exhaust side fastening boss portion 26 in the A direction is connected to the end portion of the exhaust side cylinder portion 24 in the B direction. The end surface of the cylinder head 3 in the A direction forms a planar joint surface extending in the CD direction and the EF direction and is joined to the cylinder head cover 4.

[0050] The intake hydraulic control valve 15, the exhaust hydraulic control valve 16, the intake side cylinder portion 23, and the exhaust side cylinder portion 24 extend in the CD direction. Further, the intake hydraulic control valve 15 and the intake side cylinder portion 23 are arranged side by side in the EF direction with respect to the exhaust hydraulic control valve 16 and the exhaust side cylinder portion 24.

[0051] The intake side fastening boss portion 25 and the exhaust side fastening boss portion 26 are arranged side by side in the CD direction. The intake side fastening boss portion 25 and the exhaust side fastening boss portion 26 are formed to protrude in the E direction (forward in the vehicle mounted state) in relation to the intake side cylinder portion 23.

[0052] The intake side cylinder portion 23 and the exhaust side cylinder portion 24 are arranged side by side at different positions in the crank shaft direction. The intake side cylinder portion 23 and the exhaust side cylinder portion 24 are arranged in parallel in the crank shaft direction so that a part thereof overlaps in the crank shaft direction. In this embodiment, the exhaust side cylinder portion 24 is disposed adjacent to the front side of the intake side cylinder portion 23.

[0053] Further, when the chain casing 20 is viewed along the crank shaft direction (see Fig. 4), the exhaust side cylinder portion 24 is disposed to be offset to the exhaust side (the D direction) in relation to the intake side cylinder portion 23. In this embodiment, the exhaust side cylinder portion 24 is disposed adjacently to the side of the D direction of the intake side cylinder portion 23. Thus, the exhaust side cylinder portion 24 is adjacently disposed in the E direction and the D direction of the intake side cylinder portion 23.

[0054] Thus, the intake side cylinder portion 23 is adjacently formed above the exhaust side cylinder portion 24 to be parallel to the axial direction of the exhaust side cylinder portion 24 and to be located at a position different from the exhaust side cylinder portion 24 in the axial direction.

[0055] In Figs. 3 and 4, the oil gallery portion 27 extends in a direction orthogonal to the crank shaft direction through the end portion of the intake side fastening boss portion 25 in the B direction and the end portion of the exhaust side fastening boss portion 26 in the B direction. The oil gallery portion 27 is connected to the end portion of the intake side fastening boss portion 25 in the B direction and the end portion of the exhaust side fastening boss portion 26 in the B direction.

[0056] The chain casing 20 includes a reinforcement rib 28 formed below the intake side cylinder portion 23. The reinforcement rib 28 extends in the axial direction of the intake side cylinder portion 23. The reinforcement rib 28 connects the intake side cylinder portion 23, the exhaust side cylinder portion 24, and the intake side fastening boss portion 25.

[0057] Specifically, the reinforcement rib 28 extends in the axial direction of the exhaust side cylinder portion 24 from one end portion 24C of the exhaust side cylinder portion 24 in the axial direction to at least a position above the large diameter portion along the end portion on the side opposite to the bulging portion 21 (the end portion in the B direction) in the exhaust side cylinder portion 24. The reinforcement rib 28 connects one end portion 24C of the exhaust side cylinder portion 24 in the axial direction to one end portion 23C of the intake side cylinder portion 23 in the axial direction. Specifically, the reinforcement rib 28 extends to one end portion 23C of the intake side cylinder portion 23 in the axial direction and connects one end portion 24C of the exhaust side cylinder portion 24 to a boss portion 34 formed at one end portion 23C of the intake side cylinder portion 23.

[0058] The chain casing 20 includes the boss portion 34 formed at the end portion of the intake side cylinder portion 23 in the C direction and the B direction. The boss portion 34 is provided in the B direction of the bulging portion 21. A leg portion 15C of the intake hydraulic control valve 15 is fastened to the boss portion 34. The leg portion 15C extends in the E direction and the B direction at the end portion of the large diameter portion 15A of

the intake hydraulic control valve 15 in the D direction.

[0059] The chain casing 20 includes a boss portion 35 on the side of the A direction of the end portion of the exhaust side cylinder portion 24 in the C direction. The boss portion 35 is provided in the bulging portion 21. A leg portion 16C of the exhaust hydraulic control valve 16 is fastened to the boss portion 35. The leg portion 16C extends in the E direction and the A direction at the end portion of the large diameter portion 16A of the exhaust hydraulic control valve 16 in the D direction.

[0060] An extension rib 31, a connection rib 32, and an upper rib 33 are formed on the surface of the chain casing 20. The extension rib 31, the connection rib 32, and the upper rib 33 protrude in the E direction.

[0061] A boss portion 37 which extends in the E direction is formed in the vicinity of the end portion of the bulging portion 21 of the chain casing 20 in the D direction. A boss portion 36 which extends in the E direction is formed at the end portion of the chain casing 20 in the A direction.

[0062] The extension rib 31 extends upward from the boss portion 34 formed at one end portion 23C of the intake side cylinder portion 23 in the axial direction. The reinforcement rib 28 is connected to the extension rib 31. The extension rib 31 extends from the boss portion 34 to the vicinity of the cylinder head fastening portion 42 of the end portion of the chain casing 20 in the C direction. The extension rib 31 reinforces the boss portion 34 by distributing the load acting on the boss portion 34 to the end portion of the chain casing 20 in the C direction.

[0063] The connection rib 32 is provided at a position on the side of the other end portion 24D of the exhaust side cylinder portion 24 in the axial direction in the chain casing 20 and in the vicinity of the end portion of the bulging portion 21 in the D direction. The connection rib 32 extends from the end portion of the exhaust side cylinder portion 24 in the D direction to the boss portion 37 in the A direction and the D direction. The connection rib 32 connects the other end portion 24D of the exhaust side cylinder portion 24 in the axial direction to the bulging portion 21. Specifically, the connection rib 32 connects the other end portion 24D of the exhaust side cylinder portion 24 to the boss portion 37 formed in the bulging portion 21.

[0064] Thus, the exhaust side cylinder portion 24 and the boss portion 37 are connected by the connection rib 32. Accordingly, a load acting on the exhaust side cylinder portion 24 is distributed to the chain casing 20 through the boss portion 37.

[0065] The upper rib 33 is provided in the vicinity of the end portion of the chain casing 20 in the A direction. The upper rib 33 extends from the boss portion 35 to the boss portion 36 in the A direction and the C direction. The upper rib 33 is connected to the boss portion 35 and the boss portion 36. Thus, the boss portion 35 and the boss portion 36 are connected by the upper rib 33. Accordingly, the load acting on the boss portion 35 is distributed to the boss portion 36 through the upper rib 33. Further, the reinforcement rib 38 is connected to the boss portion 35 and the reinforcement rib 38 extends from the boss portion 35 in the D direction. The load acting on the boss portion 35 is also distributed to the portion in the vicinity of the boss portion 35 of the bulging portion 21 in the D direction by the reinforcement rib 38.

[0066] As described above, in this embodiment, the exhaust side cylinder portion 24 is adjacently formed below the bulging portion 21. Further, the other end portion 24D of the exhaust side cylinder portion 24 in the axial direction is disposed below one end portion 24C of the exhaust side cylinder portion 24 in the axial direction. Then, the chain casing 20 includes the connection rib 32 which is formed on the side of the other end portion 24D of the exhaust side cylinder portion 24 in the axial direction to connect the other end portion 24D of the exhaust side cylinder portion 24 in the axial direction to the bulging portion 21.

[0067] Accordingly, when foreign matter such as flying stones flows from the road surface below the vehicle toward the exhaust hydraulic control valve 16 along the arrow A (see Fig. 4), foreign matter collides with the wall portion 21A of the bulging portion 21 or the connection rib 32 and falls without colliding with the exhaust hydraulic control valve 16. Thus, it is possible to protect the large diameter portion 16A which is a portion of the exhaust hydraulic control valve 16 exposed to the outside from foreign matter such as flying stones flying from below.

[0068] Further, in this embodiment, the chain casing 20 includes the reinforcement rib 28 which extends in the axial direction of the exhaust side cylinder portion 24 from one end portion 24C of the exhaust side cylinder portion 24 in the axial direction to at least a position above the large diameter portion along the end portion on the side opposite to the bulging portion 21 in the exhaust side cylinder portion 24.

[0069] Accordingly, the large diameter portion 16A of the exhaust hydraulic control valve 16 exposed from the exhaust side cylinder portion 24 to the outside can be surrounded from below by the reinforcement rib 28, the exhaust side cylinder portion 24, and the bulging portion 21. Therefore, when foreign matter such as flying stones flies from the road surface below the vehicle toward the exhaust hydraulic control valve 16 along the arrow B (see Fig. 4), foreign matter collides with the bulging portion 21 or the connection rib 32 and falls without colliding with the exhaust hydraulic control valve 16. Thus, it is possible to more effectively protect the large diameter portion 16A of the exhaust hydraulic control valve 16 exposed from the exhaust side cylinder portion 24 to the outside from foreign matter such as flying stones. Additionally, the intake side fastening boss portion 25 is connected to the lower surface of the reinforcement rib 28 and the intake side fastening boss portion 25 has a dimension (height) larger than that of the reinforcement rib 28 in the E direction. Therefore, it is also possible to more effectively protect the large diameter portion 16A from foreign matter such as flying stones by the intake side fastening boss

portion 25.

[0070] Further, in this embodiment, the chain casing 20 includes the intake side cylinder portion 23 adjacently formed above the exhaust side cylinder portion 24 to be parallel to the axial direction of the exhaust side cylinder portion 24 and to be located at a position different from the exhaust side cylinder portion 24 in the axial direction. Then, the reinforcement rib 28 connects one end portion 24C of the exhaust side cylinder portion 24 in the axial direction to one end portion 23C of the intake side cylinder portion 23 in the axial direction.

[0071] Accordingly, since foreign matter such as flying stones flying from the lower side of the vehicle collides with the reinforcement rib 28, it is possible to effectively protect the large diameter portion 15A of the intake hydraulic control valve 15 exposed from the intake side cylinder portion 23 to the outside.

[0072] Further, since the exhaust side cylinder portion 24 and the intake side cylinder portion 23 are connected by the reinforcement rib 28, it is possible to reinforce the exhaust side cylinder portion 24 and the intake side cylinder portion 23 by more firmly connecting them and to suppress the vibration or deformation of the exhaust side cylinder portion 24 and the intake side cylinder portion 23.

[0073] Further, in this embodiment, the reinforcement rib 28 extends to one end portion 23C of the intake side cylinder portion 23 in the axial direction. Then, the chain casing 20 includes the extension rib 31 which is connected to the reinforcement rib 28 and extends upward from one end portion 23C of the intake side cylinder portion 23 in the axial direction.

[0074] Accordingly, the large diameter portion 15A of the intake hydraulic control valve 15 inserted into the intake side cylinder portion 23 is surrounded from below by the bulging portion 21, the reinforcement rib 28, and the extension rib 31. Therefore, it is possible to more effectively protect the large diameter portion 15A of the intake hydraulic control valve 15 exposed from the intake side cylinder portion 23 to the outside from foreign matter such as flying stones.

[0075] While embodiments of this invention have been described, it is apparent that some artisan could have made changes without departing from the scope of this invention. It is intended that any and all such modifications and equivalents are involved in the appended claims.

(DESCRIPTION OF REFERENCE NUMERALS)

[0076] 1 ... Internal combustion engine, 3 ... Cylinder head, 11 ... Variable valve timing mechanism, 15 ... Intake hydraulic control valve, 15A ... Large diameter portion, 15B ... Small diameter portion, 16 ... Exhaust hydraulic control valve, 16A ... Large diameter portion, 16B ... Small diameter portion, 20 ... Chain casing, 21 ... Bulging portion, 23 ... Intake side cylinder portion (second cylinder portion), 23A ... Accommodation hole, 24 ... Exhaust side cylinder portion (cylinder portion, first cylinder portion), 24A ... Accommodation hole, 24C ... One end portion, 24D ... Other end portion, 28 ... Reinforcement rib, 31 ... Extension rib, 32 ... Connection rib

Claims

1. An internal combustion engine comprising:

a variable valve timing mechanism configured by winding a timing chain thereon;
a hydraulic control valve controlling hydraulic oil supplied to the variable valve timing mechanism; and
a chain casing fixed to a cylinder head to cover the timing chain and the variable valve timing mechanism,
wherein the chain casing includes a bulging portion bulging in a crank shaft direction and covering the variable valve timing mechanism and a cylindrical cylinder portion attaching the hydraulic control valve thereto,
wherein the hydraulic control valve includes a small diameter portion inserted from one end portion of the cylinder portion in an axial direction to the cylinder portion and a large diameter portion exposed from one end portion of the cylinder portion in the axial direction,
wherein the internal combustion engine is mounted on a vehicle so that center lines of a plurality of cylinders are inclined with respect to an up to down direction of the vehicle,
wherein the cylinder portion is adjacently formed below the bulging portion,
wherein the other end portion of the cylinder portion in the axial direction is disposed below one end portion of the cylinder portion in the axial direction, and
wherein the chain casing includes a connection rib formed on the side of the other end portion of the cylinder portion in the axial direction to connect the other end portion of the cylinder portion in the axial direction to the bulging portion.

2. The internal combustion engine according to claim 1, wherein the chain casing includes a reinforcement rib extending in the axial direction of the cylinder portion from one end portion of the cylinder portion in the axial direction to at least a position above the large diameter portion along an end portion on the side opposite to the bulging portion in the cylinder portion.

3. The internal combustion engine according to claim 2,

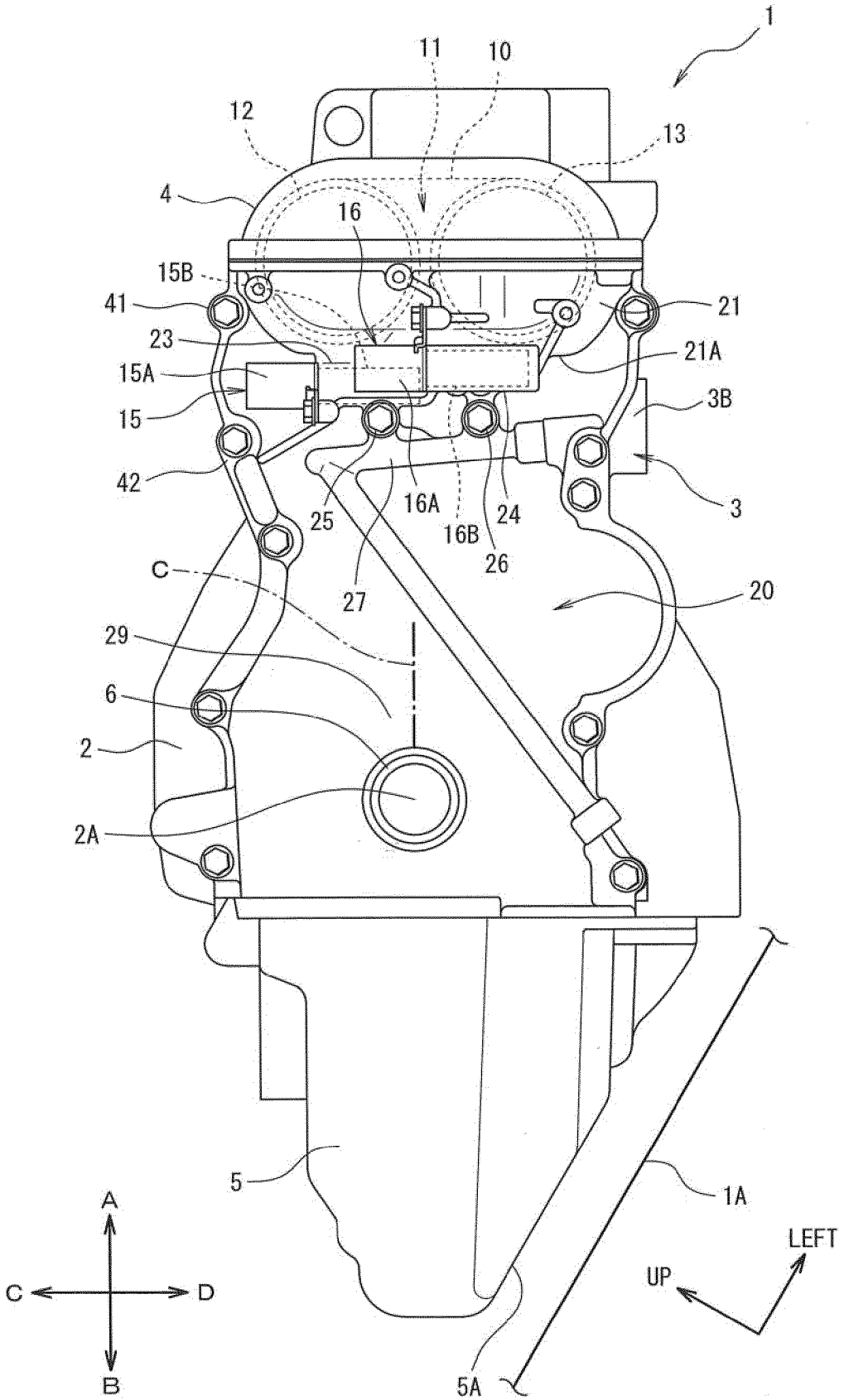
wherein when the cylinder portion is a first cylinder portion, the chain casing includes a second cylinder portion adjacently formed above the

first cylinder portion to be parallel to the axial direction of the first cylinder portion and to be located at a position different from the first cylinder portion in the axial direction, and
wherein the reinforcement rib connects one end portion of the first cylinder portion in the axial direction to one end portion of the second cylinder portion in the axial direction.

4. The internal combustion engine according to claim 3,

wherein the reinforcement rib extends to one end portion of the second cylinder portion in the axial direction, and
wherein the chain casing includes an extension rib connected to the reinforcement rib and extending upward from one end portion of the second cylinder portion in the axial direction.

FIG. 1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1A
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FIG. 2

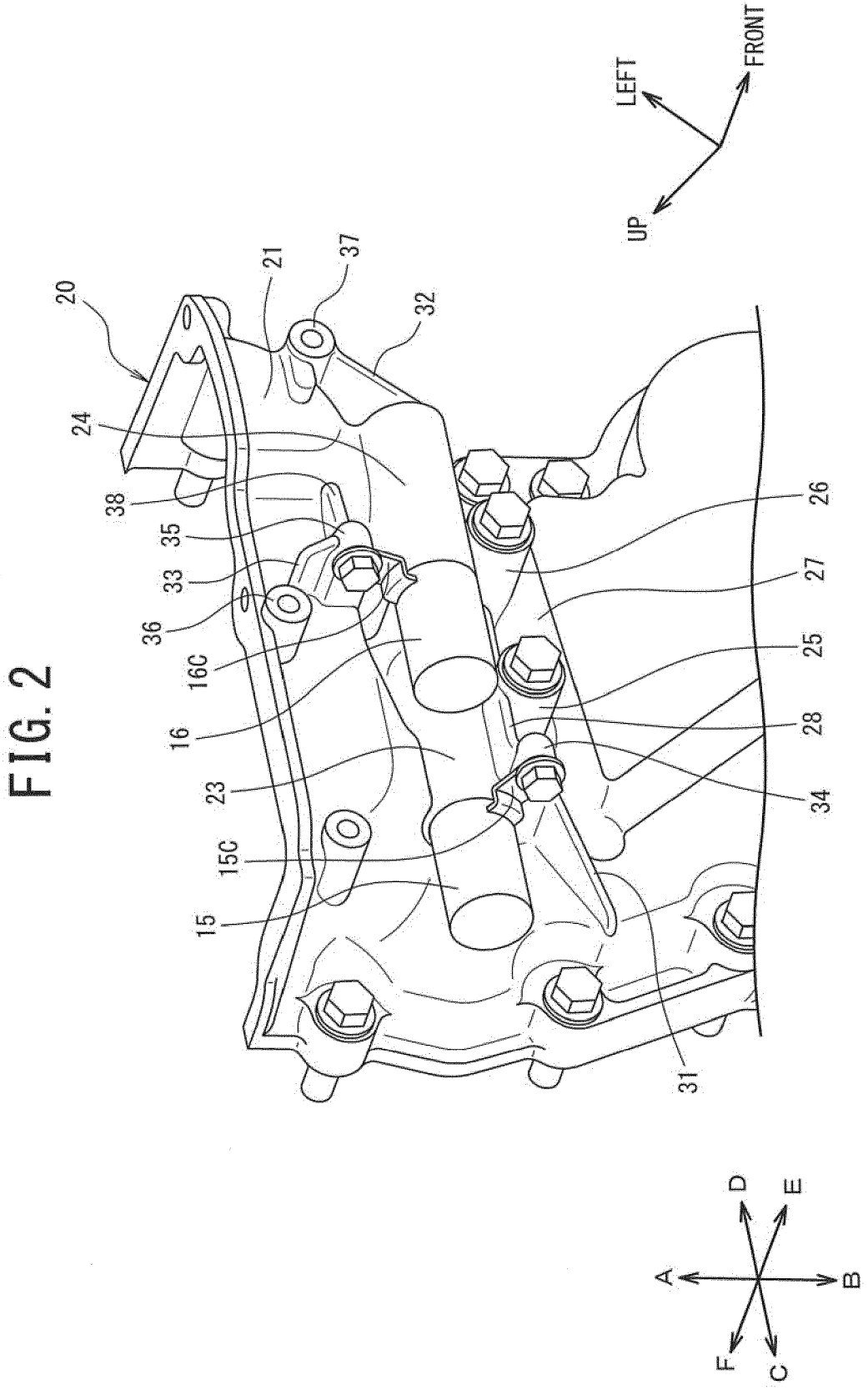
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FIG. 3

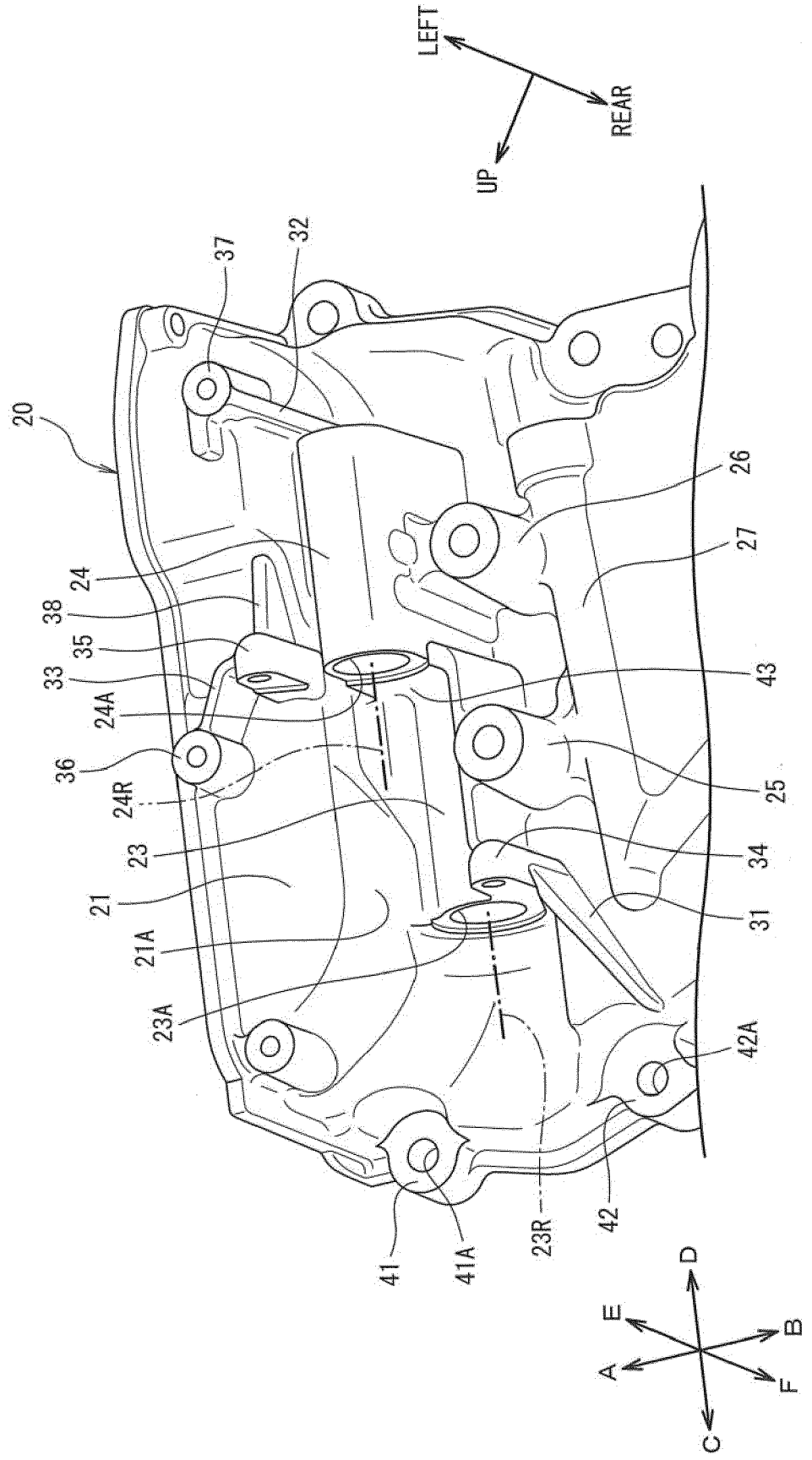
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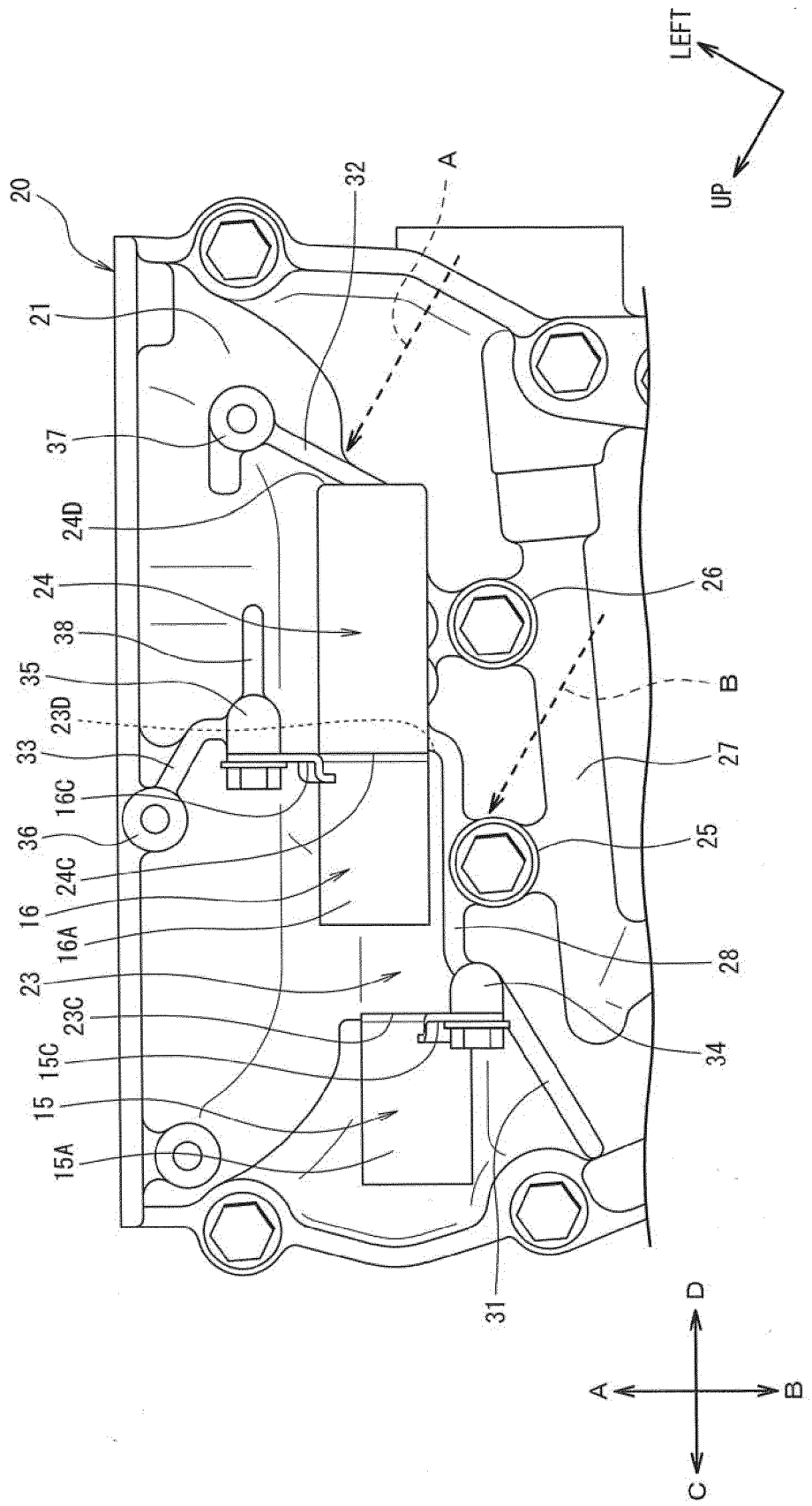
FIG. 4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EUROPEAN SEARCH REPORT

Application Number
EP 22 20 7278

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A	* paragraphs [0015] - [0038], [0070] - [0075]; figures 1-6 *	2-4	F02B67/06 F02F7/00 F01L1/02
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F02B
F02F
F01L

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	28 March 2023	Deseau, Richard

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28-03-2023

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