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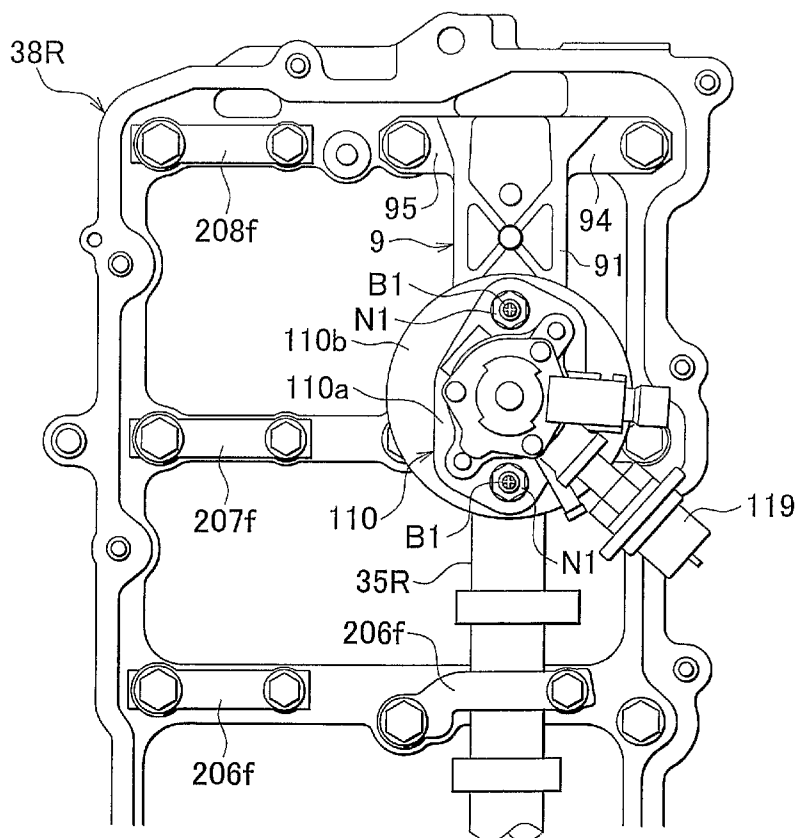
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(54) Title: FUEL PUMP SUPPORT STRUCTURE OF AN INTERNAL COMBUSTION ENGINE AND PUMP SUPPORT BRACKET USED IN THE FUEL PUMP SUPPORT STRUCTURE



(57) Abstract: A pump support bracket (9) is mounted so as to extend between a plurality of bearing portions (207, 208) of a camshaft housing (38R), and a high pressure fuel pump (110) is supported on the top surface of this pump support bracket (9). An oil jet that injects oil towards a lifter of the high pressure fuel pump (110) is formed in the pump support bracket (9). An oil collecting portion for immersing a driving cam for driving the high pressure fuel pump (110) is formed on the bearing portion (207).

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FUEL PUMP SUPPORT STRUCTURE OF AN INTERNAL COMBUSTION ENGINE
AND PUMP SUPPORT BRACKET USED IN THE FUEL PUMP SUPPORT
STRUCTURE

5 BACKGROUND OF THE INVENTION

1. Field of the Invention

The invention relates to a support structure of a fuel pump that increases the pressure of fuel supplied to a fuel injection valve (i.e., a fuel injector), as well as to a pump support bracket used in the support structure, which can be applied to an internal
10 combustion engine such as an in-cylinder direct injection type engine, for example. More particularly, the invention relates to a measure for supporting a fuel pump with high support rigidity.

2. Description of the Related Art

In an engine that requires high pressure to supply fuel to fuel injectors, such as
15 an in-cylinder direct injection type engine, for example, a high pressure fuel pump is used to pressurize fuel sent from a fuel tank and supply it to the fuel injectors.

Japanese Patent Application Publication No. JP-A-2000-297710 and Japanese Patent Application Publication No. JP-A-2003-328847, for example, describe specific examples of a structure of a fuel supply system in which such a high pressure fuel pump
20 is provided. The described fuel supply systems each include a feed pump that pumps up fuel from a fuel tank, a high pressure fuel pump that pressurizes the fuel that has been pumped up by the feed pump, and a delivery pipe that stores the fuel that has been pressurized by the high pressure fuel pump. A plurality of fuel injectors are connected to this delivery pipe. Accordingly, high pressure fuel that is stored in the delivery pipe
25 is injected from the fuel injectors toward a combustion chamber when the fuel injectors open.

Also, the high pressure fuel pump has a plunger which has been inserted into a cylinder. This plunger is driven up and down inside the cylinder by pressure applied from a driving cam via a lifter to pressurize fuel that has been drawn into a pressurizing

chamber. Also, a spill valve is provided in this kind of high pressure pump as a mechanism to adjust the amount of fuel discharged. This spill valve accomplishes this by switching between two states, i.e., open and closed. When the spill valve is open, fuel is allowed to flow between a low pressure fuel line, which is the fuel supply line
5 from the feed pump, and the pressurizing chamber of the high pressure fuel pump. When the spill valve is closed, fuel is prevented from flowing between the low pressure fuel line and the pressurizing chamber of the high pressure fuel pump.

As described above, the high pressure fuel pump is structured such that the plunger moves up and down inside the cylinder. This reciprocal motion of the plunger
10 while the pump is operating, however, generates vibration. It is therefore desirable to ensure that the support structure of the high pressure fuel pump be highly rigid. Japanese Patent Application Publication No. JP-A-2000-291503 describes one example of a support structure for a high pressure fuel pump. The described structure is one in which a generally barrel-shaped bracket is fixed to an upper portion of the cylinder head
15 and the high pressure fuel pump is mounted on this bracket.

However, presently none of these support structures for a high pressure fuel pump have high enough support rigidity to be able to sufficiently absorb the vibration generated from the reciprocal motion of the plunger. The reason for this is as follows.

A high pressure fuel pump is typically structured such that a plunger is made to
20 move up and down by pressure applied by the driving cam integrally formed on a camshaft (such as an intake camshaft) for driving a valve operating mechanism of an engine. Therefore, the high pressure fuel pump is arranged on an upper portion of the cylinder head.

However, because the cylinder head houses various parts that make up the valve
25 operating mechanism, a large portion inside of the cylinder head is open. Therefore it is difficult for the cylinder head to have a portion that is able to support the high pressure fuel pump with high support rigidity, which is why it was difficult to support the high pressure fuel pump with high enough support rigidity to be able to sufficiently absorb the vibrations simply by fixing a bracket to the upper portion of the cylinder head (such as a

portion of the cylinder head frame) like the mounting structure for a high pressure fuel pump described in Japanese Patent Application Publication No. JP-A-2000-291503.

SUMMARY OF THE INVENTION

5 This invention thus provides a fuel pump support structure for an internal combustion engine, and a pump support bracket used in the support structure, which can support a fuel pump with high support rigidity at an upper portion of a cylinder head.

 This invention is able to support a fuel pump with high support rigidity without greatly changing the structure of the cylinder head by realizing a fuel pump support
10 structure that extends between a plurality of bearing portions which are portions of the cylinder head that have relatively high rigidity compared to other portions of the cylinder head.

 Therefore, a first aspect of the invention relates to a fuel pump support structure of an internal combustion engine, which supports a fuel pump for increasing the pressure
15 of fuel to be supplied to a fuel injection valve on a cylinder head. This fuel pump support structure is characterised by including a plurality of bearing portions which are provided on the cylinder head in the direction in which cylinders of the internal combustion engine are aligned and rotatably support a camshaft of the internal combustion engine; and a pump support bracket arranged extending between at least two
20 of the bearing portions and fixedly supported by the at least two bearing portions. Further, the fuel pump is mounted to the pump support bracket.

 According to this fuel pump support structure, the fuel pump is supported by a plurality of bearing portions via a pump support bracket. The bearing portions rotatably support the camshaft that receives reaction force from a valve operating mechanism and
25 so are made to have relatively high rigidity among the portions of the cylinder head. With this structure, the fuel pump support bracket is supported across a plurality of these bearing portions so high support rigidity can be obtained. As a result, the fuel pump can be driven stably. In addition, vibrations generated when the fuel pump is driven can be suppressed so that they are inhibited from being transmitted to other members.

In the foregoing aspect, a first bearing surface that is a bearing surface for the camshaft may be formed on a bearing portion of the cylinder head, and a second bearing surface may be formed on a portion of the pump support bracket that opposes the camshaft. The first bearing surface, together with the second bearing surface, may
5 rotatably support the camshaft.

According to this structure, the pump support bracket can also function as a cam cap (i.e., a member that pins the camshaft down from above). Therefore, when the pump support bracket is arranged so as to extend between two bearing portions, for example, the pump support bracket functions as two cam caps. Also, when the pump
10 support bracket is arranged so as to extend between three bearing portions, the pump support bracket functions as three cam caps. That is, the pump support bracket obviates the need for cam caps at the portions where it is arranged, which makes it possible to reduce the size of the engine by reducing the number of parts and effectively utilizing space.

Also, one structure in which a function to improve the ability to lubricate the portion where the camshaft and the fuel pump (or more specifically, the lifter of the fuel pump) slidably contact one another to has been added to the pump support bracket is as follows. That is, in the foregoing aspect, a driving cam that drives the fuel pump may be formed on the camshaft; the fuel pump may include a cylinder, a plunger which is
20 inserted into the cylinder so as to be able to move up and down in the cylinder and defines a pressurizing chamber, and a lifter which moves the plunger in a direction that makes the pressurizing chamber smaller by applying pressure from the driving cam to the plunger; and a lubrication passage for supplying lubrication oil to a portion where the lifter and the driving cam slidingly contact one another may be formed in the pump
25 support bracket.

According to this structure, connecting part of the lubrication path in the internal combustion engine to the lubrication passage of the pump support bracket, for example, enables lubrication oil that flows into this lubrication passage to be supplied (i.e., injected) to the portion where the lifter and the driving cam slide against one another.

As a result, sliding resistance is greatly reduced between the lifter and the driving cam, thus reducing mechanical loss so that the fuel pump can be operated with high efficiency. Also, effectively utilizing the pump support bracket obviates the need for a new member to form the lubrication passage, thus preventing the number of parts from increasing.

5 Also, one structure for reducing mechanical loss using lubrication oil as described above is as follows. That is, in the foregoing aspect, a driving cam that drives the fuel pump may be formed on the camshaft; the fuel pump may be driven by pressure received from the driving cam; and a lubrication oil collecting portion for collecting lubrication oil supplied to the bearing portion (i.e., the bearing portion of the cylinder
10 head) at a location opposing an outer peripheral surface of the driving cam may be integrally formed with one of the cylinder head and the pump support bracket.

According to this structure, the driving cam rotates with its outer peripheral surface immersed in lubrication oil that has collected in the lubrication oil collecting portion. As a result, the outer peripheral surface of the driving cam, i.e., the surface that
15 slides against the lifter of the fuel pump, is always well lubricated so friction at that portion (i.e., the portion where the driving cam slides against the lifter of the fuel pump) is able to be reduced.

Also, with a structure in which a tip end (upper end) portion of the fuel pump is arranged protruding out from the cylinder head cover, one structure for sealing the
20 internal space (a so-called cam chamber) of the cylinder head cover is as follows. That is, the fuel pump support structure according to the foregoing aspect may further include a cylinder head cover in which an open portion is formed as a space within which the fuel pump is arranged, provided on an upper side of the cylinder head; a ring-shaped seal member for sealing the internal space of the cylinder head cover may be arranged at an
25 edge portion of the open portion of the cylinder head cover around the entire periphery of the open portion of the cylinder head cover; and a lip portion that suppresses vibration generated by the fuel pump from being transmitted to the cylinder head cover may be formed on the seal member.

Accordingly, the internal space of the cylinder head cover is sealed off from the

outside and vibrations from the fuel pump are absorbed by the lip portion of the seal member and thus suppressed from being transmitted to the cylinder head cover. As a result, this structure prevents abnormal noise due to vibration of the cylinder head cover (i.e., large vibrational noise that is produced by vibrations from the high pressure fuel pump being transmitted to the head cover which essentially acts as a speaker) from being produced.

A pump support bracket, which is used in the fuel pump support structure described above, is also within the scope of the invention. That is, a second aspect of the invention relates to a fuel pump support bracket that supports a fuel pump for increasing the pressure of fuel to be supplied to a fuel injection valve of an internal combustion engine on a cylinder head. This pump support bracket i) is arranged extending between at least two of a plurality of bearing portions which are provided on the cylinder head in the direction in which cylinders of the internal combustion engine are aligned and rotatably support a camshaft of the internal combustion engine; and ii) supports the fuel pump in a state fixedly supported by these bearing portions.

According to this aspect, the fuel pump is supported by the pump support bracket that is arranged extending between a plurality of bearing portions of the cylinder head. Therefore, sufficiently high support rigidity can be obtained for supporting the fuel pump, and vibrations generated when the fuel pump is driven can be sufficiently suppressed and thus inhibited from being transmitted to other members.

BRIEF DESCRIPTION OF THE DRAWINGS

The foregoing and further objects, features and advantages of the invention will become apparent from the following description of example embodiments with reference to the accompanying drawings, wherein like numerals are used to represent like elements and wherein:

FIG. 1 is a schematic diagram of the inside of a V-type engine according to one example embodiment of the invention as viewed from a direction along the axis of the crankshaft;

FIG. 2 is a system block diagram which schematically shows the engine together with intake and exhaust systems;

FIG. 3 is a view showing in frame format the structure of a fuel supply system;

FIG. 4A is a plan view of a camshaft housing and FIG. 4B is a front view of the
5 camshaft housing;

FIG. 5A is a plan view of a pump support bracket and FIG. 5B is a front view of the pump support bracket;

FIG. 6A is a side view of the pump support bracket and FIG. 6B is a bottom view of the pump support bracket;

10 FIG. 7 is an exploded perspective view of the camshaft housing, camshafts, the pump support bracket, and cam caps;

FIG. 8 is a sectional view of the pump support bracket taken along line VIII-VIII in FIG. 5A;

FIG. 9 is a sectional view of the pump support bracket taken along line IX-IX in
15 FIG. 5A;

FIG. 10 is an enlarged view of portion X shown in FIG. 9;

FIGS. 11A and 11B are views which correspond to FIG. 4A and 4B, respectively, and show the pump support bracket and the cam caps assembled to the camshaft housing;

FIG. 12 is a side view of the pump support bracket and the cam caps assembled
20 to the camshaft housing;

FIG. 13 is a plan view of the camshaft housing, the pump support bracket, and a high pressure fuel pump all integrally assembled together;

FIG. 14 is a side view of the camshaft housing, the pump support bracket, and the high pressure fuel pump all integrally assembled together;

25 FIG. 15 is an exploded perspective view of a head cover, the high pressure fuel pump, a spacer, and an insulator; and

FIG. 16 is a sectional view of the area around the location where a seal member is arranged.

DETAILED DESCRIPTION OF THE EXAMPLE EMBODIMENTS

A fuel pump support structure according to one example embodiment of the invention will now be described with reference to the accompanying drawings. In the following description of the example embodiments, the fuel pump support structure is
5 applied to a V-type eight cylinder engine (internal combustion engine) for an automobile.

- Description of the overall structure of the engine

Before describing the fuel pump support structure, the overall structure of the engine in which the fuel pump is mounted will be described.

FIG. 1 is a schematic diagram of the inside of a V-type engine E according to this
10 example embodiment as viewed from a direction along the axis of a crankshaft C. Also, FIG. 2 is a system block diagram which schematically shows the engine E together with intake and exhaust systems.

Only one pair of cylinders 5L and 5R is shown in FIG. 1; the other cylinders are omitted. Therefore, in the following description, only the cylinders 5L and 5R shown in
15 FIG. 1 will be described. As shown in the drawing, the V-type engine E has a pair of banks 2L and 2R protruding in a V shape on the upper portion of a cylinder block 1. Each bank 2L and 2R has a cylinder head 3L and 3R arranged on the upper end portion of the cylinder block 1, and a head cover 4L and 4R provided on the upper end of each cylinder head 3L and 3R. The plurality of cylinders 5L and 5R (e.g., four on each of the
20 banks 2L and 2R) are arranged on the cylinder block 1 at predetermined included angle (such as 90°). Pistons 51L and 51R are housed in a manner that enables them to move up and down inside these cylinders 5L and 5R (FIG. 1 shows only one pair of pistons housed in one pair of cylinders; the other pistons are omitted in the drawing). Also, the pistons 51L and 51R are each connected to a crankshaft C via connecting rods 52L and
25 52R so that power can be transferred to the crankshaft C. Further, a crankcase 6 is mounted to the lower side of the cylinder block 1, and the space that extends from the lower portion inside the cylinder block 1 to inside of the crankcase 6 serves as the crank chamber 61. Also, an oil pan 62 which serves as an oil collecting portion is arranged underneath the crankcase 6.

Intake valves 32L and 32R for opening and closing intake ports 31L and 31R, as well as exhaust valves 34L and 34R for opening and closing exhaust ports 33L and 33R are mounted to the cylinder heads 3L and 3R. These valves 32L, 32R, 34L, and 34R are operated open and closed by the rotation of camshafts 35L, 35R, 36L, and 36R arranged
5 in cam chambers 41L and 41R formed between the cylinder heads 3L and 3R and the head covers 4L and 4R.

Also, the cylinder heads 3L and 3R of the engine E according to this example embodiment have split structures. More specifically, the cylinder heads 3L and 3R are each formed by a cylinder head main body 37L and 37R that is mounted to the upper
10 surface of the cylinder block 1, and a camshaft housing 38L and 38R that is mounted to the upper side of this cylinder head main body 37L and 37R. The reason for this kind of split construction is because it makes it easier to assemble the component parts of the engine. That is, the intake valves 32L and 32R, the exhaust valves 34L and 34R, and the various parts of the valve operating mechanisms are assembled to the cylinder head main
15 bodies 37L and 37R, while the camshafts 35L, 35R, 36L, and 36R are supported by the camshaft housings 38L and 38R. Then the camshaft housings 38L and 38R are integrally assembled to the upper side of the cylinder head main bodies 37L and 37R by bolts or other such means, thus completing the cylinder heads 3L and 3R. Hence workability when assembling the component parts of the engine is improved.

20 Meanwhile, intake manifolds 7L and 7R, which correspond to the banks 2L and 2R, respectively, are arranged on the upper portion on the insides (i.e., the sides between the banks) of the banks 2L and 2R. The downstream ends of the intake manifolds 7L and 7R are communicated with the intake ports 31L and 31R. The intake manifolds 7L and 7R are also communicated with an intake pipe 73 which is provided with a surge tank
25 71 (see FIG. 2) and a throttle valve 72 and is common to both banks. An air cleaner 74 is provided on the upstream side of this intake pipe 73. Accordingly, air introduced from the air cleaner 74 into the intake pipe 73 is introduced into the intake manifolds 7L and 7R through the surge tank 71.

Port injection fuel injectors (i.e., port injection fuel injection valves) 75L and

75R are provided in the intake ports 31L and 31R of the cylinder heads 3L and 3R. When fuel is injected from these port injection fuel injectors 75L and 75R, it mixes with the air introduced into the intake manifolds 7L and 7R to form an air-fuel mixture which is then introduced into combustion chambers 76L and 76R as the intake valves 32L and
5 32R open.

Further, the engine E according to this example embodiment is also provided with in-cylinder direct injection fuel injectors (i.e., in-cylinder direct injection fuel injection valves) 78L and 78R. When fuel is injected from these in-cylinder direct injection fuel injectors 78L and 78R, it is injected directly into the combustion chambers
10 76L and 76R.

One example of a fuel injection mode of the port injection fuel injectors 75L and 75R and the in-cylinder direct injection fuel injectors 78L and 78R is as follows. When the engine E is operating at a low to medium load, fuel is injected from both types of fuel injectors 75L, 75R, 78L, and 78R to form a homogeneous air-fuel mixture in attempt to
15 improve fuel efficiency and reduce emissions. Also, when the engine E is operating at a high load, fuel is injected from only the in-cylinder direct injection fuel injectors 78L and 78R in attempt to improve charging efficiency and suppress knocking which are achieved by the intake air cooling effect. The fuel injection mode of these fuel injectors 75L, 75R, 78L, and 78R is not limited to this, however.

20 The fuel supply system for supplying fuel to these port injection fuel injectors 75L and 75R and in-cylinder direct injection fuel injectors 78L and 78R will be described later.

As shown in FIG. 2, spark plugs 77L and 77R are arranged at the top of the combustion chambers 76L and 76R. In the combustion chambers 76L and 76R, the
25 firing pressure of the air-fuel mixture following firing of the spark plugs 77L and 77R is transmitted to the pistons 51L and 51R, causing them to move up and down. This reciprocal motion of the pistons 51L and 51R is transmitted via the connecting rods 52L and 52R to the crankshaft C where it is converted into rotary motion and extracted as output of the engine E. Also, the camshafts 35L, 35R, 36L, and 36R shown in FIG. 1

are rotatably driven by power derived from the crankshaft C that is transmitted by a timing chain, not shown. This rotation causes the valves 32L, 32R, 34L, and 34R to open and close.

The air-fuel mixture after combustion becomes exhaust gas which is discharged
5 to exhaust manifolds 8L and 8R as the exhaust valves 34L and 34R shown in FIG. 2 open. Exhaust pipes 81L and 81R are connected to the exhaust manifolds 8L and 8R. In addition, catalytic converters 82L and 82R which house three way catalysts and the like are mounted to the exhaust pipes 81L and 81R. When the exhaust gas passes through these catalytic converters 82L and 82R, hydrocarbons (HC), carbon monoxide (CO), and
10 nitrogen oxide components (NO_x) contained in the exhaust gas are removed. Also, the downstream ends of the exhaust pipes 81L and 81R merge together and connect to a muffler 83.

- Fuel supply system

Next, a fuel supply system for supplying fuel to the port injection fuel injectors
15 75L and 75R and the in-cylinder direct injection fuel injectors 78L and 78R will be described with reference to FIG. 3. FIG. 3 is a view showing in frame format the structure of a fuel supply system 100 provided for one bank of the engine E provided according to this example embodiment. That is, the engine E has two of these fuel supply systems 100, one provided for each bank 2L and 2R. Here, the fuel supply
20 system 100 provided for the right bank 2R will be representatively described.

The fuel supply system 100 includes a feed pump 102 that pumps up fuel from a fuel tank 101. A low pressure fuel line 103 which is connected to the discharge side of this feed pump 102 branches off into a low pressure fuel line LF and a high pressure fuel line HF.

25 A low pressure fuel line delivery pipe 104 that is connected to one branch side of the low pressure fuel line 103 is provided in the low pressure fuel line FL. This low pressure fuel line delivery pipe 104 is connected to the port injection fuel injector 75R of each cylinder (i.e., each of the four cylinders), and is provided with a pulsation damper 105 for suppressing fuel pressure pulsations in the low pressure fuel line delivery pipe

104.

Meanwhile, the high pressure fuel line HF is provided with a high pressure fuel pump 110 that pressurizes fuel pumped up by the feed pump 102 and drawn in via the other branch side of the low pressure fuel line 103, and then discharges that pressurized
5 fuel toward the in-cylinder direct injection fuel injector 78R of each cylinder (i.e., each of the four cylinders).

The general structure of this high pressure fuel pump 110 includes a cylinder 111, a plunger 112, a pressurizing chamber 113, and an electromagnetic spill valve 114. A lifter 112a is mounted to the lower end of the plunger 112, and a driving cam 115 is
10 mounted to the intake camshaft 35R. This driving cam 115 has two cam lobes (cam noses) 116 formed at angles 180° apart from one another around the rotational axis of the intake camshaft 35R. Therefore, when the driving cam 115 rotates with the intake camshaft 35R, the cam noses 116 push the plunger 112 up via the lifter 112a such that the plunger 112 moves up and down inside the cylinder 111, and as it does so, the volume of
15 the pressurizing chamber 113 increases and decreases.

Incidentally, each bank of the engine E according to this example embodiment has four cylinders. Therefore, during one cycle of the engine E, i.e., for every two revolutions of the crankshaft C, fuel injection is performed once by each fuel injector(s) (either one or both of the port injection fuel injector 75R and the in-cylinder direct
20 injection fuel injector 78R) provided for each cylinder. Also, in this engine E, the intake camshaft 35R rotates once for every two revolutions of the crankshaft C. Accordingly, during one cycle of the engine E, there are four fuel injections from the fuel injectors 75R and 78R and pressurized fuel is discharged twice from the high pressure fuel pump 110.

The pressurizing chamber 113 is divided into two sections by the plunger 112
25 and the cylinder 111. This pressurizing chamber 113 is communicated with the feed pump 102 via the low pressure fuel line 103, as well as with a high pressure fuel line delivery pipe (i.e., accumulator) 107 via a high pressure line 106.

As shown in FIG. 3, the plurality of in-cylinder direct injection fuel injectors 78R are connected to the high pressure fuel line delivery pipe 107. A return line 108 is

also connected to the high pressure fuel line delivery pipe 107 via a relief valve 107a. This relief valve 107a opens when the fuel pressure inside the high pressure fuel line delivery pipe 107 exceeds a predetermined pressure (such as 15 MPa). When the relief valve 107a opens, some of the fuel stored in the high pressure fuel line delivery pipe 107
5 returns to the fuel tank 101 via the return line 108, thus preventing the fuel pressure in the high pressure fuel line delivery pipe 107 from rising too high. Also, the return line 108 and the high pressure fuel pump 110 are connected together by a fuel discharge line 109. Fuel that has leaked out from the gap between the plunger 112 and the cylinder 111 collects in a fuel collection chamber 118 above a seal unit 117 and is returned to the fuel
10 tank 101 via the fuel discharge line 109, which is connected to the fuel collection chamber 118, and the return line 108.

A filter 103a and a pressure regulator 103b are provided in the low pressure fuel line 103. The pressure regulator 103b keeps the fuel pressure inside the low pressure fuel line 103 equal to or less than a predetermined pressure by returning fuel in the low
15 pressure fuel line 103 to the fuel tank 101 when the fuel pressure in the low pressure fuel line 103 exceeds a predetermined pressure (such as 0.4 MPa). Also, a pulsation damper 119 is provided on the intake side of the high pressure fuel pump 110. This pulsation damper 119 suppresses fuel pressure pulsations in the low pressure fuel line 103 when the high pressure fuel pump 110 is operating. Also, a non-return valve 120 for preventing
20 the backflow of fuel discharged from the high pressure fuel pump 110 is provided in the high pressure fuel line 106.

The electromagnetic spill valve 114 for allowing or preventing communication between the low pressure fuel line 103 and the pressurizing chamber 113 is provided in the high pressure fuel pump 110. This electromagnetic spill valve 114 has an
25 electromagnetic solenoid 114a and is opened and closed by controlling the current flow to this electromagnetic solenoid 114a. The electromagnetic spill valve 114 opens by urging force from a coil spring 114b when current has stopped flowing to the electromagnetic solenoid 114a. Hereinafter, the opening and closing operation of this electromagnetic solenoid valve 114 will be described.

First when current has stopped flowing to the electromagnetic solenoid 114a, the electromagnetic spill valve 114 opens by the urging force from the coil spring 114b, thereby opening communication between the low pressure fuel line 103 and the pressurizing chamber 113. In this state, fuel pumped up by the feed pump 102 is drawn
5 into the pressurizing chamber 113 via the low pressure fuel line 103 when the plunger 112 moves in the direction which increases the volume of the pressurizing chamber 113 (i.e., during the intake stroke).

On the other hand, when the electromagnetic spill valve 114 closes, against the urging force of the coil spring 114b, by current flowing to the electromagnetic solenoid
10 114a when the plunger 112 moves in the direction that reduces the volume of the pressurizing chamber 113 (i.e., during the pressurizing stroke), communication between the low pressure fuel line 103 and the pressurizing chamber 113 is cut off. When the fuel pressure in the pressurizing chamber 113 reaches a predetermined value, a check valve 121 opens so that the high pressure fuel is discharged through the high pressure fuel
15 line 106 toward the high pressure line delivery pipe 107.

The amount of fuel discharged from the high pressure fuel pump 110 (hereinafter also referred to as the "fuel discharge amount") is adjusted by controlling the period of time for which the electromagnetic spill valve 114 is closed during the pressurizing stroke. That is, the fuel discharge amount increases when the
20 electromagnetic spill valve 114 is kept closed for a longer period of time which is accomplished by having the valve start to close earlier. Conversely, the fuel discharge amount decreases when the electromagnetic spill valve 114 is kept closed for a shorter period of time which is accomplished by having the valve start to close later. In this way, the fuel pressure within the high pressure fuel line delivery pipe 107 can be
25 controlled by adjusting the fuel discharge amount of the high pressure fuel pump 110.

The structure of the fuel supply system 100 provided for the right bank 2R shown in FIG. 1 is described above. The same fuel supply system 100 is also provided for the left bank 2L.

- Support structure for the high pressure fuel pump

Next, the support structure for the high pressure fuel pump 110 shown in FIG. 3 which is a structure characteristic of this example embodiment will be described. Here as well, the support structure for the high pressure fuel pump 110 provided for the right bank 2R shown in FIG. 1 will be representatively described.

5 This high pressure fuel pump 110 is supported by a pump support bracket 9 which is mounted to the upper portion of the camshaft housing 38R that makes up part of the cylinder head 3R. Hereinafter, the structures of the camshaft housing 38R and the pump support bracket 9, as well as the support structure of the high pressure fuel pump 110 will be described.

10 <Structure of the camshaft housing 38R>

FIG. 4A is a plan view of the camshaft housing 38R of the right bank 2R (as viewed from the direction along the cylinder axis of the right bank 2R), with the bottom end in the drawing being the side at the front of the engine (i.e., the side where the timing chain and the auxiliary pulley and the like are mounted). Also, FIG. 4B is a front view
15 of the camshaft housing 38R as viewed from the front of the engine.

As shown in the drawings, the camshaft housing 38R includes a frame portion 200 that has an outer edge shape that substantially matches the outer edge shape of the cylinder head main body 37R and which forms an outer frame of the camshaft housing 38R. A plurality of individual bolt holes 201 are formed at predetermined intervals in
20 the outer peripheral edge portion of this frame portion 200. The camshaft housing 38R is integrally fastened to the cylinder head main body 37R and the cylinder block 1 shown in FIG. 1 by inserting head bolts through these bolt holes 201.

The frame portion 200 includes i) a pair of first frames 202 and 202' which extend in the direction along the length of the crankshaft C shown in FIG. 1 (i.e., in the
25 length direction of the frame portion 200; in the vertical direction in FIG. 4), and ii) a pair of second frames 203 and 203' which extend in a direction orthogonal to the lengthwise direction of the crankshaft C (i.e., in the width direction of the frame portion 200). These frames 202, 202', 203, and 203' form a generally rectangular shape when viewed from above.

Bearing portions 204, 205, 206, 207, and 208 are formed in a plurality of locations extending between the pair of first frames 202 and 202'. These bearing portions 204 to 208 are formed in a total of five locations, two (204 and 208) of which are at the end portions in the lengthwise direction of the camshaft housing 38R and three (205, 206, and 207) of which are in the areas between adjacent cylinders. For the sake of simplicity, in the following description the cylinder closest to the bottom in FIG. 4A (i.e., at the front of the engine E) will be referred to as cylinder #1. Cylinder #2 and cylinder #3 are sequentially located in increasingly higher positions, and cylinder #4 is located closest to the top in FIG. 4A (i.e., at the rear of the engine E).

Hereinafter, the bearing portions 204 to 208 which are provided at these five locations will be described. The first bearing portion 204 is formed closer to the front of the engine E than cylinder #1. This first bearing portion 204 is integrated with the second frame 203 which is positioned at the front end side of the engine E. The second bearing portion 205 is formed between cylinder #1 and cylinder #2, the third bearing portion 206 is formed between cylinder #2 and cylinder #3, the fourth bearing portion 207 is formed between cylinder #3 and cylinder #4, and the fifth bearing portion 208 is formed to the rear of cylinder #4.

Intake side bearing recessed portions 204a to 208a which are semi-circular recessed portions for rotatably supporting the lower side of the intake camshaft 35R, as well as exhaust side bearing recessed portions 204b to 208b which are semi-circular recessed portions for rotatably supporting the lower side of the exhaust camshaft 36R, are formed at these bearing portions 204 to 208. Also, bolt holes 204c to 206c for retaining cam caps 204f to 206f, which will be described later, with bolts are formed on both sides of both the intake side bearing recessed portions 204a to 206a of the first bearing portion 204, the second bearing portion 205, and the third bearing portion 206 (i.e., both sides in the lengthwise direction of the bearing portions 204 to 206) and the exhaust side bearing recessed portions 204b to 206b of the first bearing portion 204, the second bearing portion 205, and the third bearing portion 206 (i.e., both sides in the lengthwise direction of the bearing portions 204 and 206).

One characteristic of this example embodiment is as follows. That is, the bolt holes 207c and 208c for retaining the cam caps 207f and 208f shown in FIG. 7 with bolts in the manner described above are formed on both sides of the exhaust side bearing recessed portions 207b and 208b of the fourth bearing portion 207 and the fifth bearing
5 portion 208 (i.e., on both sides in the lengthwise direction of the bearing portions 207 and 208), while the bolt holes 207d and 208d for retaining the pump support bracket 9 (FIGS. 5A and 5B), which will be described later, with bolts are formed on both sides of the intake side bearing recessed portions (i.e., recessed portions that form a head side bearing surface in this invention) 207a and 208a (i.e., on both sides in the lengthwise direction of
10 the bearing portions 207 and 208).

Lubrication holes 205e to 208e for supplying lubrication oil for lubricating between the camshafts 35R and 36R and the bearing recessed portions 205a to 208a and 205b to 208b toward the inside surfaces of the bearing recessed portions 205a to 208a and 205b to 208b. That is, lubrication oil which is discharged from an oil pump and
15 supplied via a main gallery to a lubrication passage formed extending between the inside of the cylinder head main body 37R and the inside of the camshaft housing 38R is supplied to the inside surfaces of the bearing recessed portions 205a to 208a and 205b to 208b.

Also, an oil collecting portion (i.e., a lubrication oil collecting portion) 210 is
20 integrally formed next to the intake side bearing recessed portion 207a of the fourth bearing portion 207. More specifically, this oil collecting portion 210 is formed continuous with the side surface of the intake side bearing recessed portion 207a of the fourth bearing portion 207 (i.e., the side surface on the side opposing the fifth bearing portion 208). This oil collecting portion 210 includes a recessed portion (i.e., a curved
25 recessed portion) 210a formed by a curved surface for collecting lubrication oil, and a wall plate 210b that forms a vertical wall of this recessed portion 210a. That is, an oil collecting space which is open from above is formed by the side surface of the intake side bearing recessed portion 207a of the fourth bearing portion 207, the recessed portion 210a, and the wall plate 210b. As a result, when the engine E is driven, some of the

lubrication oil supplied to the intake side bearing recessed portion 207a of the fourth bearing portion 207 flows into the oil collecting portion 210 where it collects. More specifically, the camshaft housing 38R shown in FIG. 4 is arranged on the right bank 2R, with the left side in FIG. 4 at a downward angle as shown in FIG. 1. The wall plate 210b is formed surrounding the left side of the recessed portion 210a from above in FIG. 4. Accordingly, oil is able to be well retained in the recessed portion 210a. Incidentally, this oil collecting portion 210 may also be integrally formed with the pump support bracket 9, which will be described later.

While the intake camshaft 35R in FIG. 1 is rotatably supported by the camshaft housing 38R, part of the driving cam 115 shown in FIG. 3 is positioned in the oil collecting space which is the space inside the oil collecting portion 210. Therefore, when oil has collected in this oil collecting portion 210, the outer peripheral surface of the driving cam 115 (i.e., the surface that slides against the lifter 112a of the high pressure fuel pump 110) is constantly immersed in oil, thereby reliably reducing friction between the outer peripheral surface of the driving cam 115 and the lifter 112a of the high pressure fuel pump 110.

<Structure of the pump support bracket 9>

Next, the pump support bracket 9 which is a member that is mounted to the camshaft housing 38R and supports the high pressure fuel pump 110 will be described. FIG. 5A is a plan view of the pump support bracket 9, FIG. 5B is a front view of the pump support bracket 9, FIG. 6A is a side view of the pump support bracket 9, and FIG. 6B is a bottom view of the pump support bracket 9. Also, FIG. 7 is an exploded perspective view of the camshaft housing 38R, the camshafts 35R and 36R, the pump support bracket 9, and cam caps 204f to 208f which will be described later.

As shown in FIGS. 5 and 6, the pump support bracket 9 includes a bracket main body portion 91 which is a portion to which the high pressure fuel pump 110 shown in FIG. 3 is mounted, and mounting leg portions 92, 93, 94, and 95 which are mounting portions for mounting the pump support bracket 9 to the camshaft housing 38R.

An opening 91a is formed on one side of the bracket main body portion 91 in the

lengthwise direction (i.e., in the vertical direction in FIG. 5A), which extends through this bracket main body portion 91 in the direction of thickness. This opening 91a is formed in a position opposing the driving cam 115 when the pump support bracket 9 is mounted to the camshaft housing 38R. Also, the upper surface of the outer peripheral portion of this opening 91a is formed as a pump mounting surface 91b that is formed by a flat surface. Bolt holes 91c are formed in two locations in this pump mounting surface 91b (i.e., two locations in the lengthwise direction of the bracket main body portion 91). A mounting flange (flange portion) 110a (see FIG. 13) of the high pressure fuel pump 110 is placed on the pump mounting surface 91b via a spacer 110b and an insulator 110c (see FIG. 15), which will be described later, such that the bolt holes formed in the mounting flange 110a are aligned with the bolt holes 91c of the pump mounting surface 91b. The high pressure fuel pump 110 is then mounted onto the pump support bracket 9 in this state by inserting mounting bolts B1 through these bolt holes (the specifics regarding the mounting structure will be described later). At this time, the lifter 112a, shown in FIG. 15, of the high pressure fuel pump 110 is inserted through the opening 91a and the outer peripheral surface of the driving cam 115 of the intake camshaft 35R which is positioned under the opening 91a abuts against the bottom surface of the lifter 112a.

Also, the bearing recessed portions (i.e., recessed portions that form bracket side bearing surfaces in this invention) 91d and 91e are formed on the lower surface of the bracket main body portion 91 at portions that face the intake side bearing recessed portion 207a of the fourth bearing portion 207 and the intake side bearing recessed portion 208a of the fifth bearing portion 208. These bearing recessed portions 91d and 91e are formed by semi-circular recessed portions for rotatably supporting the upper side of the intake camshaft 35R (see FIG. 6B). That is, when the pump support bracket 9 is arranged bridging, i.e., extending, from the fourth bearing portion 207 to the fifth bearing portion 208, this pump support bracket 9 rotatably supports the upper side of the intake camshaft 35R and thus serves as a cam cap. This obviates the need for cam caps at the portion where the pump support bracket 9 is arranged, which makes it possible to reduce the size of the engine E by reducing the number of parts and effectively utilizing space.

Meanwhile, the pump support bracket 9 has a total of four mounting leg portions 92 to 95 which extend to the outside on both sides at both end portions in the lengthwise direction of the bracket main body portion 91. The distance (distance t1 in FIG. 5) between the mounting leg portions 92 and 93 formed on one side in the lengthwise direction of the bracket main body portion 91 and the mounting leg portions 94 and 95 formed on the other side in the lengthwise direction of the bracket main body portion 91 is substantially equal to the distance (distance T1 in FIG. 4A) between the fourth bearing portion 207 and the fifth bearing portion 208 of the camshaft housing 38R. Further, bolt holes 92a to 95a are formed in positions near the tip end portions of these mounting leg portions 92 to 95, respectively. The distance between the bolt holes 92a and 93a in the mounting leg portions 92 and 93 shown in FIG. 5A that oppose the fourth bearing portion 207 shown in FIG. 4A is substantially the same as the distance between the bolt holes 207d formed on both sides of the intake side bearing recessed portion 207a of the fourth bearing portion 207 shown in FIG. 4A when the pump support bracket 9 is mounted to the camshaft housing 38R. Similarly, the distance between the bolt holes 94a and 95a in the mounting leg portions 94 and 95 shown in FIG. 5A that oppose the fifth bearing portion 208 shown in FIG. 4A is substantially the same as the distance between the bolt holes 208d formed on both sides of the intake side bearing recessed portion 208a of the fifth bearing portion 208 shown in FIG. 4A when the pump support bracket 9 is mounted to the camshaft housing 38R shown in FIG. 4A. Therefore, when the pump support bracket 9 is arranged so that it extends from the fourth bearing portion 207 to the fifth bearing portion 208, the bolt holes 92a to 95a formed in the mounting leg portions 92 to 95 of the pump support bracket 9 align with the bolt holes 207d and 208d formed in the fourth bearing portion 207 and the fifth bearing portion 208, respectively. The pump support bracket 9 is then mounted to the camshaft housing 38R by inserting the bolts B2 through these bolt holes 92a to 95a, 207d, and 208d (see FIG. 11).

One characteristic of the pump support bracket 9 is that an oil passage 96 and an oil jet 97 (which together serve as the lubrication passage in this example embodiment of the invention) for injecting oil are formed in the bottom surface of the lifter 112a of the

high pressure fuel pump 110. Hereinafter, this oil passage 96 and oil jet 97 will be described.

FIG. 8 is a sectional view of the pump support bracket 9 taken along line VIII-VIII in FIG. 5A. FIG. 9 is a sectional view of the pump support bracket 9 taken along line IX-IX in FIG. 5A. FIG. 10 is an enlarged view of portion X shown in FIG. 9.

The oil passage 96 which is a dropping recessed portion is formed extending from the bottom surface of the pump support bracket 9 that opposes the fourth bearing portion 207 of the camshaft housing 38R to the inner peripheral surface of the bearing recessed portion 91d, as shown in FIG. 8. Further, the oil jet 97 is formed extending through the inner portion of the bracket main body portion 91, with one end of the oil jet 97 being communicated with the oil passage 96 while the other end opens toward the opening 91a, as shown in FIG. 9. As a result, oil that flows into the oil passage 96 sprays out from the oil jet 97 toward the opening 91a. As described above, the lifter 112a of the high pressure fuel pump 110 is inserted into this opening 91a so that it slidably contacts the driving cam 115 of the intake camshaft 35R which is positioned below the opening 91a. Accordingly, oil from the oil jet 97 is sprayed onto the bottom surface of the lifter 112a (see the arrow in FIG. 10). As a result, good lubrication can be obtained between the lifter 112a and the driving cam 115, thus reducing mechanical loss so that the high pressure fuel pump 110 can be operated with high efficiency.

FIG. 11A is a plan view showing camshaft housing 38R and the pump support bracket 9 integrally assembled together, with the camshaft housing 38R mounted to the top surface of the cylinder head main body 37R and the pump support bracket 9 arranged so that it extends from the fourth bearing portion 207 to the fifth bearing portion 208 of the camshaft housing 38R. Also, FIG. 11B is a front view thereof, and FIG. 12 is a side view thereof. Further, in these drawings, the cam caps 204f to 208f are mounted in positions corresponding to the bearing portions 204 to 208.

In this way, when the camshaft housing 38R, the pump support bracket 9, and the cam caps 204f to 208f are integrally assembled onto the top surface of the cylinder head main body 37R, the bolts indicated by reference character B2 in FIG. 11A are

inserted through the bolt support bracket 9, the camshaft housing 38R, and the cylinder head main body 37R shown in FIG. 1, integrally fastening them together. Also, the bolts indicated by reference character B3 in FIG. 11A are inserted through the cam caps 204f to 208f, the camshaft housing 38R, and the cylinder head main body 37R, integrally fastening them together. In addition, the bolts indicated by reference character B4 in FIG. 11A are inserted through the cam caps 204f to 208f and the camshaft housing 38R, integrally fastening them together. Moreover, the bolts indicated by reference character B5 in FIG. 11A are inserted through the camshaft housing 38R and the cylinder head main body 37R shown in FIG. 1, integrally fastening them together.

Also, FIG. 13 is a plan view of high pressure fuel pump 110 mounted to the pump support bracket 9 which is assembled to the camshaft housing 38R. FIG. 14 is a view of the high pressure fuel pump 110 mounted to the pump support bracket 9 via the head cover 4R. Further, FIG. 15 is an exploded perspective view of the head cover 4R, the high pressure fuel pump 110, the spacer 110b, and the insulator 110c.

As shown in the drawings, the mounting flange 110a of the high pressure fuel pump 110 is placed on the pump mounting surface 91b via the insulator 110c and the spacer 110b so that the bolt holes 110d formed in the mounting flange 110a and the bolt holes 91c in the pump mounting surface 91b of the pump support bracket 9 shown in FIG. 5A are aligned. The high pressure fuel pump 110 is mounted onto the pump support bracket 9 in this state with mounting bolts (stud bolts) B1 which have been placed in the bolt holes 91c of the pump mounting surface 91b in advance inserted through the bolt holes 110d formed in the mounting flange 110a and nuts N1 screwed onto the mounting bolts B1 from above. Incidentally, openings for inserting the mounting bolts B1 are also formed in the spacer 110b and the insulator 110c.

Also, in this case, the portion of the high pressure fuel pump 110 that is above the mounting flange 110a is arranged so that it protrudes out from the head cover 4R (see the broken line in FIG. 14). One characteristic of this example embodiment is the shape of a seal member 220 provided to seal an internal space (i.e., a cam chamber 41R) of the head cover 4R. FIG. 16 is a sectional view of the portion around the location where this

seal member 220 is mounted.

As shown in FIG. 16, the seal member 220 is formed of a ring-shaped elastic member (such as a rubber member) that fits into an open portion 221 which serves as the space for mounting the fuel pump that is formed in the head cover 4R. This seal member 220 has a vibration absorbing lip member 22a which abuts against the bottom face of the spacer 110b when the seal member 220 is fitted between the edge portion of the open portion 221 of the head cover 4R and the spacer 110b arranged underneath the high pressure fuel pump 110. That is, the seal member 220 serves to both seal off the cam chamber 41R from the outside and absorb vibrations from the high pressure fuel pump 110 with the lip portion 220a of the seal member 220, thus suppressing those vibrations from being transmitted to the head cover 4R. As a result, this structure prevents abnormal noise due to vibration of the head cover 4R (i.e., large vibrational noise that is produced by vibrations from the high pressure fuel pump 110 being transmitted to the head cover 4R which essentially acts as a speaker) from being produced.

As described above, in this example embodiment, the high pressure fuel pump 110 is supported by the pump support bracket 9 which is arranged extending between a plurality of bearing portions 207 and 208 of the camshaft housing 38R. Therefore, the support rigidity with which the high pressure fuel pump 110 is supported is able to be sufficiently increased, and the vibrations produced when the high pressure fuel pump 110 is driven can be sufficiently absorbed so that they are not transmitted to other members.

- Other example embodiments

In the example embodiment described above, the fuel pump support structure of the invention is applied to a V-type eight cylinder engine for an automobile. The invention is not limited to this, however. That is, the invention can also be applied to an inline-type engine for an automobile, a horizontally-opposed engine for an automobile, or the like. Also, the invention is not limited to being applied to an engine for an automobile, but can also be applied to another engine. Further, the number of cylinders, the included angle of the V bank in the V-type engine E, and other specifications of the

engine E are not particularly limited.

Also, in the foregoing example embodiment, the pump support bracket 9 is arranged so that it extends from the fourth bearing portion 207 to the fifth bearing portion 208 of the camshaft housing 38R. The invention is not limited to this, however. That
5 is, the pump support bracket 9 may also be arranged so that it extends between any other adjacent bearing portions 204 to 207, or between three or more bearing portions 204 to 208. Further, the bearing portions 204 to 208 to which the pump support bracket 9 is mounted do not necessarily have to be adjacent to one another. For example, the pump support bracket 9 may also be arranged so that it extends between the third bearing
10 portion 206 and the fifth bearing portion 208 in the example embodiment.

In addition, in the foregoing example embodiment, the cylinder heads 3L and 3R have a split structure and the high pressure fuel pump 110 is supported via the pump support bracket 9 on the camshaft housings 38L and 38R. Alternatively, however, the cylinder heads 3L and 3R may not have a split structure and the high pressure fuel pump
15 110 may be supported via the pump support bracket 9 on the cylinder heads 3L and 3R.

While the invention has been described with reference to exemplary embodiments thereof, it is to be understood that the invention is not limited to the exemplary embodiments or constructions. To the contrary, the invention is intended to cover various modifications and equivalent arrangements. In addition, while the various
20 elements of the exemplary embodiments are shown in various combinations and configurations, which are exemplary, other combinations and configurations, including more, less or only a single element, are also within the spirit and scope of the invention.

CLAIMS:

1. A fuel pump support structure of an internal combustion engine, which supports a fuel pump for increasing the pressure of fuel to be supplied to a fuel injection valve on a cylinder head, characterised by comprising:

a plurality of bearing portions (204, 205, 206, 207, 208) which are provided on the cylinder head (3R, 3L) in the direction in which cylinders of the internal combustion engine are aligned and rotatably support a camshaft (35R, 36R, 35L, 36L); and

a pump support bracket (9) arranged extending between at least two of the bearing portions (204, 205, 206, 207, 208) and fixedly supported by the at least two bearing portions,

wherein the fuel pump (110) is mounted to the pump support bracket (9).

2. The fuel pump support structure according to claim 1, characterised in that:

a first bearing surface (204a, 205a, 206a, 207a, 208a, 204b, 205b, 206b, 207b, 208b) that rotatably supports the camshaft (35R, 36R, 35L, 36L) is formed on the bearing portion (204, 205, 206, 207, 208); and

a second bearing surface (91d, 91e) that rotatably supports the camshaft (35R, 36R, 35L, 36L) is formed on the pump support bracket (9).

3. The fuel pump support structure according to claim 1 or 2, characterised in that:

a driving cam (115) that drives the fuel pump (110) is formed on the camshaft (35R, 36R, 35L, 36L);

the fuel pump (110) includes a cylinder (111), a plunger (112) which is inserted into the cylinder (111) so as to be able to move up and down in the cylinder (111) and defines a pressurizing chamber (113), and a lifter (112a) which moves the plunger (112) in a direction which makes the pressurizing chamber (113) smaller by applying pressure from the driving cam (115) to the plunger (112); and

a lubrication passage (97) for supplying lubrication oil to a portion where the lifter

(112a) and the driving cam (115) slidably contact one another is formed in the pump support bracket (9).

4. The fuel pump support structure according to claim 1 or 2, characterised in that:
a driving cam (115) that drives the fuel pump (110) is formed on the camshaft (35R, 36R, 35L, 36L);

the fuel pump (110) is driven by pressure received from the driving cam (115);
and

a lubrication oil collecting portion (210) for collecting lubrication oil supplied to the bearing portion (204, 205, 206, 207, 208) at a location opposing an outer peripheral surface of the driving cam (115) is integrally formed with one of the cylinder head (3R, 3L) and the pump support bracket (9).

5. The fuel pump support structure according to any one of claims 1 to 4, characterised in that:

a cylinder head cover (4R) in which an open portion (221) is formed in a position where the fuel pump (110) is arranged is mounted to an upper side of the cylinder head (3R, 3L);

a seal member (220) which seals an internal space of the cylinder head cover (4R) is arranged at an edge portion of the open portion (221) of the cylinder head cover (4R) around the entire periphery of the open portion (221) of the cylinder head cover (4R); and

a lip portion (220a) that suppresses vibration generated by the fuel pump (110) from being transmitted to the cylinder head cover (4R) is formed on the seal member (220).

6. The fuel pump support structure according to claim 2, characterised in that the first bearing surface (204a, 205a, 206a, 207a, 208a, 204b, 205b, 206b, 207b, 208b) and the second bearing surface (91d, 91e) are each formed from a semi-circular recessed portion.

7. The fuel pump support structure engine according to claim 5, characterised in that the seal member (220) is an elastic member.

8. A pump support bracket (9) that supports a fuel pump (110) for increasing the pressure of fuel to be supplied to a fuel injection valve of an internal combustion engine on a cylinder head (3R, 3L), characterised in that:

the pump support bracket (9):

i) is arranged extending between at least two of a plurality of bearing portions (204, 205, 206, 207, 208) that are provided on the cylinder head (3R, 3L) in the direction in which cylinders of the internal combustion engine are aligned, and that rotatably support a camshaft (35R, 36R, 35L, 36L) of the internal combustion engine; and

ii) supports the fuel pump (110) in a state fixedly supported by the at least two bearing portions.

FIG. 1

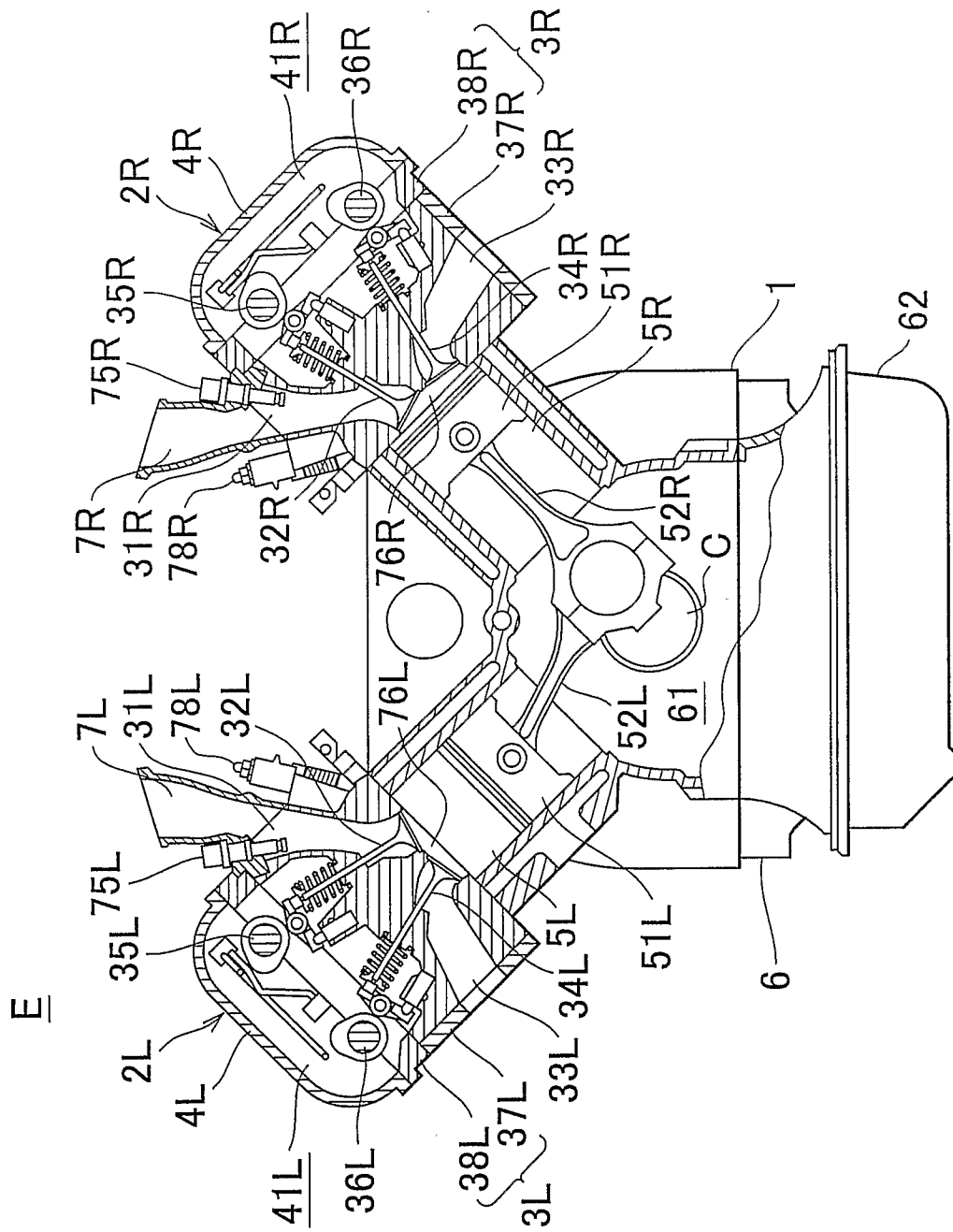
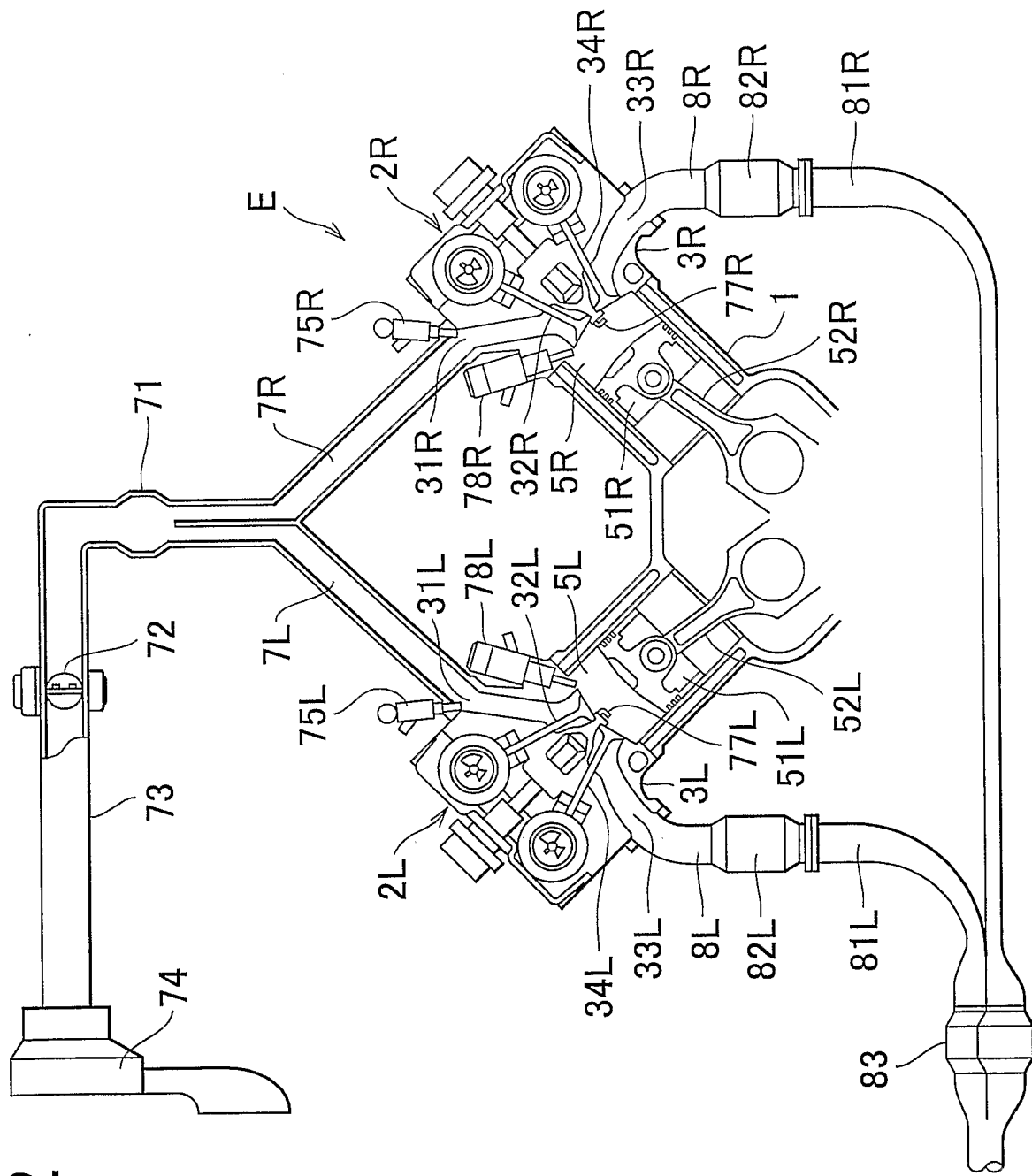


FIG. 2



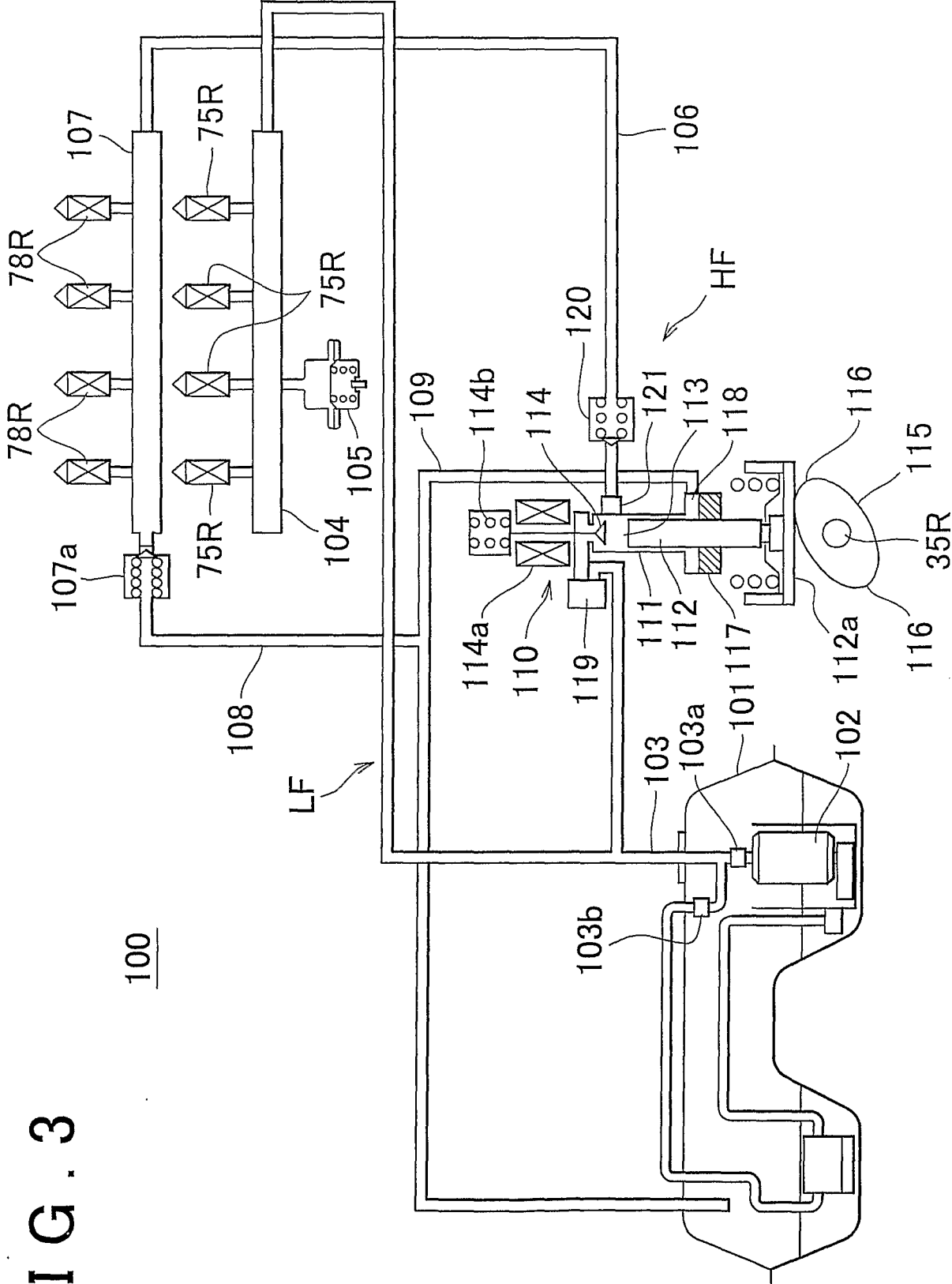


FIG. 4A

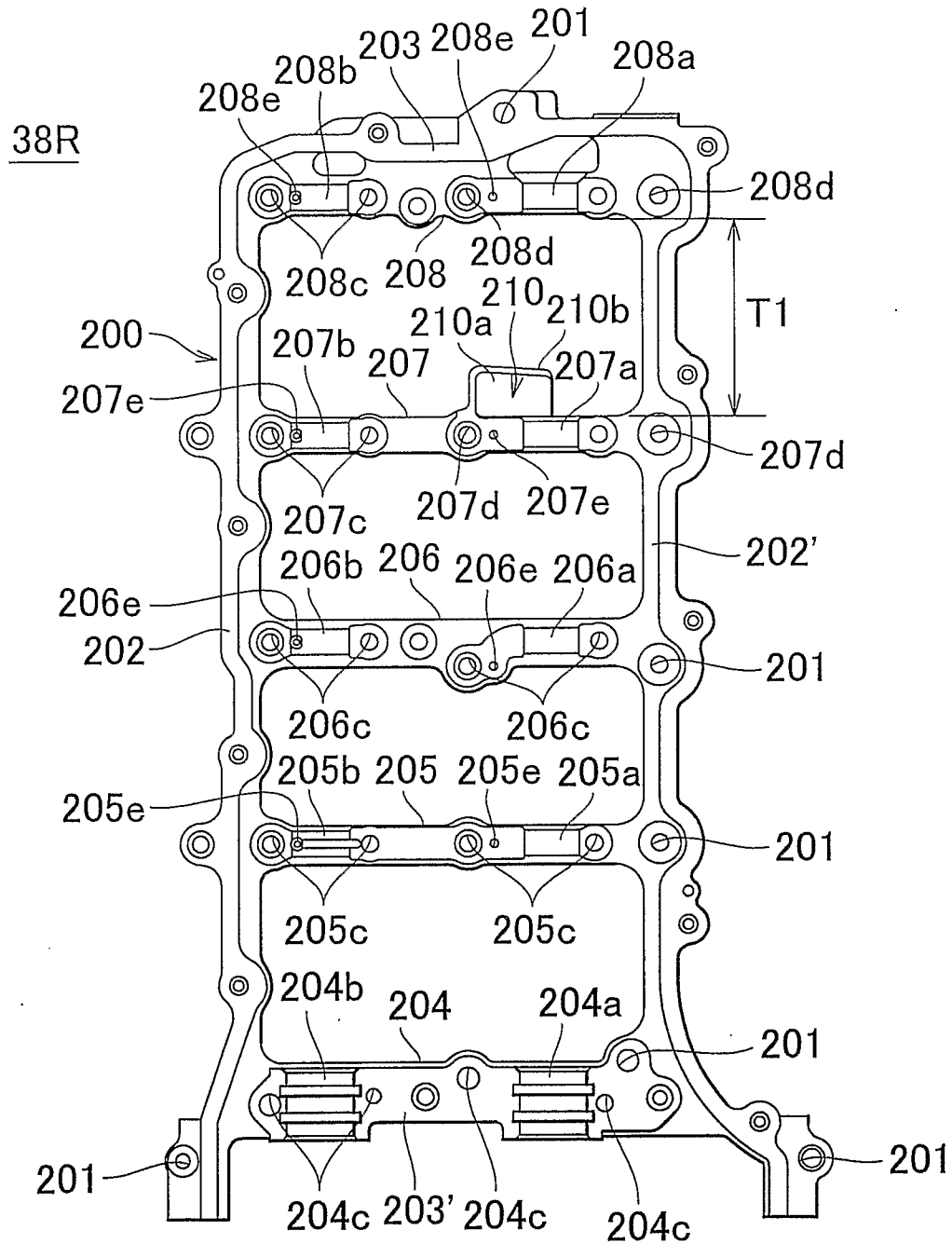


FIG. 4B

38R

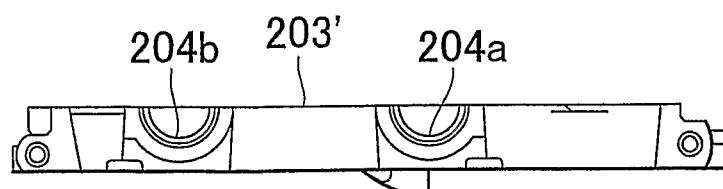


FIG. 5A

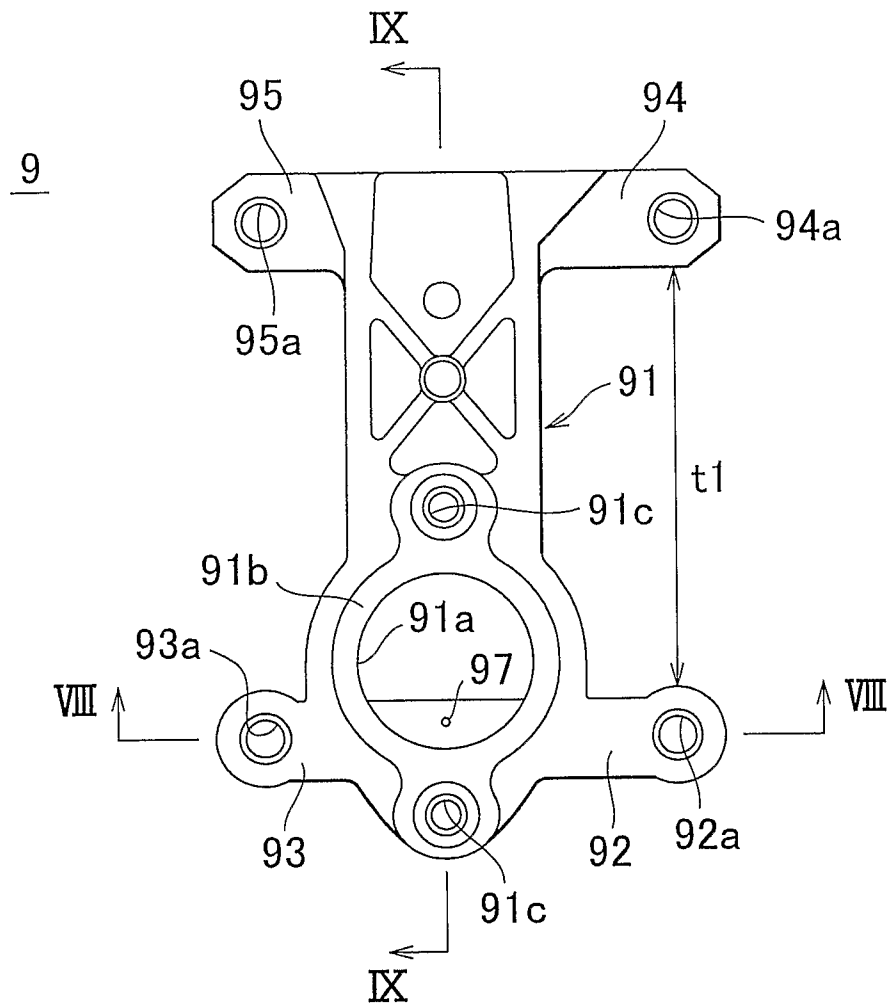


FIG. 5B

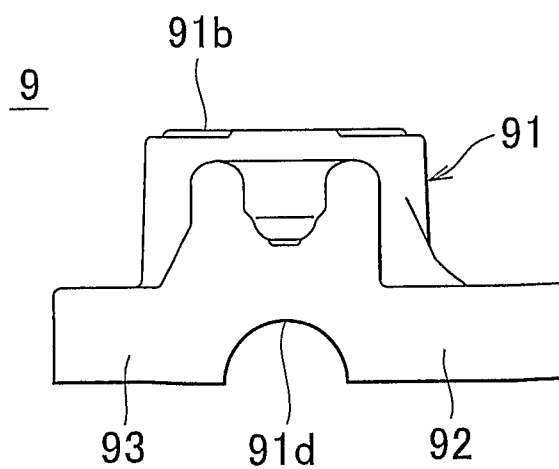


FIG. 6B

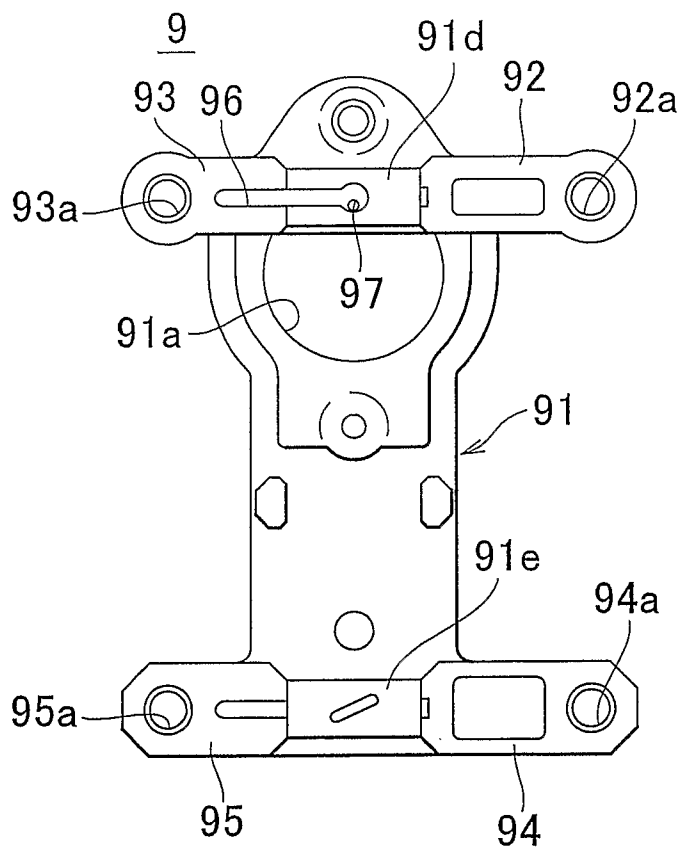


FIG. 6A

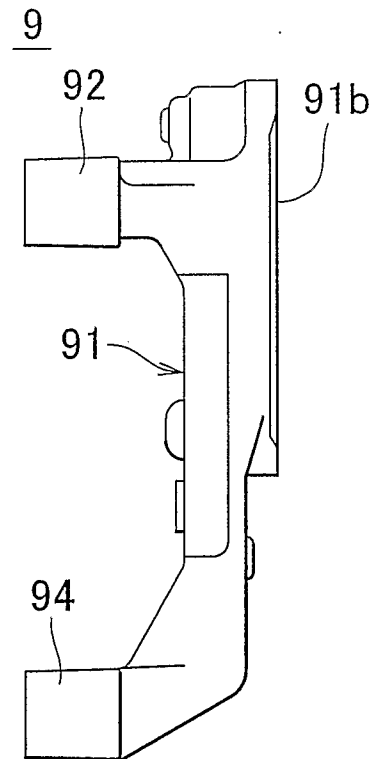


FIG. 8

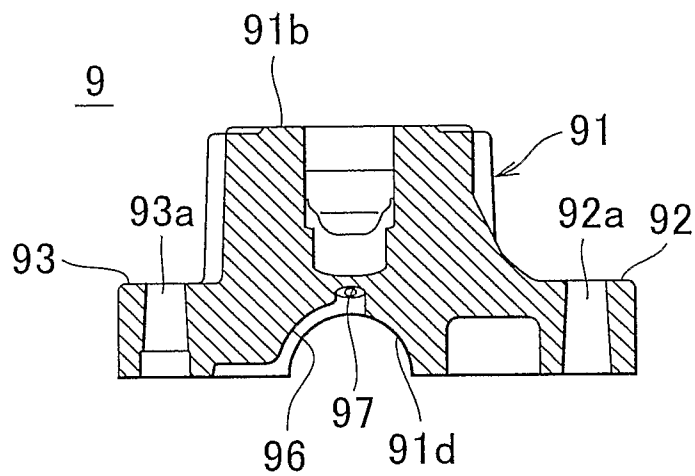


FIG. 9

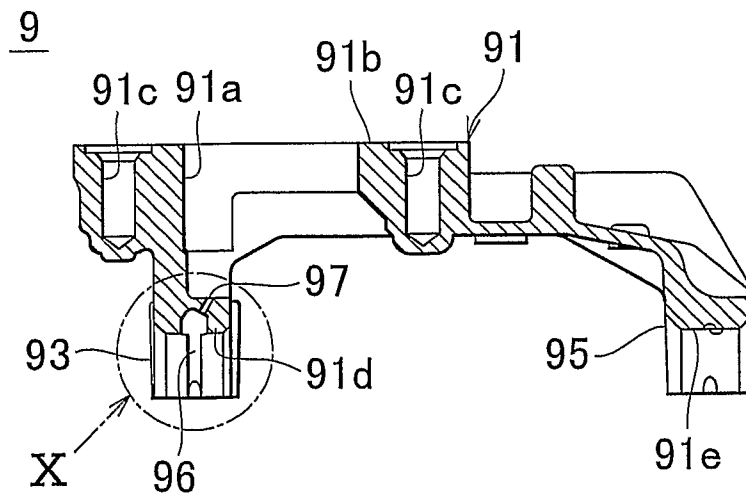


FIG. 10

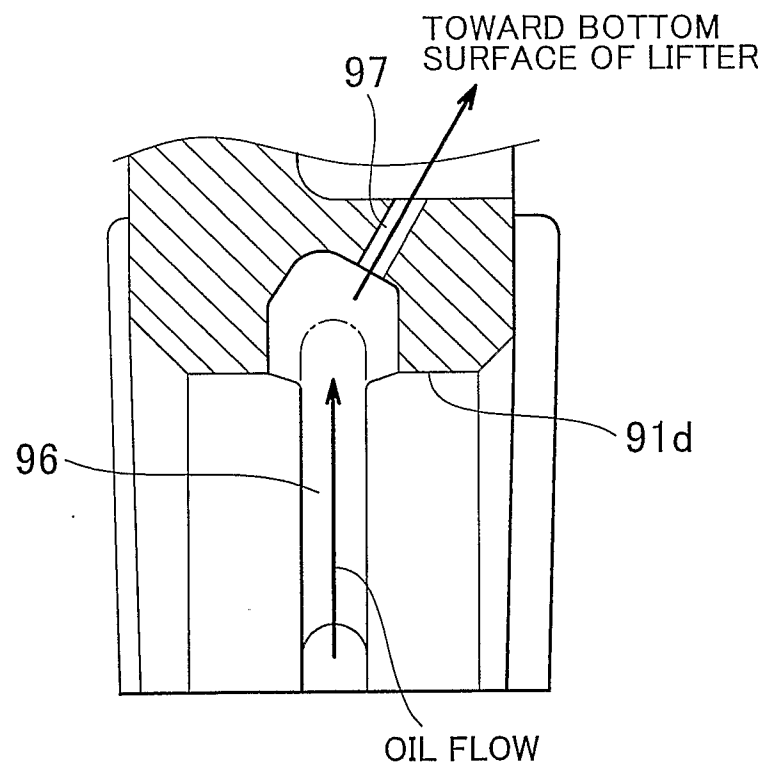


FIG. 11A

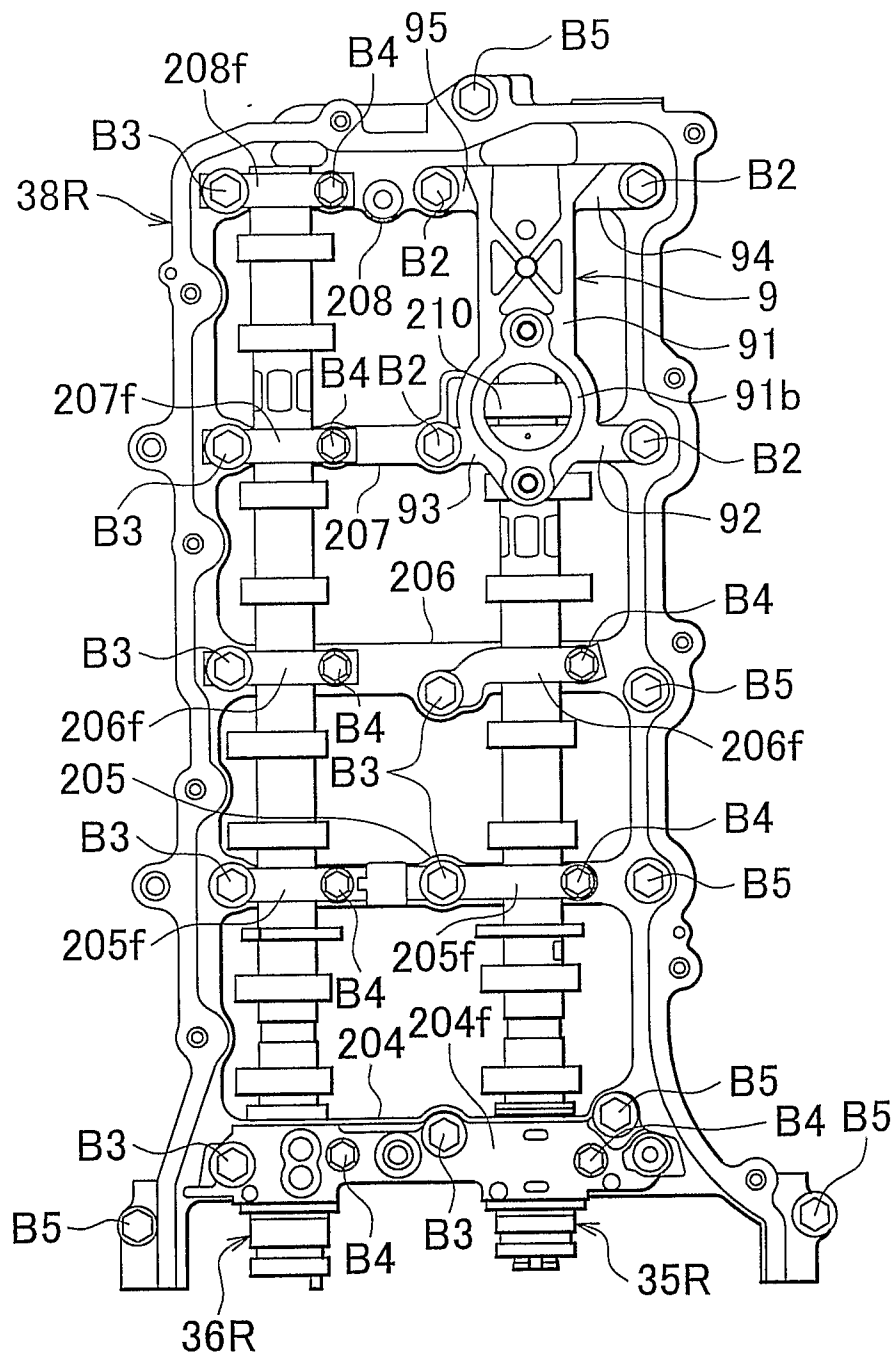


FIG. 11B

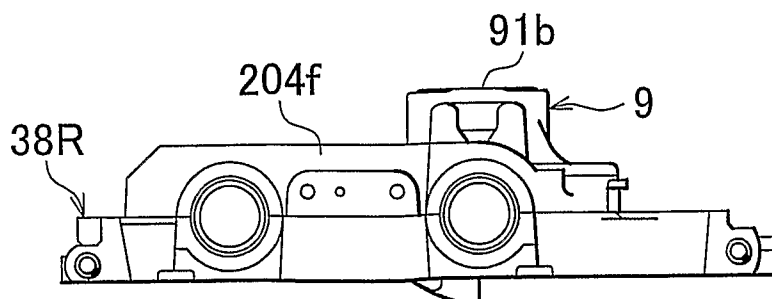


FIG. 12

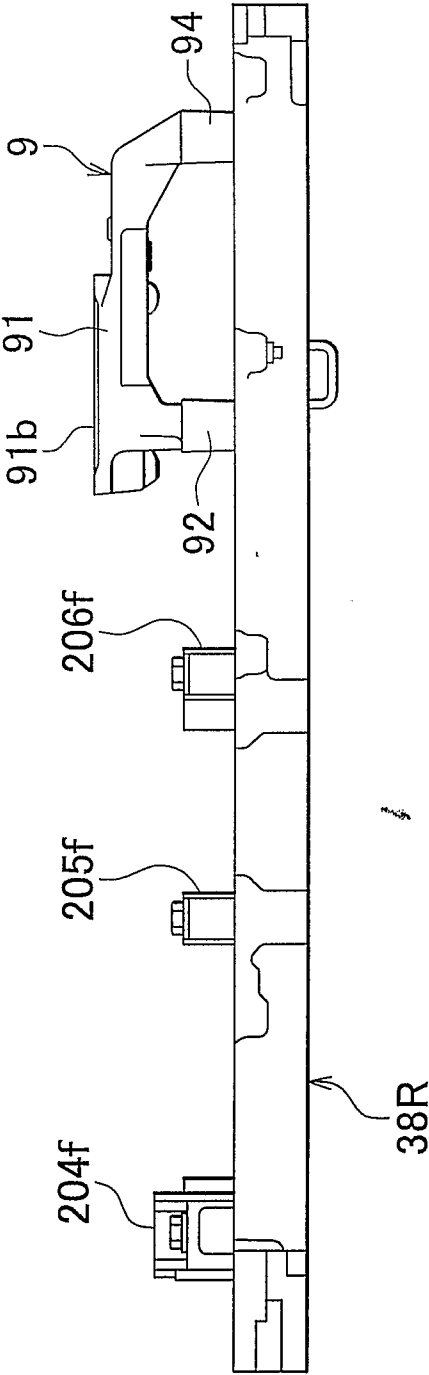


FIG. 13

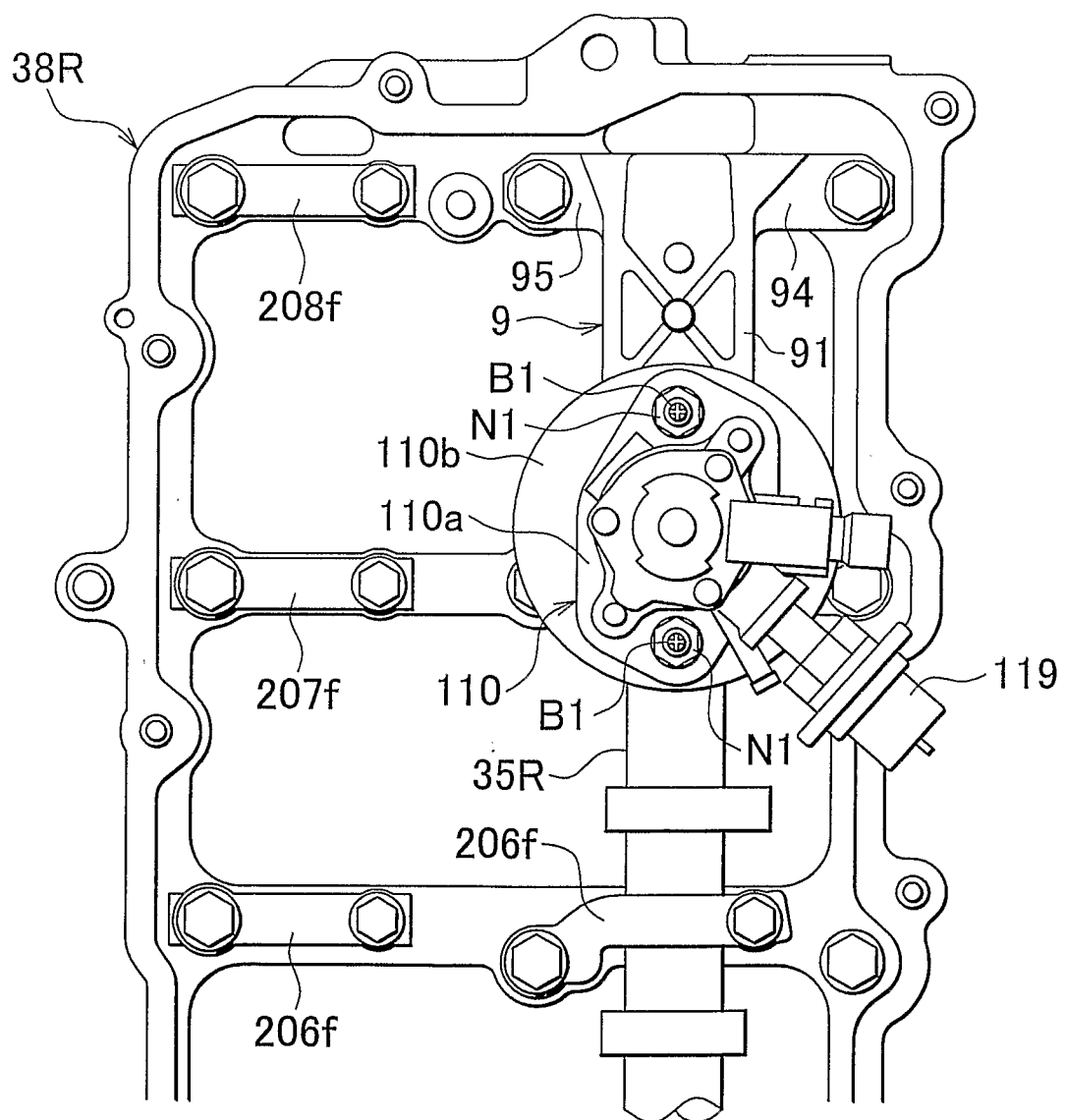


FIG. 14

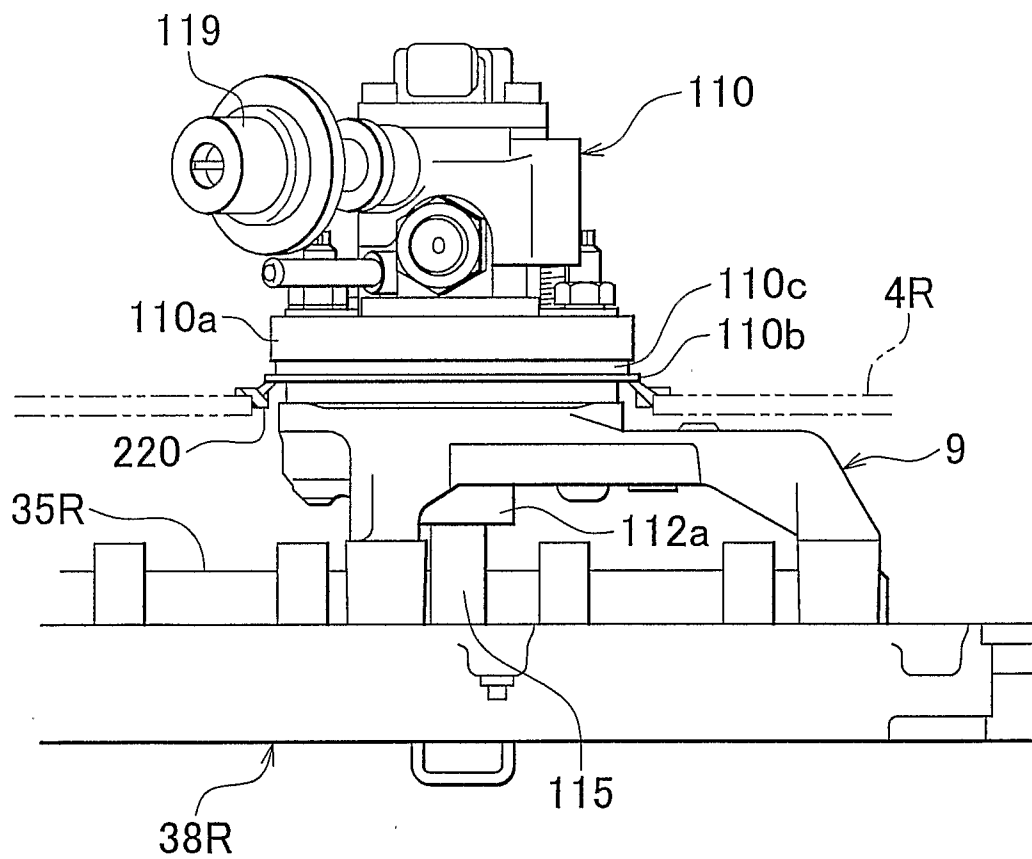


FIG. 15

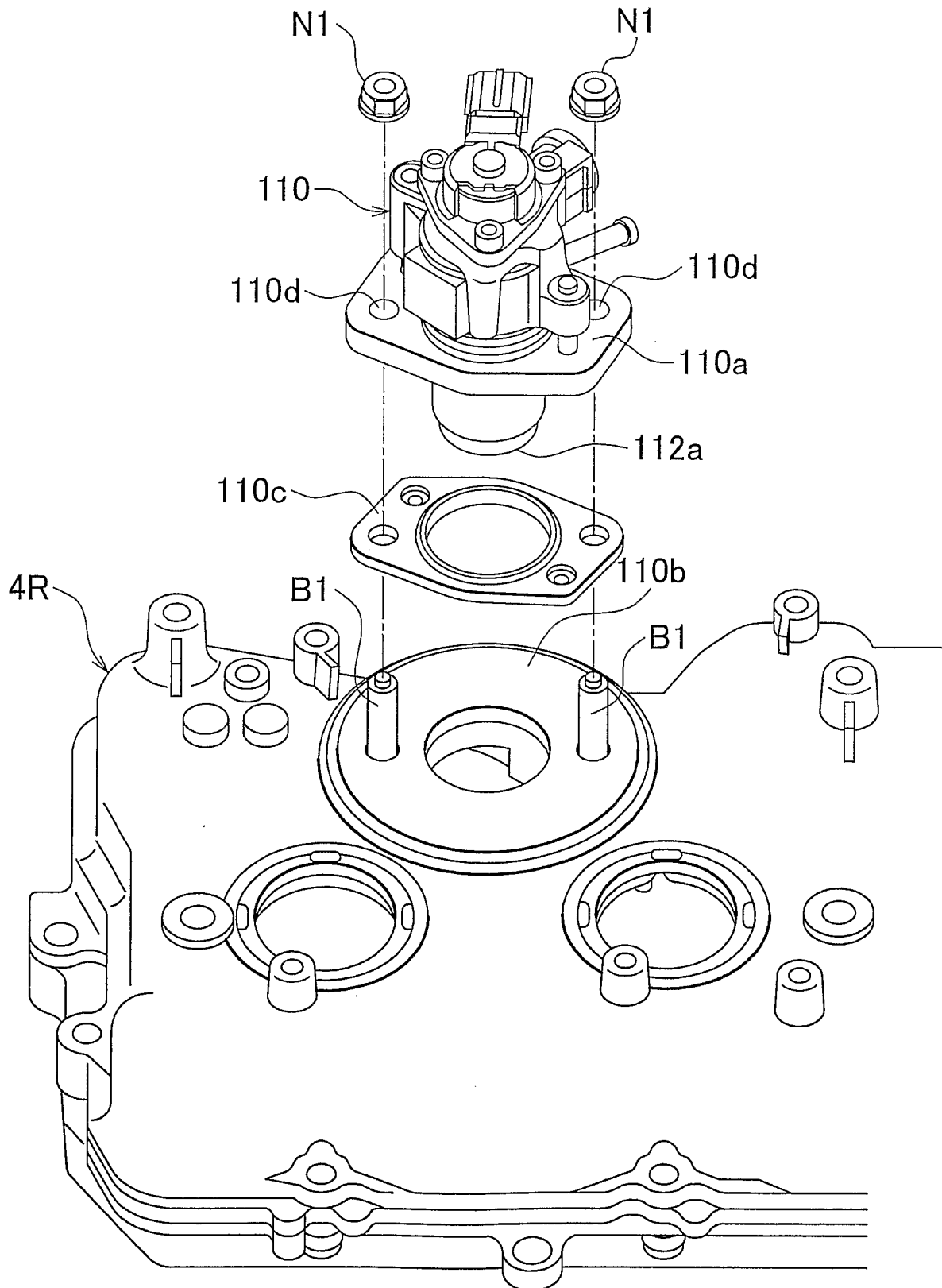
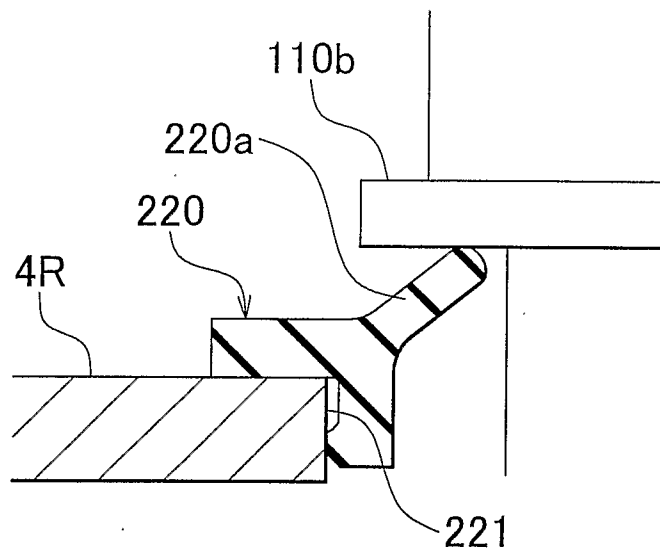


FIG. 16



INTERNATIONAL SEARCH REPORT

International application No

PCT/IB2007/001951

A. CLASSIFICATION OF SUBJECT MATTER

INV. F01L1/053 F01M9/10 F02M39/00

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)

F01L F02B F02M F01M

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

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

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2003/005903 A1 (KUNDE DETLEV [DE] ET AL KUNDE DETLEV [DE] ET AL) 9 January 2003 (2003-01-09) the whole document	1,2,5-8
Y	----- the whole document	3,4
X	EP 1 515 007 A (YAMAHA MOTOR CO LTD [JP]) 16 March 2005 (2005-03-16) the whole document	1,5,7,8
Y	----- the whole document	3
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Further documents are listed in the continuation of Box C.



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