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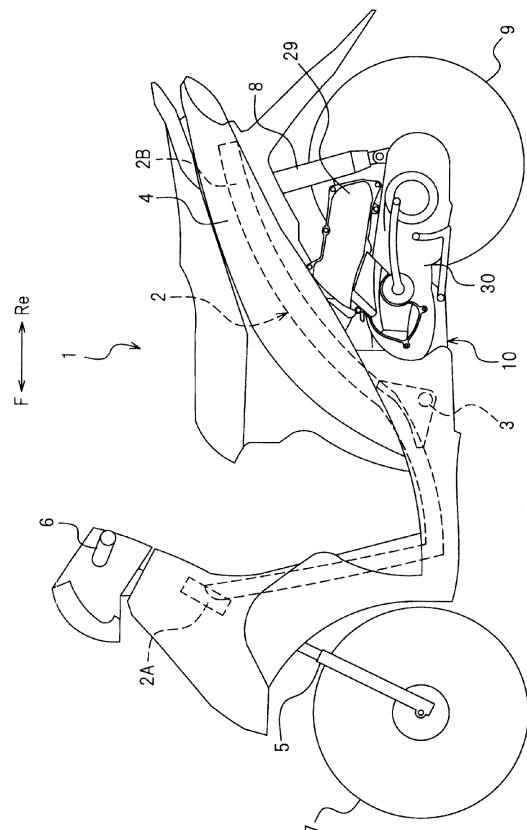
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(54) **Internal combustion engine and motorcycle equipped with the engine**

(57) An internal combustion engine has an intake valve located above the cylinder axis line. Oil is supplied to the intake valve smoothly even without forming an opening of an oil supply passage at a position directly above the intake valve. An opening (64) connected to a passage (63) of the oil supply passage (50) is formed at a position located within the inner surface of a head cover (16) and higher than the intake valve (41), the position being off a position directly above the intake valve (41). A first rib (81) is provided on the inner surface of the head cover (16). One end of the first rib (81) is located at a side of the opening (64), and the other end thereof is located directly above the intake valve (41).

[Fig.1]



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Description

TECHNICAL FIELD

[0001] The present invention relates to an internal combustion engine mounted on a straddle-type vehicle such as a motorcycle. The invention also relates to a motorcycle equipped with the engine.

BACKGROUND ART

[0002] A known example of an internal combustion engine mounted on a straddle-type vehicle such as a motorcycle has a cylinder disposed so as to extend frontward or to extend obliquely upward and frontward. The internal combustion engine contains: a cylinder block and a cylinder head that form a combustion chamber; an intake valve and an exhaust valve that respectively cause the an intake port and an exhaust port of the combustion chamber to open/close; and a camshaft for driving these valves. Hereinbelow, the intake valve, the exhaust valve, and the components for driving these valves are collectively referred to as a "valve train." The camshaft is an example of the valve train.

[0003] Since the valve train is a movable part, it needs to be oiled. Lubrication of an internal combustion engine is performed, for example, using an oil pump disposed in a crankcase. The valve train is disposed inside the cylinder head, so it is at a position far from the oil pump disposed in the crankcase. In order to supply oil to the valve train, it is necessary to provide a relatively long oil supply passage from the oil pump to the vicinity of the valve train.

[0004] It is known that piping is fitted outside the cylinder block and the cylinder head so that the piping is utilized as a portion of the oil supply passage. However, when the piping is provided separately from, for example, the cylinder block, the number of parts accordingly increases, and the assembling work becomes troublesome. In view of the problem, it has been proposed to form a passage inside a wall of, for example, the cylinder block so that an oil supply passage can be formed by the passage.

[0005] In the internal combustion engine in which a cylinder is disposed so as to extend frontward or obliquely upward and frontward, either one of the intake valve and the exhaust valve is located above the cylinder axis. Hereinbelow, one of the intake valve and the exhaust valve that is located above the cylinder axis is referred to as the "upper valve," and the one that is located below the cylinder axis is called the "lower valve." When oil is supplied to the camshaft, the oil flows down due to the gravitational force, so that the oil is also supplied to the lower valve. Thus, even without providing a dedicated oil supply passage, the oil can be supplied to the lower valve. On the other hand, to the upper valve, the oil supplied to the camshaft cannot be naturally dropped down thereto. In view of this, it has been proposed to form the oil supply

passage to a position higher than the upper valve so that the oil can be supplied to the upper valve from above.

[0006] JP H09(1997)-144520 A (hereinafter referred to as "Literature 1") discloses such an oil supply passage.

The oil supply passage disclosed Literature 1 comprises a plurality of passages formed inside a wall of a cylinder block, a wall of a cylinder head, and a wall of a cylinder head cover. An opening is formed in the inner surface of the upper wall of the cylinder head cover, and this opening is located directly above the valve stem end portion of the upper valve. The oil discharged from the oil pump is passed through the oil supply passage and supplied through the opening to the upper valve.

SUMMARY OF INVENTION

TECHNICAL PROBLEM

[0007] However, the oil supply passage disclosed in Literature 1 has the restriction that the opening must be formed directly above the valve stem end portion of the upper valve. Because of this restriction, the structure of the oil supply passage may become complicated, or the size of the cylinder head or the cylinder head cover may become large.

[0008] The present invention has been accomplished in view of the foregoing and other problems, and it is an object of the invention to provide an internal combustion engine that can supply oil smoothly to the upper valve even without forming an opening at a position directly above the upper valve.

SOLUTION TO PROBLEM

[0009] The present invention provides a an internal combustion engine comprising: a case for accommodating a crankshaft; a cylinder block formed integrally with or separately from the case, the cylinder block extending frontward or obliquely upward and frontward; a cylinder head fixed to a front end portion of the cylinder block and defining a combustion chamber together with the cylinder block, the cylinder head having an intake port and an exhaust port both facing the combustion chamber; a head cover fixed to a front end portion of the cylinder head; a valve, disposed in the head cover and the cylinder head and at least a portion of which being disposed above the cylinder axis line, for opening and closing one of the intake port and the exhaust port; an oil pump disposed in the case and driven by the crankshaft, the oil pump changing a discharge amount thereof according to a rotational speed of the crankshaft; and an oil supply passage having passages formed in a wall of the cylinder block, a wall of the cylinder head, and a wall of the head cover, for guiding oil discharged from the oil pump. An opening connected to the oil supply passage is formed at a position located within an inner surface of the head cover and higher than the valve, the position being off a position directly above the valve. The internal combustion

engine further has a first rib protruding from the inner surface of the head cover, one end of which is located at a side of the opening and the other end of which is located directly above the valve.

ADVANTAGEOUS EFFECTS OF INVENTION

[0010] The present invention makes it possible to provide an internal combustion engine that can supply oil smoothly to the upper valve even without forming an opening at a position directly above the upper valve.

BRIEF DESCRIPTION OF DRAWINGS

[0011]

Fig. 1 is a side view of a motorcycle;
 Fig. 2 is a cross-sectional view illustrating an engine unit;
 Fig. 3 is a vertical cross-sectional view illustrating the engine unit;
 Fig. 4 is a partial side view of the engine, illustrating the structure of an oil supply passage;
 Fig. 5 is a cross-sectional view taken along line V-V of Fig. 4;
 Fig. 6 is a cross-sectional view taken along line VI-VI of Fig. 4;
 Fig. 7 is a view illustrating a head cover, an air-intake valve, and the like, viewed in the direction indicated by the arrow VII in Fig. 4;
 Fig. 8 is a cross-sectional view showing the cross section taken along line VIII-VIII in Fig. 7 and the cross section of a cylinder head etc.;
 Fig. 9 is a perspective view illustrating the structures of a portion of the oil supply passage, a first rib, a second rib, and so forth;
 Fig. 10 is a perspective view illustrating the first rib, the second rib, and so forth according to a modified example;
 Fig. 11 is a front view illustrating the first rib according to the modified example;
 Fig. 12 is a front view illustrating the first rib according to another modified example; and
 Fig. 13 is a front view illustrating the first rib, the second rib, and so forth according to the other modified example.

DESCRIPTION OF EMBODIMENTS

[0012] Hereinbelow, one embodiment of the present invention will be described. In the following description, the terms "front," "rear," "left," and "right" respectively refer to front, rear, left, and right as defined based on the perspective of the rider of a motorcycle 1. Reference characters F, Re, L, and R in the drawings indicate front, rear, left, and right, respectively.

[0013] As illustrated in Fig. 1, a straddle-type vehicle in which an internal combustion engine according to the

present embodiment is mounted is a scooter type motorcycle 1. The motorcycle 1 has a body frame 2 and an engine unit 10, which is pivotably supported to the body frame 2 via a pivot shaft 3. The engine unit 10 is what is called a unit swing type engine unit. The straddle-type vehicle in which the internal combustion engine according to the present invention is to be mounted may be any other type of motorcycle, such as a moped-type motorcycle and a sport-type motorcycle. Although not shown in the drawings, the engine unit 10 may be such an engine unit non-pivotably fixed to an underbone frame, which is part of the body frame. The straddle-type vehicle according to the present invention is not limited to a motorcycle but may be any other straddle-type vehicle, such as ATV.

[0014] The sides of the body frame 2 are covered by a vehicle body cover 4. An air cleaner 29 is disposed above the engine unit 10. The body frame 2 has a head pipe 2A. A front fork 5 is supported by the head pipe 2A. A handle bar 6 is fitted to an upper portion of the front fork 5. A front wheel 7 is supported at the lower end portion of the front fork 5. The body frame 2 has a pair of left and right side frames 2B. The side frame 2B extends obliquely upward and rearward, when viewed from side. A cushion unit 8 spans between a rear portion of the engine unit 10 and a rear portion of the side frame 2B. A rear wheel 9 is supported at a rear end portion of the engine unit 10.

[0015] As illustrated in Fig. 2, the engine unit 10 includes an engine 13, which is one example of an internal combustion engine, and a V-belt type continuously variable transmission 20 (hereinafter referred to as "CVT"). The engine 13 has a crankshaft 12, and a crankcase 14 accommodating the crankshaft 12. The drive force from the crankshaft 12 is transmitted to the rear wheel 9 via the CVT 20.

[0016] The CVT 20 has a first pulley 21, which is a driving pulley, and a second pulley 22, which is a driven pulley. The V-belt 23 is wrapped around the first pulley 21 and the second pulley 22. The first pulley 21 is fitted to the left end of the crankshaft 12. The second pulley 22 is fitted to a main shaft 24. The main shaft 24 is coupled to a rear wheel shaft 25 via a gear mechanism, which is not shown in the drawings. Note that Fig. 2 depicts the state in which the transmission ratio for a front portion of the first pulley 21 and that for a rear portion of the first pulley 21 are different from each other. The second pulley 22 has the same configuration. The CVT 20 is accommodated in a transmission case 30. The transmission case 30 is disposed on the left of the crankcase 14.

[0017] As illustrated in Fig. 3, the engine 13 has a cylinder block 11 extending obliquely upward and frontward from the crankcase 14, a cylinder head 15 fixed to a front end portion of the cylinder block 11, and a head cover 16 fixed to a front end portion of the cylinder head 15. The cylinder block 11, the cylinder head 15, and the head cover 16 together constitute a cylinder.

[0018] Reference character L1 indicates the central line of the cylinder block 11, i.e., the cylinder axis line.

The cylinder axis line L1 extends obliquely upward and frontward. The cylinder axis line L1 need not necessarily extend obliquely upward and frontward but may extend frontward. The cylinder axis line L1 may be inclined from the horizontal line or may be parallel to the horizontal line. Herein, the slope angle of the cylinder axis line L1 with respect to the horizontal line is about 10 degrees, and the cylinder axis line L1 extends substantially horizontally. When the slope angle of the cylinder axis line L1 is smaller, the advantageous effects of the present invention will be obtained more significantly. However, the slope angle of the cylinder axis line L1 is not particularly limited and may be 15 degrees or less, 30 degrees or less, or even 45 degrees or less, for example.

[0019] A piston 17 is accommodated slidably in the cylinder block 11. The piston 17 and the crankshaft 12 are coupled to each other via a connecting rod 18. A combustion chamber 19 is defined by the cylinder block 11, the cylinder head 15, and the piston 17.

[0020] An intake port 31 and an exhaust port 32 are formed in the cylinder head 15. The intake port 31 and the exhaust port 32 face the combustion chamber 19. The intake port 31 is located above the cylinder axis line L1, and the exhaust port 32 is located below the cylinder axis line L1.

[0021] A valve train is disposed in the cylinder head 15 and the head cover 16. The valve train has a camshaft 35, a first rocker arm 36, a second rocker arm 37, an intake valve 41, and an exhaust valve 42.

[0022] The intake valve 41 is disposed above the exhaust valve 42. The intake valve 41 is disposed above the cylinder axis line L1, and the exhaust valve 42 is disposed below the cylinder axis line L1. This is why the intake valve 41 may be called the upper valve and the exhaust valve 42 may be called the lower valve. Various kinds of valves that are conventionally used as the intake valve and the exhaust valve for an internal combustion engine may be used for the intake valve 41 and the exhaust valve 42.

[0023] The intake valve 41 has: an umbrella portion 41a, which is slightly larger than the intake port 31; a rod-shaped valve stem 41b extending obliquely upward and frontward from the umbrella portion 41a; a retainer 41c provided at the front end portion of the valve stem 41b; and a spring 41d for urging the valve stem 41b in such a manner that the umbrella portion 41a can close the intake port 31. The retainer 41c is formed with a larger diameter than that of the valve stem 41 b. The retainer 41c supports one end of the spring 41 d.

[0024] The exhaust valve 42 has a similar configuration as the intake valve 41 and is therefore not further elaborated upon. However, unlike the intake valve 41, the exhaust valve 42 is disposed in such a posture that the valve stem extends obliquely frontward and downward.

[0025] The camshaft 35 is provided with a first cam 33 and a second cam 34. The first cam 33 and the second cam 34 are disposed at positions that are staggered with

respect to the axis of the camshaft 35 (i.e., with respect to the obverse side and the reverse side of Fig. 3). As illustrated in Fig. 6, a sprocket 40a is secured to the left end of the camshaft 35. The sprocket 40a is linked to the crankshaft 12 via a chain 40. The camshaft 35 is driven by the crankshaft 12 to rotate along with the crankshaft 12.

[0026] The first rocker arm 36 can pivot about a shaft 36a (see Fig. 3). As illustrated in Fig. 3, one end of the first rocker arm 36 is in contact with the first cam 33, while the other end thereof is in contact with the upper end of the intake valve 41. When the first cam 33 pushes one end of the first rocker arm 36 upward as the camshaft 35 rotates, the first rocker arm 36 pivots anticlockwise, and the other end of the first rocker arm 36 pushes down the intake valve 41 obliquely rearward and downward. As a result, the umbrella portion 41a opens the intake port 31. As the camshaft 35 rotates further, the position of the first cam 33 changes, and the one end of the first rocker arm 36 is no longer pushed upward by the first cam 33. Then, the spring 41d pushes the valve stem 41b obliquely upward and frontward, causing the intake valve 41 to move obliquely upward and frontward, and the umbrella portion 41a closes the intake port 31. The other end of the first rocker arm 36 is pushed upward by the intake valve 41, and the first rocker arm 36 pivots clockwise.

[0027] The second rocker arm 37 can pivot about a shaft 37a. One end of the second rocker arm 37 is in contact with the second cam 34, while the other end thereof is in contact with the lower end of the exhaust valve 42. By the second cam 34 and the second rocker arm 37, the exhaust valve 42 is driven in a similar manner to the intake valve 41.

[0028] The intake valve 41 and the exhaust valve 42 are movable parts. The intake valve 41 and the exhaust valve 42 are supplied with oil from an oil pump 38 (see Fig. 4) in the crankcase 14. Next, the mechanism for supplying oil to the intake valve 41 and the exhaust valve 42 will be described.

[0029] A plurality of passages are formed in the walls of the crankcase 14, the cylinder block 11, the cylinder head 15, and the head cover 16. The engine 13 has an oil supply passage 50 formed by these passages. The arrows in Fig. 4 indicates part of the flow of the oil in the oil supply passage 50. The oil is supplied through the oil supply passage 50 to various sliding parts. Hereinbelow, the passages that constitute the oil supply passage 50 will be described. In the present embodiment, the oil supply passage that supplies oil from the oil pump 38 to the intake valve 41 comprises passages 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, and 63, which will be described below. However, the oil supply passage that supplies oil from the oil pump 38 to the intake valve 41 is not limited to the oil supply passage comprising the just-mentioned passages 53 and so forth. It is sufficient that the oil supply passage according to the present invention have a passage formed in the walls of the cylinder block 11, the cylinder head 15, and the head cover 16, and the struc-

ture of the oil supply passage according to the present invention is not in any way limited to the structure described in the present embodiment.

[0030] As illustrated in Fig. 5, a bottom portion 14a of the crankcase 14 is formed so as to reserve oil. The bottom portion 14a of the crankcase 14 serves as an oil reservoir portion. A passage 51 extending rightward is formed in the crankcase 14. An oil filter 39 is provided on the left of the passage 51. The oil that has gathered in the bottom portion 14a of the crankcase 14 passes through the oil filter 39 and flows into the passage 51.

[0031] The right end of the passage 51 is connected to a passage 52 extending upward. The oil pump 38 is disposed above the passage 52. The passage 52 is connected to a suction port 38a of the oil pump 38. A discharge port 38b of the oil pump 38 is connected to the passage 53 (see Fig. 4) extending obliquely upward and frontward. The front end of the passage 53 is connected to the passage 54 extending rightward. As illustrated in Fig. 4, the right end of the passage 54 is connected to the passage 55 extending upward.

[0032] As illustrated in Fig. 6, the upper end of the passage 55 is connected to the passage 56 extending leftward. The left end of the passage 56 is branched into the passage 57 extending obliquely upward and frontward and a passage 70 extending obliquely rearward and downward. The oil flowing through the passage 70 is supplied to the crankshaft 12, the connecting rod 18, and the piston 17. The oil having been supplied thereto flows down into the bottom portion 14a of the crankcase 14. These passages 51 through 57 and the passage 70 are formed in the crankcase 14.

[0033] As illustrated in Fig. 4, the passage 58 connected to the passage 57 is formed between the crankcase 14 and the cylinder block 11. The upper end of the passage 58 is connected to the passage 59 extending obliquely upward and frontward. The passage 59 is formed in a wall of the cylinder block 11.

[0034] The passage 59 is connected to the passage 60 extending obliquely upward and frontward. The front end of the passage 60 is branched into the passage 61 and a passage 71. As illustrated in Fig. 6, the passage 71 is connected to a passage 72 formed inside the camshaft 35. A passage 73 extending radially is formed in the camshaft 35. The oil supplied to the passage 72 is discharged out of the camshaft 35 through the passage 73. Thus, the oil discharged out of the camshaft 35 lubricates the outer peripheral portion of the camshaft 35 and flows down due to the gravitational force, so the oil is supplied to the exhaust valve 42. The oil having been supplied thereto flows down into the bottom portion 14a of the crankcase 14. The passage 60 and the passage 71 are formed in a wall of the cylinder head 15.

[0035] As illustrated in Fig. 4, the passage 61 extends obliquely upward and frontward. The front end of the passage 61 is connected to the passage 62 extending obliquely leftward and upward. The passage 62 is connected to the passage 63 extending obliquely rearward and

downward. The passages 61, 62 and 63 are formed in a wall of the head cover 16.

[0036] Fig. 7 is a view showing a portion of the head cover 16 and so forth, viewed from the rear. In other words, Fig. 7 is a view showing a portion of the head cover 16 and so forth, viewed in the direction indicated by the arrow VII in Fig. 4. Fig. 8 is a cross-sectional view taken along line VIII-VIII in Fig. 7. Fig. 9 is a perspective view showing a portion of the head cover 16 and so forth, viewed from the rear.

[0037] As illustrated in Fig. 9, a first protruding portion 85 having a columnar shape and protruding downward is provided in an upper wall 16a of the head cover 16. The passage 61 is formed inside the first protruding portion 85. As illustrated in Fig. 8, the head cover 16 is provided with a second protruding portion 86 protruding from a front wall 16b rearward (strictly speaking, obliquely rearward and downward; note that the term "rearward" herein is meant to include "obliquely downward and rearward," in addition to "rearward" in a strict sense, unless specifically indicated otherwise). Since the second protruding portion 86 has a wall opposing the intake valve 41 at the front of the intake valve 41, it corresponds to a portion of the front wall 16b of the head cover 16. The second protruding portion 86 may also be called a corner portion stretching from the upper wall 16a to the front wall 16b. The wall thickness of the second protruding portion 86 is thicker than the wall thickness of the upper wall 16a and the wall thickness of the front wall 16b. The passage 62 and the passage 63 are formed inside the second protruding portion 86.

[0038] An opening 64 is formed at the rear end of the passage 63. The opening 64 is formed at a position located within the inner surface of the head cover 16 and higher than the intake valve 41, the position being off the position directly above the intake valve 41. The opening 64 opens toward the rear. Strictly speaking, the opening 64 opens slightly obliquely downward. As illustrated in Fig. 9, a first rib 81 is provided on the right of the opening 64. A portion of the upper wall 16a of the head cover 16 that is more rightward than the opening 64 is inclined obliquely downward. The first rib 81 is formed on the inner surface of the inclined portion so as to protrude downward. The first rib 81 extends substantially rearward. Strictly speaking, the first rib 81 extends obliquely rearward and downward (see Fig. 8). The lower end portion of the first rib 81 is formed in a tapered shape. As illustrated in Figs. 7 and 8, a tip end portion 81a of the first rib 81 is disposed at a position directly above the retainer 41c of the intake valve 41.

[0039] As illustrated in Fig. 9, a second rib 82 surrounding the periphery of the opening 64 is provided on the front face of the second protruding portion 86 of the front wall 16b. The second rib 82 is formed in a U-shape so as to surround the regions on the left, below, and partially on the right of the opening 64. The second rib 82 functions as an oil catch for catching the oil discharged from the opening 64. The right end portion of the second rib 82 is

continuous with the first rib 81. The first rib 81 and the second rib 82 as a whole are formed in a U-shape so as to surround the regions below and at the sides of the opening 64.

[0040] As illustrated in Fig. 8, a lower end portion 86b of the second protruding portion 86 is located above an upper end portion 36t of the first rocker arm 36, an upper end portion 41ct of the retainer 41c, and an upper end portion 41bt of the valve stem 41 b. The first rocker arm 36 is disposed more frontward than the retainer 41c and the valve stem 41b. The second protruding portion 86 is disposed more frontward than the first rocker arm 36, and the opening 64 is located more frontward than the first rocker arm 36. Accordingly, the opening 64 is located more frontward than the retainer 41c and the valve stem 41b. In addition, the opening 64 is located above the first rocker arm 36, the retainer 41 c, and the valve stem 41b. As illustrated in Fig. 7, the opening 64 is located above the upper end portion 36t of the first rocker arm 36 and the retainer 41 c, when viewed from the rear.

[0041] As illustrated in Fig. 8, the first rocker arm 36 is disposed in front of the intake valve 41 and is covered by the head cover 16. The intake valve 41 is covered by the head cover 16 and the cylinder head 15 (see also Fig. 3). The opening 64 is configured to supply oil not only to a portion of the intake valve 41 located in the head cover 16 but also to a portion thereof located in the cylinder head 15.

[0042] As the crankshaft 12 rotates, the oil pump 38 coupled to the crankshaft 12 is driven. Part of the oil that has gathered in the bottom portion 14a of the crankcase 14 is passed through the passages 51 to 63 and discharged from the opening 64. As illustrated in Fig. 4, the oil pump 38 is coupled to the crankshaft 12 via a gear 45. The oil pump 38 is driven by the crankshaft 12. The rotational speed of the oil pump 38 increases/decreases according to the rotational speed of the crankshaft 12. When the rotational speed of the crankshaft 12 is low, the rotational speed of the oil pump 38 is accordingly low, while when the rotational speed of the crankshaft 12 is high, the rotational speed of the oil pump 38 is accordingly high. The discharge amount and discharge pressure of the oil pump 38 changes according to the rotational speed of the crankshaft 12.

[0043] When the rotational speed of the crankshaft 12 is low, for example, when the motorcycle 1 is in an idle state, the discharge pressure of the oil pump 38 is low, so the force of the oil that is discharged from the opening 64 becomes weak. In this case, the oil discharged from the opening 64 flows along the inner surface of the head cover 16 and reaches the first rib 81. Because the second rib 82 is provided around the opening 64, the oil that has once flowed downward of the opening 64 is also guided to the first rib 81 through the second rib 82. As indicated by the arrow F1 in Fig. 8, the oil that flows along the surface of the first rib 81 flows down from the first rib 81 due to the gravitational force, so it is supplied to the first rocker arm 36 and the intake valve 41.

[0044] The tip end portion 81a of the first rib 81 is located directly above the retainer 41c of the intake valve 41. The oil that has flowed down from the tip end portion 81a of the first rib 81 is supplied to the intake valve 41. Note that the tip end portion 81a is also the lowermost end portion of the first rib 81, and it is the part from which the oil can flow down most easily. The retainer 41 has a larger area as viewed in plan than does the valve stem 41b. The retainer 41c is the part that can catch the oil most easily. Thus, the tip end portion 81 a, which is the part of the first rib 81 from which the oil can flow down most easily, is disposed above the retainer 41c, which is the part of the intake valve 41 that can catch the oil most easily, whereby the intake valve 41 can be supplied with a sufficient amount of oil.

[0045] When the rotational speed of the crankshaft 12 is high, for example, when the motorcycle 1 is running at high speed, the discharge pressure of the oil pump 38 is high, so the oil is discharged from the opening 64 with great force. For example, the oil is injected from the opening 64. As indicated by the arrow F2 in Fig. 8, the discharged oil is supplied directly to the first rocker arm 36 and the intake valve 41.

[0046] As described above, in the engine 13, the opening 64 connected to the passage 63 of the oil supply passage 50 is formed at a position located within the inner surface of the head cover 16 and higher than the intake valve 41, the position being off the position directly above the intake valve 41. When the rotational speed of the crankshaft 12 is high, the oil is discharged from the opening 64 with great force. For this reason, the intake valve 41 can be supplied with oil even though the opening 64 is not located directly above the intake valve 41. On the other hand, when the rotational speed of the crankshaft 12 is low, the force of the oil that is discharged from the opening 64 is weak. However, the first rib 81, the tip end portion 81a of which is located directly above the retainer 41c of the intake valve 41, is provided at a side of the opening 64. The oil discharged from the opening 64 flows along the inner surface of the head cover 16 and the surface of the first rib 81, and then flows down from the tip end portion 81a of the first rib 81 onto the intake valve 41. For this reason, the intake valve 41 can be supplied with oil even though the opening 64 is not located directly above the intake valve 41. With the engine 13, the intake valve 41 can be supplied with oil desirably even when, for example, in an idle state in which the discharge pressure of the oil pump 38 is low.

[0047] Moreover, with the engine 13, the number of the passages formed in the head cover 16 is smaller than that in the previously-described conventional example (see Literature 1), and therefore, the size of the head cover 16 can be reduced.

[0048] As illustrated in Fig. 9, the inner surface of the head cover 16 is provided with the second rib 82, which protrudes from below the opening 64 and is continuous with the first rib 81. The oil that has once flows downward of the opening 64 is caught by the second rib 82 and

guided to the first rib 81. Thus, the amount of the oil supplied from the first rib 81 to the intake valve 41 can be increased. Even when the rotational speed of the crankshaft 12 is low, the intake valve 41 can be supplied with a sufficient amount of oil.

[0049] As illustrated in Fig. 9, in the present embodiment, the first rib 81 and the second rib 82 are formed in a U-shape so as to surround the regions below and at the sides of the opening 64. The second rib 82 also surrounds the region opposite the first rib 81, that is, the region at the left of the opening 64. As a result, a larger amount of oil can be guided from the opening 64 to the first rib 81. Accordingly, a larger amount of oil can be supplied to the intake valve 41.

[0050] However, the shape and dimensions of the second rib 82 are not particularly restricted. For example, as illustrated in Fig. 10, it is also possible to provide a second rib 83 in a protruding shape that extends leftward from the first rib 81 in place of the U-shaped second rib 82. Thus, the second rib 83 may be disposed below a portion of the opening 64 that is adjacent to the first rib 81. Alternatively, the second rib may be in a plate shape extending in a horizontal direction.

[0051] As illustrated in Fig. 9, the first rib 81 is formed on the inner surface of the upper wall 16a of the head cover 16. Thereby, a means to supply oil to the intake valve 41 at the time when the rotational speed of the crankshaft 12 is low can be obtained with a simple configuration.

[0052] As illustrated in Fig. 8, the opening 64 is located more frontward than the front end 41f of the intake valve 41, and the first rib 81 extends obliquely rearward and downward. The opening 64 is formed in the inner surface of the front wall 16b of the head cover 16 (more specifically, in the surface of the second protruding portion 86 of the front wall 16b), and the first rib 81 extends obliquely rearward and downward. Thereby, a means to supply oil to the intake valve 41 at the time when the rotational speed of the crankshaft 12 is low can be obtained with a simple configuration, utilizing the feature of the shape of the engine 13, the cylinder axis line L1 (see Fig. 3) of which extends frontward or obliquely upward and frontward.

[0053] As illustrated in Figs. 7 and 9, the lower end portion of the first rib 81 is formed in a downwardly tapered shape. The lower face of the first rib 81 is curved in a downwardly convex shape. Thereby, oil can flow down smoothly from the first rib 81. Thus, oil can be supplied smoothly from the first rib 81 to the intake valve 41.

[0054] However, the shape of the first rib 81 is not particularly restricted. For example, As illustrated in Fig. 11, the lower end of the first rib 81 may be formed in an inverted triangular shape. The lower end of the first rib 81 may have a sharp-pointed end. As illustrated in Fig. 12, the lower end portion of the first rib 81 may not necessarily be formed in a tapered shape.

[0055] In the intake valve 41, the retainer 41c has a larger area as viewed in plan than the valve stem 41b

(see Fig. 7, etc.). As illustrated in Fig. 7, the tip end portion 81a of the first rib 81 is located directly above the retainer 41c. More specifically, the tip end portion 81a of the first rib 81 is located directly above the right end portion of the retainer 41c. The first rib 81 allows oil to flow down onto a part of the intake valve 41 that has a large area as viewed in plan. Therefore, oil can be stably supplied to the intake valve 41.

[0056] As illustrated in Fig. 9, the head cover 16 has the first protruding portion 85 protruding downward from the inner surface of the upper wall 16a. In addition, as illustrated in Fig. 8, the head cover 16 has the second protruding portion 86 protruding rearward from the inner surface of the front wall 16b. The passage 61 is formed inside the first protruding portion 85, and the passage 62 and the passage 63 are formed inside the second protruding portion 86. The first protruding portion 85 and the second protruding portion 86 have larger thicknesses than the rest of the portions. Therefore, it is unnecessary to form the passages 61 to 63 into thin wall parts, and it is easy to form the passages 61 to 63. Moreover, it is possible to prevent the decrease in the strength of the head cover 16 resulting from the formation of the passages 61 to 63. It is also possible to inhibit the size of the head cover 16 from becoming large.

[0057] In the present embodiment, the opening 64 is formed in the inner surface of the front wall 16b of the head cover 16. However, the opening 64 may be formed in the inner surface of the upper wall 16a of the head cover 16. Alternatively, the opening 64 may be formed stretching from the inner surface of the upper wall 16a of the head cover 16 to the inner surface of the front wall 16b. The opening 64 may be formed at a boundary portion between the inner surface of the upper wall 16a and the inner surface of the front wall 16b.

[0058] As illustrated in Fig. 9, in the present embodiment, the lower end of the first rib 81 is disposed at a position higher than the lower end of the second rib 82. However, as illustrated in Fig. 13, the lower end 81b of the first rib 81 and the lower end 82b of the second rib 82 may be disposed at the same height. Alternatively, the lower end portion of the first rib 81 may be disposed at a position lower than the lower end of the second rib 82.

[0059] The first rib 81 may not extend rearward, and it may be inclined leftward or rightward. The first rib 81 may not extend linearly but may be curved. The shape and dimensions of the first rib 81 are not particularly restricted.

[0060] In the present embodiment, the tip end portion 81a of the first rib 81 is located directly above the retainer 41c. However, the position of the tip end portion 81a of the first rib 81 is not particularly restricted. The tip end portion 81a of the first rib 81 may be located directly above the valve stem 41b. The tip end portion 81a of the first rib 81 may be disposed at any such position that oil can be supplied to the intake valve 41.

[0061] In the present embodiment, a closed space for accommodating the oil pump 38 is formed inside the crankcase 14. However, it is also possible to form the

closed space for accommodating the oil pump 38 by combining the crankcase with one or more other cases. The term "case" in the present invention means one that forms a closed space for accommodating the crankshaft and the oil pump, together with the cylinder block, for example. The "case" may be composed of the crankcase alone, or may be composed of the crankcase and another case. The "case" may be a single component, or may be one in which a plurality of components are combined.

[0062] In the present embodiment, the crankcase 14 and the cylinder block 11 are separate parts, and they are fitted to each other. However, the crankcase 14 and the cylinder block 11 may be an integral part. The engine 13 is not restricted to a single cylinder engine, but may be a multi-cylinder engine. For example, in a multi-cylinder engine, an upper portion and a lower portion of the crankcase 14 may be formed by separate parts, and the cylinder block 11 may be integrated with the upper portion of the crankcase 14.

REFERENCE SIGNS LIST

[0063]

10 -- Engine unit
11 -- Cylinder block
12 -- Crankshaft
13 -- Engine
14 -- Crankcase
15 -- Cylinder head
16 -- Head cover
31 -- Intake port
32 -- Exhaust port
38 -- Oil pump
41 -- Intake valve
50 -- Oil supply passage
64 -- Opening
81 -- First rib
82 -- Second rib
L 1 -- Cylinder axis line

Claims

1. An internal combustion engine comprising:

a case for accommodating a crankshaft;
a cylinder block formed integrally with or separately from the case, the cylinder block extending frontward or obliquely upward and frontward;
a cylinder head fixed to a front end portion of the cylinder block and defining a combustion chamber together with the cylinder block, the cylinder head having an intake port and an exhaust port both facing the combustion chamber;
a head cover fixed to a front end portion of the cylinder head;
a valve, disposed in the head cover and the cyl-

inder head and at least a portion of which being disposed above the cylinder axis line, for opening and closing one of the intake port and the exhaust port;

an oil pump disposed in the case and driven by the crankshaft, the oil pump changing a discharge amount thereof according to a rotational speed of the crankshaft;

an oil supply passage having passages formed in a wall of the cylinder block, a wall of the cylinder head, and a wall of the head cover, for guiding oil discharged from the oil pump;

an opening connected to the oil supply passage and formed at a position located within an inner surface of the head cover and higher than the valve, the position being off a position directly above the valve; and

a first rib protruding from the inner surface of the head cover, one end of which is located at a side of the opening and the other end of which is located directly above the valve.

2. The internal combustion engine according to claim 1, further comprising a second rib, at least a portion of which protrudes from a region below the opening in the inner surface of the head cover, the second rib being continuous with the first rib.

3. The internal combustion engine according to claim 1, wherein the first rib and the second rib are formed in a U-shape so as to surround regions below and at sides of the opening.

4. The internal combustion engine according to claim 1, wherein the first rib is formed in an inner surface of an upper wall of the head cover.

5. The internal combustion engine according to claim 1, wherein:

the opening is located more frontward than a front end of the valve; and
the first rib extends obliquely rearward and downward.

6. The internal combustion engine according to claim 1, wherein:

the opening is formed in an inner surface of a front wall of the head cover; and
the first rib extends obliquely rearward and downward.

7. The internal combustion engine according to claim 1, wherein a lower end of the first rib is formed in a downwardly tapered shape.

8. The internal combustion engine according to claim

1, wherein:

the valve has a valve stem extending obliquely upward and frontward, and a retainer provided at a front end portion of the valve stem; and 5
the other end of the first rib is located directly above the retainer.

9. The internal combustion engine according to claim 1, wherein: 10

the head cover has a first protruding portion protruding downward from an inner surface of an upper wall thereof and a second protruding portion protruding rearward from an inner surface of a front wall thereof; and 15
the oil supply passage has a passage formed inside the first protruding portion and a passage formed inside the second protruding portion. 20

10. A motorcycle comprising an internal combustion engine according to claim

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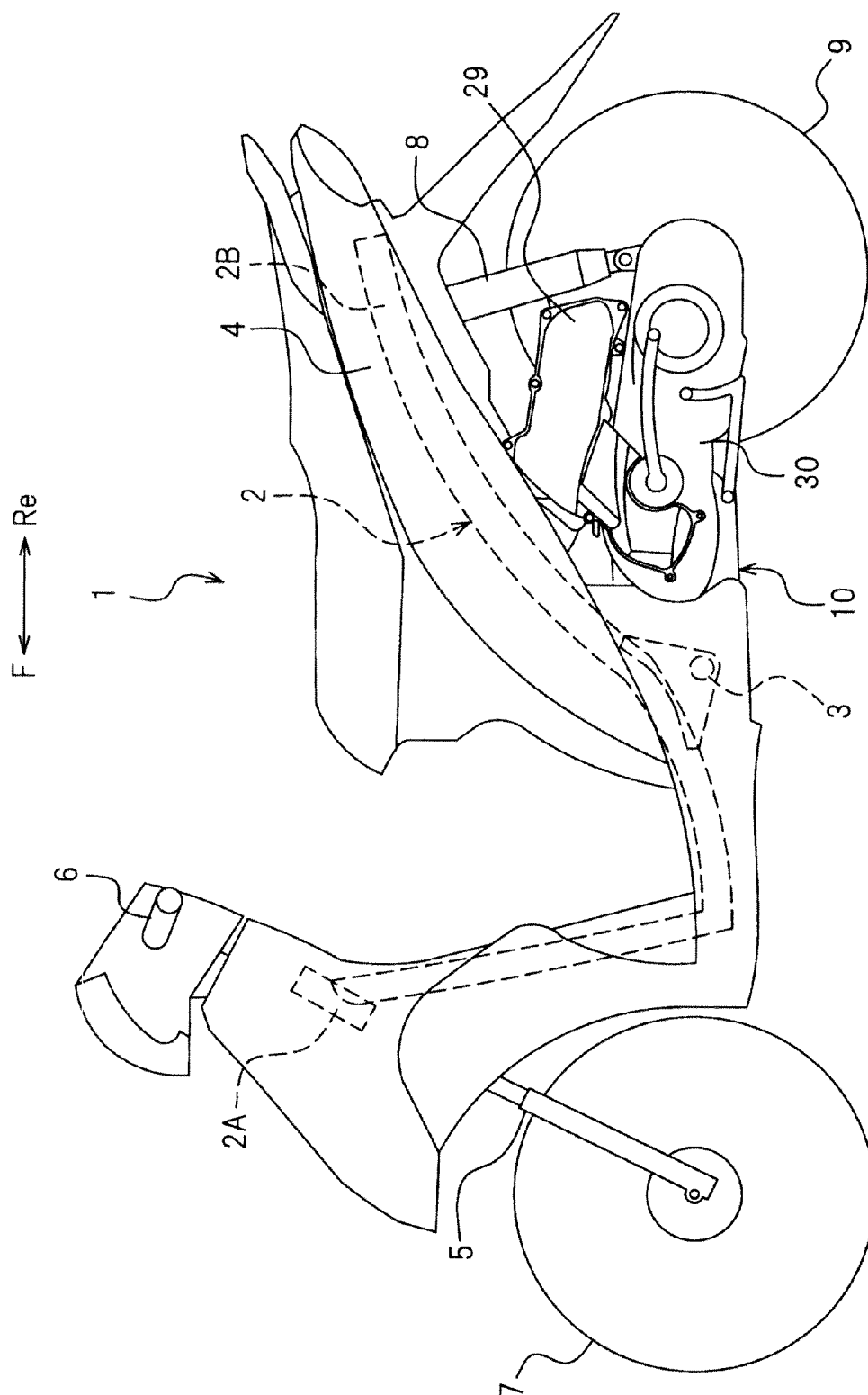
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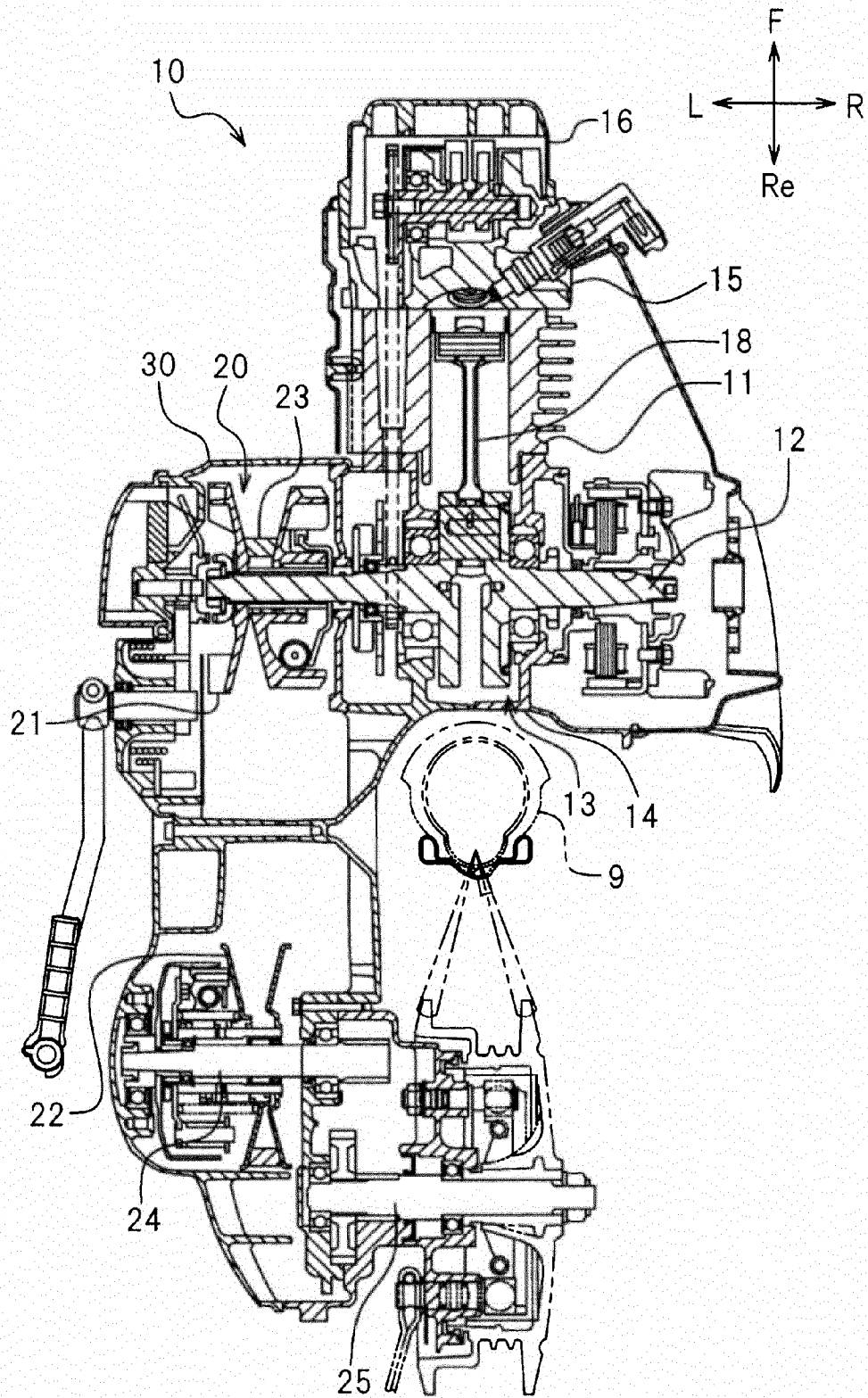
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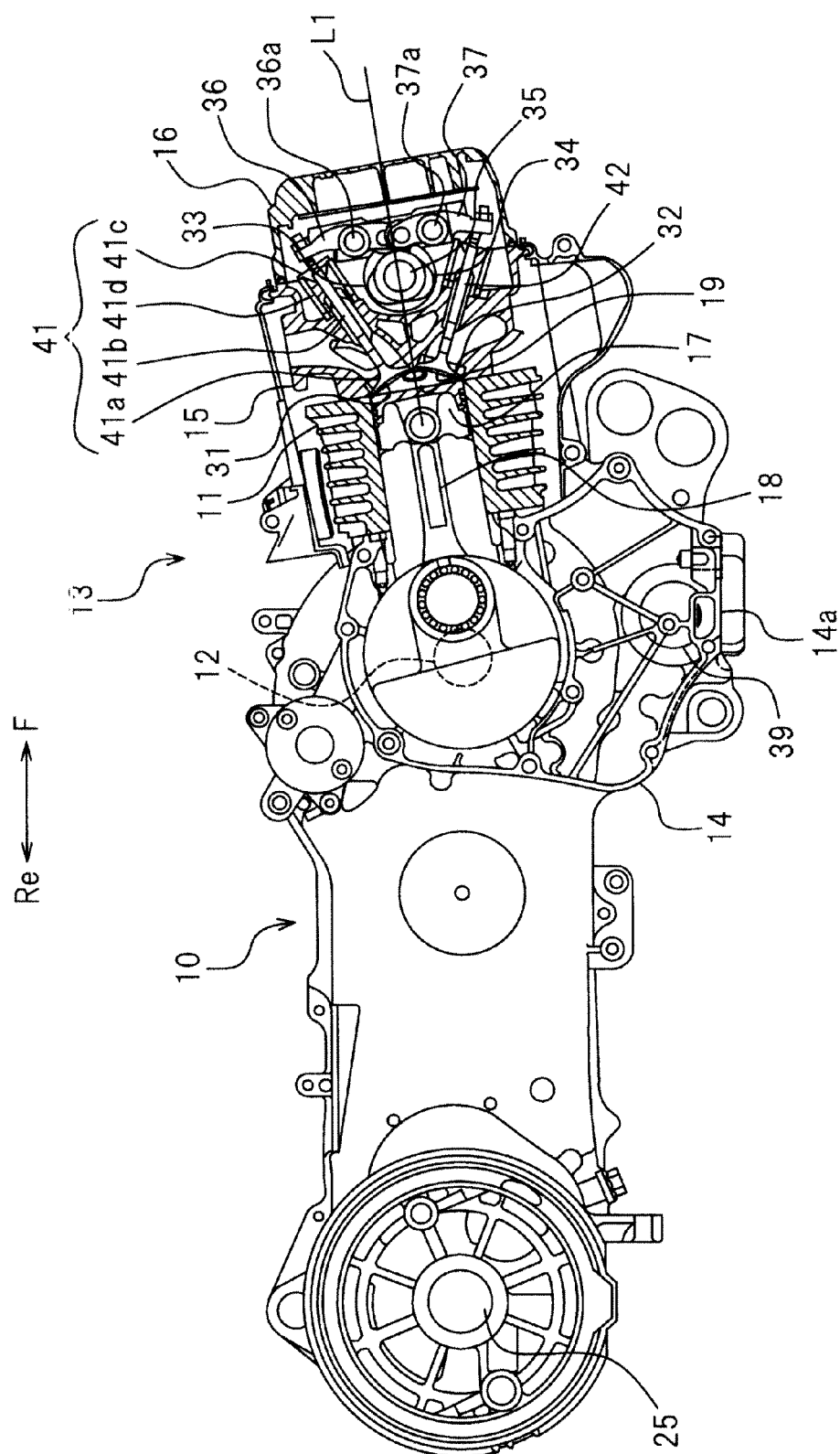
【Fig.1】



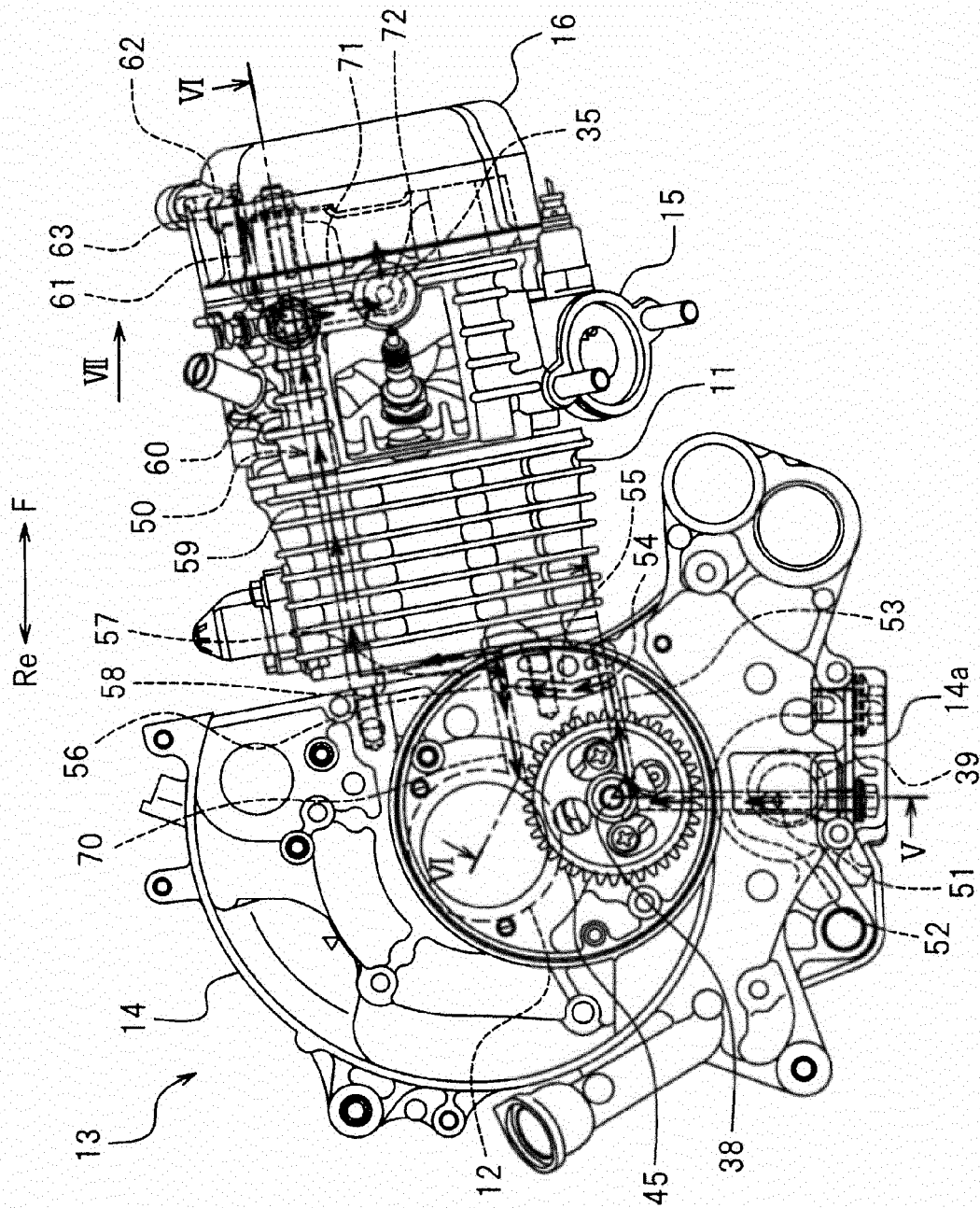
【Fig.2】



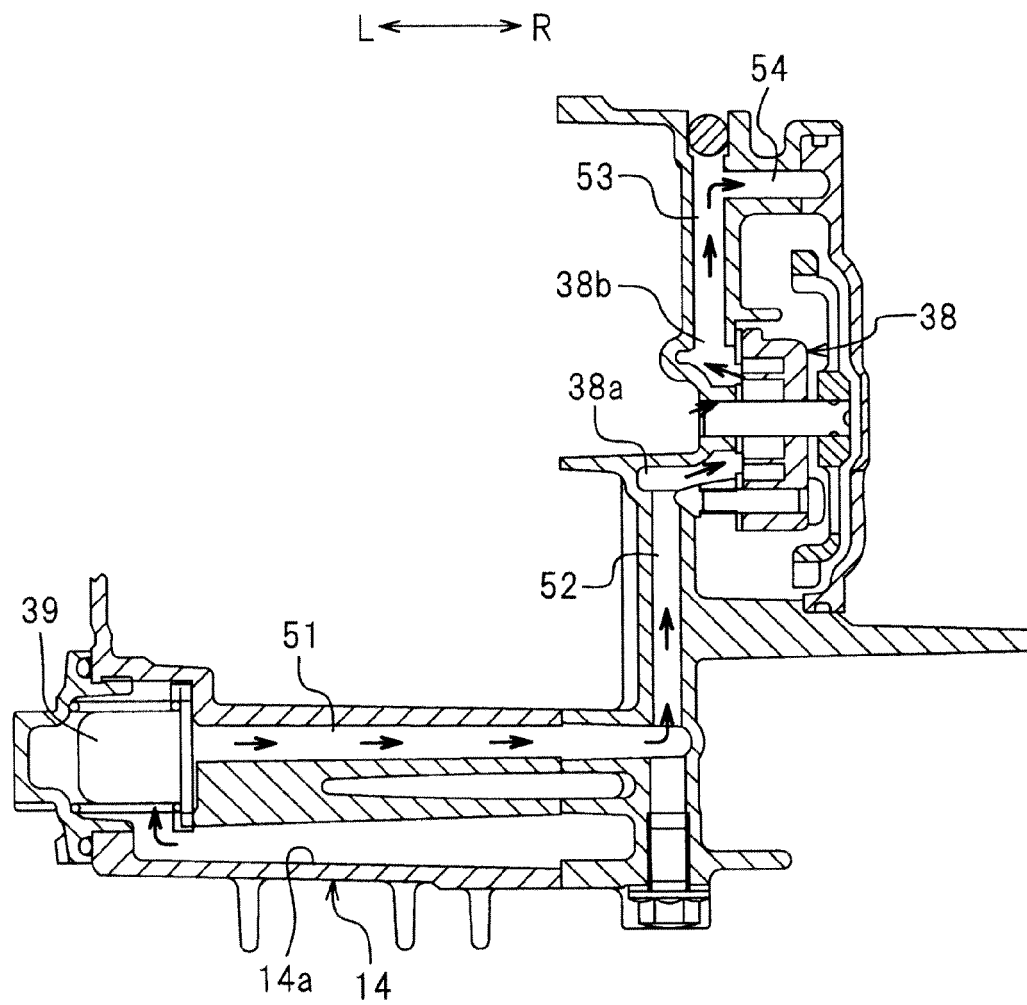
【Fig.3】



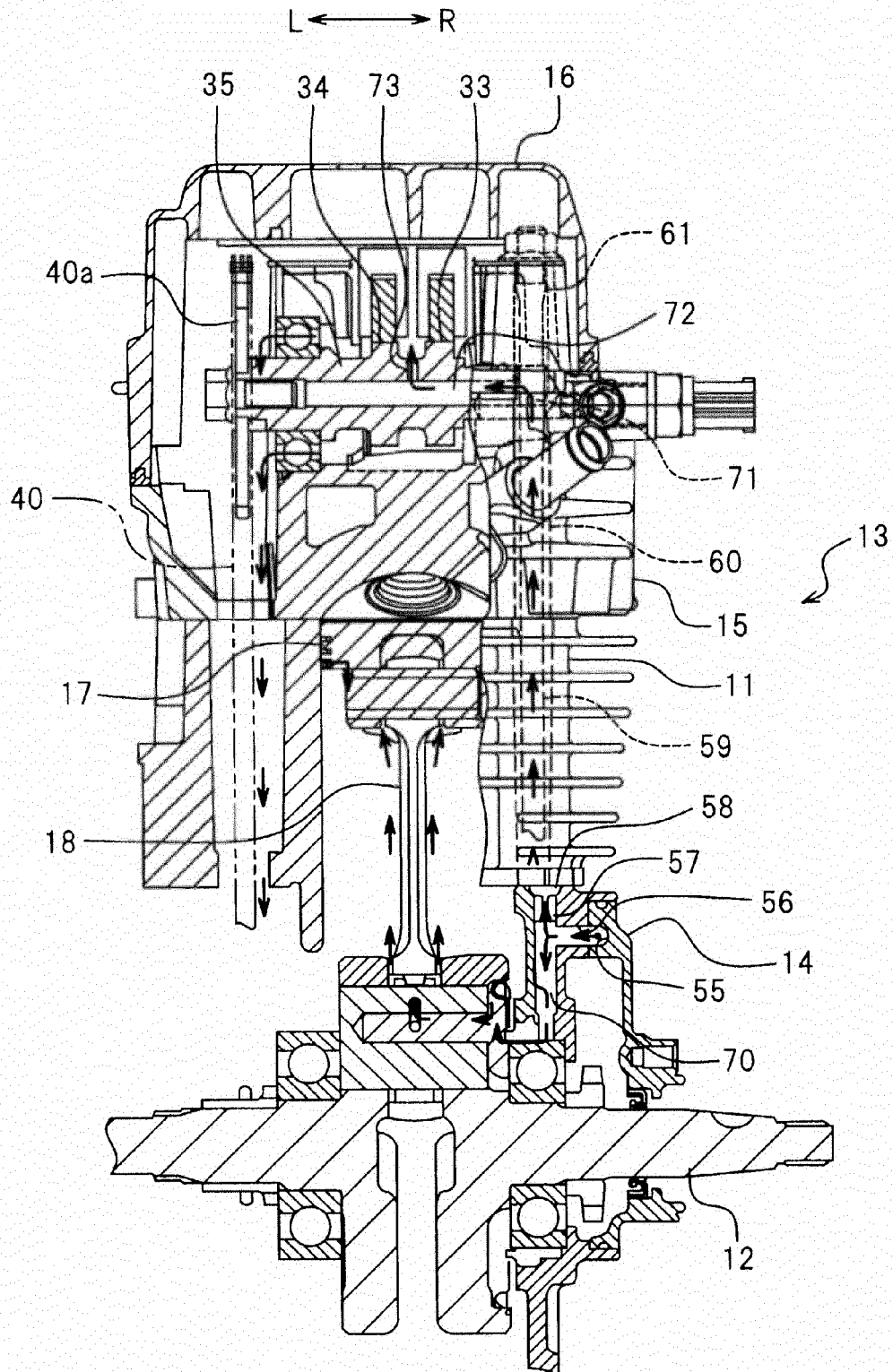
【Fig.4】



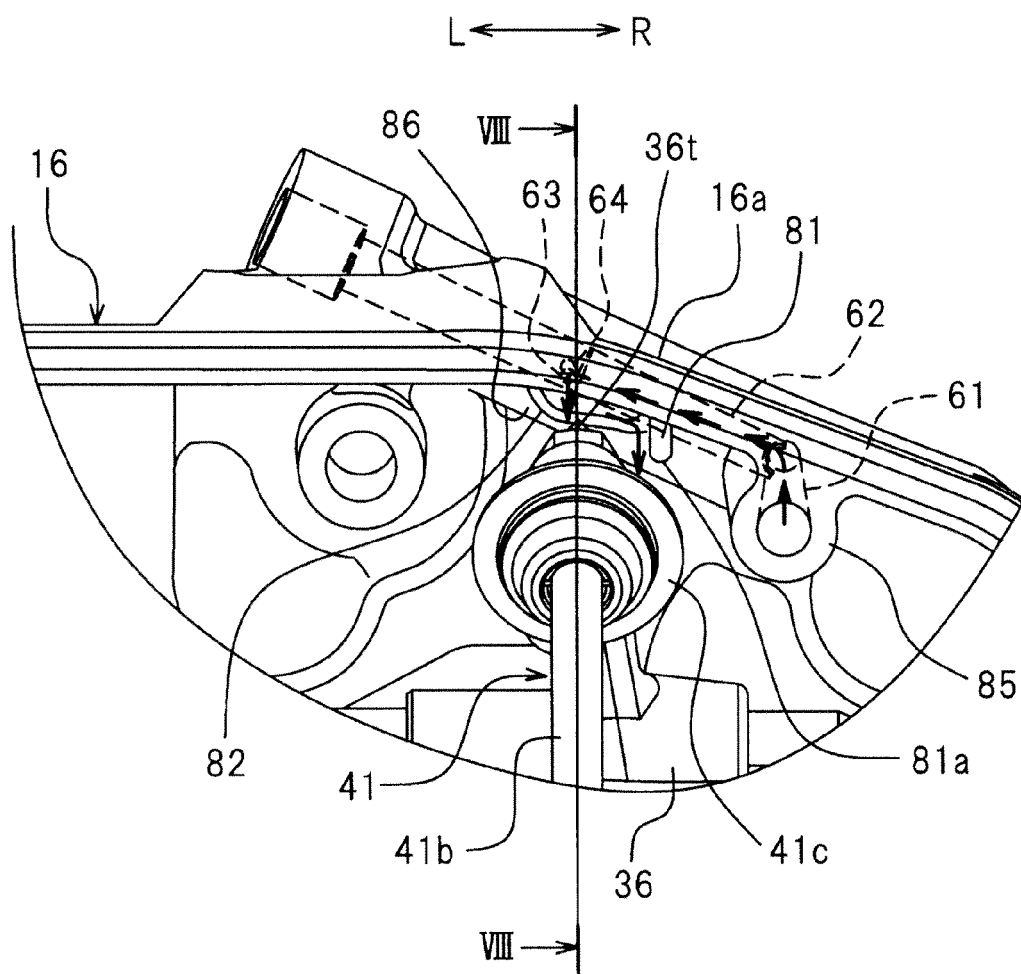
【Fig.5】



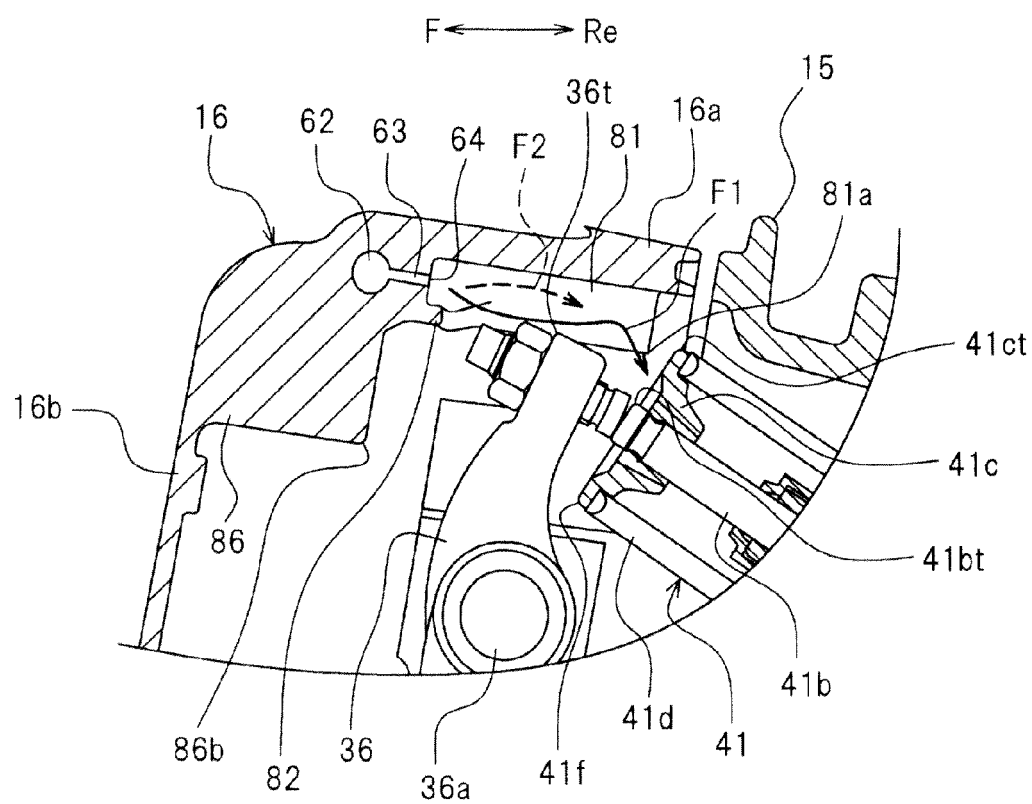
【Fig.6】



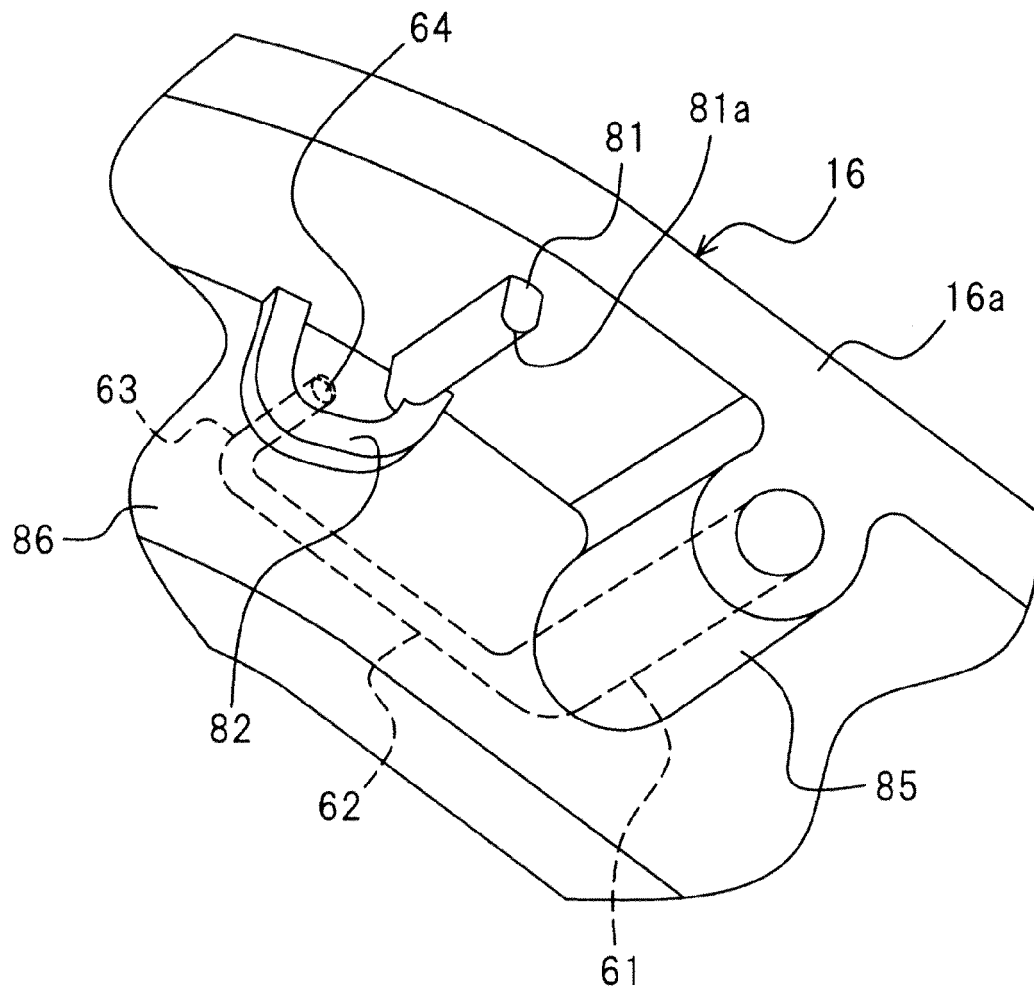
【Fig.7】



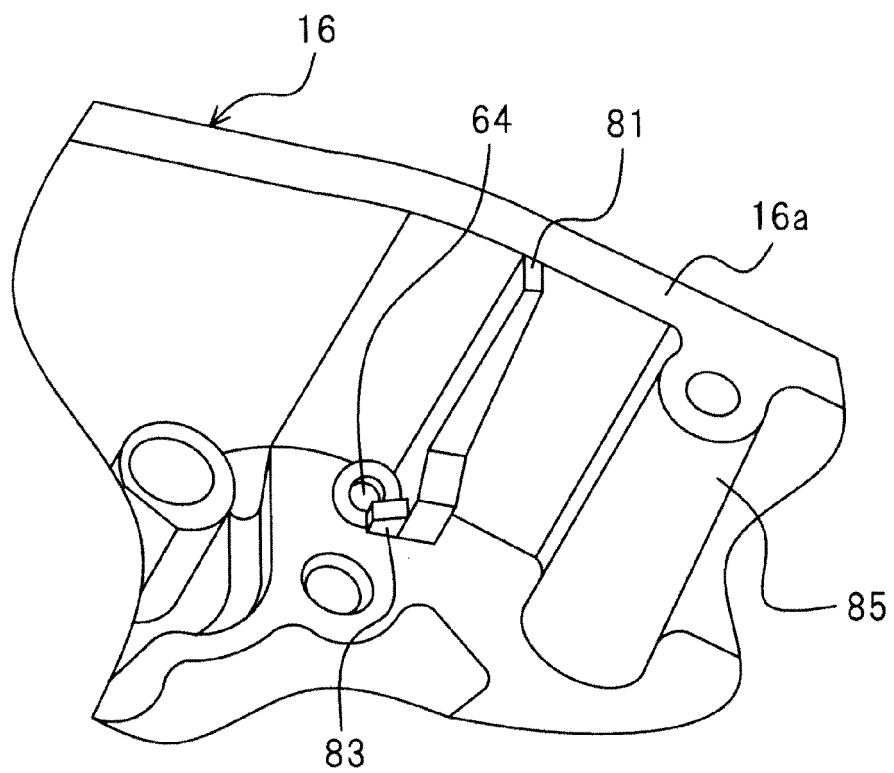
【Fig.8】



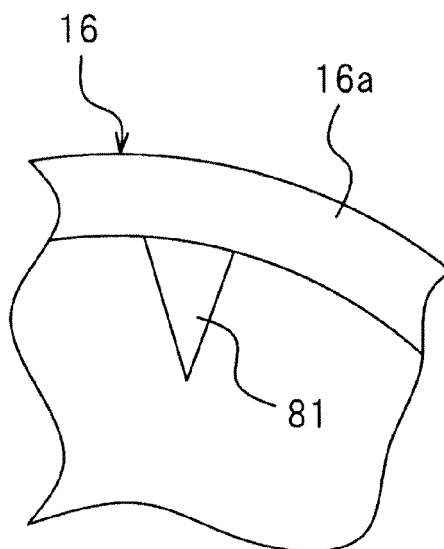
【Fig.9】



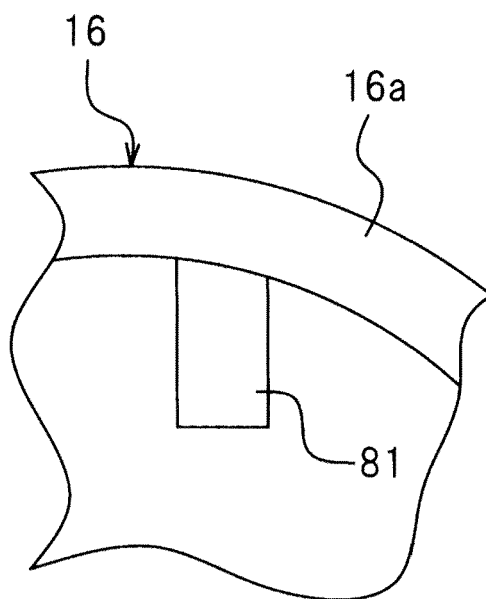
【Fig.10】



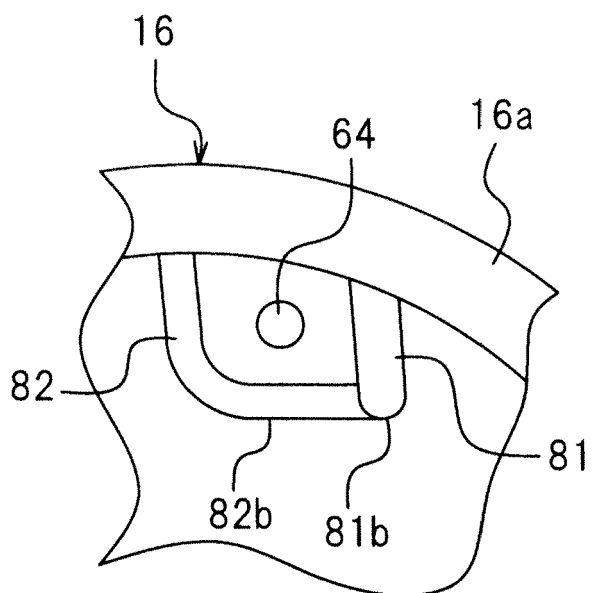
【Fig.11】



【Fig.12】



【Fig.13】





EUROPEAN SEARCH REPORT

Application Number
EP 12 16 8596

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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Place of search The Hague		Date of completion of the search 4 July 2012	Examiner Flamme, Emmanuel
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

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