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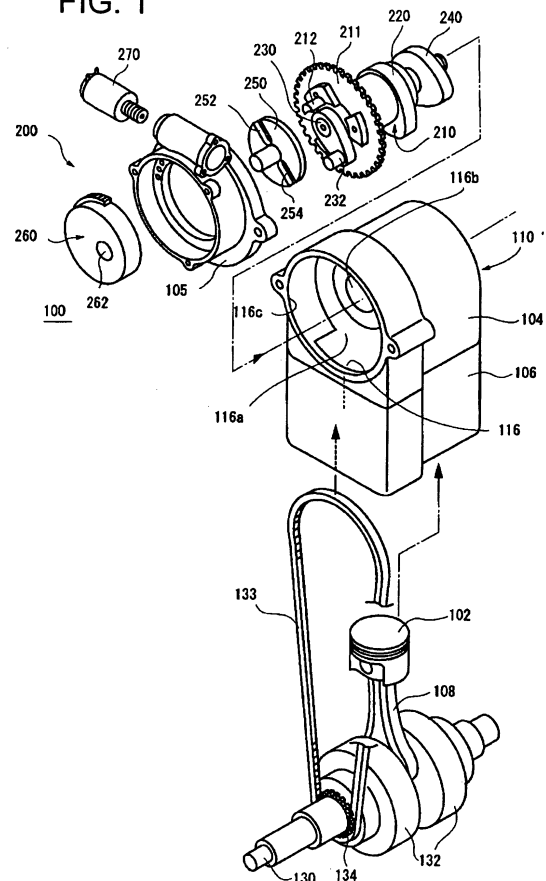
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(54) **VARIABLE VALVE DRIVE DEVICE, ENGINE, AND MOTORCYCLE**

(57) In a variable valve drive device, a cam sprocket 211 is made to rotate by a driving force transmitted from a crankshaft 130. An eccentric plate 250 is arranged at one end side of the cam sprocket 211 in the rotation axis direction thereof, and is made to rotate around an axis in the same direction as the rotation axis of the cam sprocket 211. The axis of the eccentric plate 250 is shift-able from the axle center of the rotation axis to an eccentric position. A variable camshaft 230 is made to rotate around its rotation axis by the eccentric plate 250, and when the eccentric plate 250 rotates the variable camshaft 230 at the eccentric position, the rotational phase difference thereof with respect to the cam sprocket 211 periodically fluctuates. An intake cam block 240 is arranged at the other end side of the cam sprocket 211 in the rotation axis direction thereof, and is made to rotate by the variable camshaft 230 with the same phase as that of the variable camshaft 230 to drive an intake valve.

FIG. 1



Description

Technical Field

[0001] The present invention relates to a variable valve drive device that is arranged in an engine, an engine, and a motorcycle.

Background Art

[0002] Conventionally, in the four-cycle engine, by changing the valve overlap or a period during which the intake valve and the exhaust valve are opened concurrently at the time of the high-speed rotation and the low-medium-speed rotation respectively, high output and low mileage of engine as well as reduction of exhaust gas are realized.

[0003] As a mechanism to change the valve overlap depending on the rotation of an engine, there is known the variable valve timing mechanism that changes the opening and closing timing of the valves according to the number of revolutions of an engine.

[0004] As a general variable valve timing mechanism, for example, there is known one mechanism in which, at the sprocket part for driving cams which rotates in conjunction with the rotation of the crank, a rotational phase difference is set up between the cam drive shaft part rotating in conjunction with the rotation of the crankshaft and a part that drives the camshaft part to which cams are unitedly fixed.

[0005] Being a mechanism in which the valve timing is varied without changing the duration (also referred to as working angle) of cams, the variable valve timing mechanism of this type can be realized by only changing a part of the cam sprocket part rotating in conjunction with the rotation of the crankshaft without largely changing the valve drive mechanism in the conventional engine. However, under this configuration, since the duration of cams cannot be changed, in case of using cams of a large duration so as to obtain a high output, the flow velocity of air fuel mixture flowing into the cylinder is reduced at the time of the low-medium-speed rotation. Accordingly, air fuel mixture becomes hard to vaporize completely in the cylinder, raising a problem that a high output cannot be realized.

[0006] As a technology to make the duration of cams variable, there is suggested one that makes the reduction ratio of the cam angle with respect to the crank angle periodically fluctuate by arranging a coupling (eccentric member) that brings about the angular velocity fluctuation between the cam drive shaft part and the camshaft part, and controls the fluctuation. For example, in Patent Document 1, the cam drive shaft that is driven by the rotation of the crank is made to pass through cams and an eccentric plate (eccentric member) in the form of a circular disc, and a pin arranged on the cam drive shaft is fitted with allowance in a groove extending in the radius direction at the eccentric plate. Then, when the cam drive

shaft rotates, the eccentric plate is made to rotate eccentrically with respect to the cam drive shaft through the pin and groove to drive the cams. As a technology having a fundamental configuration similar to that of the Patent Document 1, there is known Patent Document 2.

[0007] Furthermore, in Patent Document 3, an eccentric plate is arranged between a sprocket that rotates when a driving force is transmitted from the crankshaft through a gear train and the camshaft that is unitedly fixed to cams, and a motive energy is transmitted to the camshaft from the sprocket through the eccentric plate.

[0008] These variable valve timing mechanisms are mainly applied to a multi-cylinder engine of an automobile. In a multi-cylinder engine, since the periodical velocity fluctuation of cams in respective cylinders are required to be staggered by setting different phases, each cylinder has an eccentric plate.

[0009] Furthermore, as another configuration of the variable valve timing mechanism, there is known Patent Document 4. This Patent Document 4 discloses a technology in which the cam drive shaft itself, which drives the camshaft that is unitedly fixed to cams, is made eccentric with respect to the camshaft by an eccentric mechanism.

Patent Document 1: Jpn. Pat. Appln. Publication No. 47-020654

Patent Document 2: Jpn. Pat. Appln. Laid-Open Publication No. 5-118208

Patent Document 3: Jpn. Pat. Appln. Laid-Open Publication No. 3-43611

Patent Document 4: Jpn. Pat. Appln. Publication No. 61-56408

[0010] In recent years, due to the problem of the exhaust gas regulation etc., mounting the variable valve timing mechanism to motorcycles are being considered. When applying the variable valve timing mechanism to a motorcycle, especially to a scooter-type vehicle (referred to as scooter, hereinafter), depending on the restriction of the vehicle dimension, it is desired that the engine configuration is simplified.

[0011] However, according to the technologies disclosed in Patent Document 1 to Patent Document 3, the coupling (for example, an eccentric plate) as a variable mechanism that changes the duration of cams is arranged between the drive part (cam sprocket) that rotates together with the cam drive shaft under the same rotation and the camshaft. Accordingly, in case of mounting the variable valve timing mechanism to a motorcycle, it is necessary to considerably change the configuration of the conventional engine of conventional invariable specification in which a cam drive member is arranged at a position in close proximity to the cylinder axis. That is, in case of changing an engine of conventional invariable

specification into an engine of variable specification, there is brought about the necessity of changing main engine components such as the cylinder head, a component that transmits a driving force from the crankshaft to the cam drive shaft. Accordingly, there is raised a problem that main components of an engine of invariable specification cannot be used in an engine of invariable specification.

[0012] In case of realizing the variable valve timing mechanism by employing the technology disclosed in Patent Document 4, it is possible to use main components in common to a certain extent. However, according to the technology disclosed in Patent Document 4, since the cam drive shaft itself is made to shift, along with the configuration of shifting the cam drive shaft, the configuration of driving cams and the configuration of making the valve timing variable become necessarily complicated.

[0013] Furthermore, since an engine of a motorcycle has arranged therein an eccentric mechanism such as an eccentric plate between the cam sprocket and the camshaft, the cam sprocket comes to be separated from the cylinder axis, which lowers the flexural strength of the crank. There is raised a problem that it is difficult to mount the variable valve timing mechanism with the lowering of the flexural strength being prevented.

[0014] Furthermore, as compared with a conventional engine, since the cam sprocket and the cylinder axis are separately arranged, the chain line of the cam drive chain which is so arranged as to be substantially perpendicular to the crankshaft is separated from a line on which a cylinder and cams are arranged. Accordingly, an engine itself becomes large by a distance between the arrangement line for the cylinder as well as cams and the chain line. As a result, when an engine is employed in a motorcycle, in case the variable valve timing mechanism is mounted to the engine, the chain line protrudes to the outside of the engine as compared with the conventional engine, raising a problem that the engine itself is enlarged.

[0015] Especially, in a scooter, structurally, a sheave for the CVT (Continuously Variable Transmission) is arranged, on the crankshaft, at the outside of the cam drive chain away from the vehicle center. Accordingly, in case of mounting the conventional variable valve timing mechanism to a scooter, wide components such as a sheave are arranged, on the crankshaft, at the outside of rotating parts (crank pulley, timing gear, etc.) around which the cam drive chain is wound with respect to the cylinder position. Accordingly, an engine itself wholly protrudes toward a direction of the crankshaft as compared with the configuration in which the variable valve timing mechanism is not mounted. As a result, in case of a motorcycle in which an engine whose crankshaft is directed to the width direction is mounted, for example, a scooter which has a drive unit of the swing type, the width of the crank case becomes large, which makes it impossible to prepare a sufficient banking angle, raising a problem that

the travel characteristics of the vehicle are lowered.

[0016] Accordingly, the present invention has an object to overcome the above-mentioned drawbacks of the prior art by providing a variable valve drive device, an engine, and a motorcycle which can make the duration of cams variable with a simplified configuration without considerably changing the configuration of an engine.

Disclosure of the Invention

[0017] According to the present invention, there is provided a variable valve drive device, including: a cam drive member that is made to rotate by a driving force transmitted from a crankshaft; an eccentric member that is made to rotate with an axis of the same direction as the rotation axis of the cam drive member being the rotation center when the cam drive member is driven, and has the axis shiftably arranged from the axle center of the rotation axis to an eccentric position; a camshaft that is arranged on the same axis as the rotation axis, and is made to rotate by the eccentric member with the rotation axis being the rotation center, and the rotational phase difference thereof with respect to the cam drive member periodically fluctuates when the eccentric member is made to rotate at the eccentric position; a cam block that is made to rotate by the camshaft with the same rotational phase as that of the camshaft so as to drive an exhaust valve or an intake valve; wherein the eccentric member is arranged at one end of the cam drive member in the rotation axis direction thereof, and the cam block is arranged at the other end of the cam drive member in the rotation axis direction thereof.

Brief Description of the Drawings

[0018]

FIG. 1 shows an exploded perspective view of the substantial part of an engine provided with the variable valve drive device according to an embodiment of the present invention;

FIG. 2 shows a sectional view of the substantial part of the variable valve drive device;

FIG. 3 shows an exploded perspective view of the variable valve drive device;

FIG. 4 shows a view indicative of the positional relationship among the rotation center of an eccentric boss, the axle center of a variable camshaft, and the axle center of an eccentric plate;

FIG. 5 shows an exploded perspective view of an eccentric boss;

FIG. 6 shows a view indicative of an example of the positional relationship between a drive pin and a driven pin in the variable valve drive device according to an embodiment of the present invention when the center of an eccentric plate is made eccentric with respect to a variable camshaft;

FIG. 7 shows a view indicative of an example of the

valve lift by the variable valve drive device according to an embodiment of the present invention;
 FIG. 8 shows a view indicative of the flow of lubricant in the variable valve drive device according to an embodiment of the present invention;
 FIG. 9 shows a schematic side view indicative of the substantial configuration of a motorcycle provided with the variable valve drive device for an engine according to an embodiment of the present invention; and
 FIG. 10 shows a schematic plan view indicative of the substantial part of a drive unit shown in FIG. 9.

Best Mode for Carrying Out the Invention

[0019] The present invention will further be described below concerning the best modes with reference to the accompanying drawings.

[0020] FIG. 1 shows an exploded perspective view of the substantial part of an engine provided with the variable valve drive device according to an embodiment of the present invention.

[0021] FIG. 1 shows an engine 100 that includes an engine main body 110 having a cylinder part 106 having slidably housed therein a piston 102 and a cylinder head 104, a crankshaft 130 housed in a crank case 112 (refer to FIG. 10), and a variable valve drive device 200.

[0022] In the engine 100, a periodical rotational phase difference is set up between an exhaust cam block 220 and an intake cam block 240 by the variable valve drive device 200 that is arranged substantially in parallel with the crankshaft 130 so as to make the opening and closing valve timing variable according to the respective rotations. Accordingly, the valve overlap is made variable according to the number of rotations of the engine 100.

[0023] In this embodiment, the engine 100 is of the single cylinder SOHC (Single Over Head Camshaft) type to be mounted to a scooter-type motorcycle 500 (refer to FIG. 9). In this embodiment, the engine 100 is of the single cylinder SOHC type, to which the present invention is not restricted, and an engine of any type may be employed so long as the engine includes the variable valve drive device 200.

[0024] As shown in FIG. 1, the piston 102 is slidably (upward and downward) arranged in the cylinder part 106 in a direction of the cylinder axis, and has its one end connected to the crankshaft 130 through a connecting rod 108. The connecting rod 108 is rotatably attached to a crank pin, not shown, arranged between crank webs 132 mounted on the crankshaft 130. Accordingly, the piston 102 slides inside the cylinder part 106 when the crankshaft 130 rotates.

[0025] Furthermore, on the crankshaft 130, a timing gear 134 is mounted, neighboring the crank web 132 (more specifically, crank journal). Around the timing gear 134, a cam drive chain 133 as a driving force transmission member is wound. This cam drive chain 133 is wound around, in addition to the timing gear 134, a cam sprocket

211 arranged in the cylinder head 104 of the engine main body 110, and transmits a rotational driving force to the exhaust cam block 220 as well as the intake cam block 240 of the variable valve drive device 200.

[0026] The transmission line (chain line, in this embodiment) of the cam drive chain 133 is substantially perpendicular to the crankshaft 130, and is arranged at a position in close proximity to the cylinder axis of the cylinder part 106 in which the piston 102 slides. The reason is to prevent the bending stress applied to the crank itself from becoming large, the bending stress being structurally enlarged in case the cam drive chain 133 is distant from the crank part for driving the piston 102, when a tensile force is applied to the cam drive chain 133.

[0027] The cam drive chain 133 is arranged in a chain case part 116 that is unitedly formed with the cylinder part 106 of the engine main body 110. The upper part (referred to as case upper part, hereinafter) 116a of the chain case part 116 is arranged on the cylinder head 104, and the case upper part 116a is opened on the cylinder head 104 in a direction parallel with the crankshaft 130. Of thus formed openings, one opening 116b communicates with the space located over the cylinder part 106, while the other opening 116c is provided with an annular cylinder head cover (referred to as head cover, hereinafter) 105. The annular head cover 105 has arranged therein one end of the variable valve drive device 200, and the variable valve drive device 200 has its one end supported by the head cover 105.

[0028] The variable valve drive device 200 includes the cam sprocket 211, the exhaust cam block 220, a variable camshaft 230, the intake cam block 240, an eccentric plate 250, an eccentric boss 260, and an eccentricity-causing motor 270, and is attached to the cylinder head 104 in a direction substantially parallel with the crankshaft 130.

[0029] FIG. 2 shows a sectional view of the substantial part of the variable valve drive device 200 attached to the cylinder head 104, while FIG. 3 shows an exploded perspective view of the variable valve drive device 200.

[0030] In this variable valve drive device 200, rotation axes of the cam sprocket 211, exhaust cam block 220, variable camshaft 230, intake cam block 240, eccentric plate 250, and eccentric boss 260 are parallel with respect to one another.

[0031] In the variable valve drive device 200, as shown in FIG. 1 to FIG. 3, the intake cam block 240 and the exhaust cam block 220 are arranged in the cylinder head 104 over the cylinder part 106 with the variable camshaft 230 inserted therein. Furthermore, the variable camshaft 230 is inserted in the cam sprocket 211, and the cam sprocket 211 and the eccentric plate 250 are arranged in the case upper part 116a.

[0032] The eccentric boss 260 is rotatably arranged in the annular head cover 105, while the head cover 105 is fixed to the cylinder head 104. Accordingly, the variable valve drive device 200 is fixed to the cylinder head 104.

[0033] As shown in FIG. 1 to FIG. 3, the cam sprocket

211 is unitedly formed with the exhaust cam block 220 that has the same axle center and rotates to open and close the valve (exhaust valve, in this case) through a tubular part 224. That is, these cam sprocket 211, tubular part 224, and exhaust cam block 220 configure a cam drive section 210 that directly receives a driving force of the crankshaft 130 to rotate.

[0034] The cam sprocket 211 is driven by the crankshaft 130 through the timing gear 134 (refer to FIG. 1) and the cam drive chain 133 (refer to FIG. 1), and rotates under a constant reduction gear ratio with respect to the number of rotations of the crankshaft 130. In this embodiment, the cam sprocket 211 rotates with half the rotational speed of the crankshaft 130.

[0035] The axle center of the cam sprocket 211 and the exhaust cam block 220 is set to the camshaft axle center, and the camshaft axle center is arranged substantially in parallel with the crankshaft 130 (refer to FIG. 1) over the cylinder part 106.

[0036] Furthermore, as shown in FIG. 1 to FIG. 3, the cam sprocket 211 is provided with a drive pin 212 that rotates the eccentric plate 250, in such a state that drive pin 212 is so arranged as to be substantially in parallel with the rotational axis of the cam sprocket 211 and protrude toward the opposite direction with respect to the exhaust cam block 220. The drive pin 212 is fitted with allowance in a slot 252 that is formed by cutting off part of the eccentric plate 250 from the center thereof in the radius direction.

[0037] The axle center of the drive pin 212 is made eccentric with respect to the axle center of the cam sprocket 211. When the cam sprocket 211 rotates, the drive pin 212 is made to rotate around the axle center of the cam sprocket 211 to rotate the eccentric plate 250 whose rotational axis is parallel with the drive pin 212 through the slot 252. The cam sprocket 211 has attached thereto a protrusion piece 114 that protrudes in the radius direction thereof.

[0038] The protrusion piece 114 has its rotation position sensed by a sensor 114a that is attached to the cylinder head 104.

[0039] Since a driving force of the crankshaft 130 is directly transmitted to the cam sprocket 211 through the cam drive chain 133 (refer to FIG. 1), the cam sprocket 211 has its rotation position determined in conjunction with the stroke of the crank. That is, the rotation position includes information of strokes of the crank (intake stroke, compression stroke, expansion stroke, and exhaust stroke, in case of the four-cycle). Accordingly, the stroke of the crank can be determined when the sensor 114a detects the position of the protrusion piece 114 attached to the cam sprocket 211.

[0040] The same axle center of the cam sprocket 211, exhaust cam block 220, and tubular part 224, or the axle center of the cam drive section 210, is provided with an insertion opening 215 that passes through in the axis direction. The insertion opening 215 communicates with an opening 223 (refer to FIG. 2) that is formed on the

base circle surface of the exhaust cam block 220.

[0041] In the insertion opening 215, a shaft part 230a of the variable camshaft 230 is rotatably inserted in the axis direction.

[0042] The shaft part 230a of the variable camshaft 230 protrudes from both sides of the cam drive section 210 in the axis direction, and the intake cam block 240 neighboring the exhaust cam block 220 is unitedly attached to part thereof protruding at the exhaust cam block 220 side.

[0043] Furthermore, the shaft part 230a of the variable camshaft 230 is provided with a driven pin 232 at part thereof protruding at the cam sprocket 211 side of the cam drive section 210.

[0044] The variable camshaft 230 is inserted in the cam drive section 210 and is so arranged as to get across over the cylinder part 106. There are arranged a bearing 104a and a bearing 113 which rotatably support the variable camshaft 230.

[0045] Furthermore, the variable camshaft 230 is provided with a penetration opening 238 that passes through the inside of the shaft part 230a in the axis direction, and the penetration opening 238 works as the main path for lubricant to be supplied to the sliding parts of the members of the variable valve drive device 200. Hereinafter, the penetration opening 238 is explained as a main lubricant path 238.

[0046] The main lubricant path 238 communicates with the outer circumference surface of the shaft part 230a through branched lubricant paths 239a, 239b, 239c, and has its one end opened through an iris 235 that is arranged in the shaft part 230a at the chain line side.

[0047] The branched lubricant paths 239a, 239b, 239c are so formed as to be perpendicular to the main lubricant path 238 at the shaft part 230a, and are opened at the outer circumference surface of the shaft part 230a, respectively.

[0048] At the outer circumference surface of the shaft part 230a, where the branched lubricant paths 239a, 239b are opened, there are formed lubricant-pooling grooves 236, 237 in the form of recesses in the circumference direction thereof, and the branched lubricant paths 239a, 239b communicate with the lubricant-pooling grooves 236, 237.

[0049] The lubricant-pooling grooves 236, 237 are formed at the insertion opening 215 configured by the inner surface of the tubular part 224 and exhaust cam block 220, where the outer circumference surface of the variable camshaft 230 is in contact therewith, and are filled with lubricant conducted by the branched lubricant paths 239a, 239b.

[0050] The branched lubricant path 239c is so formed as to be perpendicular to the shaft part 230a from the main lubricant path 238, and is opened to communicate with an opening 245 of the intake cam block 240.

[0051] Accordingly, lubricant conducted by the branched lubricant path 239c is supplied to the part where the shaft part 230a is in contact with the intake cam block

240, lubricating the sliding part. Furthermore, at the intake cam block 240, where the outer circumference surface of the shaft part 230a is in contact therewith, there is formed a lubricant-pooling groove 246 along the inner circumference surface of the intake cam block 240 formed at the opening thereof.

[0052] One end of the variable camshaft 230 is inserted into the bearing 113 attached to the cylinder head 104. Part of the variable camshaft 230 protruding from the bearing 113 is covered by an oil seal cap 115, and an oil seal part 117 prevents lubricant from leaking to the outside of the cylinder head 104.

[0053] One end 111 of the cylinder head 104 is provided with a discharge outlet 118 of an oil pump. Lubricant is pressed into an oil-pooling space 119 that communicates with an opening 230c formed at one end of the shaft part 230a through the discharge outlet 118, and lubricant is conducted to the main lubricant path 238 through the oil-pooling space 119.

[0054] The intake cam block 240 is fitted to the outside of one end of the shaft part 230a, and a pin 241 is fitted into a cutout 243 (refer to FIG. 3) formed on the inner circumference surface of the intake cam block 240, fixing the intake cam block 240. The intake cam block 240 is arranged over the cylinder part 106 together with the exhaust cam block 220.

[0055] When the variable camshaft 230 rotates with its axle center being the rotation center, the intake cam block 240 is made to rotate with the same axle center being the rotation center. Furthermore, as shown in FIG. 2, the intake cam block 240 has formed thereon the opening 245 penetrating from the base circle surface thereof to the opening inner surface thereof formed at one end of the outer circumference surface of the shaft part 230a. The opening 245 communicates with the main lubricant path 238 inside the shaft part 230a.

[0056] Under this configuration, when lubricant is discharged from the discharge outlet 118, in the cylinder head 104, thus discharged lubricant is supplied to the respective sliding parts and respective profile parts of the intake cam block 240 and the exhaust cam block 220 through the branched lubricant paths 239a, 239b, 239c.

[0057] That is, the main lubricant path 238 is formed in the shaft part 230a of the variable camshaft 230, penetrating therethrough in the axis direction, and the variable camshaft 230 has its another end made to neighbor the eccentric plate 250 and has its one end provided with the intake cam block 240. Accordingly, the main lubricant path 238 penetrates the intake cam block 240, exhaust cam block 220, and further penetrates the cam sprocket 211 neighboring the exhaust cam block 220, getting to the eccentric plate 250.

[0058] That is, in the variable camshaft 230, to the outside of which the intake cam block 240, exhaust cam block 220, cam sprocket 211 are fitted from one end thereof, the main lubricant path 238 penetrates the cam sprocket 211 from one end thereof and has its another end opened through the iris 235.

[0059] The iris 235 optimally distributes lubricant to be supplied to the valve drive part (exhaust cam block 220, intake cam block 240) side and to the variable mechanism part (eccentric plate 250, drive pin 212, driven pin 232, slots 252, 254, etc.) side.

[0060] In this way, the main lubricant path 238 gets across in the cylinder head 104 over the cylinder part 106. Thus, lubricant supplied from one end of the shaft part 230a passes over the cam sprocket 211 that is directly driven by the crankshaft 130, and flows to the eccentric plate 250 located at the other end of the shaft part 230a through the iris 235.

[0061] The shaft part 230a has its another end provided with a plate 234, which extends in a direction substantially perpendicular to the axle center of the shaft part 230a. The plate 234 is made to rotate at a position neighboring the cam sprocket 211 when the shaft part 230a rotates.

[0062] The plate 234 is provided with the driven pin 232 (refer to FIG. 1 to FIG. 3), which protrudes in a direction opposite to the direction along which the shaft part 230a extends.

[0063] The driven pin 232 is arranged in parallel with the axle center of the shaft part 230a, and is located at a position eccentric with respect to the axle center of the shaft part 230a on the opposite side of the drive pin 212 when viewed from the shaft part 230a.

[0064] The driven pin 232 is fitted with allowance in a slot 254 that is formed by cutting off part of the eccentric plate 250 from the center thereof in the radius direction, and is made to rotate around the axle center of the shaft part 230a when the eccentric plate 250 rotates. That is, when the drive pin 212, which is made to rotate when the cam sprocket 211 rotates, rotates the eccentric plate 250, the intake cam block 240 is made to rotate when the variable camshaft 230, which is driven by the eccentric plate 250 through the driven pin 232, rotates.

[0065] The eccentric plate 250 includes a plate main body 256 in the form of a plate that is so arranged as to neighbor the plate 234 of the variable camshaft 230, and a plate shaft part 258 arranged at the center of the plate main body 256. The plate main body 256 has formed thereon the slot 252 and the slot 254 in alignment, sandwiching the plate shaft part 258, in which the drive pin 212 and the driven pin 232 are fitted with allowance respectively.

[0066] The plate shaft part 258 is so formed as to be perpendicular to the plate main body 256 and protrude to the side opposite to the plate 234, and is rotatably inserted in an eccentric opening 262 formed through the eccentric boss 260.

[0067] The eccentric opening 262 is formed through an eccentric boss main body 264 that is rotatably arranged in the inside of the head cover 105 attached to the cylinder head 104, and is located at a position eccentric with respect to the rotation center R (refer to FIG. 3). The eccentric boss main body 264 has a rack 266 formed on part of the outer circumference thereof, which is en-

gaged with a worm gear 272 of the eccentricity-causing motor 270 attached to the head cover 105. Accordingly, when the eccentricity-causing motor 270 is driven, the eccentric opening 262 can shift, keeping its position eccentric with respect to the rotation center R of the eccentric boss main body 264.

[0068] FIG. 4 shows a view indicative of the positional relationship among the rotation center R of the eccentric boss 260, the axle center C of the variable camshaft 230, and the axle center E of the eccentric plate 250.

[0069] As shown in FIG. 4, the eccentric boss 260 is rotatably fitted into the head cover 105, and is made to rotate by the eccentricity-causing motor 270 (refer to FIG. 1 to FIG. 3) with the rotation center (boss center) R being the center. The rotation center R is fixed to the engine side, and is the rotation center of the axle center (eccentricity center) E with respect to the axle center C of the variable camshaft 230, exhaust cam block 220, and intake cam block 240.

[0070] Since the axle center E of the plate shaft part 258 or the eccentric plate 250 is rotatably inserted to the eccentric opening 262 of the eccentric boss 260, when the eccentric boss 260 rotates, the axle center (eccentricity center) E of the eccentric plate 250 is made to shift with the rotation center (boss center) R being the center, depicting a circular arc. Furthermore, on a line along which the axle center (eccentricity center) E shifts, the axle center C of the variable camshaft 230 or the axle center C of the exhaust cam block 220 and intake cam block 240 is located.

[0071] When the eccentric boss 260 rotates with the boss center R being the rotation center, the axle center E of the eccentric plate 250 is made eccentric with respect to the axle center C of the variable camshaft 230, which can bring about a phase difference in the rotation of the intake cam block 240 united with the variable camshaft 230 with respect to the rotation of the exhaust cam block 220 united with the cam sprocket 211.

[0072] Furthermore, the rotation of the eccentric boss 260 can make the axle center E accord with the axle center C. At the position where the axle center E accords with the axle center C, that is, at the position where the position of the axle center E of the eccentric opening 262 formed through the eccentric boss 260 and the position of the axle center C of the variable camshaft 230 are overlapped, the eccentric boss 260 can be fixed. Accordingly, the eccentric plate 250 and the variable camshaft 230 can be made to rotate with the same axle center being the rotation center.

[0073] The rotation angle of the eccentric boss 260 in the head cover 105 is detected by angle sensors 26, 27 which are attached to the eccentric boss 260, as shown in FIG. 2. Using thus detected information, information obtained from the engine side such as the engine rotation and engine load, and information input by the user through an operation unit, not shown, the eccentric position of the eccentric opening 262 is controlled to be set to a predetermined position by a control unit, not shown.

[0074] Next, the configuration of the eccentric boss 260 will be explained.

[0075] FIG. 5 shows an exploded perspective view of the eccentric boss 260.

5 **[0076]** As shown in FIG. 5, the eccentric boss main body 264 of the eccentric boss 260 is in the form of a cylinder having the bottom, and is formed by attaching a lid 264b to a main case 264a having formed therethrough the eccentric opening 262.

10 **[0077]** The main case 264a has formed therein separated spaces 267a, 267b, 267c around the eccentric opening 262, the spaces being partitioned by partition walls 265a, 265b, 265c.

15 **[0078]** At the bottom of the separated space 267a, there are formed air holes 268 which make the separated space 267 communicate with the rear side of the eccentric boss 260 or the eccentric plate 250 side. Furthermore, at the peripheral wall of the separated space 267a, there is formed an oil return hole 268a that makes the separated space 267a communicate with the outside of the eccentric boss main body 264.

20 **[0079]** Each of the partition walls 265a, 265b is provided with a cutout 269 that makes the separated space 267a communicate with the separated space 267b, and makes the separated space 267b communicate with the separated space 267c.

25 **[0080]** The lid 264b covers the separated spaces 267a, 267b, 267c. The lid 264b has formed therethrough an opening 264c at a position corresponding to the ceiling of the separated space 267c.

30 **[0081]** In this way, the eccentric boss 260 is of communicating configuration in the axis direction or from the front side to the rear side through the air holes 268, separated spaces 267a, 267b, 267c, cutouts 269, and opening 264c. That is, even if the eccentric boss 260 is attached to the cylinder head 104 through the head cover 105, the eccentric boss 260 can make the front side thereof communicate with the rear side thereof in the cylinder head 104.

35 **[0082]** Furthermore, the head cover 105 has formed therethrough oil return holes 105a substantially in parallel with the rotation axle center of the eccentric boss 260. Thus, when lubricant from the eccentric plate 250 side flows into the inside of the eccentric boss 260, the lubricant is made to return to flow into the engine 100 through the oil return holes 105a together with the oil return hole 268a making the separated space 267a communicate with the outside thereof. That is, the separated spaces 267a, 267b, 267c work as breather spaces which prevent discharging lubricant in blow-by gas raised in the engine 100 to the outside of the engine 100.

[0083] Next, the performance of the variable valve drive device 200 in this embodiment will be explained.

40 **[0084]** In the variable valve drive device 200 shown in FIG. 1 to FIG. 3, when the crankshaft 130 rotates, the cam sprocket 211 is made to rotate through the cam drive chain 133 with half the rotational speed of the crankshaft 130. At this time, the exhaust cam block 220 that is unit-

edly attached to the cam sprocket 211 through the tubular part 224 is made to rotate. That is, the exhaust cam block 220 rotates in synchronization with the rotation of the crankshaft 130.

[0085] Furthermore, when the cam sprocket 211 rotates, the drive pin 212 that is fitted with allowance in the slot 252 of the eccentric plate 250 presses the eccentric plate 250 through the slot 252 with the plate shaft part 258 being the supporting point so as to rotate the eccentric plate 250. Since the rotation center of the eccentric plate 250, that is, the position of the plate shaft part 258 is made eccentric due to the drive of the eccentricity-causing motor 270, even if the cam sprocket 211 rotates with a constant rotational speed, the eccentric plate 250 is made to rotate with a non-constant rotational speed.

[0086] FIG. 6 shows a view indicative of an example of the positional relationship between the drive pin 212 and the driven pin 232 in the present variable valve drive device 200 when the center of the eccentric plate 250 is made eccentric with respect to the variable camshaft 230. FIG. 6 (a) to FIG. 6 (i) show the relative positional relationship between the drive pin 212 and the driven pin 232 in stages when the crankshaft 130 is made to rotate with a predetermined rotational speed. Since the slots 252 and 254 (refer to FIG. 1 to FIG. 3) in which the drive pin 212 and driven pin 232 are fitted with allowance are formed in alignment, thus formed line is simply represented by a straight line SL.

[0087] In case the drive pin 212 is located at the center (rotation axle center) E side of the eccentric plate 250 with respect to the axle center C of the cam sprocket 211, the distance between the center of the eccentric plate 250 and the center of the drive pin 212 becomes shorter than the distance between the center of the cam sprocket 211 and the center of the drive pin 212. Accordingly, the rotation angle of the eccentric plate 250 becomes larger than the rotation angle of the cam sprocket 211.

[0088] On the other hand, conversely, in case the drive pin 212 is located at the side away from the center E of the eccentric plate 250 with respect to the axle center C of the cam sprocket 211, the distance between the center of the eccentric plate 250 and the center of the drive pin 212 becomes longer than the distance between the center of the cam sprocket 211 and the center of the drive pin 212. Accordingly, the rotation angle of the eccentric plate 250 becomes smaller than the rotation angle of the cam sprocket 211.

[0089] The slot 254 formed on the plate main body 256 of the eccentric plate 250 is made to rotate with a non-constant rotational speed similar to the eccentric plate 250. Since the driven pin 232 that is fitted with allowance in the slot 254 is concentric with the cam sprocket 211 and the intake cam block 240, the rotation with a non-constant rotational speed is transmitted to the driven pin 232 through the slot 254. Then, the shaft part 230a is made to rotate with a non-constant rotational speed through the driven pin 232 to which the rotation with a

non-constant rotational speed is transmitted, which makes the intake cam block 240 rotate with a non-constant rotational speed.

[0090] It is assumed that the intake cam block 240 rotates with an angular speed that is faster than half the rotational speed of the crankshaft 130 around the crank angle at which the intake cam block 240 is opened. At this time, in case the crank rotates by the duration (for example, 268 degrees), since the intake cam is made to rotate more than the duration, the intake valve is opened and closed in a shorter time period. That is, the duration is made narrow. On the other hand, in case the intake cam rotates with a low speed, the duration is made broad.

[0091] In this way, in the variable valve drive device 200, the rotational phase difference of the intake cam block 240 that is made to rotate by the variable camshaft 230 driven through the eccentric plate 250 periodically fluctuates with respect to the exhaust cam block 220 that is unitedly attached to the cam sprocket 211. That is, the duration of the intake cam block 240 periodically varies, that is, the intake cam block 240 rotates with a non-constant rotational speed, which varies the duration as well as opening and closing timing of the intake valve (variable valve) to be opened and closed by the rotation.

[0092] At which timing the intake cam block 240 should be made to rotate with a higher speed and should be made to rotate with a lower speed with respect to the exhaust cam block 220 is determined by the positional relationship among the center of the eccentric plate 250 and the cam nose as well as the respective slots 252, 254 with respect to the center of the cam sprocket 211.

[0093] FIG. 7 shows a view indicative of an example of the valve lift by the variable valve drive device 200 according to an embodiment of the present invention. In FIG. 7, a lift curve K indicates the lift amount by the intake valve, while a lift curve H indicates the lift amount by the exhaust valve. Furthermore, OT, OT1, OT2 indicate the opening timing of the variable valve (intake valve, in this case), while TT, TT1, TT2 indicate the closing timing thereof. Moreover, in FIG. 7, the duration (also referred to as working angle) D1 of the intake cam block 240, valve overlap D2, maximum lift angles D3, D4 are shown.

[0094] As shown in FIG. 7, in the variable valve drive device 200, when the eccentric boss 260 rotates, and the position of the eccentric opening 262 or the rotation center of the eccentric plate 250 is made eccentric with respect to the camshaft, the lift curve K is varied as shown by lift curves K1, K2.

[0095] Specifically, as indicated by the lift curve K1, in case that the duration of the cam (length between the opening timing OT1 and the closing timing TT1) is made large, the rotational speed of the cam is made low during a period when the valve is opened, while the rotational speed of the cam is made high when the valve is closed.

[0096] On the other hand, as indicated by the lift curve K2, in case that the duration of the cam (length between the opening timing OT2 and the closing timing TT2) is made small, the rotational speed of the cam is made high

during a period when the valve is opened, while the rotational speed of the cam is made low when the valve is closed.

[0097] In this way, since the intake cam block 240 can be made to rotate with a periodical rotational phase difference set up with respect to the exhaust cam block 220, and the rotational phase difference can be arbitrarily varied, the length of the valve overlap D2 can be varied depending on the engine stroke.

[0098] Accordingly, controlling the overlap, at the time of the idling, by opening and closing the valve by the intake cam block 240 earlier so as to reduce or remove the overlap, the interfusion of residual gas (combustion gas) can be prevented, making it possible to combust gas with stability. Furthermore, the scavenging for the residual gas due to the effect of the exhaust-pulse and reduction of blowing back can be realized. Moreover, the intake effect for air fuel mixture is improved, which enables taking in sufficient air fuel mixture, making it possible to stabilize the idling as well as improve the starting capability.

[0099] Furthermore, blow-by can be prevented, and hydrocarbon contained in exhaust gas can be reduced, and the engine power at a low rotational speed can be enhanced, enabling the improvement of the fuel consumption.

[0100] Especially, when the engine is in the low rotational speed state, the intake cam block 240 is made to rotate such that the intake valve is fully closed when the piston 102 gets to the bottom dead point.

[0101] On the other hand, when the engine is in the medium rotational speed state (medium load range), the pumping loss can be reduced by largely opening the intake valve earlier to largely gain the overlap, which can improve the combustion efficiency, enabling the improvement of the fuel consumption.

[0102] In the variable valve drive device 200, lubricant is effectively supplied to the sliding parts of the members.

[0103] FIG. 8 shows a view indicative of the flow of lubricant in the variable valve drive device 200 according to an embodiment of the present invention.

[0104] As shown in FIG. 8, at one end of the shaft part 230a that is arranged substantially on the level in the forward and backward direction of the cylinder head 104, lubricant that is pumped up from an oil pan 620 (refer to FIG. 9) by a pump, not shown, is discharged from the discharge outlet 118.

[0105] Lubricant coming from the discharge outlet 118 flows (in a direction of an arrow S1 shown in FIG. 8) into the oil-pooling space 119 in the oil seal cap 115 that is arranged at the one end 111 (end of the cylinder part 106) side of the sealed cylinder head 104. In the oil-pooling space 119, the flowing lubricant is made to flow (in a direction of an arrow S2 shown in FIG. 8) into the main lubricant path 238 in the shaft part 230a from the opening 230c formed at one end of the rotating shaft part 230a.

[0106] Lubricant flowing into the main lubricant path 238 flows to the chain line side of the shaft part 230a.

The lubricant passes through the branched lubricant path 239c, and flows (in a direction of an arrow S3 shown in FIG. 8) to the outside of the intake cam block 240 from the opening 245, reducing the friction raised in the sliding part of the intake cam block 240.

[0107] Furthermore, lubricant in the main lubricant path 238 flows (in a direction of an arrow S4 shown in FIG. 8) into the lubricant-pooling groove 237 from the branched lubricant path 239b to lubricate the sliding part raised with the exhaust cam block 220. Furthermore, lubricant coming from (in a direction of the arrow S4 shown in FIG. 8) the branched lubricant path 239c lubricate the base circle surface of the exhaust cam block 220 from the opening 223.

[0108] Furthermore, lubricant in the main lubricant path 238 flows (in a direction of an arrow S5 shown in FIG. 8) into the lubricant-pooling groove 236 from the branched lubricant path 239a to lubricate the sliding part between the tubular part 224 and the bearing 104a arranged in the cylinder head 104.

[0109] Moreover, lubricant in the main lubricant path 238 flows (in a direction of an arrow S6 shown in FIG. 8) to the chain line side of the shaft part 230a, and flows to the outside from one end of the shaft part 230a, specifically, from the axle center thereof located at the surface of the plate 234 through the iris 235.

[0110] Since the plate 234 is so arranged as to face the eccentric plate 250 in the chain case part 116 of the cylinder head 104, lubricant coming from the main lubricant path 238 lubricates the sliding part raised with other members of the eccentric plate 250. For example, lubricant discharged from (in directions of arrows S7, S8 shown in FIG. 8) the variable camshaft 230 lubricates the sliding parts between the plate main body 256 (slots 252, 254) and the drive pin 212 as well as the driven pin 232. In case that the center of the eccentric plate 250 is eccentric with respect to the center of the camshaft, since contact pressure by a driving force is applied to the eccentric plate 250 and drive pin 212, and periodical sliding is repeated therebetween, friction has to be taken into consideration. That is, it is desired that the drive pin 212 is made of material that is obtained by treating steel product of high hardness with heat, and the eccentric plate 250 is made of high alloy steel, cast iron, or sintered alloy of iron which are excellent in abrasion resistance, and the slots 252, 254 have their surface treated so as to improve the hardness.

[0111] Furthermore, the sliding part between the cam sprocket 211 and the cam drive chain 133 (refer to FIG. 1) is lubricated (in directions of arrows S9, S10 shown in FIG. 8) by lubricant.

[0112] In thus configured variable valve drive device 200, as compared with a camshaft that is not provided with the variable valve drive mechanism, or the variable valve timing mechanism, the positional relationship among the exhaust cam block 220, intake cam block 240, and cam sprocket 211 is not varied on the cam axis line.

[0113] Accordingly, in the engine configuration of a

conventional motorcycle, especially scooter, which is not provided with the variable valve drive mechanism, the variable valve drive device 200 can be mounted by replacing the camshaft with the variable valve drive device 200.

[0114] In this case, in mounting the variable valve drive device 200, the dimension, arrangement position, etc. of the respective members to drive the camshaft such as the crankshaft, and the cylinder part, cylinder head, timing gear, etc. of the engine main body do not have to be changed.

[0115] Thus, in the engine 100, in case of employing a configuration in which the periodical rotational phase difference is not necessary for the intake cam block 240 with respect to the exhaust cam block 220, firstly, the variable valve drive device 200 and the head cover 105 are dismounted from the engine main body 110. Then, a crankshaft which is not provided with the variable mechanism such as the eccentric plate 250, and includes a cam sprocket, an exhaust cam block, an intake cam block, etc. is inserted into the cylinder head, and a head cover that is formed to correspond to the crankshaft is fixed to the cylinder head. In this way, it becomes possible to easily change the motorcycle 500 provided with the variable valve drive device 200 to a motorcycle that is not provided with the variable valve drive device 200.

[0116] Next, a vehicle to which the engine 100 in this embodiment is mounted will be explained.

[0117] In the following explanation, a vehicle to which the engine 100 is mounted is a scooter-type motorcycle. On the other hand, a vehicle to which the engine 100 is mounted is not restricted to this, and any vehicle may be employed so long as the vehicle has mounted thereto the engine 100.

[0118] FIG. 9 shows a schematic side view indicative of the substantial configuration of a motorcycle provided with the variable valve drive device for an engine according to an embodiment of the present invention. In this embodiment, the front, rear, left, right mean the front, rear, left, right which are seen at the time of sitting on the seat of the motorcycle. Furthermore, the motorcycle in this embodiment is of the scooter-type. On the other hand, any vehicle may be employed so long as the vehicle is provided with the valve drive device.

[0119] The motorcycle 500 shown in FIG. 9 is of the tandem-scooter-type, and includes a vehicle main body 503 that pivotably supports a handle 502 at the front side thereof, and a tandem seat 504 that is arranged at the rear side of the vehicle main body 503. The tandem seat 504 is openably attached to a trunk space 505 arranged on the lower side. Under the trunk space 505, there is arranged a drive unit 600.

[0120] The front end of the drive unit 600 is swingably attached to the rear side of a front side main body 503a that extends backward from the lower side of the handle 502 to the lower side of the tandem seat 504 in the upward and downward direction through a pivot shaft, not shown, which is arranged on the level in a direction of the vehicle

width.

[0121] Furthermore, to the rear end of the drive unit 600, rear wheels 508 are attached through an axle 510, and there are suspended rear suspensions 512 between the rear ends of the axle 510 and frame pivots which support the rear end of the trunk space 505. At the upper front side of the front end of the drive unit 600, the front end of the trunk space 505 is located.

[0122] FIG. 10 shows a schematic plan view indicative of the substantial part of the drive unit 600 shown in FIG. 9.

[0123] As shown in FIG. 10, in the drive unit 600, the engine 100 is mounted at the front side of the vehicle, and a driving force generated from the engine 100 is transmitted to the axle 510 that is attached to the rear end of the drive unit 600 through a CTV mechanism 610 to rotate the rear wheels 508.

[0124] The engine 100 has the axis line of the cylinder part 106 made substantially horizontal, and has the crankshaft 130 made substantially parallel with a direction of the vehicle width, and is arranged at substantially the central part in the forward and backward direction of the vehicle under the trunk space 505.

[0125] At the other end side of the crankshaft 130, or at the left side end of the vehicle in this case, there is arranged the CTV mechanism 610 that extends backward in the vehicle. The CTV mechanism 610 is arranged substantially in parallel with the cylinder axis, and includes a pulley 611 attached to the crankshaft 130, a pulley 612 attached to the axle 510, a belt 613 that is wound around the pulleys 611, 612, and a centrifugal clutch 614.

[0126] The centrifugal clutch 614 is attached to the axle 510. Furthermore, the axle 510 has attached thereto a reduction gear 615 that reduces the speed brought about by a driving force of the crankshaft 130 which is transmitted through the pulley 611 and belt 613.

[0127] Due to the problem of the exhaust gas regulation etc., it is considered that the variable valve timing mechanism is mounted to motorcycles, and especially, in case of applying the variable valve timing mechanism to a scooter-type vehicle (referred to as scooter, hereinafter), so as to restrict the vehicle dimension, it is desirable that the engine configuration is simplified.

[0128] In the engine 100 in this embodiment, the eccentric plate 250 that corresponds to the eccentric member is not arranged between the cam drive section 210 that corresponds to the cam drive shaft and the exhaust and intake cam blocks 220, 240 which are arranged over the cylinder part 106 in the conventional engine configuration.

[0129] In the engine 100, sandwiching the cam drive section 210, the eccentric plate 250 and the exhaust and intake cam blocks 220, 240 are arranged on the camshaft line.

[0130] That is, sandwiching the cam sprocket 211 arranged on the chain line of the cam drive chain 133, the eccentric plate 250 and the exhaust and intake cam

blocks 220, 240 are arranged on the camshaft line.

[0131] Structurally, in an engine, since the exhaust and intake cam blocks 220, 240 are arranged along a cylinder axis line CL over the cylinder part 106, being different from the conventional configuration, the cylinder axis line and the cam chain line are arranged at positions neighboring one another.

[0132] Accordingly, as shown in FIG. 10, as compared with a chain line LA in the conventional configuration in which the eccentric member is arranged between the cam sprocket 211 and the exhaust and intake cam blocks 220, 240, a chain line L of the engine 100 is located at a position in close proximity to the cylinder axis line CL.

[0133] Accordingly, the belt 613 line of the CTV mechanism 610 which is arranged substantially in parallel with the chain line L at the outside of the chain line L comes close to the cylinder axis line CL as compared with the conventional configuration.

[0134] Accordingly, the width of the drive unit 600 itself becomes small. Specifically, in the drive unit 600, by an amount by which the chain line L comes close to the cylinder axis line CL, the left side end surface 600a comes close to the right side end surface as compared with the left side end surface 600b in the case in which an engine provided with a variable valve drive device of the conventional configuration is mounted.

[0135] That is, structurally, the scooter-type motorcycle 500 is provided with parts arranged at the outside of the cam drive chain 133 on the crankshaft 130 such as a sheave for the CVT (Continuously Variable Transmission).

[0136] In the engine 100 mounted to the motorcycle 500, members for the variable valve drive are not arranged between the chain line L of the cam drive chain 133 and the cylinder axis line CL on the camshaft line. Accordingly, on the crankshaft 130, it is not necessary to provide a space corresponding to the members, and the cam sprocket 211 and the exhaust and intake cam blocks 220, 240 are not separately arranged as compared with an engine provided with the conventional variable valve timing mechanism.

[0137] That is, the chain line L of the cam drive chain 133 that is arranged in a direction substantially perpendicular to the crankshaft 130 is not separated from the cylinder axis line CL.

[0138] As a result, in the motorcycle 500, the width of the crank case 112 comes to be equal to that in the configuration in which the variable valve timing mechanism is not mounted.

[0139] Accordingly, a sufficient banking angle can be prepared in the motorcycle 500, making it possible to secure the motional characteristics.

[0140] Furthermore, in the variable valve drive device 200, the eccentric mechanism such as the eccentric plate 250 is not arranged between the exhaust and intake cam blocks 220, 240 and the cam sprocket 211.

[0141] Accordingly, in the engine 100, in the configuration other than the variable valve drive device 200, sub-

stantially similar corresponding components of an engine that is not provided with the variable valve drive device 200 can be used. That is, only by dismounting the variable valve drive device 200 from the cylinder head 104 of the engine main body 110, and changing the eccentric plate 250, variable camshaft 230, eccentric boss 260, and head cover 105, an engine that is not provided with the variable valve drive device 200 can be formed.

[0142] Thus, in case of mounting the engine 100 to a motorcycle, it is not necessary to widely change the configuration of a conventional engine, and main engine components such as the cylinder head can be used in common with the conventional engine of the invariable specification.

[0143] Furthermore, in the engine, since an eccentric mechanism such as an eccentric plate is not arranged between the cam sprocket and the camshaft, lowering of the flexural strength of the crank which is raised when the cam sprocket is separated from the cylinder axis is not brought about.

[0144] Moreover, being different from the configuration in which the cam drive shaft itself is shifted in the shaft direction, the overlap can be made variable with simplified configuration.

[0145] In this way, in the present embodiment, the duration of cams can be made variable with simplified configuration without widely changing the engine configuration, making it possible to realize high response and high mileage in the engine.

[0146] In this embodiment, as the engine 100, the single cylinder SOHC (Single Over Head Camshaft) type is employed, to which the present invention is not restricted, and the multi-cylinder SOHC type, DOHC (Double Over Head Camshaft) may be employed.

[0147] In the variable valve drive device 200, so as to make the duration of the intake valve variable, the rotational phase difference of the intake cam block 240 is made to periodically fluctuate with respect to the exhaust cam block 220, to which the present invention is not restricted. That is, the rotational phase difference of the exhaust cam block 220 may be made to periodically fluctuate with respect to the intake cam block 240. In this case, in the variable valve drive device 200, an intake cam block that rotates unitedly with the cam sprocket 211 and drives the intake valve is arranged, and the variable camshaft 230 is provided with an exhaust cam block that drives the exhaust valve. Employing this configuration, by making the duration of the exhaust valve variable, the overlap can be varied, making it possible to achieve the same effect as the aforementioned effect.

[0148] According to the first aspect of the present invention, there is provided a variable valve drive device, which includes a cam drive member that is made to rotate by a driving force transmitted from a crankshaft, an eccentric member that is made to rotate with an axis of the same direction as the rotation axis of the cam drive member being the rotation center when the cam drive member is driven, and has the axis shiftably arranged from the

axile center of the rotation axis to an eccentric position, a camshaft that is arranged on the same axis as the rotation axis, and is made to rotate by the eccentric member with the rotation axis being the rotation center, and the rotational phase difference thereof with respect to the cam drive member periodically fluctuates when the eccentric member is made to rotate at the eccentric position, and a cam block that is made to rotate by the camshaft with the same rotational phase as that of the camshaft so as to drive an exhaust valve or an intake valve, wherein the eccentric member is arranged at one end of the cam drive member in the rotation axis direction thereof, and the cam block is arranged at the other end of the cam drive member in the rotation axis direction thereof.

[0149] According to this configuration, as the eccentric member is made to rotate at the eccentric position from the rotation axile center of the cam drive member when the cam drive member is driven, the camshaft is made to rotate with its rotational phase difference with respect to the cam drive member periodically fluctuating.

[0150] The cam block that is made to rotate with the same rotational phase as that of the camshaft has its rotational phase difference with respect to the cam drive member made to periodically fluctuate. That is, the duration of the cam block becomes variable, which makes the duration of the exhaust valve or intake valve to be driven by the cam block variable. Since the duration of the exhaust valve or intake valve is made variable, the valve overlap becomes variable.

[0151] Accordingly, when employed in an engine of the same cylinder capacity, the overlap can be made short at the time of low-speed rotation (including idling) of the engine, while the overlap can be made short at the time of high-speed rotation.

[0152] Specifically, when the engine is in the low rotational speed state including the idling, the valve is opened or closed earlier so as to reduce or remove the overlap, which can prevent the interfusion of residual gas (combustion gas), making it possible to combust gas with stability.

[0153] Furthermore, the scavenging for the residual gas due to the effect of the exhaust-pulse and reduction of blowing back can be realized. Moreover, it becomes possible to stabilize the idling as well as improve the starting capability. Furthermore, blow-by can be prevented, and hydrocarbon contained in exhaust gas can be reduced, and the engine power at a low rotational speed can be enhanced, enabling the improvement of the fuel consumption.

[0154] On the other hand, when the engine is in the medium rotational speed state, the pumping loss can be reduced by largely gaining the overlap, which can improve the combustion efficiency. In this way, employing the variable valve drive device according to the present invention, the engine capability can be improved without changing the cylinder capacity.

[0155] Furthermore, the eccentric member is not arranged between the cam drive member and the cam

block, and the positional relationship between the exhaust valve or intake valve and the cam drive member is similar to that of the conventional engine.

[0156] Accordingly, the present variable valve drive device can be mounted to a conventional engine without widely changing the engine configuration. That is, main engine components can be used in common in an engine that is provided with the variable valve mechanism and in an engine that is not provided with the variable valve mechanism. Accordingly, in case of mounting the present variable valve drive device to an engine, which is mounted to a motorcycle and is not provided with the variable valve mechanism, it is not necessary to change other engine components such as the cylinder, crankshaft, etc., which can widely reduce the cost.

[0157] Furthermore, in case of mounting an engine provided with the present variable valve drive device to a motorcycle, especially to a scooter, such that the crankshaft is arranged in a direction of the vehicle width, since the eccentric member is not arranged between the cam drive member and the cam block, the width of the crankshaft does not become large accordingly. Specifically, in case of arranging the eccentric member between the cam drive member and the cam block, accordingly, the driving force transmission line from the crankshaft to the cam drive member is separated from the cylinder axis line on which the cam block is arranged.

[0158] Accordingly, even if a transmission means adapted to transmit a driving force from the crankshaft to the axle is arranged at the outside of the driving force transmission line, the transmission means does not protrude to the outside, which does not enlarge the width of the engine itself, preventing the reduction of the banking angle as well as the lowering of the travel capability of the vehicle.

[0159] According to the second aspect of the present invention, in above-described configuration, the variable valve drive device further includes a member-shifting part that shifts the axis of the eccentric member from the axis position to an eccentric position with respect to the rotation axis of the cam drive member.

[0160] According to this configuration, being provided with the member-shifting part that shifts the axis of the eccentric member from the axis position to an eccentric position with respect to the rotation axis of the cam drive member, by making the rotational phase difference between the cam drive member and the cam block periodically fluctuate through the member-shifting part, the duration of the exhaust valve or intake valve can be made variable.

[0161] According to the third aspect of the present invention, in above-described configuration, the variable valve drive device further includes another cam block that is made to rotate by the cam drive member with the same rotational phase as that of the cam drive member, and is arranged at a position neighboring the cam block.

[0162] According to this configuration, being provided with another cam block that is made to rotate with the

same rotational phase as that of the cam drive member, one of the cam block and another cam block can be made to work as an intake cam block for driving an intake valve, while the other thereof can be made to work as an exhaust cam block for driving an exhaust valve. Accordingly, the variable valve drive device can be easily mounted to the SOHC type engine in which the intake valve and exhaust valve are arranged on the same camshaft, which can improve the degree of freedom in employing the variable valve drive device.

[0163] According to the fourth aspect of the present invention, in above-described configuration, the cam block rotates to drive an intake valve, while another cam block rotates to drive an exhaust valve.

[0164] According to this configuration, since the cam block rotates to drive an intake valve, while another cam block rotates to drive an exhaust valve, the duration of the intake valve can be made variable with respect to the duration of the exhaust valve.

[0165] Accordingly, at the time of low-speed rotation, the overlap can be largely gained by elongating the opened period of the intake valve, which can secure the engine capability at the time of high-speed rotation without laying down the output capability at the time of low-speed rotation.

[0166] According to the fifth aspect of the present invention, in above-described configuration, the cam block rotates to drive an exhaust valve, while another cam block rotates to drive an intake valve.

[0167] According to this configuration, since the cam block rotates to drive an exhaust valve, while another cam block rotates to drive an intake valve, the duration of the exhaust valve can be made variable with respect to the duration of the intake valve.

[0168] Accordingly, the opened period of the exhaust valve can be made variable without changing the opened period of the intake valve, which can secure the engine capability at the time of high-speed rotation without laying down the idle stability.

[0169] According to the sixth aspect of the present invention, there is provided a variable valve drive device, which includes a cam drive member that is made to rotate by a driving force transmitted from a crankshaft, an eccentric member that is arranged at one end of the cam drive member in the rotation axis direction thereof, and is made to rotate with an axis of the same direction as the rotation axis of the cam drive member being the rotation center when the cam drive member is driven, and has the axis shiftably arranged from the axle center of the rotation axis to an eccentric position, a camshaft that is arranged on the same axis as the rotation axis, and is made to rotate by the eccentric member with the rotation axis being the rotation center, and the rotational phase difference thereof with respect to the cam drive member periodically fluctuates when the eccentric member is made to rotate at the eccentric position, a first valve-driving cam block that is arranged at the other end of the cam drive member in the rotation axis direction thereof,

and is made to rotate with the same rotational phase as that of the camshaft, and has its duration made invariable, and a second valve-driving cam block that is arranged at a position neighboring the first valve-driving cam block, and has its duration made variable.

[0170] According to this configuration, since other members are not arranged between the two valve-driving cam blocks, the variable valve drive device can be compactly configured.

[0171] According to the seventh aspect of the present invention, there is provided an engine, which includes a variable valve drive device including a cam drive member that is made to rotate by a driving force transmitted from a crankshaft, an eccentric member that is made to rotate with an axis of the same direction as the rotation axis of the cam drive member being the rotation center when the cam drive member is driven, and has the axis shiftably arranged from the axle center of the rotation axis to an eccentric position, a camshaft that is arranged on the same axis as the rotation axis, and is made to rotate by the eccentric member with the rotation axis being the rotation center, and the rotational phase difference thereof with respect to the cam drive member periodically fluctuates when the eccentric member is made to rotate at the eccentric position, and a cam block that is made to rotate by the camshaft with the same rotational phase as that of the camshaft so as to drive an exhaust valve or an intake valve, wherein the eccentric member is arranged at one end of the cam drive member in the rotation axis direction thereof, the cam block is arranged at the other end of the cam drive member in the rotation axis direction thereof, in which the crankshaft is arranged substantially in parallel with the rotation axis of the cam drive member, and the cam drive member rotates in conjunction with the rotation of the crankshaft through a driving force transmission part that is arranged in a direction substantially perpendicular to the crankshaft.

[0172] According to this configuration, the eccentric member for improving the engine capability is not arranged between the cam drive member and the cam block, and the positional relationship between the exhaust valve or intake valve and the cam drive member is similar to that of the conventional engine, in which the cylinder capacity is not changed. Accordingly, the variable valve drive device can be mounted without widely changing the conventional engine configuration. That is, main engine components can be used in common in an engine that is provided with the variable valve mechanism and in an engine that is not provided with the variable valve mechanism. Accordingly, in case of mounting the variable valve drive device to an engine, which is mounted to a motorcycle and is not provided with the variable valve mechanism, for assembling, it is not necessary to change other engine components such as the cylinder, crankshaft, etc., which can widely reduce the cost in assembling.

[0173] Furthermore, in case of mounting the engine to a motorcycle, especially to a scooter, such that the crank-

shaft is arranged in a direction of the vehicle width, since the eccentric member is not arranged between the cam drive member and the cam block, the width of the crankshaft does not become large accordingly. Specifically, in case of arranging the eccentric member between the cam drive member and the cam block, accordingly, the driving force transmission line from the crankshaft to the cam drive member is separated from the cylinder axis line on which the cam block is arranged. Accordingly, even if a transmission means adapted to transmit a driving force from the crankshaft to the axle is arranged at the outside of the driving force transmission line, the transmission means does not protrude to the outside, which does not enlarge the width of the engine itself, preventing the reduction of the banking angle as well as the lowering of the travel capability of the vehicle.

[0174] According to the eighth aspect of the present invention, there is provided an engine, which includes a variable valve drive device including a cam drive member that is made to rotate by a driving force transmitted from a crankshaft, an eccentric member that is arranged at one end of the cam drive member in the rotation axis direction thereof, and is made to rotate with an axis of the same direction as the rotation axis of the cam drive member being the rotation center when the cam drive member is driven, and has the axis shiftably arranged from the axle center of the rotation axis to an eccentric position, a camshaft that is arranged on the same axis as the rotation axis, and is made to rotate by the eccentric member with the rotation axis being the rotation center, and the rotational phase difference thereof with respect to the cam drive member periodically fluctuates when the eccentric member is made to rotate at the eccentric position, a first valve-driving cam block that is arranged at the other end of the cam drive member in the rotation axis direction thereof, and is made to rotate with the same rotational phase as that of the camshaft, and has its duration made invariable, and a second valve-driving cam block that is arranged at a position neighboring the first valve-driving cam block, and has its duration made variable, wherein the crankshaft is arranged substantially in parallel with the rotation axis of the cam drive member, and the cam drive member rotates in conjunction with the rotation of the crankshaft through a driving force transmission part that is arranged in a direction substantially perpendicular to the crankshaft.

[0175] According to this configuration, since other members are not arranged between the two valve-driving cam blocks in the variable valve drive device, the engine can be compactly configured.

[0176] According to the ninth aspect of the present invention, in above-described configuration, the engine is of the single cylinder type.

[0177] According to this configuration, when employing the single cylinder type, due to the simply configured variable valve drive device, the valve can be opened and closed corresponding to the engine at the time of low-speed rotation and high-speed rotation.

[0178] According to the tenth aspect of the present invention, there is provided a motorcycle that has mounted thereto the engine such that the crankshaft is arranged in a direction of the vehicle width.

[0179] According to this configuration, since the engine that is provided with a variable valve drive device in which the eccentric member is not arranged between the cam drive member and the cam block is arranged such that the crankshaft thereof is arranged in a direction of the vehicle width, the width of the crankshaft does not become large accordingly. Specifically, in case of arranging the eccentric member between the cam drive member and the cam block, accordingly, the driving force transmission line from the crankshaft to the cam drive member is separated from the cylinder axis line on which the cam block is arranged. Accordingly, even if a transmission means adapted to transmit a driving force from the crankshaft to the axle is arranged at the outside of the driving force transmission line, the transmission means does not protrude to the outside, which does not enlarge the width of the engine itself, preventing the reduction of the banking angle as well as the lowering of the vehicle travel capability.

Industrial Applicability

[0180] According to the variable valve drive device, engine, and motorcycle according to the present invention, the duration of cams can be made variable with a simplified configuration without considerably changing the configuration of an engine.

Claims

1. A variable valve drive device, comprising:

a cam drive member that is made to rotate by a driving force transmitted from a crankshaft;
 an eccentric member that is made to rotate with an axis of the same direction as the rotation axis of the cam drive member being the rotation center when the cam drive member is driven, and has the axis shiftably arranged from the axle center of the rotation axis to an eccentric position;
 a camshaft that is arranged on the same axis as the rotation axis, and is made to rotate by the eccentric member with the rotation axis being the rotation center, and the rotational phase difference thereof with respect to the cam drive member periodically fluctuates when the eccentric member is made to rotate at the eccentric position;
 a cam block that is made to rotate by the camshaft with the same rotational phase as that of the camshaft so as to drive an exhaust valve or an intake valve; **characterized in that**

the eccentric member is arranged at one end of the cam drive member in the rotation axis direction thereof, and
the cam block is arranged at the other end of the cam drive member in the rotation axis direction thereof.

2. The variable valve drive device according to Claim 1, **characterized by** further comprising:

a member-shifting part that shifts the axis of the eccentric member from the axis position to an eccentric position with respect to the rotation axis of the cam drive member.

3. The variable valve drive device according to Claim 1, **characterized by** further comprising:

another cam block that is made to rotate by the cam drive member with the same rotational phase as that of the cam drive member, and is arranged at a position neighboring the cam block.

4. The variable valve drive device according to Claim 3, wherein the cam block rotates to drive an intake valve, while another cam block rotates to drive an exhaust valve.

5. The variable valve drive device according to Claim 3, **characterized in that** the cam block rotates to drive an exhaust valve, while another cam block rotates to drive an intake valve.

6. A variable valve drive device, **characterized by** comprising:

a cam drive member that is made to rotate by a driving force transmitted from a crankshaft;
an eccentric member that is arranged at one end of the cam drive member in the rotation axis direction thereof, and is made to rotate with an axis of the same direction as the rotation axis of the cam drive member being the rotation center when the cam drive member is driven, and has the axis shiftably arranged from the axle center of the rotation axis to an eccentric position;
a camshaft that is arranged on the same axis as the rotation axis, and is made to rotate by the eccentric member with the rotation axis being the rotation center, and the rotational phase difference thereof with respect to the cam drive member periodically fluctuates when the eccentric member is made to rotate at the eccentric position;
a first valve-driving cam block that is arranged at the other end of the cam drive member in the rotation axis direction thereof, and is made to

rotate with the same rotational phase as that of the camshaft, and has its duration made invariable; and

a second valve-driving cam block that is arranged at a position neighboring the first valve-driving cam block, and has its duration made variable.

7. An engine, comprising:

a variable valve drive device, including:

a cam drive member that is made to rotate by a driving force transmitted from a crankshaft;

an eccentric member that is made to rotate with an axis of the same direction as the rotation axis of the cam drive member being the rotation center when the cam drive member is driven, and has the axis shiftably arranged from the axle center of the rotation axis to an eccentric position;

a camshaft that is arranged on the same axis as the rotation axis, and is made to rotate by the eccentric member with the rotation axis being the rotation center, and the rotational phase difference thereof with respect to the cam drive member periodically fluctuates when the eccentric member is made to rotate at the eccentric position;

a cam block that is made to rotate by the camshaft with the same rotational phase as that of the camshaft so as to drive an exhaust valve or an intake valve; **characterized in that**

the eccentric member is arranged at one end of the cam drive member in the rotation axis direction thereof,

the cam block is arranged at the other end of the cam drive member in the rotation axis direction thereof,

the crankshaft is arranged substantially in parallel with the rotation axis of the cam drive member, and

the cam drive member rotates in conjunction with the rotation of the crankshaft through a driving force transmission part that is arranged in a direction substantially perpendicular to the crankshaft.

8. An engine, comprising:

a variable valve drive device, including:

a cam drive member that is made to rotate by a driving force transmitted from a crankshaft;

an eccentric member that is arranged at one

end of the cam drive member in the rotation
 axis direction thereof, and is made to rotate
 with an axis of the same direction as the
 rotation axis of the cam drive member being
 the rotation center when the cam drive 5
 member is driven, and has the axis shiftably
 arranged from the axile center of the rotation
 axis to an eccentric position;
 a camshaft that is arranged on the same
 axis as the rotation axis, and is made to ro- 10
 tate by the eccentric member with the rota-
 tion axis being the rotation center, and the
 rotational phase difference thereof with re-
 spect to the cam drive member periodically
 fluctuates when the eccentric member is 15
 made to rotate at the eccentric position;
 a first valve-driving cam block that is ar-
 ranged at the other end of the cam drive
 member in the rotation axis direction there- 20
 of, and is made to rotate with the same ro-
 tational phase as that of the camshaft, and
 has its duration made invariable; and
 a second valve-driving cam block that is ar-
 ranged at a position neighboring the first
 valve-driving cam block, and has its dura- 25
 tion made variable; **characterized in that**
 the crankshaft is arranged substantially in
 parallel with the rotation axis of the cam
 drive member, and
 the cam drive member rotates in conjunc- 30
 tion with the rotation of the crankshaft
 through a driving force transmission part
 that is arranged in a direction substantially
 perpendicular to the crankshaft.

9. The engine according to Claim 7 or 8, **characterized**
in that the engine is of the single cylinder type.

10. A motorcycle that has mounted thereto an engine 40
 according to Claim 7 or 8, such that the crankshaft
 is arranged in a direction of the vehicle width.

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FIG. 1

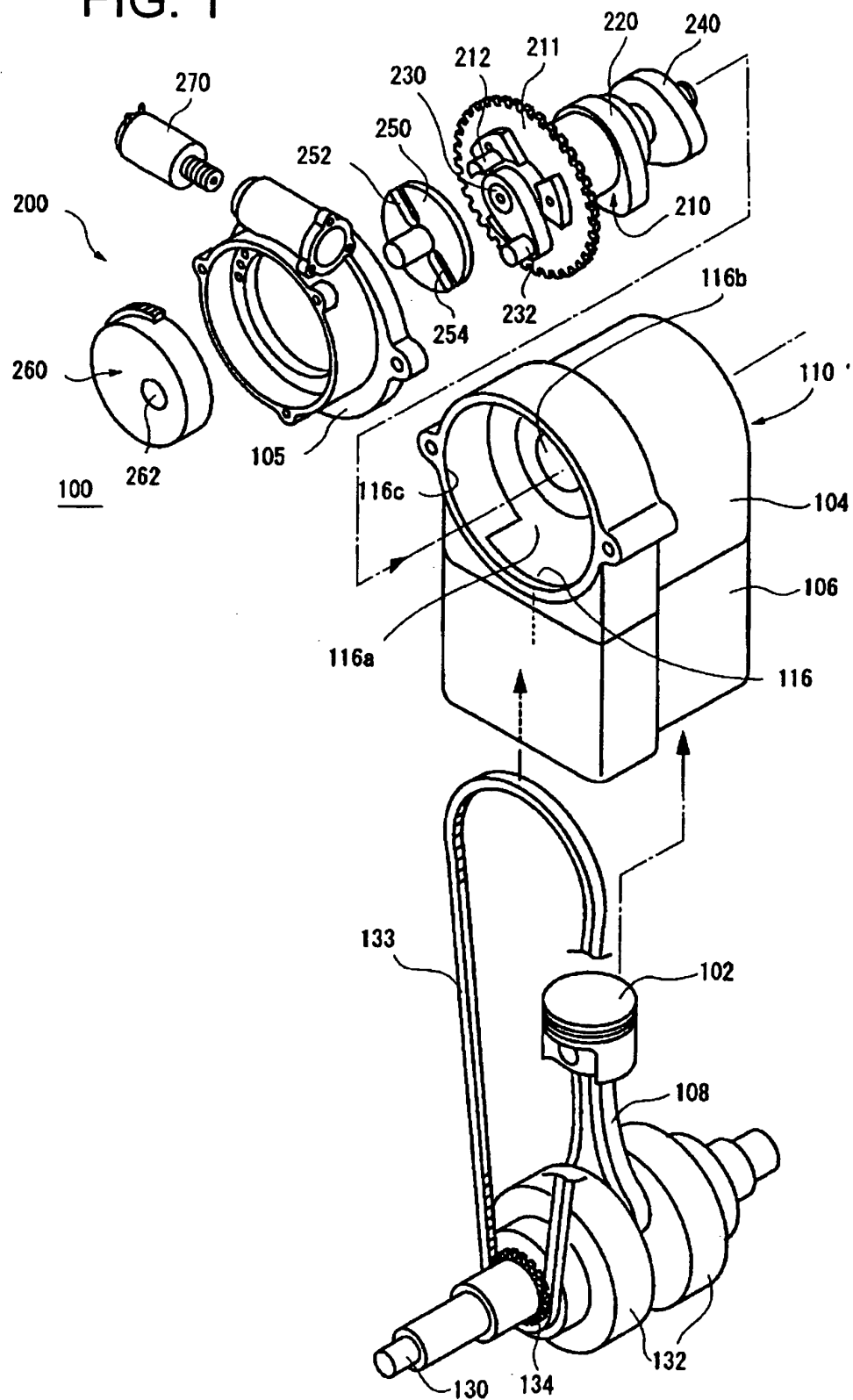


FIG. 2

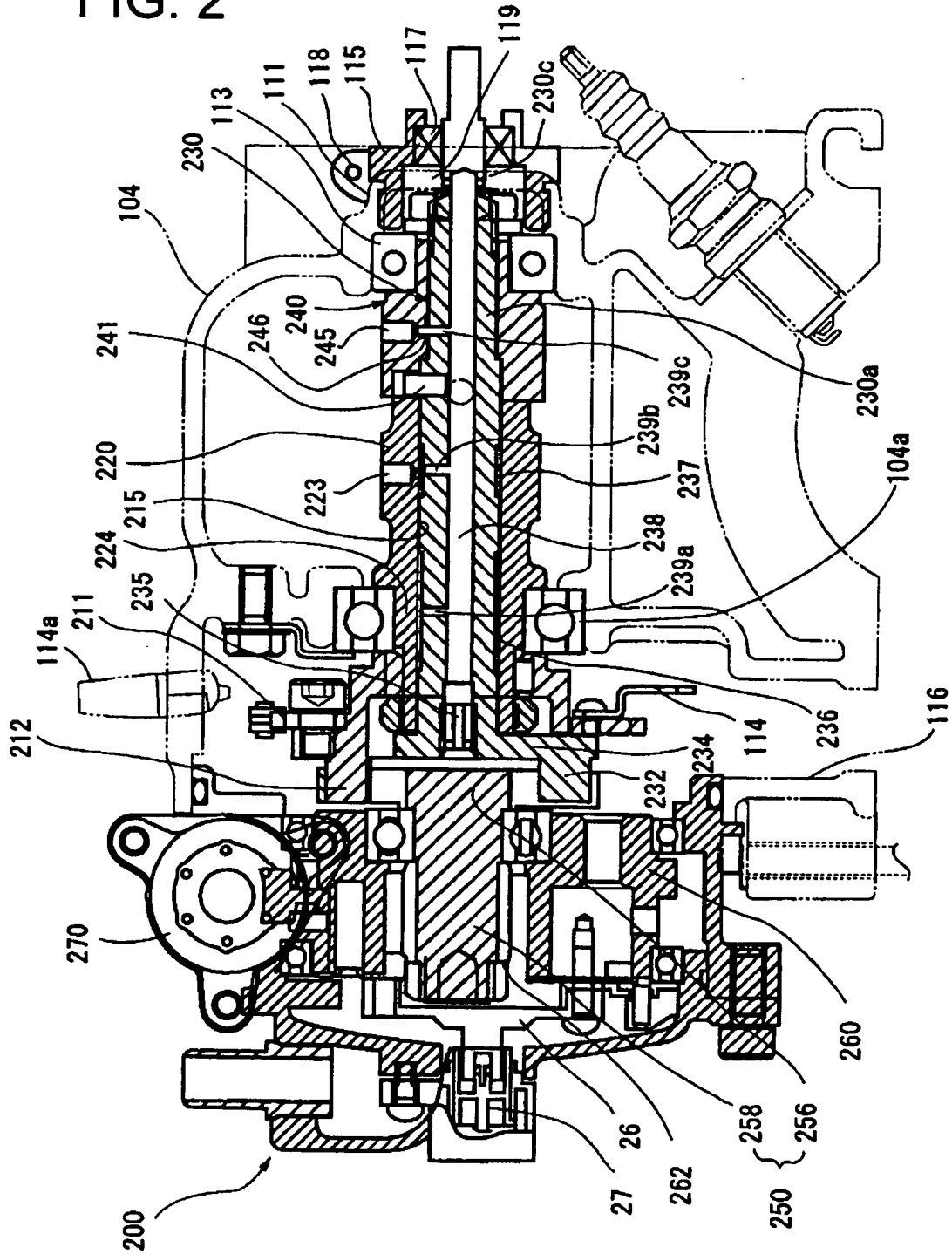


FIG. 3

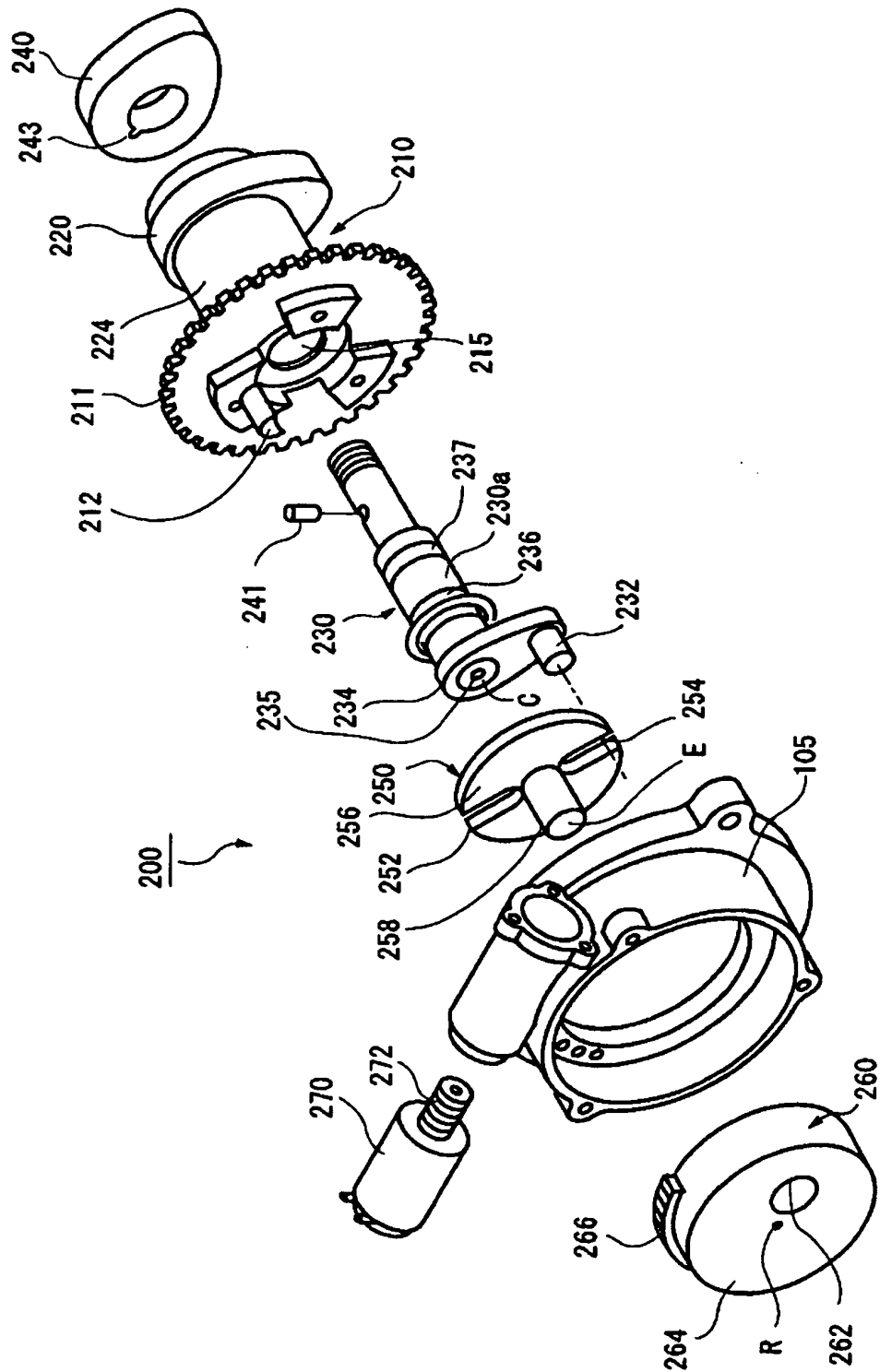


FIG. 4

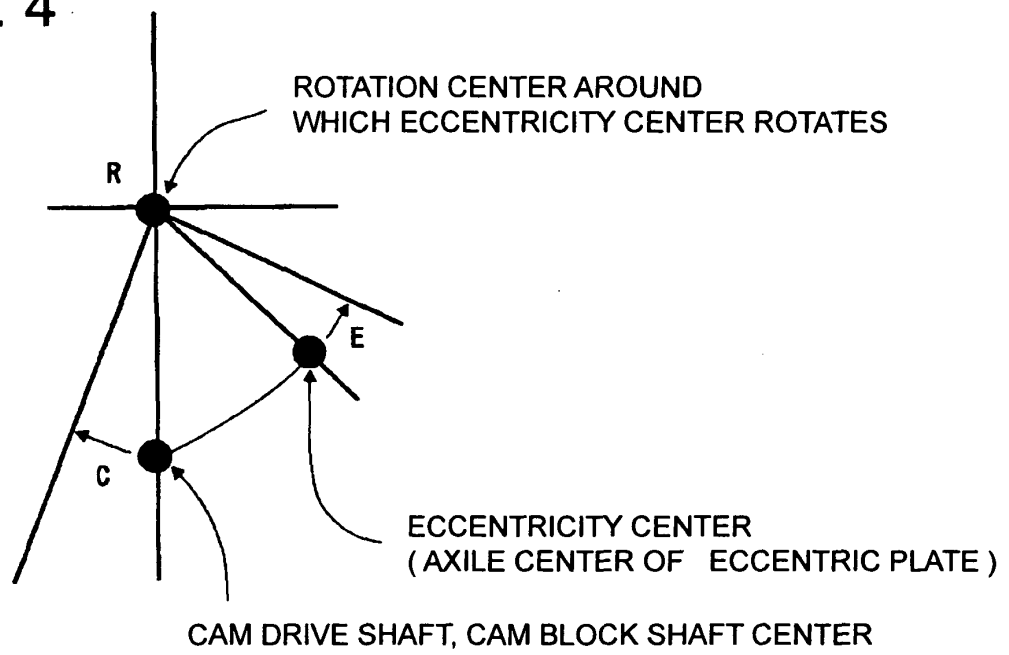


FIG. 5

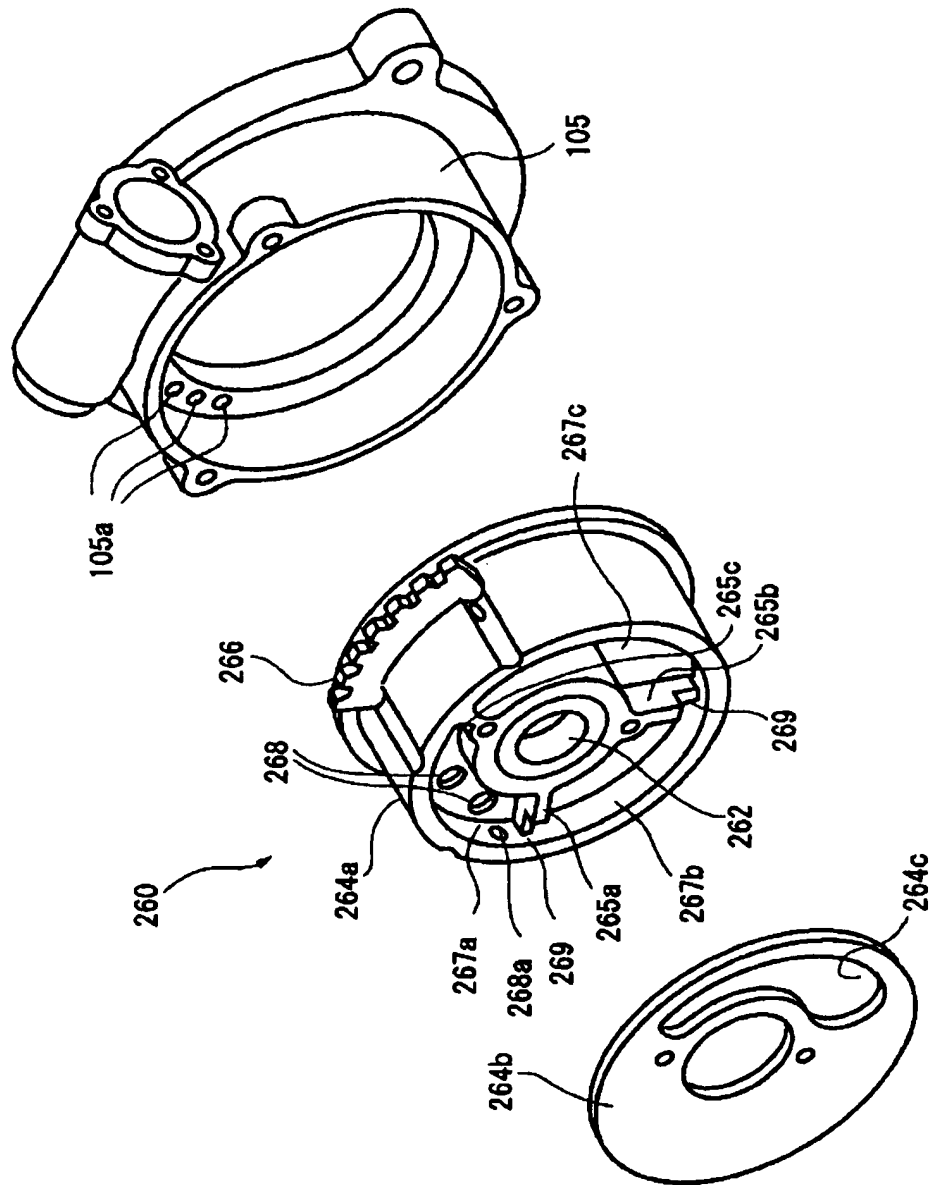


FIG. 6

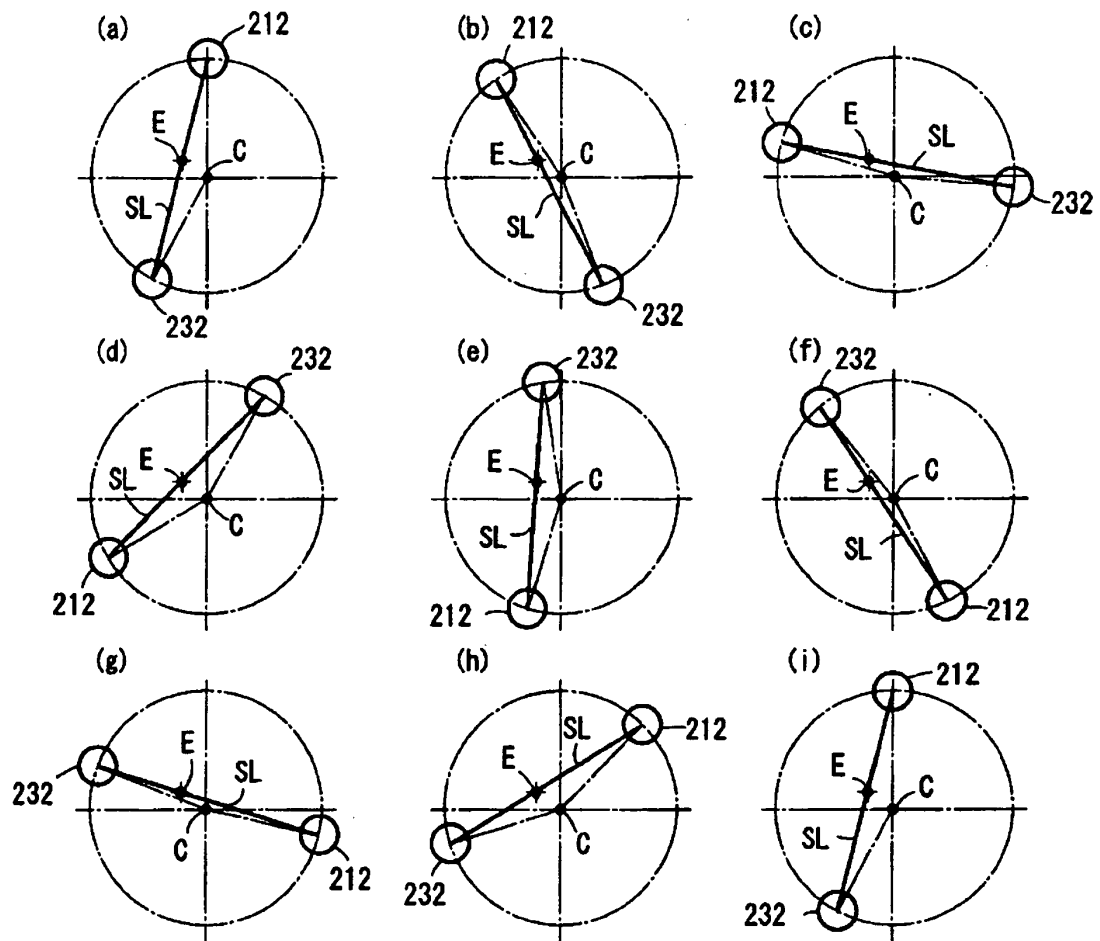


FIG. 7

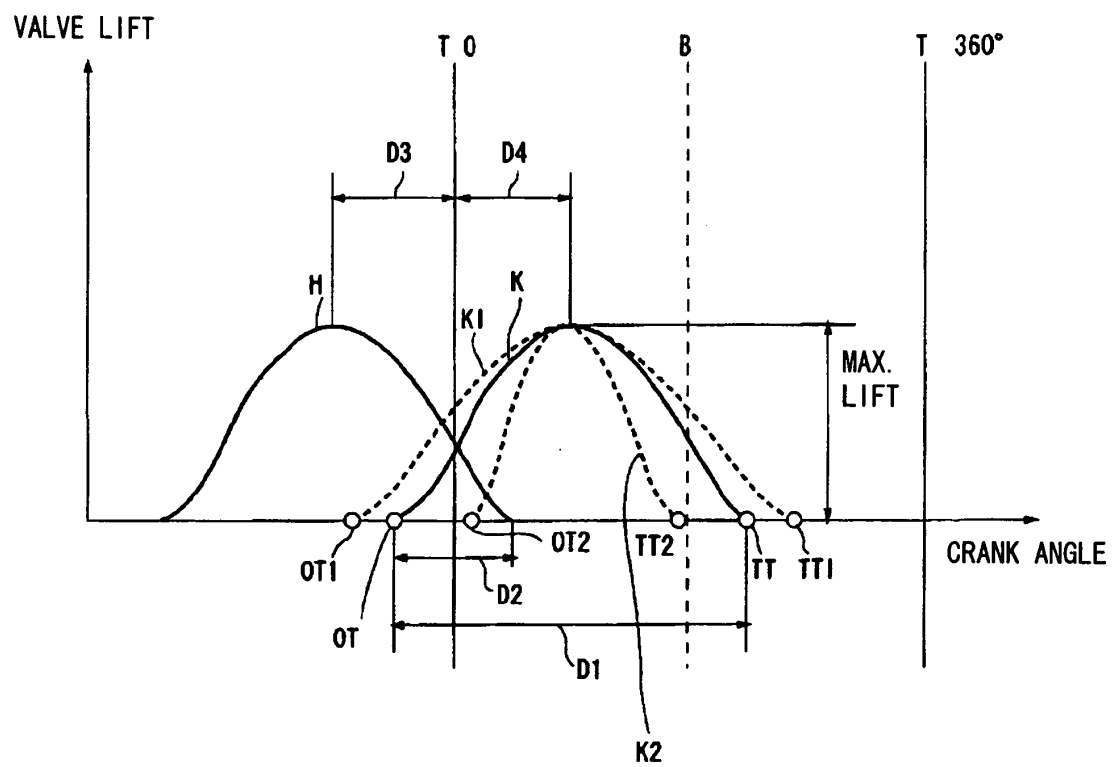


FIG. 8

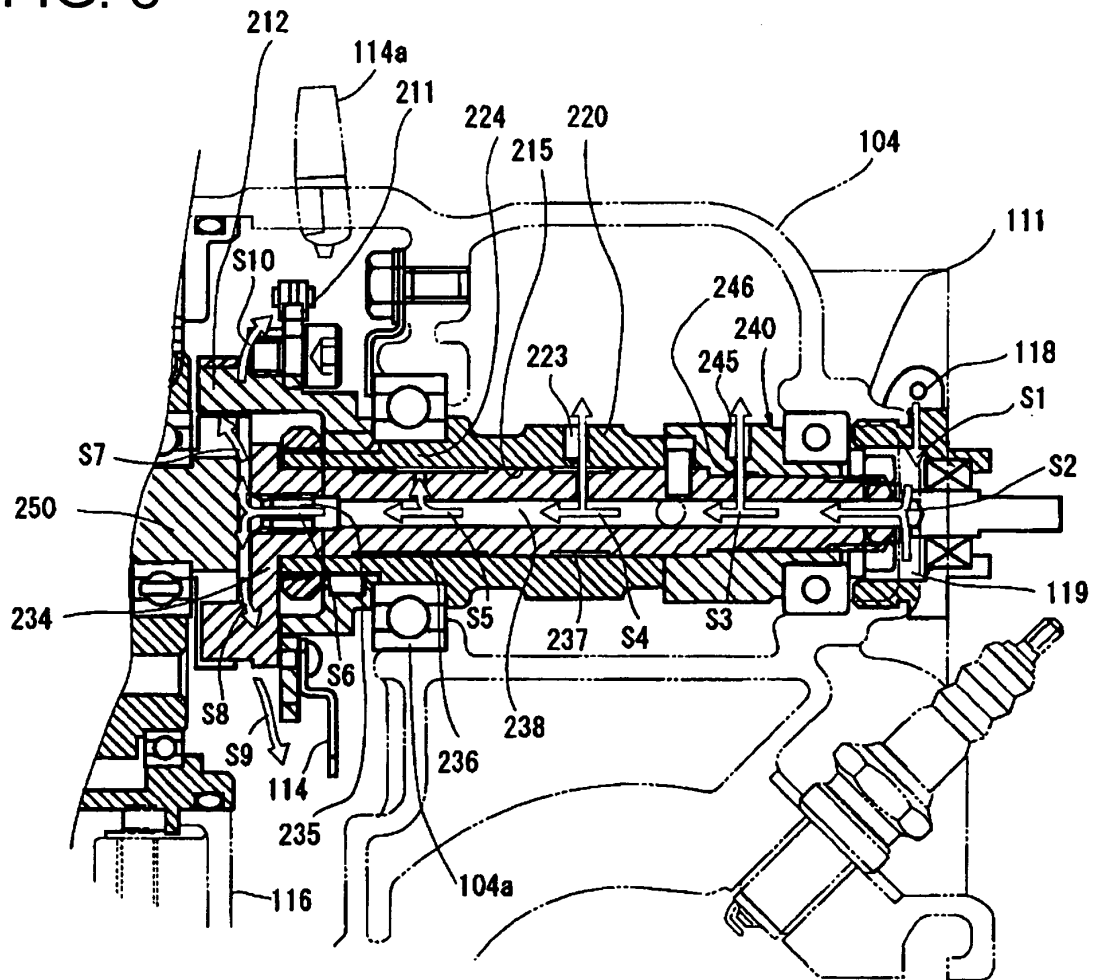


FIG. 9

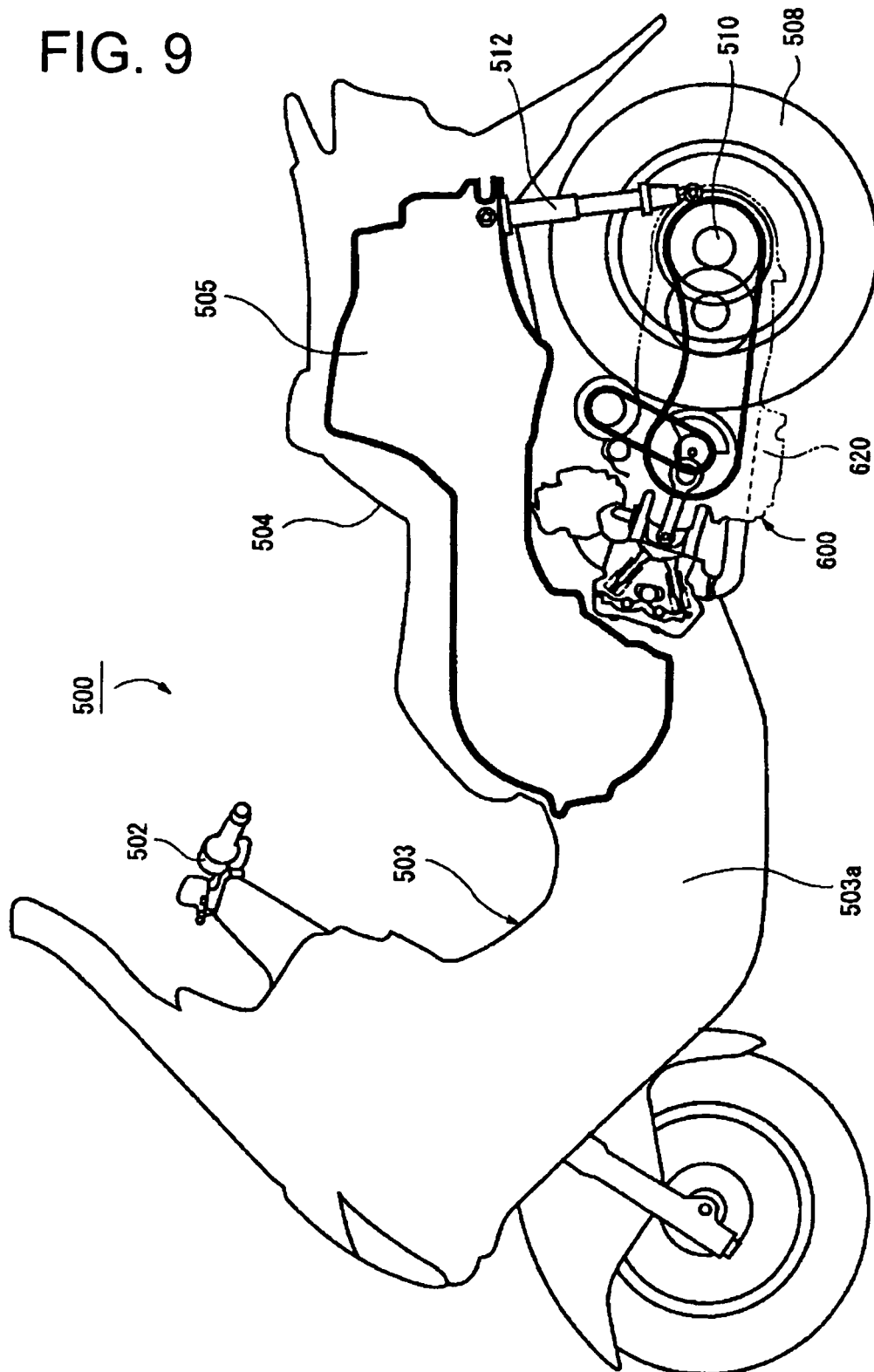
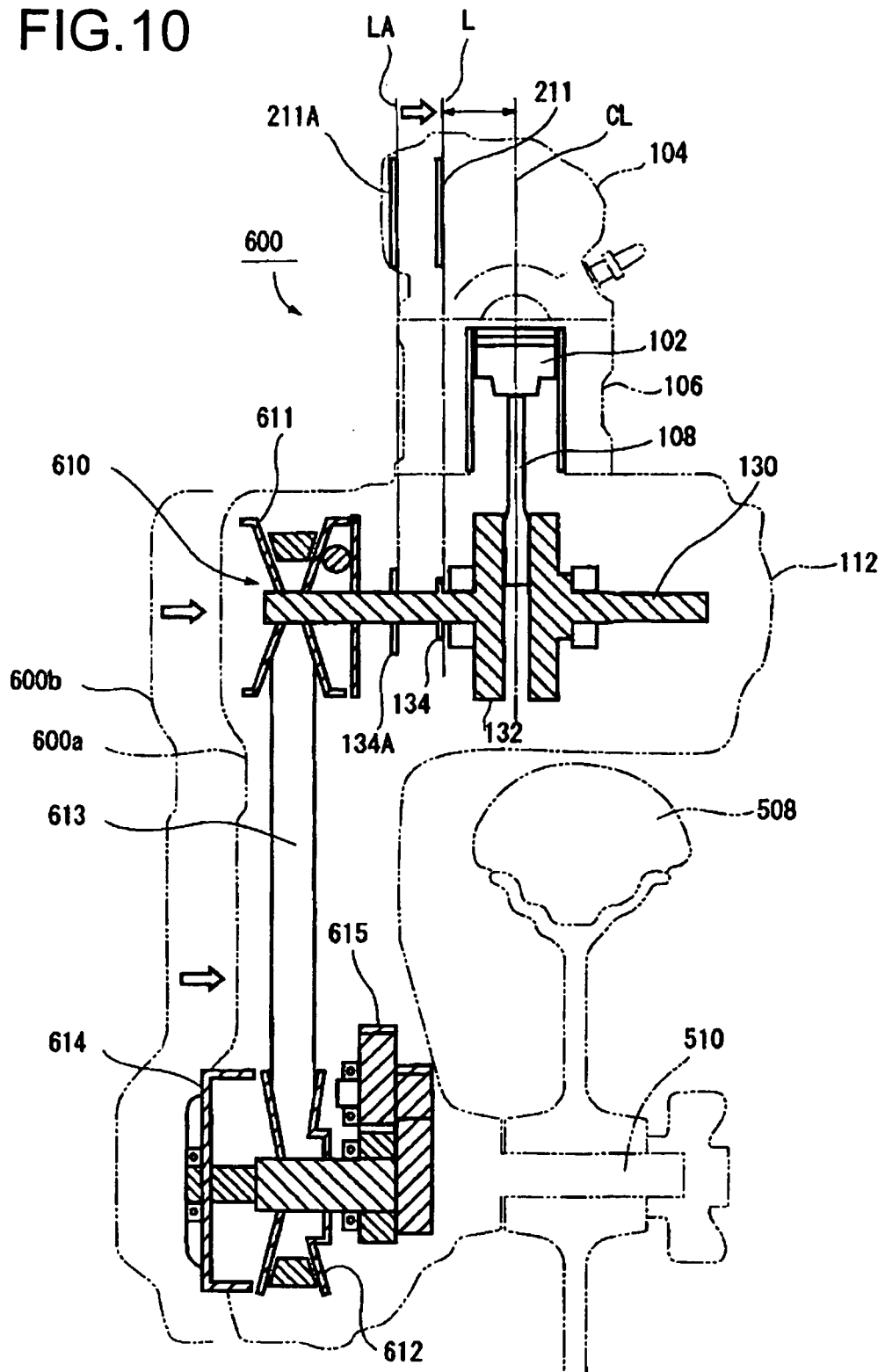


FIG.10



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2005/014086

A. CLASSIFICATION OF SUBJECT MATTER F01L1/34 (2006.01), F01L1/04 (2006.01)		
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) F01L1/34 (2006.01), F01L1/04 (2006.01)		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched Jitsuyo Shinan Koho 1922-1996 Jitsuyo Shinan Toroku Koho 1996-2005 Kokai Jitsuyo Shinan Koho 1971-2005 Toroku Jitsuyo Shinan Koho 1994-2005		
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 11-13437 A (Unisia Jecs Corp.), 19 January, 1999 (19.01.99), Par. Nos. [0018] to [0034]; Figs. 1, 2 (Family: none)	1-10
A	JP 8-338212 A (Mitsubishi Chemical Corp.), 24 December, 1996 (24.12.96), Figs. 1 to 4 (Family: none)	1-10
A	JP 3-43611 A (Honda Motor Co., Ltd.), 25 February, 1991 (25.02.91), Figs. 1, 2 (Family: none)	1-10
☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.		
* Special categories of cited documents: "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier application or patent but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art "&" document member of the same patent family		
Date of the actual completion of the international search 13 October, 2005 (13.10.05)		Date of mailing of the international search report 08 November, 2005 (08.11.05)
Name and mailing address of the ISA/ Japanese Patent Office		Authorized officer
Facsimile No.		Telephone No.

Form PCT/ISA/210 (second sheet) (April 2005)

REFERENCES CITED IN THE DESCRIPTION

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