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

(11) **EP 1 956 197 A1**

(12) **EUROPEAN PATENT APPLICATION**
published in accordance with Art. 158(3) EPC

(43) Date of publication:
13.08.2008 Bulletin 2008/33

(21) Application number: **06832653.7**

(22) Date of filing: **15.11.2006**

(51) Int Cl.:
F01L 1/12 *(2006.01)* ***F01L 13/00*** *(2006.01)*

(86) International application number:
PCT/JP2006/322722

(87) International publication number:
WO 2007/060865 (31.05.2007 Gazette 2007/22)

(84) Designated Contracting States:
AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HU IE IS IT LI LT LU LV MC NL PL PT RO SE SI SK TR
Designated Extension States:
AL BA HR MK RS

(30) Priority: **28.11.2005 JP 2005341591**

(71) Applicant: **Yamaha Hatsudoki Kabushiki Kaisha**
Iwata-shi, Shizuoka 438-8501 (JP)

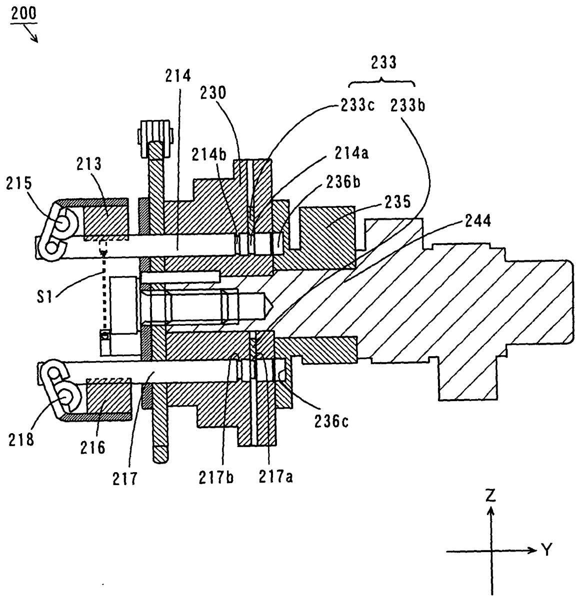
(72) Inventors:
- **YAMAMOTO, Minoru**
  Shizuoka-ken 438-8501 (JP)
- **NAGAI, Yoshitaka**
  Iwata-shi, Shizuoka-ken 438-8501 (JP)

(74) Representative: **Grünecker, Kinkeldey, Stockmair & Schwanhäusser Anwaltssozietät**
Leopoldstrasse 4
80802 München (DE)

(54) ADJUSTABLE VALVE DEVICE, AND ENGINE DEVICE AND VEHICLE USING THE SAME

(57) During a low revolution period, centrifugal force applied to a weight is small and therefore the rotating operation of the weight is restricted. This prevents a lock pin from being fitted to the lock pin fitting hole of a floating cam portion, and the floating cam portion idles around a cam fixing shaft. During a high revolution period, centrifugal force applied to the weight increases, and therefore the weight rotates around the rotation shaft. In this way, the tip end of the lock pin is fitted to the lock pin fitting portion of the floating cam portion. Therefore, during the high revolution period, the floating cam portion is fixed with respect to the rotating direction of the variable valve system by the lock pin.

F I G. 7



EP 1 956 197 A1

Description

[Technical Field]

[0001] The present invention relates to a variable valve system that drives a valve in an engine, and an engine device and a vehicle including the system.

[Background Art]

[0002] Many kinds of variable valve mechanisms that control intake/exhaust have been developed in order to improve fuel consumption, reduce toxic substances in exhaust gas, and achieve high power output in a particular revolution range.

[0003] The amount of intake is preferably adjusted to an optimum amount in a low speed range where the revolution speed of the engine is low and in a high speed range where the revolution speed of the engine is high in order to improve the intake/exhaust efficiency.

[0004] In general, the space occupied by an engine in a motorcycle is smaller than that of a four-wheeled automobile and the like. There has been a demand for motorcycles that can be manufactured less costly. Therefore, there has been a demand for more compact variable valve mechanisms for use in motorcycles.

[0005] Patent Document 1 proposes a valve system for an engine that has a simple and compact structure to switch between a low speed cam and a high speed cam. In the valve system, the low speed cam is fixed to the camshaft, and the high speed cam is provided parallel to the low speed cam and in a relatively displaceable manner to the camshaft. A control shaft is provided in the camshaft so that it can reciprocate in the axial direction. The axial movement of the control shaft causes the high speed cam to protrude in the direction orthogonal to the camshaft, so that the low speed cam and the high speed cam are switched.
[Patent Document 1] JP 09-256827 A

[Disclosure of the Invention]

[Problems to be Solved by the Invention]

[0006] The valve system disclosed by Patent Document 1 switches from the low speed cam to the high speed cam using a hydraulic actuator. More specifically, a control lever is provided to operate in response to the operation of the control shaft, and the control lever energized by a spring is moved by the hydraulic actuator. In this way, the control shaft moves in the axial direction, and the low speed cam is switched to the high speed cam.

[0007] However, large oil pressure is necessary to move the control lever against the energizing force of the spring, the reaction force applied from the valve to the high speed cam, and the reaction force applied from the valve to the control shaft. Therefore, a larger size, more expensive oil pump is necessary as an oil pump to supply oil to the hydraulic actuator. This increases the manufacturing cost and hinders a vehicle from being reduced in size.

[0008] It is an object of the invention to provide a compact and low cost variable valve system that can switch between the cams in an optimum manner in response to the revolution speed of the engine, and an engine device and a vehicle including the same. [Means for Solving the Problems]

(1) A variable valve system according to an aspect of the invention is a variable valve system adapted to drive a valve in an engine and includes a rotation shaft provided to be rotatable in response to the revolution of the engine, a first cam member provided to rotate together with the rotation shaft and operating to open/close the valve, a second cam member provided rotatably with respect to the rotation shaft and operating to open/close the valve, an engaging member provided to be switchable between a first state in which the second cam member is allowed to rotate with respect to the rotation shaft and a second state in which the second cam member is engaged to the rotation shaft, an energizing member that generates energizing force that switches the engaging member to the first state, and a driving member that operates to switch the engaging member to the second state against the energizing force by the energizing member by centrifugal force generated by the rotation of the rotation shaft, the first cam member operates to open/close the valve when the engaging member is in the first state, and the second cam member operates to open/close the valve when the engaging member is in the second state.

In the variable valve system, the rotation shaft rotates in response to the revolution of the engine. The first cam member rotates together with the rotation of the rotation shaft. The second cam member attains a rotatable state with respect to the rotation shaft when the engaging member is in the first state and is engaged to the rotation shaft when the engaging member is in the second state. The engaging member switches between the first state and the second state in response to the revolution speed of the rotation shaft.

When the revolution speed of the rotation shaft is low, the engagingmember is switched to the first state by the energizing force generated by the energizing member. This allows the second cam member to be rotated with respect to the rotation shaft by the engagingmember. Therefore, the second cammember is switched to the state in which it does not rotate together with the rotation of the rotation shaft. In this case, the first cammember operates to open/close the valve.

Meanwhile, when the revolution speed of the rotation shaft is high, the engagingmember is switched to the second state against the energizing force by the energizingmember by centrifugal force applied to the driving member. In this way, the second cam member is engaged to the rotation shaft. Therefore, the second cammember rotates together with the rotation of the rotation shaft. In this case, the second cam member operates to open/close the valve.

In this way, the state in which the first cam member acts upon the valve and the state in which the second cam member acts upon the valve are switched according to the revolution speed of the engine. Therefore, the first cam member and the second cammember may be formed into optimum shapes for the low revolution period and the high revolution period for the engine, so that oil consumption during normal driving (middle and low speed driving) can be improved, toxic substances in exhaust gas can be reduced, and high power output during high speed driving can be achieved.

The first cam member and the second cam member are switched using the centrifugal force generated by the rotation of the rotation shaft, and therefore a driving source by an oil pressure system is not necessary. Therefore, a compact and low cost variable valve system can be provided.

(2) The driving member may be provided pivotably from a first position to a second position by centrifugal force generated by the rotation of the rotation shaft, the engaging member may be provided movably in one direction along the rotation shaft as the driving member pivots from the first position to the second position, the energizing member may apply energizing force to the driving member so that the driving member is moved toward the first position, and the engaging member may attain the first state when the driving member is in the first position and the second state when the driving member is in the second position.

In this case, the energizing force caused by the energizing member acts so that the driving member moves toward the first position. The centrifugal force generated by the rotation of the rotation shaft acts so that the driving member pivots from the first position to the second position.

When the revolution speed of the rotation shaft is low, the energizing force acting on the driving member is larger than the centrifugal force, and therefore the driving member is in the first position. Therefore, the engaging member is in the first state. As a result, the second cam member can rotate with respect to the rotation shaft, so that the first cammember operates to open/close the valve.

When the revolution speed of the rotation shaft is high, the centrifugal force acting on the driving member is larger than the energizing force, so that the driving member pivots from the first position to the second position. This causes the engaging member to move in one direction along the rotation shaft, and the first state is switched to the second state. Therefore, the second cam member rotates together with the rotation shaft, so that the second cam member operates to open/close the valve.

In this way, depending on the magnitude of the centrifugal force applied to the driving member, the engaging member switches to the first state or the second state. In this way, the first cam member and the second cam member can be switched with simple arrangement.

(3) The engaging member may have an engaging portion, the second cam member may have an engagement portion to be engaged by the engaging portion of the engaging member, the engaging portion may be disengaged from the engagement portion when the engaging member is in the first state, and the engaging portion may engage the engagement portion when the engaging member is in the second state.

When the revolution speed of the rotation shaft is low, the engaging portion of the engaging member is disengaged from the engagement portion of the second cam member. This allows the second cam member to rotate with respect to the rotation shaft. When the revolution speed of the rotation shaft is high, the engaging portion of the engaging member engages the engagement portion of the second cam member. In this way, the second cam member is fixed to the rotation shaft. In this way, the first cam member and the second cam member can be switched with simple arrangement.

(4) The engaging member may include a rod-shaped member, the engaging portion may be an end of the rod-shaped member, and the engagement portion of the second cam member may be a hole to which the end of the rod-shaped member can be fitted.

When the revolution speed of the rotation shaft is low, the end of the rod-shaped member is disengaged from the hole of the second cammember. This allows the second cammember to rotate with respect to the rotation shaft. When the revolution speed of the rotation shaft is high, the end of the rod-shaped member is fitted to the hole of the second cam member. This causes the second cam member to be fixed to the rotation shaft. In this way, the first cam member and the second cam member can be switched with simple arrangement.

(5) The engaging member may be a plurality of rod-shaped members, the engagement portion of the second cam member may be a plurality of holes to which ends of the plurality of rod-shaped members can be fitted, and the plurality of rod-shaped members may be provided in asymmetric positions with one another with respect to the center of the rotation shaft.

In this case, the plurality of rod-shapedmembers are fitted to the plurality of corresponding holes, which allows the second cam member to be surely fixed with respect to the rotation shaft. The plurality of rod-shaped members are in asymmetric positions with one another with respect to the center of the rotation shaft, so that the rod-shaped members are surely inserted into the corresponding holes, respectively.

(6) The variable valve system may further include a movement stopping member that prevents the movement of the engaging member when the engaging member is in at least one of the first state and the second state.

In this case, the engaging member is surely fixed in the first state or the second state, so that the engaging member can be prevented from being unstable because of the reaction force applied from the valve. Furthermore, when force that switches the engaging member to the first state by the energizing force generated by the energizing member and force that switches the engaging member to the second state by the centrifugal force applied to the driving member are balanced, the engaging member can be prevented from being unstable between the first state and the second state. Consequently, the first cam member and the second cam member can stably be switched, so that the opening/closing of the valve can be prevented from being unstable.

(7) The engaging member may have at least one groove, and the movement stopping member may have a fitting portion that can be fitted to the groove when the engaging member is in at least one of the first state and the second state.

In this way, the fitting portion of the movement stopping member is fitted to the groove of the engaging member when the engaging member is in at least one of the first state and the second state. Therefore, the engaging member is sufficiently fixed in the first state or the second state, so that the engaging member can surely be prevented from being unstable because of the reaction force applied from the valve. Furthermore, when force that switches the engaging member to the first state by the energizing force generated by the energizing member and force that switches the engaging member to the second state by the centrifugal force applied to the driving member are balanced, the engaging member can sufficiently be prevented from being unstable between the first state and the second state.

(8) The groove of the engaging member and the fitting portion of the movement stopping member may be formed so that the fitting portion can be withdrawn from the at least one groove at least one of when the engaging member switches from the first state to the second state and when the engaging member switches from the second state to the first state.

In this way, when the engaging member is in the first state or the second state, the fitting portion of the movement stopping member is fitted to the groove of the engaging member, and when the engaging member is switched from the first state to the second state or from the second state to the first state, the fitting portion of the movement stopping member withdraws from the groove of the engaging member. In this way, when the engaging member is in the first state or the second state, the engaging member can be prevented from being unstable, and the transition from the first state to the second state or the transition from the second state to the first state can stably be carried out.

(9) The variable valve system may further include a first transmission member that swings in response to the rotation of the first cam member and moves the valve up and down, and a second transmission member that swings the first transmission member in response to the rotation of the second cam member.

In this way, the first cam member rotates together with the rotation of the rotation shaft, so that the first transmission member swings. This causes the valve to move up and down.

When the second cammember is engaged to the rotation shaft, the second cam member rotates together with the rotation of the rotation shaft, so that the second transmission member swings. This causes the first transmission member to swing and the valve to move up and down.

In this way, when the first cam member and the second cam member rotate, the upward and downward movement of the valve is carried out by the swinging of the first transmission member. Therefore, as compared to the case of moving the valve up and down separately by the first transmission member and the second transmission member, the valve can be more compact and an unbalanced load can be prevented from being applied on the valve.

(10) The first cam member may operate to open the valve with a first lift amount in the first state, and the second cam member may operate to open the valve with a second lift amount larger than the first lift amount in the second state.

Here, when the revolution speed of the rotation shaft is low, the first cam member rotates together with the rotation of the rotation shaft. The second cam member is allowed to rotate with respect to the rotation shaft, so that the second cam member does not rotate together with the rotation of the rotation shaft. Therefore, the first cam member operates to open the valve with the first lift amount.

When the revolution speed of the rotation shaft is high, the first cam member rotates together with the rotation of the rotation shaft, and the second cammember is engaged to the rotation shaft and rotates. In this way, the first cam member operates to open the valve with the first lift amount, while the second cam member operates to open the valve with the second lift amount greater than the first lift amount. In this way, the valve moves up and down with the second lift amount.

In this way, the lift amount of the valve is switched between the first lift amount and the second lift amount according to the revolution speed of the engine. Therefore, oil consumption during normal driving can be improved, toxic substances in exhaust gas can be reduced, and high power output during high speed driving can be achieved.

(11) The first cam member may operate to open the valve with a first operation angle in the first state, and the second cam member may operate to open the valve with a second operation angle larger than the first operation angle in the second state.

Here, when the revolution speed of the rotation shaft is low, the first cam member operates to open the valve with the first operation angle.

When the revolution speed of the rotation shaft is high, the second cam member operates to open the valve with the second operation angle larger than the first operation angle.

In this way, the operation angle of the valve is switched between the first operation angle and the second operation angle according to the revolution speed of the engine. Therefore, oil consumption during normal driving can be improved, toxic substances in exhaust gas can be reduced, and high power output during high speed driving can be achieved.

(12) The valve may be an intake valve. In this case, the state in which the first cam member acts on the intake valve and the state in which the second cam member acts on the intake valve are switched according to the revolution speed of the engine. In this way, the first cam member and the second cam member may be formed in optimum shapes for the low revolution period and the high revolution period for the engine, so that the intake amount or the intake timing can be adjusted. Therefore, oil consumption during normal driving can be improved, toxic substances in exhaust gas can be reduced, and high power output during high speed driving can be achieved.

(13) An engine device according to another aspect of the invention includes an engine having a valve, and a variable valve system adapted to drive the valve in the engine, the variable valve system includes a rotation shaft provided to be rotatable in response to the revolution of the engine, a first cam member provided to rotate together with the rotation shaft and operating to open/close the valve, a second cam member provided rotatably with respect to the rotation shaft and operating to open/close the valve, an engaging member provided to be switchable between a first state in which the second cam member is allowed to rotate with respect to the rotation shaft and a second state in which the second cam member is engaged to the rotation shaft, an energizing member that generates energizing force that switches the engaging member to the first state, and a driving member that operates to switch the engaging member to the second state against the energizing force by the energizingmember by centrifugal force generated by the rotation of the rotation shaft, the first cam member operates to open/close the valve when the engaging member is in the first state, and the second cam member operates to open/close the valve when the engaging member is in the second state.

In the engine device, the valve in the engine is driven by the variable valve system.

In the variable valve system, the rotation shaft rotates together with the revolution of the engine. The first cam member rotates together with the rotation of the rotation shaft. The second cam member attains a rotatable state with respect to the rotation shaft when the engaging member is in the first state and is engaged to the rotation shaft when the engaging member is in the second state. The engaging member is switched to the first state or the second state according to the revolution speed of the rotation shaft.

When the revolution speed of the rotation shaft is low, the engaging member is switched to the first state by the energizing force generated by the energizing member. This allows the second cam member to be rotated with respect to the rotation shaft by the engaging member. Therefore, the second cammember is switched to the state in which it does not rotate together with the rotation of the rotation shaft. In this case, the first cammember operates to open/close the valve.

Meanwhile, when the revolution speed of the rotation shaft is high, the engaging member is switched to the second state against the energizing force by the energizingmember by centrifugal force applied to the driving member. In this way, the second cam member is engaged to the rotation shaft. Therefore, the second cammember rotates together with the rotation of the rotation shaft. In this case, the second cam member operates to open/close the valve.

In this way, the state in which the first cam member acts upon the valve and the state in which the second cam member acts upon the valve are switched according to the revolution speed of the engine. Therefore, the first cam member and the second cam member may be formed into optimum shapes for the low revolution period and the high revolution period for the engine, so that oil consumption during normal driving can be improved, toxic substances in exhaust gas can be reduced, and high power output during high speed driving can be achieved.

The first cam member and the second cam member are switched using the centrifugal force generated by the rotation of the rotation shaft, and therefore a driving source by an oil pressure system is not necessary. Therefore, a compact and low cost variable valve system can be provided.

(14) A vehicle according to yet another aspect of the invention includes an engine device, a driving wheel,

and a transmission mechanism that transmits motive power generated by the engine device to the driving wheel, the engine device includes an engine having a valve, and a variable valve system adapted to drive the valve in the engine, the variable valve system includes a rotation shaft provided to be rotatable in response to the revolution of the engine, a first cam member provided to rotate together with the rotation shaft and operating to open/close the valve, a second cam member provided rotatably with respect to the rotation shaft and operating to open/close the valve, an engaging member provided to be switchable between a first state in which the second cam member is allowed to rotate with respect to the rotation shaft and a second state in which the second cam member is engaged to the rotation shaft, an energizingmember that generates energizing force that switches the engaging member to the first state, and a driving member that operates to switch the engaging member to the second state against the energizing force by the energizing member by centrifugal force generated by the rotation of the rotation shaft, the first cam member operates to open/close the valve when the engaging member is in the first state, and the second cam member operates to open/close the valve when the engaging member is in the second state.

[0009] In the vehicle, the motive power generated by the engine device is transmitted to the driving wheel by the transmission mechanism, and the driving wheel is driven. Here, in the engine device, the valve in the engine is driven by the variable valve system.

[0010] In this case, in the variable valve system, the state in which the first cam member acts upon the valve and the state in which the second cam member acts upon the valve are switched according to the revolution speed of the engine. Therefore, the first cam member and the second cam member may be formed into optimum shapes for the low revolution period and the high revolution period for the engine, so that oil consumption during normal driving can be improved, toxic substances in exhaust gas can be reduced, and high power output during high speed driving can be achieved.

[0011] The first cam member and the second cam member are switched using the centrifugal force generated by the rotation of the rotation shaft, and therefore a driving source by an oil pressure system is not necessary. Therefore, a compact and low cost variable valve system can be provided.

[Effects of the Invention]

[0012] According to the invention, the state in which the first cam member acts upon the valve and the state in which the second cam member acts upon the valve are switched according to the revolution speed of the engine. Therefore, the first cam member and the second cam member may be formed into optimum shapes for the low revolution period and the high revolution period for the engine, so that oil consumption during normal driving can be improved, toxic substances in exhaust gas can be reduced, and high power output during high speed driving can be achieved. The first cam member and the second cam member are switched using the centrifugal force generated by the rotation of the rotation shaft, and therefore a driving source by an oil pressure system is not necessary. Therefore, a compact and low cost variable valve system can be provided.

[Brief Description of the Drawings]

[0013]

[FIG. 1] Fig. 1 is a schematic view of a motorcycle according to one embodiment of the invention.

[FIG. 2] Fig. 2 is a view for use in illustrating the general structure of a variable valve system according to the embodiment of the invention.

[FIG. 3] Fig. 3 is a perspective view for use in illustrating how a variable valve system is assembled.

[FIG. 4] FIG. 4 is a perspective view for use in illustrating how a variable valve system is assembled.

[FIG. 5] FIG. 5 is a perspective view for use in illustrating how a variable valve system is assembled.

[FIG. 6] FIG. 6 is a sectional view of a lock plate storing member having a lock plate and a spring inserted therein taken along an X-Z plane.

[FIG. 7] FIG. 7 is a sectional view of a state of a variable valve system during a low revolution period.

[FIG. 8] FIG. 8 is a sectional view of a state of a variable valve system during a high revolution period.

[FIG. 9] Fig. 9 is a view for use in illustrating in detail the operation of a lock plate and lock pins in Figs. 7 and 8.

[FIG. 10] Fig. 10 is a sectional view of how the variable valve system is attached to an engine.

[FIG. 11] Fig. 11 is a top view of the arrangement of the variable valve system, an intake high cam rocker arm, an intake low cam rocker arm, and an exhaust cam rocker arm in Fig. 10.

[FIG. 12] Fig. 12 is a sectional view of a cylinder head taken along line R-R in Fig. 10.

[FIG. 13] Fig. 13 is a chart showing the displacements of an intake valve and an exhaust valve in Fig. 12.

[FIG. 14] Fig. 14 is a view of a modification of the variable valve system.

[Best Mode for Carrying out the Invention]

[0014] A variable valve system, and an engine device and a vehicle including the same according to an embodiment of the present invention will be described. In the embodiment, a small size motorcycle will be described as the vehicle.

(1) Structure of Vehicle

[0015] Fig. 1 is a schematic view of a motorcycle according to the embodiment of the invention.

[0016] In the motorcycle 100, a head pipe 3 is provided at the front end of a main body frame 6. A front fork 2 provided at the head pipe 3 can swing from side to side. At the lower end of the front fork 2, the front wheel 1 is rotatably supported. A handle 4 is attached to the upper end of the head pipe 3.

[0017] An engine 7 is held in the center of the main body frame 6. A fuel tank 8 is provided above the engine 7, and a seat 9 is provided behind the fuel tank 8.

[0018] A rear arm 10 is connected to the main body frame 6 to extend behind the engine 7. The rear arm 10 holds the rear wheel 11 and a rear wheel driven sprocket 12 in a rotatable manner. An exhaust pipe 13 is connected to the engine 7. A muffler 14 is attached to the rear end of the exhaust pipe 13.

[0019] A rear wheel drive sprocket 15 is attached to the drive shaft 26 of the engine 7. The rear wheel drive sprocket 15 is coupled to the rear wheel driven sprocket 12 of the rear wheel 11 through a chain 16.

[0020] The engine 7 includes a variable valve system. Now, the variable valve system according to the embodiment will be described.

(2) General Structure of Variable Valve System

[0021] Fig. 2 is a view for use in illustrating the general structure of the variable valve system according to the embodiment of the invention. Fig. 2 (a) is a schematic top view of the variable valve system provided in the engine 7. Fig. 2 (b) is a schematic side view of the variable valve system provided in the engine 7.

[0022] As shown in Fig. 2 (a) and (b), the variable valve system 200 is provided at a cylinder head 7S in the engine 7. The variable valve system 200 includes a cam driven sprocket 220, an intake high cam 237, an intake low cam 241, and an exhaust cam 242.

[0023] As a piston 21 reciprocates in a cylinder 20, a crankshaft 23 rotates and a cam drive sprocket 24 provided at the crankshaft 23 rotates.

[0024] The turning force of the cam drive sprocket 24 is transmitted to the cam driven sprocket 220 of the variable valve system 200 through a chain 25. This rotates the variable valve system 200.

[0025] In the variable valve system 200, the intake high cam 237 and the intake low cam 2 41 are switched in response to the revolution speed of the engine 7 and changes in the revolution speed (rise and fall in the revolution speed) . This changes the lift amount of the intake valve that will be described, and the intake amount into the cylinder 20 changes accordingly.

(3) Structure of Variable Valve System

[0026] The structure of the variable valve system 200 will be described in detail. Figs. 3 to 5 are perspective views for use in illustrating how the variable valve system 200 is assembled. In Figs. 3 to 5, the three directions orthogonal to one another as indicated by the arrows X, Y, and Z are defined as the X-, Y-, and Z- directions, respectively.

[0027] The variable valve system 200 mainly includes a lock pin holding mechanism 210 (see Fig. 3), a cam driven sprocket 220 (see Fig. 4), a lock pin engaging mechanism 230 (see Fig. 4), a floating cam portion 235 (see Fig. 5), and a camshaft 240 (see Fig. 5).

[0028] Fig. 3 is a perspective view showing how the lock pin holding mechanism 210 is assembled. As shown in Fig. 3, the lock pin holding mechanism 210 has a supporter 211 parallel to the X-Z plane. A through hole 211G is formed in the center of the supporter 211.

[0029] Projections 211a and 211b are formed to extend in the Y-direction from the upper and lower ends of one side of the supporter 211. A spring holding piece 212a bent in a U shape on one side of the supporter 211 and a projection 211c extending in the X-direction are formed between the projections 211a and 211b.

[0030] Projections 211d and 211e are bent and extend in the Y-direction from the upper and lower ends of the other side of the supporter 211. Aproj ection 211f extending in the X-direction and a spring holding piece 212b bent in a U shape on one side of the supporter 211 are formed between the projections 211d and 211e.

[0031] The projections 211a to 211f have through holes 211A to 211F, respectively and the spring holding pieces 212a and 212b have through holes 212A and 212B, respectively.

[0032] Recessed notches 211H and 211I are formed in the centers of the upper and lower ends of the supporter 211, respectively.

[0033] A weight 213 has a weight main body 213a, a plate shaped extension 213d, two tubular portions 213e, and two hook portions 213f. The weight main body 213a has a substantially rectangular shape extending in the X-direction.

[0034] The extension 213d extends in the Y-direction from the upper surface of the weight main body 213a. The two tubular portions 213e are formed in the X-direction on both ends of the extension 213d.

[0035] The two hook portions 213f extend to be inclined from the center of the extension 213d in the X-direction to the lower side of the extension 213d. The two hook portions 213f each have their tip ends bent partially cylindrical.

[0036] A lock pin 214 that extends in the Y-direction is attached to the two hook portions 213f. In the vicinity of one end of the lock pin 214, a support pin 214t extending in the X-direction is formed. Since the support pin 214t is provided at the hook portion 213f, the lock pin 214 is pivotably held by the weight 213. Part of the lock pin 214 can abut against the weight main body 213a.

[0037] Circular grooves 214a and 214b are formed parallel to each other at the outer circumferential surface in the vicinity of the other end of the lock pin 214.

[0038] A rotation shaft 215 is inserted into the tubular portions 213e of the weight 213. In this way, the rotation shaft 215 can hold the weight 213 in a pivotable manner. In this state, both ends of the rotation shaft 215 are inserted into the through holes 211A and 211D of the supporter 211. In this way, the weight 213 is pivotably held on the supporter 211. The lock pin 214 is provided to pass through the notch 211H of the supporter 211.

[0039] A weight 216 has the same structure as the weight 213. During assembly of the lock pin holding mechanism 210, the weight 216 is provided to oppose the weight 213.

[0040] In Fig. 3, the weight main body 216a, the extension 216d, the two tubular portions 216e and the two hook portions 216f of the weight 216 correspond to the weight main body 213a, the extension 213d, the two tubular portions 213e and the two hook portions 213f of the weight 213, respectively.

[0041] The lock pin 217 has the same structure as that of the lock pin 214. The grooves 217a and 217b of the lock pin 217 correspond to the grooves 214a and 214b. The support pin 217t corresponds to the support pin 214t.

[0042] A rotation shaft 218 is inserted to the tubular portions 216e of the weight 216. In this way, the rotation shaft 218 can hold the weight 216 in a pivotable manner. In this state, both ends of the rotation shaft 218 are inserted into the through holes 211B and 211E of the supporter 211. In this way, the weight 216 is held pivotably on the supporter 211. The lock pin 217 is provided through the notch 211I of the supporter 211.

[0043] The lock pins 214 and 217 are provided orthogonally to the supporter 211. Note that the distance between the through holes 211G of the supporter 211 and the lock pin 214 is smaller than the distance between the through hole 211G and the lock pin 217.

[0044] Screws 219 are inserted into the two through holes 211C and 211F of the two projections 211c and 211f of the supporter 211.

[0045] Fig. 4 is a perspective view showing how the lock pin holding mechanism 210, the cam driven sprocket 220, and the lock pin engaging mechanism 230 are assembled. The cam driven sprocket 220 is provided parallel to the X-Z plane and the lock pin engaging mechanism 230 has its axial center J arranged parallel to the Y-direction.

[0046] In the lock pin holding mechanism 210, a spring S1 has one end engaged through the through hole provided at the projection (not shown) of the weight 213 and its other end engaged through the through hole 212B of the spring holding piece 212b. A spring S2 has one end engaged through the through hole of the projection (not shown) of the weight 216 and its other end engaged through the through hole 212A of the spring holding piece 212a.

[0047] The cam driven sprocket 220 has through holes 220a to 220e. The through hole 220a formed in the center of the camdriven sprocket 220 has a diameter larger than those of the other through holes 220b to 220e.

[0048] The through holes 220a, 220b, and 220c are formed on the same straight line parallel to the Z-direction, and the through holes 220b and 220c have equal diameters. Note that the distance between the through holes 220a and 220b is smaller than the distance between the through holes 220a and 220c. The through holes 220d and 220e are formed in symmetrical positions to each other around the through hole 220a and have equal diameters.

[0049] The lock pin engaging mechanism 230 includes a cylindrical pivot shaft 231 and a disk-shaped lock plate storing member 232.

[0050] The lock pin engaging mechanism 230 has through holes 230H, 230b, and 230c formed therethrough. The through hole 230H is formed in the axial center J of the lock pin engaging mechanism 230. More specifically, the through hole 230H is formed from the center of an end of the pivot shaft 231 to the center of an end of the lock plate storing member 232. The through holes 230H, 230b, and 230c are provided on the same straight line parallel to the Z-direction and the through holes 230b and 230c have equal diameters. Note that the distance between the through holes 230H and 230b is smaller than the distance between the through holes 230H and 230c.

[0051] Screw holes 230d and 230e are formed at an end of the pivot shaft 231 of the lock pin engaging mechanism 230. The screw holes 230d and 230e are formed in symmetrical positions around the through hole 230H and have equal diameters. The screw holes 230d and 230e are threaded. A stepped portion 231a is formed at the outer circumferential surface of the pivot shaft 231.

[0052] A slit type lock plate inlet 232A and a substantially circular spring inlet 232B are formed at the outer circumferential surface of the lockplate storingmember 232 of the lockpin engaging mechanism 230. The lock plate inlet 232A is in communication with a lock plate storing space 232b (that will be described in conjunction with Fig. 6) formed in the lock storing member 232, and the spring inlet 232B is in communication with a spring storing space 232c (that will be described in conjunction with Fig. 6) formed in the lock plate storing member 232.

[0053] The plate-shaped lock plate 233 is inserted into the lock plate storing space 232b (Fig. 6) in the lock plate storing member 232 through the lock plate inlet 232A. The spring 234 is inserted into the spring storing space 232c (Fig. 6) in the lock plate storing member 232 through the spring inlet 232B.

[0054] The lock plate 233 includes a substantially rectangular support plate 233a, an elongated lock pin engaging portion 233b, and an elongated lock pin engaging portion 233c. The lock pin engaging portion 233b extends in one direction along one side of the support plate 233a, and the lock pin engaging portion 233c extends obliquely outwardly from one corner of the support plate 233a and bents so as to be parallel to the lock pin engaging portion 233b. A through hole 233A is formed in the center of the support plate 233a.

[0055] A columnar member 234a is attached to one end of the spring 234 so that the spring can readily be attached/detached to/from the lock pin engaging mechanism 230.

[0056] Now, with reference to Fig. 6, the positional arrangement of the lock plate 233 and the spring 234 in the lock plate storing member 232 will be described.

[0057] Fig. 6 is a sectional view of a lock plate storing member 232 having a lock plate 233 and a spring 234 inserted therein taken along an X-Z plane.

[0058] As shown in Fig. 6, a pin 233d is inserted through the through hole 233A of the lock plate 233. In this way, the lock plate 233 is held in the lock storing space 232b of the lock plate storing member 232 in a swingable manner.

[0059] The spring 234 is inserted into the spring storing space 232c in the Z-direction, and the lower end of the spring 234 abuts against the upper end of the lock pin engaging portion 233b of the lock plate 233. In this way, the lock plate 233 is energized downwardly.

[0060] The lower end of the lock pin engaging portion 233c of the lock plate 233 is fitted into the groove 214a (Fig. 3) or the groove 214b (Fig. 3) of the lock pin 214 inserted into the lock plate storing member 232 in the Y-direction. The lower end of the lock pin engaging portion 233b of the lock plate 233 is fitted into the groove 217a (Fig. 3) or the groove 217b (Fig. 3) of the lock pin 217 inserted into the lock plate storing member 232 in the Y-direction.

[0061] In this way, the movement of the lock pins 214 and 217 in the Y-direction is restricted by the lock plate 233, details of which will be described in the following.

[0062] As shown in Fig. 4, the relative position of the through holes 220d and 220e with respect to the through hole 220a of the cam driven sprocket 220 is the same as the relative position of the screw holes 230d and 230e with respect to the through hole 230H of the lock pin engaging mechanism 230. The diameter of the through holes 230d and 230e is the same as the diameter of the screw holes 220d and 220e.

[0063] When the lock pin holding mechanism 210, the cam driven sprocket 220 and the lock pin engaging mechanism 230 are assembled, the position of the through hole 220d of the cam driven sprocket 220 is registered to the position of the through hole 230d of the lock pin engaging mechanism 230 and the position of the through hole 220e of the cam driven sprocket 220 is registered to the position of the through hole 230e of the lock pin engaging mechanism 230. In this state, the screws 219 of the lock pin holding mechanism 210 are fitted into the holes.

[0064] In this way, the lock pin holding mechanism 210 is fixed to one surface of the cam driven sprocket 220, and the lock pin engaging mechanism 230 is fixed to the other surface of the cam driven sprocket 220.

[0065] At the time, the lock pin 214 is inserted into the through hole 220b of the cam driven sprocket 220 and the through hole 230b of the lock pin engaging mechanism 230, and the lock pin 217 is inserted into the through hole 220c of the camdriven sprocket 220 and the through hole 230c of the lock pin engaging mechanism 230. The pivotal movement of the weights 213 and 216 switches between the state in which the lock pins 214 and 217 protrude from the end of the lock pin engaging mechanism 230 on the side of the lock plate storing member 232 of the lock pin engaging mechanism 230 and the state in which the lock pins 214 and 217 are stored in the lock pin engaging mechanism 230, details of which will be described later in the following.

[0066] Fig. 5 is a perspective view of the assembly of the structure assembled as shown in Fig. 4 (hereinafter referred to as "assembled structure"), the floating cam portion 235 and the camshaft 240. Note that the floating cam portion 235 and the camshaft 240 have their axial center J arranged parallel to the Y-direction.

[0067] The floating cam portion 235 includes a lock pin fitting portion 236 and an intake high cam 237 having a cam nose 237A. A through hole 235H is formed at the part of the floating cam portion 235 corresponding to the axial center J. More specifically, the through hole 235H is formed from the center of the end of the lock pin fitting portion 236 to the center of the end of the intake high cam 237.

[0068] Lock pin fitting holes 236b and 236c are formed at the lock pin fitting portion 236 of the floating cam portion 235. The lock pin fitting holes 236b and 236c and the through hole 235H are provided on the same straight line parallel to the Z-direction, and the lock pin fitting holes 236b and 236c have equal diameters. Note that the distance between the through hole 235H and the lock pin fitting hole 236b is smaller than the distance between the through hole 235H and the lock pin fitting hole 236c.

[0069] The camshaft 240 includes an intake low cam 241 having a cam nose 241A, an exhaust cam 242 having a cam nose 242A, a stepped portion 243, a cam fixing shaft 244, and a projection shaft 245.

[0070] In the Y-direction, the camshaft 240 has the cam fixing shaft 244 extending in the Y-direction on one end side, the stepped portion 243, the intake low cam 241, and the exhaust cam 242 at the center, and the projection shaft 245 extending in the Y-direction on the other end side. A threaded hole 240H is formed at the end of the cam fixing shaft 244.

[0071] Note that the length of the cam nose 237A of the intake high cam 237 of the floating cam portion 235 is larger than the length of the cam nose 241A of the intake low cam 241.

[0072] When the assembled structure, the floating cam portion 235, and the camshaft 240 are assembled, the floating cam portion 235 and the camshaft 240 are attached to the lock plate storing member 232 of the assembled structure.

[0073] In this case, the cam fixing shaft 244 of the camshaft 240 is inserted into the through hole 235H of the floating cam portion 235 and the through hole 230H (Fig. 4) of the lock pin engaging mechanism 230. In this way, the floating cam portion 235 is rotatably held by the camshaft 240.

[0074] The threaded hole 240H of the cam fixing shaft 244 opposes the through hole 220a (Fig. 4) of the cam driven sprocket 220 in the through hole 235H (Fig. 5) of the lock pin engaging mechanism 230. The through hole 220a (Fig. 4) of the cam driven sprocket 220 and the through hole 211G of the lock pin holding mechanism 210 oppose to each other.

[0075] In this state, a screw 250 is screwed in the threaded hole 240H of the cam fixing shaft 244 from the through hole 211G of the lock pin holding mechanism 210. In this way, the camshaft 240 is fixed to the cam driven sprocket 220. This completes the variable valve system 200.

[0076] Note that the pivot shaft 231 and the lock plate storing member 232 of the lock pin engaging mechanism 230 may be formed either integrally or discretely. The intake low cam 241, the exhaust cam 242, the stepped portion 243, the cam fixing shaft 244, and the projecting shaft 245 of the camshaft 240 may be formed either integrally or discretely.

[0077] Although not shown in Fig. 5, a fixing mechanism that restricts the rotation of the camshaft 240 relative to the cam driven sprocket 220 may be provided at the connecting part of the cam fixing shaft 244 and the through hole 220a (Fig. 4).

[0078] The fixing mechanism may be implemented for example by providing a projection portion at a tip end of the cam fixing shaft 244 of the camshaft 240 and providing a groove that can be fitted with the projection portion of the cam fixing shaft 244 at the through hole 220a (Fig. 4) of the cam driven sprocket 220.

(4) Operation of Variable Valve System

[0079] The state of the variable valve system 200 having the structure as shown in Figs. 3 to 6 is switched in response to the revolution speed of the engine. Now, how the state of the variable valve system 200 is switched will be described. Note that in the following description, the state in which the revolution speed of the engine 7 (see Figs. 1 and 2) is higher than a prescribed value will be referred to as "high revolution period" and the state in which the speed is lower than the prescribed value will be referred to as "low revolution period." The revolution speed of the cam fixing shaft 244 is half the revolution speed of the engine 7. The revolution speed of the cam fixing shaft 244 at the time of switching between the high revolution period and the low revolution period will be referred to as "threshold."

[0080] To begin with, the engine 7 starts to operate, which causes the variable valve system 200 (Figs. 3 to 6) to rotate. This allows centrifugal force to be acted on the weights 213 and 216 of the variable valve system 200 in addition to energizing force from the springs S1 and S2. The magnitude of the centrifugal force acting on the weights 213 and 216 changes depending on the revolution speed of the variable valve system 200. The change in the centrifugal force is used to switch the state of the variable valve system 200.

[0081] Fig. 7 is a sectional view of the state of the variable valve system 200 during the low revolution period, and Fig. 8 is a sectional view of the state of a variable valve system 200 during the high revolution period.

[0082] In Figs. 7 and 8, the two directions orthogonal to each other denoted by the arrows Y and Z are defined as the Y- and Z- directions. Note that a direction directed by an arrow is defined as "+" direction, while its opposite direction is defined as "-" direction.

[0083] As shown in Fig. 7, the energizing force in the - Z-direction by the spring S1 as well as the centrifugal force in the + Z-direction caused by the rotation of the variable valve system 200 is applied to the weight 213. During the low revolution period (when the revolution speed of the cam fixing shaft 244 is lower than the threshold), the centrifugal force applied to the weight 213 is so small that the rotation of the weight 213 around the rotation shaft 215 is restricted by the energizing force of the spring S1.

[0084] The lock pin engaging portion 233c of the lock plate 233 is fitted to the groove 214a of the lock pin 214. The lock plate 233 is energized in the - Z-direction by the spring 234 (Figs. 4 and 6). Therefore, the movement of the lock pin 214 in the + Y-direction is restricted.

[0085] In this way, the lock pin 214 is fixed as its tip end is stored in the lock pin engaging mechanism 230.

[0086] Similarly, energizing force in the + Z-direction is applied to the weight 216 by the spring S2 (Figs. 3 and 5) while centrifugal force in the - Z-direction caused by the rotation of the variable valve system 200 is applied to the weight 216. During the low revolution period, the centrifugal force applied to the weight 216 is so small that the rotation of the weight 216 around the rotation shaft 218 is restricted by the energizing force by the spring S2.

[0087] The lock pin engaging portion 233b of the lock plate 233 is fitted to the groove 217a of the lock pin 217 and the lock plate 233 is energized in the - Z-direction by the spring 234, so that the movement of the lock pin 217 in the + Y-direction is restricted.

[0088] In this way, the lock pin 217 is fixed as its tip end stored in the lock pin engaging mechanism 230.

[0089] The lock pins 214 and 217 are not fitted into the lock pin fitting holes 236b and 236c of the floating cam portion 235, and the floating cam portion 235 idles around the cam fixing shaft 244.

[0090] Meanwhile, as shown in Fig. 8, during the high revolution period (when the revolution speed of the cam fixing shaft 244 exceeds the threshold), the centrifugal force applied to the weight 213 in the + Z-direction is greater than the energizing force in the - Z-direction caused by the spring S1, so that the force that causes the weight 213 to rotate in the direction denoted by the arrow M1 around the rotation shaft 215 is generated.

[0091] This causes force that moves the lock pin 214 in the + Y-direction. In this way, the lock pin engaging portion 233c of the lock plate 233 is disengaged from the groove 214a of the lock pin 214. As a result, when the position of the lock pin fitting hole 236b of the floating cam portion 235 and the position of the tip end of the lock pin 214 match, the tip end of the lock pin 214 protrudes from one surface of the lock pin engaging mechanism 230 to be fitted into the lock pin fitting portion 236b of the floating camportion 235. At the time, the lock pin engaging portion 233c of the lock plate 233 is fitted into the groove 214b of the lock pin 214. This restricts the movement of the lock pin 214 in the - Y-direction. Therefore, the lock pin 214 is fixed as it is fitted to the lock pin fitting portion 236b of the floating cam portion 235.

[0092] Similarly, the centrifugal force in the - Z-direction applied to the weight 216 is greater than the energizing force in the + Z-direction caused by the spring S2 (Figs. 3 to 5), so that force that causes the weight 216 to rotate in the direction denoted by the arrow M2 around the rotation shaft 218 is generated.

[0093] This causes force that moves the lock pin 217 in the + Y-direction. In this way, the lock pin engaging portion 233b of the lock plate 233 is disengaged from the groove 217a of the lock pin 217. As a result, when the position of the lock pin fitting hole 236c of the floating cam portion 235 and the position of the tip end of the lock pin 217 match, the tip end of the lock pin 217 protrudes from one surface of the lock pin engaging mechanism 230 to be fitted into the lock pin fitting portion 236c of the floating camportion 235. At the time, the lock pin engaging portion 233b of the lock plate 233 is fitted into the groove 217b of the lock pin 217. This restricts the movement of the lock pin 214 in the - Y direction. Therefore, the lock pin 217 is fixed as it is fitted to the lock pin fitting hole 236c of the floating cam portion 235.

[0094] In this way, during the high revolution period, the floating cam portion 235 is fixed in the rotation direction of the variable valve system 200 by the function of the lock pins 214 and 217.

[0095] As shown in Figs. 3 to 5, the lock pins 214 and 217 and the lock pin fitting holes 236b and 236c are apart from the cam fixingshaft244bydifferentdistances. Inthisway, the floating cam portion 235 is fixed to the rotation shaft always in the same phase, not in the inverted state.

[0096] With a switching mechanism using such centrifugal force in general, the centrifugal force applied to the weights 213 and 216 and the energizing force by the springs S1 and S2 are balanced with one another in a certain revolution speed range of the engine 7. If the balanced state continues, the movement of the lock pins 214 and 217 becomes unstable.

[0097] Therefore, according to the embodiment, the movement of the lock pins 214 and 217 is restricted by the lock plate 233. In this way, the movement of the lock pins 214 and 217 is carried out in a stable manner. Now, the operation will be described in detail.

[0098] Fig. 9 is a view for use in illustrating in detail the operation of the lock plate 233 and the lock pins 214 and 217 in Figs. 7 and 8. Fig. 9(a) shows the state of the lock plate 233 and the lock pins 214 and 217 during the low revolution period (as shown in Fig. 7), Fig. 9(c) shows the state of the lock plate 233 and the lock pins 214 and 217 during the high revolution period (as shown in Fig. 8), and Fig. 9(b) shows the state of the lock plate 233 and the lock pins 214 and 217 during the transition period from the state in Fig. 9(a) to the state in Fig. 9(c).

[0099] Note that the definition of the Y- and Z- directions in Figs. 7 and 8 also applies in Fig. 9. Fig. 9 shows only the lock pin 214 among the lock pins 214 and 217 and only the lock pin engaging portion 233c among the lock pin engaging portions 233c and 233b of the lock plate 233. The relation between the lock pin 217 and the lock pin engaging portion 233b is the same as the relation between the lock pin 214 and the lock pin engaging portion 233c.

[0100] As shown in Fig. 9, the grooves 214a and 214b of the lock pin 214 have a V-shaped cross section. The section of the lower end of the lock pin engaging portion 233c has a tapered shape complementary to the sectional shape of the grooves 214a and 214b.

[0101] During the transition from the low revolution state in Fig. 9(a) to the high revolution period in Fig. 9(c), as shown in Fig. 9(b), the pin engaging portion 233c has its lower end raised in the + Z-direction along the inclined surface of the groove 214a of the lock pin 214 and disengaged from the groove 214a. In this way, the lock pin 214 moves in the + Y direction. The transition from the high revolution state to the low revolution state is carried out in the sequence reversed from the above.

[0102] As described above, the movement of the lock pin 214 is restricted by the lock plate 233, so that during the transition from the low engine speed state to the high engine speed state, the lock pin 214 does not move unless the moving force upon the lock pin 214 in the + Y-direction is large enough to move the lock pin 214. More specifically, when the centrifugal force in the + Z-direction applied to the weight 213 is larger than by a prescribed value ormore the energizing force in the - Z-direction caused by the spring S1 (when the revolution speed of the cam fixing shaft 244 is equal to or higher than the threshold by a prescribed value), the lock pin 214 moves.

[0103] During the transition from the high engine speed state to the low engine speed state, the lock pin 214 does not move unless the moving force upon the lock pin 214 in the + Y-direction is large enough to move the lock pin 214. More specifically, when the centrifugal force in the + Z-direction applied to the weight 213 is smaller than by a prescribed value or more the energizing force in the - Z-direction caused by the spring S1 (when the revolution speed of the cam fixing shaft 244 is equal to or lower than the threshold by a prescribed value), the lock pin 214 moves.

[0104] In this way, while the centrifugal force applied to the weights 213 and 216 is balanced with the energizing force caused by the springs S1 and S2, the movement of the lock pins 214 and 217 is prevented from being unstable.

(5) Attachment of Variable Valve System to Engine

[0105] Fig. 10 is a sectional view showing how the variable valve system 200 is attached to the engine 7. In Fig. 10, the three directions orthogonal to one another as indicated by the arrows X, Y, and Z are defined as the X-, Y-, and Z- directions, respectively.

[0106] As shown in Fig. 10, there is a space secured in the upper part of a cylinder head 7S for attaching the variable valve system 200.

[0107] Bearings B1 and B2 are attached at the outer circumference of the pivot shaft 231 of the variable valve system 200 and the outer circumference of the projection shaft 245.

[0108] In the cylinder head 7S, one end of the bearing B1 orthogonal to the Y-direction abuts against an abutment surface BH1 in the cylinder head 7S. One end of the bearing B2 orthogonal to the Y-direction abuts against an abutment surface BH2 in the cylinder head 7S. A part of the other end of the bearing B1 orthogonal to the Y-direction abuts against a fixing plate BH3 connected to the cylinder head 7S. In this way, the variable valve system 200 is fixed rotatably in the cylinder head 7S.

[0109] An intake high cam rocker arm 330, an intake low cam rocker arm 340, and an exhaust cam rocker arm 350 are provided above the variable valve system 200. The intake high cam rocker arm 330 abuts against the intake high cam 237 in the variable valve system 200, the intake low cam rocker arm 340 abuts against the intake low cam 241 in the variable valve system 200, and the exhaust cam rocker arm 350 abuts against the exhaust cam 242 in the variable valve system 200.

[0110] A side cover SC is provided to the cylinder head 7S to cover the side of the lock pin holding mechanism 210 of the variable valve system 200. A chain 25 is engaged with the cam driven sprocket 220.

(6) Driving Valve Using Variable Valve System

[0111] Fig. 11 is a top view showing the positional arrangement of the variable valve system 200, the intake high cam rocker arm 330, the intake low cam rocker arm 340, and the exhaust cam rocker arm 350 in Fig. 10. Fig. 12 shows a sectional view of the cylinder head 7S taken along line R-R in Fig. 10. Note that in Figs. 11 and 12, the definition of the X-, Y-, and Z- directions is the same as that in Fig. 10.

[0112] As shown in Fig. 11, the variable valve system 200 is attached in the cylinder head 7S by the bearings B1 and B2. The intake high cam rocker arm 330 and the intake low cam rocker arm 340 are arranged in parallel on one side of the variable valve system 200 and rotatably held in their central parts by a shaft 341. The intake high cam rocker arm 330 has its one end extended as it is bent above (in the Z-direction of) the intake high cam 237, and the intake low cam rocker arm 340 has its one end extended as it is bent above (in the Z-direction of) the intake low cam 241.

[0113] The exhaust cam rocker arm 350 is provided on the other side of the variable valve system 200 and rotatably held by a shaft 351 in its central part. One end of the exhaust cam rocker arm 350 is extended above (in the Z-direction of) the exhaust cam 242.

[0114] As shown in Fig. 12, the intake low cam rocker arm 340 includes a cam receiving portion 340T, an arm 340R, an adjuster 342, and a nut 343.

[0115] The cam receiving portion 340T abutted against the intake low cam241 is provided at one end of the arm 340R in the X-direction, and the adjuster 342 is attached at the other end by the nut 343.

[0116] A pin 345 extending in the Y-direction is attached at a part of the arm 340R in the vicinity of the adjuster 342 and protrudes below the intake high cam rocker arm 330.

[0117] The intake high cam rocker arm 330 includes a cam receiving portion (not shown), an arm 330R, an adjuster 332, and a nut 333.

[0118] The cam receiving portion abutted against the intake high cam 237 is provided at one end of the arm 330R in the X-direction, and the adjuster 332 is provided at the other end by the nut 333. The adjuster 332 of the intake high cam rocker arm 330 abuts against the top of the pin 345 of the intake low cam rocker arm 340.

[0119] As the intake low cam 241 rotates in the direction of the arrow Q2, the cam receiving portion 340T moves up and down. As a result, the arm 340R pivots around the shaft 341, which causes the adjuster 342 to move up and down. Similarly, as the intake high cam 237 rotates in the direction of the arrow Q2, the cam receiving portion moves up and down. In this way, the arm 330R pivots around the shaft 341 and the adjuster 332 moves up and down.

[0120] An intake valve 344 is positioned under the adjuster 342 of the intake low cam rocker arm 340. The stem end 344a of the upper end of the intake valve 344 abuts against the adjuster 342. The intake valve 344 is provided with a valve spring 347. The valve spring 347 energizes the intake valve 344 in the upward direction.

[0121] As shown in Fig. 5, the length of the cam nose 237A of the intake high cam 237 is larger than the length of the cam nose 241A of the intake low cam 241. Therefore, the moving distance of the adjuster 332 in the downward direction caused by the rotation of the intake high cam 237 is larger than the moving distance of the adjuster 342 in the downward direction caused by the rotation of the intake low cam 241. When the intake high cam 237 rotates, the downward moving force of the adjuster 332 of the intake high cam rocker arm 330 is transmitted to the intake low cam rocker arm 340 through the pin 345.

[0122] As shown in Fig. 7, according to the embodiment, the intake high cam 237 during the low revolution period is rotatable with respect to the cam fixing shaft 244 of the camshaft 240. Therefore, the rotation force of the cam fixing shaft 244 is not transmitted to the intake high cam 237. In contrast, as shown in Fig. 8, the intake high cam 237 is fixed to the cam fixing shaft 244 by the lock pins 214 and 217 during the high revolution period. Therefore, the rotation force of the cam fixing shaft 244 is transmitted to the intake high cam 237.

[0123] More specifically, during the low revolution period, the intake high cam rocker arm 330 is not driven by the intake high cam 237. Therefore, the adjuster 342 of the intake low cam rocker arm 340 is moved up and down by the rotation of the intake low cam 241, and the intake valve 344 moves up and down (carries out lifting operation) accordingly. In this way, the intake valve 344 is opened/closed.

[0124] Meanwhile, during the high revolution period, the intake high cam rocker arm 330 is driven by the intake high cam 237. In this way, the intake low cam rocker arm 340 is driven by the intake high cam rocker arm 330. Therefore, the adjuster 342 of the intake low cam rocker arm 340 is moved up and down by the rotation of the intake high cam 237, so that the intake valve 344 moves up and down (carries out lifting operation). In this way, the intake valve 344 is opened/closed.

[0125] As described above, the rotation force of the intake low cam 241 is transmitted to the intake valve 344 through the intake low cam rocker arm 340, and the rotation force of the intake high cam 237 is transmitted to the intake valve 344 through the intake high cam rocker arm 330 and the intake low cam rocker arm 340. The displacement amount (hereinafter referred to as "lift amount") of the intake valve 344 during the low revolution period depends on the length of the cam nose 241A of the intake low cam 241 and the lift amount of the intake valve 344 during the high revolution period depends on the length of the cam nose 237A of the intake high cam 237.

[0126] In this case, the area of the upper surface of the stem end 344a of the intake valve 344 must be large so that the adjuster 332 of the intake high cam rocker arm 330 and the adjuster 342 of the intake low cam rocker arm 340 are both abutted against the stem end 344a. In contrast, according to the embodiment, the upward and downward movement of the intake high cam rocker arm 330 is transmitted to the intake valve 344 through the intake low cam rocker arm 340, so that the area of the upper surface of the stem end 344a of the intake valve 344 can be reduced and an unbalanced load can be prevented from being applied to the intake valve 344.

[0127] The exhaust cam rocker arm 350 includes a cam receiving portion 350T, an arm 350R, an adjuster 352, and a nut 353 similarly to the intake high cam rocker arm 330 and the intake low cam rocker arm 340.

[0128] An exhaust valve 354 is positioned under the adjuster 352 of the exhaust cam rocker arm 350. The exhaust valve 354 is provided with a valve spring 357. The valve spring 357 energizes the intake valve 344 in the upward direction. The exhaust cam rocker arm 350 is driven by the exhaust cam 242. Therefore, the adjuster 352 of the exhaust cam rocker arm 350 is moved up and down by the rotation of the exhaust cam 242, so that the exhaust valve 354 moves up and down (carries out lifting operation) . In this way, the exhaust valve 354 is opened/closed.

(7) Valve Lift Amount

[0129] Fig. 13 shows the lift amounts of the intake valve 344 and the exhaust valve 354 shown in Fig. 12.

[0130] In Fig. 13, the abscissa represents the crank angle (the rotation angle of the crank shaft 23), and the ordinate represents the lift amounts of the exhaust valve 354 and the intake valve 344 (the displacement amounts of the exhaust valve 354 and the intake valve 344 in the upward and downward directions).

[0131] In Fig. 13, the exhaust valve 354 and the intake valve 344 are open when the lift amounts are greater than zero and closed when the lift amounts are zero.

[0132] The shown crank angle ranges from -360° to +360°. When the crank angle is 0°, 360°, and -360°, the piston 21 (Fig. 2) is positioned at the top dead center TDC in the cylinder 20, and when the crank angle is 180° and -180°, the piston 21 (Fig. 2) is positioned at the bottom dead center BDC in the cylinder 20.

[0133] The valve lift curve 242L denoted by the solid line shows changes in the lift amount of the exhaust valve 354 caused by the rotation of the exhaust cam 242 (Fig. 9). As denoted by the valve lift curve line 242L, the maximum lift amount of the exhaust valve 354 is the maximum value L1.

[0134] The valve lift curve 241L denoted by the chain-dotted line shows changes in the lift amount of the intake valve 344 during the low revolution period. As denoted by the valve lift curve 241L, the maximum lift amount of the intake valve 344 is the maximum value L2. In this case, the lift amount of the intake valve 344 depends on the length of the cam nose 241A of the intake low cam 241 as described above.

[0135] Meanwhile, the valve lift curve 237L denoted by the dotted line shows changes in the lift amount of the intake valve 344 during the high revolution period. As denoted by the valve lift curve 237L, the maximum lift amount of the intake valve 344 is the maximum value L1 that is larger than the maximum value L2 and equal to the maximum lift amount of the exhaust valve 354. In this case, the lift amount of the intake valve 344 depends on the length of the cam nose 237A of the intake high cam 237.

[0136] In this way, the lift amount of the intake valve 344 during the high revolution period is larger than the lift amount of the intake valve 344 during the low revolution period. Therefore, during the high revolution period, an intake amount into the cylinder 20 in Fig. 2 that is greater than the amount during the low revolution period can be secured. Consequently, fuel consumption can be improved during normal driving, toxic substances in exhaust gas can be reduced, and high power output during high speed driving can be achieved.

[0137] Note that according to the embodiment, the maximum lift amount of the exhaust valve 354 is set to be equal to the maximum lift amount of the intake valve 344 during the high revolution period, while the maximum lift amount of the exhaust valve 354 and the maximum lift amount of the intake valve 344 during the high revolution period may be different.

(8) Effects of the Embodiment

[0138] According to the embodiment, the variable valve system 200 uses centrifugal force generated by rotation in order to switch between the intake high cam 237 and the intake low cam 241. In this way, as compared to the case of switching the two intake cams by oil pressure, the intake high cam 237 and the intake low cam 241 can be switched with a smaller size and less costly since the embodiment is removed of a hydraulic actuator and a hydraulic pump. Therefore, fuel consumption can be improved during normal driving, toxic substances in exhaust gas can be reduced, and high power output during high speed driving can be achieved.

[0139] Furthermore, the switching operation between the intake high cam 237 and the intake low cam 241 can be carried out by inserting and withdrawing the lock pins 214 and 217 to the lock pin fitting holes 236b and 236c without the aid of frictional force between the components. Therefore, the components are hardly degraded by abrasion. Consequently, the variable valve system 200 can have a prolonged useful life without using anti-abrasion materials and can still, and the cost can be reduced.

[0140] In addition, the lock pins 214 and 217 can be inserted/withdrawn to/from the lock pin fitting holes 236b and 236c simply by a mechanical arrangement, so that high working precision is not requested and therefore the system can be more readily manufactured.

(9) Correspondences between Elements Recited in Claims and Elements of Embodiment

[0141] In the following paragraphs, correspondences between various elements recited in the claims and those described above with respect to various embodiments are explained but the invention is not limited to the following examples.

[0142] In the embodiment described above, the intake valve 344 and the exhaust valve 354 are examples of a valve, the cam fixing shaft 244 is an example of a rotation shaft, the intake low cam 241 is an example of a first cam member, the floating cam portion 235 is an example of a second cam member, the lock pins 214 and 217 are examples of an engaging member, the springs S1 and S2 are examples of an energizing member, and the weights 213 and 216 are examples of a driving member.

[0143] The tip ends of the lock pins 214 and 217 are examples of an engaging portion, the lock pin fitting holes 236b and 236c are examples of an engagement portion, the lock plate 233 is an example of a movement stopping member, the grooves 214a, 214b, 217a, and 217b are examples of a groove, the lock pin engaging portions 233b and 233c are examples of a fitting portion, the intake low cam rocker arm 340 is an example of a first transmission member, and the intake high cam rocker arm 330 is an example of a second transmission member.

[0144] The state of the lock pins 214 and 217 during the low revolution period in Fig. 7 is an example of a first state, the positions of the weights 213 and 216 during the low revolution period are examples of a first position, and the state of the lock pins 214 and 217 during the high revolution period in Fig. 8 is an example of a second state, the positions of the weights 213 and 216 during the high revolution period are examples of a second position, the lift amount of the intake valve 344 during the low revolution period denoted by the chain-dotted line in Fig. 13 is an example of a first lift amount, and the lift amount of the intake valve 344 during the high revolution period denoted by the dotted line is an example of a second lift amount.

[0145] The engine 7 and the variable valve system 200 are an example of an engine device, and the motor cycle 100 is an example of a vehicle, and the rear wheel 11 is an example of a driving wheel, the rear wheel driven sprocket 12, the drive shaft 26, the rear wheel drive sprocket 15 and the chain 16 are an example of a transmission mechanism.

[0146] As the elements recited in the claims, various other elements having the structure or function as recited in the claims may be employed.

(10) Other Embodiments

(10-1)

[0147] The two weights 213 and 216 and the two lock pins 214 and 217 are provided in the variable valve system 200 according to the embodiment described above, while only one of the weights 213 and 216 and one of the lock pins 214 and 217 may be provided. An example of the variable valve system 200 in this arrangement is shown in Fig. 14.

[0148] The variable valve system 200 shown in Fig. 14 does not have the weight 213 and the lock pin 214 in the variable valve system 200 as shown in Figs. 3 to 13.

[0149] Fig. 14 (a) is a sectional view of the variable valve system 200 during the low revolution period, and Fig. 14 (b) is a sectional view taken along line P-P in Fig. 14(a).

[0150] As shown in Fig. 14(a), the variable valve system 200 includes a lock pin holding mechanism 210, a cam driven sprocket 220, a lock pin engaging mechanism 230, a floating cam portion 235, and a camshaft 240.

[0151] The lock pin holding mechanism 210 includes the weight 216 and the lock pin 217. As shown in Figs. 7 and 8, the weight 216 and the lock pin 217 switch the state of the floating cam portion 235 between a rotatable state and a fixed state with respect to the cam fixing shaft 244 based on the revolution speed of the engine 7.

[0152] The movement of the lock pin 217 is restricted by the lock pin engaging portion 233b of the lock plate 233.

[0153] In this case, as shown in Fig. 14 (b), the lock plate 233 has an elongated lock pin engaging portion 233b extending along one side of an approximately rectangular support plate 233a.

[0154] If a pair of a weight 216 and a lock pin 217 is provided to the variable valve system 200 as in this embodiment, fuel consumption during normal driving can be improved, toxic substances in exhaust gas can be reduced, and high power output during high speed driving can be achieved. In addition, the variable valve system 200 may be even more compact.

(10-2)

[0155] The variable valve system 200 according to the above described embodiment, the intake high cam 237 and the intake low cam 241 may be switched, so that the lift amount of the intake valve 344 is changed, but the operation angle of the intake valve 344 may be changed instead. Here, the operation angle of the intake valve 344 refers to the range of the crank angle while the intake valve 344 is lifted. In Fig. 13, for example, the operation angle of the intake valve 344 is 260° (from -30° to 230°).

[0156] In this case, the width of the cam nose 237A of the intake high cam 237 is formed to be larger than the width of the cam nose 241A of the intake low cam 241, so that the operation angle of the intake valve 344 during the high revolution period is larger than the operation angle of the intake valve 344 during the low revolution period.

[0157] If the length of the cam nose 237A of the intake high cam 237 is equal to the length of the cam nose 241A of the intake low cam 241, the operation angle of the intake valve 344 may be switched. If the length of the cam nose 237A of the intake high cam 237 is larger than the length of the cam nose 241A of the intake low cam 241 similarly to the embodiment described above, both the lift amount of the intake valve 344 and the operation angle of the intake valve 344 can be switched.

(10-3)

[0158] The variable valve system 200 according to the invention may be applied to the exhaust valve 354.

[0159] In this case, a floating cam portion, a lock pin engaging mechanism, and a cam driven sprocket having the same structures as those of the floating cam portion 235, the lock pin engaging mechanism 230, and the cam driven sprocket 220 are provided in the vicinity of the exhaust valve 354, and an exhaust high cam rocker arm having the same structure as the intake high cam rocker arm 330 is provided.

[0160] In this way, the lift amount of the exhaust valve 354 can be switched.

(10-4)

[0161] In the above-described embodiment, the lock pins 214 and 217 are provided with the two grooves 214a and 217a and the two grooves 214b and 217b, respectively but only one groove may be provided for each pin.

[0162] For example, the lock pin 214 may be provided with only the groove 214a, and the lock pin 217 may be provided with only the groove 217a. In this case, during the low revolution period, the lock pin engaging portions 233b and 233c of the lock plate 233 are fitted to the grooves 214a and 217a in the lock pins 214 and 217, so that the movement of the lock pins 214 and 217 is restricted.

[0163] The lock pin 214 may be provided with only the groove 214b and the lock pin 217 may be provided with only the groove 217b. In this case, during the high revolution period, the lock pin engaging portions 233b and 233c of the lock plate 233 are fitted to the grooves 214b and 217b of the lock pins 214 and 217 and the movement of the lock pins 214 and 217 is restricted.

(10-5)

[0164] In the above described embodiment, the plate shaped lock plate 233 is used as a moving stopping member to restrict the movement of the lock pins 214 and 217, but a moving stopping member in a different shape such as a pin may be used. In this case, the shape of the grooves 214a, 214b, 217a, and 217b formed at the lock pins 214 and 217 may be determined accordingly based on the shape of the moving stopping member.

(10-6)

[0165] In the above-described embodiment, the variable valve system 200 is provided in the SOHC (single overhead camshaft) type engine 7, but the engine 7 including the variable valve system 200 may be of any type as long as the engine can be provided with a camshaft.

[0166] For example, the engine 7 may be an SV (side valve) type engine, an OHV (overhead valve) type engine, or a DOHC (double overhead camshaft) type engine.

(10-7)

[0167] As described above with reference to Figs. 10 to 12, the variable valve system 200 is provided in the engine 7 including the intake high cam rocker arm 330, the intake low cam rocker arm 340, and the exhaust cam rocker arm 350, while the variable valve system 200 may be provided in the type of engine in which a cam directly pushes a valve.

(10-8)

[0168] In the above described embodiment, the variable valve system 200 includes the springs S1 and S2 used to energize the weights 213 and 216 in a prescribed direction. However, a resilient material such as rubber may be employed instead of the springs S1 and S2 as long as it energizes the weights 213 and 216 in the prescribed direction.

(10-9)

[0169] In the embodiment, the motorcycle has been described as a vehicle, but the variable valve system 200 may be provided not only to the motorcycle but also to an engine in a small vehicle with a small displacement such as a tractor and a cart and to an engine in a small ship.

[Industrial Applicability]

[0170] The present invention is applicable to various vehicles including an engine such as a motorcycle and a four-wheeled automobile and crafts including an engine.

Claims

1. A variable valve system adapted to drive a valve in an engine, comprising:

a rotation shaft provided to be rotatable in response to the revolution of said engine;
a first cam member provided to rotate together with said rotation shaft and operating to open/close said valve;
a second cam member provided rotatably with respect to said rotation shaft and operating to open/close said valve;
an engaging member provided to be switchable between a first state in which said second cam member is allowed to rotate with respect to said rotation shaft and a second state in which said second cam member is engaged to said rotation shaft;
an energizing member that generates energizing force that switches said engaging member to said first state; and
a driving member that operates to switch said engaging member to said second state against the energizing force by said energizing member by centrifugal force generated by the rotation of said rotation shaft,
said first cam member operating to open/close said valve when said engaging member is in said first state, said second cam member operating to open/close said valve when said engaging member is in said second state.

2. The variable valve system according to claim 1, wherein said driving member is provided pivotably from a first position to a second position by centrifugal force generated by the rotation of said rotation shaft,
said engaging member is provided movably in one direction along said rotation shaft as said driving member pivots from said first position to said second position,
said energizing member applies energizing force to said driving member so that said driving member is moved toward said first position, and
said engaging member attains said first state when said driving member is in said first position and said second state when said driving member is in said second position.

3. The variable valve system according to claim 1, wherein said engaging member has an engaging portion,
said second cam member has an engagement portion to be engaged by said engaging portion of said engaging member,
said engaging portion is disengaged from said engagement portion when said engaging member is in said first state, and
said engaging portion engages said engagement portion when said engaging member is in said second state.

4. The variable valve system according to claim 3, wherein said engaging member includes a rod-shaped member, said engaging portion is an end of said rod-shaped member, and
said engagement portion of said second cam member is a hole to which the end of said rod-shaped member can be fitted.

5. The variable valve system according to claim 4, wherein said engaging member is a plurality of rod-shaped members, said engagement portion of said second cam member is a plurality of holes to which ends of said plurality of rod-shaped members can be fitted, and
said plurality of rod-shaped members are provided in asymmetric positions with one another with respect to the center of said rotation shaft.

6. The variable valve system according to claim 1, further comprising a movement stopping member that prevents the movement of said engaging member when said engaging member is in at least one of said first state and said second state.

7. The variable valve system according to claim 6, wherein said engaging member has at least one groove, and
said movement stopping member has a fitting portion that can be fitted to said groove when said engaging member is in at least one of said first state and said second state.

8. The variable valve system according to claim 7, wherein said groove of said engaging member and said fitting portion of said movement stopping member are formed so that said fitting portion can be withdrawn from said at least one groove at least one of when said engaging member switches from said first state to said second state and when said engaging member switches from said second state to said first state.

9. The variable valve system according to claim 1, further comprising a first transmission member that swings in response to the rotation of said first cam member and moves said valve up and down, and
a second transmission member that swings said first transmission member in response to the rotation of said second cam member.

10. The variable valve system according to claim 1, wherein said first cam member operates to open said valve with a first lift amount in said first state, and
said second cam member operates to open said valve with a second lift amount larger than said first lift amount in said second state.

11. The variable valve system according to claim 1, wherein said first cam member operates to open said valve with a first operation angle in said first state, and
said second cam member operates to open said valve with a second operation angle larger than said first operation angle in said second state.

12. The variable valve system according to claim 1, wherein said valve is an intake valve.

13. An engine device, comprising:

an engine having a valve; and
a variable valve system adapted to drive said valve in said engine,
said variable valve system including:

a rotation shaft provided to be rotatable in response to the rotation of said engine;
a first cam member provided to rotate together with said rotation shaft and operating to open/close said valve;
a second cam member provided rotatably with respect to said rotation shaft and operating to open/close said valve;
an engaging member provided to be switchable between a first state in which said second cam member is allowed to rotate with respect to said rotation shaft and a second state in which said second cam member is engaged to said rotation shaft;
an energizing member that generates energizing force that switches said engaging member to said first state; and
a driving member that operates to switch said engaging member to said second state against the energizing force by said energizing member by centrifugal force generated by the rotation of said rotation shaft,
said first cam member operating to open/close said valve when said engaging member is in said first state, said second cam member operating to open/close said valve when said engaging member is in said second state.

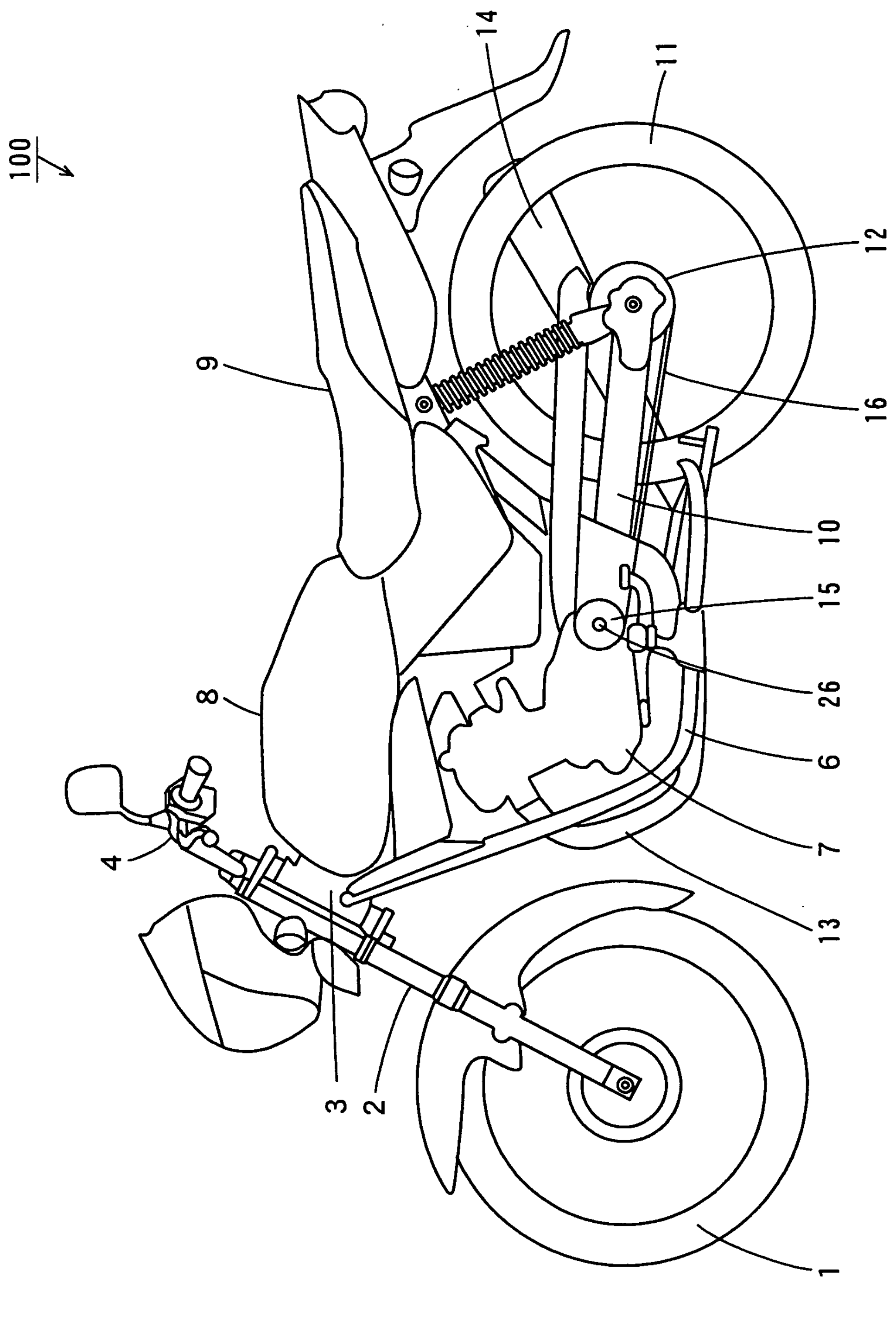
14. A vehicle, comprising:

an engine device;
a driving wheel; and
a transmission mechanism that transmits motive power generated by said engine device to said driving wheel,
said engine device including:

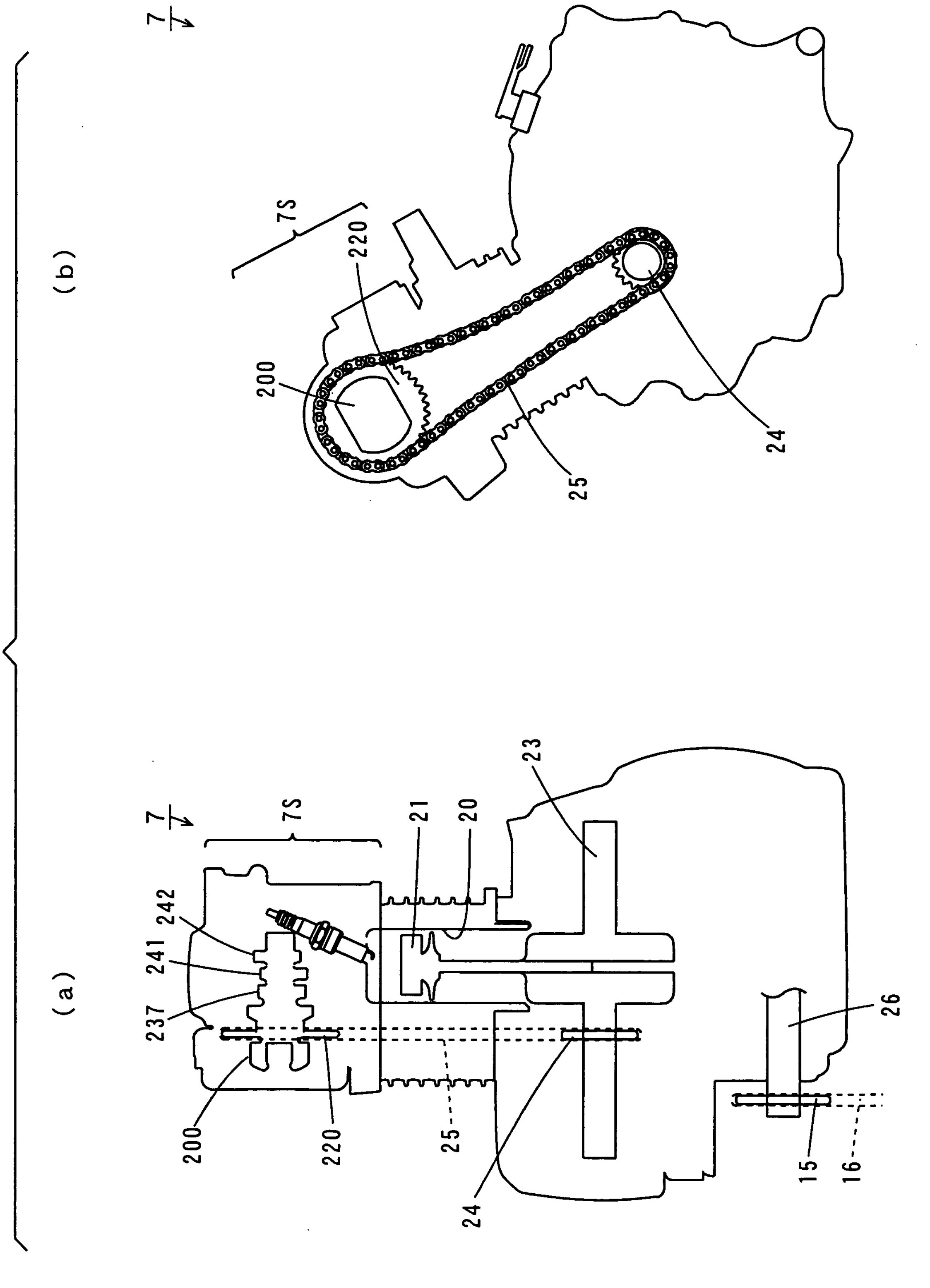
an engine having a valve; and
a variable valve system adapted to drive said valve in said engine,
said variable valve system including:

a rotation shaft provided to be rotatable in response to the rotation of said engine;
a first cam member provided to rotate together with said rotation shaft and operating to open/close said valve;
a second cam member provided rotatably with respect to said rotation shaft and operating to open/close said valve;
an engaging member provided to be switchable between a first state in which said second cam member is allowed to rotate with respect to said rotation shaft and a second state in which said second cam member is engaged to said rotation shaft;
an energizing member that generates energizing force that switches said engaging member to said first state; and
a driving member that operates to switch said engaging member to said second state against the energizing

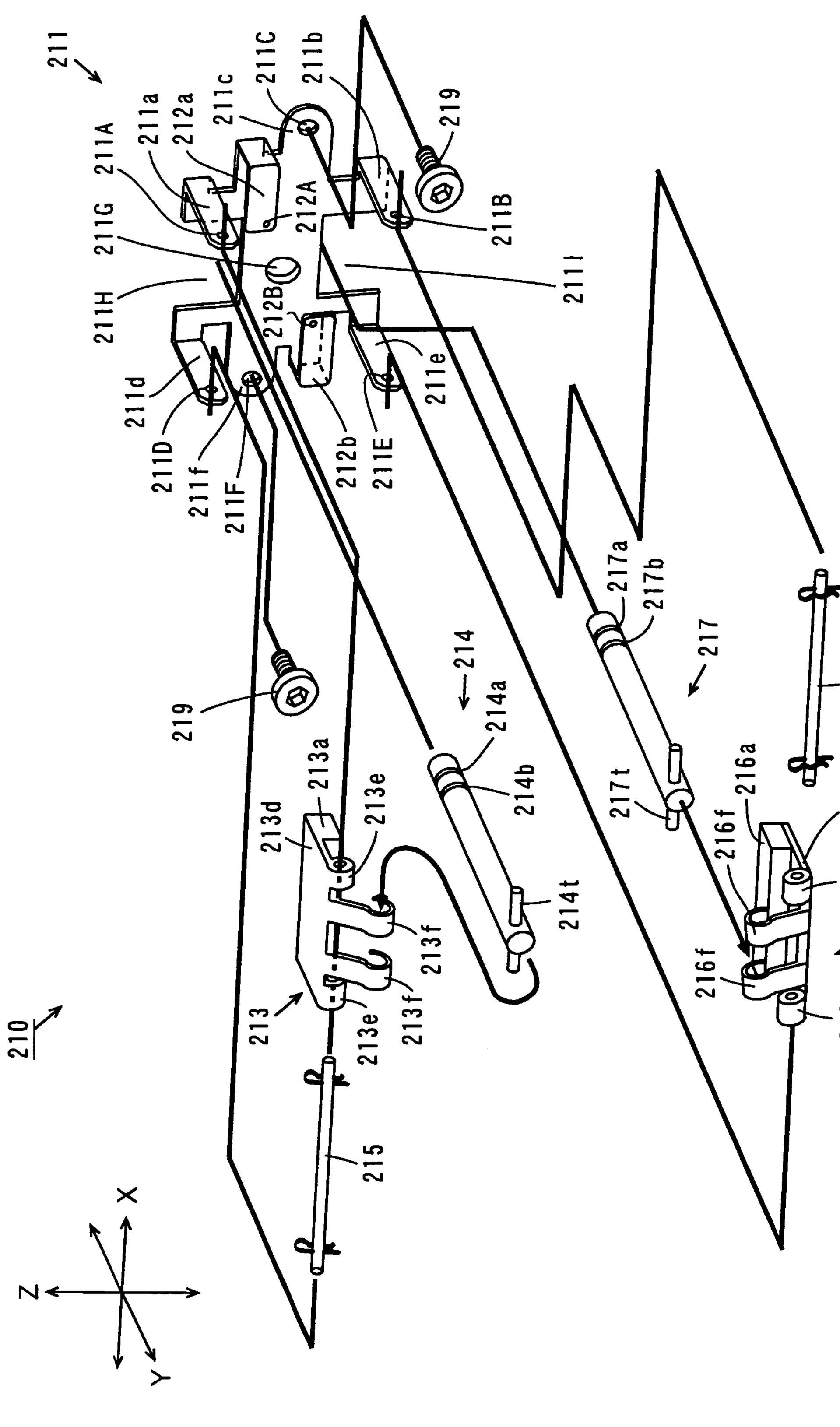
force by said energizing member by centrifugal force generated by the rotation of said rotation shaft,
said first cam member operating to open/close said valve when said engaging member is in said first state,
said second cam member operating to open/close said valve when said engaging member is in said second state.



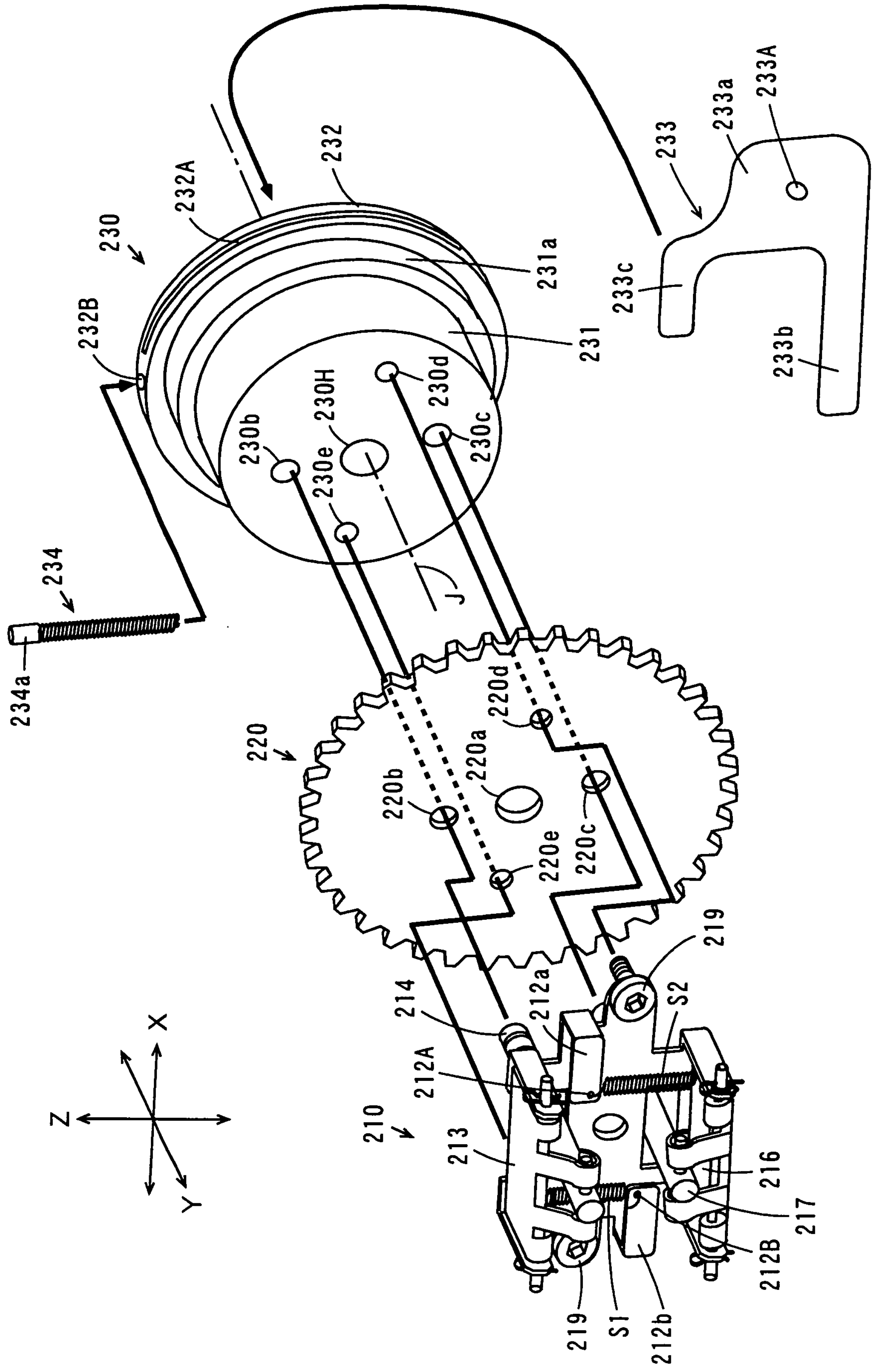
F I G. 1



F I G. 2

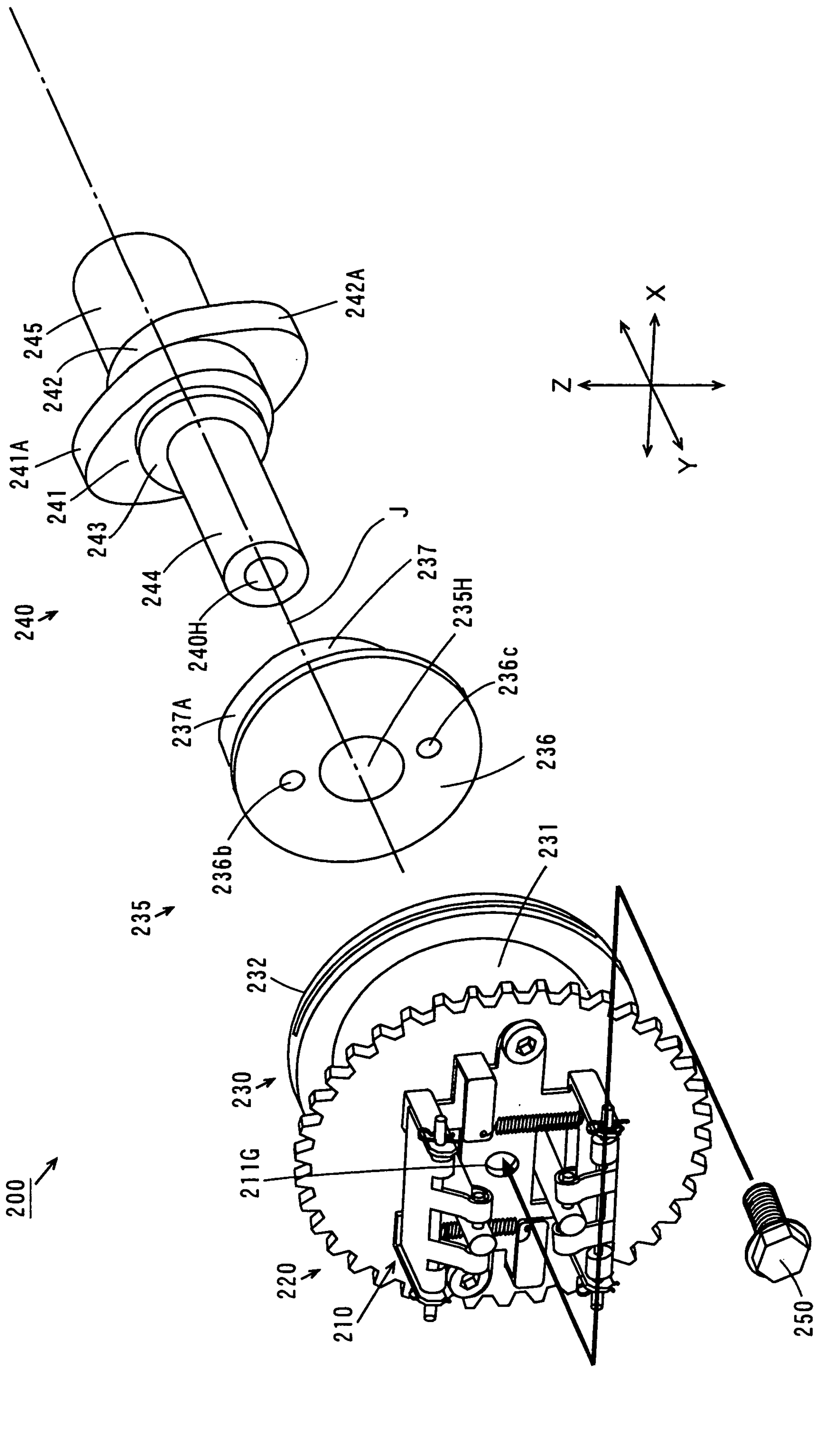

211
211A
211a
212a
211c
211C
211b
219
211G
212A
211B
211H
212B
211I
211d
211D
211f
211F
212b
211E
211e
217a
217b
217
218
214
214a
214b
214t
219
213a
213d
213e
213f
213
213e
213f
217t
216a
216f
216d
216e
216f
216e
216
210
215
X
Z
Y

F I G. 3



230
232B
232A
232
231a
231
230b
230H
230d
230e
230c
233
233a
233A
233c
233b
234
234a
J
220
220a
220b
220d
220e
220c
219
214
212a
212A
S2
210
213
216
217
212B
219
S1
212b
X
Z
Y

F I G. 4


200
245
242
242A
241A
241
243
244
240
240H
J
237
235H
236c
237A
236
236b
235
231
232
230
211G
220
210
250
X
Y
Z

F I G. 5

FIG. 6

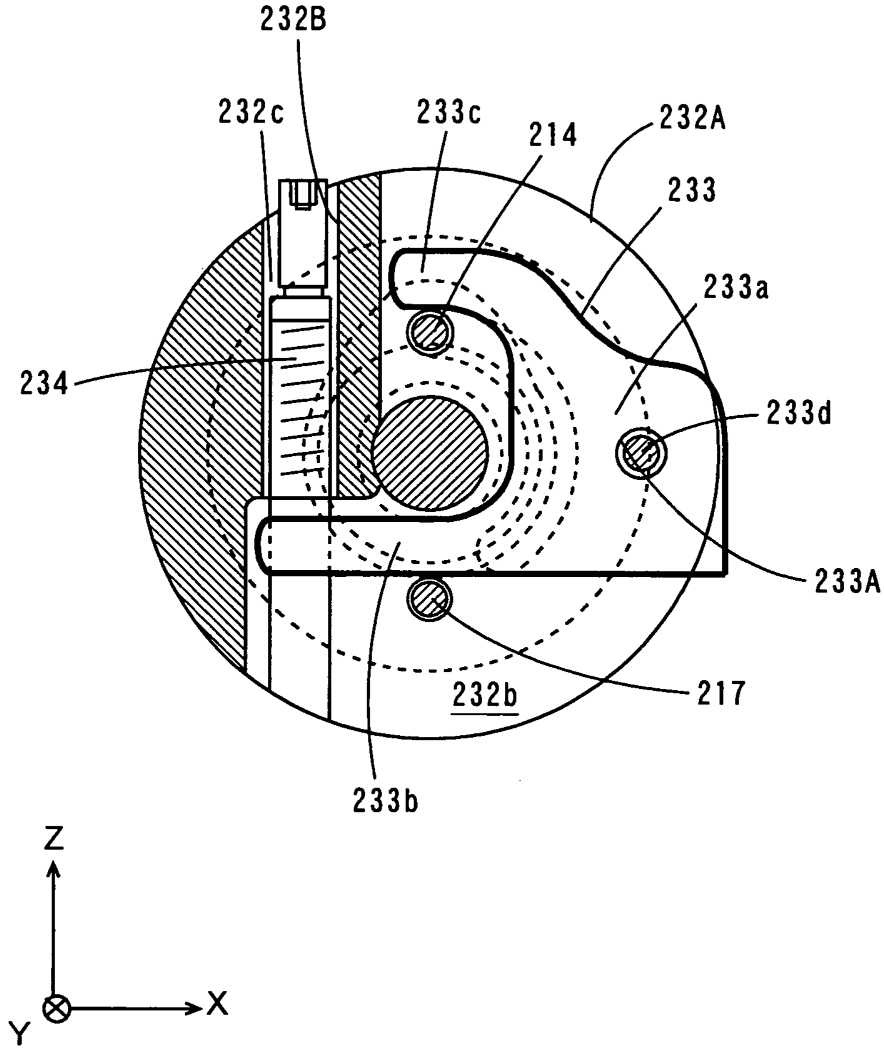
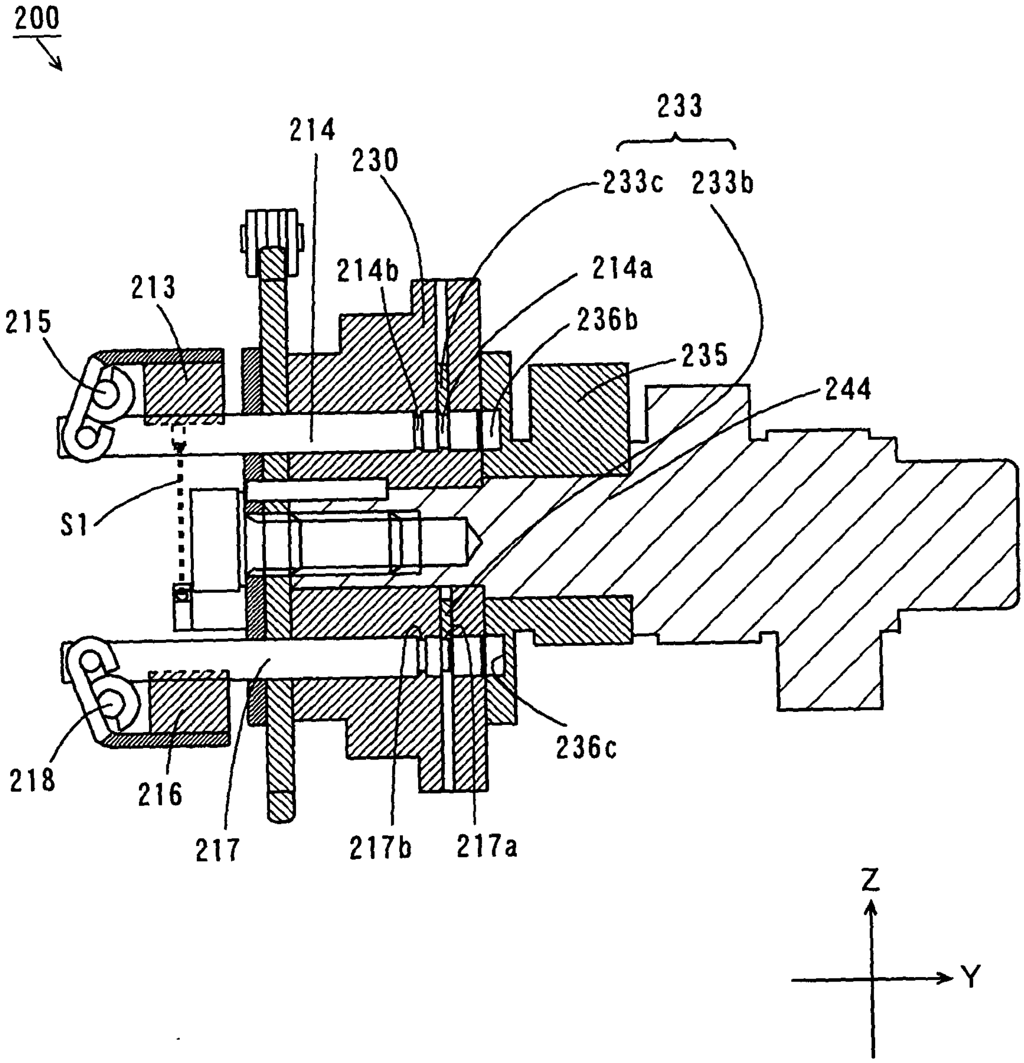
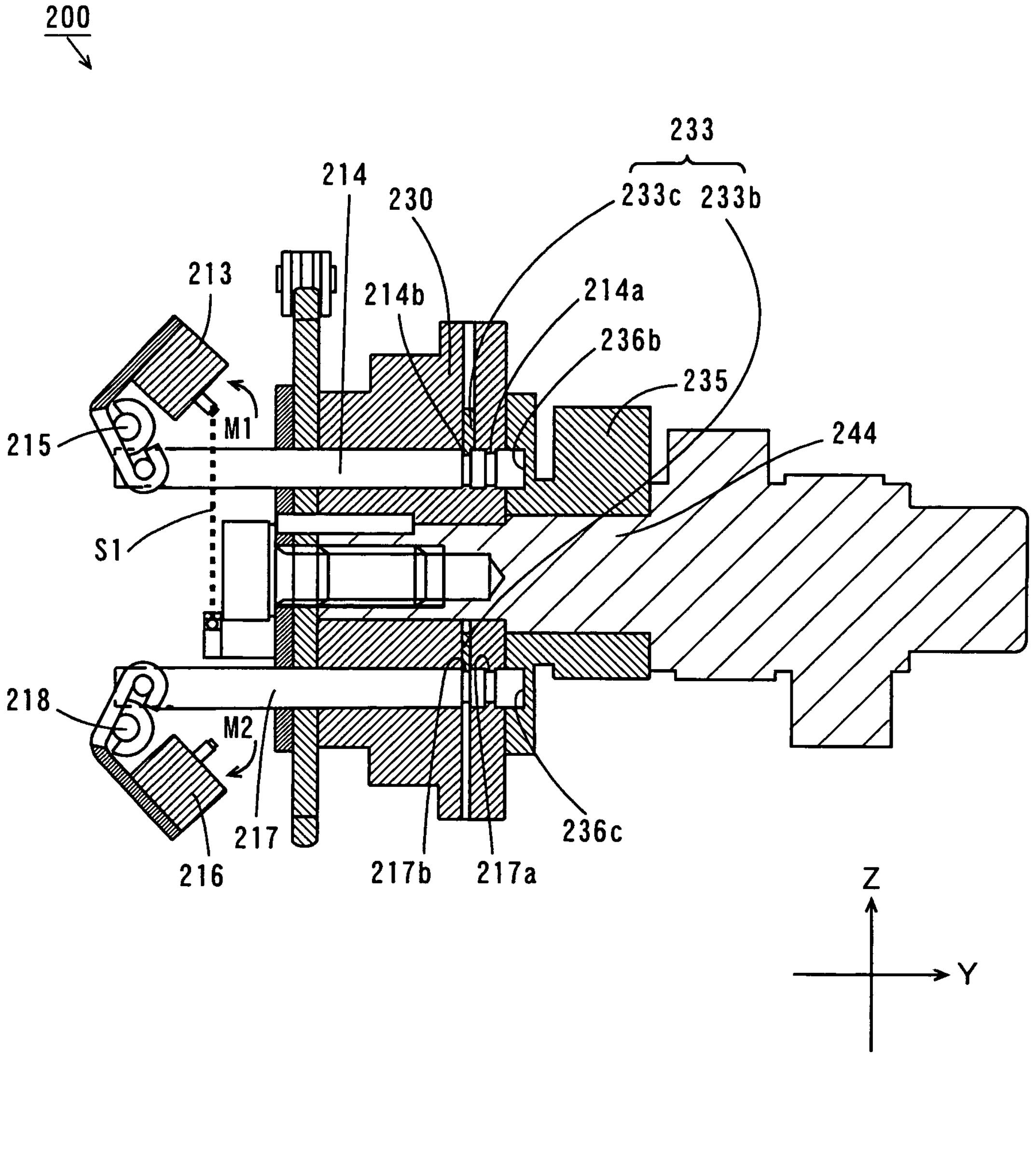

232B
232c
233c
214
232A
233
233a
234
233d
233A
217
232b
233b
Z
X
Y

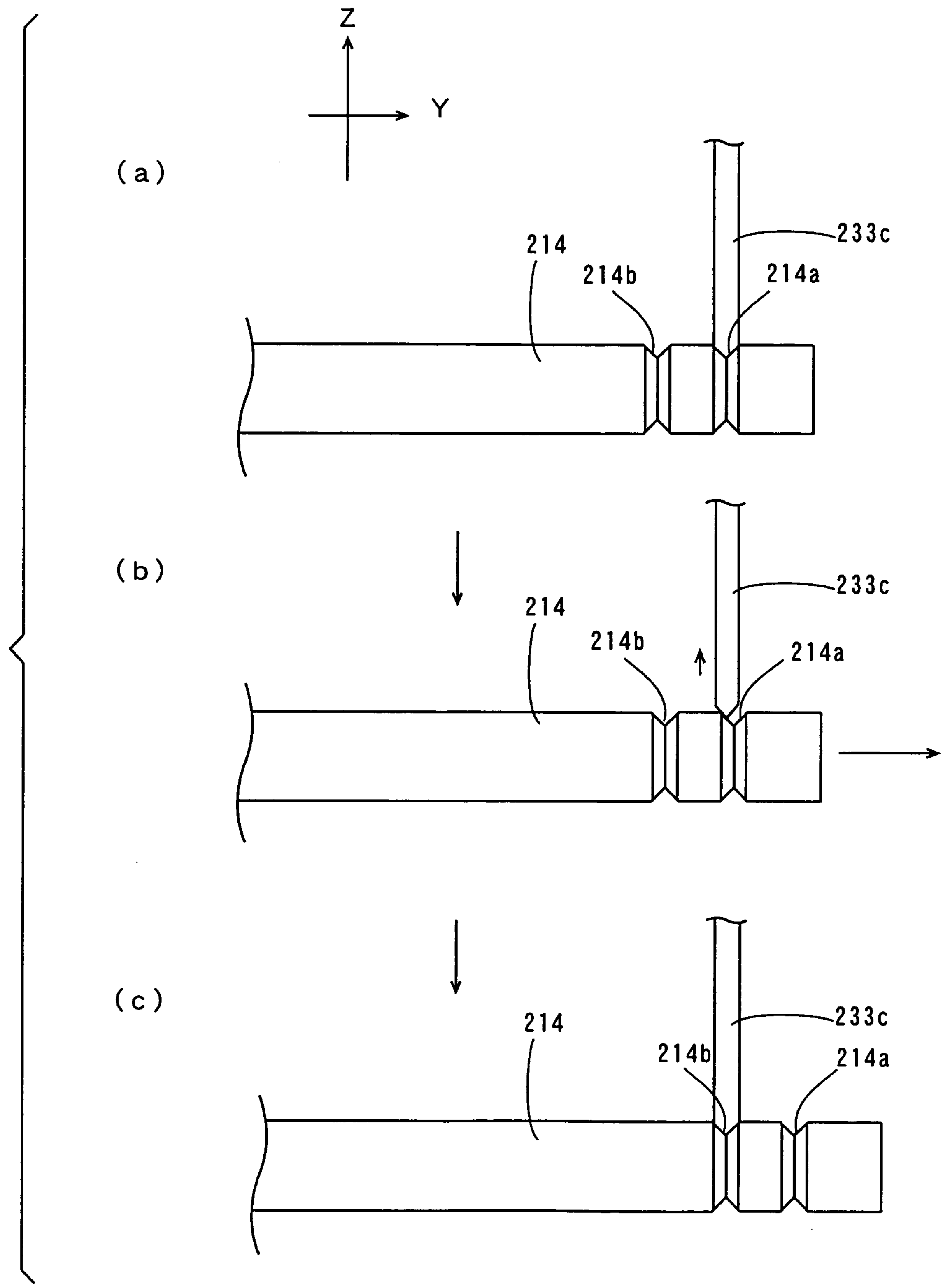
FIG. 7


200
233
214
230
233c
233b
214b
214a
213
236b
215
235
244
S1
236c
218
216
217
217b
217a
Z
Y

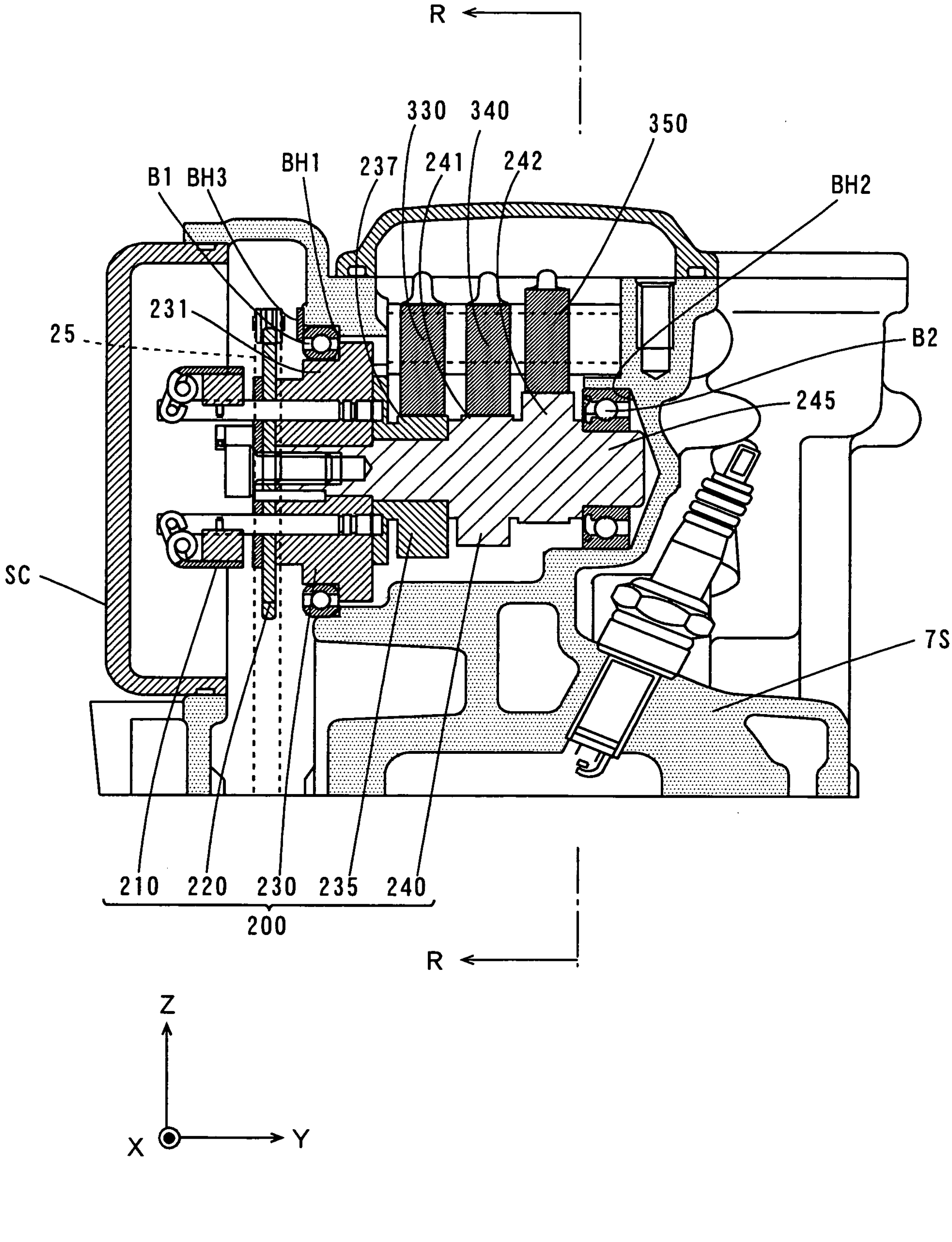
F I G. 8

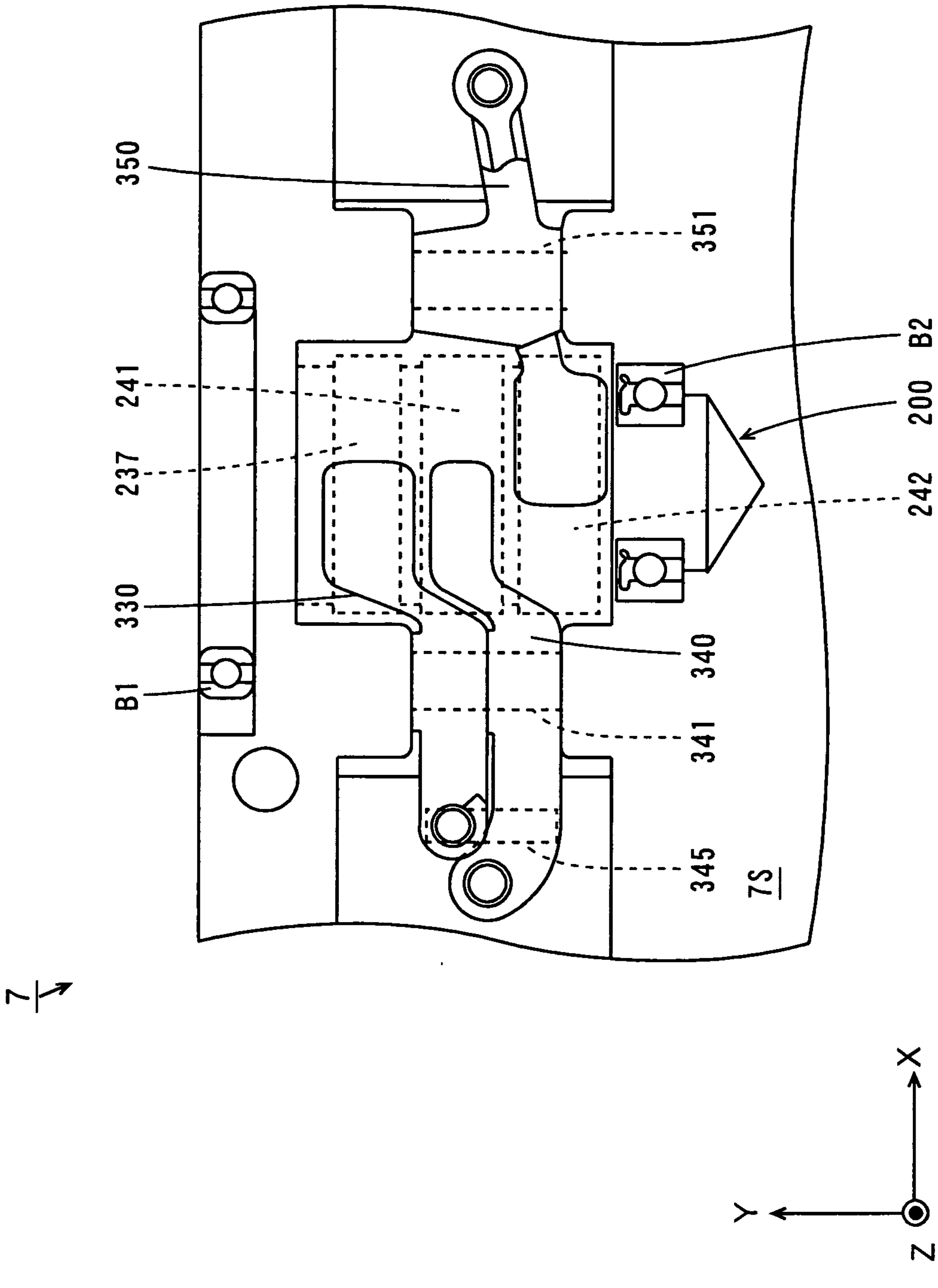

200
233
214
230
233c
233b
213
214b
214a
236b
235
M1
215
244
S1
218
M2
217
216
217b
217a
236c
Z
Y

F I G. 9


Z
Y
(a)
214
214b
214a
233c
(b)
214
214b
214a
233c
(c)
214
214b
214a
233c

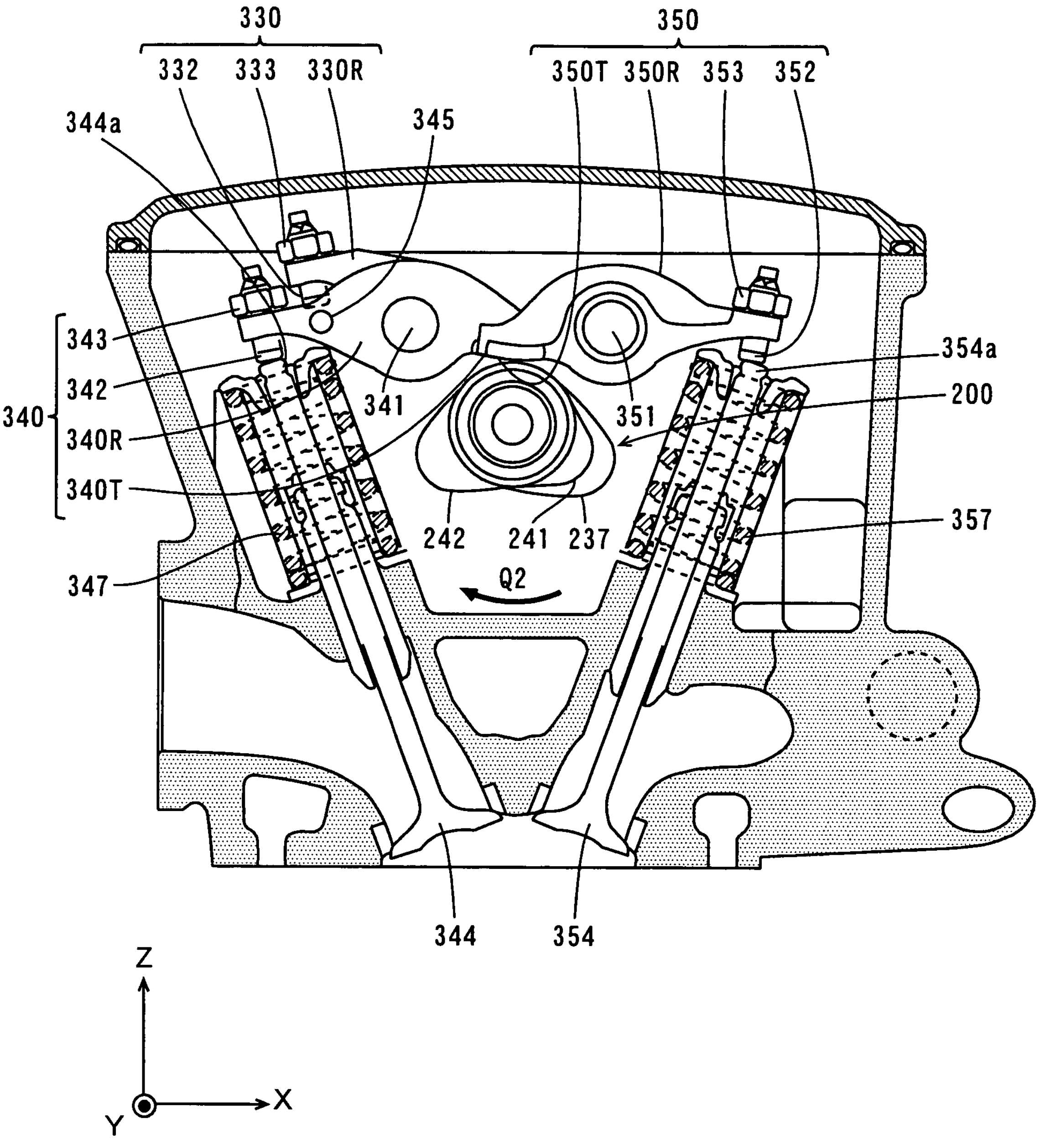
F I G. 1 0


R
R
330
340
350
B1
BH3
BH1
237
241
242
BH2
231
25
B2
245
SC
7S
210
220
230
235
240
200
Z
X
Y

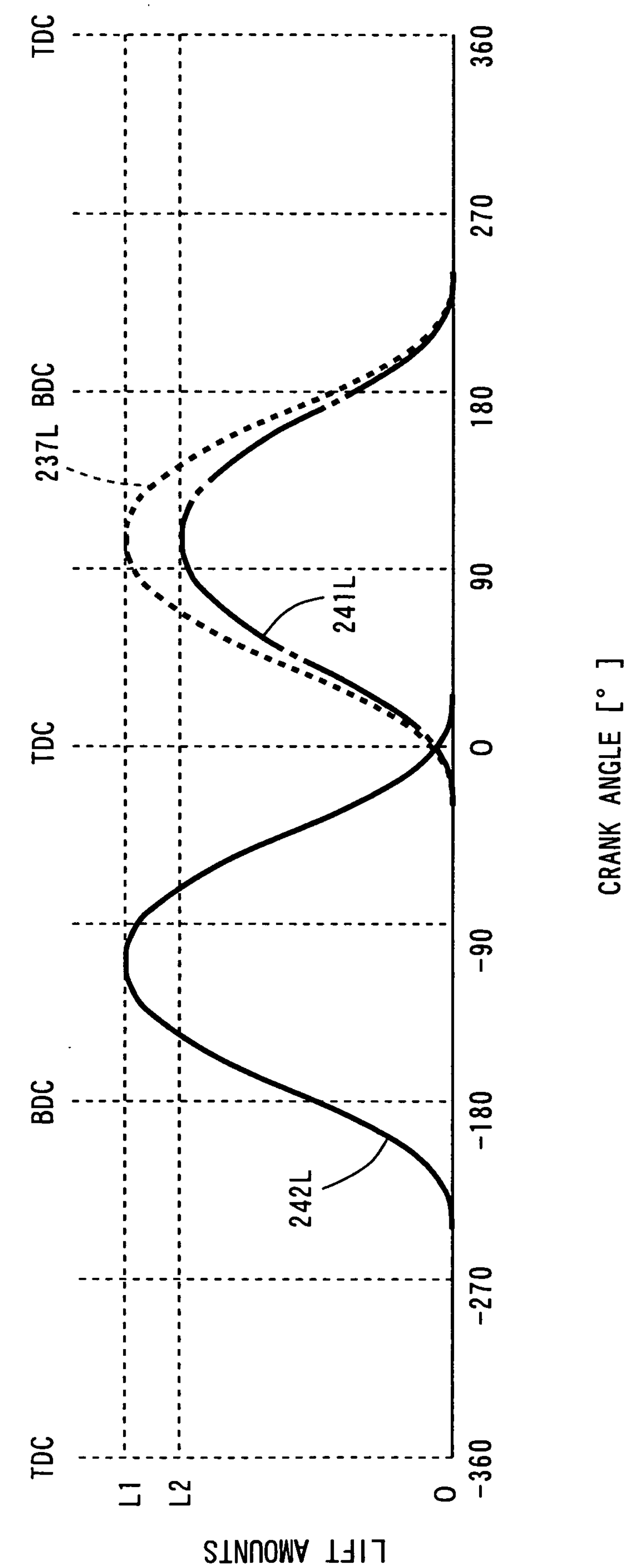


F I G. 1 1

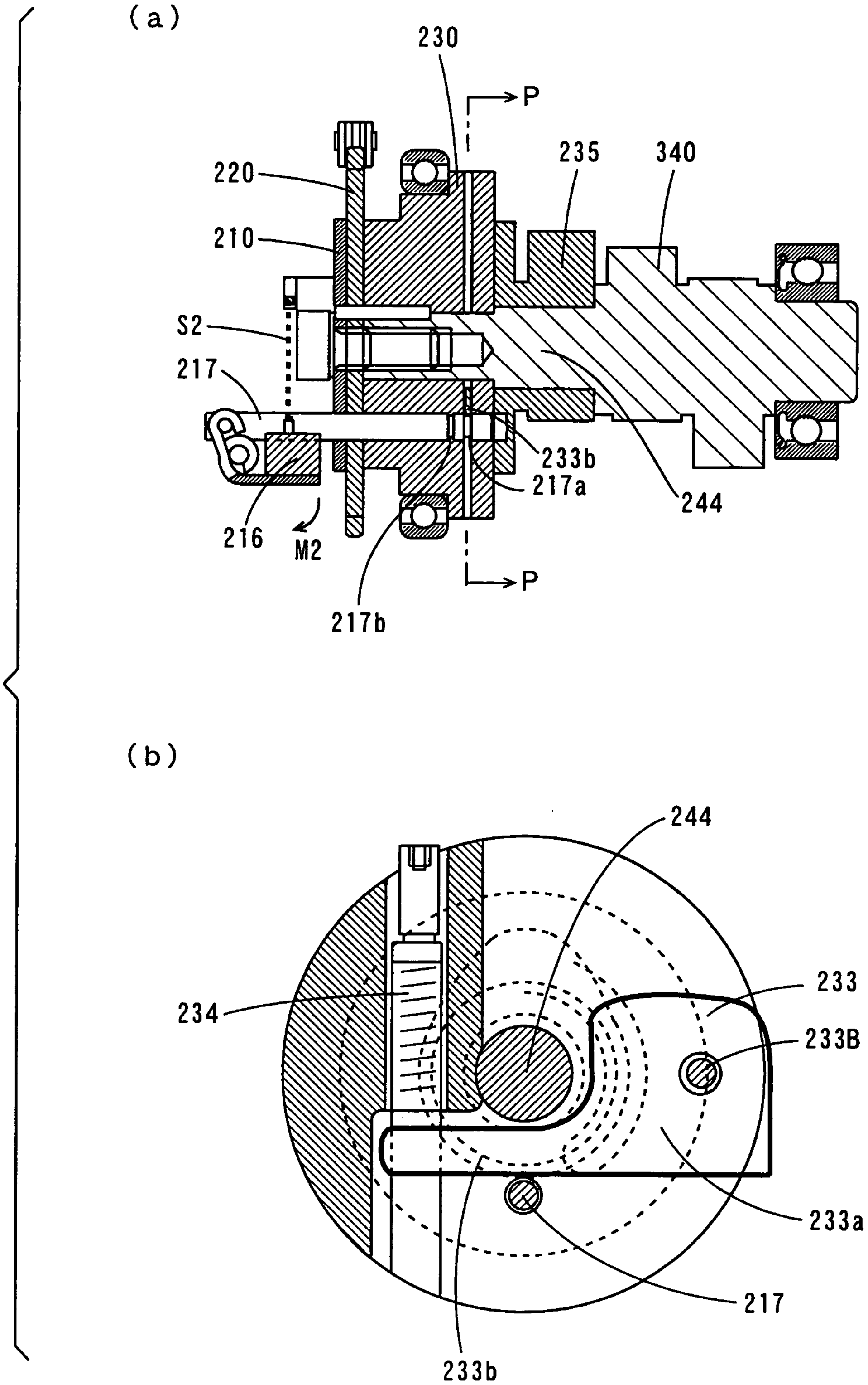
FIG. 12


330
332
333
330R
350
350T
350R
353
352
344a
345
343
342
340
340R
340T
347
341
351
354a
200
242
241
237
357
Q2
344
354
Z
Y
X

F I G. 1 3


TDC
BDC
TDC
BDC
TDC
237L
241L
242L
L1
L2
0
LIFT AMOUNTS
-360
-270
-180
-90
0
90
180
270
360
CRANK ANGLE [°]

F I G. 1 4


(a)
230
P
220
235
340
210
S2
217
233b
217a
244
216
M2
P
217b
(b)
244
233
234
233B
233a
217
233b

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2006/322722

A. CLASSIFICATION OF SUBJECT MATTER
F01L13/00(2006.01)i, *F01L1/12*(2006.01)i

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)
F01L13/00, F01L1/12

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	1996-2007
Kokai Jitsuyo Shinan Koho	1971-2007	Toroku Jitsuyo Shinan Koho	1994-2007

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.
X A	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 100731/1983(Laid-open No. 8402/1985) (Mitsubishi Motors Corp.), 21 January, 1985 (21.01.85), Page 8, line 8 to page 12, line 13; Figs. 2 to 3 (Family: none)	1-3,10-14 4-9

☒ 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 08 February, 2007 (08.02.07)	Date of mailing of the international search report 20 February, 2007 (20.02.07)
Name and mailing address of the ISA/ Japanese Patent Office Facsimile No.	Authorized officer Telephone No.

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

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2006/322722

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 84381/1979(Laid-open No. 2004/1981) (Yanmar Diesel Engine Co., Ltd.), 09 January, 1981 (09.01.81), Page 4, line 11 to page 7, line 14 (Family: none)	1-14
A	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 52317/1988(Laid-open No. 157208/1989) (Suzuki Motor Co., Ltd.), 30 October, 1989 (30.10.89), Full text; all drawings (Family: none)	1-14
A	JP 11-229831 A (Honda Motor Co., Ltd.), 24 August, 1999 (24.08.99), Par. Nos. [0030] to [0036]; Figs. 1 to 10 (Family: none)	1-14

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

REFERENCES CITED IN THE DESCRIPTION

Patent documents cited in the description

- JP 9256827 A **[0005]**