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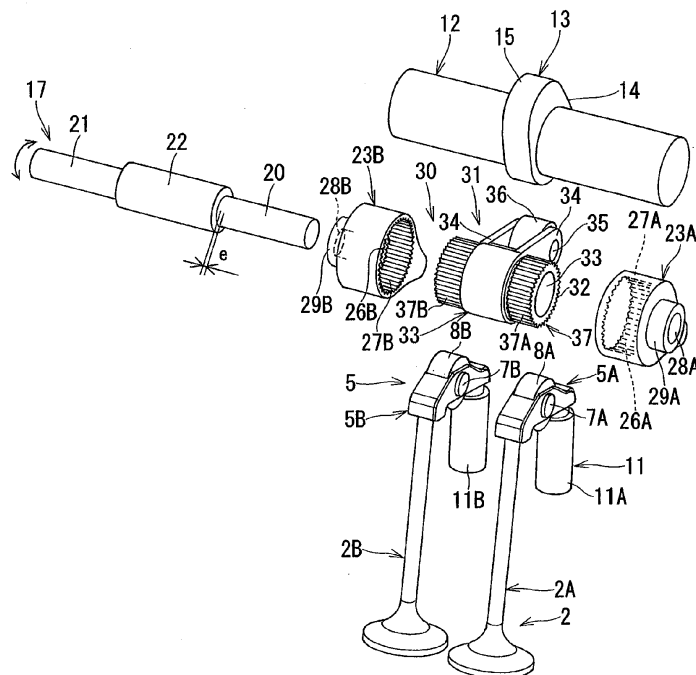
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80796 München (DE)**(54) Variable valve operating system for internal combustion engine**

(57) A variable valve operating system includes a circular eccentric portion (22) provided for a control shaft (17), an external gear formed on a cam follower (31) swingably supported on the eccentric shaft portion, and an internal gear formed on a rocking cam (23) so as to be engaged with the external gear. The external gear is

revolved by the eccentric shaft portion (22) around the axis of the control shaft (17), an engaged portion of the internal gear with the external gear is moved in a circumferential direction of the internal gear by the revolution of the external gear, and the position of the rocking cam (23) with respect to the cam follower (31) is changed by the movement of the engaged portion of the internal gear.

**FIG. 2**

Description**BACKGROUND OF THE INVENTION****Field of the Invention**

[0001] The present invention relates to a variable valve operating system for an internal combustion engine, and more particularly, to a variable valve operating system for an internal combustion engine which continuously changes lift characteristics of an engine valve.

Related Art

[0002] In a conventional art, in order to continuously change lift amount and operating angle of an engine valve according to an operating state of an internal combustion engine, there has been provided a vehicle internal combustion engine including a variable valve operating system. The variable valve operating system swingably supports a rocking cam which lifts the engine valve on a control shaft, couples a cam follower, which is rocked by a rotating cam of a camshaft and rocks the rocking cam, to the rocking cam through a position changing mechanism, and changes lift characteristics of the engine valve by changing a relative positional relationship of the rocking cam with respect to the cam follower by the position changing mechanism.

[0003] According to the variable valve operating mechanism for internal combustion engine and intake air amount control device disclosed in Patent Document 1 (Japanese Patent No. 3799944), for example, a relative phase difference between an input portion and an output portion of an intermediary drive mechanism is changed. That is, a phase difference between a rocker arm for inputting from a cam to a control shaft different from a camshaft and a rocking cam for outputting to a roller rocker arm is changed by engagement of a helical spline. At this time, axial movement of the control shaft achieves and realizes a change in engagement of the helical spline.

[0004] However, in a conventional structure such as disclosed in the above Patent Document 1, the variable valve operating mechanism for the internal combustion engine provides a matter to be solved such that the phase is controlled by the axial movement of the control shaft, and thus, an error in a valve lift between cylinders increases with the temperature difference of the internal combustion engine. This is because the cylinder head is made of aluminum and the control shaft is made of iron, both of which are components or parts of the variable valve operating mechanism, so that the change in length due to temperature change differs between the cylinder head and the control shaft.

[0005] Further, it is difficult to manufacture the helical spline, which may cause an increase in cost, thus being inconvenient and disadvantageous.

[0006] Furthermore, in the above configured variable valve operating system, although the valve lift amount is

advantageously variable, the cam timing for operating the engine valve is fixed, which may likely cause disadvantageous matter in terms of performance.

SUMMARY OF THE INVENTION

[0007] The present invention was conceived in consideration of the circumstances mentioned above and an object of the present invention is to provide a variable valve operating system for an internal combustion engine capable of eliminating variations in lift characteristics for each engine valve due to the thermal expansion difference between structural components or parts as well as improving manufacturability of the internal combustion engine.

[0008] The above and other objects can be achieved according to the present invention by providing, in one preferable aspect, a variable valve operating system for an internal combustion engine including an engine valve and a cam shaft operating the engine valve, the variable valve operating system comprising:

a rocking cam, which lifts the engine valve, supported to a control shaft to be swingable;

a cam follower rocking the rocking cam;

a position changing mechanism which couples the cam follower with the rocking cam, the position changing mechanism being configured to change a relative positional relationship of the rocking cam with respect to the cam follower to thereby change lift characteristics of the engine valve,

[0009] the position changing mechanism comprising: a circular eccentric portion which is formed to the control shaft in a manner decentered from an axis of the control shaft; an external gear formed on the cam follower swingably supported on the eccentric shaft portion with the eccentric shaft portion as the rotating shaft; and an internal gear formed on the rocking cam with the control shaft as the rotating shaft so as to be engaged with the external gear,

[0010] wherein the control shaft is rotated when opening/closing characteristics of the engine valve are changed, the external gear is revolved by the eccentric shaft portion around the axis of the control shaft, an engaged portion of the internal gear with the external gear is moved in a circumferential direction of the internal gear by the revolution of the external gear, and the position of the rocking cam with respect to the cam follower is changed by the movement of the engaged portion of the internal gear.

[0011] In a preferred embodiment of the above aspect of the present invention, it may be desired that when the control shaft is rotated, the cam follower moves such that a contact point to the rotating cam moves along an outer circumference of the rotating cam and the movement of the rocking cam causes a lift amount of the engine valve to be changed, and when the control shaft is rotated in

a direction to reduce the lift amount of the engine valve, the contact point between the cam follower and the rotating cam moves in a direction opposite to the rotating direction of the rotating cam.

[0012] It may be also desired that the rocking cam includes a base circle portion which prevents the engine valve from being lifted and a cam portion which is projected radially from the base circle portion, a hollow portion is formed on an inner circumference of the base portion, the internal gear is formed on an inner circumference surface of the hollow portion, and the external gear and the eccentric shaft portion are arranged inside the hollow portion.

[0013] According to the present invention of the characters mentioned above, it becomes possible to effectively eliminate variations in lift characteristics for each engine valve due to the thermal expansion difference between parts and improve manufacturability, thus being effective and advantageous.

[0014] The nature and further characteristic features of the present invention will be made clearer from the following descriptions made with reference to the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015] In the accompanying drawings:

Fig. 1 is a perspective view of a variable valve operating system for an internal combustion engine according to an embodiment of the present invention; Fig. 2 is an exploded view of the variable valve operating system for the internal combustion engine according to the embodiment;

Fig. 3 is a sectional view of the variable valve operating system for the internal combustion engine according to the embodiment, taken along the line III-III in Fig. 1;

Fig. 4 illustrates an operation of an engine valve and includes Fig. 4A representing an engine valve operation under small lift and non-operating conditions, and Fig. 4B representing the engine valve operation under small lift and operating conditions;

Fig. 5 illustrates an operation of an engine valve and includes Fig. 5A representing an engine valve operation under large lift and non-operating conditions, and Fig. 5B representing the engine valve operation under large lift and operating conditions; and

Fig. 6 is a graph representing a relationship between a lift amount and an opening/closing timing of the engine valve according to the embodiment of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

[0016] A variable valve operating system for an internal combustion engine according to a preferred embodiment of the present invention will be described hereunder with

reference to the accompanying drawings for achieving an object mentioned hereinbefore.

[0017] Further, it is to be noted that, in the following description with reference to the illustrated embodiment, a crank (crankshaft) axial direction of an internal combustion engine 1 (Fig. 3) is called "a front-back (longitudinal) direction", a cylinder axial direction is called "a vertical direction", and a direction perpendicular to the crank axial direction and cylinder axial direction is called "a lateral direction", and furthermore, it is also noted that terms "upper", "lower", "right", "left" and the like terms are used herein with reference to the illustrated embodiment and in an actually arranged state of the internal combustion engine.

[0018] With reference to Figs. 1 to 3, an internal combustion engine 1 includes an engine valve 2 having an intake valve and an exhaust valve for opening and closing an intake port and an exhaust port communicated with a combustion chamber of a cylinder head. As illustrated in Fig. 3, in a front view, the engine valve 2 has an axial line C inclined at a predetermined angle and supported on the cylinder head so as to be vertically movable.

[0019] The engine valve 2 includes one side engine valve 2A arranged on a front side and the other side engine valve 2B arranged on a rear side, which are arranged side by side one another.

[0020] The one side (front side) engine valve 2A includes one side (front side) valve head 3A having a distal end portion detachably connected to a port opening, and this one side valve stem 4A having a distal end side continuously connected to the one side valve head 3A. The other side (rear side) engine valve 2B includes the other side (rear side) valve head 3B having a distal end portion detachably connected to the port opening, and the other side valve stem 4B having a distal end side continuously connected to the other side valve head 3B.

[0021] Further, the one side valve head 3A and the other side valve head 3B constitute a valve head 3, and the one side valve stem 4A and the other side valve stem 4B constitute a valve stem 4.

[0022] The internal combustion engine 1 further includes a roller finger follower (RFF: rocker arm) 5 which opens and closes the engine valve 2 in accordance with the axial (upward/ downward) movement thereof.

[0023] The roller finger follower 5 includes one side roller finger follower 5A corresponding to the one side engine valve 2A, and the other side roller finger follower 5B corresponding to the other side engine valve 2B.

[0024] The one side roller finger follower 5A includes: one side arm portion 6A arranged so as to be oriented in a horizontal direction and a left/right direction, one side roller shaft 7A supported at a central portion of the one side arm portion 6A; one side roller 8A mounted to the one side roller shaft 7A to be rotatable; one side valve abutting portion 9A formed at a left end portion of the one side arm portion 6A; and one side adjuster support portion 10A formed at a right end portion of the one side arm portion 6A. This one side adjuster support portion 10A is

supported on a top spherical portion of one side hydraulic lash adjuster portion 11A.

[0025] In the like manner, the other side roller finger follower 5B includes: the other side arm portion 6B arranged so as to be oriented in a horizontal direction and a left/right direction; one side roller shaft 7B supported on a central portion of the other side arm portion 6B; the other side roller 8B mounted to the other side roller shaft 7B to be rotatable; the other side valve abutting portion 9B formed at a left end portion of the other side arm portion 6B; and the other side adjuster support portion 10B formed at a right end portion of the other side arm portion 6B. This other side adjuster support portion 10B is supported on a top spherical portion of the other side hydraulic lash adjuster portion 11B.

[0026] In this illustrated structure, the one side arm portion 6A and the other side arm portion 6B constitute an arm portion 6. The one side roller shaft 7A and the other side roller shaft 7B constitute a roller shaft 7. The one side roller 8A and the other side roller 8B constitute a roller 8. The one side adjuster support portion 10A and the other side adjuster support portion 10B constitute an adjuster support 10. The one side hydraulic lash adjuster portion 11A and the other side hydraulic lash adjuster portion 11B constitute a hydraulic lash adjuster 11.

[0027] A camshaft 12 is arranged so as to be supported on the cylinder head of the internal combustion engine 1 in a forward-backward direction and to be rotatable in synchronism with a crankshaft of the internal combustion engine 1 to thereby drive the engine valve 2.

[0028] A rotating cam 13 is integrally mounted on the camshaft 12, and the rotating cam 13 includes a base circle portion 14 and a cam portion 15 projected radially from the base circle portion 14.

[0029] The internal combustion engine 1 further includes a variable valve operating system 16 which changes lift characteristics of the engine valve 2.

[0030] As illustrated in Figs. 1 to 3, the variable valve operating system 16 includes a control shaft 17 arranged between the engine valve 2 and the camshaft 12 longitudinally in parallel with the camshaft 12. The control shaft 17 is rotated and controlled by an actuator 18 including an electric motor. The actuator 18 is driven and controlled by a control unit 19.

[0031] As illustrated in Figs. 2 and 3, the control shaft 17 includes: one side shaft portion 20 with a predetermined diameter at a front end portion thereof; the other side shaft portion 21 with the same diameter as that of the one side shaft portion 20 at a rear end portion thereof; and a circular eccentric shaft portion 22 arranged between the one side shaft portion 20 and the other side shaft portion 21, having a larger diameter than that of the one side shaft portion 20 and the other side shaft portion 21, with its shaft center decentered by a predetermined eccentric amount (offset) "e" from the one side shaft portion 20 and the other side shaft portion 21. The one side shaft portion 20, the other side shaft portion 21, and the circular eccentric shaft portion 22 are integrally connect-

ed.

[0032] More specifically, a shaft center O2 of the eccentric shaft portion 22 is set eccentrically so as to be decentered radially by an eccentric amount "e" from a shaft center O1 of the one side shaft portion 20 and the other side shaft portion 21, and the eccentric shaft portion 22 is eccentrically rotated around the shaft center O1 of the one side shaft portion 20 and the other side shaft portion 21.

[0033] The control shaft 17 is mounted with a rocking cam 23 in a swingable manner so as to be capable of lifting the engine valve 2.

[0034] The rocking cam 23 includes one side rocking cam member 23A attached to the one side shaft portion 20 and the other side rocking cam member 23B attached to the other side shaft portion 21.

[0035] The one side rocking cam member 23A includes one side base circle portion 24A which prevents the one side engine valve 2A from being lifted; and one side cam portion 25A which is projected radially from the one side base circle portion 24A and causes the one side engine valve 2A to be lifted.

[0036] As illustrated in Fig. 2, one side hollow portion 26A having an internal diameter larger than a diameter of the one side shaft portion 20 is formed on an inner circumferential surface of the one side base circle portion 24A, and one side internal gear piece 27A as a spur gear is formed on an inner circumferential surface of the one side hollow portion 26A. The center of the one side base circle portion 24A is coaxially aligned with that of the one side shaft portion 20.

[0037] Furthermore, one side support portion 29A having one side shaft hole 28A through which the one side shaft portion 20 passes is projected axially and continuously connected to an outer end portion of the one side base circle portion 24A. More specifically, the one side rocking cam member 23A includes the one side base circle portion 24A which prevents a lift of a cam portion 15 of a rotating cam 13 of the camshaft 12 from being transmitted to the one side roller finger follower 5A, and the one side cam portion 25A which causes a lift of the cam portion 15 of the rotating cam 13 of the camshaft 12 to be transmitted to the one side roller finger follower 5A.

[0038] It is further to be noted that the center of the one side base circle portion 24A is coaxially aligned with that of the one side shaft portion 20 of the control shaft 17. Therefore, when the control shaft 17 is rotated, the control shaft 17 does not press or move the one side roller finger follower 5A.

[0039] The other side rocking cam member 23B includes the other side base circle portion 24B which prevents the other side engine valve 2B from being lifted, and the other side cam portion 25B which is projected radially from the other side base circle portion 24B and causes the other side engine valve 2B to be lifted.

[0040] As illustrated in Fig. 2, the other side hollow portion 26B having an internal diameter larger than the diameter of the other side shaft portion 21 is formed on

an inner circumferential surface of the other side base circle portion 24B, and the other side internal gear piece 27B as a spur gear is formed on an inner circumferential surface of the other side hollow portion 26B. The center of the other side base circle portion 24B is coaxially aligned with that of the other side shaft portion 21.

[0041] Furthermore, the other side support portion 29B having the other side shaft hole 28B through which the other side shaft portion 21 passes is projected radially and continuously connected to an outer end portion of the other side base circle portion 24B.

[0042] More specifically, the other side rocking cam member 23B includes the other side base circle portion 24B which prevents a lift of the cam portion 15 of the rotating cam 13 of the camshaft 12 from being transmitted to the other side roller finger follower 5B, and the other side cam portion 25B which causes a lift of the cam portion 15 of the rotating cam 13 of the camshaft 12 to be transmitted to the other side roller finger follower 5B.

[0043] It is further to be noted that the center of the other side base circle portion 24B is coaxially aligned with that of the other side shaft portion 21 of the control shaft 17. Therefore, when the control shaft 17 is rotated, the control shaft 17 does not press or move the other side roller finger follower 5B.

[0044] In the above structure, the one side base circle portion 24A and the other side base circle portion 24B constitute a base circle portion 24 of the rocking cam 23. The one side cam portion 25A and the other side cam portion 25B constitute a cam portion 25 of the rocking cam 23. The one side hollow portion 26A and the other side hollow portion 26B constitute a hollow portion 26 of the rocking cam 23. The one side internal gear piece 27A and the other side internal gear piece 27B constitute an internal gear piece 27 of the rocking cam 23.

[0045] A cam follower (rocker arm) 31 is coupled to the rocking cam 23 through the position changing mechanism 30. The cam follower 31 is rocked by the rotating cam 13 of the camshaft 12 and causes the rocking cam 23 to be rocked.

[0046] The cam follower 31 includes: a tubular body 33 having a shaft through hole 32 into which the eccentric shaft portion 22 of the control shaft 17 is fitted; a pair of roller support portions 34 and 34 projected toward the camshaft side in an axial center position of the tubular body 33; a roller pin 35 supported on the pair of roller support portions 34 and 34; and a roller 36 rotatably supported on the roller pin 35 between the pair of roller support portions 34 and 34.

[0047] The cam follower 31 is swingably supported on the eccentric shaft portion 22.

[0048] As illustrated in Figs. 2 and 3, the tubular body 33 includes one side external gear piece 37A which is formed in a front end portion thereof as a spur gear engaged with one side internal gear piece 27A of the one side rocking cam member 23A with the eccentric shaft portion 22 as the rotating shaft, and the other side external gear piece 37B which is formed in a rear end portion

thereof as a spur gear engaged with the other side internal gear piece 27B of the other side rocking cam 23B with the eccentric shaft portion 22 as the rotating shaft.

[0049] The one side external gear piece 37A and the other side external gear piece 37B constitute an external gear 37 of the cam follower 31.

[0050] Further, the one side external gear piece 37A, the other side external gear piece 37B, and the eccentric shaft portion 22 are arranged inside the one side hollow portion 26A and the other side hollow portion 26B, respectively. Thus, the axial length of the eccentric shaft portion 22 can be shortened and mountability of the variable valve operating system 16 on the internal combustion engine 1 can be improved.

[0051] As illustrated in Fig. 3, the axial centers of the shaft of the one side external gear piece 37A and the other side external gear piece 37B are coaxially aligned with the rocking center of the cam follower 31. Further, the axial centers of the shaft of the one side internal gear piece 27A and the other side internal gear piece 27B are coaxially aligned with the rocking center of the rocking cam 23. Thus, the one side internal gear piece 27A and the other side internal gear piece 27B are engaged with the one side external gear piece 37A and the other side external gear piece 37B offset by an eccentric amount "e".

[0052] In the present embodiment, the position changing mechanism 30 is configured as a cycloid mechanism including the eccentric shaft portion 22, the one side internal gear piece 27A, the other side internal gear piece 27B, the one side external gear piece 37A, and the other side external gear piece 37B. The position changing mechanism 30 changes lift characteristics of the one side engine valve 2A and the other side engine valve 2B by changing a relative positional relationship of the one and the other side rocking cam members 23A and 23B with respect to the cam follower 31.

[0053] As illustrated in Fig. 3, the one side and the other side internal gear pieces 27A and 27B of the one side and the other side rocking cam members 23A and 23B are engaged with the one and the other side external gear pieces 37A and 37B of the tubular body 33 of the cam follower 31, respectively, in an eccentric direction of the eccentric shaft portion 22. Thus, each number of teeth of the one and the other side internal gear pieces 27A and 27B, and each number of the one and the other side external gear pieces 37A 37B are determined, respectively, by the eccentric amount "e".

[0054] Further, it is to be noted that the one side rocking cam member 23A and the other side rocking cam member 23B are attached to the front end portion and the rear end portion of the tubular body 33 of the cam follower 31, respectively. Therefore, two valves 2A and 2B can be driven by one cam follower 31.

[0055] The variable valve operating system 16 according to the present embodiment has a structure in which the control shaft 17, the cam follower 31, and the rocking cam 23 are additionally arranged to a conventional roller

rocker valve train system between the camshaft 12 and the roller finger follower 5.

[0056] As illustrated in Figs. 4 and 5, the lift amount of the engine valve 2 is continuously changed by changing a nip angle (β) between the cam follower 31 and the rocking cam 23 by a rotational angle (α) of the control shaft 17.

[0057] Further, as illustrated in Fig. 3, the variable valve operating system 16 operates the engine valve 2 by causing the rocking cam 23 to press and move the roller finger follower 5, but the roller finger follower 5 may be replaced with a tappet or the like to be applicable to various valve train systems.

[0058] The variable valve operating system 16 operates as follows. When the opening/closing characteristics of the engine valve 2 are changed, the control shaft 17 is rotated to thereby revolve the external gear 37 around the axial center of the control shaft by the eccentric shaft portion 22. This revolving motion of the external gear 37 causes an engagement point "G" (see Figs. 4 and 5) of the internal gear 27 with respect to the external gear 37 to be moved in a circumferential direction of the internal gear 27, and the position of the rocking cam 23 with respect to the cam follower 31 is then changed by the movement of the engagement point "G" of the internal gear 27.

[0059] As described above, the position changing mechanism 30 is constructed as a cycloid mechanism including the eccentric shaft portion 22 of the control shaft 17, the external gear 37 of the cam follower 31, and the internal gear 27 of the rocking cam 23, and the position changing mechanism 30 operates such that the position of the rocking cam 23 with respect to the cam follower 31 is changed by the rotation of the control shaft 17 to thereby change the lift characteristics of the engine valve 2. According to the position changing mechanism 30 of the structure mentioned above, the lift characteristics of the engine valve 2 are not affected by a relative thermal expansion difference between the control shaft 17 and the internal combustion engine 1.

[0060] Furthermore, the position changing mechanism 30 is configured by the external gear 37 and the internal gear 27 made of a spur gear which can be easily manufactured in comparison with a conventional helical spline, thus simplifying the structure and improving the productivity of the variable valve operating system 16.

[0061] Further, when the control shaft 17 is rotated, the cam follower 31 moves such that a contact point thereof to the rotating cam 13 moves along an outer circumference of the rotary cam 13, and the lift amount of the engine valve 2 is changed by the movement of the rocking cam 23. When the control shaft 17 is rotated in a direction to reduce the lift amount of the engine valve 2, the contact point between the cam follower 31 and the rotating cam 13 moves in a direction opposite to the rotating direction of the rotating cam 13 (toward an advance angle side). According to such movement, as the lift amount of the engine valve 2 is reduced, the cam timing of closing the engine valve 2 can be advanced and pump-

ing loss can be reduced.

[0062] Next, a lifting operation of the variable valve operating system 16 will be described with reference to Figs 4 and 5.

[0063] As illustrated in Fig. 4A, in order to reduce the lift amount when the engine valve 2 is not operated, the control shaft 17 is rotated counterclockwise. At this time, the angle of the rotated control shaft 17 with respect to a reference position is assumed to be α_1 . More specifically, the rotation of the eccentric shaft portion 22 causes the external gear 37 to be revolved counterclockwise around the shaft center O1 of the one side shaft portion 20 and the other side shaft portion 21. Then, the nip angle between the cam follower 31 and the rocking cam 23 is decreased to β_1 and the contact position between the rotating cam 13 and the cam follower 31 is moved in an advance angle direction to γ_1 . At this time, even if the cam portion 15 of the rotating cam 13 contacts the roller 36 to swing the rocking cam 23, as illustrated in Fig. 4B, the rocking cam 23 and the roller 8 of the roller finger follower 5 contact to each other through the base circle portion 24. Therefore, the engine valve 2 is scarcely lifted, and the lift amount is minimized (small lift condition) (see R1 in Fig. 6).

[0064] Meanwhile, as illustrated in Fig. 5A, in order to increase the lift amount when the engine valve 2 is not operated, the control shaft 17 is rotated clockwise until the angle with respect to the reference position is changed from an angle of α_1 to an angle of α_2 . Then, the external gear 37 is rotated clockwise around the shaft center O2 of the eccentric shaft portion 22. Then, the position changing mechanism 30 operating as a cycloid mechanism causes the cam follower 31 to slide rightward (illustrated by an arrow M in Fig. 5A) until the contact position between the rotating cam 13 and the cam follower 31 is changed from γ_1 to γ_2 . Thus, the valve timing retards. At the same time, the rocking cam 23 is rotated clockwise (in a valve opening direction) around the shaft center O1 of the one and the other side shaft portions 20 and 21 until the nip angle between the cam follower 31 and the rocking cam 23 is increased from β_1 to β_2 .

[0065] At this time, the nip angle is $\beta_2 > \beta_1$, and as illustrated in Fig. 5B, when the engine valve 2 is operated, the contact range between the rocking cam 23 and the roller finger follower 5 via the cam portion 25 is increased. Thus, the roller finger follower 5 is greatly swung around the top spherical portion of the hydraulic lash adjuster 11, and the engine valve 2 is greatly operated (i.e., a large lift condition) (see R2 in Fig. 6).

[0066] Further, as illustrated in Fig. 6, in a relationship between the lift amount of the engine valve 2 and the opening/closing timing, the smaller the lift amount, the more the maximum lift position (top portion of the lift curve) moves in an advance angle direction.

[0067] This is because when the lift amount of the engine valve 2 is reduced, the contact position between the cam follower 31 and the rotating cam 13 moves in a direction (advance angle direction) opposite to the rotating

direction of the rotating cam 13, and thus, the opening/closing timing of the engine valve 2 is sped up. Accordingly, when the engine valve 2 is under a small lift condition, the engine valve 2 can be controlled to be quickly closed, thereby reducing the pumping loss and improving fuel consumption efficiency.

[0068] Furthermore, unlike the conventional system, since there is no need for axial control of the control shaft, a stable accuracy or performance can be obtained even under a small lift condition without being affected by a thermal expansion coefficient of the material constituting the parts or components of the engine due to temperature change.

[0069] The use of the position changing mechanism 30 as a cycloid mechanism in the present embodiment provides the following advantages.

[0070] According to the reduction principle of the cycloid mechanism, a deflection angle of $\alpha > \beta$ is obtained. More specifically, in term of the rotation of the control shaft 17 to the rotation of the rocking cam 23, equation $(\alpha_2 - \alpha_1) > (\beta_2 - \beta_1)$ is obtained, and thus, a large deceleration is enabled, and in the meantime, in term of the torque transmission, the control shaft 17 on the acceleration side is not susceptible to torque variation. In other word, this leads to improvement of reliability of the actuator 18 for driving the control shaft 17.

[0071] Furthermore, since the internal gear 27 of the rocking cam 23 and the external gear 37 of the cam follower 31 are in a relationship between the external gear and the internal gear, a large contact ratio (tooth surface contact ratio) can be ensured and the slip ratio can be reduced, thus advantageously improving the reliability of the tooth surface.

[0072] Still furthermore, since the eccentric amount "e" of the rotating shafts of the internal gear 27 and the external gear 37 is generally very small, even when the rotating cam 13 is operated, both gears have a very small amount of slip, thus advantageously improving the reliability of the tooth surface.

[0073] It is further to be noted that the present invention is not limited to the described embodiment and many other changes and modifications may be made without departing from the scopes of the appended claims.

[0074] For example, in the described embodiment, although two external gears are attached to one cam follower and two valves are driven by one cam portion, the present invention may be configured to provide two cam portions and two cam followers.

[0075] Furthermore, in the described embodiment, although a valve train system using a roller finger follower (RFF) is used as an example, the present invention may be applied to a direct acting valve train system using a tappet or the like.

[0076] The variable valve operating system according to the present invention can be applied to an internal combustion engine of various vehicles.

Claims

1. A variable valve operating system for an internal combustion engine including an engine valve and a cam shaft operating the engine valve, the variable valve operating system comprising:

a rocking cam, which lifts the engine valve, supported to a control shaft to be swingable;
a cam follower rocking the rocking cam; and
a position changing mechanism which couples the cam follower with the rocking cam, the position changing mechanism being configured to change a relative positional relationship of the rocking cam with respect to the cam follower to thereby change lift characteristics of the engine valve,
the position changing mechanism comprising: a circular eccentric portion which is formed to the control shaft in a manner decentered from an axis of the control shaft; an external gear formed on the cam follower swingably supported on the eccentric shaft portion with the eccentric shaft portion as the rotating shaft; and an internal gear formed on the rocking cam with the control shaft as the rotating shaft so as to be engaged with the external gear,

wherein the control shaft is rotated when opening/closing characteristics of the engine valve are changed, the external gear is revolved by the eccentric shaft portion around the axis of the control shaft, an engaged portion of the internal gear with the external gear is moved in a circumferential direction of the internal gear by the revolution of the external gear, and the position of the rocking cam with respect to the cam follower is changed by the movement of the engaged portion of the internal gear.

2. The variable valve operating system for an internal combustion engine according to claim 1, wherein when the control shaft is rotated, the cam follower moves such that a contact point to the rotating cam moves along an outer circumference of the rotating cam and the movement of the rocking cam causes a lift amount of the engine valve to be changed, and when the control shaft is rotated in a direction to reduce the lift amount of the engine valve, the contact point between the cam follower and the rotating cam moves in a direction opposite to the rotating direction of the rotating cam.
3. The variable valve operating system for an internal combustion engine according to claim 1, wherein the rocking cam includes a base circle portion which prevents the engine valve from being lifted and a cam portion which is projected radially from the base circle portion, a hollow portion is formed on an inner

circumference of the base portion, the internal gear is formed on an inner circumference surface of the hollow portion, and the external gear and the eccentric shaft portion are arranged inside the hollow portion.

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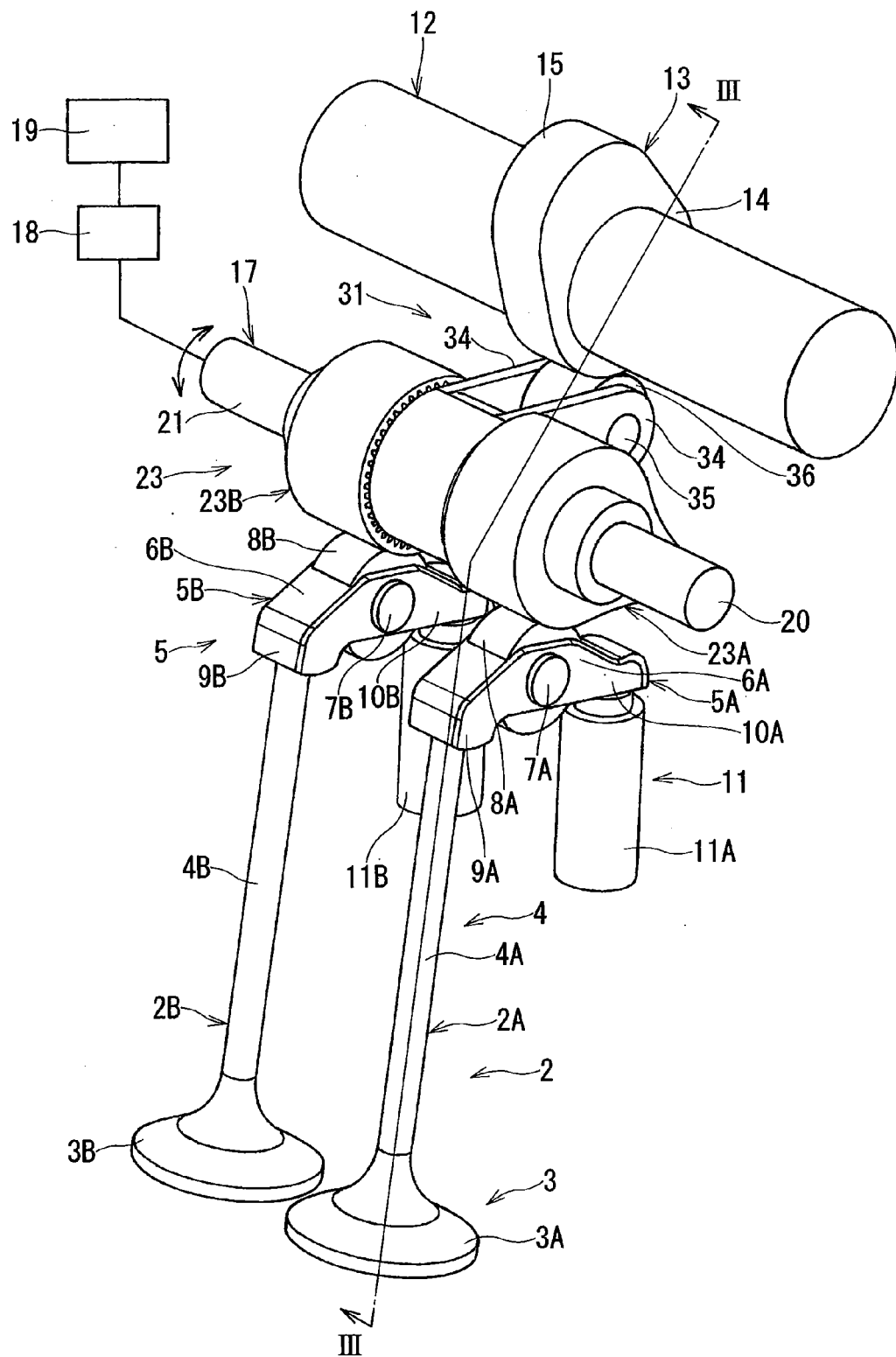


FIG. 1

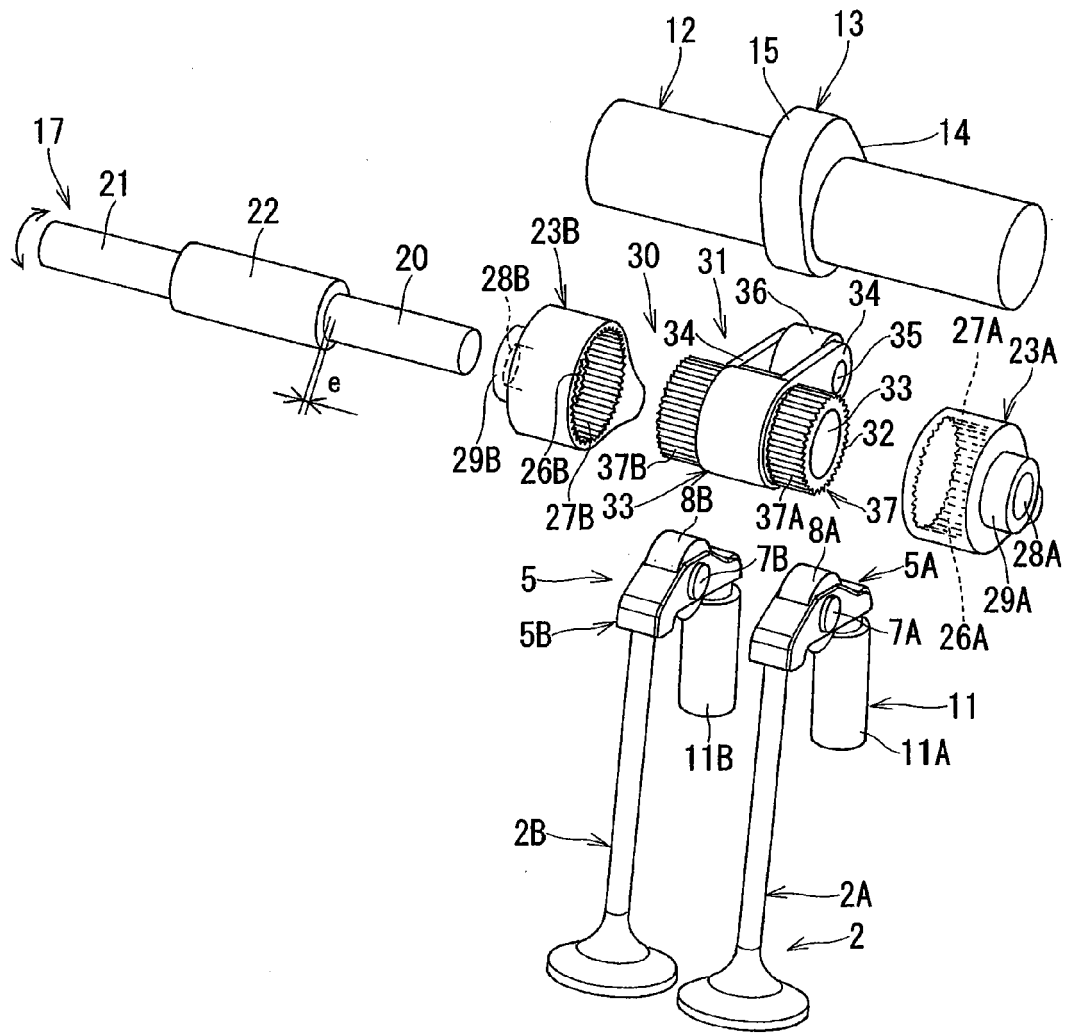


FIG. 2

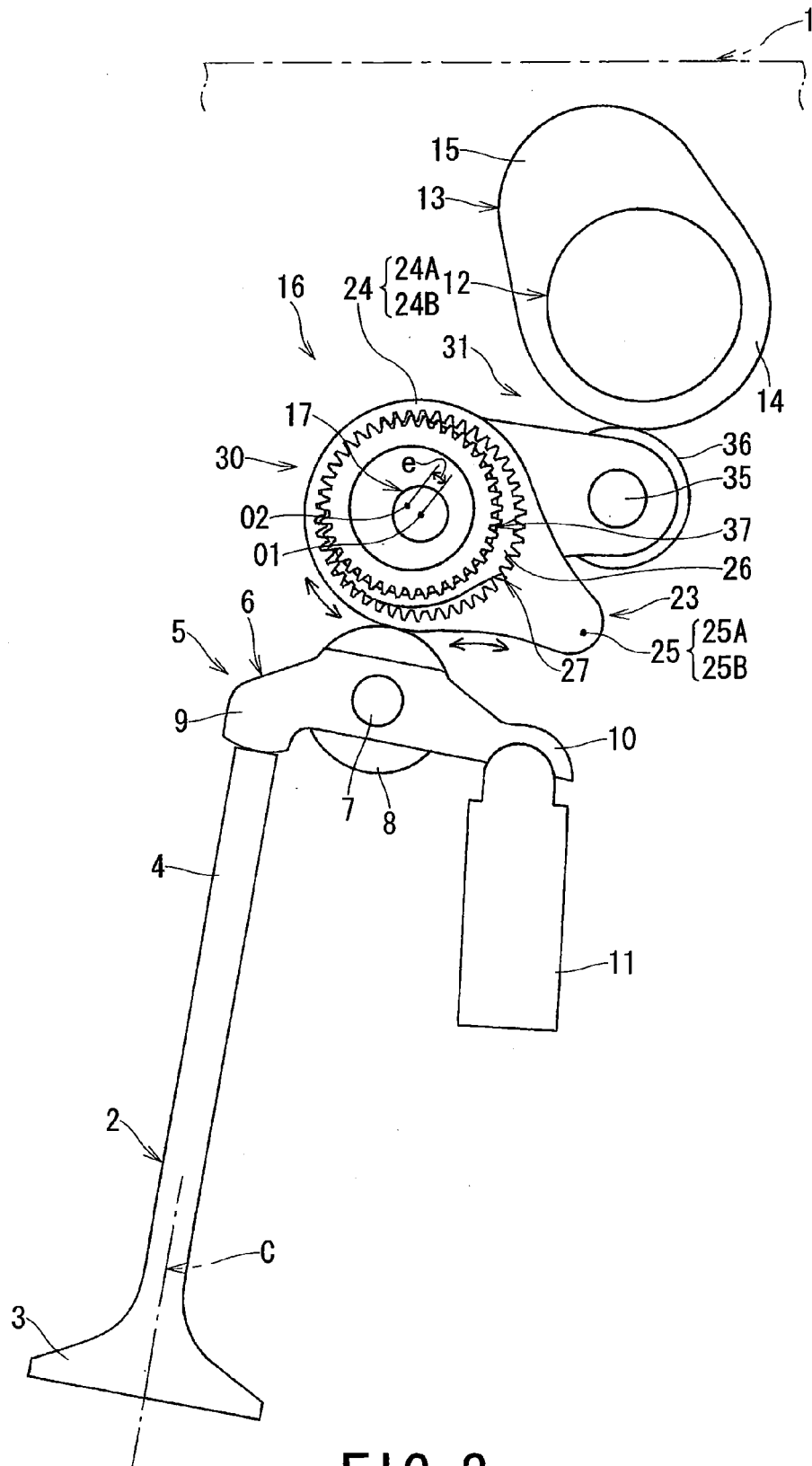


FIG. 3

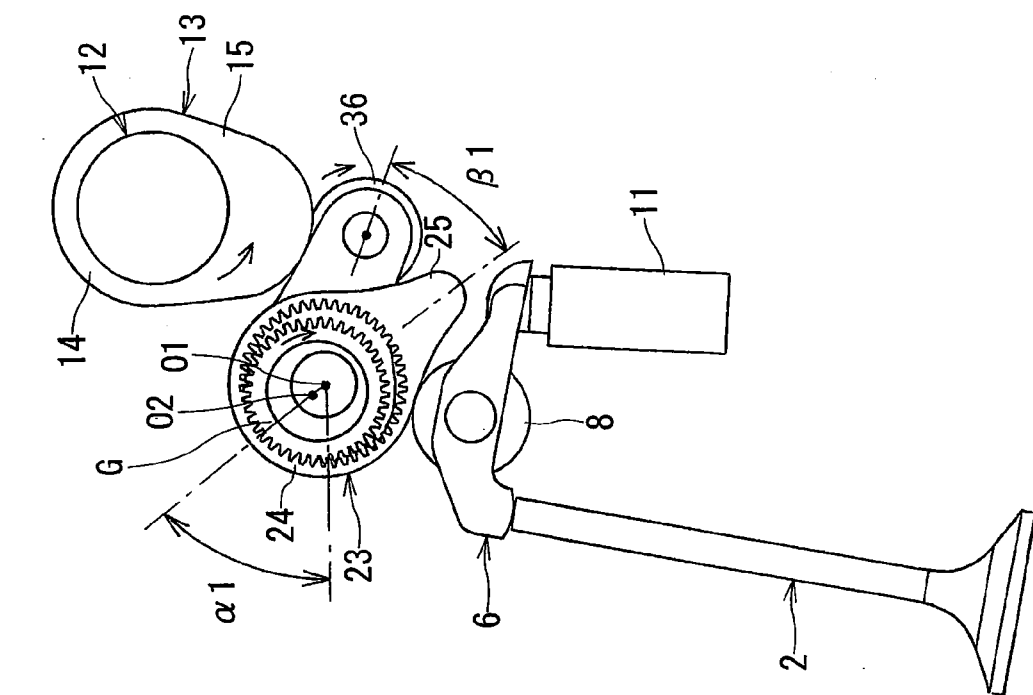


FIG. 4A

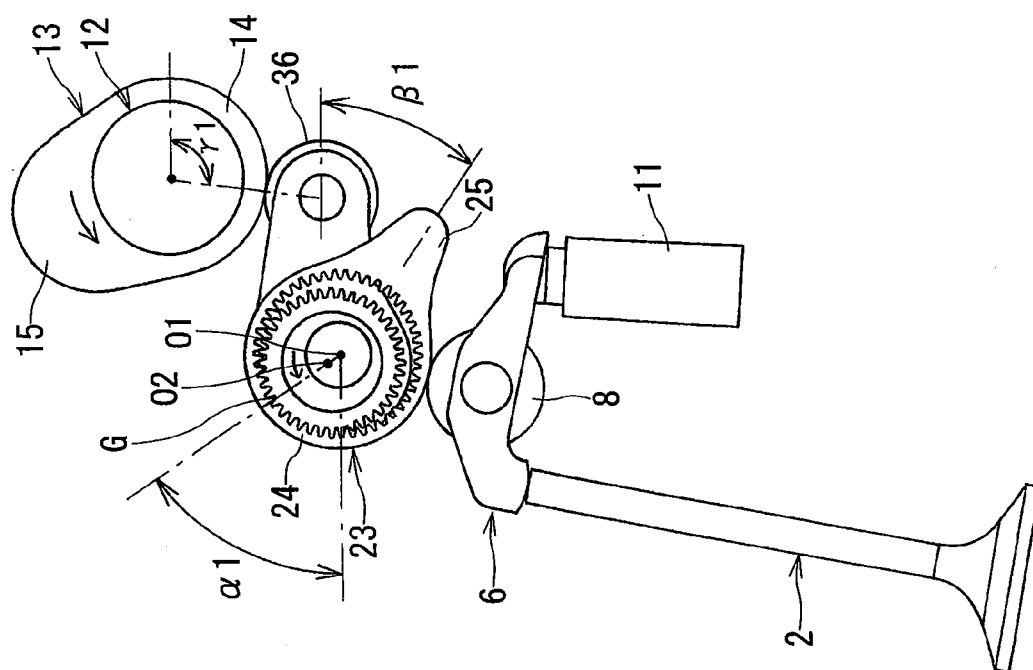
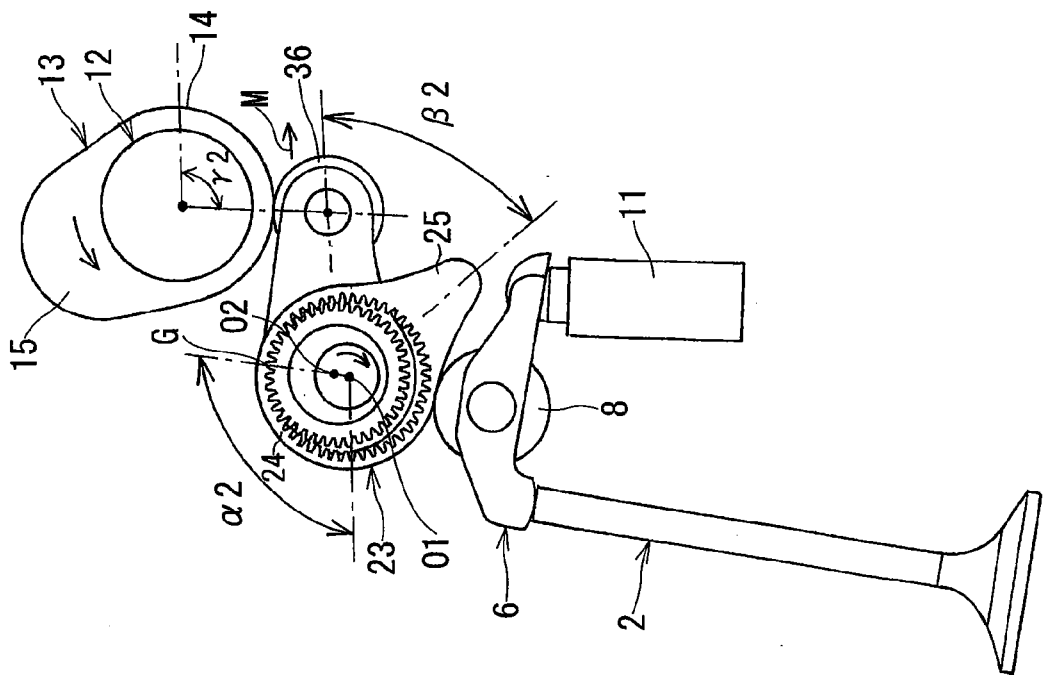
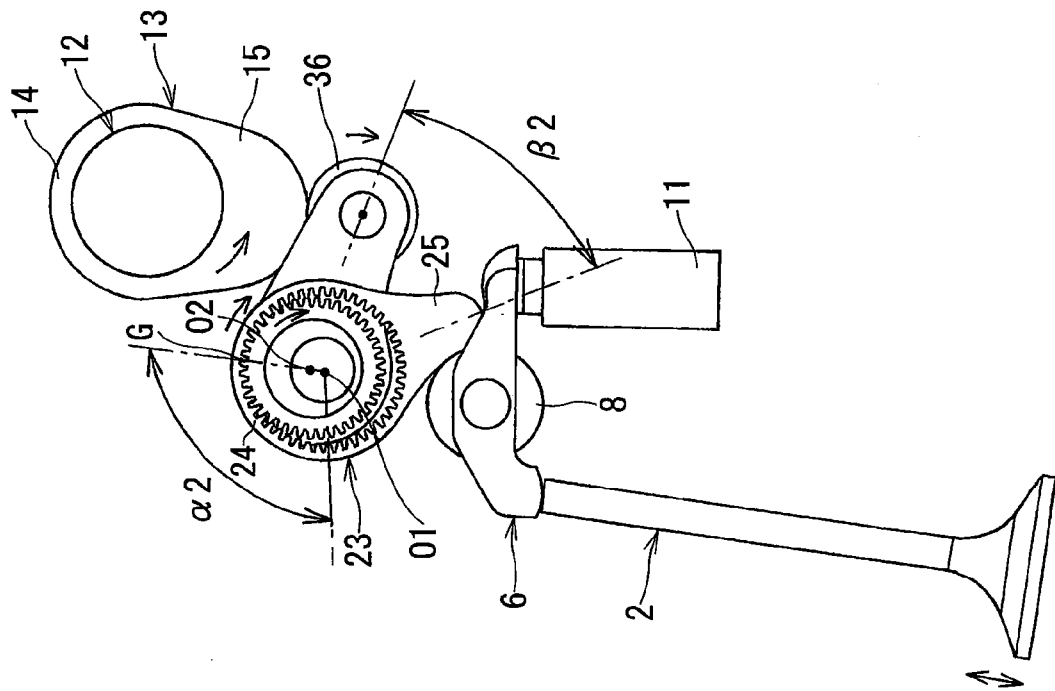


FIG. 4B



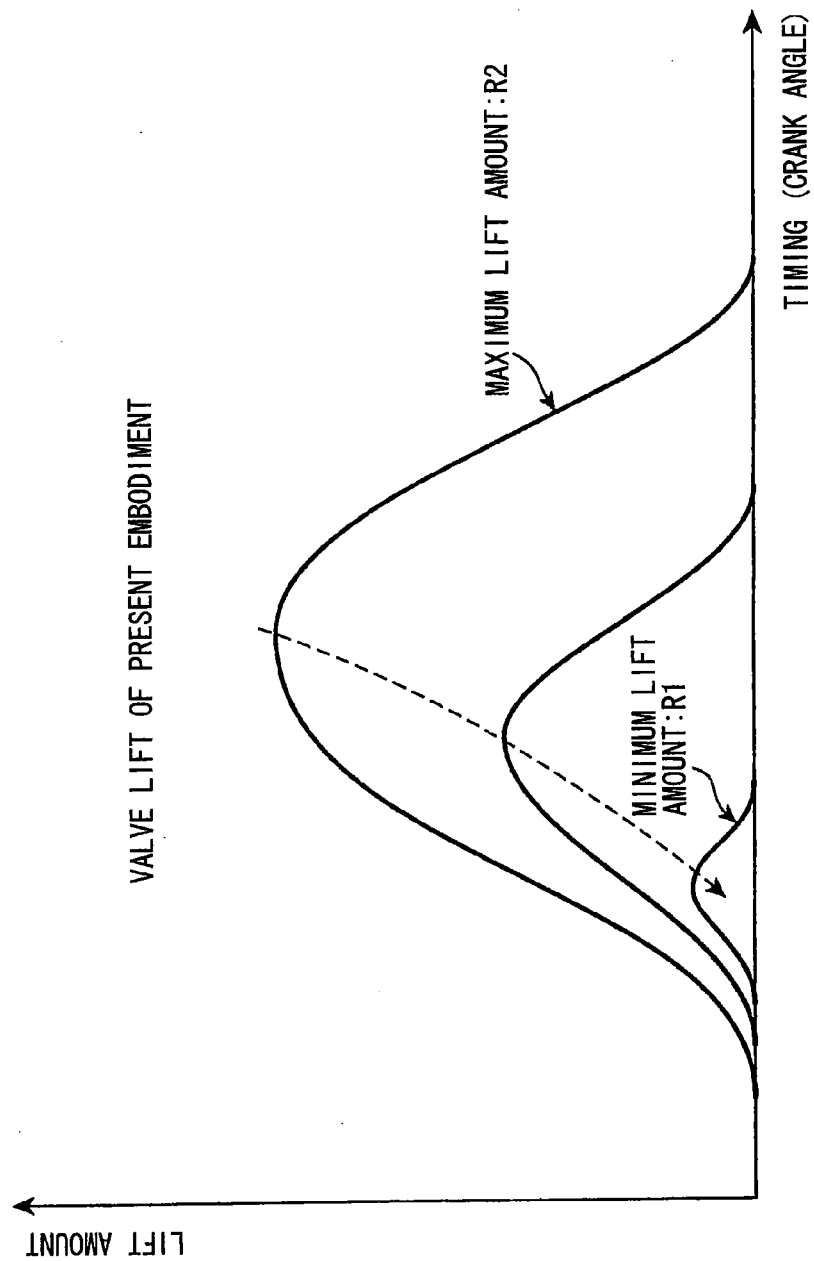


FIG. 6



EUROPEAN SEARCH REPORT

Application Number
EP 10 19 0636

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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			F01L
The present search report has been drawn up for all claims			
Place of search The Hague		Date of completion of the search 18 February 2011	Examiner Paquay, Jeannot
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	

1
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18-02-2011

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