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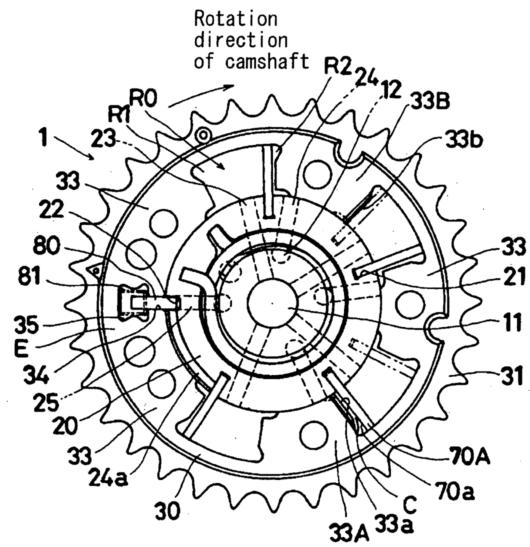
(54) **Variable valve timing control device**

(57) A variable valve timing control device (1) includes a housing member (3), a rotor member (2) assembled to the housing member so as to be rotatable relative thereto and including vane portions (70) each forming an advanced angle chamber (R1) and a retarded angle chamber (R2) within the housing member (3), a stopper (33a,33b) formed on the convex portion for defining a relative rotation between the housing member (3) and the rotor member (2), a lock mechanism (22,88) for restricting the relative rotation by a lock member (80), and a fluid pressure circuit for controlling an operation oil to be supplied to or discharged from the advanced angle chamber (R1), the retarded angle chamber (R2), and the lock mechanism (22,80). When the relative rotation is restricted, the lock member (80) is in contact with an inner peripheral face of the receiving hole (22) on the advanced angle side and the retarded angle side between an opening portion (22a) and a bottom portion (22b) of the receiving hole (22).

F I G. 2



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Description

FIELD OF THE INVENTION

[0001] This invention generally relates to a variable valve timing control device. More particularly, the present invention pertains to a variable valve timing control device for controlling an opening and closing timing of an intake valve and exhaust valve of an internal combustion engine.

BACKGROUND

[0002] Known variable valve timing control devices are disclosed in Japanese Patent Nos. 3266013 and 3146956. The disclosed variable valve timing control devices each include a housing member integrally rotating with one of a crankshaft and a camshaft of an internal combustion engine, a rotor member assembled to the housing member so as to be rotatable relative thereto and being slidable on a convex portion formed on the housing member. The rotor member includes vane portions each forming an advanced angle chamber and a retarded angle chamber within the housing member, and integrally rotating with the other one of the crankshaft and the camshaft. The variable valve timing control device also includes a stopper formed on the convex portion and being in contact with at least one of the vane portions for defining the relative rotation between the housing member and the rotor member to an advanced angle side or a retarded angle side. The variable valve timing control device further includes a lock mechanism for restricting the relative rotation between the housing member and the rotor member by a lock member disposed on the housing member to be inserted into a receiving hole formed on the rotor member when a relative rotation phase between the housing member and the rotor member is positioned at a predetermined phase, and a fluid pressure circuit for controlling an operation oil to be supplied to or discharged from the advanced angle chamber, the retarded angle chamber, and the lock mechanism.

[0003] According to the variable valve timing control device disclosed in Japanese Patent No. 3266013, when the lock member is in contact with an opening edge portion of a receiving hole within which the lock member is positioned, plastic flow of material forming the receiving hole may be caused due to tangential stress. Then, the opening edge portion may be raised towards the housing member side. Further, the opening edge portion being raised may interfere with the relative rotation between the housing member and the rotor member. In order to address the above problem, the lock member includes an engaging taper face on a side of the receiving hole while the receiving hole includes a guiding taper face gradually expanding towards an opening side of the receiving hole. The lock member is in contact with an inner peripheral face of the receiving hole under the condition that a taper angle of the guiding taper face is larger than that of the engaging taper face. Then, the plastic flow may be prevented from occurring in the opening edge portion of the receiving hole.

[0004] In addition, according to the variable valve timing control device disclosed in Japanese Patent No. 3146956, a clearance is formed between the lock member and the receiving hole considering a receiving performance of the lock member in the receiving hole. When the advanced angle chamber or the retarded angle chamber is not sufficiently supplied with the operation fluid from an oil pump at a time of an engine start, the rotor member and the housing member starts rotating relative to each other due to the fluctuation torque of the cam being applied. At this time, since the clearance is formed between the lock member and the receiving hole, an inner periphery of the receiving hole and an outer periphery of the lock member may become in contact with each other repeatedly, thereby causing a hitting sound. In order to address the above problem, a taper face is formed on at least one of the lock member and the receiving hole being in contact with each other. Then, a biasing force to bias the rotor member in the rotational direction is generated in the housing member to strongly press the stopper and the vane portion to each other so that the rotor member and the housing member are constrained at a locked position.

[0005] According to the variable valve timing control device disclosed in Japanese Patent No. 3266013, the lock member can be in contact with the inner circumferential face of the receiving face. However, a clearance may be formed between the lock member and the receiving hole, which causes a looseness therebetween. Further, the hitting sound due to the looseness may occur.

[0006] In addition, according to the variable valve timing control device disclosed in Japanese Patent No. 3146956, the rotor member and the housing member are constrained at the locked position and thus the lock member may not be able to move from the receiving hole.

[0007] Thus, a need exists for a variable valve timing control device which can prevent an occurrence of hitting sound due to a relative rotation between a lock member and a receiving hole in case of the relative rotation being locked.

[0008] A need also exists for a variable valve timing control system in which the lock member is prevented from being constrained in the receiving hole when the locked state of the relative rotation is released.

SUMMARY OF THE INVENTION

[0009] According to an aspect of the present invention, a variable valve timing control device includes a housing member integrally rotating with one of a crankshaft and a camshaft of an internal combustion engine, and a rotor member assembled to the housing member so as to be rotatable relative thereto and being slidable on a convex portion formed on the housing member, the rotor member including vane portions each forming an advanced angle chamber and a retarded angle chamber within the housing member, the rotor member integrally rotating with the other one of the crankshaft and the camshaft. The variable valve timing control device also includes a stopper formed on the convex portion and being in contact with at least one of the vane portions for defining a relative rotation between the housing member and the rotor member to an advanced angle side or a retarded angle side, a lock mechanism for restricting the relative rotation between the housing member and the rotor member by a lock member disposed on the housing member to be inserted into a receiving hole formed on the rotor member when a relative rotation phase between the housing member and the rotor member is positioned at a predetermined phase, and a fluid pressure circuit for controlling an operation oil to be supplied to or discharged from the advanced angle chamber, the retarded angle chamber, and the lock mechanism. When the relative rotation between the housing member and the rotor member is restricted, the lock member is in contact with an inner peripheral face of the receiving hole on the advanced angle side and the retarded angle side between an opening portion and a bottom portion of the receiving hole.

[0010] According to the above-mentioned invention, the lock member is in contact with the inner peripheral face of the receiving hole on the advanced angle side and the retarded angle side between the opening portion and the bottom portion of the receiving hole when the relative rotation between the rotor member and the housing member is restricted. Thus, the lock member and the receiving hole are in contact with each other to thereby restrict the relative rotation between the rotor member and the housing member to the advanced angle side and the retarded angle side. The occurrence of the hitting sound due to the contact between the lock member and the receiving hole may be prevented accordingly.

[0011] According to another aspect of the prevent invention, a variable valve timing control device includes a housing member integrally rotating with one of a crankshaft and a camshaft of an internal combustion engine, and a rotor member assembled to the housing member so as to be rotatable relative thereto and being slidable on a convex portion formed on the housing member, the rotor member including vane portions each forming an advanced angle chamber and a retarded angle chamber within the housing member, the rotor member integrally rotating with the other one of the crankshaft and the camshaft. The variable valve timing control device also includes a stopper formed on the convex portion and being in contact with at least one of the vane portions for defining a relative rotation between the housing member and the rotor member to an advanced angle side or a retarded angle side, a lock mechanism for restricting the relative rotation between the housing member and the rotor member by a lock member disposed on the housing member to be inserted into a receiving hole formed on the rotor member when a relative rotation phase between the housing member and the rotor member is positioned at a predetermined phase, and a fluid pressure circuit for controlling an operation oil to be supplied to or discharged from the advanced angle chamber, the retarded angle chamber, and the lock mechanism. When the relative rotation between the housing member and the rotor member is restricted, a contact width in a circumferential direction of a contact portion of the lock member, with which an inner peripheral face of the receiving hole on the advanced angle side and the retarded angle side is in contact, is larger than a bottom width in the circumferential direction of a bottom portion of the receiving hole.

[0012] According to the above-mentioned invention, when the relative rotation is restricted, the lock member and the receiving hole are in contact with each other since the contact width in the circumferential direction of the contact portion of the lock member, with which the inner peripheral face of the receiving hole on the advanced angle side and the retarded angle side is in contact, is larger than the bottom width in the circumferential direction of the bottom portion of the receiving hole, thereby avoiding the occurrence of the hitting sound.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013] The foregoing and additional features and characteristics of the present invention will become more apparent from the following detailed description considered with reference to the accompanying drawings, wherein:

[0014] Fig. 1 is a longitudinal sectional view of a variable valve timing control device according to an embodiment of the present invention;

[0015] Fig. 2 is a cross-sectional view taken along the ling A-A of Fig. 1;

[0016] Fig. 3 is an enlarged view of E portion of Fig. 2; and

[0017] Fig. 4 is an enlarged view of F portion of Fig. 3.

DETAILED DESCRIPTION

[0018] An embodiment of the present invention is explained referring to attached drawings. A variable valve timing control device 1 shown in Figs. 1 to 3 includes a rotor member 2 for opening/closing a valve, which includes a camshaft 10 rotatably supported on a cylinder head 100 of an internal combustion engine and an inner rotor 20 integrally fixed to a tip end portion of the camshaft 10. The variable valve timing control device 1 also includes a housing member 3 having an outer rotor 30 being rotatable relative to the inner rotor 20 within a predetermined range, a front plate 40, and a rear plate 50. A timing sprocket 31 is integrally formed on an outer periphery of the outer rotor 30. Further, the variable valve timing control device 1 includes a torsion spring 60 disposed between the inner rotor 20 and the front plate 40, four vanes 70 assembled to the inner rotor 20, and a lock plate 80 (lock member) (see Fig. 2) assembled to the outer rotor 30.

[0019] The timing sprocket 31 receives the rotation force in the clockwise direction thereof, which is shown as a rotation direction of camshaft in Fig. 2. The rotation force is transmitted from a crankshaft (not shown) via a crank sprocket (not shown) and a timing chain (not shown).

[0020] The camshaft 10 includes a known cam (not shown) for opening/closing an exhaust valve (not shown). An advanced angle fluid passage (fluid pressure circuit) 11 and a retarded angle fluid passage (fluid pressure circuit) 12 extending in an axial direction of the camshaft 10 are provided inside of the camshaft 10. The advanced angle fluid passage 11 is connected to a first connecting port 201 of a switching valve 200 via a passage 71 provided on the camshaft 10 in the radial direction thereof, an annular groove 14, and a connecting passage 16 provided on the cylinder head 100. In addition, the retarded angle fluid passage 12 is connected to a second connecting port 202 of the switching valve 200 via a passage 72 provided on the camshaft 10 in the radial direction thereof, an annular groove 13, and a connecting passage 15 provided on the cylinder head 100.

[0021] The switching valve 200 is a known type in which a spool 204 is moved against a biasing force of a spring (not shown) by energizing a solenoid 203. When the solenoid 203 is de-energized, a supply port 206 connected to an oil pump 205 that is driven by the internal combustion engine communicates with the first connecting port 201 as shown in Fig. 1. At the same time, the second connecting port 202 communicates with a discharge port 207. When the solenoid 203 is energized, the supply port 206 communicates with the second connecting port 202 and at the same time the first connecting port 201 communicates with the discharge port 207. Therefore, in case that the solenoid 203 of the switching valve 200 is de-energized, the operation fluid (fluid pressure) is supplied to the advanced angle fluid passage 11. In case that the solenoid 203 is energized, the operation fluid is supplied to the retarded angle fluid passage 12. Energization of the solenoid 203 of the switching valve 200 is duty-controlled by which a ratio of energization/de-energization per unit time is changed. For example, when the switching valve 200 is duty-controlled at 50%, the first and second ports 201 and 202, and the supply and discharge ports 206 and 207 are not connected to each other.

[0022] The inner rotor 20 is integrally fixed to the camshaft 10 via an installation bolt 91. As shown in Fig. 2, four vane grooves 21 and a receiving hole 22 are formed on the inner rotor 20. In addition, four first fluid passages 23 (fluid pressure circuit), three second fluid passages 24 (fluid pressure circuit) extending in the radial direction of the inner rotor 20, a fluid groove 24a (fluid pressure circuit), and a lock fluid passage 25 for connecting a bottom portion 22d of the receiving hole 22 to the advanced angle fluid passage 11.

[0023] As shown in Fig. 2, the vanes 70 are positioned in the vane grooves 21 respectively, being movable in the radial direction of the inner rotor 20. The four vanes 70 are movable within four fluid pressure chambers R0 respectively, which are each defined between the outer rotor 30 and the inner rotor 20 and arranged, dividing each fluid pressure chamber R0 into an advanced angle chamber R1 and a retarded angle chamber R2. Each vane 70 is biased in the radially outward direction by a vane spring 73 (see Fig. 1) disposed between the bottom portion of each vane groove 21 and the bottom face of each vane 70.

[0024] As shown in Fig. 2, the operation fluid (fluid pressure) is supplied to or discharged from the four advanced angle chambers R1, which are defined and divided by the vanes 70, via the advanced angle fluid passage 11 and the first fluid passage 23. In addition, the operation fluid is supplied to or discharged from three retarded angle chambers R2 out of four via the retarded angle fluid passage 12 and the second fluid passage 24. The operation fluid is supplied to the lock plate 80 from the lock fluid passage 25 formed on the bottom portion 22d of the receiving hole 22. When the lock plate 80 is moved, the operation fluid is supplied to or discharged from the remaining (i.e. one out of four) retarded angle chamber R2 via the fluid groove 24a connecting the lock fluid passage 25 and that retarded angle chamber R2. Accordingly, for one retarded angle chamber R2 out of four, the second fluid passage 24 is not provided and the lock fluid passage 25 is shared to be used, which may achieve a simple structure of the fluid pressure circuit.

[0025] Both side portions of the outer rotor 30 in the axial direction thereof are integrally fixed to the annular shaped front plate 40 and the rear plate 50 respectively via five connecting bolts 92. The timing sprocket 31 is integrally formed on an outer periphery of the outer rotor 30 and on an end side in the axial direction thereof to which the rear plate 50 is connected. In addition, five convex portions 33 are formed on the inner circumference of the outer rotor 30 in the circumferential direction thereof so as to project in the radially inward direction. Each inner circumferential face of each convex portion 33 is slidably in contact with an outer circumferential face of the inner rotor 20. That is, the outer rotor 30 is rotatably supported on the inner rotor 20. A side face 33a (stopper) of one convex portion 33A out of the five convex portions 33 is in contact with a side face 70a of a vane 70A, thereby defining a relative rotational angle between the outer rotor 30 and the inner rotor 20 to the advanced angle side. In addition, a side face 33b (stopper) of one convex portion 33B is in contact with a side face 70b of a vane 70B, thereby defining the relative rotational angle between the outer rotor 30 and the inner rotor 20 to the retarded angle side. A retracting groove portion 34 for accommodating the lock plate 80, and a receiving bore 35 connected to the retracting groove portion 34 for accommodating a coil spring 81 that biases the lock plate 80 in the radially inward direction of the outer rotor 30 are formed between the two convex portions 33 out of five. The four fluid pressure chambers R0 mentioned above are formed between five convex portions 33, respectively.

[0026] As shown in Fig. 3, a head portion 80a of the lock plate 80, i.e. facing the bottom portion 22d of the receiving hole 22, has a trapezoidal shape in cross section formed by a convex taper portion extending in the radially inward direction of the outer rotor 30 and a top portion. An inner peripheral face 22b is formed by a concave taper portion 22c having a trapezoidal shape in cross section and gradually expanding towards an opening portion 22a, and the bottom portion 22d. When the relative rotation between the inner rotor 20 and the outer rotor 30 is restricted, the lock plate 80 is positioned in the receiving hole 22. An end portion 80b (contact portion) of the top portion of the lock plate 80 is in contact with the inner peripheral face 22b of the receiving hole 22 on the advanced angle side and the retarded angle side between the opening portion 22a and the bottom portion 22d of the receiving hole 22. In addition, a contact width B in the circumferential direction of the contact portion 80b of the lock plate 80, with which the inner peripheral face 22b of the receiving hole 22 on the advanced angle side and the retarded angle side is in contact, is larger than a bottom width D in the circumferential direction of the bottom portion 22d of the receiving hole 22. Therefore, when the lock plate 80 is positioned in the receiving hole 22, the end portion 80b of the lock plate 80 and the taper portion 22c of the inner peripheral face 22b of the receiving hole 22 are in contact with each other on the advanced angle side and the retarded angle side, thereby restricting the relative rotation between the inner rotor 20 and the outer rotor 30. As a result, the occurrence of the hitting sound by the contact between the end portion 80b and the taper portion 22c due to the fluctuation torque of the cam may be prevented. The head portion 80a of the lock plate 80 may have a substantially rectangular shape instead of the trapezoidal shape. The end portion 80b of the lock plate 80 may be chamfered.

[0027] When the relative rotation between the inner rotor 20 and the outer rotor 30 is restricted, the lock plate 80 is positioned in the receiving hole 22. At the same time, a gap C is formed between the side face 33a of the convex portion 33A and the side face 70a of the vane 70A. Therefore, when the fluctuation torque by the camshaft 10 is applied to the end portion 80b and the taper portion 22c in the advanced angle direction and the retarded angle direction alternately under the condition that the operation fluid is supplied to the receiving hole 22 and thus the relative rotation between the inner rotor 20 and the outer rotor 30 is permitted, i.e. the locked state thereof is released, the lock plate 80 and the receiving hole 22 are prevented from being strongly constrained each other. Then, the lock plate 80 and the receiving hole 22 rotate relative to each other, which brings the end portion 80b of the lock plate 80 to be pushed by the taper portion 22c of the inner peripheral face 22b of the receiving hole 22. The lock plate 80 is thus biased to move from the receiving hole 22, thereby causing the locked state of the relative rotation between the inner rotor 20 and the outer rotor 30 to be easily released.

[0028] A size of the gap C is defined such that when the side face 70a of the vane 70A is in contact with the side face 33a of the convex portion 33A to thereby restrict the relative rotation between the inner rotor 20 and the outer rotor 30 at the most advanced angle phase, the head portion 80a of the lock plate 80 is guided in radially inward direction of the receiving hole 22 with being in contact with the inner peripheral face 22b of the receiving hole 22. That is, when the relative rotation between the inner rotor 20 and the outer rotor 30 is restricted at the most advanced angle phase by the side face 70a of the vane 70A being in contact with the side face 33a of the convex portion 33A, the head portion 80a of the lock plate 80 is guided in the radially inward direction of the receiving hole 22. Then, when the vane 70 is separated from the convex portion 33 due to the fluctuation torque of the cam, the head portion 80a of the lock plate 80 is further inserted into the radially inward direction of the receiving hole 22. The end portion 80b of the lock plate 80 and the taper portion 22c of the inner peripheral face 22b of the receiving hole 22 are in contact with each other on the advanced angle side and the retarded angle side, thereby restricting the relative rotation between the inner rotor 20 and the outer rotor 30.

[0029] The torsion spring 60 is provided by engaging with the front plate 40 at one end and the inner rotor 20 at the other end. The torsion spring 60 biases the inner rotor 20 towards the advanced angle side (clockwise direction in Fig. 2) relative to the outer rotor 30, the front plate 40 and the rear plate 50. Thus, the operation response of the inner rotor 20 to the advanced angle side may be improved.

[0030] According to the above-mentioned embodiment, when the internal combustion engine is stopped, the oil pump 205 is stopped and also the switching valve 200 is not energized. Thus, the operation fluid is not supplied to the fluid pressure chambers R0. At this time, the head portion 80a of the lock plate 80 is positioned within the receiving hole 22 of the inner rotor 20 and thus the relative rotation between the inner rotor 20 and the outer rotor 30 is restricted. Even when the internal combustion engine is started and the oil pump 205 is driven, the operation fluid supplied from the oil pump 205 is only virtually provided to the advanced angle chamber R1 via the connecting passage 16, the advanced angle fluid passage 11, and the first fluid passage 23 while the duty ratio is small for energizing the switching valve 200 (i.e. the ratio of energizing time relative to the de-energizing time per unit time is small). Therefore, the variable valve timing control device 1 is maintained in a locked state.

[0031] When the retarded angle phase is required for the valve timing depending on the operation condition of the internal combustion engine, the duty ratio for energizing the switching valve 200 is brought to be large and then the position of the spool 204 is switched. The operation fluid supplied from the oil pump 205 is provided to the retarded angle chamber R2 by passing through the connecting passage 15, the retarded angle fluid passage 12, and the second fluid passage 24, or by passing through the fluid groove 24a after supplied to the receiving hole 22 from the lock fluid passage 25.

[0032] Meanwhile, the operation fluid stored in the advanced angle chamber R1 is sent to the first fluid passage 23, the advanced angle fluid passage 11, and the connecting passage 16 to be discharged from the discharge port 207 of the switching valve 200. Therefore, the lock plate 80 is moved against the biasing force of the spring 81, thereby moving the head portion 80a from the receiving hole 22. Then, the locked state between the inner rotor 20 and the outer rotor 30 is released. At the same time, the inner rotor 20 integrally rotating with the camshaft 10 and each vane 70 rotate relative to the outer rotor 30, the front plate 40, and the rear plate 50 in the retarded angle direction (counterclockwise direction in Fig. 2). Due to the aforementioned relative rotation, the timing of the cam is brought in the advanced angle state. The relative rotation phase may be defined arbitrarily by controlling the duty ratio of the switching valve 200. For example, the relative rotation between the inner rotor 20 and the outer rotor 30 may be stopped at the intermediate phase.

[0033] According to the aforementioned embodiment, when the relative rotation is restricted, the lock plate 80 and the receiving hole 22 are prevented from being strongly constrained each other under the condition that the fluctuation torque by the camshaft 10 is applied to the contact portion 80b and the inner peripheral face 22b in the advanced angle direction and the retarded angle direction alternately since the gap C is formed between the side face 33a of the convex portion 33A and the side face 70a of the vane 70A. Thus, the lock plate 80 is moved from the receiving hole 22 by the operation fluid that is produced when the locked state of the relative rotation is released.

[0034] The principles, preferred embodiment and mode of operation of the present invention have been described in the foregoing specification. However, the invention which is intended to be protected is not to be construed as limited to the particular embodiments disclosed. Further, the embodiments described herein are to be regarded as illustrative rather than restrictive. Variations and changes may be made by others, and equivalents employed, without departing from the sprit of the present invention. Accordingly, it is expressly intended that all such variations, changes and equivalents which fall within the spirit and scope of the present invention as defined in the claims, be embraced thereby.

[0035] It is explicitly stated that all features disclosed in the description and/or the claims are intended to be disclosed separately and independently from each other for the purpose of original disclosure as well as for the purpose of restricting the claimed invention independent of the composition of the features in the embodiments and/or the claims. It is explicitly stated that all value ranges or indications of groups of entities disclose every possible intermediate value or intermediate entity for the purpose of original disclosure as well as for the purpose of restricting the claimed invention, in particular as limits of value ranges.

Claims

1. A variable valve timing control device (1) comprising a housing member (3) integrally rotating with one of a crankshaft and a camshaft (10) of an internal combustion engine, a rotor member (2) assembled to the housing member so as to be rotatable relative thereto and being slidable on a convex portion (33) formed on the housing member, the rotor member including vane portions (70) each forming an advanced angle chamber (R1) and a retarded angle chamber (R2) within the housing member, the rotor member integrally rotating with the other one of the crankshaft and the camshaft, a stopper (33a, 33b) formed on the convex portion and being in contact with at least one of the vane portions for defining a relative rotation between the housing member and the rotor member to an advanced angle side or a retarded angle side, a lock mechanism (22, 80) for restricting the relative rotation between the housing member and the rotor member by a lock member (80) disposed on the housing member to be inserted into a receiving hole (22) formed on the rotor member when a relative rotation phase between the housing member and the rotor member is positioned at a predetermined phase, and a fluid pressure circuit (23, 24, 25) for controlling an operation oil to be supplied to or discharged from the advanced angle chamber, the retarded angle chamber, and the lock mechanism **characterized in that** when the relative rotation between the housing member and the rotor member is restricted, the lock member is in contact with an inner peripheral face (22b) of the receiving hole on the advanced angle side and the retarded angle side between an opening portion (22a) and a bottom portion (22d) of the receiving hole.

2. A variable valve timing control device (1) comprising a housing member (3) integrally rotating with one of a crankshaft and a camshaft (10) of an inter-

nal combustion engine, a rotor member (2) assembled to the housing member so as to be rotatable relative thereto and being slidable on a convex portion (33) formed on the housing member, the rotor member including vane portions (70) each forming an advanced angle chamber (R1) and a retarded angle chamber (R2) within the housing member, the rotor member integrally rotating with the other one of the crankshaft and the camshaft, a stopper (33a, 33b) formed on the convex portion and being in contact with at least one of the vane portions for defining a relative rotation between the housing member and the rotor member to an advanced angle side or a retarded angle side, a lock mechanism (22, 80) for restricting the relative rotation between the housing member and the rotor member by a lock member (80) disposed on the housing member to be inserted into a receiving hole (22) formed on the rotor member when a relative rotation phase between the housing member and the rotor member is positioned at a predetermined phase, and a fluid pressure circuit (23, 24, 25) for controlling an operation oil to be supplied to or discharged from the advanced angle chamber, the retarded angle chamber, and the lock mechanism **characterized in that** when the relative rotation between the housing member and the rotor member is restricted, a contact width (B) in a circumferential direction of a contact portion (80b) of the lock member, with which an inner peripheral face (22b) of the receiving hole on the advanced angle side and the retarded angle side is in contact, is larger than a bottom width (D) in the circumferential direction of a bottom portion (22d) of the receiving hole.

3. A variable valve timing control device according to claim 1, wherein when the relative rotation between the housing member and the rotor member is restricted, a gap (C) is formed between the stopper and the vane portion.

4. A variable valve timing control device according to claim 2, wherein when the relative rotation between the housing member and the rotor member is restricted, a gap (C) is formed between the stopper and the vane portion.

5. A variable valve timing control device according to claim 3, wherein the lock member includes a head portion (80a) facing the bottom portion of the receiving hole and having a trapezoidal shape in cross section formed by a convex taper portion extending in a radially inward direction of the housing member and a top portion including a contact portion (80b) with which the inner peripheral face of the receiving hole is in contact.

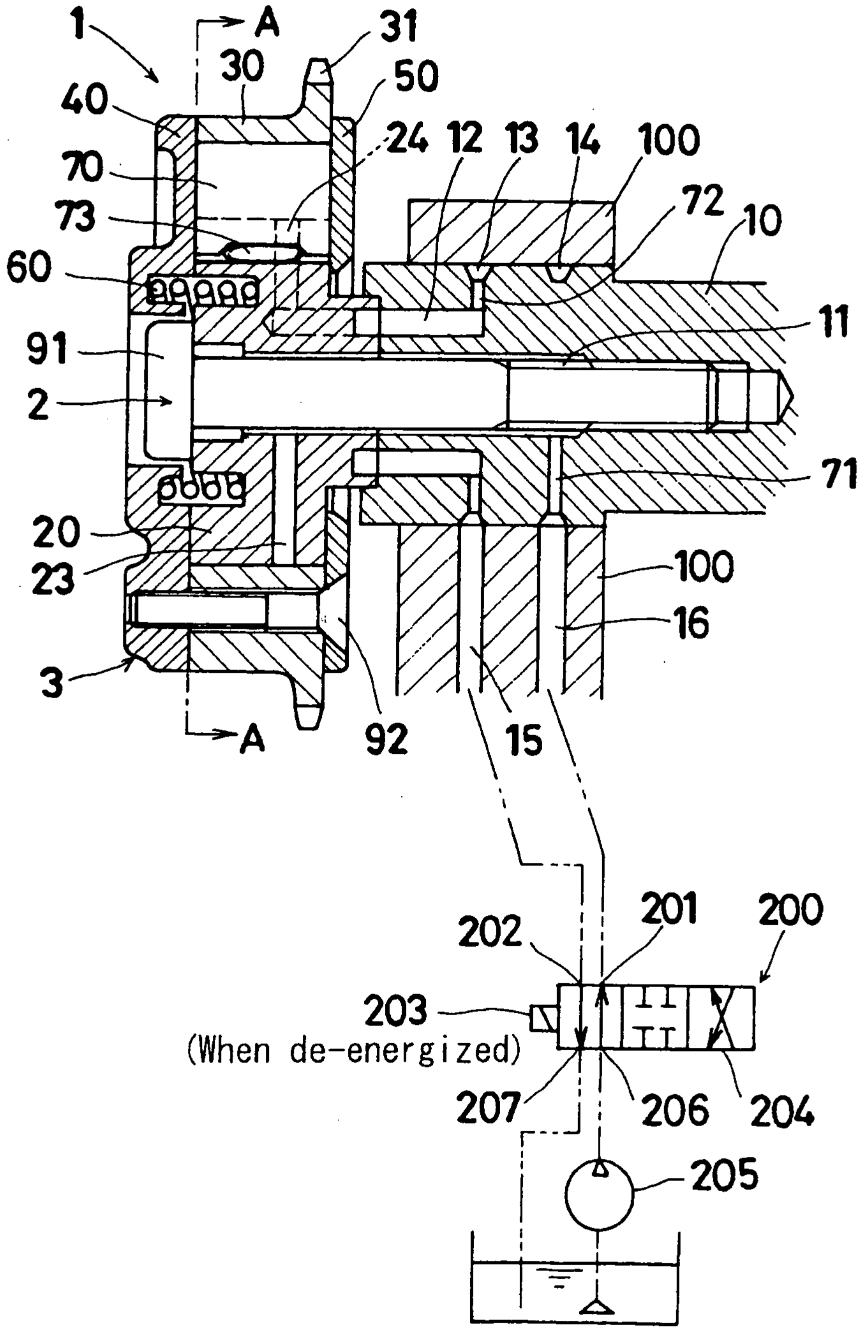
6. A variable valve timing control device according to claim 4, wherein the lock member includes a head portion (80a) facing the bottom portion of the receiving hole and having a trapezoidal shape in cross section formed by a convex taper portion extending in a radially inward direction of the housing member and a top portion including a contact portion (80b) with which the inner peripheral face of the receiving hole is in contact.

7. A variable valve timing control device according to claim 5, wherein the inner peripheral face of the receiving hole includes a concave taper portion (22c) having a trapezoidal shape in cross section and gradually expanding towards the opening portion of the receiving hole.

8. A variable valve timing control device according to claim 6, wherein the inner peripheral face of the receiving hole includes a concave taper portion (22c) having a trapezoidal shape in cross section and gradually expanding towards an opening portion of the receiving hole.

9. A variable valve timing control device according to claim 7, wherein the contact portion of the head portion of the lock member and the concave taper portion of the inner peripheral face of the receiving hole are in contact with each other on the advanced angle side and the retarded angle side when the relative rotation between the housing member and the rotor member is restricted.

F I G. 1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70
72
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73
60
11
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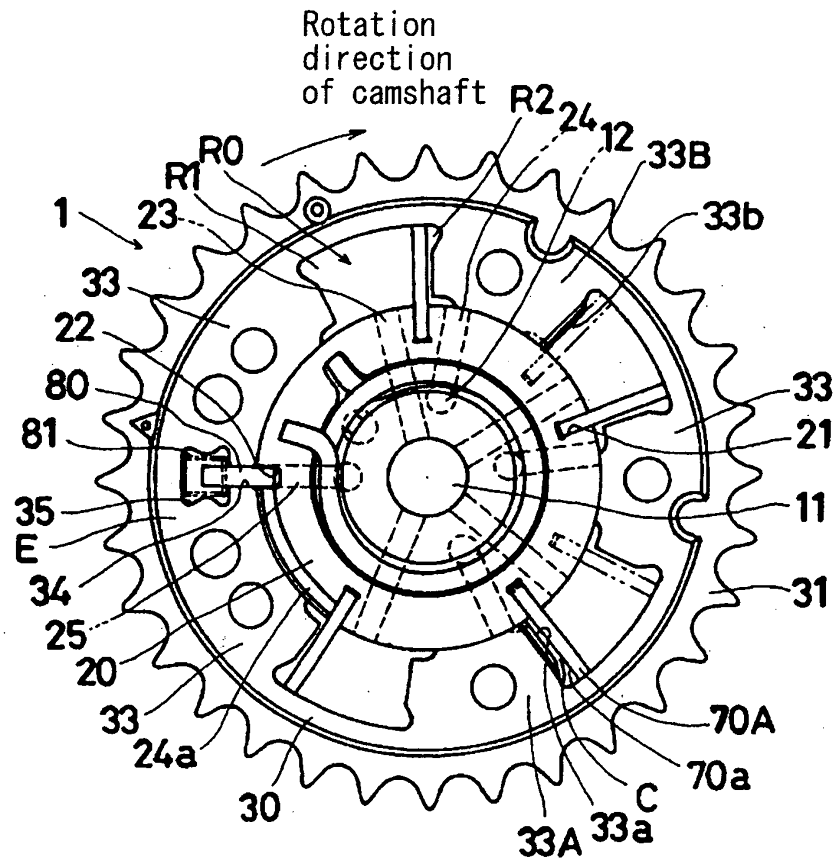
2
71
20
100
23
16
3
A
92
15
202
201
200
203
(When de-energized)
207
206
204
205

FIG. 2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direction
of camshaft
R0
R1
R2
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25
20
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24a
30
33A
33a
C
70a
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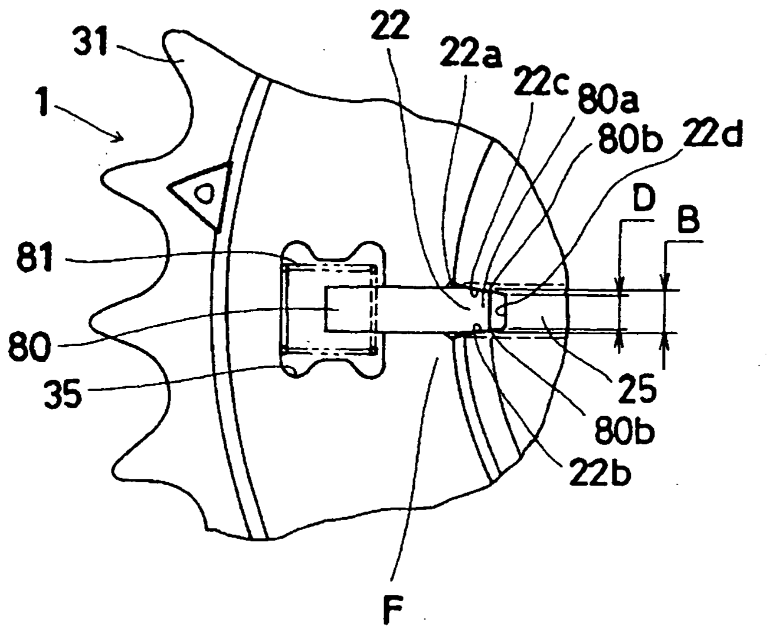
31
11
21
33

FIG. 3


31
1
22
22a
22c
80a
80b
22d
D
B
81
80
35
25
80b
22b
F

F I G. 4