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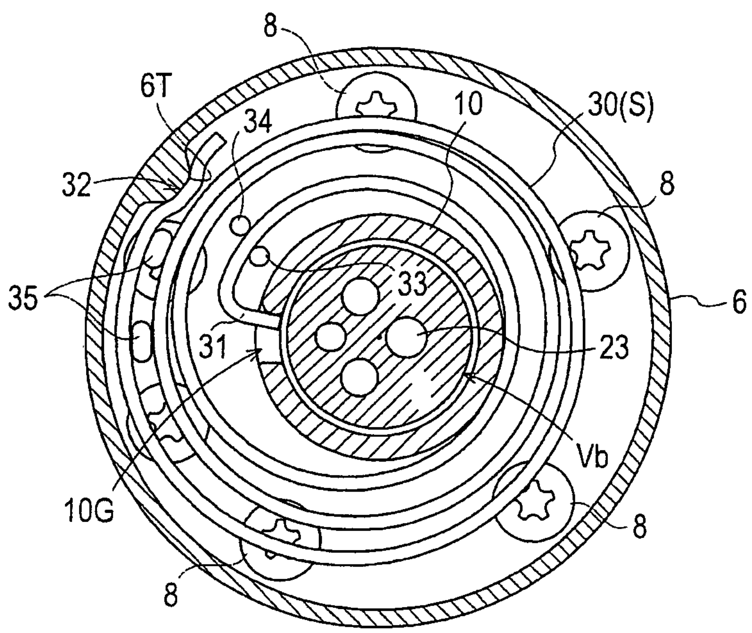
(54) Valve opening/closing timing control device

(57) A valve opening/closing timing control device includes: a driving side rotational member; a driven side rotational member; a retarded angle chamber and an advanced angle chamber; a lock mechanism; and a spiral spring providing a biasing force in a predetermined phase direction in a retarded angle region of a relative rotational phase of the driven side rotational member to the driving side rotational member from a most retarded angle phase to a predetermined phase, and not providing the biasing force to a most advanced angle phase from the predetermined phase.

FIG.2B



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Description

TECHNICAL FIELD

[0001] This disclosure relates to a valve opening/closing timing control device capable of adjusting the opening/closing timing of the intake valves or exhaust valves of an internal combustion engine used in vehicles such as automobile, and more particularly to a valve opening/closing timing control device including a driving side rotational member synchronously rotatable with a crankshaft, a driven side rotational member arranged coaxially with the driving side rotational member in a relatively rotational manner and integrally rotatable with a camshaft that opens and closes valves of an internal combustion engine, a retarded angle chamber and an advanced angle chamber which are formed by the driving side rotational member and the driven side rotational member, in which the retarded angle chamber moves a relative rotational phase of the driven side rotational member to the driving side rotational member in a retarded angle direction, and the advanced angle chamber moves the relative rotational phase of both rotational members in an advanced angle direction, and a lock mechanism confining the relative rotational phase to a predetermined lock phase, specifically, a technique for biasing the driving side rotational member and the driven side rotational member in a direction of a lock phase.

BACKGROUND DISCUSSION

[0002] JP-A-2000-345816 (Patent Document 1; paragraphs [0057] to [0067], and Figs. 1, 2, 3 and 6) discloses a valve opening/closing timing control device including a driving side rotational member (a shoe housing in Patent Document 1) and a driven side rotational member (a vane rotor in Patent Document 1), in which an accommodation chamber is divided into two parts, an advanced angle chamber and a retarded angle chamber, by a vane provided on the driven side rotational member. The valve opening/closing timing control device further includes a fitting type restriction means for setting a phase difference between the driving side rotational member and the driven side rotational member to an optimum intermediate position, and a spring as an advanced angle means for rotating the driven side rotational member with respect to the driving side rotational member in the advanced angle direction. One end portion of the spring is locked to a locking hole of the driving side rotational member, and the other end portion of the spring is locked to a locking hole of an elongated hole shape (second embodiment).

[0003] With the above configuration, if the engine starts up in a state in which the driven side rotational member (camshaft side) is more to the retarded angle side than an intermediate position, the driven side rotational member is rotated in the direction of the intermediate position by the biasing force of the spring to fit the restriction means, and thus the engine starts up quickly. After the engine starts up, operating oil is supplied to the restriction means to release the fitting, and the operating oil is supplied to any one of the advanced angle chamber and the retarded angle chamber to achieve a relative rotation between the driving side rotational member and the driven side rotational member.

[0004] In Patent Document 1, when the driven side rotational member is relatively rotated toward the advanced angle side with respect to the driving side rotational member by releasing the fitting of the restriction means, the other end portion of the spring is moved in the engaging hole with the elongated hole shape, so that the biasing force of the spring does not act.

[0005] Further, a valve opening/closing timing control device disclosed in JP-A-2009-074384 (Patent Document 2; paragraphs [0026] to [0028], and Figs. 3 to 7) includes a driving side rotational member and a driven side rotational member, in which an accommodation chamber is divided into two parts, an advanced angle chamber and a retarded angle chamber, by a vane provided on the driven side rotational member. The valve opening/closing timing control device further includes a lock mechanism for fixing and maintaining the driving side rotational member and the driven side rotational member to an intermediate lock phase, and a torsion spring to bias the driving side rotational member and the driven side rotational member in the direction of the intermediate lock phase which generates an assisting force.

[0006] The torsion spring serves to suppress displacement of the retarded angle side in a region between an intermediate regulation phase which is placed in the direction of the retarded angle phase than the intermediate lock phase, and a most retarded angle phase, and has the role of a stopper at the displacement from the intermediate lock phase to the intermediate regulation phase after the engine starts up.

[0007] In Patent Document 2, one end portion of the torsion spring is fixed to the driving side rotational member, and the other end portion can abut against an opening formed diametrically in the driven side rotational member. A spring receiving groove to which the other end portion is inserted is formed in the driving side rotational member. As the other end portion of the torsion spring abuts against an abutting surface of the opening in an effective range between the intermediate regulation phase and the most retarded angle phase by the configuration, the biasing force acts on the driven side rotational member. Further, the other end portion abuts against a stopper surface of the spring receiving groove in the intermediate regulation phase, so that no biasing force acts on the driven side rotational member.

[0008] As disclosed in Patent Document 1 or Patent Document 2, the torsion spring is used between the driving side rotational member and the driven side rotational member as the biasing means for biasing the rotational members in the direction of the lock phase from the most retarded angle phase. The number of turns in a coil portion of the torsion spring is required to some degree, thereby causing the whole valve opening/closing timing control device to become larger.

[0009] That is, so as not to vary spring load significantly in the relative rotational region of the driven side rotational member with respect to the driving side rotational member from the most retarded angle phase to the lock phase, the number of turns in the coil portion is required to some degree. Therefore, there is a need for a space in the direction of a shaft core by a dimension corresponding to the number of turns, which causes the whole valve opening/closing timing control device to become larger.

[0010] A need thus exists for a valve opening/closing timing control device without impairing the function of biasing the driving side rotational member and the driven side rotational member from a most retarded angle phase to the direction of a predetermined phase.

SUMMARY

[0011] According to an aspect of this disclosure, there is provided a valve opening/closing timing control device including a driving side rotational member synchronously rotatable with a crankshaft of an internal combustion engine, a driven side rotational member arranged coaxially with the driving side rotational member in a relatively rotational manner and integrally rotatable with a camshaft that opens and closes valves of the internal combustion engine, a retarded angle chamber and an advanced angle chamber which are formed by the driving side rotational member and the driven side rotational member, in which the retarded angle chamber moves a relative rotational phase of the driven side rotational member to the driving side rotational member in a retarded angle direction in accordance with volume increase, and the advanced angle chamber moves the relative rotational phase in an advanced angle direction in accordance with volume increase, a lock mechanism confining the relative rotational phase to a predetermined lock phase, and a spiral spring providing a biasing force in a predetermined phase direction in a retarded angle region of the relative rotational phase from a most retarded angle phase to a predetermined phase of the driven side rotational member to the driving side rotational member, and not providing the biasing force to a most advanced angle phase from the predetermined phase.

[0012] At the time of starting of the internal combustion engine, it is preferable that the relative rotational phase of the driven side rotational member to the driving side rotational member is at the predetermined lock phase, but is not necessary at the predetermined lock phase. For example, it may be at the retarded angle region side near the predetermined lock phase or at the advanced angle region side near the predetermined lock phase, on the basis of the predetermined lock phase. That is, at the time of starting of the internal combustion engine, if the relative rotational phase of the driven side rotational member to the driving side rotational member is in a predetermined region including the predetermined lock phase, proper starting is achieved.

[0013] In this aspect of this disclosure, if the internal combustion engine starts up in a state in which the relative rotational phase of the driven side rotational member to the driving side rotational member is in the retarded angle region, the relative rotational phase acts in the predetermined phase direction by the biasing force of the spiral spring, so that the relative rotational phase is early moved in the predetermined phase direction to enhance the starting ability of the internal combustion engine. Further, in a case in which the relative rotational phase is more towards the advanced angle region than the predetermined phase, the biasing force of the spiral spring does not act. In particular, since no space corresponding to the coil portion of the torsion spring is required by using the spiral spring, it is possible to suppress the device from becoming larger. As a result, the valve opening/closing timing control device can be compactly configured without impairing the function of biasing the driving side rotational member and the driven side rotational member in the predetermined phase direction from the most retarded angle phase.

[0014] The aspect this disclosure may include the spiral spring providing the biasing force in the predetermined lock phase direction in the retarded angle region of the relative rotational phase from the most retarded angle phase to the predetermined lock phase, and not providing the biasing force to the most advanced angle phase from the predetermined lock phase.

[0015] If the internal combustion engine starts up in a state in which the relative rotational phase of the driven side rotational member to the driving side rotational member is in the retarded angle region, the relative rotational phase acts in the predetermined lock phase direction as the predetermined phase by the biasing force of the spiral spring, so that the relative rotational phase is maintained early to the predetermined lock phase to enhance the starting ability of the internal combustion engine. Further, in a case in which the relative rotational phase is in the advanced angle region than the predetermined lock phase, the biasing force of the spiral spring does not act.

[0016] In the aspect of this disclosure, the outer circumference of a shaft-shaped body which rotates integrally with the driven side rotational member is provided with an engaging concave portion having a region distance corresponding to the advanced angle region from the predetermined lock phase to the most advanced angle phase. An engaging portion formed by bending an inner end portion of the spiral spring is engaged to the engaging concave portion, and a support portion of an outer end portion of the spiral spring is supported by a support body which rotates integrally with the driving side rotational member. The engaging portion is biased in a direction of engaging the engaging concave portion by the spiral spring.

[0017] In the configuration, in accordance with the setting of the positional relationship between the engaging portion of the spiral spring and the engaging concave portion of the shaft-shaped body, the biasing force can act to rotate the driven side rotational member in the predetermined lock phase direction in a case in which the relative rotational phase of the driven side rotational member to the driving side rotational member is in the retarded angle region. Further, in a case in which the relative rotational phase of the driven side rotational member to the driving side rotational member is in the advanced angle phase, the free rotation of the driven side rotational member is allowed. In addition, since the engaging portion is biased in a direction of a shaft core, it does not lead to problems in which the engaging portion becomes released from the engaging concave portion.

[0018] The aspect of this disclosure may include a regulation piece to restrict displacement of the engaging portion in the direction of the advanced angle region by abutment of the engaging portion.

[0019] In the configuration, since the position of the engaging portion is restricted by the regulation piece, it is possible to set the range of which the biasing force of the spiral spring acts.

[0020] The aspect of this disclosure may include a suppression piece to suppress displacement of the engaging portion in the direction in which the spiral spring bulges.

[0021] In the configuration, since the suppression piece suppresses displacement of the engaging portion of the spiral spring in a releasing direction from the engaging concave portion, it does not lead to problems of the engaging portion releasing from the engaging concave portion.

[0022] According to the aspect of this disclosure, the support portion is formed in a concave surface which is concave in the center direction of the spiral spring, and the support body is formed in a protruding surface which fits into the concave surface. The concave surface and the engaging portion may be disposed at a position in which a spring body is sandwiched in a radial direction.

[0023] In the configuration, when the protruding surface is fitted into the concave surface and the engaging portion is engaged to the engaging concave portion, a force acts in the direction of compressing the spring body in the radial direction. By the spring load generated by the action of the force, the biasing force is generated from the spring body so that the protruding surface is fitted into the concave surface and the engaging portion is fitted into the engaging concave portion. Consequently, it is possible to reliably support the spiral spring and provide the biasing force between the driving side rotational member and the driven side rotational member reliably.

BRIEF DESCRIPTION OF THE DRAWINGS

[0024] The foregoing and additional features and characteristics of this disclosure will become more apparent from the following detailed description considered with the reference to the accompanying drawings, wherein:

[0025] Fig. 1 is a cross-sectional view illustrating a valve opening/closing timing control device including an electromagnetic control valve;

[0026] Figs. 2A and 2B are cross-sectional views taken along the line IIa-IIa and the line IIb-IIb in Fig. 1 in a most retarded angle phase;

[0027] Figs. 3A and 3B are cross-sectional views illustrating an outer rotor and an inner rotor at a lock phase, and a spiral spring at the lock phase;

[0028] Figs. 4A and 4B are cross-sectional views illustrating the outer rotor and the inner rotor at a most advanced angle phase, and the spiral spring at the most advanced angle phase; and

[0029] Fig. 5 is a perspective view illustrating the shape of the spiral spring.

DETAILED DESCRIPTION

[0030] Embodiments disclosed here will now be described with reference to the accompanying drawings.

(Basic configuration)

[0031] As shown in Fig. 1 and Figs. 2A and 2B, a valve opening/closing timing control device includes an outer rotor 1 serving as a driving side rotational member and synchronously rotatable with a crankshaft (not shown) of an engine (an internal combustion engine), an inner rotor 2 serving as a driven side rotational member and coaxially and synchronously rotatable with a camshaft 3 which opens and closes an intake valve or an exhaust valve in a combustion chamber of the engine, and an electromagnetic control valve V.

[0032] The valve opening/closing timing control device includes a configuration in which the inner rotor 2 (driven side rotational member) is inserted in the outer rotor 1 (driving rotational member). Consequently, the outer rotor 1 and the inner rotor 2 can be relatively freely rotated around a core X of a rotational shaft in the range of a predetermined relative rotational phase. A fluid pressure chamber is formed between the outer rotor 1 and the inner rotor 2, the fluid pressure chamber is partitioned into a retarded angle chamber 11 and an advanced angle chamber 12 by a vane 5 installed therein.

[0033] The vane 5 is inserted into a vane groove formed in the outer circumference of the inner rotor 2, and is biased in a protruding direction by a leaf spring. Consequently, at the time of relative rotation of the outer rotor 1 and the inner rotor 2, an outer end portion of the vane 5 is slidable on an inner surface of the outer rotor in the fluid pressure chamber.

[0034] The camshaft 3 is coaxially arranged with the core X of the rotational shaft. The camshaft 3 is connected to the inner rotor 2 by a connecting bolt 4. A front plate 6 is placed on one surface of the outer rotor 1, and a rear plate 7 is placed on the other surface of the outer rotor 1. The front plate 6 and the rear plate 7 are fixed to the outer rotor 1 by a plurality of fixing bolts 8. With the configuration, the inner rotor 2 is interposed between the front plate 6 and the rear plate 7.

[0035] Further, the front plate 6 includes a spiral spring S to provide a biasing force on the outer rotor 1 (driving side rotational member) and the inner rotor 2 (driven side rotational member), and a cover 9 to cover the spiral spring. The detailed configuration of the spiral spring S will be described below.

[0036] A timing sprocket 7S is integrally installed on the outer circumference of the rear plate 7. Between the timing sprocket 7S and a gear attached to the crankshaft of the engine, there is provided a power transmission member (not shown) such as a timing chain or a timing belt.

[0037] In the configuration, upon start-up of the engine, a rotational driving force of the crankshaft is transmitted to the timing sprocket 7S through the power transmission member, and the outer rotor 1 rotates in a rotational direction T shown in Fig. 2A or the like. As the inner rotor 2 rotates in the rotational direction T in conjunction with the rotation, the camshaft 3 rotates, and the intake valve or the exhaust valve of the engine is opened or closed by the driving rotation of a cam (not shown) provided on the camshaft 3.

[0038] In the valve opening/closing timing control device, when the engine operates, if the advanced angle chamber 12 is supplied with operating oil, the volume of the advanced angle chamber 12 is enlarged by the pressure acting on the vane 5, and thus the inner rotor 2 is moved in a direction denoted by an arrow T1 with respect to the outer rotor 1. Consequently, the relative rotational phase of the outer rotor 1 and the inner rotor 2 is shifted in the advanced angle direction. In contrast, if the retarded angle chamber 11 is supplied with the operating oil, the volume of the retarded angle chamber 11 is enlarged by the pressure acting on the vane 5 in an adverse direction, and thus the inner rotor 2 is moved in a direction denoted by an arrow T2 with respect to the outer rotor 1. Consequently, the relative rotational phase of the outer rotor 1 and the inner rotor 2 is shifted in the retarded angle direction. The opening and closing timing of the intake vale or exhaust valve is controlled by changing a rotational phase of the camshaft 3 with respect to the rotational phase of the crankshaft.

[0039] Engine oil is used as the operating oil, and the valve opening/closing timing control device includes a lock mechanism L to maintain the relative rotational phase between the outer rotor 1 and the inner rotor 2 at a lock phase suitable for the start-up of the engine. In other words, the lock mechanism L restricts the relative rotation between the outer rotor 1 and the inner rotor 2 when the relative rotational phase between the outer rotor 1 and the inner rotor 2 becomes the predetermined phase, i.e., the predetermined lock phase. The lock mechanism L confines (locks) the outer rotor 1 and the inner rotor 2 at a set relative rotational phase in circumstances in which the pressure of the operating oil is an unstable state immediately after the start-up of the engine. Therefore, the rotational phase of the camshaft 3 with respect to the rotational phase of the crankshaft is maintained at a phase suitable for the start-up of the engine, thereby providing the stable start-up of the engine.

[0040] The lock mechanism L is constituted of a pair of lock pieces 14 of a plate shape extendable and withdrawing freely to and from the outer rotor 1, a spring 15 biasing each of the lock pieces 14 in a protruding direction (direction of the inner rotor 2), and a pair of lock concave portions 16 formed on the outer circumferential portion of the inner rotor 2 in a concave shape so as to be engaged to each of the lock pieces 14. In this instance, as the shape of the lock pieces 14, a pin shape may be employed, as well as the plate shape shown in this embodiment.

[0041] In the valve opening/closing timing control device, the inner rotor 2 is provided with a retarded angle chamber side oil passage 11a through which the operating oil is distributed to a plurality of retarded angle chambers 11, an advanced angle chamber side oil passage 12a through which the operating oil is distributed to a plurality of advanced angle chambers 12, and a lock release oil passage 16a through which the operating oil is distributed to the lock concave portion 16.

[0042] As shown in Fig. 1 and Figs. 2A and 2B, the cam shaft 3 is fitted with a bush 18, and the bush 18 is relatively rotated with respect to the camshaft 3. There is an oil passage system to supply sequentially the operating oil to an internal oil passage 3a of the camshaft 3 and an internal oil passage 2a of the inner rotor 2 from a supply oil passage 18a of the bush 18. The operating oil supplied from a hydraulic pump P to the supply oil passage 18a is supplied to a cylindrical space 2S of the inner rotor 2 by the oil passage system. Further, the operating oil supplied to the inner rotor 2 is supplied to the retarded angle chamber side oil passage 11a, the advanced angle chamber side oil passage 12a, and the lock release oil passage 16a by the electromagnetic control valve V, and is discharged from the retarded angle chamber side oil passage 11a, the advanced angle chamber side oil passage 12a and the lock release oil passage 16a by the electromagnetic control valve V.

(Electromagnetic control valve)

[0043] The electromagnetic control valve V includes an operating oil control portion Va having a spool valve 22 which is operated by an electromagnetic solenoid 21, and an operating oil supply/discharge portion Vb of a cylindrical shape to perform distribution of the operating oil, in which the operating oil control portion and the operating oil supply/discharge portion are integrally formed. The operating oil supply/discharge portion Vb includes a check valve C provided in a main oil passage 23 to receive the operating oil from the above-described inner oil passage 2a. In an entire circumference of an outer surface of the operating oil supply/discharge portion Vb, three ports 24, 25 and 26 are formed in a groove shape, in which the distribution of the operating oil is controlled by the spool valve 22. An oil seal 27 is fitted from outside on the outer circumference of the operating oil supply/discharge portion Vb to suppress leakage of the operating oil from each of the ports 24, 25 and 26.

[0044] The above-described cylindrical space 2S is formed in the inner rotor 2 so as to form a cylindrical shape around the core X of the rotational shaft, and the above-described operating oil supplying/discharging portion Vb of the electromagnetic control valve V is relatively rotatably fitted in the cylindrical space 2S. In this instance, the retarded angle chamber side oil passage 11a, the advanced angle chamber side oil passage 12a and the lock release oil passage 16a are in communication with the ports 24, 25 and 26 in the figure, but the relative disposition of the oil passages is not limited thereto.

[0045] In the valve opening/closing timing control device, a gap is formed between the inner rotor 2 and the front plate 6 and between the inner rotor 2 and the rear plate 7, in which the operating oil slightly leaks there through. The operating oil slightly leaks through the other movable portion. The leaked operating oil is collected by an oil pan (not shown).

(Outline of control system)

[0046] Although not shown in the figures, the control system of the valve opening/closing timing control device includes a crank angle sensor detecting the rotational angle of the crankshaft of the engine, a camshaft angle sensor detecting the rotational angle of the camshaft 3, and an ECU (not shown) controlling the electromagnetic control valve V

[0047] The ECU is provided with a signal system acquiring ON/OFF information of an ignition key, information from an oil temperature sensor detecting the temperature of the engine oil, or the like, and control information of the optimum relative rotational phase according to the driving state of the engine is stored in a nonvolatile memory.

[0048] The ECU detects the relative phase of the outer rotor 1 and the inner rotor 2 based on information of the driving state (e.g., revolutions of engine, temperature of cooling water or the like) and the detected result of the above-described crank angle sensor and camshaft angle sensor. The distribution of the operating oil to the retarded angle chamber side oil passage 11a, the advanced angle chamber side oil passage 12a and the lock release oil passage 16a is performed by operating the electromagnetic control valve V based on the information, thereby controlling the relative rotational phase of the outer rotor 1 and the inner rotor 2. Consequently, the phase control is achieved between the most retarded angle phase (relative rotational phase in which the volume of the retarded angle chamber 11 is maximized) and the most advanced angle phase (relative rotational phase in which the volume of the advanced angle chamber 12 is maximized), and the lock state and the unlock state by the lock mechanism L are achieved.

[0049] If an operation is performed to stop the engine, the ECU moves the relative phase of the outer rotor 1 and the inner rotor 2 in the lock phase direction by supplying the operating oil to the retarded angle chamber 11 or the advanced angle chamber 12 in a state in which the operating oil is discharged from the lock release oil passage 16a. Consequently, the engine stops in a state in which the pair of lock pieces 14 is engaged to the pair of the corresponding lock concave portions 16. When the engine starts up after stopping, the engine starts up reliably by confining (restricting) the outer rotor 1 and the inner rotor 2 with the lock mechanism L to hold the relative rotation (to the predetermined lock phase).

[0050] After the start-up of the engine, the ECU supplies the operating oil to the lock release oil passage 16a to lift the lock pieces 14 up from the lock concave portions 16 to thereby release the lock. The ECU changes the relative phase of the outer rotor 1 and the inner rotor 2 in a state in which the pressure of the operating oil acts on the lock release oil passage 16a, so that the control of the opening and closing timing of the intake valve and the exhaust valve is performed by the ECU.

[0051] In a case where the inner rotor 2 with respect to the outer rotor 1 is in the retarded angle side region than the lock phase, the above-described spiral spring S has a function of providing the biasing force in the lock phase direction (direction of the predetermined phase) with respect to the inner rotor 2. Therefore, a problem in which the relative phase of the inner rotor 2 integrally rotating with the camshaft 3 is retarded with respect to the rotation of the outer rotor 1 since the camshaft 3 receives resistance from the valve spring is solved.

[0052] In a case where the engine is in the stop state since excessive load is applied to the engine, the inner rotor 2 may reach the most retarded angle phase with respect to the outer rotor 1. When the engine starts up in this situation, the ECU controls the phase of the inner rotor 2 with respect to the outer rotor 1 to move to the lock phase early and thus set the phase in a lock state so as to perform reliable start-up of the engine.

[0053] As a detailed control mode, the electromagnetic control valve V discharges the operating oil from the lock release oil passage 16a, discharges the operating oil from the retarded angle side oil passage 11a and supplies the operating oil to the advanced angle chamber side oil passage 12a by the control of the ECU, so that the inner rotor 2 with respect to the outer rotor 1 is moved in the lock phase direction. Under the control, the lock pieces 14 are engaged to the lock concave portions 16 at the timing in which the outer rotor 1 and the inner rotor 2 reach the lock phase, so that the lock mechanism L is in the lock state. In this instance, the rotational phase of the most retarded angle phase, in which the inner rotor 2 is disposed at the most retarded angle side, is referred to as a super-retarded angle phase.

[0054] However, in a case in which the engine starts up in the state in which the inner rotor 2 is at the most retarded angle phase, the time is needed until the relative rotational phase reaches the lock phase, so that the start-up of the engine is not smoothly performed. In particular, the operating oil is cold at the time of stopping the engine in cold climates, the viscosity of the operating oil is high, and thus the distribution of the operating oil to each of the retarded angle chamber 11 and the advanced angle chamber 12 is not smoothly performed. For this reason, the start-up of the engine is not smoothly performed. In order to address the above problem, it is aimed to shorten the time required to reach the lock phase by assisting the relative movement of the outer rotor 1 and the inner rotor 2 in the direction of the lock phase by the above-described spiral spring S.

(Spiral spring)

[0055] As shown in Fig. 2B and Fig. 5, the spiral spring S operates to bias the relative rotational phase of the inner rotor 2 (driven side rotational member) with respect to the outer rotor 1 (driving side rotational member) in the direction of the lock phase in a retarded angle region A from the most retarded angle phase to the lock phase. In addition, the spiral spring S operates so as not to provide the biasing force in an advanced angle region B from the lock phase to the most advanced angle phase. In this instance, it is not necessary for the spiral spring S to provide the biasing force in the direction of the lock phase in the whole area of the retarded angle region A. For example, the biasing force may act from the super-retarded angle phase to near the lock phase, or the biasing force may act in the advanced angle side on the basis of the lock phase to the advanced angle region A near the lock phase. The phase on which the biasing force of the spiral spring S acts is the predetermined phase of the embodiment disclosed here and thus becomes a proper phase (region) suitable for the start-up of the engine (internal combustion engine).

[0056] Since the spiral spring S is formed in a spiral shape from a strap of spring material, the thickness (dimension of the rotational shaft in the direction of core X) can be thinned as compared with one including a coil portion such as a torsion spring. In a case where the spiral spring S is installed, since a large space is not required in the direction of the core X of the rotational shaft, it is possible to downsize the valve opening/closing timing control device.

[0057] The outer circumference of an axial portion 10 (one example of the axial body) of the inner rotor 2 is provided with an engaging concave portion 10G having an opening width (opening width in a circumferential direction) of a region distance corresponding the advanced angle region B. The front plate 6 connected to the outer rotor 1 is provided with a protruding surface 6T protruding in the direction of the core X of the rotational shaft.

[0058] The spiral spring S has a spring body 30 of a spiral shape. An engaging portion 31 is formed by bending the inner end portion of the spiral spring and is engaged to the engaging concave portion 10G, and a concave surface 32 (one example of the support portion) is formed on an outer end portion of the spiral spring in a concaved shape in a center direction (core X of the rotational shaft) of the spiral spring S so that the protruding surface 6T (one example of the support body) is inserted into the concave surface.

[0059] The front plate 6 is provided with a suppression piece 33 constituted of a pin which abuts against the engaging portion 31 to suppress a displacement of the engaging portion 31 in the direction of the advanced angle region B. In addition, the front plate 6 is provided with a suppression piece 34 constituted of a pin which abuts against an adjacent portion of the engaging portion 31 of the spiral spring S to suppress a displacement of the engaging portion 31 in a direction in which the diameter of the spiral spring S is bulged.

[0060] In the region of the same direction on the basis of the center position of the spiral spring S, the engaging portion 31 and the concave surface 32 described above are positioned in a position to which the spring body 30 is sandwiched. Further, the spiral spring S is set in such a manner that the distance from the engaging portion 31 to the concave surface 32 is slightly longer than that from the engaging concave portion 10G to the protruding surface 6T in a no-load free state. In addition, spacers 35 are inserted into a gap of the spring body 30 in the vicinity of the outer circumference of the spiral spring S.

[0061] According to the arrangement and the feature of the spiral spring S, the above-described biasing force is obtained by compressing the spring body 30 in a radial direction so as to shorten the distance of the engaging portion 31 and the concave surface 32 slightly when the spiral spring S is set. Consequently, the engaging portion 31 is biased in a direction (direction of the core X of the rotational shaft) of fitting it into the engaging concave portion 10G by the resilient force of the spring body 30. Simultaneously, the concave surface 32 is biased in a direction of pressing it against the protruding surface 6T. Further, the appropriate gap is formed in the spring body 30 by the spacers 35. Therefore, both ends of the spiral spring S can be supported reliably and the biasing force can provide between the outer rotor 1 and the inner rotor 2 reliably.

[0062] As shown in Fig. 2A, in a state in which the engine stops at the relative phase of the inner rotor 2 with respect to the outer rotor 1 which is at the super-retarded angle, an opened end portion of the engaging concave portion 10G abuts against the engaging portion 31, as shown in Fig. 2B, and the spiral spring S provides the biasing force to move the relative rotational phase of the outer rotor 1 and the inner rotor 2 in the lock phase.

[0063] In a case where the engine stops in this state, the biasing force of the spiral spring S is provided on the outer rotor 1 and the inner rotor 2 continuously through the protruding surface 6T and the axial portion 10 until reaching the lock phase. As shown in Fig. 3A, if the relatively rotational phase of the outer rotor 1 and the inner rotor 2 reaches the lock phase, the engaging portion 31 abuts against the regulation piece 33, as shown in Fig. 3B. The region, on which the biasing force of the spiral spring S acts, corresponds to the retarded angle region A.

[0064] If the relative rotational phase reaches the lock phase and the engaging portion 31 abuts against the regulation piece 33, the biasing force of the spiral spring S does not act on the axial portion 10. Further, the lock pieces 14 of the lock mechanism L fit into the lock concave portions 16 to reach the lock state, the stable start-up of the engine is achieved. Since the engaging portion 31 of the spiral spring S abuts against the suppression piece 34, it is possible to suppress the displacement of the spiral spring S in the bulging direction, so that the engaging portion 31 is not released from the engaging concave portion 10G.

[0065] After the engine starts, as shown in Fig. 4A, in a case where the inner rotor 2 moves to the advanced angle region B in the direction of the advanced angle, the inner rotor reaches a position in which the engaging portion 31 is spaced apart from the opened end portion of the engaging concave portion 10G, as shown in Fig. 4B. Therefore, the biasing force of the spiral spring S does not act on the inner rotor 2, and the appropriate relative movement is achieved by supply of the operating oil to any one of the outer rotor 1 and the inner rotor 2.

[0066] In particular, the outer end portion of the spiral spring S may be formed to have a support structure in such a manner that the front plate 6 is provided with a concave portion or a hole for engagement, and the outer end portion of the spiral spring S is bent to be engaged to the concave portion or the hole. Further, the configuration may be formed in such a manner that a pin or the like serving as the engaging portion 31 protrudes from the inner end portion of the spiral spring S to be engaged to the engaging concave portion 10G.

[0067] Since the valve opening/closing timing control device disclosed here includes the spiral spring S to bias the relative rotational phase of the outer rotor 1 and the inner rotor 2 in the lock phase direction, the space corresponding to the coil portion such as the torsion spring is not required, thereby suppressing the device from becoming larger.

[0068] The spiral spring S applies the biasing force in the lock phase direction at the relative rotational phase only in a case where the relative rotational phase of the inner rotor 2 (driven side rotational member) to the outer rotor 1 (driving side rotational member) is in the retarded angle region A from the most retarded angle phase to near the lock phase. Consequently, if the engine starts up in the state in which the relative rotational phase of the inner rotor 2 to the outer rotor 1 is at the most retarded angle phase, the movement of the inner rotor 2 with respect to the outer rotor 1 is assisted until reaching the lock phase.

[0069] In a case where the relative rotational phase of the outer rotor 1 and the inner rotor 2 exceeds the lock phase and is in the advanced angle region B, the biasing force of the spiral spring S does not act, and the relative rotation is smoothly performed.

[0070] The embodiment disclosed here can be used in the whole valve opening/closing timing control devices capable of setting opening and closing timing of any one of an intake valve and an exhaust valve of an engine.

[0071] 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 spirit 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.

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 valve opening/closing timing control device comprising:

   a driving side rotational member (1) synchronously rotatable with a crankshaft of an internal combustion engine;

   a driven side rotational member (2) arranged coaxially with the driving side rotational member in a relatively rotational manner and integrally rotatable with a camshaft that opens and closes valves of the internal combustion engine;

   a retarded angle chamber (11) and an advanced angle chamber (12) which are formed by the driving side rotational member and the driven side rotational member, in which the retarded angle chamber moves a relative rotational phase of the driven side rotational member to the driving side rotational member in a retarded angle direction in accordance with volume increase, and the advanced angle chamber moves the relative rotational phase in an advanced angle direction in accordance with vol-

ume increase;
a lock mechanism (L) confining the relative rotational phase to a predetermined lock phase; and
a spiral spring (S) providing a biasing force in a predetermined phase direction in a retarded angle region of the relative rotational phase of the driven side rotational member to the driving side rotational member from a most retarded angle phase to a predetermined phase, and not providing the biasing force to a most advanced angle phase from the predetermined phase.

2. The valve opening/closing timing control device according to Claim 1, wherein the spiral spring (S) provides the biasing force in the predetermined lock phase direction in the retarded angle region of the relative rotational phase from the most retarded angle phase to the predetermined lock phase, and does not provide the biasing force to the most advanced angle phase from the predetermined lock phase.

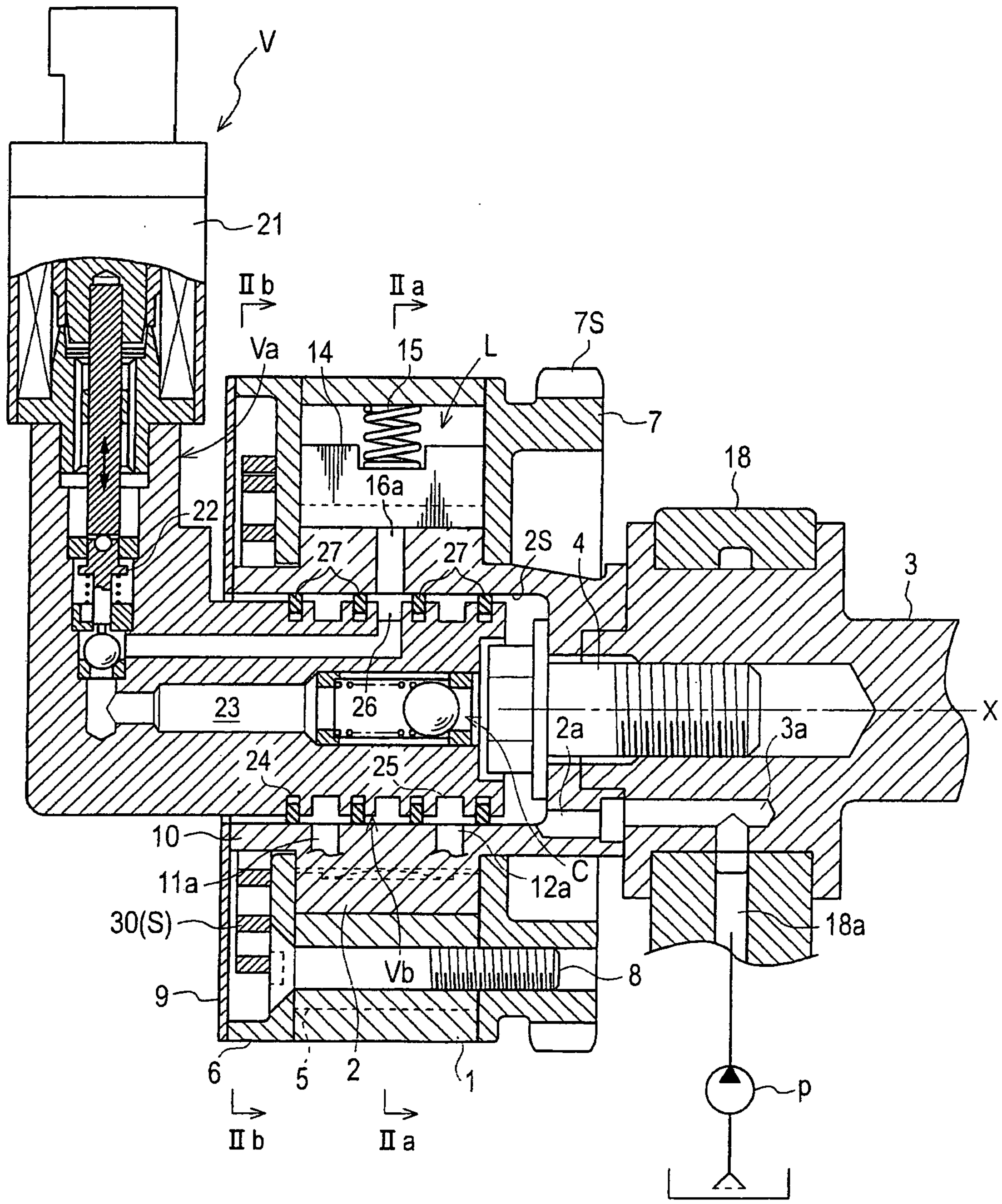
3. The valve opening/closing timing control device according to Claim 1 or 2, wherein an outer circumference of a shaft-shaped body which rotates integrally with the driven side rotational member (2) is provided with an engaging concave portion (10G) having a region distance corresponding to the advanced angle region from the predetermined lock phase to the most advanced angle phase;
an engaging portion (31) formed by bending an inner end portion of the spiral spring (S) is engaged to the engaging concave portion, and a support portion (32) of an outer end portion of the spiral spring is supported by a support body (6T) which rotates integrally with the driving side rotational member (1); and
the engaging portion is biased in a direction of engaging the engaging concave portion by the spiral spring.

4. The valve opening/closing timing control device according to Claim 3, further comprising a regulation piece to regulate displacement of the engaging portion (31) in a direction of the advanced angle region by abutment of the engaging portion.

5. The valve opening/closing timing control device according to Claim 3 or 4, further comprising a suppression piece (33) to suppress displacement of the engaging portion (31) in a direction in which the spiral spring bulges.

6. The valve opening/closing timing control device according to any one of Claims 3 to 5, wherein the support portion (32) is formed in a concave surface which is concave in a center direction of the spiral spring (S), and the support body (6T) is formed in a protruding surface which fits into the concave surface; and
the concave surface and the engaging portion are disposed at a position in which a spring body is sandwiched in a radial direction.

FIG.1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IIb
IIa
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2a
3a
24
25
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Vb
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6
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2
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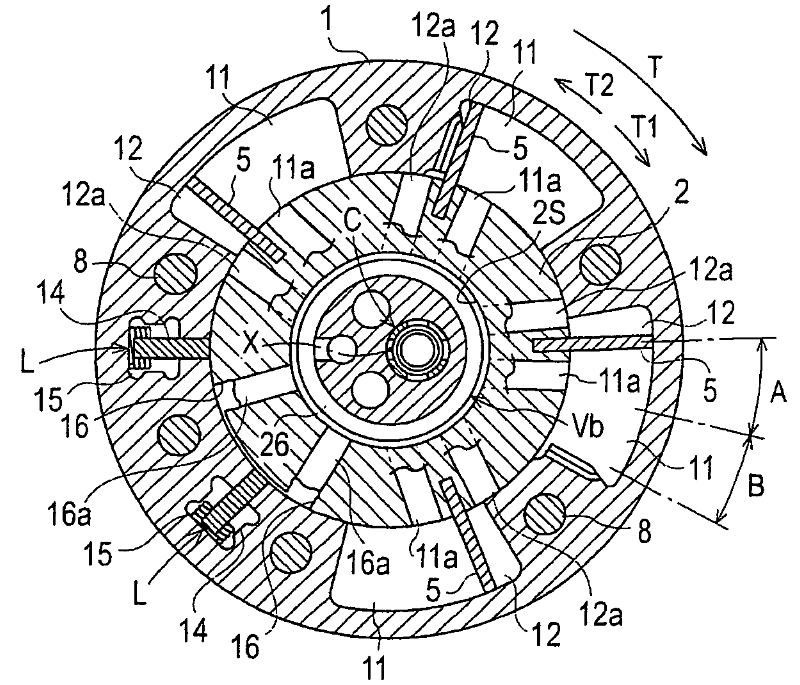
IIb
IIa

FIG.2A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14
12
L
X
15
11a
5
A
16
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16a
11a
L
5
12a
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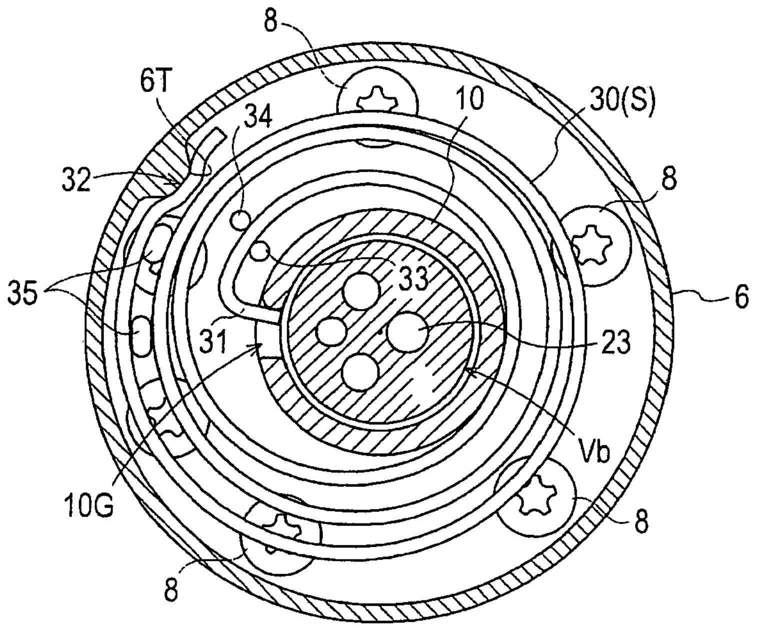
12
11

FIG.2B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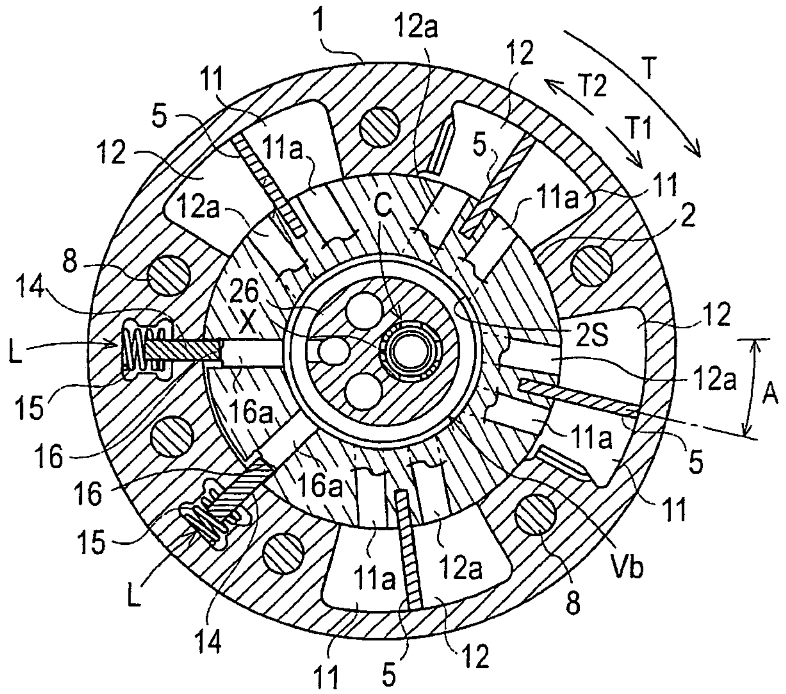
31
23
Vb
10G
8
8

FIG.3A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X
2S
12
L
12a
A
15
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L
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11
5
12

FIG.3B

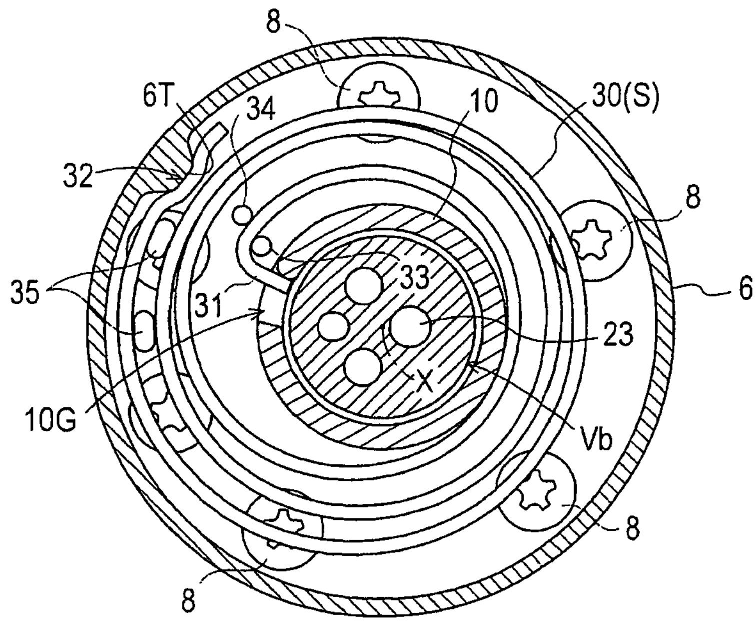
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FIG.4A

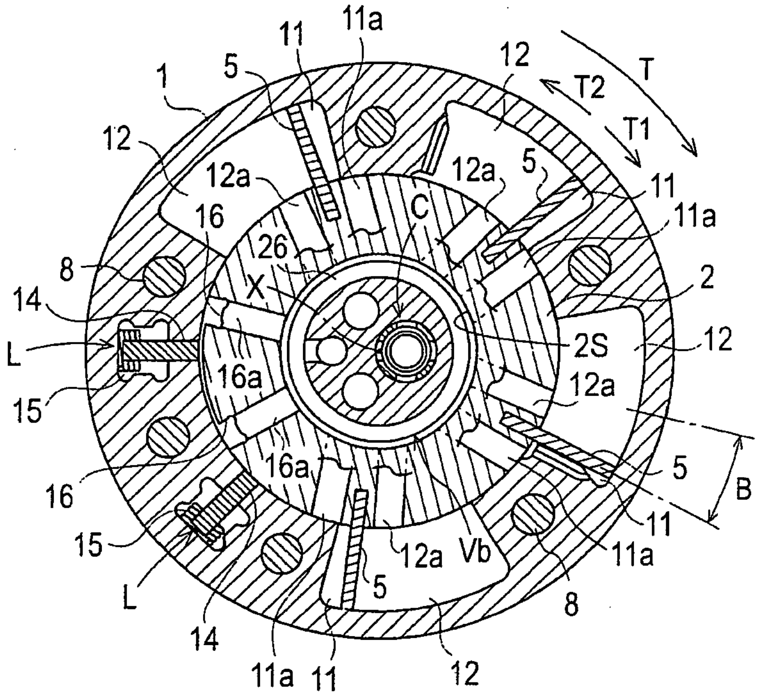
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FIG.4B

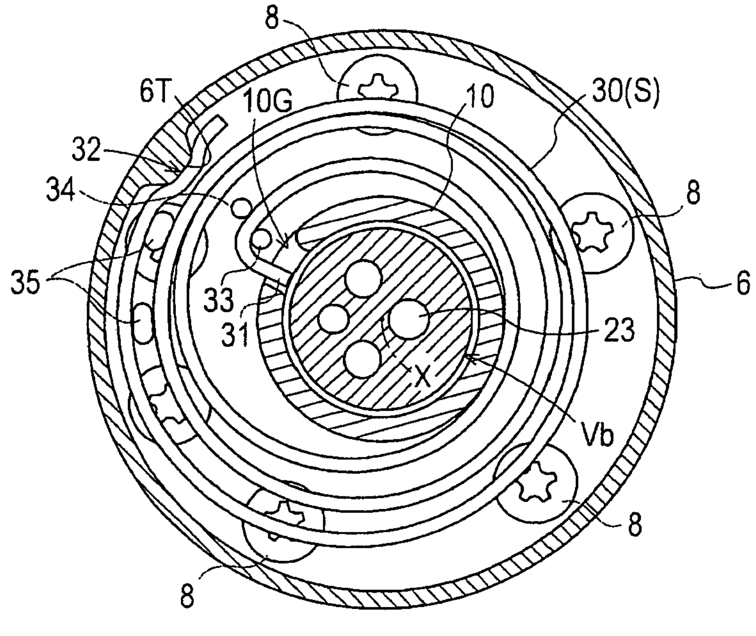
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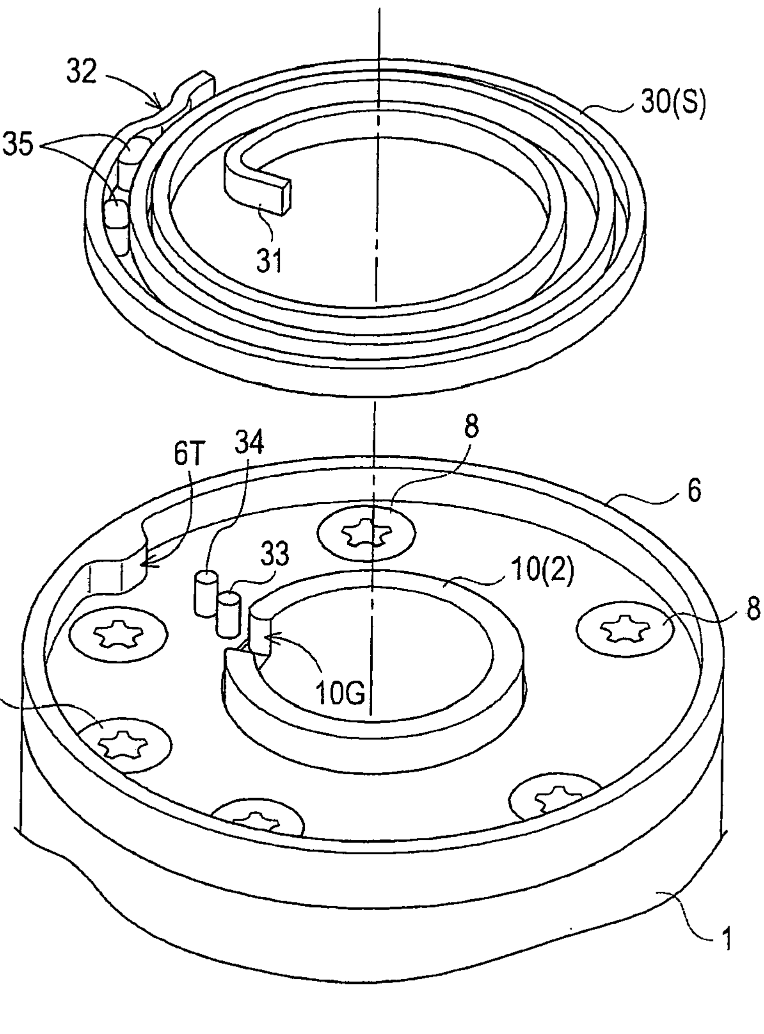
FIG.5



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EUROPEAN SEARCH REPORT

Application Number
EP 10 00 2825

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	US 2009/211549 A1 (MYERS JESSE [US] ET AL) 27 August 2009 (2009-08-27) * page 1 * * figures * -----	1,2	INV. F01L1/344
X	WO 2005/049976 A1 (INA SCHAEFFLER KG [DE]; SCHAEFER JENS [DE]; AUCHTER JOCHEN [DE]; DEGEL) 2 June 2005 (2005-06-02) * abstract * * figures * -----	1,2	
X	US 2009/188456 A1 (DUPUIS CRAIG [CA] ET AL) 30 July 2009 (2009-07-30) * page 1 * * figures * -----	1,2	
X	US 2007/277757 A1 (FISCHER THOMAS H [US] ET AL) 6 December 2007 (2007-12-06) * abstract * * figures * * paragraph [0011] * -----	1,2	TECHNICAL FIELDS SEARCHED (IPC)
A	DE 198 54 891 A1 (AISIN SEIKI [JP]) 10 June 1999 (1999-06-10) * the whole document * -----	1-6	F01L
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The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	17 December 2010	Paulson, Bo

CATEGORY OF CITED DOCUMENTS

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17-12-2010

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