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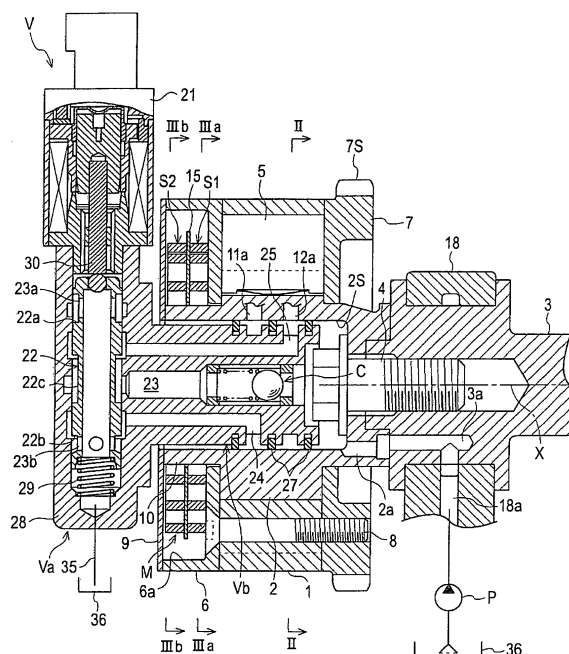
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(54) **Valve opening/closing timing control device**

(57) A valve opening/closing timing control device includes: a driving side rotational member synchronously rotatable with a crankshaft of an internal combustion engine; a driven side rotational member arranged coaxially with the driving side rotational member and synchronously rotatable with a camshaft that opens and closes any one of intake and exhaust valves of the internal combustion engine; a phase converting mechanism displacing a relative phase between the driving side rotational member and the driven side rotational member to an advanced angle phase side or a retarded angle phase side by distributing an operating fluid to each of two kinds of pressure chambers, the volume of which is complementarily varied by a movable partition; and a biasing member biasing the relative phase toward a predetermined phase suitable for a start-up of the internal combustion engine except for a most advanced angle phase and a most retarded angle phase.

FIG.1



Description

TECHNICAL FIELD

[0001] This disclosure relates to 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 and synchronously rotatable with a camshaft that opens and closes at least any one of intake and exhaust valves of the internal combustion engine, and a phase converting mechanism displacing a relative phase between the driving side rotational member and the driven side rotational member by distributing an operating fluid to each of two kinds of pressure chambers, the volume of which is complementarily varied by a movable partition.

BACKGROUND DISCUSSION

[0002] JP-A-2009-074384 (Patent Document 1; paragraphs 0009 and 0029, Figs. 1, 2 and 3) is provided as literature information of the related art concerning a valve opening/closing timing control device. The valve opening/closing timing control device disclosed in Patent Document 1 includes a lock mechanism capable of locking a relative phase to an intermediate phase which is suitable for starting of an internal combustion engine, if necessary. The lock mechanism has a lock groove formed in the driven side rotational member, and a lock pin movably supported by the driving side rotational member so as to be fitted into the lock groove. The lock pin is biased by a spring in a direction of fitting the lock pin into the lock groove. If the relative phase of both rotational members reaches the intermediate phase, the lock pin automatically enters the lock groove by a biasing force of the spring. After the starting of the internal combustion engine is completed, the locking state of the lock mechanism is generally released by a pressure of oil supplied from an oil pump or the like, and, simultaneously, a displacement operation from the intermediate phase to an advanced angle side is performed by the pressure of the oil.

[0003] In general, there are many cases in which the valve opening/closing timing control device is provided with a biasing mechanism, such as a torsion spring, for biasing the relative phase in a direction of the intermediate phase, as a means for suppressing a tendency in which the driven side rotational member is retarded with respect to the driving side rotational member by a reaction force of a cam received from a valve spring of the intake valve or the exhaust valve. In particular, according to the torsion spring of the valve opening/closing timing control device disclosed in Patent Document 1, since its

retarded angle phase, and the biasing function is not effective in a region between an advanced angle phase and the intermediate phase, a displacement operation from the advanced angle phase to the intermediate phase or the intermediate control phase is quickly performed by the reaction force of the cam and an oil pressure of the pump.

[0004] However, in the valve opening/closing timing control device disclosed in Patent Document 1, since the lock operation to the intermediate phase depends upon entry operation of the lock pin when it reaches the intermediate phase, for example, if the movement of the lock pin is interfered with by foreign substances existing in the oil, the lock pin is not reliably fitted into the lock groove. Therefore, the lock may not be sufficiently displaced to the intermediate phase.

[0005] After the starting of the internal combustion engine is completed at the intermediate phase, in order to displace the relative phase from the intermediate phase to the advanced angle phase, there is a need for an oil supply mechanism or the like to push the lock pin out from the lock groove. Therefore, the valve opening/closing timing control device has a tendency to become larger and be complicated.

[0006] A need thus exists for a valve opening/closing timing control device capable of maintaining an intermediate phase effectively without being influenced by the existence of foreign substances. Further, another need exists for a valve opening/closing timing control device which is simple in mechanical structure, thus not susceptible to failure and which can be downsized.

SUMMARY

[0007] The needs as mentioned above are fulfilled with a valve opening/closing timing control device according to the appended claims.

[0008] According to a first aspect of this disclosure, a valve opening/closing timing control device includes 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 and synchronously rotatable with a camshaft that opens and closes any one of intake and exhaust valves of the internal combustion engine, a phase converting mechanism displacing a relative phase between the driving side rotational member and the driven side rotational member toward an advanced angle phase side or a retarded angle phase side by distributing an operating fluid to each of two kinds of pressure chambers, the volume of which is complementarily varied by a movable partition, and a biasing member biasing the relative phase toward a predetermined phase suitable for a start-up of the internal combustion engine except for a most advanced angle phase and a most retarded angle phase.

[0009] The valve opening/closing timing control device according to the first aspect of this disclosure does not

require a lock mechanism constituted of a lock groove formed on one rotational member and a lock pin supported by the other rotational member, but includes the biasing member biasing the relative phase toward a predetermined phase (start-up optimum phase) suitable for a start-up of the internal combustion engine except for a most advanced angle phase and a most retarded angle phase. Consequently, in a state in which it is free of the force of operating oil, the relative phase is shifted to the start-up optimum phase by the movement of the biasing member. Accordingly, since there is no problem in that the movement of the lock pin is interfered with by foreign substances contained in the oil, the maintenance of the relative phase in the start-up optimum phase is carried out reliably by the biasing member.

[0010] Further, since the lock mechanism is not constituted of a lock groove formed on one rotational member and a lock pin supported by the other rotational member, but constituted of a biasing member interposed between the driving side rotational member and the driven side rotational member, it is mechanically simple, and thus the valve opening/closing timing control device which is not susceptible to failure is obtained. In addition, it is possible to downsize the valve opening/closing timing control device.

[0011] Furthermore, since it does not require a lock mechanism with a lock pin which alternatively performs fitting and leaving to each of a lock groove, noise is not generated by the lock mechanism when the internal combustion engine starts up.

[0012] According to a second aspect of this disclosure, the biasing member includes a first biasing member to bias the relative phase in a direction of the advanced angle phase and a second biasing member to bias the relative phase in a direction of the retarded angle phase, and the biasing member further includes a first restricting portion to define the biasing force of the first biasing member between the predetermined phase and the most retarded angle phase, and a second restricting portion to define the biasing force of the second biasing member between the predetermined phase and the most advanced angle phase.

[0013] The biasing member biasing the relative phase toward the predetermined phase in a range from the most advanced angle phase side to the most retarded angle phase side may be constituted by one torsion spring (biasing member) to bias the relative phase toward the predetermined phase under circumstances in which an external force does not act. However, since the biasing force of the biasing member is most small near the predetermined phase, it is difficult to maintain the relative phase reliably at the predetermined phase. Further, as it is deviated from the predetermined phase to the most advanced angle phase side or the most retarded angle phase side, a restoring force of the biasing member is increased. As a result, high oil pressure is needed to displace the relative phase against the biasing force of the biasing member, which tends to increase energy loss.

[0014] However, as the configuration, if it is constituted of two biasing members, in which a biasing direction thereof is opposite to each other, and the relative phase is biased to the predetermined phase in cooperation with an acting force from two biasing members, the relative phase can be maintained reliably at the predetermined phase, for example, as compared with the above configuration in which one torsion spring (biasing member) is installed.

[0015] In the configuration, when the relative phase is operated from the predetermined phase to the retarded angle phase side or the advanced angle phase side by operation of the oil pressure or the like, for example, when the relative phase is operated toward the retarded angle phase side, only the biasing force of one biasing member acts in a state in which the biasing force of the second biasing member is defined between the predetermined phase and the most advanced angle phase by the second restriction portion. Therefore, the relative phase can be displaced by relatively small oil pressure.

[0016] In addition, in the configuration, according to the respective restriction portions, the biasing force by the first biasing member is defined between the predetermined phase and the most retarded angle phase and the biasing force by the second biasing member is defined between the predetermined phase and the most advanced angle phase. Therefore, in a state in which there is no oil pressure or the like for performing the displacement operation of the relative phase, the predetermined phase is achieved in a state in which the biasing force by the first biasing member toward the advanced angle phase rather than the predetermined phase is restricted by the first restriction portion, and the biasing force by the second biasing member toward the retarded angle phase rather than the predetermined phase is restricted by the second restriction portion. As a result, in a case where two biasing forces are not equal to each other through error in manufacturing precision of the biasing members or the like, the relative phase can be easily controlled at the original desired phase without deviating to the retarded phase side or the advanced angle phase side through the error.

[0017] According to a third aspect of this disclosure, the biasing member has the biasing force against a displacing force acting on the driven side rotational member based on torque fluctuation of the camshaft.

[0018] With the configuration, since the biasing force of the biasing member tends to offset the displacing force acting on the driven side rotational member based on the torque fluctuation of the camshaft, it is possible to increase the maintaining accuracy of the relative phase by the biasing member in the predetermined phase, and control accuracy of the relative phase by oil pressure is enhanced.

[0019] According to a fourth aspect of this disclosure, the biasing member is a spring placed between the driving side rotational member and the driven side rotational member.

[0020] With the configuration, since the aspect of this disclosure can be implemented by the biasing member of a simple configuration in which a spring such as a torsion spring or a spiral spring is disposed between the driving side rotational member and the driven side rotational member which are placed adjacent to each other, an assembling operation of the valve opening/closing timing control device is easily performed, and miniaturization can be easily performed.

[0021] According to a fifth aspect of this disclosure, a valve opening/closing timing control device includes 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 and synchronously rotatable with a camshaft that opens and closes any one of intake and exhaust valves of the internal combustion engine, a retarded angle chamber and an advanced angle chamber formed by the driving side rotational member and the driven side rotational member, in which the retarded angle chamber moves a relative phase of the driven side rotational member to the driving side rotational member in a retarded angle direction as a volume thereof is enlarged, and the advanced angle chamber moves the relative phase in an advanced angle direction as a volume thereof is enlarged, and a biasing member biasing the relative phase toward a predetermined phase except for a most advanced angle phase and a most retarded angle phase.

[0022] That is, the valve opening/closing timing control device according to the fifth aspect of this disclosure does not require a lock mechanism constituted of a lock groove formed on one rotational member and a lock pin supported by the other rotational member, but includes the biasing member biasing the relative phase toward a predetermined phase except for the most advanced angle phase and the most retarded angle phase. Consequently, in a state in which it is free of the force of the operating oil, the relative phase is shifted to the predetermined phase by the movement of the biasing member. Accordingly, since there is no problem in that the movement of the lock pin is interfered with by foreign substances contained in the oil, the maintenance of the relative phase in the predetermined phase (e.g., start-up optimum phase) is carried out reliably by the biasing member.

[0023] According to a sixth aspect of this disclosure, the biasing member includes a first biasing member to bias the relative phase to a first predetermined phase which is positioned in a direction of the advanced angle phase rather than the most retarded angle phase, and a second biasing member to bias the relative phase to a second predetermined phase which is positioned in a direction of the retarded angle phase rather than the most advanced angle phase. The first biasing member biases the relative phase from the most retarded angle phase to the first predetermined phase and does not bias the relative phase from the first predetermined phase to the most advanced angle phase. The second biasing mem-

ber biases the relative phase from the most advanced angle phase to the second predetermined phase and does not bias the relative phase from the second predetermined phase to the most retarded angle phase.

[0024] The biasing member biasing the relative phase toward the predetermined phase in a range from the most advanced angle phase side to the most retarded angle phase side may be constituted by, for example, one torsion spring. However, since the biasing force of the biasing member is most small near the predetermined phase, it is difficult to maintain the relative phase reliably at the predetermined phase. Further, as it is deviated from the predetermined phase to the most advanced angle phase side or the most retarded angle phase side, a restoring force of the biasing member is increased. As a result, high oil pressure is needed to displace the relative phase against the biasing force of the biasing member, which tends to increase energy loss.

[0025] In the configuration, if it is constituted of two biasing members, in which a biasing direction thereof is opposite to each other, and the relative phase is biased to the predetermined phase in cooperation with an acting force from two biasing members, the relative phase can be maintained reliably at the predetermined phase, for example, as compared with the above configuration in which one torsion spring is installed.

[0026] In the configuration, when the relative phase is operated from the predetermined phase to the retarded angle phase side or the advanced angle phase side by operation of the oil pressure or the like, for example, when the relative phase is operated toward the retarded angle phase side, only the biasing force of one biasing member acts in a state in which the biasing force of the second biasing member is defined between the predetermined phase and the most advanced angle phase by the second restriction portion. Therefore, the relative phase can be displaced by relatively small oil pressure.

[0027] In addition, in the configuration, in a state in which there is no oil pressure or the like for performing displacement operation of the relative phase, the first biasing portion does not bias the predetermined phase from the first predetermined phase to the most advanced angle phase, and the second biasing portion does not bias the predetermined phase from the second predetermined phase to the most retarded angle phase. As a result, in a case where two biasing forces are not equal to each other through error in manufacturing precision of the biasing members or the like, the relative phase can be easily controlled at the original desired phase without deviating to the retarded phase side or the advanced angle phase side through the error.

BRIEF DESCRIPTION OF THE DRAWINGS

[0028] 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:

[0029] Fig. 1 is a cross-sectional view illustrating an overall structure of a valve opening/closing timing control device according to a first embodiment;

[0030] Fig. 2 is a cross-sectional view of the valve opening/closing timing control device in a predetermined phase taken along the line II-II in Fig. 1;

[0031] Figs. 3A and 3B are cross-sectional views taken along the line IIIa-IIIa and IIIb-IIIb in the state of Fig. 2;

[0032] Fig. 4 is a cross-sectional view of the valve opening/closing timing control device at a most retarded angle phase taken along the line II-II in Fig. 1;

[0033] Figs. 5A and 5B are cross-sectional views taken along the line IIIa-IIIa and IIIb-IIIb in the state of Fig. 4;

[0034] Fig. 6 is a cross-sectional view of the valve opening/closing timing control device at a most advanced angle phase taken along the line II-II in Fig. 1;

[0035] Figs. 7A and 7B are cross-sectional views taken along the line IIIa-IIIa and IIIb-IIIb in the state of Fig. 6;

[0036] Fig. 8 is an exploded perspective view of major parts of the valve opening/closing timing control device according to the first embodiment;

[0037] Figs. 9A and 9B are views illustrating a valve opening/closing timing control device according to a second embodiment which correspond to Figs. 3A and 3B;

[0038] Figs. 10A and 10B are views illustrating the valve opening/closing timing control device according to the second embodiment which correspond to Figs. 5A and 5B;

[0039] Figs. 11 A and 11 B are views illustrating the valve opening/closing timing control device according to the second embodiment which correspond to Figs. 7A and 7B;

[0040] Fig. 12 is an exploded perspective view of major parts of the valve opening/closing timing control device according to the second embodiment;

[0041] Fig. 13 is a cross-sectional view illustrating an overall structure of a valve opening/closing timing control device according to a third embodiment;

[0042] Figs. 14A and 14B are cross-sectional views taken along the line XIVa-XIVa and XIVb-XIVb in Fig. 13 in a predetermined phase state;

[0043] Fig. 15 is an exploded perspective view of major parts of a valve opening/closing timing control device according to a fourth embodiment; and

[0044] Figs. 16A and 16B are operation diagrams of major parts of a valve opening/closing timing control device according to a fifth embodiment.

DETAILED DESCRIPTION

[0045] Embodiments disclosed here will now be described with reference to the accompanying drawings.

(First embodiment)

(Basic configuration)

[0046] As shown in Fig. 1, a valve opening/closing tim-

ing 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 a fluid control valve mechanism V.

[0047] 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 side rotational member). Consequently, the outer rotor 1 and the inner rotor 2 can be relatively rotated around a core X of a rotational shaft in the range of a desired relative rotational phase. A fluid pressure chamber is formed between the outer rotor 1 and the inner rotor 2, and as shown in Fig. 2, the fluid pressure chamber is partitioned into a retarded angle chamber 11 and an advanced angle chamber 12 by a vane 5 serving as a partitioning portion supported on an outer circumference of the inner rotor 2.

[0048] 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 or the like. Consequently, irrespective of a relative phase of the outer rotor 1 and the inner rotor 2, an outer end portion of the vane 5 is always slidably held on an inner surface of the outer rotor in the fluid pressure chamber.

[0049] 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 means of 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 means of a plurality of fixing bolts 8. The inner rotor 2 is interposed between the front plate 6 and the rear plate 7.

[0050] A timing sprocket 7S is integrally installed on the outer periphery 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.

[0051] 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. 2 or the like. As the inner rotor 2 rotates in the same direction as 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.

[0052] 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 an 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 a retarded angle direction. The opening and closing timing of the intake valve or exhaust valve is controlled by changing a rotational phase of the camshaft 3 with respect to the rotational phase of the crankshaft.

[0053] Engine oil is used as the operating oil, and the valve opening/closing timing control device includes a maintenance mechanism M to maintain the relative rotational phase between the outer rotor 1 and the inner rotor 2 at a start-up optimum phase (referred to as an intermediate phase, and one example of the predetermined phase) suitable for the start-up of the engine. The maintenance mechanism M maintains the outer rotor 1 and the inner rotor 2 at the set relative rotational phase in circumstances in which the pressure of the operating oil is very low 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 the start-up optimum phase, thereby providing the stable start-up of the engine.

[0054] A general maintenance mechanism in the valve opening/closing timing control device of a related art is constituted of a lock groove formed in the inner rotor, and a lock pin supported on the outer rotor to be extendable and retractable to each of the lock groove.

[0055] However, the maintenance mechanism M disclosed here includes two spiral springs S1 and S2 applying the biasing force between the outer rotor 1 (driving side rotational member) and the inner rotor 2 (driven side rotational member) in mutually reverse directions. The first spiral spring S1 biases the relative phase toward the advanced angle side, and the second spiral spring S2 biases the relative phase toward the retarded angle side. The two spiral springs S1 and S2 are kept in a concave portion 6a formed in the front plate 6, and a disc spacer 15 is interposed between the spiral springs S1 and S2. The concave portion 6a is covered by a disc cover 9. The operation of the spiral springs S1 and S2 will be described in detail.

[0056] As shown in Figs. 1 and 2, the inner rotor 2 is provided with a retarded angle chamber side passage 11a through which the operating oil is supplied or discharged to or from the plurality of retarded angle chambers 11, and an advanced angle chamber side passage 12a through which the operating oil is supplied or discharged to or from the plurality of advanced angle chambers 12 in a penetrating manner. Since the lock pin is not provided as the maintenance mechanism, there is no lock release passage or the like for pushing the lock pin out

from the lock groove.

[0057] As shown in Figs. 1 and 2, the valve opening/closing timing control device includes a bush 18 fitted to the outer circumference of the camshaft 3 so as to relatively rotate 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.

[0058] Further, the operating oil supplied to the cylindrical space 2S is supplied to the retarded angle chamber side passage 11a and the advanced angle chamber side passage 12a described above through the fluid control valve mechanism V which is relatively rotatably supported with respect to the outer rotor 1 and the inner rotor 2, and is discharged from the retarded angle chamber side passage 11a and the advanced angle chamber side passage 12a.

(Fluid control valve mechanism)

[0059] The fluid control valve mechanism V includes, as shown in Fig. 1, a housing 28 integrally constituted of an operating oil control portion Va having a spool valve 22, and an operating oil supply/discharge portion Vb of a cylindrical shape to perform the distribution of the operating oil. The spool valve 22 is slid by an electromagnetic solenoid 21 disposed on an upper end portion of the operating oil control portion Va in an upper and lower portion on the figure. The operating oil supply/discharge portion Vb is rotatably inserted in the cylindrical space 2S of the inner rotor 2.

[0060] A main oil passage 23 penetrates into the center portion of the operating oil supply/discharge portion Vb to receive the operating oil from the above-described inner oil passage 2a, and a check valve C is provided in the main oil passage 23 to block flow of the fluid toward the cylindrical space 2S. The spool valve 22 has a bottomed cylindrical shape.

[0061] The housing 28 is fixed to a front cover or the like of the engine, and the inner rotor 2 is rotatably supported by the operating oil supply/discharge part Vb.

[0062] In the outer circumference of the operating oil supply/discharge part Vb, two ports 24 and 25 are formed in a groove, in which the distribution of the operating oil is controlled by the spool valve 22. An oil seal 27 is formed on the outer circumference of the operating oil supply/discharge portion Vb to suppress leakage of the operating oil from the first port 24 and the second port 25. The first port 24 is always in communication with the retarded angle chamber side passage 11a, and the second port 25 is always in communication with the advanced angle chamber side passage 12a.

[0063] A compression spring 29 is installed between the spool valve 22 and the bottom surface of the housing

28 to bias the spool valve 22 in an upward direction on the figure. If the solenoid 21 is energized in the state of Fig. 1, an operation rod 30 protruding downward from the solenoid 21 moves the spool valve 22 to a downward position. If the energization is stopped, the operation rod 30 is retracted toward the solenoid 21 side, and the spool valve 22 is returned to an upward position shown in Fig. 1 by the biasing force of the compression spring 29 while following up with the movement of the rod 22.

[0064] In the outer circumferential surface of the spool valve 22, ring-shaped discharge grooves 22a and 22b and a ring-shaped supply groove 22c are formed. The discharge grooves 22a and 22b are respectively provided with through-holes 23a and 23b penetrating an inner hollow portion.

[0065] A position relationship between the discharge grooves 22a and the 22b and the supply groove 22c is set in such a manner that the supply groove 22c is in communication with the main oil passage 23 and the advanced angle chamber communication hole 12a and the discharge groove 22b is in communication with the retarded angle chamber side passage 11a, as shown in Fig. 1, when the solenoid 21 is deenergized. Further, it is set in such a manner that the supply groove 22c is in communication with the main oil passage 23 and the retarded angle chamber side passage 11a and the discharge groove 22a is in communication with the advanced angle chamber side passage 12a, when the solenoid 21 is energized.

[0066] 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, through which the operating oil slightly leaks. The operating oil slightly leaks through the other movable portion. The leaked operating oil is collected by an oil pan 36.

(Operation of valve opening/closing timing control device)

[0067] As shown in Fig. 1, in the case where the relative rotational phase is displaced in the advanced angle direction T1, the solenoid 21 is in a deenergized state during the operation of the oil pressure pump P. Then, the spool valve 22 is placed at the upward position of the solenoid 21 together with the rod 30 of the solenoid 21 by the biasing force of the compression spring 29. The operating oil supplied to the main oil passage 23 of the camshaft 8 from the hydraulic pump P is fed to each advanced angle chamber 12 through the cylindrical space 2S, the main oil passage 23, the supply groove 22c, the advanced angle chamber side passage 12a and the second port 25, as shown in Fig. 1. The vane 5 is moved in the advanced angle direction T1 by the feeding, and the operating oil of each retarded angle chamber 11 is discharged. The operating oil discharged from the retarded angle chamber 11 is discharged to the oil pan 36 through the first port 24, the retarded angle chamber side passage 11a, the discharge groove 22b and a drain pas-

sage 35.

[0068] On the other hand, in the case where the relative rotational phase is displaced in the retarded angle direction T2, the solenoid 21 is energized during the operation of the oil pressure pump P. The spool valve 22 is pushed into the rod 22 of the solenoid 21 and then is positioned at the downward position. The operating oil supplied to the main oil passage 23 of the camshaft 8 from the fluid pump P is fed to each retarded angle chamber 11 through the cylindrical space 2S, the main oil passage 23, the supply groove 22c, the retarded angle chamber side passage 11a and the first port 24. The vane 5 is moved in the retarded angle direction T2 by the feeding, so that the operating oil of each advanced angle chamber 12 is discharged. The operating oil discharged from the advanced angle chamber 12 is discharged to the oil pan 36 through the second port 25, the advanced angle chamber side passage 12a, the discharge groove 22a and the drain passage 35.

(Schematic description of control system)

[0069] 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 fluid control valve mechanism V.

[0070] 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.

[0071] The ECU detects the relative phase of the outer rotor 1 and the inner rotor 2 from the detected result of the above-described crank angle sensor and camshaft angle sensor. The distribution of the operating oil to each of the retarded angle chamber 11 and the advanced angle chamber 12 is performed by operating the fluid control valve mechanism V based on the information of the relative phase and the information of the driving state (e.g., revolutions of engine, temperature of cooling water or the like), 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).

[0072] If the operation is performed to stop the engine, the ECU stops the distribution of the operating oil to the retarded angle chamber 11 and the advanced angle chamber 12 by the fluid control valve mechanism V, so that the vane 5 is not applied with the operating oil of any

direction. Consequently, the engine stops in the state in which the relative phase of the outer rotor 1 and the inner rotor 2 is displaced at the start-up optimum phase suitable for next start-up by the above-described biasing operation of the spiral springs S1 and S2. When the engine starts up after the stop, the engine starts up reliably.

[0073] In this instance, when the inner rotor 2 is positioned in the area in the retarded angle side than the start-up optimum phase with respect to the outer rotor 1, the above-described spiral springs S1 and S2 have a function of applying the biasing force to the inner rotor 2 in a direction of the start-up optimum phase against the reaction force received from the valve spring of the intake valve or exhaust valve in cooperation with each other. More specifically, the biasing force of the spiral spring S1 biasing the relative phase to the advanced angle side is set to be higher than that of the spiral spring S2 biasing the relative phase to the retarded angle side. Consequently, a problem that the relative phase of the inner rotor 2 integrally rotating with the camshaft 3 tends to be retarded with respect to the rotation of the outer rotor 1 due to the reaction force received from the valve spring of the intake valve or exhaust valve, or the tendency that the relative phase is maintained at the retarded angle side rather than the start-up optimum phase when the operating oil is discharged from the retarded angle chamber 11 and the advanced angle chamber 12 are suppressed.

[0074] After the start-up of the engine, the ECU performs the distribution of the operating oil to each of the retarded angle chamber 11 and the advanced angle chamber 12 by the fluid control valve mechanism V to change the relative phase of the outer rotor 1 and the inner rotor 2, so that the control of the opening and closing timing of the intake valve and the exhaust valve is performed by the ECU.

[0075] 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, in order to perform stable engine starting, the ECU controls the phase of the inner rotor 2 with respect to the outer rotor 1 to move at the start-up optimum phase early.

[0076] As a detailed control mode, the fluid control valve mechanism V discharges the operating oil from the retarded angle chamber 11 and supplies the operating oil to advanced angle chamber 12 by the control of the ECU, the inner rotor 2 with respect to the outer rotor 1 is moved in the direction of the start-up optimum phase. 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 the most retarded angle phase.

[0077] However, according to the above-described control, 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 rota-

tional phase reaches the start-up optimum 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 start-up optimum phase by assisting the relative movement of the outer rotor 1 and the inner rotor 2 in the direction of the start-up optimum phase by means of the above-described difference in the intensity of the spiral springs S1 and S2.

(Spiral spring)

[0078] As shown in Figs. 3A and 3B to Fig. 8, the first spiral spring S1 operates to bias the rotational phase of the inner rotor 2 with respect to the outer rotor 1 in the direction of the start-up optimum phase in a retarded angle region A from the most retarded angle phase to the start-up optimum phase. In contrast, the second spiral spring S2 operates to bias the rotational phase of the inner rotor 2 with respect to the outer rotor 1 in the direction of the start-up optimum phase in an advanced angle region B from the most advanced angle phase to the start-up optimum phase.

[0079] As shown in Fig. 8, since the spiral springs S1 and S2 are formed in a spiral shape from a strap of spring material, the thick (dimension of the rotational shaft in the direction of the core X) can be thinned as compared with one including a coil portion such as a torsion spring. As shown in Fig. 1, in a case where two spiral springs S1 and S2 are 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.

[0080] As shown in Figs. 3A and 3B, each of the spiral springs S1 and S2 has a spiral spring body 30 in a spiral shape. An end portion thereof in an inner diameter side is provided with an inner engaging portion 31 which is formed by bending the end portion in a radially inward direction and is engaged to the inner rotor 2. An end portion thereof in an outer diameter side is provided with an outer engaging portion 32 which is formed by bending the end portion in a radially outward direction and is fixed to the outer rotor 1.

[0081] The outer circumference of an axial portion 10 of the inner rotor 2 is provided on one portion thereof with an engaging concave portion 10G which may be engaged to the inner engaging portion 31, so as to correspond to the shape of the spiral springs S1 and S2. The inner surface of the front plate 6 connected to the outer rotor 1 is provided on one portion thereof with an engaging concave portion 6T which may be engaged to the outer engaging portion 32.

[0082] When the spiral springs S1 and S2 are set, first,

after the engaging concave portion 6T of the outer rotor 1 is engaged and fixed to the outer engaging portion 32, the inner engaging portion 31 is turned by predetermined turns against the biasing force of the spiral springs S1 and S2 which tend to be returned in a straight direction, in other words, in a direction of the spring body 30 which is curled in an inner diameter direction around the axis X, the inner engaging portion 31 is engaged and fixed to the engaging concave portion 10G. The rotation operating direction of the inner engaging portion 31 at the time of performing the setting corresponds to a counterclockwise direction in the first spring S1, and corresponds to a clockwise direction in the second spiral spring S2, in Fig. 2.

[0083] By setting the springs in the above manner, both ends of the spiral springs S1 and S2 are reliably fixed to each of the outer rotor 1 and the inner rotor 2 so as to prevent the relative movement therebetween, thereby achieving the configuration in which the inner engaging portion 31 of the first spiral spring S1 biases the inner rotor 2 toward the advanced angle side (clockwise direction in Fig. 2) and the inner engaging portion 31 of the second spiral spring S2 biases the inner rotor 2 toward the retarded angle side (counterclockwise direction in Fig. 2).

[0084] In this instance, only one of the two spiral springs S1 and S2 may be disposed in the concave portion 6a formed in the front plate 6, and the other may be disposed in the concave portion formed in the rear plate 7. In this instance, the disc spacer 15 is not required.

(Operation control)

[0085] As described above, since the distribution of the operating oil to each of the retarded angle chamber 11 and advanced angle chamber 12 is stopped at the general start-up of the engine, as shown in Fig. 2 and Figs. 3A and 3B, the relative phase of the outer rotor 1 and the inner rotor 2 is maintained at the start-up optimum phase between the most retarded angle phase and the most advanced angle phase by the biasing operation of the spiral springs S1 and S2. Consequently, the engine can start up reliably. If the start-up of the engine is instructed by ON operation of the ignition key, cranking is executed by a cell motor, and the engine starts up. The hydraulic pump P rotates, so that the operating oil can be supplied to the retarded angle chamber 11 and the advanced angle chamber 12.

[0086] After the start-up of the engine, since the operating oil is generally supplied to the retarded angle chamber 11 by the fluid control valve mechanism V in accordance with the control of the ECU, the relative rotational phase is displaced to the intermediate control phase slightly closer to the retarded angle phase side rather than the start-up optimum phase. The intermediate control phase is a phase suitable for improvement of the emission or torque-up at cold temperatures, and this phase is generally maintained during warm air driving.

In this instance, Fig. 4 and Figs. 5A and 5B show the state of the most retarded angle phase exceeding the intermediate control phase.

[0087] Since the displacement operation from the start-up optimum phase to the retarded angle phase side such as the intermediate control phase by the supply of the operating oil to the retarded angle chamber 11 is followed by the relative rotation operation of the inner rotor 2 in a counterclockwise direction in Fig. 4 and Figs. 5A and 5B, it is performed against the biasing force of the first spiral spring S1, that is, with the further pulling-up of the first spiral spring S1. Meanwhile, since the second spiral spring S2 is set in a state in which it is sufficiently pulled up, the second spiral spring S2 is simply loosen in the displacement from the start-up optimum phase to the retarded angle phase side, as compared with the state in the start-up optimum phase. Therefore, it does not exert the biasing force to move the relative rotational phase in the advanced angle direction. If the period of the warm air driving has been passed, the ECU transits to a general driving control.

[0088] When the displacement operation is performed to the advanced angle side rather than the start-up optimum phase in the general driving control, it is followed by the relative rotation operation of the inner rotor 2 in a clockwise direction in Fig. 6 and Figs. 7A and 7B, it is performed against the biasing force of the second spiral spring S2, that is, with the further tightening of the second spiral spring S2. Meanwhile, since the first spiral spring S1 is set in a state in which it is sufficiently pulled up, the first spiral spring is simply loosen in the displacement from the start-up optimum phase to the advanced angle phase side, as compared with the state in the start-up optimum phase. Therefore, it does not exert the biasing force to move the relative rotational phase in the retarded angle direction. In this instance, Fig. 6 and Figs. 7A and 7B show the state of the most advanced angle phase.

(Second Embodiment)

[0089] A second embodiment disclosed here will now be described with reference to the accompanying drawings.

[0090] The second embodiment includes two spiral springs S1 and S2 to bias a biasing force in a mutually reverse direction, as the maintenance mechanism M for maintaining the relative rotational phase of the outer rotor 1 and the inner rotor 2 at the start-up optimum phase suitable for the start-up of the engine, similar to the first embodiment.

[0091] The first feature of the configuration according to the second embodiment is that the width of the engaging concave portion 10G of the inner rotor 2 in a circumferential direction is sufficiently larger than the thickness of the inner engaging portion 31 of the spiral springs S1 and S2, as shown in Figs. 9A to 12. With the above configuration, the respective inner engaging portions 31 engaged to the engaging concave portion 10G are movable

along the circumferential direction in the engaging concave portion 10G.

[0092] The second feature of the configuration according to the second embodiment is that the front plate 6 is provided with first restriction piece 33A in a standing manner which can abut against the inner engaging portion 31 of the first spiral spring S1, and the front plate 6 is provided with second restriction piece 33B in a standing manner which can abut against the inner engaging portion 31 of the second spiral spring S2. The first restriction piece 33A restricts the displacement of the inner engaging portion 31 of the first spiral spring S1 in the direction of the advanced angle region B, and the second restriction piece 33B restricts the displacement of the inner engaging portion 31 of the second spiral spring S2 in the direction of the retarded angle region A.

[0093] As a result, as shown in Fig. 10A, the first spiral spring S1 operates to bias the rotational phase of the inner rotor 2 with respect to the outer rotor 1 in the direction of the start-up optimum phase in the retarded angle region A from the most retarded angle phase to the first predetermined phase (corresponding to the start-up optimum phase) defined by the first restriction piece 33A. In contrast, as shown in Fig. 11B, the second spiral spring S2 operates to bias the rotational phase of the inner rotor 2 with respect to the outer rotor 1 in the direction of the start-up optimum phase in the advanced angle region B from the most advanced angle phase to the second predetermined phase (corresponding to the start-up optimum phase) defined by the second restriction piece 33B.

[0094] As shown in Fig. 10B, in the retarded angle region A from the most retarded angle phase to the start-up optimum phase, since the inner engaging portion 31 of the second spiral spring S2 is engaged by the second restriction piece 33B, it does not move relatively in the engaging concave portion 10G with the wide width in the advanced angle direction to act on the inner rotor 2 at the earliest. For this reason, only the biasing force of the first spiral spring S1 acts on the rotational phase, and the biasing force does not act on the rotational phase from the second spiral spring S2.

[0095] In contrast, as shown in Fig. 11A, in the advanced angle region B from the most advanced angle phase to the start-up optimum phase, since the inner engaging portion 31 of the first spiral spring S1 is engaged by the first restriction piece 33A, it does not move relatively in the engaging concave portion 10G with the wide width in the retarded angle direction to act on the inner rotor 2 at the earliest. For this reason, only the biasing force of the second spiral spring S2 acts on the rotational phase, and the biasing force does not act on the rotational phase from the first spiral spring S1.

[0096] As a result, since the biasing operation position to the inner rotor 2 by the inner engaging portion 31 of the respective spiral springs S1 and S2 is limited to each position of the first and second restriction pieces 33A and 33B, if the distribution of the operating oil to each of the retarded angle chamber 11 and the advanced angle

chamber 12 is stopped, as shown in Figs. 9A and 9B, in a case where the balance of the biasing force of the respective spiral springs S1 and S2 is lost from an original state due to long-termed use, the rotational phase is not deviated by the collapse in the balance, and can be maintained at the start-up optimum phase with high accuracy.

(Third Embodiment)

[0097] A third embodiment employs not the spiral spring, but two torsion springs S1 and S2 as a biasing member for maintaining the relative phase at the start-up optimum phase, as shown in Fig. 13 and Figs. 14A and 14B. The first torsion spring S1 biasing the relative phase toward the advanced angle side is received in the concave portion 6a of the front plate 6, while the second torsion spring S2 biasing the relative phase toward the retarded angle side is received in a concave portion 7a of the rear plate 7.

[0098] Figs. 14A and 14B show the state of the respective torsion springs S1 and S2 at the start-up optimum phase.

[0099] The outer engaging portions 32 of the torsion springs S1 and S2 are engaged to the engaging concave portion 6T in a relatively non-movable manner in the inner surface of the front plate 6 which is connected to the outer rotor 1. However, the inner engaging portions 31 of the torsion springs S1 and S2 are engaged to the engaging concave portion 10G with a wide width in a relatively movable manner, the width of the engaging concave portion being cut sufficiently rather than an outer diameter of the inner engaging portion 31.

[0100] The restriction pieces 33A and 33B engaging to the inner engaging portions 31 of the torsion springs S1 and S2 protrude from the bottom portion of the front plate 6.

[0101] The same working effect as the second embodiment is achieved by the engaging concave portion 10G with the wide width and the restriction pieces 33A and 33B.

[0102] As will be understood from Fig. 14A, in the advanced angle region B from the most advanced angle phase to the start-up optimum phase, since the inner engaging portion 31 of the first torsion spring S1 is engaged by the first restriction piece 33A, it does not act on the inner rotor 2. For this reason, only the biasing force of the second torsion spring S2 acts on the rotational phase, and the biasing force does not act on the rotational phase from the first torsion spring S1.

[0103] In contrast, as will be understood from Fig. 14B, in the retarded angle region A from the most retarded angle phase to the start-up optimum phase, since the inner engaging portion 31 of the second torsion spring S2 is engaged by the second restriction piece 33B, it does not act on the inner rotor 2. For this reason, only the biasing force of the first torsion spring S1 acts on the rotational phase, and the biasing force does not act on the rotational phase from the second torsion spring S2.

[0104] As a result, since the biasing operation position to the inner rotor 2 by the inner engaging portion 31 of the respective torsion springs S1 and S2 is limited to each position of the first and second restriction pieces 33A and 33B, if the distribution of the operating oil to each of the retarded angle chamber 11 and the advanced angle chamber 12 is stopped, in a case where the balance of the biasing force of the respective torsion springs S1 and S2 is lost from an original state due to long-term use, the rotational phase is not deviated by the collapse in the balance, and can be maintained at the start-up optimum phase with high accuracy. The position of the first restriction piece 33A corresponds to the first predetermined phase, and the position of the second restriction piece 33B corresponds to the second predetermined phase.

(Fourth Embodiment)

[0105] A fourth embodiment employs single torsion spring S having an inner engaging portion 31 which is engaged to the engaging concave portion 10G of the inner rotor 2 and an outer engaging portion 32 which is engaged to the engaging concave portion 6T of the outer rotor 1, as a biasing member for maintaining the relative phase at the start-up optimum phase, as shown in Fig. 15.

[0106] In this embodiment, if the distribution of the operating oil to each of the retarded angle chamber 11 and the advanced angle chamber 12 is stopped, the relative phase is displaced at the start-up optimum phase by the biasing force of the torsion spring S, and is maintained at this phase. The displacement operation from the start-up optimum phase to the retarded angle side by the operating oil is performed, with being accompanied by deformation in which the inner engaging portion 31 of the torsion spring S relatively rotates in a counterclockwise direction with respect to the outer engaging portion 32, when seen at plane view in Fig. 15, that is, the diameter of the torsion spring S is decreased. In contrast, the displacement operation from the start-up optimum phase to the advanced angle side is performed, being accompanied by deformation in which the inner engaging portion 31 of the torsion spring S relatively rotates in a clockwise direction with respect to the outer engaging portion 32, when seen at plane view in Fig. 15, that is, the diameter of the torsion spring S is increased.

(Fifth Embodiment)

[0107] A fifth embodiment employs the engaging concave portion 10 of the inner rotor 2 extended long in a circumferential direction and single torsion spring S fitted to the cylindrical operating oil supply/discharge portion Vb, as a biasing member for maintaining the relative phase at the start-up optimum phase. Both ends 31a and 31b of the torsion spring S are extended outwardly in a radial direction, and the torsion spring S is fitted into the engaging concave portion 10 in a state in which both

ends 31a and 31b are close to each other against the biasing force of the torsion spring S.

[0108] The front plate 6 is provided with a pair of restriction pieces 34A and 34B in a standing manner which abut against or are adjacent to the outside of the torsion spring S in the vicinity of both ends 31a and 31b. In a state in which the distribution of the operating oil to each of the retarded angle chamber 11 and the advanced angle chamber 12 is stopped, as shown in Fig. 16A, both ends 31a and 31b of the torsion spring S are simultaneously pushed by both ends 10a and 10b of the engaging concave portion 10 and the pair of the restriction pieces 34A and 34B, thereby biasing the relative phase at the start-up optimum phase.

[0109] If the relative phase is displaced toward the retarded angle side by the operation of the operating oil, as shown in Fig. 16B, the displacement operation is performed by pushing the other end portion 31a of the torsion spring S in a counterclockwise direction with one end surface 10a of the engaging concave portion 10G of the inner rotor 2, with one end portion 31b of the torsion spring S being pushed by the restriction piece 34B.

[0110] The embodiments disclosed here can be used in the whole valve opening/closing timing control devices capable of setting the opening and closing timing of any one of an intake valve and an exhaust valve of an engine.

[0111] 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 and synchronously rotatable with a camshaft that opens and closes any one of intake and exhaust valves of the internal combustion engine;
- a retarded angle chamber (11) and an advanced angle chamber (12) formed by the driving side rotational member and the driven side rotational member, in which the retarded angle chamber moves a relative phase of the driven side rotational member to the driving side rotational member in a retarded angle direction as a volume thereof is enlarged, and the advanced angle chamber moves the relative phase in an advanced angle direction as a volume thereof is enlarged; and
- a biasing member (S1, S2) biasing the relative phase toward a predetermined phase except for a most advanced angle phase and a most retarded angle phase.
2. The valve opening/closing timing control device according to claim 1, wherein the biasing member includes a first biasing member (S1) to bias the relative phase in a first predetermined phase which is positioned in a direction of an advanced angle phase than the most retarded angle phase, and a second biasing member (S2) to bias the relative phase in a second predetermined phase which is positioned in a direction of a retarded angle phase than the most advanced angle phase; the first biasing member biases the relative phase from the most retarded angle phase to the first predetermined phase and does not bias the relative phase from the first predetermined phase to the most advanced angle phase; and the second biasing member biases the relative phase from the most advanced angle phase to the second predetermined phase and does not bias the relative phase from the second predetermined phase to the most retarded angle phase.
 3. The valve opening/closing timing control device according to claim 1 or 2, wherein a front plate (6) and a rear plate (7) are fixed to the driving side rotational member (1), and both of the first biasing member (S1) and the second biasing member (S2) are disposed between the driven side rotational member (2) and the front plate or between the driven side rotational member and the rear plate.
 4. The valve opening/closing timing control device according to claim 1 or 2, wherein a front plate (6) and a rear plate (7) are fixed to the driving side rotational member,
- the first biasing member (S1) is disposed either between the driven side rotational member (2) and the front plate or between the driven side rotational member and the rear plate, and
- the second biasing member (S2) is disposed either between the driven side rotational member and the front plate or between the driven side rotational member and the rear plate.
5. A valve opening/closing timing control device according to claim 1, wherein the retarded angle chamber (11) and the advanced angle chamber (12) are included in a phase converting mechanism displacing a relative phase between the driving side rotational member and the driven side rotational member to an advanced angle phase side or a retarded angle phase side by distributing an operating fluid to each of the two kinds of chambers, the volume of which is complementarily varied by a movable partition; and wherein the biasing member (S1, S2) biases the relative phase toward a predetermined phase suitable for a start-up of the internal combustion engine except for a most advanced angle phase and a most retarded angle phase.
 6. The valve opening/closing timing control device according to claim 5, wherein the biasing member includes a first biasing member (S1) to bias the relative phase in a direction of the advanced angle phase and a second biasing member (S2) to bias the relative phase in a direction of the retarded angle phase, and the valve opening/closing timing control device further includes a first restricting portion (33A) to define the biasing force of the first biasing member between the predetermined phase and the most retarded angle phase, and a second restricting portion (33B) to define the biasing force of the second biasing member between the predetermined phase and the most advanced angle phase.
 7. The valve opening/closing timing control device according to claim 5 or 6, wherein the biasing member (S1, S2) has the biasing force against a displacing force acting on the driven side rotational member (2) based on torque fluctuation of the camshaft.
 8. The valve opening/closing timing control device according to any one of claims 5 to 7, wherein the biasing member is a spring (S1, S2) placed between the driving side rotational member (1) and the driven side rotational member (2).
 9. The valve opening/closing timing control device ac-

cording to any one of claims 5 to 8, wherein a front plate (6) and a rear plate (7) are fixed to the driving side rotational member (1), and both of the first biasing member (S1) and the second biasing member (S2) are disposed between the driven side rotational member (2) and the front plate or between the driven side rotational member and the rear plate.

10. The valve opening/closing timing control device according to any one of claims 5 to 9, wherein a front plate (6) and a rear plate (7) are fixed to the driving side rotational member (1), the first biasing member (S1) is disposed either between the driven side rotational member (2) and the front plate or between the driven side rotational member and the rear plate, and the second biasing member (S2) is disposed either between the driven side rotational member and the front plate or between the driven side rotational member and the rear plate.

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FIG. 1

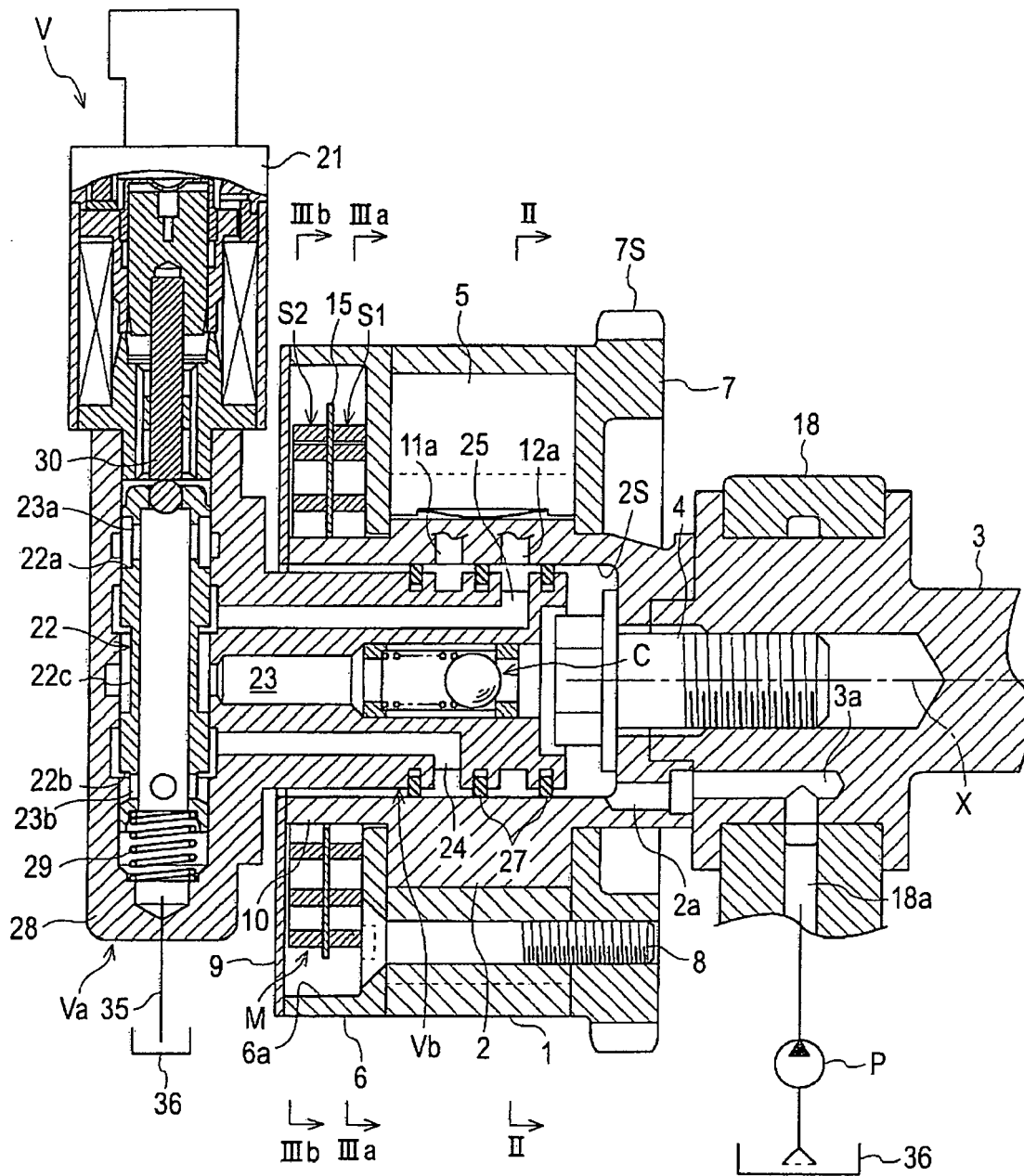


FIG. 2

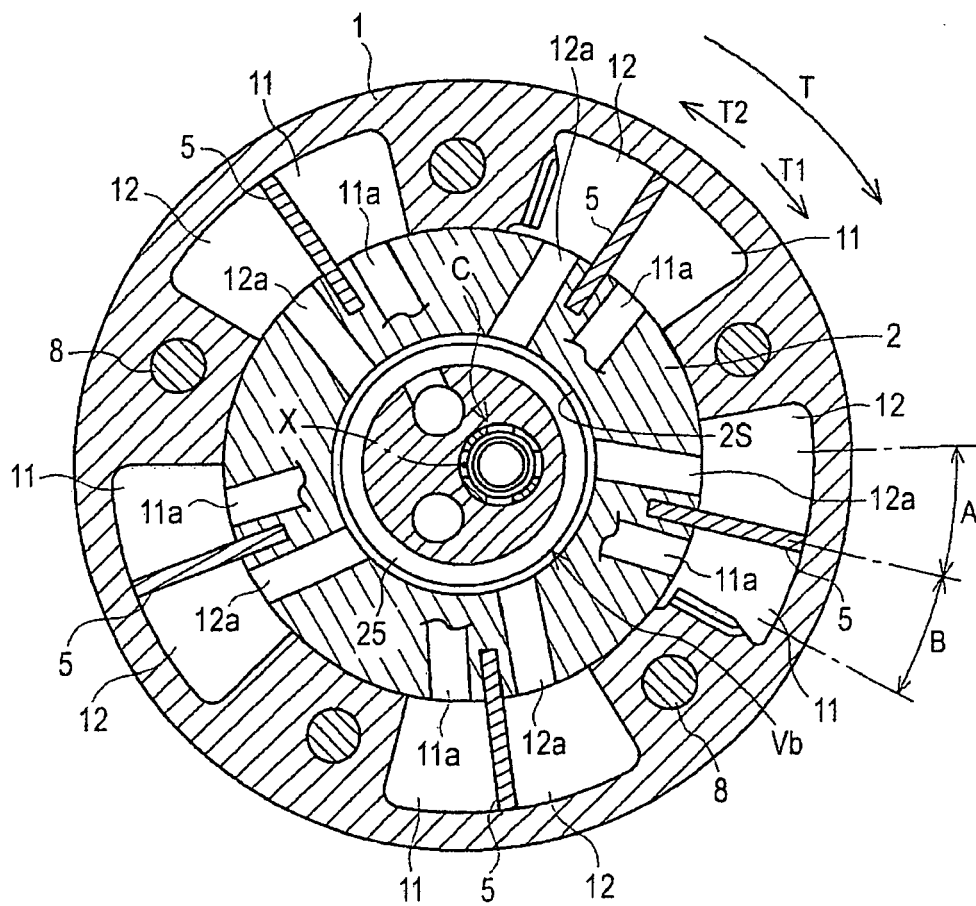


FIG.3A

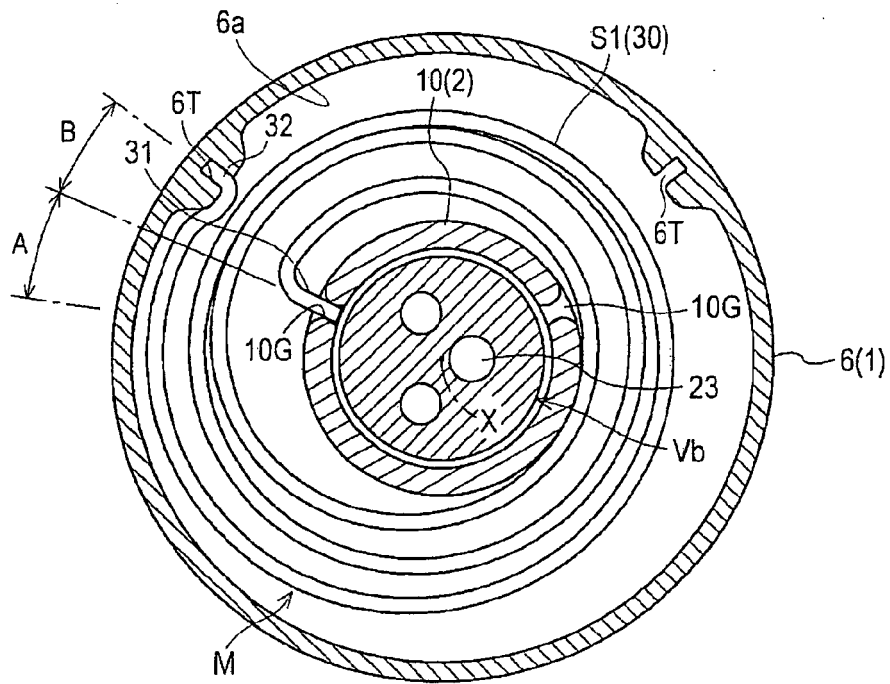


FIG.3B

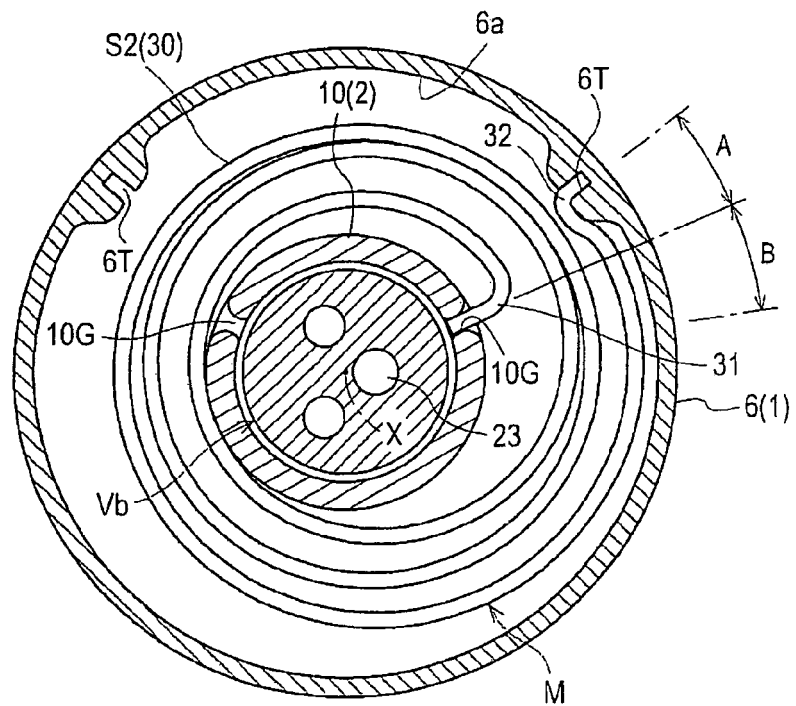


FIG. 4

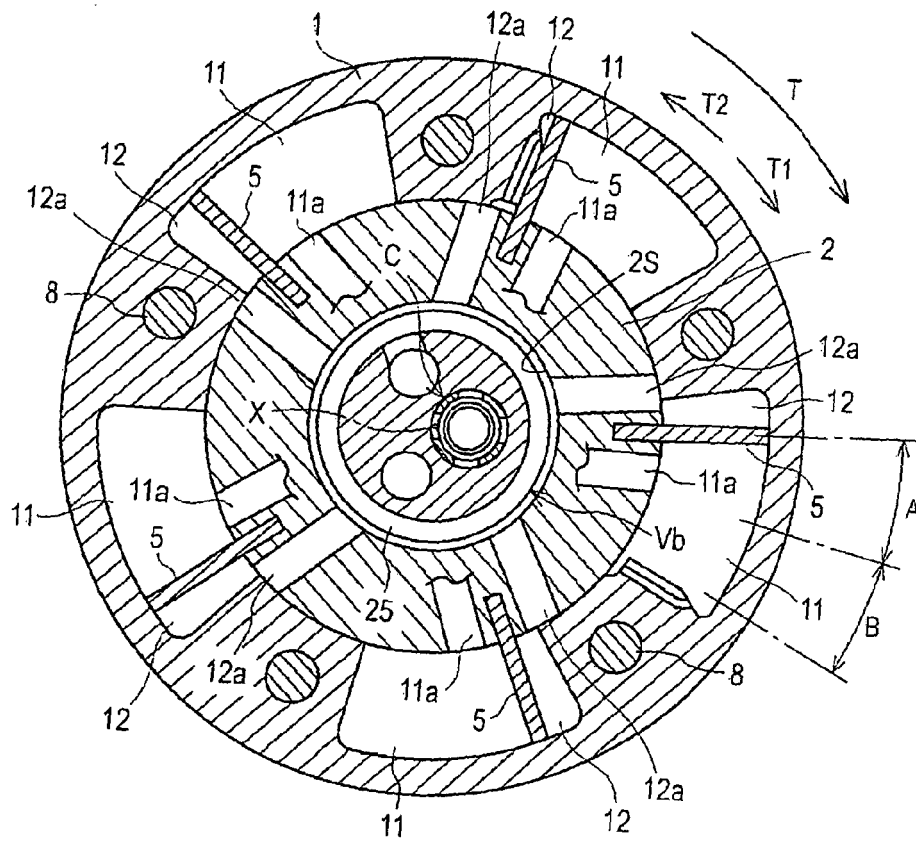


FIG.5A

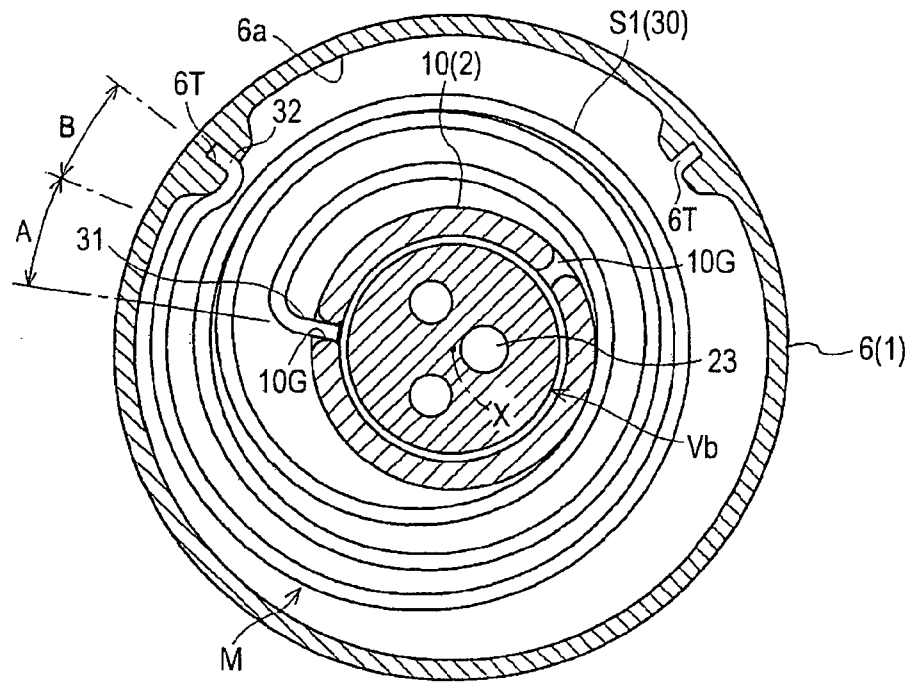


FIG.5B

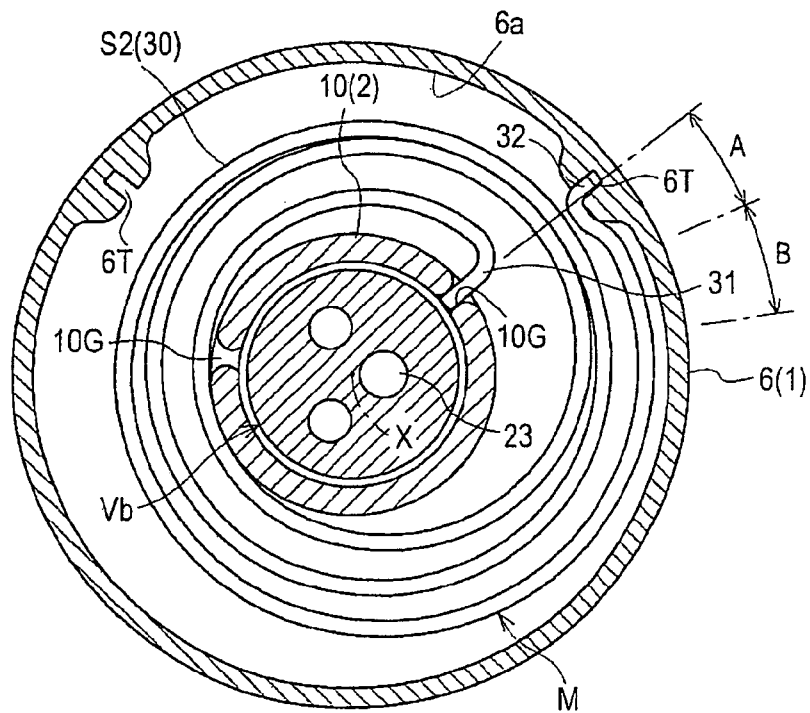


FIG.6

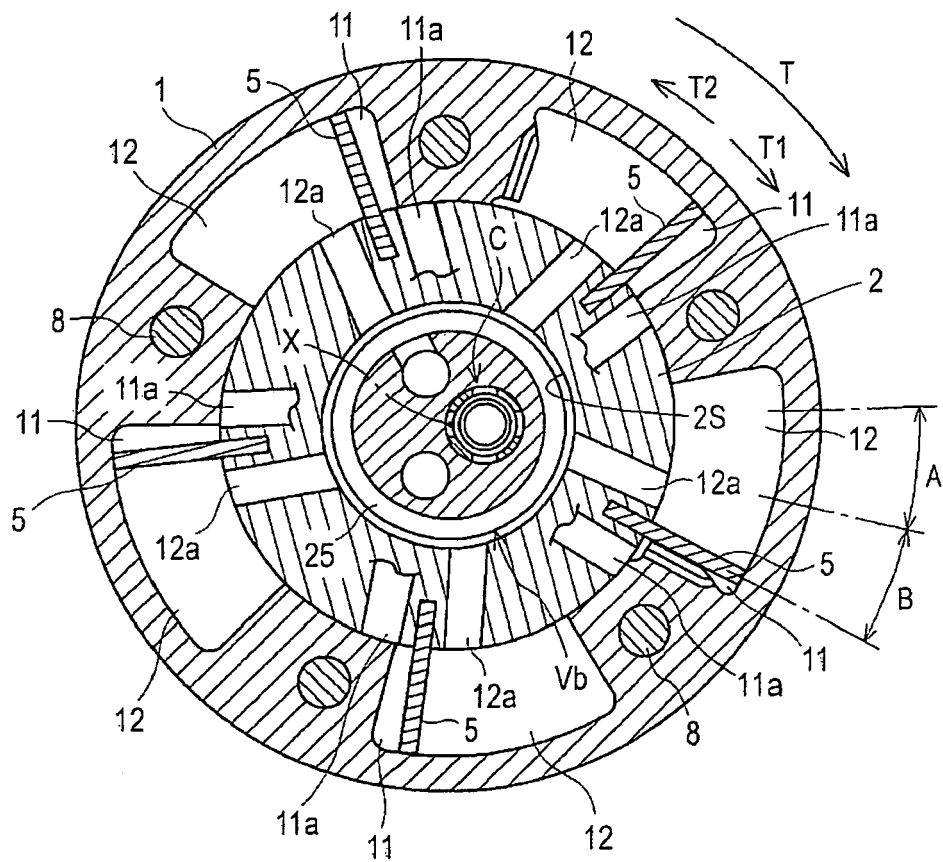


FIG. 7A

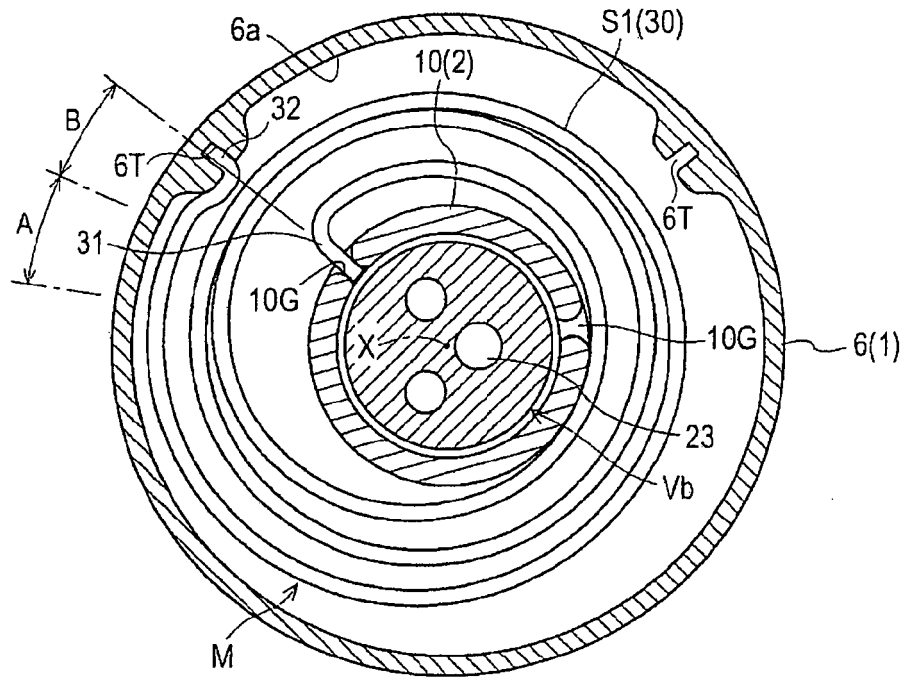


FIG. 7B

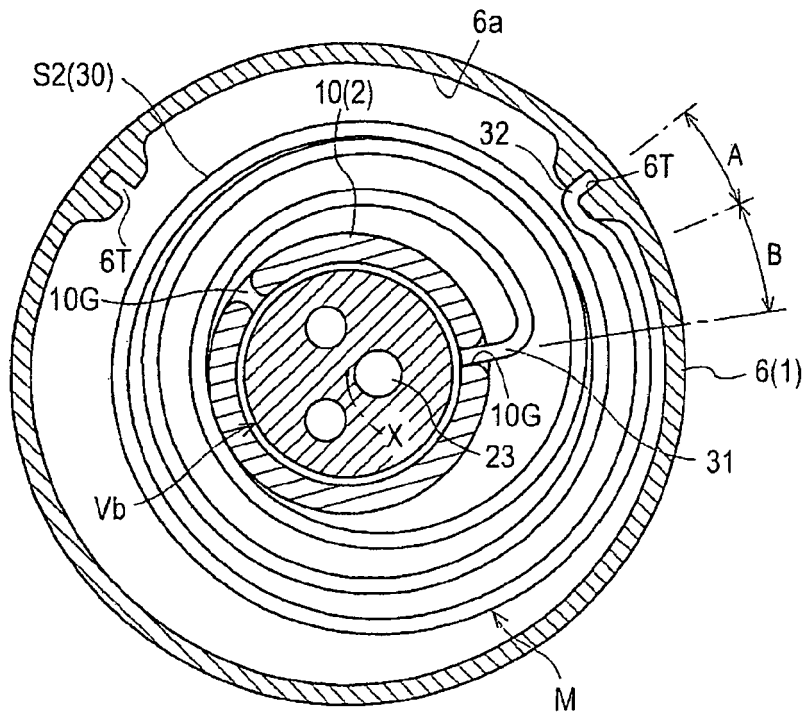


FIG.8

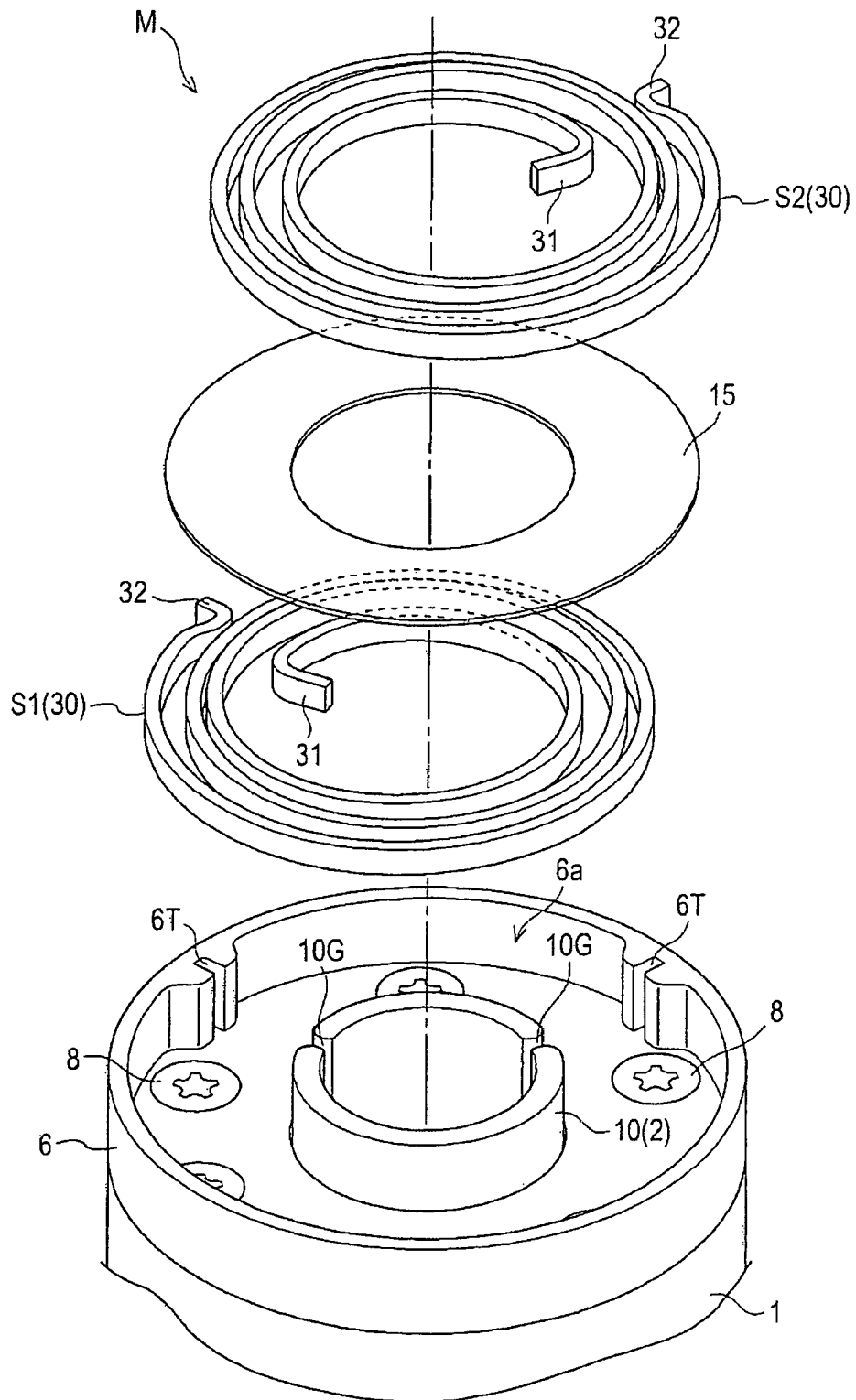


FIG.9A

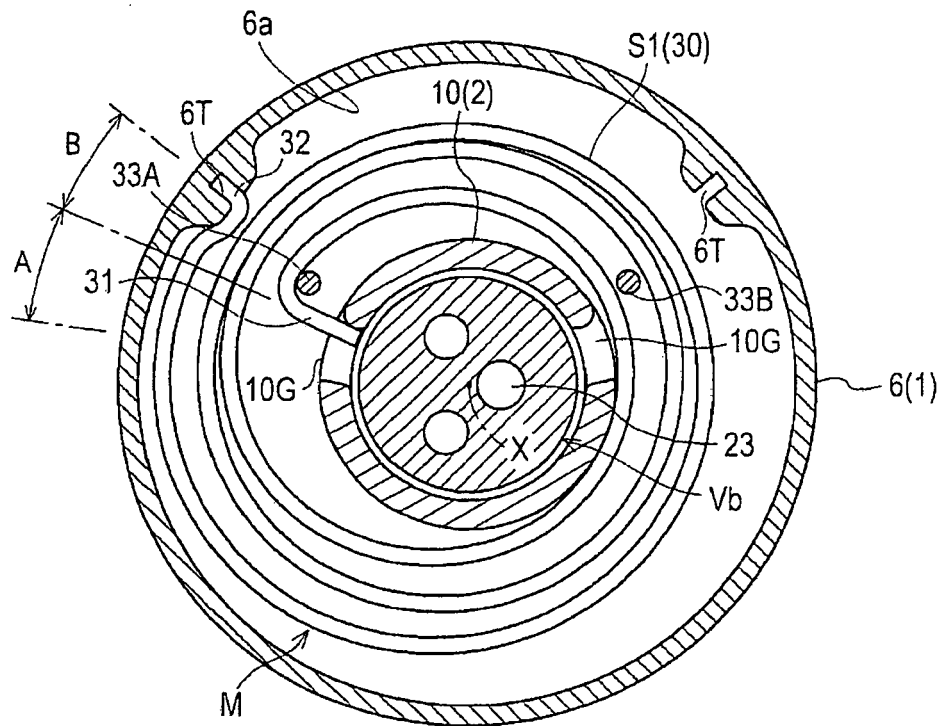


FIG.9B

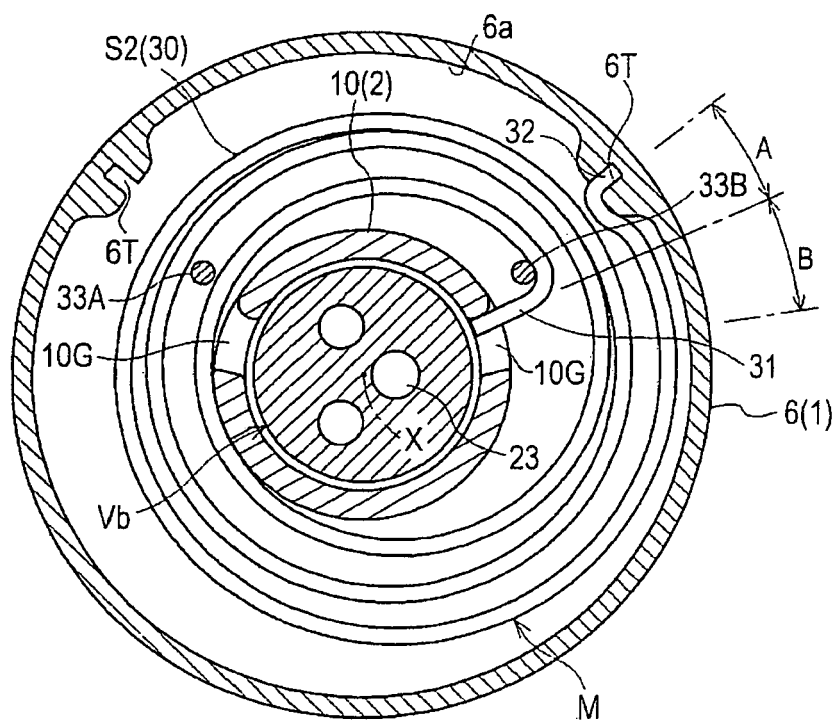


FIG. 10A

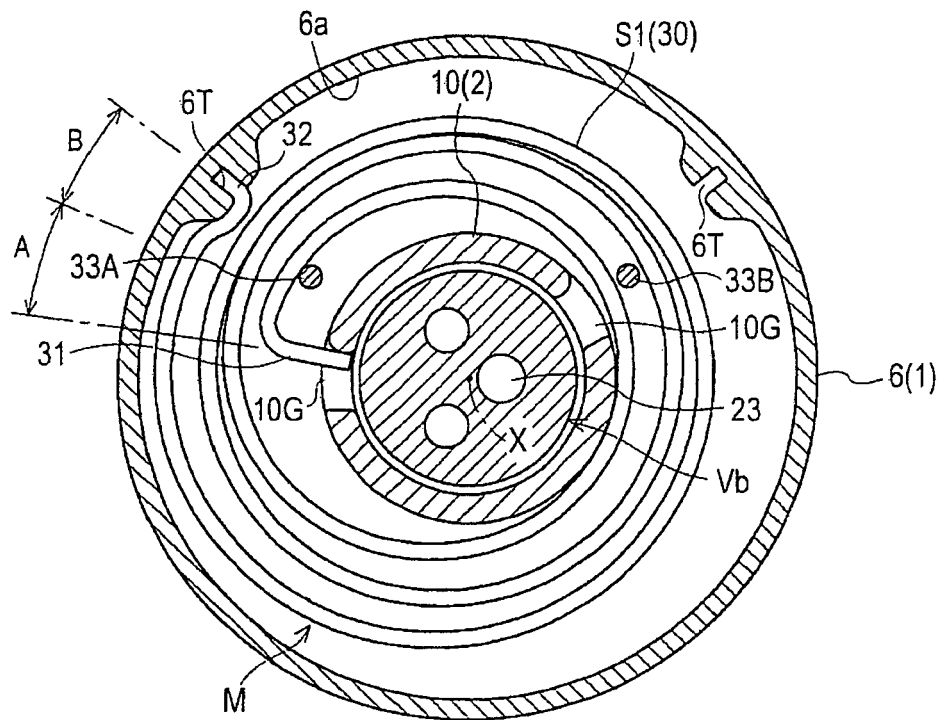


FIG. 10B

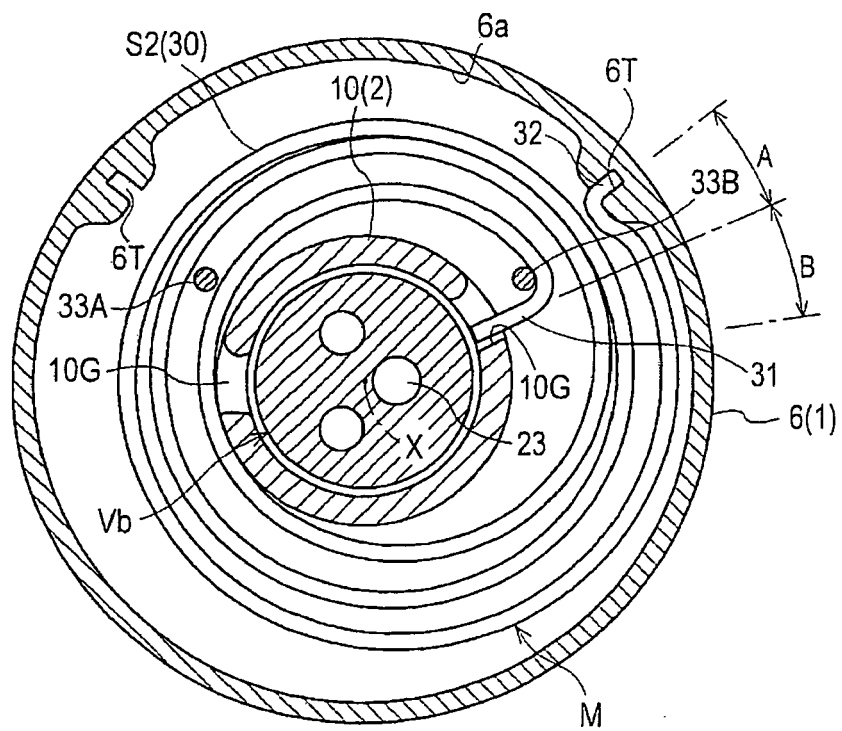


FIG. 11A

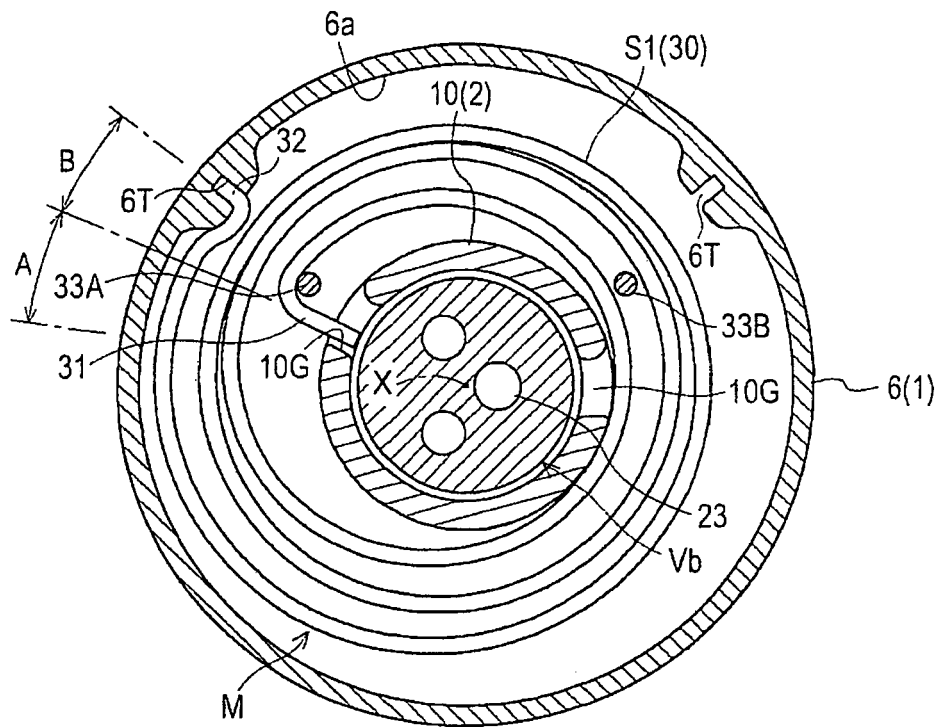


FIG. 11B

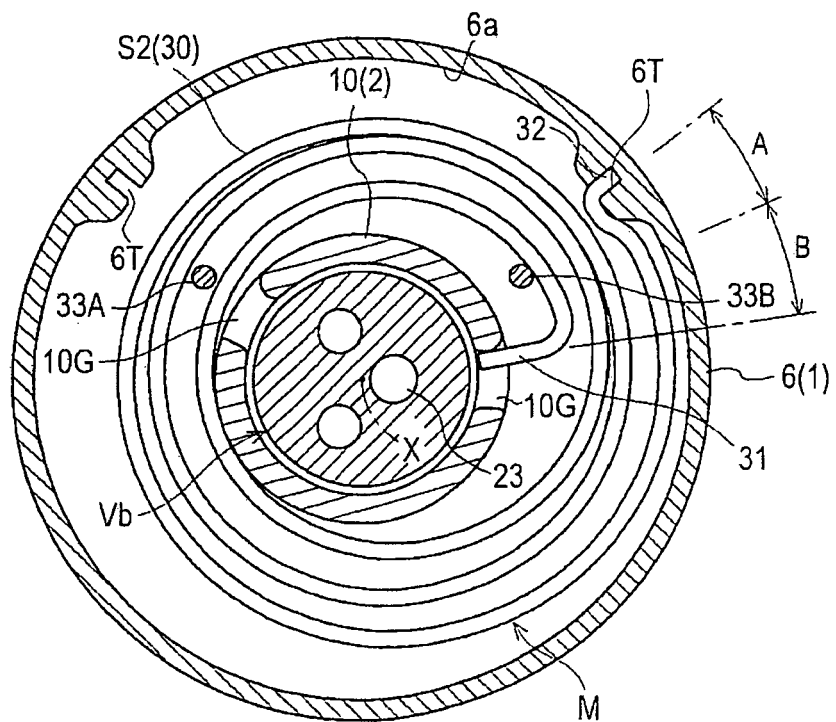


FIG. 12

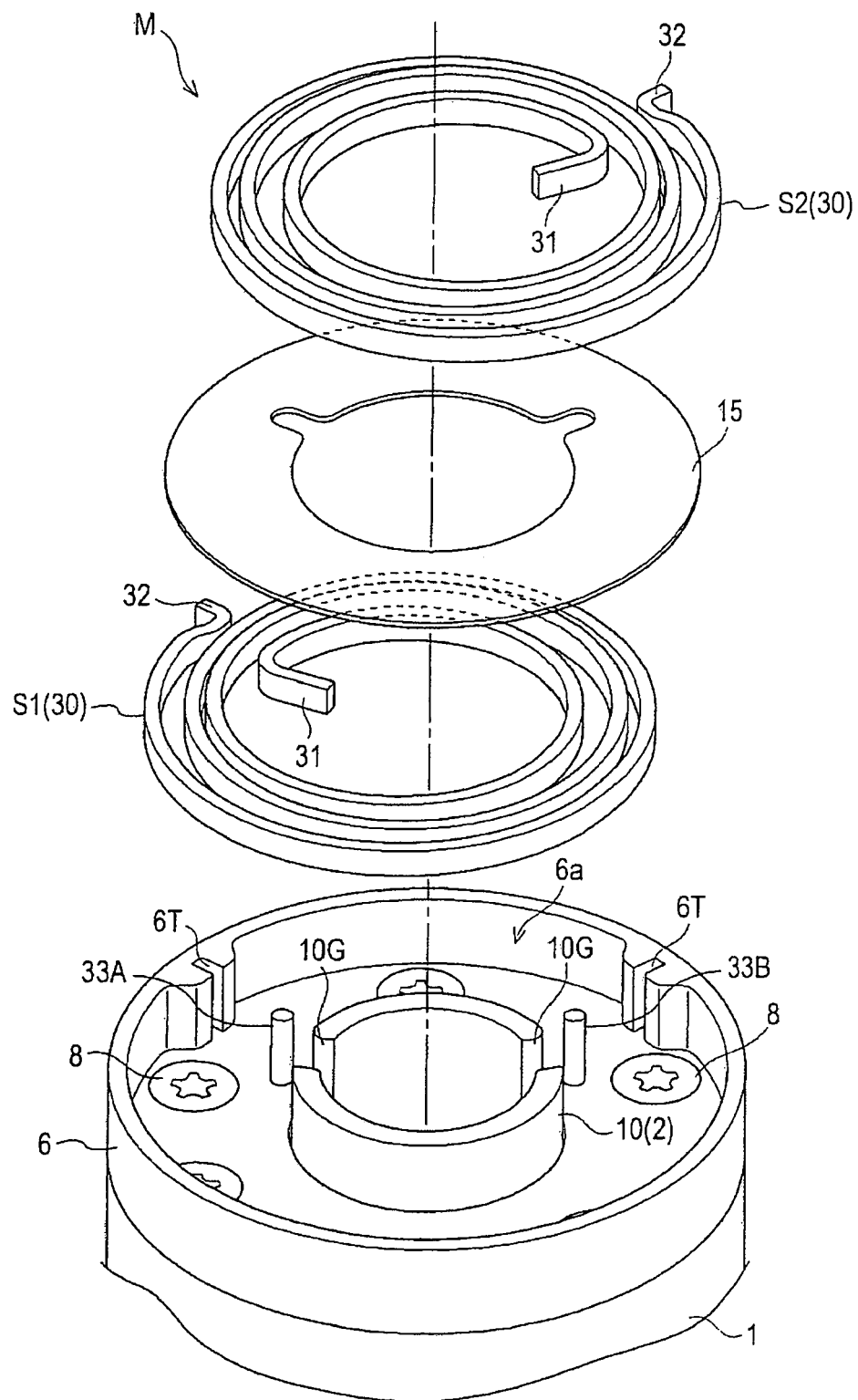


FIG. 13

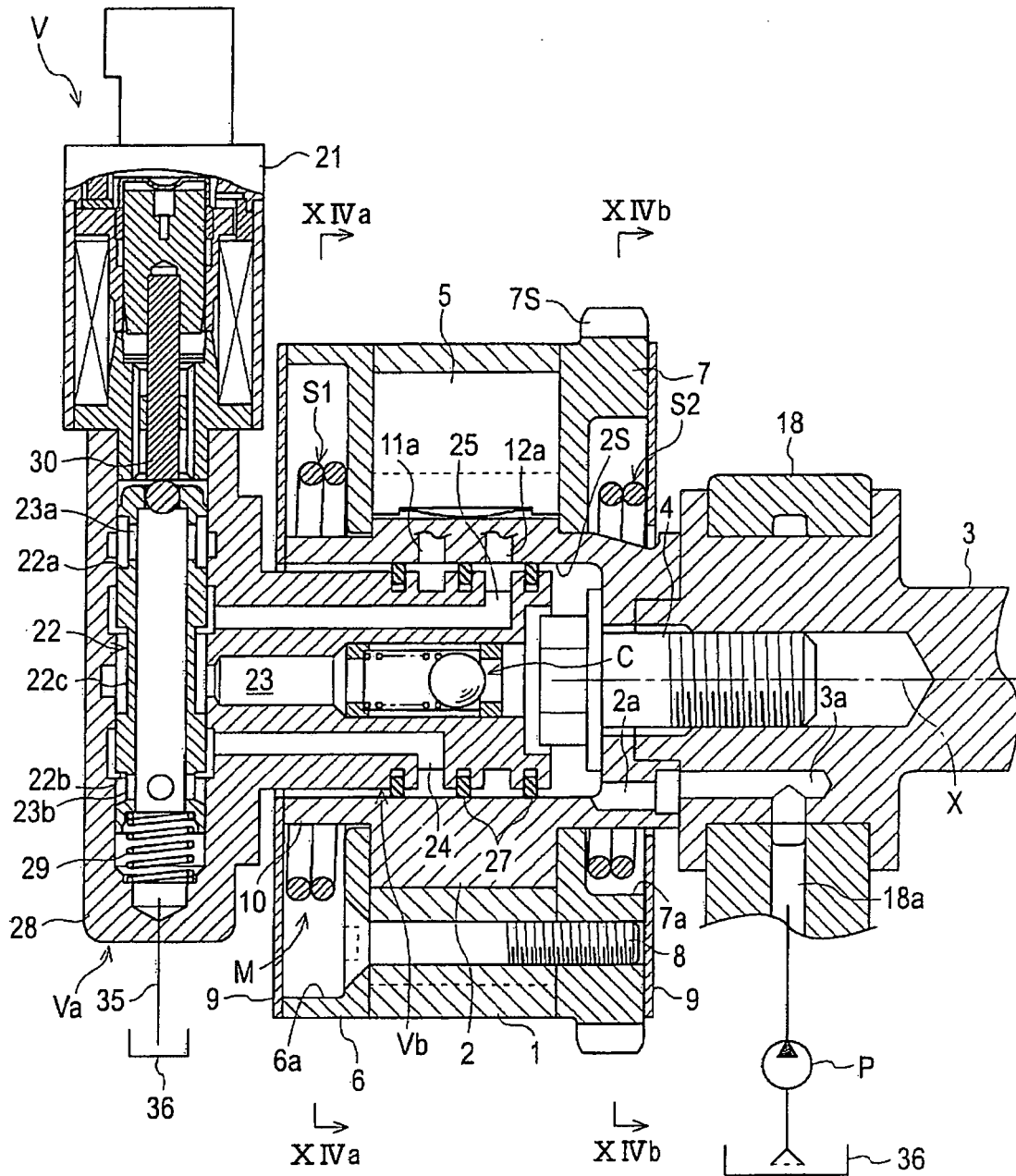


FIG.14A

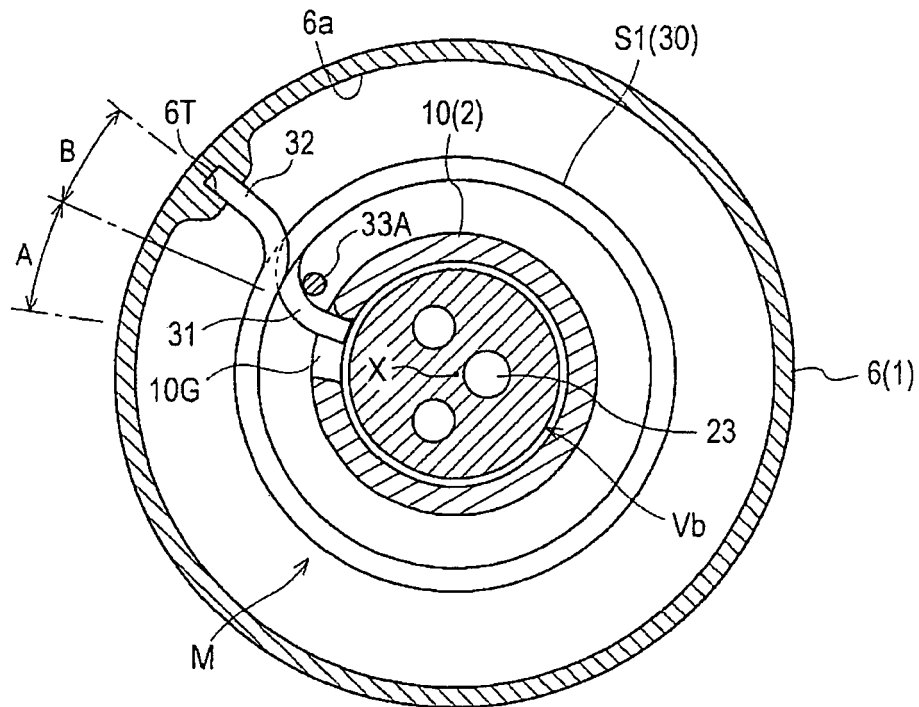


FIG.14B

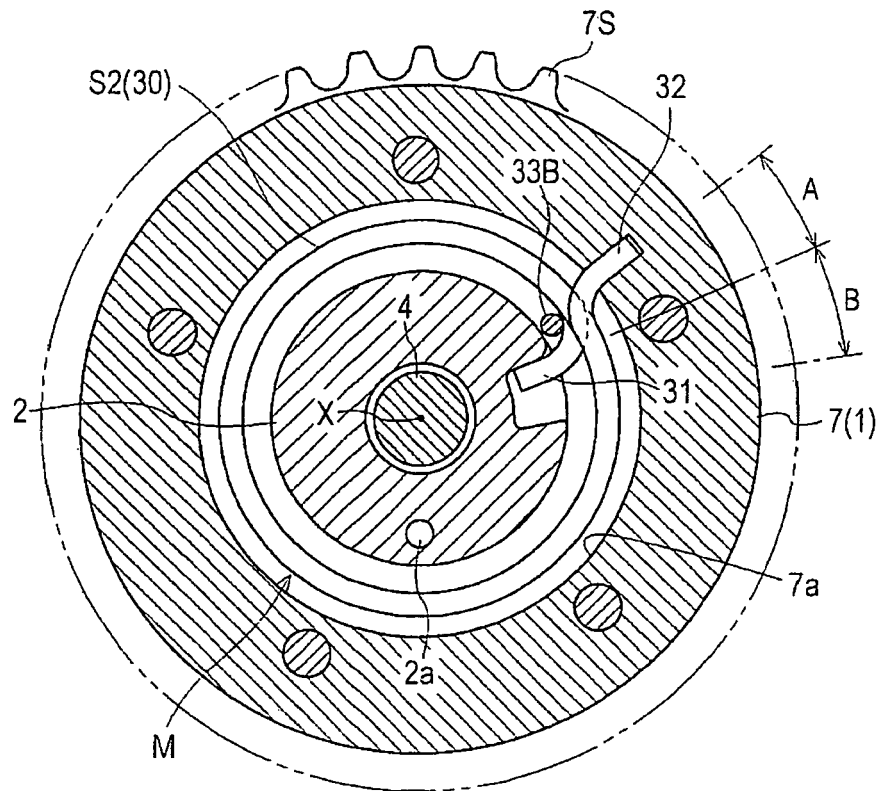


FIG.15

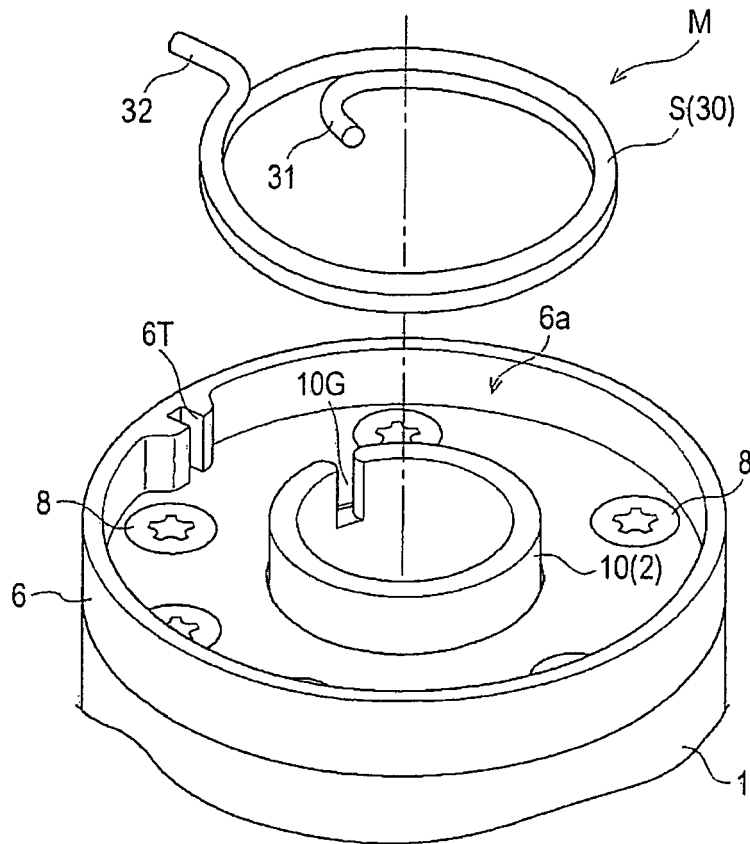


FIG.16A

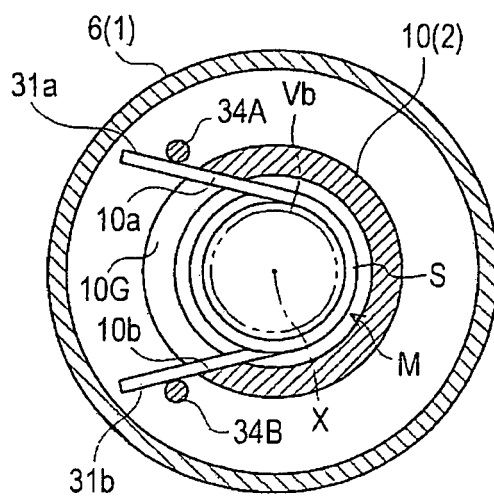
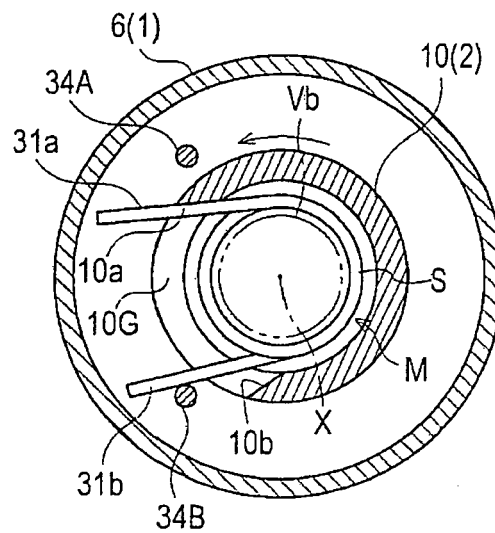


FIG.16B





EUROPEAN SEARCH REPORT

Application Number
EP 10 00 2953

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	US 2009/235884 A1 (FISCHER THOMAS H [US] ET AL) 24 September 2009 (2009-09-24) * the whole document *	1	INV. F01L1/344
A	US 2009/211549 A1 (MYERS JESSE [US] ET AL) 27 August 2009 (2009-08-27) * the whole document *	1-10	
A	US 2009/188456 A1 (DUPUIS CRAIG [CA] ET AL) 30 July 2009 (2009-07-30) * the whole document *	6	
X	GB 2 437 305 A (MECHADYNE PLC [GB]) 24 October 2007 (2007-10-24) * the whole document *	1,5	
A		2-4,6-10	
X	DE 10 2006 004760 A1 (SCHAEFFLER KG [DE]) 11 October 2007 (2007-10-11) * the whole document *	1,2,5-8	
The present search report has been drawn up for all claims			TECHNICAL FIELDS SEARCHED (IPC)
			F01L
Place of search		Date of completion of the search	Examiner
The Hague		21 December 2010	Klinger, Thierry
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
EPO FORM 1503 03.82 (P04.001)

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ON EUROPEAN PATENT APPLICATION NO.**

EP 10 00 2953

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21-12-2010

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2009235884 A1	24-09-2009	NONE	
US 2009211549 A1	27-08-2009	NONE	
US 2009188456 A1	30-07-2009	DE 102009005114 A1	06-08-2009
GB 2437305 A	24-10-2007	EP 1862648 A1	05-12-2007
		US 2007245994 A1	25-10-2007
DE 102006004760 A1	11-10-2007	US 2007245991 A1	25-10-2007

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2009074384 A [0002]