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

(11) EP 2 843 201 A1

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
04.03.2015 Bulletin 2015/10

(51) Int Cl.:
F01L 1/344 *(2006.01)*

(21) Application number: **14182160.3**

(22) Date of filing: **25.08.2014**

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME

(30) Priority: **28.08.2013 JP 2013177121**

(71) Applicant: **AISIN SEIKI KABUSHIKI KAISHA**
Kariya-shi, Aichi-ken 448-8650 (JP)

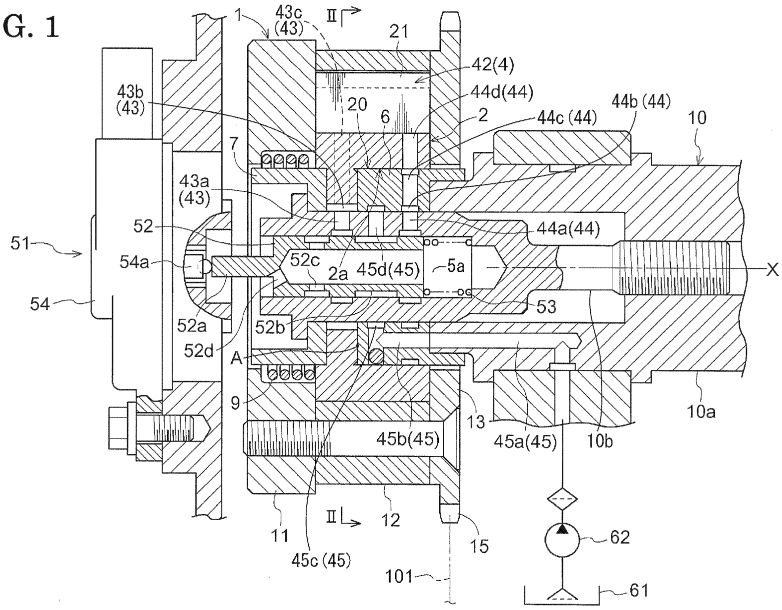
(72) Inventors:
- **KAWAI, Yoshihiro**
  Kariya-shi, Aichi-ken,, 448-8650 (JP)
- **KOBAYASHI, Masaki**
  Kariya-shi, Aichi-ken,, 448-8650 (JP)
- **YAMAKAWA, Yoshiaki**
  Kariya-shi, Aichi-ken,, 448-8650 (JP)
- **OTSUKI, Atsushi**
  Kariya-shi, Aichi-ken,, 448-8650 (JP)

(74) Representative: **Winter, Brandl, Fürniss, Hübner, Röss, Kaiser, Polte - Partnerschaft mbB**
Patent- und Rechtsanwaltskanzlei
Bavariaring 10
80336 München (DE)

(54) Variable valve timing control device

(57) A variable valve timing control device includes a driving side rotation member (1), a driven side rotation member (2), a fluid pressure chamber (4, 41, 42), a first flow path (43) and a second flow path (44) allowing a flow of an operation fluid into and out of the fluid pressure chamber (4, 41, 42), an intermediate member (6) being provided between an inner circumferential surface of the driven side rotation member (2) and an outer circumferential surface of a camshaft (10), and a contact portion (A) where the intermediate member (6) and the driven side rotation member (2) come in contact with each other at a position between the first flow path (43) and the second flow path (44) when mounting the intermediate member (6) to the camshaft (10).

FIG. 1



EP 2 843 201 A1

Printed by Jouve, 75001 PARIS (FR)

Description

TECHNICAL FIELD

[0001] This disclosure generally relates to a variable valve timing control device.

BACKGROUND DISCUSSION

[0002] A known variable valve timing control device favorably includes a driven side rotation member which is formed with a lightweight material which has small rotation inertia in order to easily change a relative rotational phase of the driven side rotation member relative to a driving side rotation member. Therefore, the driven side rotation member is generally made from a low strength material, for example, an aluminum material. On the other hand, a camshaft connected to the driven side rotation member is generally made from a high-strength material, for example, an iron material. Thus, a gap is easily formed at an interface between the driven side rotation member and the camshaft due to a difference between a coefficient of linear expansion of the driven side rotation member and a coefficient of linear expansion of the camshaft. Along with that, the driven side rotation member may be easily damaged because the high-strength camshaft is directly in contact with the low-strength driven side rotation member.

[0003] Especially, in a case where a flow path of the operation fluid which changes a relative rotational phase of the driven side rotation member relative to the driving side rotation member extends over the driven side rotation member and the camshaft, and the gap is generated at the interface of the driven side rotation member and the camshaft, the relative rotational phase cannot be changed precisely at the right time, or proper timing because of the leakage of the operation fluid via the gap.

[0004] A known variable valve timing control device is disclosed in JP2012-57578A (hereinafter referred to as Patent reference 1). The variable valve timing control device disclosed in Patent reference 1 is provided with a driving side rotation member (housing), a driven side rotation member (inner rotor), and a fluid pressure chamber defined between the driving side rotation member and the driven side rotation member, and a first flow path and a second flow path allowing an operation fluid to flow in or flow out of the fluid pressure chamber. The variable valve timing control device further includes an intermediate member between an inner circumferential surface of the driven side rotation member and an outer circumferential surface of the camshaft and connects the driven side rotation member and the camshaft. A space configuring a part of the first flow path is defined between the driven side rotation member and the camshaft, whereas a part of the second flow path is placed at the intermediate member. A contact portion where the intermediate member is in contact with the driven side rotation member is provided between the first flow path and the second flow path. The driven side rotation member is made from an aluminum material, whereas the intermediate member is made from an iron material.

[0005] According to the variable valve timing control device disclosed in Patent reference 1, because the variable valve timing control device includes the intermediate member which is positioned between the inner circumferential surface of the driven side rotation member and the outer circumferential surface of the camshaft, to connect the driven side rotation member and the camshaft, the driven side rotation member made from the aluminum material does not come in contact with the camshaft. Thus, in a case where the camshaft is made from a high-strength material, the driven side rotation member made from the aluminum material may be prevented from being damaged. Further, because the intermediate member is made from the iron material which includes a coefficient of linear expansion that is close to a coefficient of linear expansion of the camshaft which is made from the high-strength material, the gap is not generated at the interface of the intermediate member and the camshaft. Accordingly, in a case where the flow path of the operation fluid extends over the intermediate member and the camshaft, the operation fluid does not leak easily. However, as a result of mounting the intermediate member inwardly of the driven side rotation member between the driven side rotation member and the camshaft in order to prevent the driven side rotation member and the camshaft from being in contact with each other, the space formed between the driven side rotation member and the camshaft corresponds to the part of the first flow path, whereas the part of the second flow path is provided at the intermediate member. Thus, in a state where a gap is generated at an interface between the driven side rotation member and the intermediate member, the first flow path and the second flow path communicate with each other via the gap, and the operation fluid leaks out of and flows into the first and second flow paths. Accordingly, the relative rotational phase of the driven side rotation member relative to the driving side rotation member may not be changed precisely at the right time, or proper timing. Thus, in order to change the relative rotational phase of the driven side rotation member relative to the driving side rotation member precisely at the right time, or proper timing, the contact portion where the intermediate member and the driven side rotation member come in contact with each other in the entire circumference between the first and second flow paths is provided to prevent the operation fluid from leaking out of and flowing into the first and second flow paths.

[0006] According to the variable valve timing control device disclosed in Patent reference 1, the intermediate member is inserted from an end of the driven side rotation member to be positioned between the inner circumference of the driven side rotation member and an outer circumference of the camshaft. Thus, after mounting the driven side rotation member and the intermediate member to the driving side rotation member, the intermediate member may easily come out of the driven side rotation member when the camshaft is mounted to the variable valve timing control device. Accordingly, the mounting process of the variable valve timing control device may be complicated. Further, in a case where the intermediate member is press-fitted into the driven side rotation member, a gap may be generated between the intermediate member and the driven side rotation member because of a resistance force applied when the intermediate member is press-fitted into the driven side rotation member. The first and second flow paths communicate with each other via the gap, leading to the inferior operation.

[0007] A need thus exists for a variable valve timing control device that prevents a driven side rotation member from being damaged by a camshaft which is made from a high-strength material, that restrains an operation fluid from leaking out of and flowing into the first and second flow paths while simplifying the mounting process of the variable valve timing control device.

SUMMARY

[0008] According to an aspect of this disclosure, a variable valve timing control device includes a driving side rotation member configured to synchronously rotate with a driving shaft of an internal combustion engine, a driven side rotation member provided inwardly of the driving side rotation member to be coaxial with the driving side rotation member, the driven side rotation member integrally rotating with a camshaft for opening and closing a valve of the internal combustion engine, a fluid pressure chamber defined between the driving side rotation member and the driven side rotation member, a first flow path and a second flow path allowing a flow of an operation fluid into and out of the fluid pressure chamber to change a relative rotational phase of the driven side rotation member relative to the driving side rotation member between a most advanced angle phase and a most retarded angle phase, an intermediate member being provided between an inner circumferential surface of the driven side rotation member and an outer circumferential surface of the camshaft, the intermediate member connecting the driven side rotation member and the camshaft, and a contact portion where the intermediate member and the driven side rotation member come in contact with each other at a position between the first flow path and the second flow path when mounting the intermediate member to the camshaft after mounting the intermediate member and the driven side rotation member to the driving side rotation member after mounting the intermediate member to the driven side rotation member by press-fitting in a state where a space configuring a part of the first flow path is defined between the driven side rotation member and the camshaft and the intermediate member includes a part of the second flow path.

[0009] According to the aforementioned construction of this disclosure, the intermediate member comes in contact with the driven side rotation member between the first flow path and the second flow path when the intermediate member is mounted to the camshaft after the intermediate member and the driven side rotation member are mounted to the driving side rotation member after the intermediate member is press-fitted into the driven side rotation member. Thus, when the intermediate member and the driven side rotation member are mounted to the driving side rotation member, the intermediate member is positioned inside the driven side rotation member by press-fitting. Accordingly, without having to be glued by an adhesive material or attracted by a magnetic force of a magnet, the intermediate member is prevented from being coming out of the driven side rotation member by a friction force applied between the driven side rotation member and the intermediate member before mounting the driven side rotation member and the intermediate member to the camshaft. Thus, after mounting the driven side rotation member and the intermediate member to the driving side rotation member, the intermediate member is prevented from coming out of the driven side rotation member before mounting the camshaft to the intermediate member.

[0010] According to the aforementioned construction of this disclosure, the driven side rotation member is prevented from being damaged by the camshaft which is made from a high-strength material. Along with that, the mounting process is simplified while adopting the construction where the operation fluid is prevented from leaking out of and flowing into the first and second flow paths.

[0011] According to another aspect of this disclosure, the variable valve timing control device further includes a control valve being positioned inwardly of the intermediate member in a radial direction, the control valve controlling the operation fluid to flow into and out of the fluid pressure chamber.

[0012] According to the aforementioned construction of this disclosure, comparing to a case where a control valve is positioned outside a camshaft, a flow path in which the operation fluid flows in and out of the fluid chamber is shortened. Accordingly, the control valve of this disclosure may be mounted to a reduced space while reducing the process for configuring the flow path.

[0013] According to further aspect of this disclosure, the intermediate member is press-fitted to a portion of an inner wall of the driven side rotation member.

[0014] According to the aforementioned construction of this disclosure, the intermediate member may be processed with a reduced man-hour and a reduced size of the portion to be processed.

[0015] According to still another aspect of this disclosure, the intermediate member is press-fitted to the inner wall of the driven side rotation member at plural positions being equally spaced apart along a circumferential direction relative to an axis.

[0016] According to the aforementioned construction of this disclosure, the intermediate member may be processed with a reduced man-hour and a further reduced size of the portion to be processed.

[0017] According to another aspect of this disclosure, the intermediate member is fitted only to a portion positioned between a portion where the second flow path is formed and the contact portion of the inner wall.

[0018] According to the aforementioned construction of this disclosure, the intermediate member may be processed with a reduced man-hour and a reduced size of the portion to be processed.

[0019] According to the still further aspect of this disclosure, the driven side rotation member includes plural press-fitting portions which are irregularly positioned along the circumferential direction of the driven side rotation member, and come in contact with the intermediate member when press-fitting to the intermediate member, and a length from the press-fitting portion to a center of the driven side rotation member is shorter than a length from the inner wall to a center of the driven side rotation member.

[0020] According to the aforementioned construction of this disclosure, the intermediate member may be processed with a reduced man-hour and a further reduced size of the portion to be processed.

BRIEF DESCRIPTION OF THE DRAWINGS

[0021] 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:

Fig. 1 is a cross sectional view illustrating an entire configuration of a variable valve timing control device according to a first embodiment disclosed here;
Fig. 2 is a cross-sectional view of the variable valve timing control device taken along line II-II in Fig. 1;
Fig. 3 is a detailed view of an oil control valve when controlling a relative rotational phase of a driven side rotation member relative to a driving side rotation member to establish an advanced angle position;
Fig. 4 is a detailed view of the oil control valve when controlling the relative rotational phase of the driven side rotation member relative to the driving side rotation member to establish a retarded angle position;
Fig. 5 is an exploded perspective view partially illustrating the configuration of the variable valve timing control device;
Fig. 6 is a cross sectional view illustrating an entire configuration of a variable valve timing control device according to a second embodiment; and
Fig. 7 is a cross sectional view partially explaining a configuration of a variable valve control device according to a third embodiment:

DETAILED DESCRIPTION

[0022] Embodiments of a variable valve timing control device for controlling, or regulating the timing for opening and closing an intake valve of an engine for a vehicle will be explained hereunder with reference to the drawings.

[0023] A first embodiment of the variable valve timing control device of this disclosure will be explained with reference to Figs. 1 to 5.

[0024] As shown in Figs. 1 and 2, the variable valve timing control device includes a driving side rotation member 1 (a housing) and a driven side rotation member 2 (an inner rotor). The aluminum-alloy-made driving side rotation member 1 synchronously rotates with a crankshaft of an engine for a vehicle. The aluminum-alloy-made driven side rotation member 2 is positioned inwardly of the driving side rotation member 1 to be coaxial with the driving side rotation member 1. The driven side rotation member 2 integrally rotates with a camshaft 10 which opens and closes an intake valve of the engine.

[0025] The driven side rotation member 2 is relatively rotatably supported by the driving side rotation member 1. The camshaft 10 is coaxially configured with a camshaft body 10a and a steel-made oil control valve bolt 10b, or a steel-made OCV bolt 10b. The steel-made OCV bolt 10b is coaxially positioned within the driven side rotation member 2 and is screwed and fixed to the camshaft body 10a. The engine for the vehicle corresponds to an internal combustion engine, whereas the crankshaft corresponds to a driving shaft of the internal combustion engine.

[0026] A steel-made intermediate rotation member 6 serving as an intermediate member is provided between an inner circumference of the driven side rotation member 2 and an outer circumferential surface of the OCV bolt 10b. The intermediate rotation member 6 is coaxially inserted and press-fitted into the driven side rotation member 2 to be positioned therein from a direction of a camshaft body 10a. The cylindrical rotation member 6 transmits the rotation of the driven side rotation member 2 to the OCV bolt 10b. The OCV bolt 10b is positioned between the driven side rotation member 2 and the intermediate rotation member 6 and screwed and fixed to an end portion of the camshaft body 10a. The intermediate rotation member 6 connects the driven side rotation member 2 and the camshaft 10. The camshaft body 10a serves as a rotation shaft of a cam which controls, or regulates the opening and closing of the intake valve of the engine. The camshaft body 10a integrally rotates with the driven side rotation member 2, the intermediate rotation member 6, and the OCV bolt 10b. The camshaft body 10a is rotatably mounted to a cylinder head of the engine.

[0027] As shown in Fig. 1, the driving side rotation member 1 is integrally configured with a front plate 11, an outer rotor 12 and a rear plate 13. The front plate 11 is positioned on the opposite side of the camshaft body 10a relative to the intermediate rotation member 6. The driven side rotation member 2 is covered by the outer rotor 12. The rear plate 13 is integrally provided with a timing sprocket 15. The driven side rotation member 2 is accommodated in the driving side rotation member 1 and a fluid pressure chamber 4 is defined between the driving side rotation member 1 and the driven side rotation member 2.

[0028] When the crankshaft rotates, a rotational force is transmitted to the timing sprocket 15 via a force transmission member 100. The driving side rotation member 1 rotates in a rotation direction S shown in Fig. 2. In response to the rotation of the driving side rotation member 1, the driven side rotation member 2 is activated to rotate in the rotation direction S. Accordingly, the camshaft 10 rotates and the cam being provided at the camshaft body 10a pushes down the intake valve of the engine to open the valve.

[0029] As shown in Fig. 2, plural projections 14 is positioned inwardly of the outer rotor 12 and protrudes inwardly in a radial direction and being spaced apart along the rotation direction S. Thus, the fluid pressure chamber 4 is provided between the driven side rotation member 2 and the outer rotor 12. The projection 14 functions as a shoe relative to an outer circumferential surface of the driven side rotation member 2. Projections 21 are provided on the outer circumferential surface of the driven side rotation member 2 to be positioned at portions which face the fluid pressure chambers 4, respectively. The fluid pressure chamber 4 is divided into an advanced angle chamber 41 serving as a fluid pressure chamber and a retarded angle chamber 42 serving as a fluid pressure chamber by the projection 21 along the rotation direction S. According to the embodiment, four fluid pressure chambers 4 are provided, however, the construction is not limited to the foregoing.

[0030] The oil serving as the operation fluid is supplied to and drained from the advanced angle chamber 41 and the retarded angle chamber 42, or is blocked to be supplied to and drained from the advanced angle chamber 41 and the retarded angle chamber 42, to apply the oil pressure to the projection 21. Accordingly, the relative rotational phase of the driven side rotation member 2 relative to the driving side rotation member 1 is displaced in either the advanced angle direction or the retarded angle direction, or the relative rotational phase is maintained at a predetermined phase. The advanced angle direction is defined as a direction where the volume of the advanced angle chamber 41 increases and is indicated with an advanced angle direction S1 (serving as a first rotation direction) in Fig. 2. The retarded angle direction is defined as a direction where the volume of the retarded angle chamber 42 increases and is indicated with a retarded angle direction S2 (serving as a second rotation direction) in Fig. 2. The relative rotational phase when the volume of the advanced angle chamber 41 is maximized is defined as a most advanced angle phase. The relative rotational phase when the volume of the advanced angle chamber 42 is maximized is defined as a most retarded angle phase.

[0031] The variable valve timing control apparatus includes a lock mechanism 8 which locks, or retains the relative rotational phase of the driven side rotation member 2 relative to the driving side rotation member 1 at a predetermined lock phase which is positioned between the most advanced angle phase and the most retarded angle phase. In a state where the oil pressure is not stable immediately after starting the engine, the rotational phase of the camshaft 10 relative to the crankshaft may be maintained properly and the engine may rotate stably by locking, or retaining the relative rotational phase.

[0032] As shown in Fig. 2, a lock member 81 is movably configured along an axial direction. The lock member 81 is maintained in a locked state, or a retained state by being held in an engaged state with a lock groove provided at either the front plate 11 or the rear plate 13 by using a biasing member. A lock passage 82 is provided at the driven side rotation member 2 and connects the lock mechanism 8 and an advanced angle oil passage 43 (serving as a first flow path). When the advanced angle control is operated to displace the relative rotational phase of the driven side rotation member 2 relative to the driving side rotation member 1 to the advanced angle direction S1, the oil pressure is applied to the lock mechanism 8. As a result, the lock member 81 comes out of the lock groove against the biasing force applied by the biasing member to release the locked state.

[0033] As shown in Fig. 1, the OCV 51 serves as a control valve and controls, or regulates a supply and draining of the oil to and from the fluid pressure chamber 4. The OCV 51 is coaxially provided with the camshaft 10 and positioned inwardly of the intermediate rotation member 6 in the radial direction. The OCV 51 includes a spool 52, a spring 53 which biases the spool 52, and an electromagnetic solenoid 54 which activates the spool 52. The spool 52 is accommodated in an accommodation space 5a which is provided at an end portion of the OCV bolt 10b and is slidable along an axis X inside the accommodation space 5a. The electromagnetic solenoid 54 adopts a known structure.

[0034] A spring 53 is provided inside the accommodation space 5a at a position which is axially inward of the accommodation space 5a and constantly biases the spool 52 in a direction opposite to the camshaft body 10a. Upon supplying electricity to the electromagnetic solenoid 54, a push pin 54a provided at the electromagnetic solenoid 54 pushes a rod portion 52a which is provided at the spool 52. In consequence, the spool 52 slides towards the camshaft body 10a against the biasing force of the spring 53. The OCV 51 is configured to regulate, or control the position of the spool 52 by regulating, or controlling a duty ratio of the electric power supplied to the electromagnetic solenoid 54. Further, the feeding amount by the OCV 51 to the electromagnetic solenoid 54 is controlled by an electric control unit, or an ECU.

[0035] As shown in Fig. 5, the cylindrical intermediate rotation member 6 is positioned inwardly of the driven side rotation member 2, specifically, positioned at a portion closer to the cam shaft body 10a (the right in Fig. 5). A washer member 7 is positioned inwardly of the driving side rotation member 1 and the driven side rotation member 2 and positioned opposite from the camshaft body

10a (the left in Fig. 5) relative to the intermediate rotation member 6. The intermediate rotation member 6 and the washer member 7 are positioned inwardly of the driven side rotation member 2. As shown in Figs. 1 and 5, in a state where the driven side rotation member 2 is covered by the driving side rotation member 1, the OCV bolt 10b is placed inwardly of each center hole of the washer member 7, the driven side rotation member 2 and the intermediate rotation member 6 and screwed and fixed to the camshaft body 10a. As shown in Fig.1, the intermediate rotation member 6 and the driven side rotation member 2 are in contact with each other along the entire circumference in the axial direction between the advanced angle oil passage 43 and a retarded angle oil passage 44 (serving as a second flow path) and include a contact portion A. Thus, the intermediate rotation member 6 comes in contact with the driven side rotation member 2 at a position between the advanced angle oil passage 43 and the retarded angle oil passage 44 when mounting the intermediate rotation member 6 to the camshaft 10 after mounting the intermediate rotation member 6 and the driven side rotation member 2 to the driving side rotation member 1.

[0036] The washer member 7 increases a tightening force of the OCV bolt 10 relative to the camshaft body 10a. A torsion spring 9 is mounted to position between the washer member 7 and the front plate 11 and biases the washer member 7 and the front plate 11 to rotate the driven side rotation member 2 relative to the driving side rotation member 1 in the advanced angle direction S1.

[0037] An outer diameter of the intermediate rotation member 6 is set to be slightly greater than an inner diameter of a cylindrical inner wall 2a (serving as an inner wall) of the driven side rotation member 2. In a state where the intermediate rotation member 6 is inserted into the driven side rotation member 2 to be positioned inside thereof along the axis X, a fitting portion 20 fits the entire outer circumferential surface of the intermediate rotation member 6 into the entire inner circumferential surface of the cylindrical inner wall 2a. Accordingly, the intermediate rotation member 6 is integrally mounted to the driven side rotation member 2 by press-fitting into the driven side rotation member 2 at the fitting portion 20.

[0038] A fitting pressure level of the fitting portion 20 to the driven side rotation member 2 is set to be a pressure level that allows the intermediate rotation member 6 to forcibly move to come in contact with the driven side rotation member 2 when the OCV bolt 10 which is inserted into and extends through the washer member 7, the driven side rotation member 2, and the intermediate rotation member 6 from a direction of the front plate 11 is screwed and fixed to the camshaft body 10a. Accordingly, the intermediate rotation member 6 reliably comes in contact with the driven side rotation member 2 throughout the circumference between the advanced angle oil passage 43 and the retarded angle oil passage 44 to prevent the oil from leaking out of and flowing into the advanced angle oil passage 43 and the retarded angle oil passage 44.

[0039] When the driven side rotation member 2 and the intermediate rotation member 6 are mounted to the driving side rotation member 1, a certain amount of a friction force is applied to the fitting portion 20 between the driven side rotation member 2 and the intermediate rotation member 6. Then, the friction force serves as a resistance force and prevents the intermediate rotation member 6 from coming out of the driven side rotation member 2 until the camshaft 10 is connected to the intermediate rotation member 6 after mounting the intermediate rotation member 6 to the driven side rotation member 2.

[0040] As shown in Fig. 1, the oil reserved in the oil pan 61 is sucked by a mechanical oil pump 62 that is actuated in response to the transmission of the rotational drive force of the crankshaft, and is supplied to an oil supply passage 45. The OCV 51 controls the supplying and draining, or the blocking operation to supply and drain the oil to and from the advanced angle oil passage 43 and the retarded angle oil passage 44.

[0041] The advanced angle oil passage 43 serves as an oil passage for changing the relative rotational phase of the driving side rotation member 1 and the driven side rotation member 2 in the advanced angle direction S1. The retarded angle oil passage 44 serves as an oil passage for changing the relative rotational phase of the driving side rotation member 1 and the driven side rotation member 2 in the retarded angle direction S2. Thus, the advanced angle oil passage 43, the retarded angle oil passage 44 and a supply oil passage 45 correspond to flow paths which selectively supply and drain the oil to and from the fluid pressure chamber 4 in order to change the relative rotational phase of the driven side rotation member 2 relative to the driving side rotation member 1 between a most advanced angle phase and a most retarded angle phase. The advanced angle oil passage 43 corresponds to a first flow path and the retarded angle oil passage 44 corresponds to a second flow path.

[0042] As shown in Fig. 1 and Fig. 2, the advanced angle oil passage 43 which communicates with the advanced angle chamber 41 is configured with a first through hole 43a, a first annular oil passage 43b, and a second through hole 43c. The first through hole 43a is provided at the OCV bolt 5b. The first annular oil passage 43b is positioned between the OCV bolt 5b and the driven side rotation member 2. The second through hole 43c is provided at the driven side rotation member 2. Thus, the space configuring the first annular oil passage 43b which corresponds to a part of the advanced angle oil passage 43 is defined between the driven side rotation member 2 and the OCV bolt 10b.

[0043] The retarded angle oil passage 44 which communicates with the retarded angle chamber 42 is configured with a third through hole 44a, a second annular oil passage 44b, a fourth through hole 44c, and a fifth through hole 44d. The third through hole 44a is provided at the OCV bolt 5b. The second annular oil passage 44b is provided at an inner circumferential surface of the intermediate rotation member 6 between the OCV bolt 10b and the intermediate rotation member 6. The fourth through hole 44c is provided at the intermediate rotation member 6. The fifth through hole 44d is provided at the driven side rotation member 2. Thus, the second annular oil passage 44b and the fourth through hole 44c which configure parts of the retarded angle oil passage 44 are provided at the intermediate rotation member 6.

[0044] The oil supply passage 45 selectively supplying the oil to the advanced angle oil passage 43 and the retarded angle oil passage 44 is configured with a first passage 45a, a second passage 45b, a third annular passage 45c, and a sixth through hole 45d. The first passage 45a is provided at the camshaft body 10a. The second passage 45b is provided at the intermediate rotation member 6. The third annular passage 45c is provided at the intermediate rotation member 6 between the intermediate rotation member 6 and the OCV bolt 10b. The sixth through hole 45d is provided at the OCV bolt 10b.

[0045] Thus, the intermediate rotation member 6 includes the second annular oil passage 44b, the fourth though hole 44c, the second passage 45b and the third annular oil passage 45c which are the parts of the advanced angle oil passage 43, the retarded angle oil passage 44, and the supply oil passage 45 which supply and drain the oil to and from the fluid pressure chamber 4.

[0046] As shown in Fig. 1, the oil which flows inside the supply oil passage 45 flows into an annular groove 52b which is provided at an outer circumferential surface of the spool 52. In a state where the annular groove 52b communicates with neither the first through hole 43a nor the third through hole 44a which are provided at the OCV bolt 10b, the oil is not supplied to the advanced angle chamber 41 and the retarded angle chamber 42. In this state, because the first through hole 43a is configured so as not to communicate with the seventh through hole 52c which is provided at the spool 52, the oil in the advanced angle chamber 41 is not drained to the outside of the variable valve timing control device via the advanced angle oil passage 43, the seventh through hole 52c, the accommodation space 5a and a drain hole 52d. In addition, in this state, the third through hole 44a is configured so as not to communicate with the accommodation space 5a, the oil in the retarded angle chamber 42 is not drained to the outside of the variable valve timing control device via the retarded angle oil passage 44, the accommodation space 5a and a drain hole 52d. That is, upon supplying a predetermined amount of electricity to the electromagnetic solenoid 54 to control the OCV 51 to hold the spool 52 at the position shown in Fig. 1, the relative rotational phase of the driven side rotation member 2 relative to the driving side rotation member 1 is maintained because the oil is blocked so as not to be supplied and drained to and from the advanced angle chamber 41 and the retarded angle chamber 42.

[0047] When the electromagnetic solenoid 54 is not energized, the spool 52 is held at the position shown in Fig. 3 by the biasing force of the spring 53. In those circumstances, the annular groove 52b of the spool 52 communicates with the first through hole 43a of the OCV bolt 10b and does not communicate with the third through hole 44a. Simultaneously, the third through hole 44a communicates with the accommodation space 5a. Thus, the oil supplied to the supply oil passage 45 is supplied to the advanced angle chamber 41 via the advanced angle oil passage 43, whereas the oil in the retarded angle chamber 42 is drained to the outside of the variable valve timing control device via the retarded angle oil passage 44, the accommodation space 5a, and the drain hole 52d. In those circumstances, the relative rotational phase is displaced in the advanced angle direction S1 by the oil pressure applied to the advanced angle chamber 41.

[0048] When the electromagnetic solenoid 54 is energized maximally, the spool 52 is held at the position shown in Fig. 4 against the biasing force of the spring 53. In those circumstances, the annular groove 52b of the spool 52 communicates with the third through hole 44a of the OCV bolt 10b and does not communicate with the first through hole 43a. Simultaneously, the first through hole 43a communicates with the seventh through hole 52c of the spool 52. Thus, the oil supplied to the supply oil passage 45 is supplied to the retarded angle chamber 42 via the retarded angle oil passage 44, whereas the oil in advanced angle chamber 41 is drained to the outside of the variable valve timing control device via the advanced angle oil passage 43, the seventh through hole 52c, the accommodation space 5a, and the drain hole 52d. In those circumstances, the relative rotational phase is displaced in the retarded angle direction S2 by the oil pressure applied to the retarded angle chamber 42.

[0049] A second embodiment of this disclosure will be explained referring to Fig. 6. In the second embodiment, the fitting portion 20 of the intermediate rotation member 6 is press-fitted to a portion of the cylindrical inner wall 2a along the direction of the axis X, specifically, only the portion positioned between a portion where the retarded angle oil passage 44 is formed and the contact portion A. The outer circumferential surface of the intermediate rotation member 6 protruding towards the rear plate 13 relative to the driven side rotation member 2 is relatively rotationally in close contact with the rear plate 13.

[0050] That is, in a state where the fitting portion 20 press-fits only to the portion of the cylindrical inner wall 2a positioned between the portion where the retarded angle oil passage 44 is formed and the contact portion A, the intermediate rotation member 6 is in close contact with the driven side rotation member 2 at the fitting portion 20 and at the contact portion A. Accordingly, the advanced angle oil passage 43 and the retarded angle oil passage 44 are prevented from communicating with each other via the interface between the intermediate rotation member 6 and the driven side rotation member 2.

[0051] On the other hand, in a state where the gap is generated between the outer circumferential surface of the intermediate rotation member 6, specifically, a part protruding towards the rear plate 13 relative to the portion where the retarded angle oil passage 44 is formed, and the rear plate 13, the oil may leak to the outside of the variable valve timing control device via the retarded angle oil passage 44 which extends over the intermediate rotation member 6 and the driven side rotation member 2. Thus, the outer circumferential surface of the intermediate rotation member 6 is configured so as to be relatively rotationally in close contact with the rear plate 13 to prevent the oil from leaking out via the retarded angle oil passage 44. Constructions other than the aforementioned configuration are similar to the constructions of first embodiment.

[0052] A third embodiment of this disclosure will be explained referring to Fig. 7. Similarly to Fig. 6 showing the configuration of the second embodiment, according to the third embodiment, the outer circumferential surface of the intermediate rotation member 6, specifically, the part protruding towards the rear plate 13 relative to the driven side rotation member 2 is relatively rotationally in close contact with the rear plate 13 to prevent the oil from leaking to the outside via the retarded angle oil passage 44. In the third embodiment, plural fitting portions 200 which are formed on the outer circumferential surface of the intermediate rotation member 6 in order to be fitted to the cylindrical inner wall 2a of the driven side rotation member 2 are press-fitted to plural portions of the cylindrical inner wall 2a, the plural portions which are equally spaced apart along the circumferential surface of the cylindrical inner wall 2a.

[0053] That is, press-fitting portions 20a include the same width and are equally spaced apart on the cylindrical inner wall 2a of the driven side rotation member 2 in a circumferential direction at, for example, three portions. A length from an inner surface of the press-fitting portions 20a to a center of the driven side rotation member 2 is shorter than a length from the cylindrical inner wall 2a to a center of the intermediate rotation member 6. The intermediate rotation member 6 includes the fitting portions 200 which are equally spaced apart and press-fitted to the press-fitting portions 20a.

[0054] According to the third embodiment, for example, three outer diameter portions 6a of the intermediate rotation member 6 are reliably press-fitted to the cylindrical inner wall 2a. Thus, the intermediate rotation member 6 is coaxially positioned with the driven side rotation member 2 precisely while reducing the size of the portion of the intermediate rotation member 6 to be processed for press-fitting.

[0055] Alternatively, the fitting portions 200 may include the plural press-fitting portions 20a which are unequally spaced apart on the cylindrical inner wall 2a in the circumferential direction. That is, according to the third embodiment, the driven side rotation member 2 includes the plural press-fitting portions 20a which are irregularly positioned along the circumferential direction of the driven side rotation member 2 and come in contact with the intermediate rotation member 6 when press-fitting to the intermediate rotation member 6. A length from the press-fitting portion to a center of the driven side rotation member 2 is shorter than a length from the cylindrical inner wall 2a to a center of the driven side rotation member 2.

[0056] Alternatively, according to the variable valve timing control device of the disclosure controls an opening and closing timing of an exhaust valve.

[0057] Alternatively, according to the variable valve timing control device of the disclosure is applicable to an internal combustion engine for an automobile and for other purposes.

Claims

1. A variable valve timing control device, comprising:

a driving side rotation member (1) configured to synchronously rotate with a driving shaft of an internal combustion engine;
a driven side rotation member (2) provided inwardly of the driving side rotation member (1) to be coaxial with the driving side rotation member (1), the driven side rotation member (2) integrally rotating with a camshaft (10) for opening and closing a valve of the internal combustion engine;
a fluid pressure chamber (4, 41, 42) defined between the driving side rotation member (1) and the driven side rotation member (2);
a first flow path (43) and a second flow path (44) allowing a flow of an operation fluid into and out of the fluid pressure chamber (4, 41, 42) to change a relative rotational phase of the driven side rotation member (2) relative to the driving side rotation member (1) between a most advanced angle phase and a most retarded angle phase;
an intermediate member (6) being provided between an inner circumferential surface of the driven side rotation member (2) and an outer circumferential surface of the camshaft (10), the intermediate member (6) connecting the driven side rotation member (2) and the camshaft (10); and
a contact portion (A) where the intermediate member (6) and the driven side rotation member (2) come in contact with each other at a position between the first flow path (43) and the second flow path (44) when mounting the intermediate member (6) to the camshaft (10) after mounting the intermediate member (6) and the driven side rotation member (2) to the driving side rotation member (1) after mounting the intermediate member (6) to the driven side rotation member (2) by press-fitting in a state where a space configuring a part of the first flow path (43) is defined

between the driven side rotation member (2) and the camshaft (10) and the intermediate member (6) includes a part of the second flow path (44).

2. The variable valve timing control device according to claim 1, further comprising:

a control valve (51) being positioned inwardly of the intermediate member (6) in a radial direction, the control valve (51) controlling the operation fluid to flow into and out of the fluid pressure chamber (4, 41, 42).

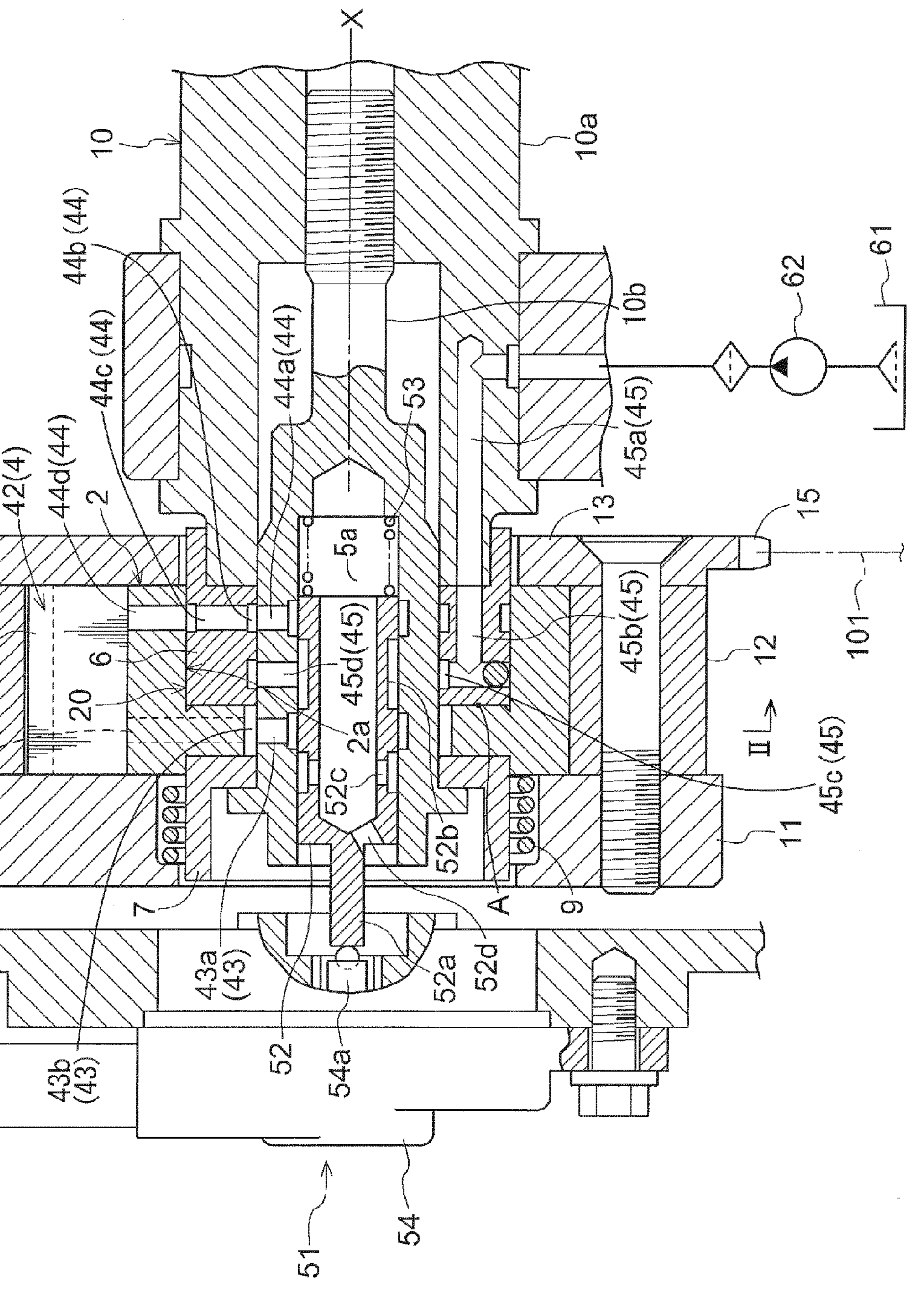
3. The variable valve timing control device according to either claim 1 or 2, wherein the intermediate member (6) is press-fitted to a portion of an inner wall (2a) of the driven side rotation member (2).

4. The variable valve timing control device according to claim 3, wherein the intermediate member (6) is press-fitted to the inner wall (2a) of the driven side rotation member (2) at a plurality of positions being equally spaced apart along a circumferential direction relative to an axis (X).

5. The variable valve timing control device according to claim 3, wherein the intermediate member (6) is fitted only to a portion positioned between a portion where the second flow path (44) is formed and the contact portion (A) of the inner wall (2a).

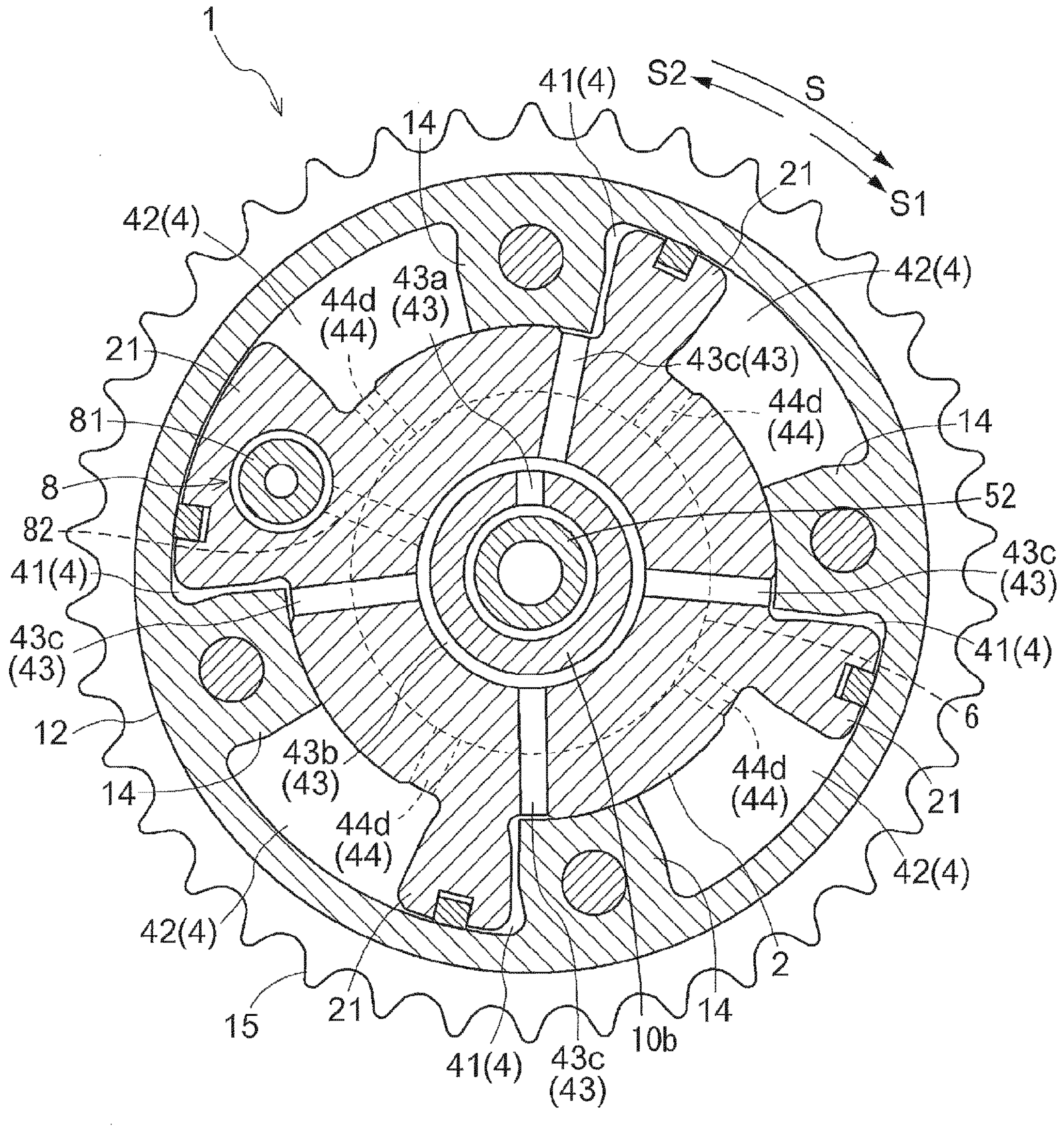
6. The variable valve timing control device according to claim 3, wherein:

the driven side rotation member (2) includes a plurality of press-fitting portions (20a) being irregularly positioned along a circumferential direction of the driven side rotation member (2), the plurality of press-fitting portions (20a) coming in contact with the intermediate member (6) when press-fitting to the intermediate member (6); and
a length from the press-fitting portion (20a) to a center of the driven side rotation member (2) is shorter than a length from the inner wall (2a) to the center of the driven side rotation member (2).


X
10
10a
10b
44b (44)
44c (44)
44a (44)
44d (44)
42(4)
2
21
6
20
2a
45d(45)
5a
53
45a(45)
62
61
13
15
101
12
45b(45)
45c (45)
52c
52b
43c
(43)
1
7
9
11
A
43a
(43)
52a
52d
52
54a
43b
(43)
51
54
II
II

F I G. 1

F I G. 2


1
41(4)
S2
S
S1
14
21
42(4)
42(4)
44d
(44)
43a
(43)
21
43c(43)
44d
(44)
81
14
8
52
82
43c
(43)
41(4)
41(4)
43c
(43)
6
12
43b
(43)
44d
(44)
21
14
44d
(44)
42(4)
42(4)
2
15
21
14
10b
41(4)
43c
(43)

F I G. 3

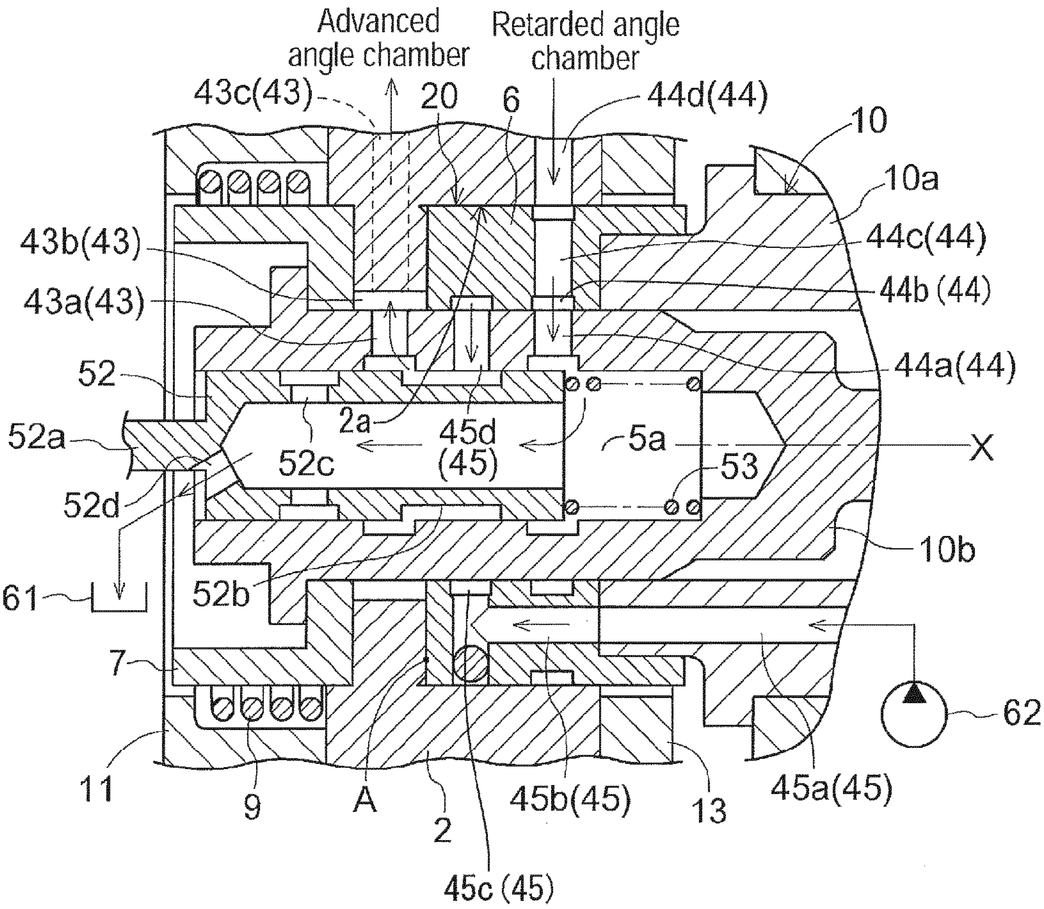
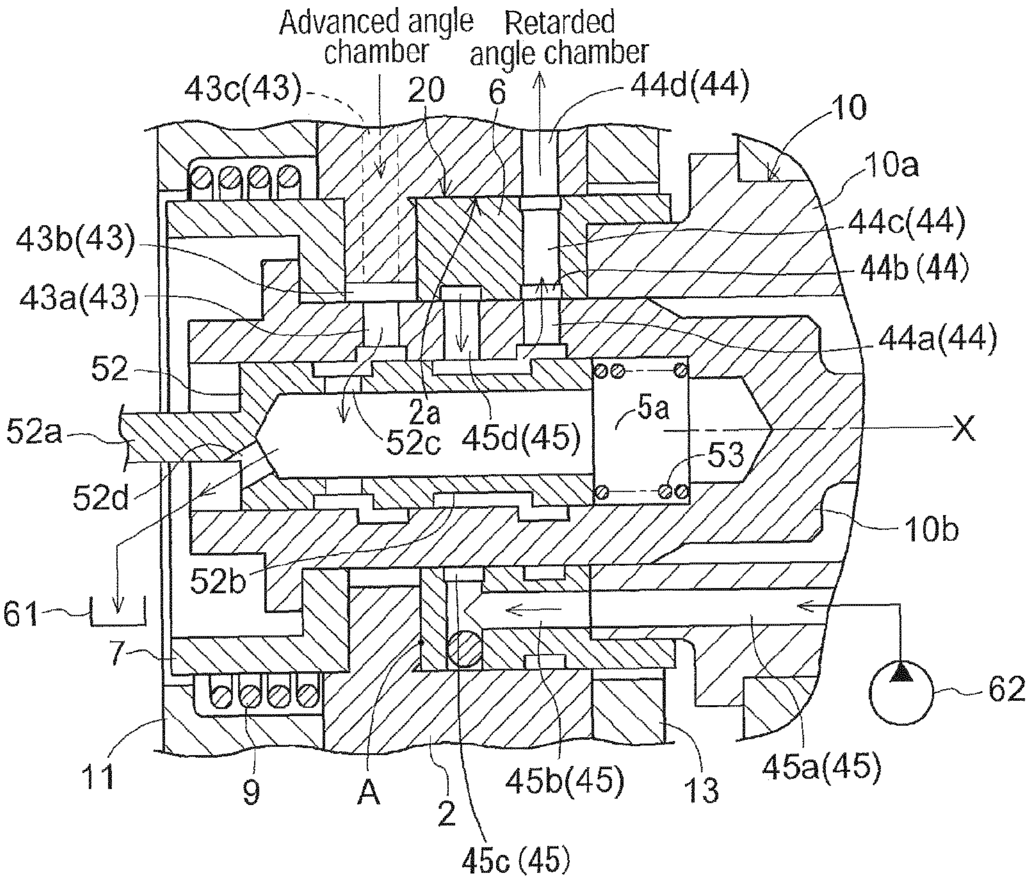

Advanced angle chamber
Retarded angle chamber
43c(43)
20
6
44d(44)
10
10a
44c(44)
43b(43)
44b (44)
43a(43)
44a(44)
52
2a
45d
(45)
5a
52a
52c
53
X
52d
10b
61
52b
7
62
11
9
A
2
45b(45)
13
45a(45)
45c (45)

FIG. 4


Advanced angle chamber
Retarded angle chamber
43c(43)
20
6
44d(44)
10
10a
44c(44)
43b(43)
44b (44)
43a(43)
44a(44)
52
2a
5a
52a
52c
45d(45)
X
53
52d
10b
52b
61
7
62
11
9
A
2
45b(45)
13
45a(45)
45c (45)

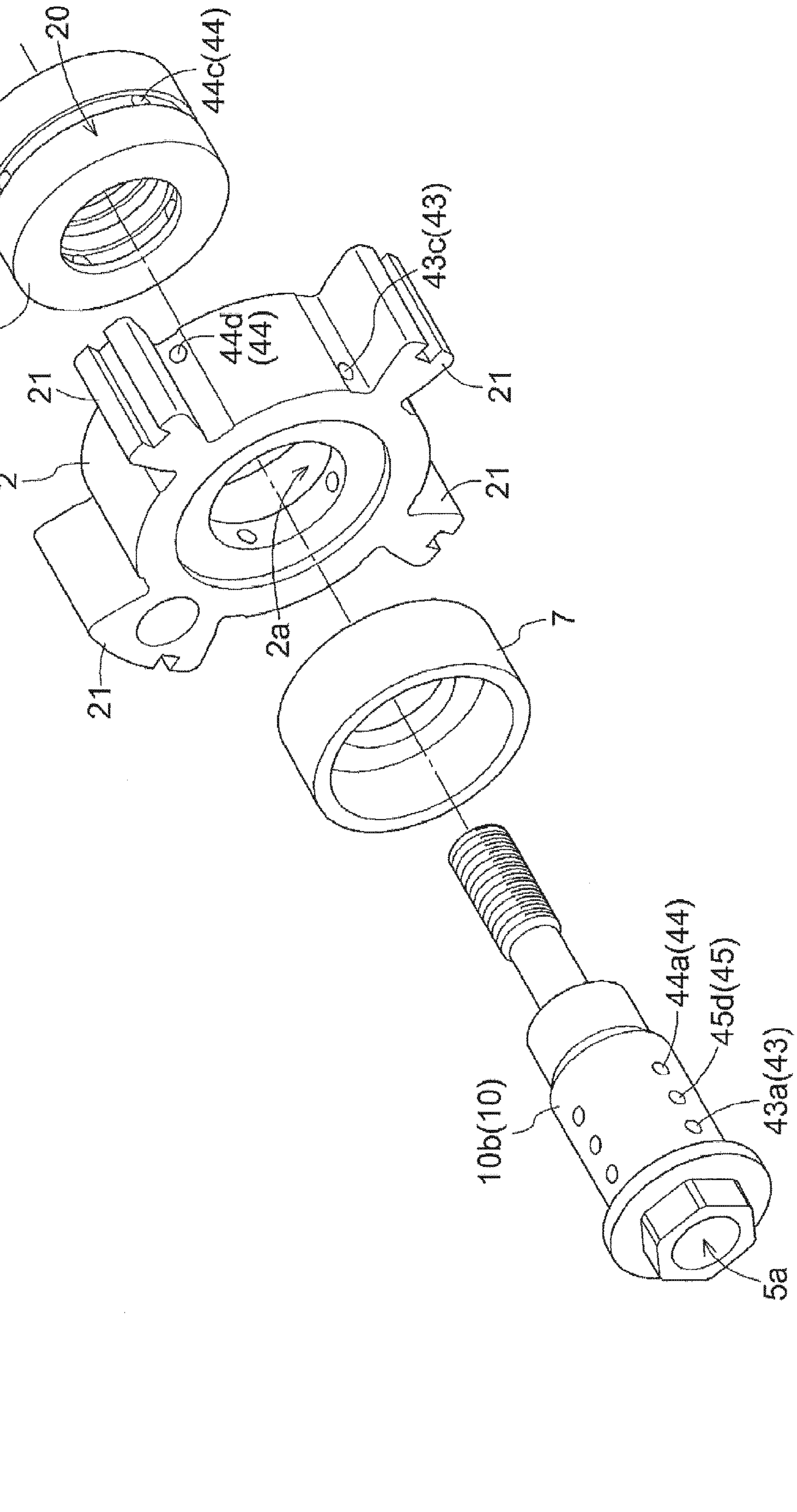
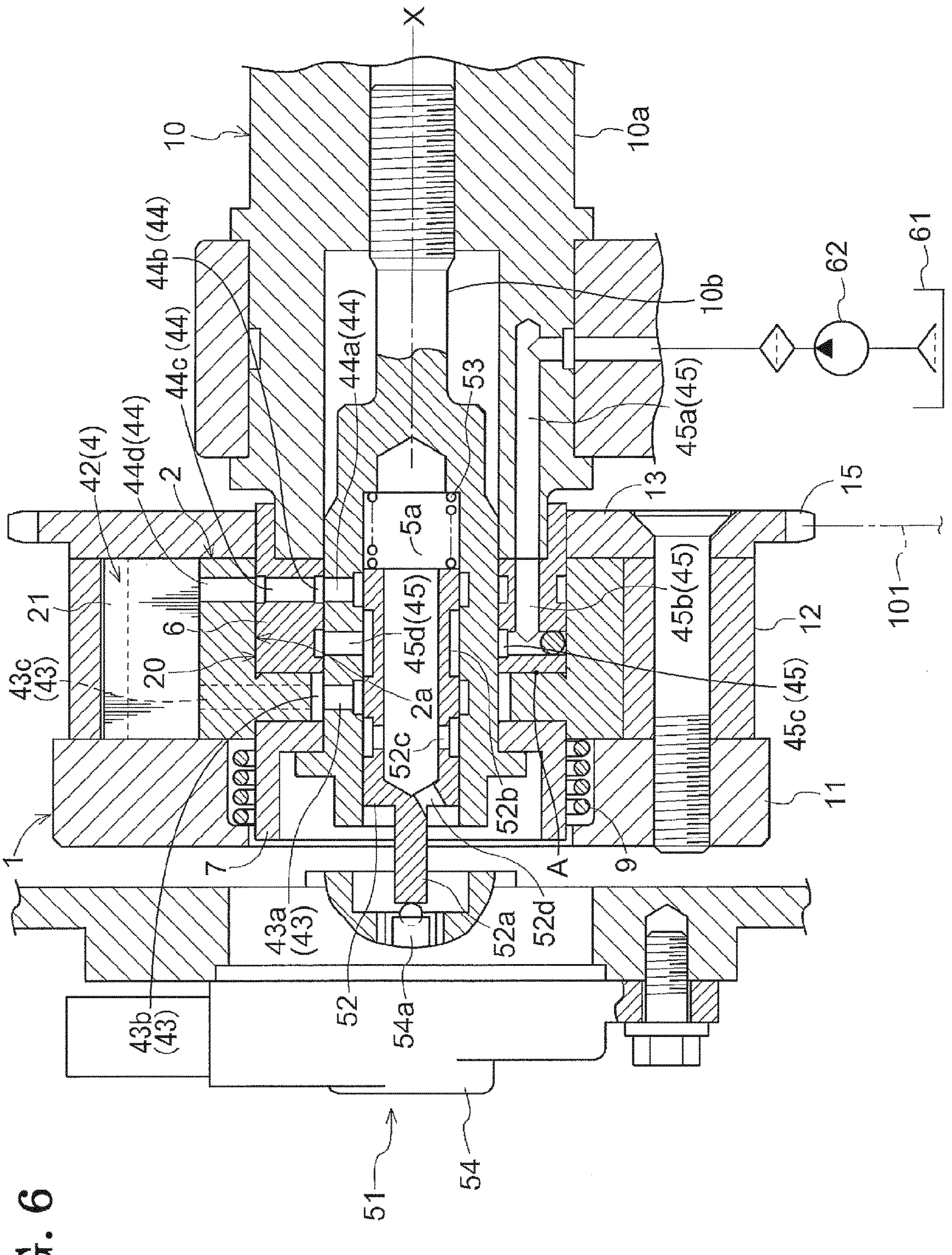
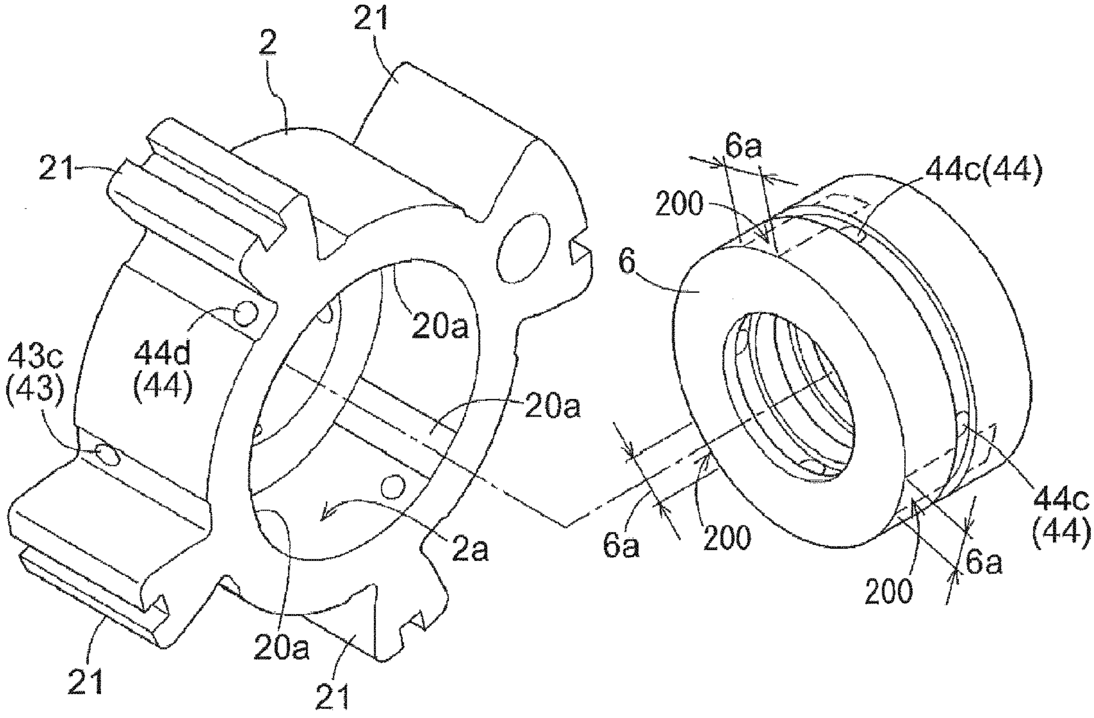

20
44c(44)
6
43c(43)
44d
(44)
21
21
2
21
21
2a
7
44a(44)
45d(45)
43a(43)
10b(10)
5a

FIG. 5


X
10
10a
10b
44b (44)
44c (44)
44a(44)
44d(44)
42(4)
2
21
6
20
43c
(43)
2a
45d(45)
5a
53
45a(45)
13
15
45b(45)
12
101
45c (45)
45 (45)
52c
52b
A
9
11
1
7
43a
(43)
52
52a
52d
54a
43b
(43)
54
51
62
61

F I G. 6

F I G. 7


21
2
21
6a
44c(44)
200
6
20a
44d
(44)
43c
(43)
20a
2a
6a
200
44c
(44)
6a
200
20a
21
21

Europäisches Patentamt
European Patent Office
Office européen des brevets

EUROPEAN SEARCH REPORT

Application Number
EP 14 18 2160

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,D Y	EP 2 428 656 A1 (AISIN SEIKI) 14 March 2012 (2012-03-14) * the whole document * & JP 2012 057578 A (AISIN SEIKI) 22 March 2012 (2012-03-22) -----	1,2 3-6	INV. F01L1/344
Y	WO 2012/111388 A1 (AISIN SEIKI [JP]; ADACHI KAZUNARI [JP]; NOGUCHI YUJI [JP]; HOMMA ATSUS) 23 August 2012 (2012-08-23) * abstract; figures * -----	3-6	
			TECHNICAL FIELDS SEARCHED (IPC)
			F01L

The present search report has been drawn up for all claims

2

Place of search	Date of completion of the search	Examiner
The Hague	9 January 2015	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

EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 14 18 2160

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

09-01-2015

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 2428656 A1	14-03-2012	CN 102400728 A	04-04-2012
		EP 2428656 A1	14-03-2012
		JP 5585832 B2	10-09-2014
		JP 2012057578 A	22-03-2012
		US 2012060779 A1	15-03-2012
WO 2012111388 A1	23-08-2012	CN 103339348 A	02-10-2013
		EP 2677126 A1	25-12-2013
		JP 5321925 B2	23-10-2013
		JP 2012172558 A	10-09-2012
		KR 20130095312 A	27-08-2013
		US 2013247855 A1	26-09-2013
		WO 2012111388 A1	23-08-2012

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- JP 2012057578 A **[0004]**