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(54) **VARIABLE VALVE TIMING DEVICE AND ASSEMBLY METHOD OF VARIABLE VALVE TIMING DEVICE**

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(57) **ABSTRACT**

A case for rotating integrally with a crankshaft of an engine; a rotor housed in the case, to be rotated integrally with a camshaft of the engine by fastening the rotor coaxially to the camshaft with a center bolt; and a groove provided around an axis of the rotor on an opposite side of the rotor to the camshaft, and having an inner wall intersecting a rotation direction of the rotor are provided.

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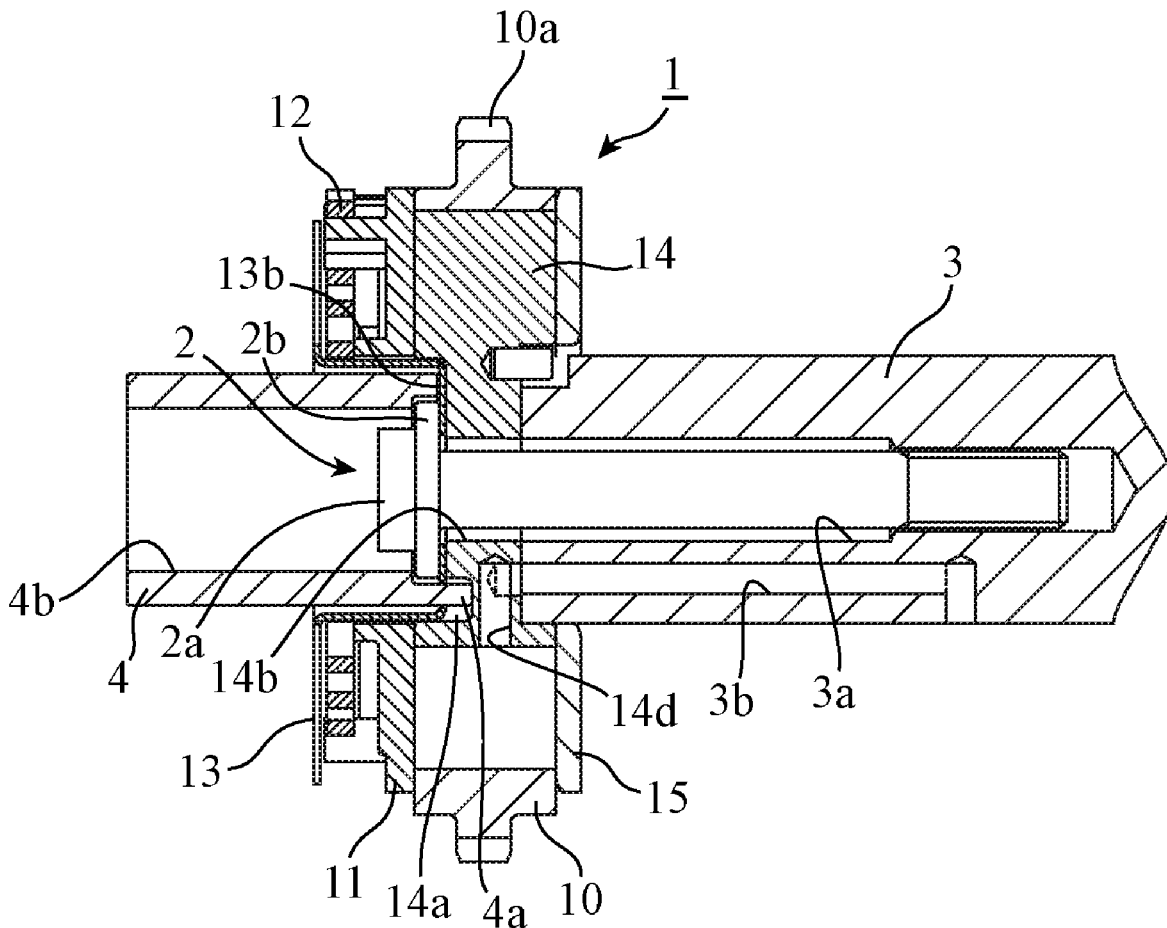


FIG. 1

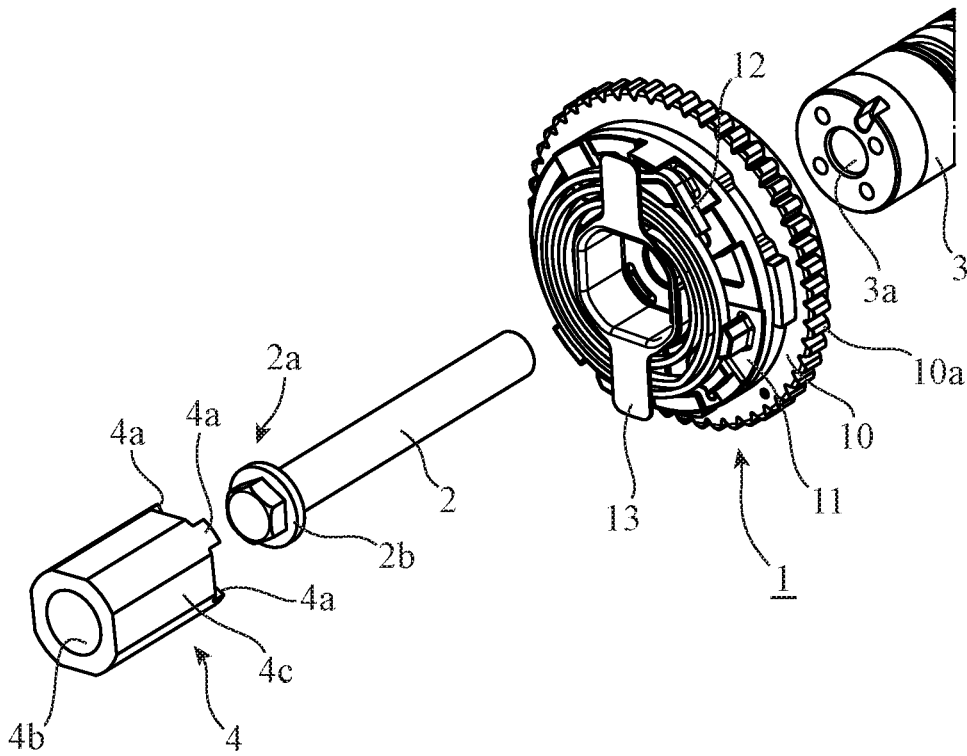


FIG. 2

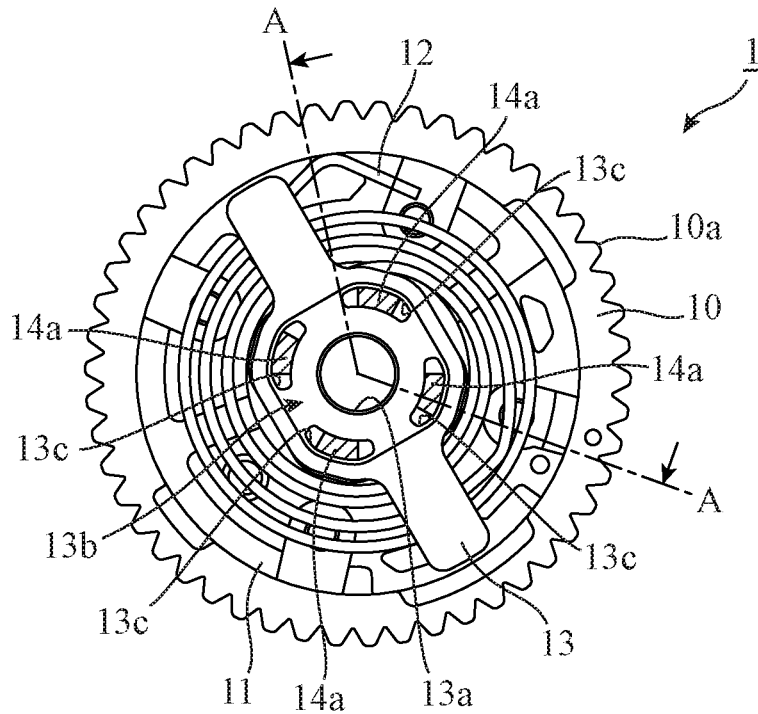


FIG. 3

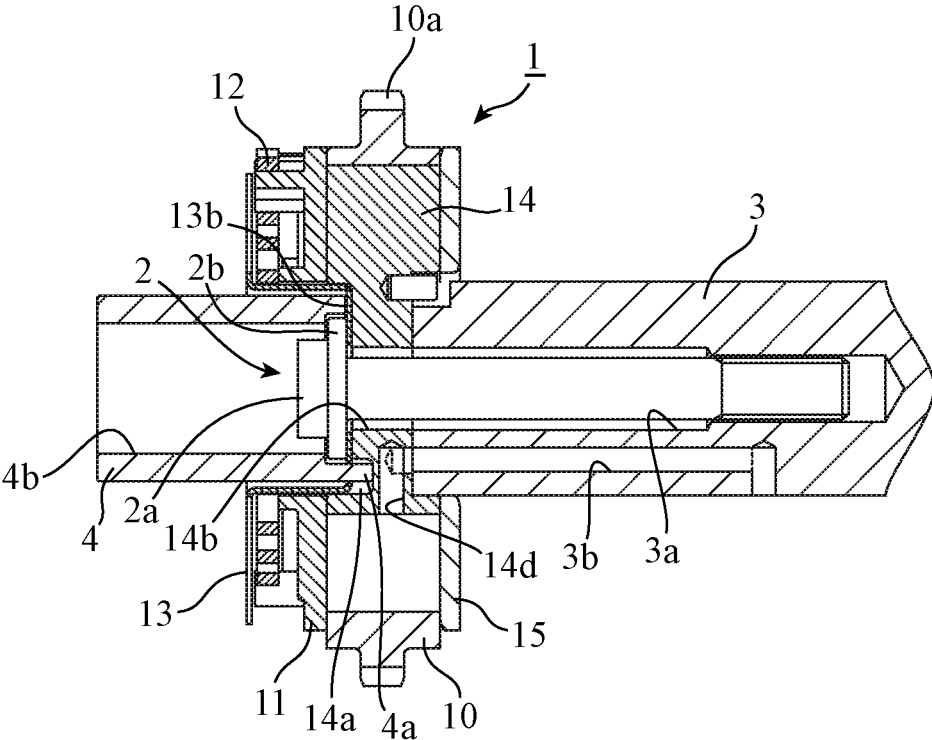




FIG. 5A

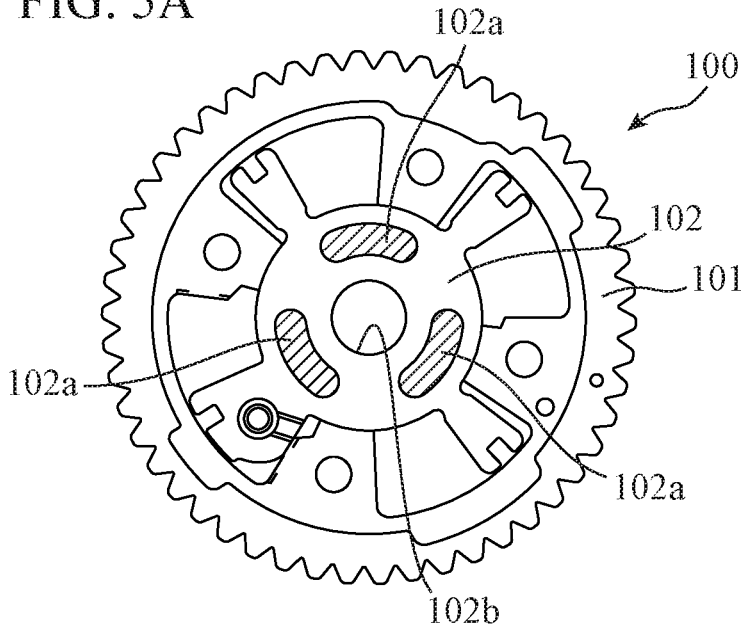


FIG. 5B

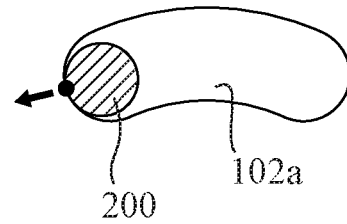


FIG. 6

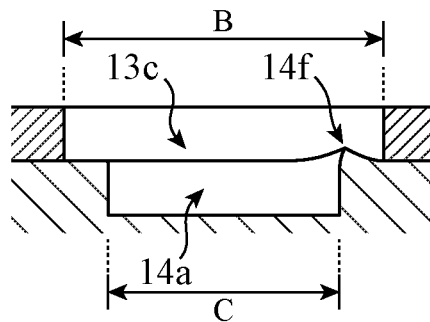


FIG. 7A

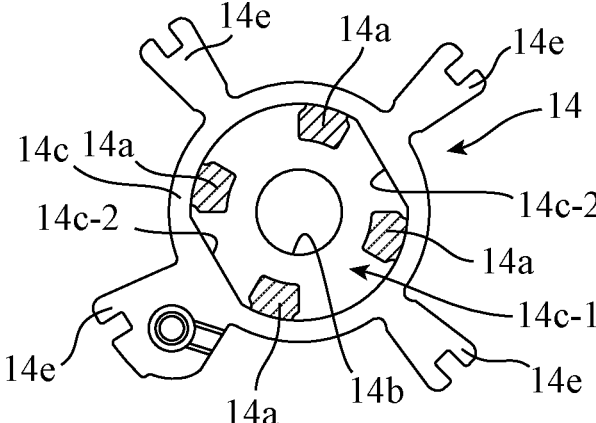


FIG. 7B

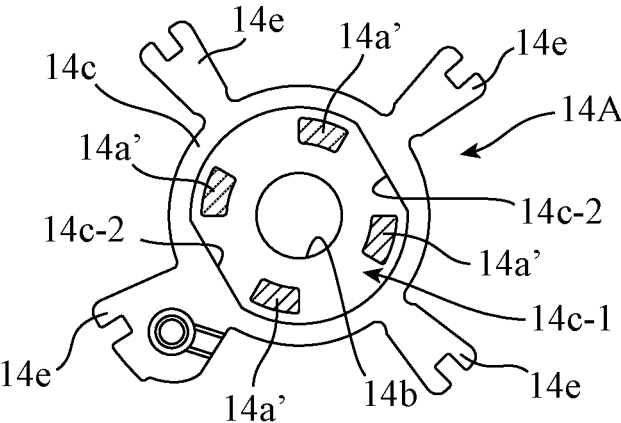


FIG. 8A

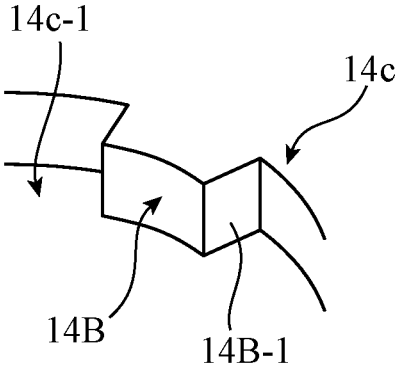


FIG. 8B

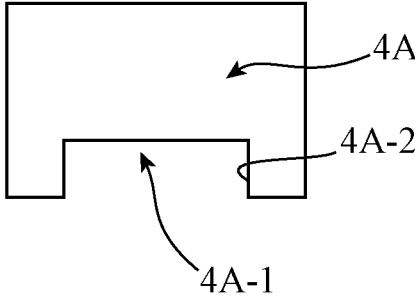
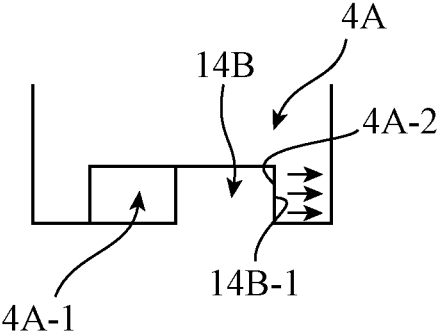


FIG. 8C



**VARIABLE VALVE TIMING DEVICE AND  
ASSEMBLY METHOD OF VARIABLE VALVE  
TIMING DEVICE**

TECHNICAL FIELD

**[0001]** The present invention relates to a variable valve timing device (hereinafter referred to as a VVT device) and an assembly method of the VVT device.

BACKGROUND ART

**[0002]** A VVT device is a device that variably controls opening and closing timing of an intake valve or an exhaust valve of an engine of a vehicle, and is fastened to a camshaft by a bolt (see, for example, Patent Literature 1).

**[0003]** Fastening torque generated when the VVT device is assembled to the camshaft by the bolt is received by the camshaft if the camshaft is held.

**[0004]** If the camshaft cannot be held, when the VVT device is assembled to the camshaft, a rotor and the camshaft are interlocked, so that rotation of the camshaft is fixed via the rotor.

**[0005]** For example, a projection provided on a jig is inserted into a groove provided around an axis of the rotor to fix rotation of the rotor and the camshaft, and in this state, the VVT device is fastened to the camshaft using the bolt. A load of fastening torque generated at this time is applied to a contact portion between the projection of the jig and an inner wall of the groove of the rotor.

CITATION LIST

Patent Literatures

**[0006]** Patent Literature 1: JP 2014-139422 A

SUMMARY OF INVENTION

Technical Problem

**[0007]** In the conventional VVT device, the load of the fastening torque concentrates on the contact portion between the projection of the jig and the inner wall of the groove of the rotor, so there is a possibility that the groove or the jig may be damaged by the excessive load.

**[0008]** In order to prevent the concentration of the load of the fastening torque, it is conceivable to lengthen the projection of the jig and deepen the groove of the rotor to increase a contact area between them.

**[0009]** However, with this configuration, a size of the groove increases in an axial direction of the rotor, a size of the rotor is thereby increased, which hampers downsizing or weight reduction of the VVT device.

**[0010]** It is an object of the present invention to provide a VVT device and an assembly method of the VVT device capable of suppressing stress concentration caused by torque generated by assembling the VVT device.

Solution to Problem

**[0011]** A VVT device according to the present invention includes: a case for rotating integrally with a crankshaft of an engine; a rotor housed in the case, fastened coaxially to a camshaft of the engine by a center bolt, and for rotating integrally with the camshaft; and a torque receiving unit

provided around an axis of the rotor on a side opposite to the camshaft, and having a flat surface in a rotation direction of the rotor.

Advantageous Effects of Invention

**[0012]** According to the present invention, by providing the torque receiving unit having the flat surface in the rotation direction of the rotor, a load of fastening torque generated by tightening a bolt is applied to a portion where the flat surface and a part of a jig are in surface contact with each other. Consequently, it is possible to suppress concentration of stress due to the fastening torque.

BRIEF DESCRIPTION OF DRAWINGS

**[0013]** FIG. 1 is an exploded perspective view showing an assembling structure of a VVT device according to a first embodiment of the present invention to a camshaft.

**[0014]** FIG. 2 is a front view showing the VVT device according to the first embodiment.

**[0015]** FIG. 3 is a sectional arrow view showing a state in which the VVT device according to the first embodiment is cut off along line A-A in FIG. 2.

**[0016]** FIG. 4A is a view showing the inside of the VVT device according to the first embodiment. FIG. 4B is a view showing a groove of a rotor in the first embodiment.

**[0017]** FIG. 4C is a view showing a contact state between the groove of the rotor and a projection of a jig in the first embodiment.

**[0018]** FIG. 5A is a view showing the inside of a conventional VVT device. FIG. 5B is a view showing a contact state between a groove of a conventional rotor and a projection of a jig.

**[0019]** FIG. 6 is a sectional view showing the groove of the rotor and a long hole of a spring holder in the first embodiment.

**[0020]** FIG. 7A is a front view showing the rotor in first embodiment. FIG. 7B is a front view showing another example of a rotor in the first embodiment.

**[0021]** FIG. 8A is an enlarged perspective view showing a projection of the rotor in the first embodiment. FIG. 8B is a side view showing a recess of a jig. FIG. 8C is a view showing a contact state between the projection of the rotor and the recess of the jig in the first embodiment.

DESCRIPTION OF EMBODIMENTS

**[0022]** Hereinafter, in order to explain the present invention in more detail, embodiments for carrying out the present invention will be described with reference to the accompanying drawings.

First Embodiment

**[0023]** FIG. 1 is an exploded perspective view showing an assembling structure of a VVT device 1 according to a first embodiment of the present invention to a camshaft 3. FIG. 2 is a front view showing the VVT device 1. FIG. 3 is a sectional arrow view showing a state in which the VVT device 1 is cut off along line A-A in FIG. 2.

**[0024]** As shown in FIG. 1, the VVT device 1 is fastened coaxially with the camshaft 3 using a center bolt 2. A jig 4 is a jig for fixing rotation of a rotor 14 and the camshaft 3 when fastening the VVT device 1 to the camshaft 3 with the



center bolt 2. The jig 4 is a tubular member and has a plurality of projections 4a that protrudes in an axial direction from one end.

[0025] The VVT device 1 mainly includes a case 10, a cover 11, a spiral spring 12, a spring holder 13, the rotor 14, and a housing 15.

[0026] The case 10 has a chain sprocket 10a for transmitting driving force from a crankshaft of an engine (not shown) to the camshaft 3, and transmits rotational driving force of the engine to the VVT device 1 via this chain sprocket 10a. The rotor 14 and the camshaft 3 are integrally rotated by the rotational driving force of the engine to change a rotational phase of the camshaft 3 and the crankshaft.

[0027] The spiral spring 12 is disposed coaxially with the rotor 14 by the spring holder 13, and both ends of the spiral spring 12 are locked on the cover 11. As the spiral spring 12 is twisted and deformed via the spring holder 13, assist torque for assisting the rotation of the rotor 14 is generated.

[0028] The spring holder 13 is a holder that holds the spiral spring 12 on the cover 11. As shown in FIG. 2, a center hole 13a through which the center bolt 2 passes and a long hole 13c through which the projection 4a of the jig 4 passes are formed at a bottom 13b of the spring holder 13. The long hole 13c is an arcuate through hole centered on an axis of the rotor 14.

[0029] The center bolt 2 has a flange 2b projecting radially outward from a head 2a. As shown in FIG. 3, the bottom 13b of the spring holder 13 is fastened to the rotor 14 by the center bolt 2 in a state that the bottom 13b is sandwiched between the flange 2b of the center bolt 2 and the rotor 14. The assist torque generated by the spiral spring 12 is transmitted to the rotor 14 by the spring holder 13 fastened to the rotor 14.

[0030] The rotor 14 is housed in a space in which the cover 11 and the housing 15 are assembled to the case 10, and is fastened to one end of the camshaft 3 by the center bolt 2.

[0031] As shown in FIG. 2, a plurality of grooves 14a is formed around the axis of the rotor 14 on a side opposite to the camshaft 3. Each of the plurality of grooves 14a has an inner wall that is a flat surface in a rotation direction of the rotor 14, and functions as a torque receiving unit that receives fastening torque or loosening torque of the center bolt 2.

[0032] Next, a procedure for assembling the VVT device 1 to the camshaft 3 will be described.

[0033] After the end of the camshaft 3 is fitted to the housing 15 side of the VVT device 1, the center bolt 2 is passed through a center hole 14b of the rotor 14, and the jig 4 is mounted on the VVT device 1.

[0034] When the jig 4 is mounted on the VVT device 1, each of the plurality of projections 4a is inserted into the groove 14a of the rotor 14 through the long hole 13c of the spring holder 13, and the head 2a of the center bolt 2 enters a through hole 4b.

[0035] By fixing the jig 4 with a tool or the like in this state, a contact portion between the projection 4a and the groove 14a serves as a rotation stop of the rotor 14, and rotation of the rotor 14 and the camshaft 3 is fixed.

[0036] After the jig 4 is fixed in this manner, the center bolt 2 is screwed into a female screw hole 3a of the camshaft 3, so that the VVT device 1 is fastened to the camshaft 3. Thereafter, the jig 4 is removed from the VVT device 1.

[0037] FIG. 4A is a view showing the inside of the VVT device 1, showing a state in which the cover 11, the spiral spring 12, and the spring holder 13 in FIG. 2 are removed. FIG. 4B is a view showing the groove 14a of the rotor 14. FIG. 4C is a view showing a contact state between the groove 14a and the projection 4a of the jig 4. FIG. 5A is a view showing the inside of a conventional VVT device 100 and shows the same state as FIG. 4A. FIG. 5B is a view showing a contact state between a groove 102a of a conventional rotor 102 and a projection 200 of a jig.

[0038] As shown in FIG. 4A, the rotor 14 includes a boss 14c and a vane 14e protruding from an outer periphery of the boss 14c, and a recess for fitting the spring holder 13 is formed at a center of the boss 14c. The groove 14a and the center hole 14b are formed on a bottom surface 14c-1 of the recess. In the groove 14a of the rotor 14, for example, the four grooves 14a are disposed at an equal angle about the axis of the rotor 14. By disposing the grooves 14a in this way, the rotor 14 is fastened to the camshaft 3 without tilt in the axial direction, and rotation balance of the VVT device 1 can be secured. Thereby, rotation efficiency of the VVT device 1 can be increased.

[0039] The recess of the boss 14c is a recess of a width across flat shape having inner walls 14c-2, 14c-2 faced in parallel. A main body of the spring holder 13 has an outer peripheral shape corresponding to this recess. By fitting the main body of the spring holder 13 into the recess of the boss 14c, a relative angle between the spring holder 13 and the rotor 14 can be positioned.

[0040] As shown in FIG. 4B, the groove 14a is a fan-shaped groove requiring an axial center of the rotor 14 in a plan view, and has an inner wall 14a-1 which is a flat surface in the rotation direction of the rotor 14. An inner wall 14a-2 is a cut surface for making it easier for a mold used for molding the groove 14a to escape.

[0041] The projection 4a of the jig 4 is a columnar member having a rectangular cross section and having a flat surface 4a-1.

[0042] On the other hand, in the conventional VVT device 100, like the VVT device 1, the rotor 102 is housed in a case 101, and the grooves 102a are formed around an axis of the rotor 102.

[0043] As shown in FIGS. 5A and 5B, the groove 102a is a long rounded groove whose both ends are rounded, and does not have the flat surface in the groove 14a.

[0044] The projection 200 of the conventional jig is a columnar member having a circular cross section.

[0045] As indicated by arrows in FIG. 4C, fastening torque generated when the center bolt 2 is tightened is received by the flat surface 4a-1 of the projection 4a and the inner wall 14a-1 of the groove 14a. Likewise, upon removal of the VVT device 1, loosening torque when the center bolt 2 is loosened is received by the flat surface 4a-1 of the projection 4a and the inner wall 14a-1 of the groove 14a.

[0046] Also in the conventional VVT device 100, as indicated by an arrow in FIG. 5B, fastening torque is received by the projection 200 of the jig and an inner wall of the groove 102a.

[0047] Likewise, upon removal of the VVT device 100 from a camshaft, loosening torque generated when a center bolt is loosened is received by the projection 200 of the jig and the inner wall of the groove 102a.

[0048] However, in the conventional VVT device 100, a load of the fastening torque is applied to a portion where the

projection 200 and the inner wall of the groove 102a are in line contact with each other in a depth direction of the groove 102a.

[0049] Thus, there is a possibility that the groove 102a or the projection 200 of the jig is damaged by stress concentrated on a narrow contact area.

[0050] On the other hand, in the VVT device 1, a load of the fastening torque is applied to a portion where the flat surface 4a-1 and the inner wall 14a-1 are in surface contact with each other. Therefore, the stress concentration as in the conventional VVT device 100 does not occur, and damage to the projection 4a or the groove 14a resulting from this can be avoided.

[0051] Further, in the conventional VVT device 100, when securing the contact area between the groove 102a and the projection 200 of the jig, it is necessary to lengthen the projection 200 of the jig and deepen the groove 102a.

[0052] On the other hand, the VVT device 1 has a structure in which the flat surface 4a-1 and the inner wall 14a-1 come into surface contact and no stress concentrates, so that it is possible to make a depth of the groove 14a shallow.

[0053] Thus, for example, as shown in FIG. 3, an oil passage 14d can be provided in a lower portion of the groove 14a. The oil passage 14d communicates with an oil passage 3b provided in the camshaft 3, and oil is supplied or discharged to an oil pressure chamber in the case 10 through the oil passage 3b and the oil passage 14d.

[0054] In this manner, in the VVT device 1, since a space for forming the oil passage can be ensured also in the lower portion of the groove 14a, it is possible to reduce size and weight of the VVT device 1.

[0055] Note that, when an oil passage is formed at a position shifted from the lower portion of the groove 14a, the groove 14a may be a through hole. Thereby, weight of the rotor 14 can be reduced.

[0056] FIG. 6 is a sectional view showing the groove 14a of the rotor 14 and the long hole 13c of the spring holder 13. As shown in FIG. 6, a circumferential dimension B of the long hole 13c is larger than a circumferential dimension C of the groove 14a. For example, when the jig 4 is slightly inclined at the time of assembling the VVT device 1 to the camshaft 3, there is a possibility that stress concentrates on a contact portion between the projection 4a and an opening peripheral edge of the groove 14a. When the opening peripheral edge of the groove 14a is plastically deformed due to the concentration of the stress, a minute raised portion 14f may be formed.

[0057] In the VVT device 1, as shown in FIG. 6, since the long hole 13c can avoid the raised portion 14f, the raised portion 14f does not prevent the spring holder 13 from being assembled to the rotor 14.

[0058] As shown in FIG. 7A, an inner wall on a radially outer side of the groove 14a of the rotor 14 is continuous with the inner wall of the recess of the boss 14c. With such a configuration, it is possible to remove a mold for sinter molding, and the recess having the width across flat shape and the groove 14a can be formed by sinter molding.

[0059] Thereby, the rotor 14 can be formed by inexpensive sinter molding.

[0060] In a rotor 14A shown in FIG. 7B, an inner wall on a radially outer side of a groove 14a' is not continuous with an inner wall of a recess of a boss 14c. In this configuration, when a distance between the inner wall on the radially outer side of the groove 14a' and the inner wall of the recess of the

boss 14c is not separated equal to or more than an allowable range, sinter molding is damaged. Therefore, the rotor 14A may be less compact than the rotor 14. Further, from a viewpoint of design, when the distance between the inner wall on the radially outer side of the groove 14a' and the inner wall of the recess of the boss 14c cannot be separated equal to or more than the allowable range, the rotor 14A is formed by machining more expensively than the sinter molding.

[0061] In the above description, the configuration in which the projection 4a of the jig 4 and the groove 14a of the rotor 14 receive the fastening torque is shown, but in the VVT device 1 according to the first embodiment, a recess of a jig and a projection of the rotor may receive fastening torque.

[0062] FIG. 8A is an enlarged perspective view showing a projection 14B of the rotor 14. As shown in FIG. 8A, the projection 14B is provided in the recess of the boss 14c of the rotor 14, and protrudes radially inward from the inner wall of the recess on the bottom surface 14c-1. The projection 14B has a flat surface 14B-1 in the rotation direction of the rotor 14. FIG. 8B is a side view showing a recess 4A-1 of a jig 4A. Like the jig 4 shown in FIG. 1, the jig 4A is a cylindrical member, and has the recess 4A-1 recessed in an axial direction at one end. The recess 4A-1 has an inner wall 4A-2 that is in surface contact with the flat surface 14B-1 of the projection 14B.

[0063] FIG. 8C is a view showing a contact state between the projection 14B of the rotor 14 and the recess 4A-1 of the jig 4A. As indicated by arrows in FIG. 8C, fastening torque generated when the center bolt 2 is tightened is received by the flat surface 14B-1 of the projection 14B and the inner wall 4A-2 of the recess 4A-1. Likewise, upon removal of the VVT device 1, loosening torque when the center bolt 2 is loosened can be received by the flat surface 14B-1 of the projection 14B and the inner wall 4A-2 of the recess 4A-1.

[0064] A load of the fastening torque is applied to a portion where the flat surface 14B-1 of the projection 14B and the inner wall 4A-2 of the recess 4A-1 are in surface contact. Therefore, the stress concentration as in the conventional VVT device 100 does not occur, and damage to the projection 14B or the recess 4A-1 resulting from this can be avoided.

[0065] A space for providing an oil passage is ensured at a lower portion of the projection 14B of the rotor 14 is ensured, so that the VVT device 1 can be reduced in size and weight.

[0066] Further, the projection 14B may be disposed at an equal angle around the axis of the rotor 14. With such a configuration, as in a case of the groove 14a, rotation balance of the VVT device 1 can be ensured, and rotation efficiency of the VVT device 1 can be increased.

[0067] As described above, the VVT device 1 according to the first embodiment includes the case 10, the rotor 14, and the groove 14a or the projection 14B. With this configuration, a load of fastening torque generated by tightening the center bolt 2 is applied to the portion where the rotor 14 and the jig 4 are in surface contact. Consequently, it is possible to suppress concentration of stress due to the fastening torque.

[0068] In the VVT device 1 according to the first embodiment, the torque receiving unit is disposed at an equal angle around the axis of the rotor 14. With such a configuration, rotation balance of the VVT device 1 can be ensured, and rotation efficiency of the VVT device 1 can be enhanced.

[0069] For example, three or more torque receiving units may be disposed at an equal angle around the axis of the rotor **14**.

[0070] In the VVT device **1** according to the first embodiment, the torque receiving unit is a groove penetrating the rotor **14** in the axial direction. By configuring in this way, weight of the rotor **14** can be reduced.

[0071] In the VVT device **1** according to the first embodiment, the rotor **14** has the recess in the center of the boss **14c**, the groove **14a** is provided on the bottom surface **14c-1** of the recess, and the inner wall on the radially outer side is continuous with the inner wall of the recess. By configuring in this way, it becomes possible to remove a mold for sinter molding, and the recess having the width across flat shape and the groove **14a** can be formed by inexpensive sinter molding.

[0072] Note that the present invention can modify arbitrary constituent elements in the embodiment or omit arbitrary constituent elements in the embodiment within the scope of the invention.

#### INDUSTRIAL APPLICABILITY

[0073] Since the VVT device according to the present invention can suppress concentration of a load of fastening torque generated by assembly using the bolt, it is suitable for a VVT device attached to a camshaft of an engine to control opening/closing timing of an intake valve or an exhaust valve.

#### REFERENCE SIGNS LIST

[0074] **1, 100**: VVT device, **2**: center bolt, **2a**: head, **2b**: flange, **3**: camshaft, **3a**: female screw hole, **3b, 14d**: oil passage, **4, 4A**: jig, **4A-1**: recess, **4A-2, 14a-1, 14a-2, 14c-2**: inner wall, **4a, 14B, 200**: projection, **4a-1, 14B-1**: flat surface, **4b**: through hole, **10, 101**: case, **10a**: chain sprocket, **11**: cover, **12**: spiral spring, **13**: spring holder, **13a, 14b**: center hole, **13b**: bottom, **13c**: long hole, **14, 14A, 102**: rotor,

**14a, 14a', 102a**: groove, **14c**: boss, **14c-1**: bottom surface, **14e**: vane, **14f**: raised portion, and **15**: housing

**1.-6.** (canceled)

**7.** A variable valve timing device comprising:  
a case for rotating integrally with a crankshaft of an engine;

a rotor housed in the case, to be rotated integrally with a camshaft of the engine by fastening the rotor coaxially to the camshaft with a center bolt; and

at least one torque receiving part provided around an axis of the rotor on an opposite side of the rotor to the camshaft, and having a flat surface intersecting a rotation direction of the rotor, wherein

the at least one torque receiving part is a groove or a projection,

the rotor has a recess in a center of a boss, and

the groove is provided on a bottom surface of the recess, and an inner wall on a radially outer side of the groove is continuous with an inner wall of the recess.

**8.** The variable valve timing device according to claim **7**, wherein the at least one torque receiving part includes a plurality of torque receiving parts, and

the plurality of torque receiving parts are equiangularly spaced around the axis of the rotor.

**9.** The variable valve timing device according to claim **7**, wherein the groove penetrates the rotor in an axial direction of the rotor.

**10.** An assembly method of a variable valve timing device comprising:

attaching a jig to the at least one torque receiving part of the variable valve timing device according to claim **7**; and

fastening the rotor to the camshaft with the center bolt in a state in which the flat surface of the at least one torque receiving part and a part of the jig are in surface contact with each other in the rotation direction of the rotor.

\* \* \* \* \*