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(71) Applicant: **Aisin Seiki Kabushiki Kaisha**
**Kariya-shi Aichi 448-8650 (JP)**

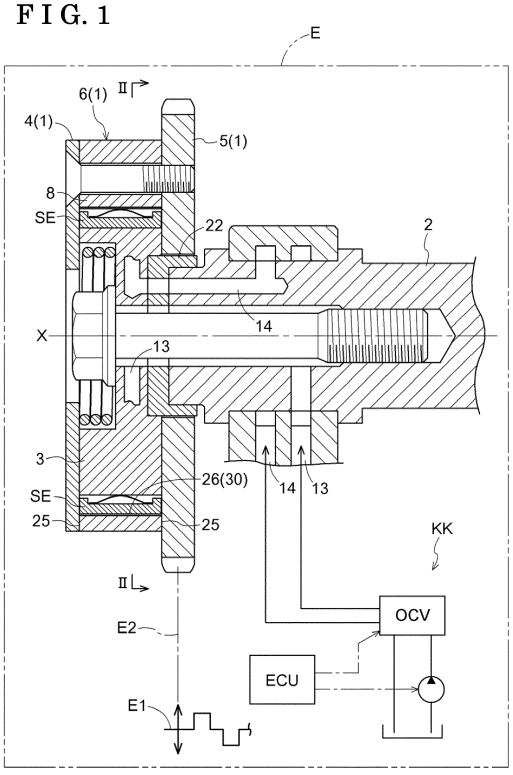
(72) Inventors:
- **ASAHI, Takeo**
  **Kariya-shi, Aichi 448-8650 (JP)**
- **NOGUCHI, Yuji**
  **Kariya-shi, Aichi 448-8650 (JP)**
- **ADACHI, Kazunari**
  **Kariya-shi, Aichi 448-8650 (JP)**
- **SUGIMOTO, Tadashi**
  **Imizu-shi, Toyama 934-8588 (JP)**

(74) Representative: **Kramer Barske Schmidtchen**
**Patentanwälte PartG mbB**
**European Patent Attorneys**
**Landsberger Strasse 300**
**80687 München (DE)**

# (54) VALVE-OPENING/CLOSING-TIMING CONTROL DEVICE, AND PRODUCTION METHOD FOR DRIVE-SIDE ROTATIONAL BODY OF VALVE-OPENING/CLOSING-TIMING CONTROL DEVICE

(57) To provide a valve opening/closing timing control device where oil leakage is inhibited from occurring, for example, from a gap between members constituting a drive side rotational body while lubrication and abrasion resistance of a slide surface of a housing main body are maintained. The valve opening/closing timing control device includes a housing main body that includes an opening which opens to at least one side in a direction along a rotational axis X and a cover plate closing the opening by making contact with an end surface of the opening, the drive side rotational body rotating synchronously with a crankshaft, and a driven side rotational body housed within the drive side rotational body and defining an advance chamber and a retardation chamber relative to an inner peripheral surface of the housing main body, the driven side rotational body rotating integrally with a camshaft and coaxially with the rotational axis. In addition, the housing main body includes a hard layer formed at least at the inner peripheral surface of the housing main body in a surface thereof excluding the end surface of the opening.

FIG. 1

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## Description

### TECHNICAL FIELD

**[0001]** The present invention relates to a valve opening/closing timing control device and a production method for a drive side rotational body of the valve opening/closing timing control device including a drive side rotational body rotating synchronously with a crankshaft of an internal combustion engine and a driven side rotational body arranged at an inner peripheral side of the drive side rotational body to be coaxial therewith and rotating integrally with a camshaft for opening and closing valves of the internal combustion engine.

### BACKGROUND ART

**[0002]** A valve opening/closing timing control device controls a rotational phase of a driven side rotational body relative to a housing main body constituting a drive side rotational body to thereby change an opening and closing timing of an intake valve or an exhaust valve of an internal combustion engine. At this time, an inner peripheral surface of the housing main body and a partition member, for example, provided at the driven side rotational body slide on each other. At such a sliding portion, a seal member is provided to inhibit oil leakage from a hydraulic chamber within the housing main body. Nevertheless, in a case where the housing main body is formed of metal such as aluminum material, for example, the inner peripheral surface of the housing main body may be easily worn by the sliding with the seal member, for example, which is a cause of oil leakage. Thus, a valve opening/closing timing control device as disclosed in Patent document 1 where a hard layer such as coating of self-lubricating resin and alumite coating, for example, is formed at the inner peripheral surface of the housing main body is proposed.

### DOCUMENT OF PRIOR ART

### PATENT DOCUMENT

**[0003]** Patent document 1: JP2001-132415A

### OVERVIEW OF INVENTION

### PROBLEM TO BE SOLVED BY INVENTION

**[0004]** In the valve opening/closing timing control device in Patent document 1, in order to perform an alumite treatment at an entire surface of the housing main body, an end surface of an opening in addition to the inner peripheral surface is formed with the hard layer. An alumite layer (hard layer) usually grows in a vertical direction relative to a surface of aluminum material. Nevertheless, the growth of the alumite layer at an edge portion formed by the inner peripheral surface and the end surface of the opening is unstable and a surface form of the edge portion may become unevenness. In a case where a cover plate is mounted to the housing main body, the unstable surface form is sandwiched between mating surfaces of the housing main body and the cover plate, which generates a gap therebetween. The gap is a cause of oil leakage from the inside of the housing main body. In addition, the hard layer is difficult to be formed at the edge portion of the end surface of the opening of the housing main body and instability may occur in a direction where the hard layer is formed. Accordingly, the hard layer at the edge portion may be formed thinner relative to the driven side rotational body or formed to protrude from the end surface of the opening of the housing main body. Thus, a gap is generated between the hard layer in the vicinity of the end surface of the opening of the housing main body and the driven side rotational body or between the end surface of the opening and the cover plate.

**[0005]** In addition, a clearance between the driven side rotational body and the cover plate is desirably specified as small as possible within a range not disturbing a sliding movement of the driven side rotational body so as to avoid oil leakage. Nevertheless, in a case where the hard layer is formed at the end surface of the opening of the housing main body and the thickness of the end surface portion of the opening of the housing main body is uneven, setting of the aforementioned clearance is difficult, which leads to deterioration of control responsiveness because of the generation of oil leakage

**[0006]** The object of the present invention is to provide a valve opening/closing timing control device where oil leakage is inhibited from occurring, for example, from a gap between members constituting a drive side rotational body while maintaining lubrication and abrasion resistance of a slide surface of a housing main body.

### MEANS FOR SOLVING PROBLEM

**[0007]** A characteristic construction of a valve opening/closing timing control device according to the present invention for achieving the aforementioned object includes a drive side rotational body including a housing main body that includes an opening which opens to at least one side in a direction along a rotational axis and a cover plate closing the opening by making contact with an end surface of the opening, the drive side rotational body rotating synchronously with a crankshaft, and a driven side rotational body housed within the drive side rotational body and defining an advance chamber and a retardation chamber relative to an inner peripheral surface of the housing main body, the driven side rotational body rotating integrally with a camshaft and coaxially with the rotational axis. In addition, the housing main body includes a hard layer formed at least at the inner peripheral surface of the housing main body in a surface thereof excluding the end surface of the opening.

**[0008]** As in the present construction, in the housing main body of the drive side rotational body, the hard layer

is provided to be formed at the inner peripheral surface via which at least a portion of the driven side rotational body slides relative to the drive side rotational body. Thus, abrasion resistance of the housing main body may improve. Meanwhile, the hard layer is inhibited from being formed at the end surface of the opening of the housing main body so that adhesion properties at a mating portion between the end surface of the opening and the cover plate is enhanced at the time of assembly of the drive side rotational body. Thus, leakage of hydraulic oil that fills the advance chamber or the retardation chamber is restrained, which may obtain the valve opening/closing timing control device with improved operation responsiveness.

**[0009]** In the valve opening/closing timing control device according to the present invention, it is favorable that the housing main body is in an annular form and the hard layer at the inner peripheral surface is formed up to the same position as the end surface of the opening in an axis direction of the housing main body.

**[0010]** As in the present construction, in a case where the hard layer at the inner peripheral surface is formed up to the same position as the end surface of the opening in the axis direction of the housing main body, a pressure-receiving area of the hard layer relative to a partition portion provided at the driven side rotational body increases, which increases the abrasion resistance of the hard layer. In addition, because the partition portion of the driven side rotational body makes contact with the hard layer which is formed up to the same position as the end surface of the opening, the leakage of hydraulic oil may be restrained.

**[0011]** A characteristic measure of a production method for a drive side rotational body of a valve opening/closing timing control device according to the present invention, the valve opening/closing timing control device including a drive side rotational body including at least one housing main body that includes an opening which opens to at least one side in a direction along a rotational axis and a cover plate closing the opening by making contact with an end surface of the opening, the drive side rotational body rotating synchronously with a crankshaft, and a driven side rotational body housed within the drive side rotational body and defining an advance chamber and a retardation chamber relative to an inner peripheral surface of the housing main body, the driven side rotational body rotating integrally with a camshaft and coaxially with the rotational axis, the characteristic measure of the production method includes forming a hard layer at least at the inner peripheral surface of the housing main body in a region thereof excluding the end surface of the opening.

**[0012]** According to the present production method, when forming the housing main body of the drive side rotational body, the hard layer is formed at the inner peripheral surface of the housing main body, for example, to thereby enhance the abrasion resistance of the housing main body. Meanwhile, in the present embodiment, the end surface of the opening is covered at the time of forming the hard layer at the inner peripheral surface of the housing main body. Thus, the hard layer is inhibited from being formed at the end surface of the opening of the housing main body. Accordingly, the adhesion properties between the end surface of the opening and the cover plate are enhanced. The leakage of hydraulic oil that fills the advance chamber or the retardation chamber is restrained, which obtains the valve opening/closing timing control device with the improved operation responsiveness. In addition, it is not required to perform a specific process on the end surface of the opening after a hardening process of the inner peripheral surface is completed. Thus, the housing main body including an expected performance may be effectively obtained.

**[0013]** In the production method for the drive side rotational body of the valve opening/closing timing control device according to the present invention, the housing main body is made of an aluminum material and the end surface of the opening of the housing main body is covered by a rubber member constituted by at least two types of rubber materials including different hardness. The rubber material including a high hardness in the rubber member is disposed at a portion making contact with an edge portion of the end surface of the opening in a vicinity of the inner peripheral surface of the housing main body among edge portions of the end surface of the opening.

**[0014]** In a case where the housing main body is made of the aluminum material, an alumite process is often used as a hardening process of the aluminum material. In the present embodiment, the alumite process is performed on the inner peripheral surface of the housing main body while not being performed on the end surface of the opening at which the cover plate is mounted. Accordingly, while the abrasion resistance of the housing main body is enhanced, the leakage of hydraulic oil is restrained. However, in doing so, a sound alumite layer is necessarily formed up to a boundary position of the inner peripheral surface relative to the end surface of the opening specifically by the alumite process performed on the inner peripheral surface of the housing main body.

**[0015]** Therefore, in the present production method, the rubber material including a high hardness is used to make contact with the edge portion of the end surface of the opening in the rubber member that covers the end surface of the opening of the housing main body. The rubber material including a low hardness is used to a portion facing other than the edge portion in the end surface of the opening of the housing main body. In a case where the aforementioned rubber member is pressed against the end surface of the opening, the rubber member is comparatively compressively deformed and the rubber member that protrudes from the edge portion of the end surface of the opening is pushed out to a center side of the inner peripheral surface. In the present embodiment, the rubber member at the aforementioned portion includes a high hardness so that such push-out of the rubber material may be reduced. Accordingly, the alumite layer (hard layer) may soundly grow to the bound-

ary position of the inner peripheral surface relative to the end surface of the opening.

**[0016]** In the production method for the drive side rotational body of the valve opening/closing timing control device according to the present invention, the hard layer is formed at least at an inner peripheral surface of a cylinder body among the inner peripheral surface and an outer peripheral surface of the cylinder body. The cylinder body is cut along a cutting-plane line which is specified at the outer peripheral surface depending on a thickness dimension of the housing main body to form the drive side rotational body.

**[0017]** In the present construction, plural housing main bodies where the hard layer is inhibited from being formed at the end surface of the opening may be produced from the cylinder member. The housing main body produced from a portion of the cylinder member in the vicinity of a center thereof includes the end surface of the opening where the hard layer is not formed, only by the cutting along the cutting-plane line. The hard layer formed at the end surface at each side of the opening of the cylinder member may be scraped by performing a cutting process, for example. Accordingly, the housing main body where the hard layer is formed at least at the inner peripheral surface may be effectively produced.

## BRIEF DESCRIPTION OF DRAWINGS

**[0018]**

[Fig. 1] is an entire block diagram illustrating a valve opening/closing timing control device.

[Fig. 2] is a cross-sectional view on arrows II-II in Fig. 1.

[Fig. 3] is a perspective view of a housing main body where a hard layer is formed.

[Fig. 4] is a perspective view of the housing main body and a covering member.

[Fig. 5] is a perspective view of a covering member according to another embodiment.

[Fig. 6] is a partial cross-sectional view illustrating a state where the covering member is provided at the housing main body.

[Fig. 7] is a perspective view of a cylinder member.

## MODE FOR CARRYING OUT THE INVENTION

[Entire configuration]

**[0019]** As illustrated in Fig. 1, a valve opening/closing timing control device includes a housing 1 (example of a drive side rotational body) rotating synchronously with a crankshaft E1 of an engine E and an inner rotor 3 (example of a driven side rotational body) housed within the housing 1 and rotating integrally with a camshaft 2 of the engine E. The housing 1 and the inner rotor 3 are arranged on an identical axis X.

[Housing and rotor]

**[0020]** As illustrated in Figs. 1 and 2, the housing 1 includes a front plate 4 (example of a cover plate) provided at a front side, i.e., at an opposite side from the camshaft 2, a rear plate 5 (example of the cover plate) provided at a rear side, i.e., at a side where the camshaft 2 is provided, and an outer rotor 6 (example of a housing main body) disposed between the front plate 4 and the rear plate 5. A sprocket is formed at an outer peripheral portion of the rear plate 5. The front plate 4, the rear plate 5, and the outer rotor 6 are fixed together by a screw. The outer rotor 6 includes an opening 24 (see Fig. 3) that opens to at least one side in a direction along the rotational axis X. The front plate 4 and the rear plate 5 occlude the opening 24 by making contact with respective end surfaces 25 of the opening 24 of the outer rotor 6. The sprocket may not be formed at the outer peripheral portion of the rear plate 5 and may be formed at an outer peripheral portion of the outer rotor 6.

**[0021]** In a case where the crankshaft E1 is driven to rotate, a rotation driving force thereof is transmitted to the rear plate 5 via a power transmission member E2. The outer rotor 6 is then driven to rotate in a rotation direction S (see Fig. 2). In association with the rotational driving of the outer rotor 6, the inner rotor 3 is driven to rotate in the rotation direction S, which causes the camshaft 2 to rotate to thereby press down an intake valve (not illustrated) of the engine by a cam (not illustrated) provided at the camshaft 2.

**[0022]** As illustrated in Fig. 2, plural protruding portions 8 protruding to a radially inner side are formed at an inner peripheral portion of the outer rotor 6. The protruding portions 8 are arranged to be spaced away from one another along the rotation direction S. Plural partition portions 9 protruding to a radially outer side are formed at an outer peripheral portion of the inner rotor 3. The partition portions 9 are arranged to be spaced away from one another along the rotation direction S in the same way as the protruding portions 8. A void between an inner peripheral surface 26 of the outer rotor 6 and the inner rotor 3 is divided into plural hydraulic chambers. The hydraulic chambers are divided into advance chambers 11 and retardation chambers 12 by the partition portions 9. In order to inhibit leakage of engine oil between the advance chambers 11 and the retardation chambers 12, seal members SE are provided at positions at the protruding portions 8 facing an outer peripheral surface of the inner rotor 3 and at positions at the partition portions 9 facing an inner peripheral surface of the outer rotor 6.

**[0023]** The outer rotor 6 is formed of sintered metal of stainless, iron, copper alloy and the like, aluminum, or aluminum alloy, for example. In the outer rotor 6, as illustrated in Fig. 3, a hard layer 30 is formed at the inner peripheral surface 26 in the surface of the outer rotor 6 excluding the end surfaces 25 of the opening 24.

**[0024]** The hard layer 30 is formed of fluorine resin such as polytetrafluoroethylene resin (PTFE), for exam-

ple, or hard resin such as polyphenylene sulfide resin (PPS), polyimide resin (PI), polyamide-imide resin (PAI), polyamide resin (PA), fully aromatic polyester resin (ARPES), polyether ketone resin (PEK), and polyetherether ketone resin (PEEK), for example. As a formation method of the hard layer 30, an electrostatic powder coating process, a derivative coating process, a fluidization dip coating process, a spray coating process, a brushing process or the like may be employed. The outer rotor 6 may be formed of aluminum material and an alumite layer may be formed as the hard layer 30 at the inner peripheral surface 26.

**[0025]** Accordingly, the hard layer 30 formed at least at the inner peripheral surface 26 in the outer rotor 6 is provided to thereby enhance abrasion resistance of the outer rotor 6 in a case where a portion of the inner rotor 3 slides on the outer rotor 6. Meanwhile, the hard layer 30 is inhibited from being formed at the end surfaces 25 of the opening 24 of the outer rotor 6 so that adhesion properties between the end surface 25 of the opening 24 and the front plate 4 are enhanced at the time of assembly of the housing 1. Thus, leakage of hydraulic oil that fills the advance chambers 11 or the retardation chambers 12 is restrained, which may obtain the valve opening/closing timing control device with improved operation responsiveness.

**[0026]** As illustrated in Figs. 1 and 2, an advance passage 13 and a retardation passage 14 are formed at inner portions of the inner rotor 3, a connection member 22 and the camshaft 2. The advance passage 13 connects each of the advance chambers 11 and a supply and discharge mechanism KK which conducts and blocks supply and discharge of engine oil. The retardation passage 14 connects each of the retardation chambers 12 and the supply and discharge mechanism KK.

**[0027]** The supply and discharge mechanism KK includes an oil pan, an oil motor, a fluid control valve OCV which conducts and blocks supply and discharge of engine oil relative to the advance passage 13 and the retardation passage 14, and an electronic control unit ECU controlling an operation of the fluid control valve OCV. By the control of the supply and discharge mechanism KK, a relative rotational phase between the inner rotor 3 and the outer rotor 6 is displaced in an advance direction (direction of an arrow S1 in Fig. 2) or in a retardation direction (direction of an arrow S2 in Fig. 2) or is maintained at any phase.

**[0028]** A lock mechanism RK locks the inner rotor 3 and the outer rotor 6 at a predetermined relative rotational phase. The lock mechanism RK is formed by a lock member 16 including an end portion which is projectable and retractable in the direction along the rotational axis X relative to a recess portion (not illustrated) formed at the rear plate 5, the lock member 16 being provided at one of the partition portions 9 of the inner rotor 3. In addition, a hydraulic chamber (not illustrated) is provided for generating a the surfa to the lock member 16. The aforementioned hydraulic chamber is in communication with the advance passage 13 or the retardation passage 14. According to the aforementioned configuration, the lock mechanism RK is switched to a lock state where the end portion of the lock member 16 enters the recess portion by receiving a biasing force of a biasing member (not illustrated) such as a compression spring, for example. In addition, the lock mechanism RK is switched to a lock release state where the end portion removes from the recess portion towards the inner rotor 3 against the biasing force of the biasing member.

[Production method of housing (drive side rotational body)]

**[0029]** For example, in a case where the outer rotor 6 (example of the housing main body) constituting the housing 1 is formed of aluminum material, the alumite treatment is performed on the inner peripheral surface 26 to form the hard layer 30. In order to form such the hard layer 30, first, the end surfaces 25, 25 at opposed sides of the opening 24 of the outer rotor 6 are covered by covering members 40, 40 (see Fig. 4). Each of the covering members 40 is formed by a hard rubber member or a copper plate, for example, so as to extend along the opening 24 of the outer rotor 6. The covering member 40 illustrated in Fig. 4 includes substantially the same configuration as the end surface 25 of the opening 24 of the outer rotor 6, however, any configuration of the covering member 40 is acceptable as long as the covering member 40 fully covers the end surface 25 of the opening 24 of the outer rotor 6.

**[0030]** After the end surfaces 25, 25 of the opening 24 are covered by the covering members 40, 40 (see Fig. 4), the hard layer 30 is formed at least at the inner peripheral surface 26 in a region of the surface of the outer rotor 6 excluding the end surfaces 25 of the opening 24. As for the alumite treatment, a general method is employed except for the usage of the covering members 40, 40. The hard layer 30 may be formed at an outer peripheral surface 27 along with the inner peripheral surface 26, instead of being formed only at the inner peripheral surface 26. After the hard layer 30 is formed at the outer rotor 6, each of the covering members 40 is removed from each of the end surfaces 25 of the opening 24 so that the front plate 4 and the rear plate 5 are mounted to the end surfaces 25, 25 of the opening 24 to complete the housing 1.

**[0031]** In the housing 1, if the outer rotor 6 and one of the front plate 4 and the rear plate 5 are integrally formed, the covering member 40 is arranged only at the end surface 25 at one side of the opening 24.

**[0032]** Accordingly, the hard layer 30 is formed at the inner peripheral surface 26 of the outer rotor 6 to thereby improve the abrasion resistance of the outer rotor 6. Meanwhile, the hard layer 30 is inhibited from being formed at the end surfaces 25 of the opening 24 of the outer rotor 6. Thus, in a case where the front plate 4 is mounted to the end surface 25 of the opening 24 of the

outer rotor 6, the front surface of the end surface 25 of the opening 24 is likely to make close contact with the front plate 4. As a result, leakage of hydraulic oil that fills the advance chambers 11 or the retardation chambers 12 is restrained, which obtains the valve opening/closing timing control device with the improved operation responsiveness.

**[0033]** In addition, in the present production method, the end surfaces 25 of the opening 24 are covered at the time of forming the hard layer 30 at the inner peripheral surface 26. Thus, it is not required to perform a specific process on the end surfaces 25 of the opening 24 after the hardening process of the inner peripheral surface 26 is completed. Thus, the housing member including an expected performance may be effectively obtained.

**[0034]** In order to bring the hard layer 30 formed at the inner peripheral surface 26 to securely make contact with a portion of the inner rotor 3 over the entire width thereof, the sound alumite layer (hard layer) 30 is necessarily formed up to a boundary position relative to each of the end surfaces 25 of the opening 24. Nevertheless, in a case where the rubber member (example of the covering member) 40 is pressed against the end surface 25 of the opening 24 of the outer rotor 6, for example, the rubber member 40 is comparatively compressively deformed. A portion of the rubber member 40 protruding from an edge portion 25a of the end surface 25 of the opening 24 is pushed out to a center side of the inner peripheral surface 26. In a case where such push-out of the rubber member 40 increases, a void where the alumite layer (hard layer) 30 should grow is blocked by the rubber member 40 at the boundary position of the inner peripheral surface 26 relative to the end surface 25 of the opening 24, which makes the sound alumite layer (hard layer) 30 difficult to be formed.

**[0035]** Then, as illustrated in Figs. 5 and 6, the rubber member 40 covering each of the end surfaces 25 of the opening 24 is constituted by two difference types of rubber materials 41 and 42 including different hardness. In the rubber member 40, the rubber material 41 including a high hardness is disposed at a portion making contact with the edge portion 25a in the vicinity of the inner peripheral surface 26 of the outer rotor 6 among edge portions of the end surface 25 of the opening 24 and the rubber material 42 including a low hardness is disposed at a portion facing other than the edge portion 25a of the end surface 25 of the opening 24.

**[0036]** As mentioned above, in the rubber member 40, the rubber material 41 that makes contact with the edge portion 25a of the end surface 25 of the opening 24 includes a high hardness to thereby reduce the push-out of the rubber material 41 to the center side of the inner peripheral surface 26. Accordingly, the alumite layer (hard layer) 30 may grow soundly up to the boundary position of the inner peripheral surface 26 relative to the end surface 25 of the opening 24 in the inner peripheral surface 26. The improved hard layer 30 may be formed at the inner peripheral surface 26 of the outer rotor 6 over the direction of the rotational axis X.

**[0037]** That is, the hard layer 30 at the inner peripheral surface 26 is formed up to the same position as the end surface 25 of the opening 24 in the axis direction of the outer rotor 6. Accordingly, a pressure-receiving area of the hard layer 30 relative to the partition portion 9 of the inner rotor 3 increases, which increases the abrasion resistance of the hard layer 30. In addition, because the partition portion 9 of the inner rotor 3 makes contact with the hard layer 30 which is formed up to the same position as the end surface 25 of the opening 24, leakage of hydraulic oil may be restrained.

[Another embodiment]

**[0038]**

(1) In the aforementioned embodiment, an example where the end surfaces 25 of the opening 24 of the single outer rotor 6 are covered by the covering members 40 is explained. As illustrated in Fig. 7, plural outer rotors 6 may be produced by using an elongated cylinder member 60. The cylinder member 60 may be formed by extrusion molding, for example. Plural cutting-plane lines C are provided at an outer peripheral surface of the cylinder member 60. The cutting-plane lines C are specified depending on a thickness dimension along the axis direction of the outer rotor 6. In order to produce the outer rotors 6, the hard layer 30 is formed at only the inner peripheral surface 26 of the cylinder member 60 or at both the inner peripheral surface 26 and the outer peripheral surface 27, and thereafter the cylinder member 60 is cut along the cutting-plane lines C. The hard layer formed at the end surface 25 at each end of the opening 24 of the cylinder member 60 is scraped by performing a cutting process.
Accordingly, the plural outer rotors 6 at each of which the hard layer 30 is inhibited from being formed at the end surface 25 of the opening 24 may be produced from the cylinder member 60. The outer rotor 6 that is produced from a portion of the cylinder member 60 in the vicinity of a center thereof includes the end surfaces 25 of the opening 24 where the hard layer 30 is not formed, only by the cutting along the cutting-plane lines C. Accordingly, the plural outer rotors 6 may be manufactured by covering the end surfaces 25 at the opposed sides of the opening 24 of the cylinder member 60, which leads to an effective production of the outer rotors 6.
(2) In the aforementioned embodiment, an example where the housing 1 is constituted by three members of the outer rotor 6, the front plate 4 and the rear plate 5 is explained. Alternatively, the housing 1 may be constituted by the outer rotor 6 at which one of the front plate 4 and the rear plate 5 is integrally formed.
(3) In the aforementioned embodiment, an example

where the rubber member 40 is constituted by two types of the rubber materials 41 and 42 including the different hardness is explained. Alternatively, the rubber member 40 may be constituted by three or more than three types of rubber materials including different hardness as long as the push-out of the rubber material to the center side of the inner peripheral surface 26 from the end surface 25 of the opening 24 is reduced.

INDUSTRIAL AVAILABILITY

**[0039]** The present invention is applicable to a valve opening/closing timing control device of an internal combustion engine for an automobile or others.

EXPLANATION OF REFERENCE NUMERALS

**[0040]**

| | |
|---|---|
| 1 | housing (drive side rotational body) |
| 2 | camshaft |
| 3 | inner rotor (driven side rotational body) |
| 4 | front plate (cover plate) |
| 5 | rear plate (cover plate) |
| 6 | outer rotor (housing main body) |
| 11 | advance chamber |
| 12 | retardation chamber |
| 24 | opening |
| 25 | end surface |
| 25a | edge portion |
| 26 | inner peripheral surface |
| 30 | hard layer |
| 40 | covering member |
| 41 | rubber material including high hardness |
| 42 | rubber material including low hardness |
| 60 | cylinder member |
| X | rotational axis |

**Claims**

**1.** A valve opening/closing timing control device comprising:

a drive side rotational body including a housing main body that includes an opening which opens to at least one side in a direction along a rotational axis and a cover plate closing the opening by making contact with an end surface of the opening, the drive side rotational body rotating synchronously with a crankshaft; and
a driven side rotational body housed within the drive side rotational body and defining an advance chamber and a retardation chamber relative to an inner peripheral surface of the housing main body, the driven side rotational body rotating integrally with a camshaft and coaxially with the rotational axis, wherein
the housing main body includes a hard layer formed at least at the inner peripheral surface of the housing main body in a surface thereof excluding the end surface of the opening.

**2.** The valve opening/closing timing control device according to claim 1, wherein the housing main body is in an annular form and the hard layer at the inner peripheral surface is formed up to the same position as the end surface of the opening in an axis direction of the housing main body.

**3.** A production method for a drive side rotational body of a valve opening/closing timing control device, the valve opening/closing timing control device including:

a drive side rotational body including at least one housing main body that includes an opening which opens to at least one side in a direction along a rotational axis and a cover plate closing the opening by making contact with an end surface of the opening, the drive side rotational body rotating synchronously with a crankshaft; and
a driven side rotational body housed within the drive side rotational body and defining an advance chamber and a retardation chamber relative to an inner peripheral surface of the housing main body, the driven side rotational body rotating integrally with a camshaft and coaxially with the rotational axis,

the production method comprising forming a hard layer at least at the inner peripheral surface of the housing main body in a region thereof excluding the end surface of the opening.

**4.** The production method for the drive side rotational body according to claim 3, wherein
the housing main body is made of an aluminum material and the end surface of the opening of the housing main body is covered by a rubber member constituted by at least two types of rubber materials including different hardness,
the rubber material including a high hardness in the rubber member is disposed at a portion making contact with an edge portion of the end surface of the opening in a vicinity of the inner peripheral surface of the housing main body among edge portions of the end surface of the opening.

**5.** The production method for the drive side rotational body according to claim 3, wherein the hard layer is formed at least at an inner peripheral surface of a cylinder body among the inner peripheral surface and an outer peripheral surface of the cylinder body,

the cylinder body is cut along a cutting-plane line which is specified at the outer peripheral surface depending on a thickness dimension of the housing main body to form the drive side rotational body.

FIG. 1

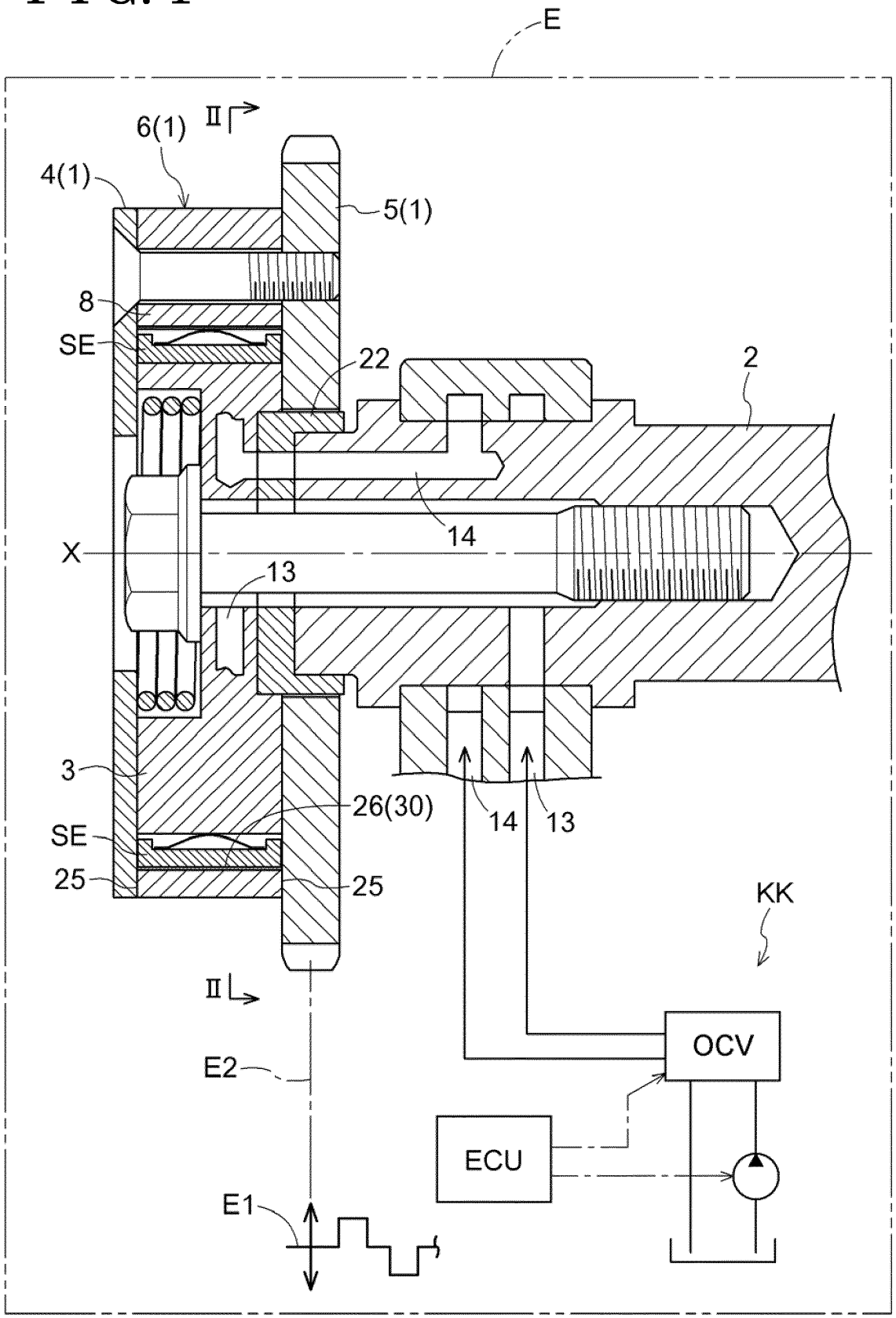
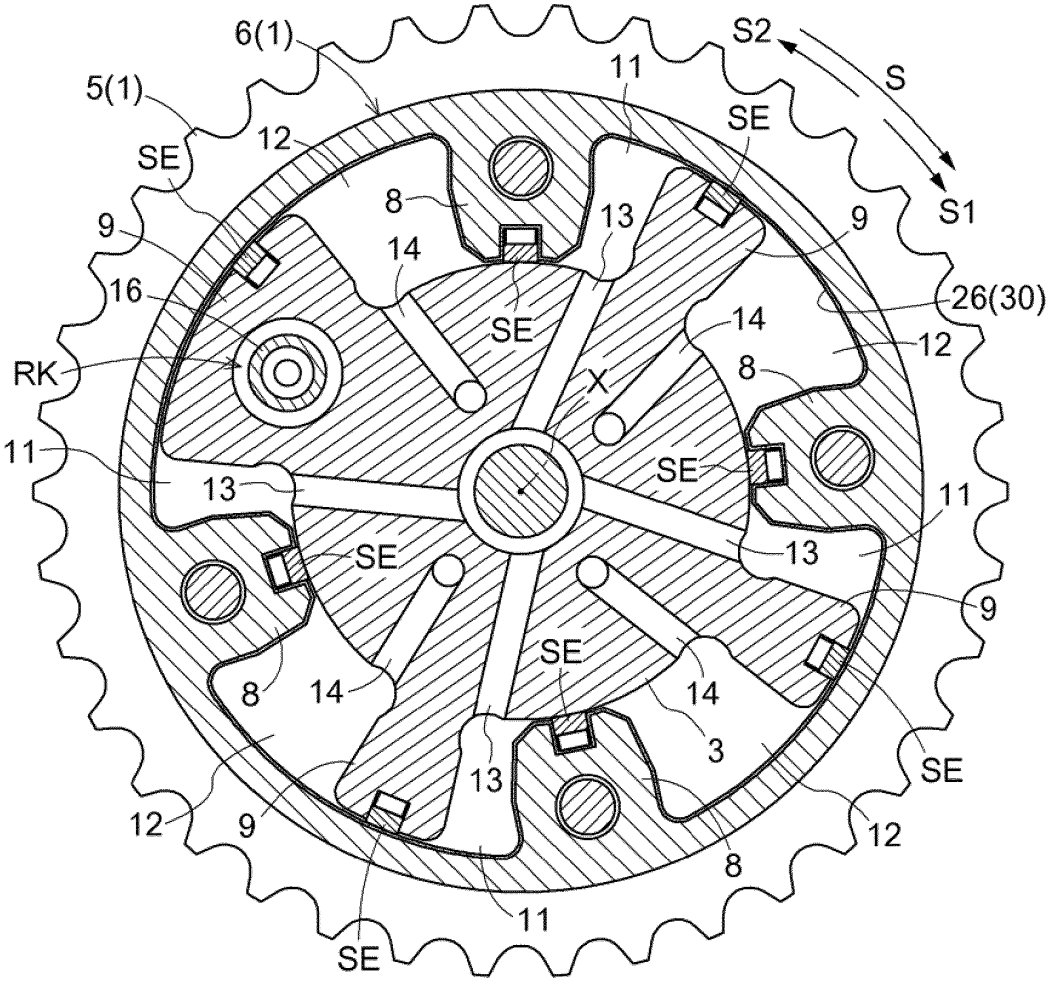


FIG. 2


6(1)
5(1)
SE
12
11
S2
S
S1
SE
8
13
9
14
16
SE
26(30)
14
RK
12
X
8
11
13
SE
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SE
8
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12
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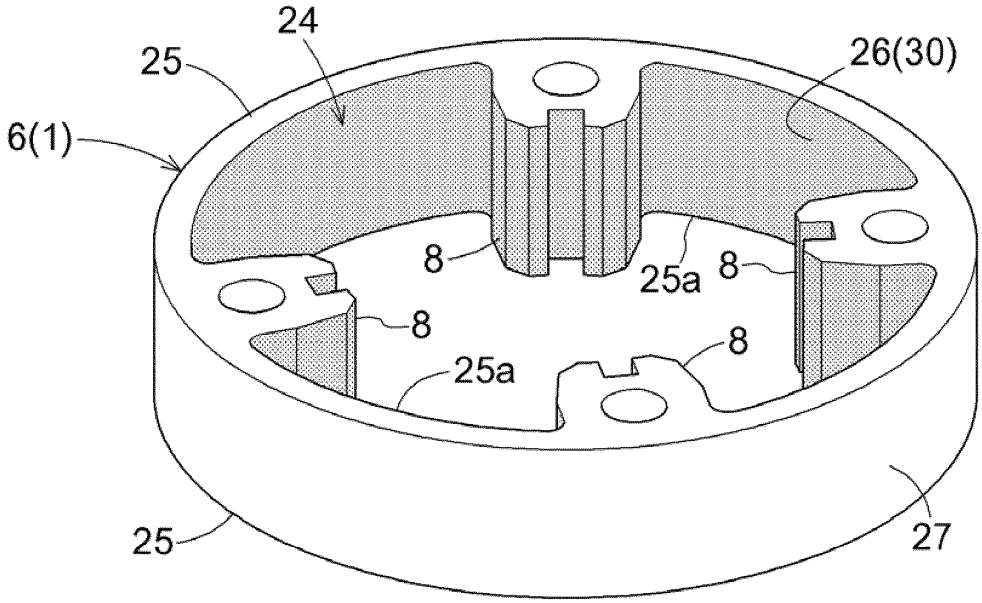
11
SE

FIG. 3


24
25
26(30)
6(1)
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25a
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25a
25
27

FIG. 4

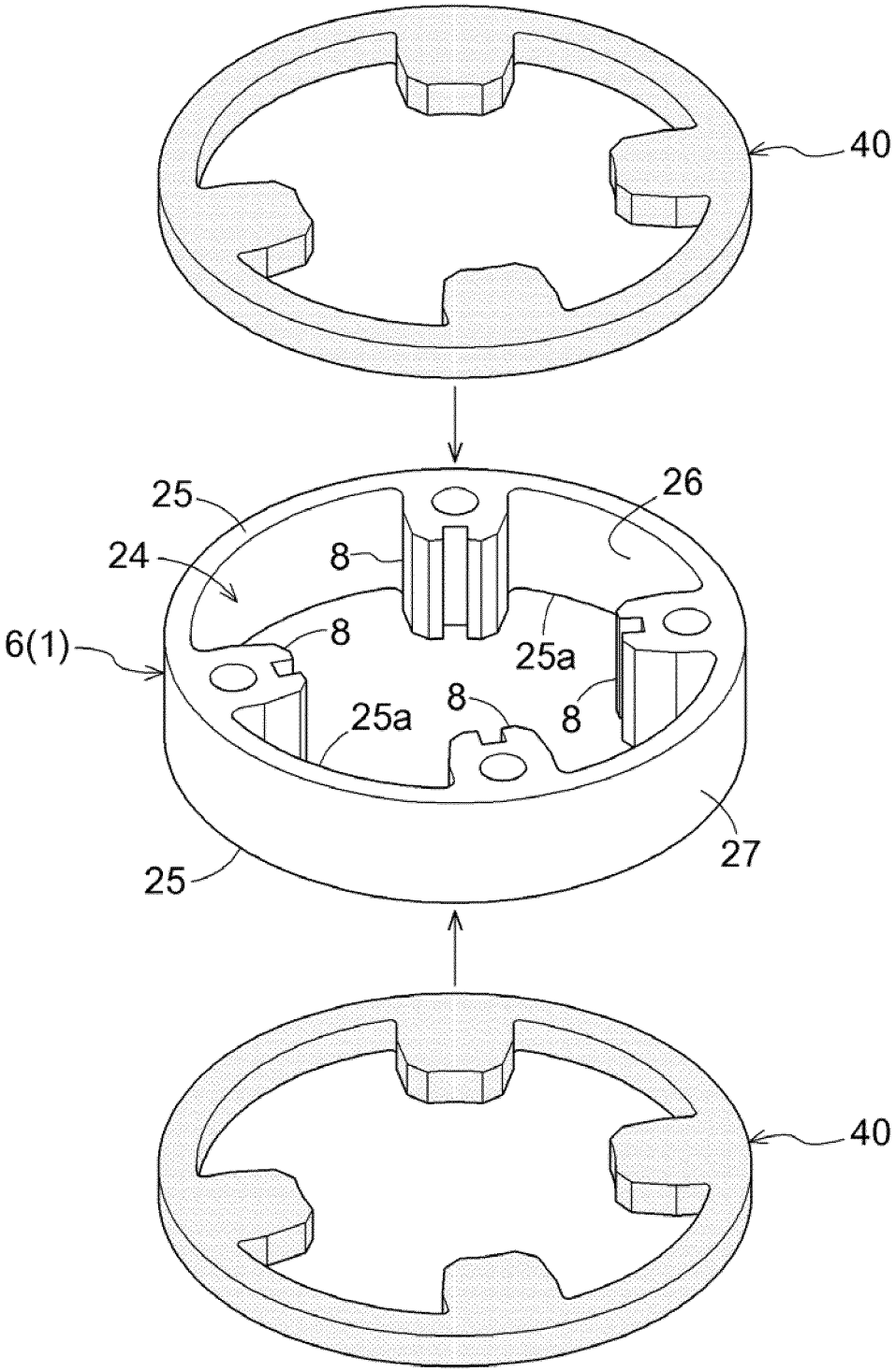


FIG. 5

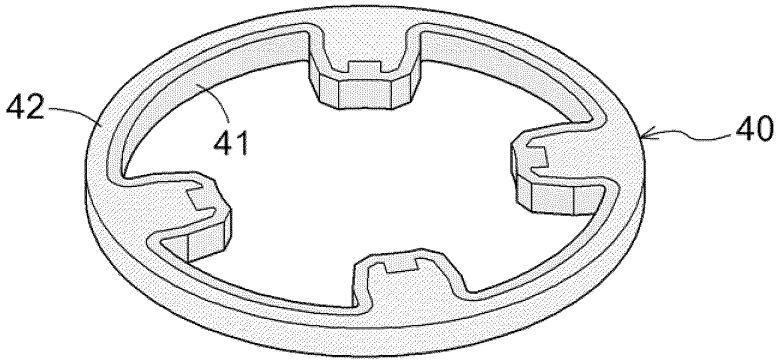



FIG. 6

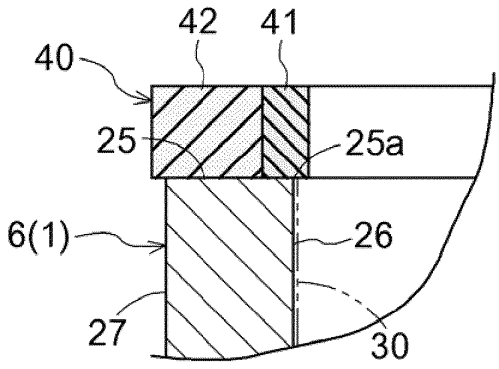
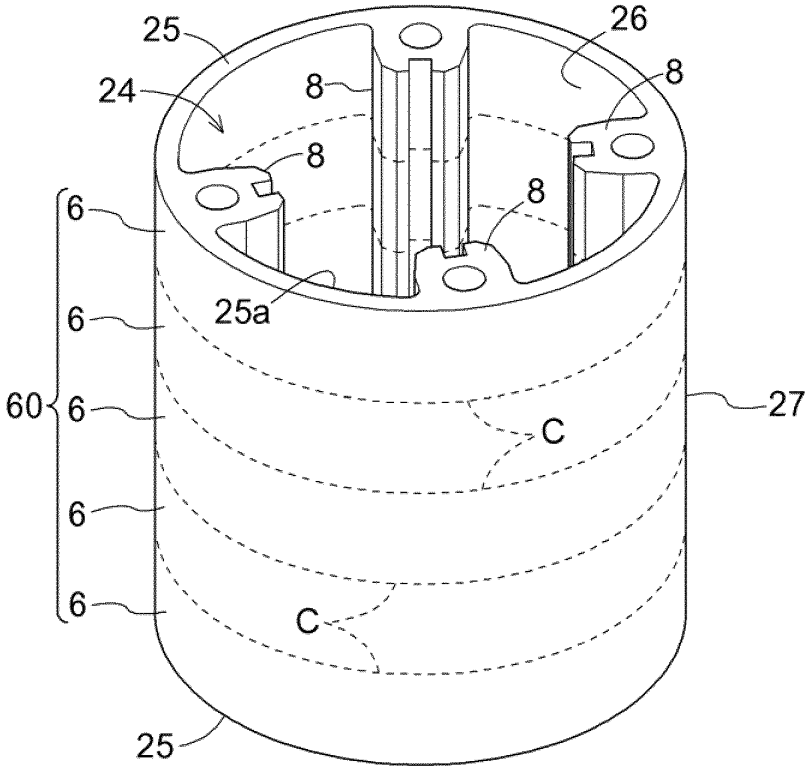



FIG. 7



**INTERNATIONAL SEARCH REPORT**

International application No.
PCT/JP2014/056960

A. CLASSIFICATION OF SUBJECT MATTER
*F01L1/356*(2006.01)i, *C25D11/04*(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
F01L1/356, C25D11/04

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Jitsuyo Shinan Koho 1922-1996 Jitsuyo Shinan Toroku Koho 1996-2014
Kokai Jitsuyo Shinan Koho 1971-2014 Toroku Jitsuyo Shinan Koho 1994-2014

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
| X<br>A | JP 2013-19418 A (Hitachi Automotive Systems, Ltd.), 31 January 2013 (31.01.2013), paragraphs [0015], [0053] (Family: none) | 1-3,5<br>4 |
| X<br>A | JP 2010-196674 A (Hitachi Automotive Systems, Ltd.), 09 September 2010 (09.09.2010), paragraphs [0017], [0194] & US 2010/0218736 A1 & US 2012/0192819 A1 | 1-3,5<br>4 |
| A | JP 2010-186157 A (Hoya Corp.), 26 August 2010 (26.08.2010), paragraphs [0023], [0031] (Family: none) | 1-5 |

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| Date of the actual completion of the international search | Date of mailing of the international search report |
|---|---|
| 04 June, 2014 (04.06.14) | 17 June, 2014 (17.06.14) |
| Name and mailing address of the ISA/<br>Japanese Patent Office<br><br>Facsimile No. | Authorized officer<br><br>Telephone No. |

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**INTERNATIONAL SEARCH REPORT**

International application No.
PCT/JP2014/056960

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
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| A | JP 9-292729 A (Mitsubishi Chemical Corp.), 11 November 1997 (11.11.1997), paragraphs [0010] to [0014], [0019] (Family: none) | 1-5 |

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## REFERENCES CITED IN THE DESCRIPTION

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