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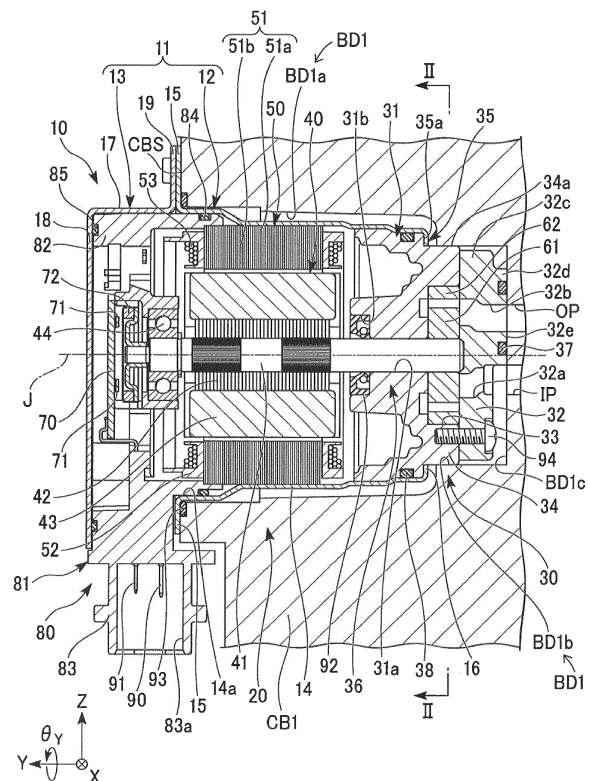
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**(54) PUMP DEVICE COMPRISING A MOTOR PORTION AND A PUMP PORTION WITH A HOUSING**

(57) One exemplary embodiment of the present disclosure is a pump device (10, 110, 210, 310) comprising a motor portion (20), a pump portion (30, 130, 230, 330) and a housing (12). The pump portion (30, 130, 230, 330) has an inner rotor (61), an outer rotor (62), a pump body (31, 131, 231, 331) and a pump cover (32). The pump body (31, 131, 231, 331) has a pump chamber (33) which is recessed from a surface on one axial side toward the other axial side and accommodates the inner rotor (61) and the outer rotor (62), and a through-hole (31a) which axially penetrates through the pump body (31, 131, 231, 331) and through which a shaft (41) passes. The pump cover (32) has an inlet (32a) and an outlet (32b) which are in communication with the pump chamber (33). The housing (12) has a tube portion (14) which covers at least a radially outer side of a stator (50) and a flange portion (15) which extends radially outward from an end portion on the other axial side of the tube portion (14). The pump body (31, 131, 231, 331) has an exposure portion (34, 134, 234, 334) which is disposed on one axial side from the tube portion (14) and exposed outside the housing (12). The exposure portion (34, 134, 234, 334) has an outer circumferential surface (34a, 134a, 234a, 334a) which surrounds a radially outer side of a center axis (J).



**Fig.1**

## Description

### Field of the Disclosure

**[0001]** The present disclosure relates to a pump device.

### Description of the Related Art

**[0002]** In the past, an electric pump has been mounted on an automatic transmission (for example, JP Patent Application Publication No. 2011-94553).

**[0003]** In the above-described electric pump, for example, a portion of the electric pump is inserted into a mounting hole provided on a casing, and a flange portion of a case is fixed to an outer surface of the casing of the automatic transmission. As a result, the electric pump is mounted on the automatic transmission. The electric pump has an inlet port and an outlet port. A hydraulic path is provided to an inner surface of the mounting hole, and the inlet port and the outlet port of the electric pump are connected to the hydraulic path. An O-ring and other elements are provided to a connection point between the inlet port and the hydraulic path, and to a connection point between the outlet port and the hydraulic path.

**[0004]** A vibration of the automatic transmission is delivered to the electric pump through the flange portion. The vibration delivered to the electric pump is propagated being amplified as it goes away from the flange portion. For this reason, the vibration of the automatic transmission is easily delivered to the inlet port and the outlet port connected to the hydraulic path provided on the inner surface of the mounting hole in a greatly amplified manner. Accordingly, the O-ring and other elements provided to the connection point may easily wear out due to friction.

**[0005]** In consideration of the above-described technical problem, one of the objectives of an exemplary embodiment of the present disclosure is to provide a pump device having a structure that is capable of preventing vibration from being delivered to the inlet port and the outlet port.

### Summary of the Disclosure

**[0006]** One embodiment of the present disclosure is a pump device, comprising: a motor portion having a shaft having its center on an axially extending center axis, a rotor which is fixed to the shaft, and a stator which is disposed on a radially outer side of the rotor; a pump portion which is disposed on one axial side of the motor portion, and driven by the motor portion; and a cylindrical housing which holds the motor portion and the pump portion, the pump portion including: an inner rotor which is attached to the shaft; an annular outer rotor which surrounds a radially outer side of the inner rotor; a pump body which accommodates the inner rotor and the outer rotor; and a pump cover which is attached to one axial side of the pump body, wherein the pump body has a

pump chamber which is recessed from a surface on one axial side toward the other axial side, and accommodates the inner rotor and the outer rotor, and a through-hole which axially penetrates through the pump body and through which the shaft passes, the pump cover has an inlet and an outlet which are in communication with the pump chamber, the housing has a tube portion which at least cover a radially outer side of the stator, and a flange portion which extends from an end portion on the other axial side of the tube portion toward a radially outer side, the pump body has an exposure portion which is disposed on one axial side of the tube portion, and exposed to an outside of the housing, and the exposure portion has an outer surface which surrounds a radially outer side of the center axis.

**[0007]** The above and other elements, features, steps, characteristics and advantages of the present disclosure will become more apparent from the following detailed description of the preferred embodiments with reference to the attached drawings.

### Brief Description of the Drawings

**[0008]** Embodiments will now be described, by way of example only, with reference to the accompanying drawings which are meant to be exemplary, not limiting, and wherein like elements are numbered alike in several Figures, in which:

FIG. 1 is a cross-sectional view of a pump device according to the first embodiment.

FIG. 2 illustrates a portion of the pump device according to the first embodiment, and corresponds to a cross-sectional view taken along the II-II line shown in FIG. 1.

FIG. 3 is a cross-sectional view of a portion of another example of the pump device according to the first embodiment.

FIG. 4 is a cross-sectional view of a portion of another example of the pump device according to the first embodiment.

FIG. 5 is a cross-sectional view of a portion of a pump device according to the second embodiment.

FIG. 6 illustrates a portion of the pump device according to the second embodiment, and corresponds to a cross-sectional view taken along the VI-VI line shown in FIG. 5.

### Detailed Description of the Preferred Embodiments

**[0009]** Hereinafter, a pump device according to the preferred embodiments of the present disclosure will be explained with reference to the accompanying drawings. Further, the scope of the present disclosure is not limited to the following embodiments, but may be arbitrarily changed within the scope of the technical spirit of the present disclosure. Further, each structure illustrated in the following drawings may be different in its scale, the

number of members thereof, etc., from those in an actual pump device or members, for better understanding of each component.

**[0010]** In the drawings, an X-Y-Z coordinate system is provided as a suitable three-dimensional orthogonal coordinate system. In the X-Y-Z coordinate system, a direction parallel to the axial direction of a center axis J shown in FIG. 1 is referred to as Y-axis direction. A vertical direction of FIG. 1, that is, a direction orthogonal to the Y-axis direction, is referred to as Z-axis direction. A direction orthogonal to both the Y-axis direction and the Z-axis direction is referred to as X-axis direction.

**[0011]** In the following description, a Z-axis direction that is orthogonal to a direction in which the center axis J extends is referred to as vertical direction. That is, a positive side (+Z side) of the Z-axis direction may be referred to as 'upper side,' and a negative side (-Z side) of the Z-axis may be referred to as 'lower side.' Further, it is to be understood that the descriptions of the vertical direction, the upper side and the lower side are used for explanation only, and they do not limit the actual positional relation or direction.

**[0012]** In the following description, a positive side (+Y side) of the Y-axis direction may be referred to as 'counter-output side (the other axial side),' and a negative side (-Y side) of the Y-axis direction may be referred to as 'output side (one axial side).' Also, unless otherwise explained, a direction parallel to the center axis J (Y-axis direction) may be simply referred to as 'axial direction,' a radial direction having its center on the center axis J may be simply referred to as 'radial direction,' and a circumferential direction ( $\theta_Y$  direction) having its center on the center axis J, that is, the axial circumference of center axis J, may be simply referred to as 'circumferential direction.'

**[0013]** Further, herein, descriptions such as being 'axially extended' do not only refer to a case of strictly being extended in the axial direction, but it may also include a case of being extended in a direction inclined at less than 45° relative to the axial direction. Also, descriptions such as being 'radially extended' do not only refer to a case of strictly being extended in the radial direction, that is, the direction perpendicular to the axial direction, but it may also include a case of being extended in a direction inclined at less than 45° relative to the radial direction.

<First Embodiment>

**[0014]** FIG. 1 is a cross-sectional view of a pump device 10 according to the first embodiment. As shown in FIG. 1, the pump device 10 is fixed to a car body CB1. The car body CB1 is a component of a vehicle. The car body CB1 is not particularly limited, and therefore may be, for example, an automatic transmission.

**[0015]** The pump device 10 includes a case 11, a motor portion 20 and a pump portion 30. The case 11 accommodates the motor portion 20 and the pump portion 30 therein. The case 11 has a housing 12 and a motor cover

13. That is, the pump device 10 includes the housing 12 and the motor cover 13.

**[0016]** In the following description, descriptions such as 'accommodating' a subject do not only refer to a case of strictly accommodating the entire subject, but it may also include a case of partially accommodating a portion of the subject. That is, for example, when it is described that 'the case 11 accommodates both the motor portion 20 and the pump portion 30,' a portion of the motor portion 20 and a portion of the pump portion 30 may still be arranged outside the case 11.

**[0017]** The housing 12 has a cylindrical or substantially cylindrical shape, and holds the motor portion 20 and the pump portion 30 therein. The housing 12 extends in the axial direction (Y-axis direction). The housing 12 is made of, for example, metal. The housing 12 is formed by, for example, press processing. Yet, the housing 12 and a method of forming the housing 12 are not limited to a particular type.

**[0018]** The housing 12 preferably has a housing tube portion 14, a housing flange portion 15 and an extending portion 16. The housing tube portion 14 has a tubular shape, and covers at least a radially outer side of a stator 50, which will be described in detail in a subsequent section. The housing tube portion 14 has, for example, a multi-stepped cylindrical shape having its center on the center axis J. The housing tube portion 14 is open toward both axial sides ( $\pm Y$  side). A diameter of the housing tube portion 14 gradually decreases from the counter-output side (+Y side) toward the output side (-Y side).

**[0019]** The housing flange portion 15 extends radially outward from an end portion on the counter-output side (+Y side) of the housing tube portion 14. The extending portion 16 extends radially inward from an end portion on the output side (-Y side) of the housing tube portion 14.

**[0020]** The motor cover 13 is fixed to the counter-output side (+Y side) of the housing 12. The motor cover 13 preferably has a cover tube portion 17, a lid portion 18 and a cover flange portion 19. The cover tube portion 17 has a tubular shape, and covers a radially outer side of a bus bar unit 80, which will be described in detail in a subsequent section. The lid portion 18 is connected to the counter-output side (+Y side) of the cover tube portion 17. The lid portion 18 has, for example, a planar shape. The lid portion 18 is arranged on the counter-output side from the bus unit 80. The lid portion 18 covers an opening on the counter-output side of a holder main body portion 82, which will be described in detail in a subsequent section.

**[0021]** The cover flange portion 19 extends radially outward from an end portion on the output side (-Y side) of the cover tube portion 17. A surface on the output side of the cover flange portion 19 is in contact with a surface on the counter-output side (+Y side) of the housing flange portion 15. The cover flange portion 19 and the housing flange portion 15 are axially (Y-axis direction) fixed by, for example, caulking. With this, the housing 12 is fixed to the motor cover 13.

**[0022]** The motor portion 20 preferably has a shaft 41, a counter-output side bearing 44, a rotor 40, the stator 50, the bus bar unit 80, a circuit board 70, a rotation sensor 71 and a sensor magnet 72.

**[0023]** The shaft 41 extends along the axially (Y-axis direction) extending center axis J. An end portion on the output side (-Y side) of the shaft 41 extends from the motor portion 20 to the pump portion 30. The shaft 41 is rotatably supported by the counter-output side bearing 44 and a bearing portion 36 of the pump body 31, which will be described in detail in a subsequent section, and rotates around the axis in the circumferential direction ( $\pm\theta_y$  direction).

**[0024]** The counter-output side bearing 44 is arranged on the counter-output side (+Y side) from the stator 50. In this embodiment, the counter-output side bearing 44 is a ball-and-roller bearing. The counter-output side bearing 44 is held by a bus bar holder 81 of the bus bar unit 80, which will be described in detail in a subsequent section. Further, a bearing other than the ball-and-roller type may be used as the counter-output side bearing 44.

**[0025]** The shaft 41 is fixed to the rotor 40. The rotor 40 preferably has a rotor core 42 and a rotor magnet 43. The rotor core 42 preferably has an axially penetrating through-hole and at least a portion of an end portion on the counter-output side (+Y side) of the shaft 41 is arranged in the through-hole. That is, the rotor core 42 surrounds the shaft 41 in the circumferential direction ( $\theta_y$  direction), and the shaft 41 is fixed to the rotor core 42. The rotor magnet 43 is fixed to an outer surface along a circumference of the rotor core 42. The rotor core 42 and the rotor magnet 43 integrally rotate with the shaft 41. Yet, the rotor magnet 43 does not necessarily need to be fixed to an outer surface of the rotor 42. At least a portion of the rotor magnet 43 may be embedded in the rotor core 42.

**[0026]** The stator 50 is arranged on a radially outer side of the rotor 40. The stator 50 preferably has a stator core 51, an insulating member 52 and a coil 53. The stator core 51 preferably has a core back portion 51a and a plurality of teeth portions 51b.

**[0027]** The core back portion 51a has, for example, a cylindrical or substantially cylindrical shape which is concentric with the shaft 41. The core back portion 51a is fixed to an inner circumferential surface of the housing tube portion 14. The plurality of teeth portions 51b extend from an inner surface of the core back portion 51a toward the shaft 41. The plurality of teeth portions 51b is arranged at equal intervals along the circumferential direction. The teeth portions 51b radially face the rotor magnet 43.

**[0028]** The insulating member 52 is provided to each of the teeth portions 51b. The coil 53 is provided to each of the teeth portions via the insulating member 52. The coil 53 is formed by winding up an electrically conductive wire.

**[0029]** The bus bar unit 80 is arranged on the counter-output side (+Y side) of the stator 50. The bus bar unit

80 preferably has the bus bar holder 81, a phase bus bar 90 and a sensor bus bar 91.

**[0030]** The bus bar holder 81 holds the phase bus bar 90 and the sensor bus bar 91. The bus bar holder 81 preferably has a holder main body portion 82 and a connector portion 83. The holder main body portion 82 has a cylindrical or substantially cylindrical shape that is concentric with the shaft 41. The holder main body portion 82 is arranged on an opening 14a on the counter-output (+Y side) of the housing tube portion 14. An end portion on the output side (-Y side) of the holder main body portion 82 is arranged on a radially inner side of the housing tube portion 14. An O-ring 84 is arranged between the holder main body portion 82 and the housing tube portion 14. That is, the O-ring 84 covers the entire circumference of a radial gap between the housing main body portion 82 and the housing tube portion 14 in the circumferential direction.

**[0031]** An opening on the counter-output side (+Y side) of the holder main body portion 82 is closed up by the lid portion 18. An O-ring 85 is arranged between a surface on the counter-output side of the holder main body portion 82 and the lid portion 18. The O-ring 85 covers the entire circumference of an opening on the counter-output side of the holder main body portion 82 in the circumferential direction.

**[0032]** The holder main body portion 82 has a holding portion at the center portion thereof, for holding the counter-output side bearing 44. The connector portion 83 protrudes radially outward from the holder main body portion 82. As shown in FIG. 1, the connector portion 83 protrudes downward (-Z side) from the holder main body portion 82. The connector portion 83 has a connector concave portion 83a which is open toward the lower side and recessed toward the upper side. The connector portion 83 is connected to an outside power supply which is not illustrated in the drawings.

**[0033]** The phase bus bar 90 is electrically connected to the coil 53. The sensor bus bar 91 is electrically connected to the circuit board 70. One end of the phase bus bar 90 and one end of the sensor bus bar 91 protrude downward (-Z side) from a bottom surface of the connector concave portion 83a.

**[0034]** The circuit board 70 is fixed to the holder main body portion 82. The circuit board 70 is accommodated on a radially inner side of the holder main body portion 82. As shown in FIG. 1, a substrate surface of the circuit board 70 is orthogonal to the axial direction (Y-axis direction). Yet, the substrate surface of the circuit board 70 does not necessarily need to be orthogonal to the axial direction (Y-axis direction).

**[0035]** The rotation sensor 71 is attached to a surface on the output side (-Y side) of the circuit board 70. The rotation sensor 71 is, for example, a hall element. The rotation sensor 71 axially (Y-axis direction) faces the sensor magnet 72. Yet, a sensor other than the hall element type may be used as the rotation sensor 71.

**[0036]** The sensor magnet 72 is fixed to the shaft 41.

As shown in FIG. 1, the sensor magnet 72 is fixed to an outer circumferential surface of an end portion on the counter-output side (+Y side) of the shaft 41 via a mounting member. The sensor magnet 72 has, for example, an annular or substantially annular shape. Magnetic poles of the sensor magnet 72 are provided such that N-poles and S-poles are alternately arranged along the circumferential direction.

**[0037]** The pump portion 30 is arranged on the output side (-Y side) of the motor portion 20. The pump portion 30 is driven by the motor portion 20. The pump portion 30 preferably has a pump body 31, a pump cover 32, an inner rotor 61 and an outer rotor 62.

**[0038]** The pump body 31 is fixed on an inner surface of the housing tube portion 14. The pump body 31 is made of, for example, metal. The pump body 31 is formed by, for example, cutting work. The pump body 31 preferably has a pump chamber 33, an oil seal holding portion 31b, a through-hole 31a, a bearing portion 36 and an exposure portion 34. Yet, the pump body 31 may be made of a material other than metal, and may be formed by a processing method other than cutting work.

**[0039]** The pump chamber 33 is recessed from a surface on the output side (-Y side) of the pump body 31 toward the counter-output side (+Y side). The pump chamber 33 accommodates the inner rotor 61 and the outer rotor 62 on an inner side thereof. That is, the pump body 31 accommodates the inner rotor 61 and the outer rotor 62. The output side (-Y side) of the pump chamber 33 is closed by the pump cover 32.

**[0040]** FIG. 2 illustrates a portion of the pump device 10 in this embodiment, and corresponds to a cross-sectional view taken along II-II shown in FIG. 1. The shaft 41, the inner rotor 61 and the outer rotor 62 is not illustrated in FIG. 2. As shown in FIG. 2, when seen in the axial direction (Y-axis direction), an opening portion of the pump chamber 33 has a circular or substantially circular shape. As shown in FIG. 2, the center axis J passes through the center of the pump chamber 33. Further, when seen in the axial direction, the opening portion of the pump chamber 33 does not necessarily need to have a circular shape, and it may have other shapes such as a polygonal shape, or the like.

**[0041]** As shown in FIG. 1, the oil seal holding portion 31b is recessed from a surface on the counter-output side (+Y side) of the pump body 31 toward the output side (-Y side). An oil seal 92 is held in the oil seal holding chamber 31b. The oil seal 92 prevents oil that is introduced into the oil seal holding portion 31b from the pump chamber 33 via the through-hole 31a from advancing into the motor portion 20.

**[0042]** The through-hole 31a axially (Y-axis direction) penetrates the pump body 31. The shaft 41 passes through the through-hole 31a. An end portion on the counter-output side (+Y side) of the through-hole 31a is open toward the oil seal holding portion 31b. An end portion on the output side (-Y side) of the through-hole 31a is open toward the pump chamber 33. As shown in FIG.

2, when seen in the axial direction, an opening edge of the through-hole 31a has, for example, a circular or substantially circular shape that is concentric with the pump chamber 33. Yet, when seen in the axial direction, the opening edge of the through-hole 31a does not necessarily need to have a circular shape.

**[0043]** As shown in FIG. 1, the bearing portion 36 supports the shaft 41. In this embodiment, the bearing portion 36 is a slide bearing. As shown in FIG. 1, the bearing portion 36 is an inner wall portion of the through-hole 31a. Yet, a bearing other than the slide bearing type may be used as the bearing portion 36.

**[0044]** The exposure portion 34 is arranged on the output side (-Y side) from the housing tube portion 14. The exposure portion 34 is exposed outside the housing 12. As shown in FIG. 1 and FIG. 2, the exposure portion 34 has an axially extending (Y-axis direction) columnar shape. The exposure portion 34 has an outer circumferential surface 34a which surrounds a radially outer side of the center axis J. In this embodiment, the outer circumferential surface 34a is provided, for example, to surround the entire circumference of the exposure portion in the circumferential direction.

**[0045]** Further, herein, descriptions such as 'an outer circumferential surface surrounding a radially outer side of the center axis' do not only strictly refer to a case in which the outer circumferential surface surrounds the entire circumference, but it may include a case, for example, in which the outer circumferential surface is provided only to a circumferential portion thereof. When the outer circumferential surface is provided only to a circumferential portion thereof, it may also include a case, for example, in which a plurality of exposure portions is arranged in the circumferential direction, and each corresponding outer circumferential surface surrounds a radially outer side of the center axis, and the like.

**[0046]** Also, herein, descriptions such as 'the exposure portion having a columnar shape' may include a case of having a substantially columnar shape. The description of 'a substantially columnar shape' includes, for example, a columnar shape with a cut-off portion, a columnar shape having a partially protruding portion, and the like.

**[0047]** In this embodiment, the exposure portion 34 radially overlaps with the pump chamber 33. As shown in FIG. 2, the outer circumferential surface 34a of the exposure portion 34 has a pump body side concave portion 34b which is recessed radially inward. The pump body side concave portion 34b axially extends on the outer circumferential surface 34a. When seen in the axial direction (Y-axis direction), an opening of the pump body side concave portion 34b has a rectangular or substantially rectangular shape. The pump body side concave portion 34b is provided to the exposure portion 34, for example, throughout the entire axial direction. Yet, when seen in the axial direction (Y-axis direction), the opening of the body pump side concave portion 34b is not necessarily limited to a rectangular shape.

**[0048]** As shown in FIG. 1, in this embodiment, pump

body 31 has a stepped portion 35 where a radial dimension becomes smaller toward the output side (-Y side). The stepped portion 35 has a stepped surface 35a which intersects the axial direction (Y-axis direction). The stepped surface 35a is in contact with the extending portion 16. Specifically, the stepped surface 35a is in contact with a surface on the counter-output side (+Y side) of the extending portion 16. With this, it is possible to determine the axial position of the pump body 31 relative to the housing 12.

**[0049]** In the pump body 31, a portion on the counter-output side (+Y side) from the stepped portion 35a is fixed inside the housing tube portion 14 by press-fitting, or the like. The portion on the counter-output side (+Y side) from the stepped portion 35a of the pump body 31 (that is, the exposure portion 34) protrudes to the output side from the housing tube portion 14.

**[0050]** An O-ring 38 is arranged in a radial between the pump body 31 and the housing tube portion 14, and covers the entire circumference of the gap in the circumferential direction.

**[0051]** The shaft 41 is attached to the inner rotor 61. Specifically, an end portion on the output side (-Y side) of the shaft 41 is fixed to the inner rotor 61. The inner rotor 61 is accommodated inside the pump chamber 33. The inner rotor 61 rotates around the center axis J ( $\pm \theta_Y$  direction) with the rotation of the shaft 41.

**[0052]** The outer rotor 62 has an annular or substantially annular shape, and surrounds a radially outer side of the inner rotor 61. The outer rotor 62 is accommodated inside the pump chamber 33. The outer rotor 62 and the inner rotor 61 are engaged with each other. For this reason, the outer rotor 62 rotates with the rotation of the inner rotor 61. A rotary axis of the outer rotor 62 is a different axis from the center axis J that is, for example, parallel with the center axis J.

**[0053]** The pump cover 32 is attached to the output side (-Y side) of the pump body 31. In this embodiment, the pump cover 32 is fixed to a surface on the output side of the exposure portion 34 of the pump body 31 by a screw 94. The pump cover 32 covers the output side (-Y side) of the pump chamber 33. The pump cover 32 preferably has a pump cover main body portion 32c and a protrusion portion 32d. Yet, the pump cover 32 may be fixed to the surface on the output side of the exposure portion 34 of the pump body 31 by other methods.

**[0054]** A surface on the counter-output side (+Y side) of the pump cover main body portion 32c is in contact with a surface on the output side (-Y side) of the pump body 31. The protrusion portion 32d protrudes toward the output side from the pump cover main body portion 32c.

**[0055]** The pump cover 32 has an inlet 32a and an outlet 32b. The inlet 32a and the outlet 32b axially (Y-axis direction) penetrate the pump cover 32. The inlet 32a and the outlet 32b communicate with the pump chamber 33. As shown in FIG. 1, the inlet 32a is arranged on a lower side (-Z side) than the outlet 32b. The outlet

32b is arranged on the protrusion portion 32d. The outlet 32b is open toward a contact surface 32e, which is a surface on the output side (-Y side) of the protrusion portion 32d.

**[0056]** Next, a state will be explained in which the pump device 10 is attached to a car body CB1. The car body CB1 preferably has a pump device accommodation portion BD1, an in-port portion IP and an out-port portion OP. The pump device accommodation portion BD1 is a concave portion which is recessed from a car body surface CBS toward the output side (-Y side). The pump device 10 is accommodated inside the pump device accommodation portion BD1. In this embodiment, a surface on a radially inner side of the pump device accommodation portion BD1 has a cylindrical or substantially cylindrical shape. The pump device accommodation portion BD1 has an accommodation main body portion BD1a and a fitting portion BD1b.

**[0057]** The accommodation main body portion BD1a is where a portion of the motor portion 20 is arranged on a radially inner side. The accommodation main body portion BD1a is open toward the car body surface CBS. The fitting portion BD1b is arranged on the output side (-Y side) of the accommodation main body portion BD1a. A diameter of the fitting portion BD1b is smaller than a diameter of the accommodation main body portion BD1b. The fitting portion BD1b is fitted with the exposure portion 34.

**[0058]** As shown in FIG. 2, a radially inwardly protruding car body side convex portion CB1a is provided on an inner circumferential surface of the fitting portion BD1b. When seen in the axial direction (Y-axis direction), the car body side convex portion CB1a has, for example, a rectangular shape. The car body side convex portion CB1a is preferably provided to the fitting portion BD1b throughout the entire axial direction.

**[0059]** As shown in FIG. 1, the in-port portion IP and the out-port portion OP are open toward a bottom surface of the pump device accommodation portion BD1. That is, the in-port portion IP and the out-port portion OP are open toward an accommodation portion bottom surface BD1c, which is a bottom surface of the fitting portion BD1b. The pump device 10 inhales fluid from the in-port portion IP, and discharges the fluid through the out-port portion OP. The fluid that is inhaled and discharged by the pump device 10 is not limited to a particular type; for example, oil may be used. In the following descriptions, the fluid sent out by the pump device 10 will be considered as oil.

**[0060]** The housing flange portion 15 axially (Y-axis direction) overlaps with the cover flange portion 19. The pump device 10 is coupled to the car body CB1 by a screw, via the housing flange portion 15 and the cover flange portion 19. That is, the pump device 10 is fixed to the car body CB1 via the housing flange portion 15. A surface on the output side (-Y side) of the housing flange portion 15 is in contact with the car body surface CBS.

**[0061]** An O-ring 93 is arranged between the housing

flange portion 15 and the car body surface CBS. The O-ring covers the entire circumference of a gap between the housing flange portion 15 and the car body surface CBS in the circumferential direction.

**[0062]** A portion of the pump device 10 on the output side (-Y side) from the housing flange portion 15 is inserted into the pump device accommodation portion BD1. An end portion on the output side of the pump device 10 is in contact with the accommodation portion bottom surface BD1c.

**[0063]** That is, an end portion on the output side of the pump cover 32 is in contact with the accommodation portion bottom surface BD1c. An end portion on the output side of the pump cover 32 is the contact surface 32e of the protrusion portion 32d. The pump cover 32 is inserted into the fitting portion BD1b. The pump cover 32 is provided on a radially inner side, spaced apart from an inner surface of the fitting portion BD1b.

**[0064]** The in-port portion IP is connected to the inlet 32a of the pump cover 32. Accordingly, oil is introduced into the pump chamber 33 from the in-port portion IP via the inlet 32a. The out-port portion OP is connected to the outlet 32b of the pump cover 32. Accordingly, the oil introduced into the pump chamber 33 is discharged from the out-port portion OP via the outlet 32b.

**[0065]** An O-ring 37 is arranged between the contact surface 32e of the protrusion portion 32d and the accommodation portion bottom surface BD1c. The O-ring 37 surrounds the outlet 32b and the out-port portion OP in the circumferential direction. Accordingly, it is possible to prevent the oil introduced into the pump device 10 from the in-port portion IP from flowing into the out-port portion OP via the contact surface 32e and the accommodation portion bottom surface BD1c.

**[0066]** The exposure portion 34 is fitted with the fitting portion BD1b of the pump accommodation portion BD1. In this embodiment, the exposure portion 34 is, for example, clearance-fitted into the fitting portion BD1b. For this reason, it is possible to prevent a vibration of the car body CB1 from being delivered to the outlet 32b via the inlet 32a. Herein, this feature will be explained in more detail.

**[0067]** The vibration of the car body CB1 is delivered to the inlet 32a and the outlet 32b via the housing flange portion 15. In order to inhibit the propagation of this vibration, it is preferable to support the pump device 10 of the car body CB1 in the vicinity of the inlet 32a and the outlet 32b. For example, a configuration may be considered in which an outer surface of the housing 12 is fitted into the fitting portion BD1b to support the pump device 10. In this configuration, it is necessary to increase a dimensional accuracy of an inner surface of the housing 12, so as to fit the pump body 31 and the stator 50 into the inner surface of the housing 12.

**[0068]** However, in a case where the housing 12 is manufactured by press processing, when the inner surface of the housing 12 is accurately formed, the dimensional accuracy of the outer surface may be relatively

low. Therefore, when an outer surface of the housing is fitted into the fitting portion BD1b, the pump device 10 may not be fitted into the fitting portion BD1b in a highly precise manner. As a result, the pump device 10 may not be securely supported by the fitting portion BD1b, and the vibration that is delivered from the car body CB1 to the inlet 32a and the outlet 32b may not be sufficiently suppressed.

**[0069]** According to this embodiment, the exposure portion 34 is fitted into the fitting portion BD1b. The pump body 31 is manufactured by, for example, performing cutting work on a metal member. Therefore, when cutting work is performed, the outer circumferential surface 34a of the exposure portion 34 is accurately formed. Accordingly, the exposure portion 34 may be fitted into the fitting portion BD1b in a highly precise manner. With this, the pump body 10 is fixed to the car body CB1 via the housing flange portion, and simultaneously, the exposure portion 34 is securely fitted into the fitting portion BD1b so that the pump device 1 is supported in the vicinity of the inlet 32a and the outlet 32b. As a result, it is possible to prevent the vibration of the car body CB1, which is delivered to the pump device 10 through the housing flange 15, from being delivered to the inlet 32a and the outlet 32b which are arranged on the output side (-Y side) from the exposure portion 34 in a greatly amplified manner.

**[0070]** Accordingly, it is possible to prevent the O-ring 37, which seals around the outlet 32b from wearing off due to the rubbing movement which may be caused by the vibration.

**[0071]** Further, another method of accurately forming an outer surface of the housing 12 may be considered, by when the housing 12 is manufactured by performing additional processing on an outer surface of the housing 12 after manufacturing the housing 12 by press processing. This method is also capable of fitting the outer surface of the housing 12 into the fitting portion BD1b in a highly precise manner.

**[0072]** However, in this case, it is necessary to additionally process the housing 12, which has been manufactured by press processing, by lathe-chuck process, or the like. Therefore, the step of forming the housing 12 is increased. As a result, manufacturing cost of the pump device 10 is increased.

**[0073]** According to this embodiment, the pump body 31 is manufactured by performing cutting work, or the like, on a metal member. Therefore, by performing cutting work when manufacturing the pump body 31, it is possible to accurately form the outer circumferential surface 34a of the exposure portion 34. That is, in the process of manufacturing the pump body 31 by cutting work, by performing an additional process on the pump body 31 which has been already cut by lathe-chuck processing, or the like, it is possible to accurately form the outer peripheral surface 34a on the pump body 31. Thus, there is no need to change the machine tool used to process a member in order to form a portion that is to be fitted into the fitting portion BD1b, and therefore it is possible to suppress the

increase of manufacturing time and cost involved in producing the pump device 10.

**[0074]** Further, in order to suppress the propagation of vibrations of the car body CB1, another configuration may be considered, in which the protrusion portion 32d of the pump cover 32 is fitted into the out-port portion OP, or the like, to support the pump device 10. However, in this case, if the diameter of the protrusion portion 32d is sufficiently increased, the protrusion portion 32d may be deformed or damaged by the stress caused by the vibration of the car body CB1. Therefore, since it is necessary to relatively increase the diameter of the protrusion portion 32d, the entire pump device 10 may increase in size.

**[0075]** According to this embodiment, it is unnecessary to increase the protrusion portion 32d in order to fit the exposure portion 34 to the car body BD1b. Therefore, it is possible to suppress the size increase in the pump device 10.

**[0076]** Further, another configuration may be considered, in which the pump cover main body portion 32c is fitted into the fitting portion BD1b to support the pump device 10, in order to suppress the propagation of vibrations of the car body CB1. However, the pump cover 32 is attached to the pump body 31 by the screw 94. Therefore, as compared with the pump body 31, it is more likely that an assembly error may occur between the pump cover 32 and the housing 12. Thus, the pump cover body 32c may not be fitted into the fitting portion BD1b in a highly precise manner.

**[0077]** As compared with the pump cover 31, it is less likely for an assembly error to occur between the exposure portion 34 of the pump body 31 and the housing 12. In this embodiment, the exposure portion 34 of the pump body 31 is fitted into the fitting portion BD1b. Therefore, it is possible to fit the exposure portion 34 in to the fitting portion BD1b in a highly precise manner.

**[0078]** Further, as discussed above, according to this embodiment, the cover pump 32 is attached to the exposure portion 34. Also, the pump cover 32 is attached to the exposure portion 34 after the pump body 31 is fixed inside the housing 12. For this reason, the order of assembly of the pump device 10 may be arbitrarily changed, and the assembly of the pump device 10 may be easily performed. Further, after the pump device 10 is assembled, the pump cover 32 may be removed from the pump device 10. With this, it is possible to exchange the inner rotor 61 and the outer rotor 62 inside the pump chamber 33, and thereby the maintenance of the pump device 10 may be easily performed.

**[0079]** According to this embodiment, the exposure portion 34 radially overlaps with the pump chamber 33. For this reason, it is possible to support the inner rotor 61 and the outer rotor 62, which are accommodated inside the pump chamber 33, by fitting a radially outer portion thereof into the fitting portion BD1b. Accordingly, it is possible to prevent the vibration due to the rotation of the inner rotor 61 and outer rotor 62 from being delivered to the inlet 32a and the outlet 32b. As a result, it is also

possible to further prevent the O-ring 37 from wearing off.

**[0080]** In a case where the exposure 34 does not radially overlap with the pump chamber 33, another configuration may be considered, for example, in which the exposure portion 34 is disposed on the output side (+Y side) from the pump chamber 33. In this configuration, an axial (Y-axis direction) size of the portion of the pump body 31 protruding to the output side (-Y side) from the housing 12 is likely to increase. Therefore, the axial size of the entire pump device 10 is likely to increase.

**[0081]** In contrast, according to this embodiment, since the exposure portion 34 radially overlaps with the pump chamber 33, it is possible to suppress the size increase of a portion of the pump body 31 protruding toward the output side (-Y side) from the housing 12. Therefore, according to this embodiment, it is possible to suppress the axial size increase in the pump device 10.

**[0082]** Further, according to this embodiment, the pump body 31 has the bearing portion 36 which supports the shaft 41. Therefore, by fitting the pump body 31 into the fitting portion BD1b in a highly precise manner, it is possible to attach the pump device 10 to the car body CB1 with a high axis precision of the shaft 41.

**[0083]** As shown in FIG. 2, the exposure 34 and the car body CB1 are provided with a position adjustment portion PA1 which determines a relative circumferential position between the exposure portion 34 and the car body CB1. The position adjustment portion PA1 is defined by the pump body side concave portion 34b and the car body side convex portion CB1a. That is, the position adjustment portion PA1 includes the pump body side concave portion 34b and the car body side convex portion CB1a. The pump body side concave portion 34b is arranged on the outer circumferential surface 34a of the exposure portion 34, and recessed radially inward. The car body side convex portion CB1a is arranged on the inner circumferential surface of the fitting portion BD1b, and protrudes radially inward.

**[0084]** In a state in which the pump body 10 is attached to the car body CB1, the pump body side concave portion 34b radially faces the car body side convex portion CB1a. With this structure, a relative circumferential position of the exposure portion 34 and the car body CB1 is determined. Therefore, the pump device 10 is easily attached to the car body CB1.

**[0085]** The pump body side concave portion 34b and the car body side convex portion CB1a may be, for example, fittingly engaged with each other. With this structure, it is possible to determine the relative circumferential position of the exposure portion 34 to the car body CB1 in a highly precise manner.

**[0086]** In the present disclosure, the description of 'the pump body side concave portion which is disposed on the outer circumferential surface of the exposure portion and recessed radially inward' includes a portion on a radially inner side from the cylindrical outer circumferential surface of the exposure portion.

**[0087]** When the motor portion 20 is driven and the



shaft 41 rotates, the inner rotor 61, which is fixed to the shaft 41, rotates. With the rotation of the inner rotor 61, the outer rotor 62 rotates. With the rotation of the inner rotor 61 and the outer rotor 62, oil is introduced into the pump chamber 33 from the in-port portion IP, through the inlet 32a. With the rotation of the inner rotor 61 and the outer rotor 62, the oil that was introduced into the pump chamber 33 moves inside the pump chamber 33, and is discharged out of the pump device 10 from the out-port portion OP, through the outlet 32b. With this, the pump portion 30 is driven by the motor portion 20, and the pump device 10 sends oil from the in-port portion IP to the out-port portion OP.

**[0088]** Further, in this embodiment, the following configuration may be employed. In the following description, similar features from the previous description will be described with identical reference numbers, and they will not be explained in further detail.

**[0089]** There may not be just one exposure portion 34, and a plurality of exposure portions may be provided. In this case, the plurality of exposure portions 34 are arranged along the circumferential direction. The plurality of exposure portions 34 surround a radially outer side of the center axis J. That is, an outer surface on the radially outer side of the plurality of exposure portions 34 surround the radially outer side of the center axis J.

**[0090]** The exposure portion 34 may not radially overlap with the pump chamber 33. The exposure portion 34 may be arranged on the output side (-Y side) or the counter-output side (+Y side) from the pump chamber 33.

**[0091]** The bearing portion 36 may be a bearing other than the slide bearing type, such as roll bearing, and the like. Further, the pump body 31 may not have the bearing portion 36.

**[0092]** The type of fitting performed between the exposure portion 34 and the fitting portion BD1b is not particularly limited, and may be, for example, interference fitting.

**[0093]** The structure of the position adjustment portion PA1 is not particularly limited, and may employ, for example, the structure shown in FIG. 3 and FIG. 4.

**[0094]** FIG. 3 is a cross-sectional view of a portion of another example of a pump device 110 according to this embodiment. As shown in FIG. 3, the pump device 110 is attached to a car body CB2. The pump device 110 includes a pump portion 130. The pump portion 130 has a pump body 131. The pump body 131 has an exposure portion 134.

**[0095]** The car body CB2 has a pump device accommodation portion BD2. The pump device accommodation portion BD2 has a fitting portion BD2b. The exposure portion 134 is fitted into the fitting portion BD2b.

**[0096]** A position adjustment portion PA2 is provided to the exposure portion 134 and the car body CB2. The position adjustment portion PA2 preferably has a pump body side concave portion 134b and a car body side convex portion CB2a. The pump body side concave portion 134b is arranged on an outer circumferential surface

134a of the exposure portion 134, and recessed radially inward. As shown in FIG. 3, when seen in the axial direction, an opening portion of the pump body side concave portion 134b has a partially linearly notched circular shape. As shown in FIG. 3, when seen in the axial direction, a contour of the exposure portion 134 has a partially linearly notched circular shape.

**[0097]** The car body side convex portion CB2a is arranged on an inner circumferential surface of the fitting portion BD2b, and protrudes radially inward. As shown in FIG. 3, when seen in the axial direction (Y-axis direction), the car body side convex portion CB2a has a partially linearly notched circular shape.

**[0098]** In the example shown in FIG. 3, the pump body side concave portion 134b may radially face the car body side convex portion CB2a, and fitted with each other. With this, the position adjustment portion PA2 is defined, and a relative circumferential position between the exposure portion 134 and the car body CB2 is determined by the position adjustment portion PA2. Other elements of the pump device 110 are identical to those of the pump device 10 shown in FIG. 1 and FIG. 2. Other elements of the car body CB2 are identical to those of the car body CB1 shown in FIG. 1 and FIG. 2.

**[0099]** FIG. 4 is a cross-sectional view of a portion of another example of a pump device 210 according to this embodiment. As shown in FIG. 4, the pump device 210 is attached to a car body CB3. The pump device 210 includes a pump portion 230. The pump portion 230 has a pump body 231. The pump body 231 has an exposure portion 234.

**[0100]** The car body CB3 has a pump device accommodation portion BD3. The pump device accommodation portion BD3 has a fitting portion BD3b. The exposure portion 234 is fitted into the fitting portion BD3b.

**[0101]** A position adjustment portion PA3 is provided to the exposure portion 234 and the car body CB3. The position adjustment portion PA3 has a pump body side convex portion 234b and a car body side concave portion CB3a. The pump body side convex portion 234b is arranged on an outer circumferential surface 234a of the exposure portion 234, and protrudes radially outward. When seen in the axial direction (Y-axis direction), the pump body side convex portion 234b has a rectangular or substantially rectangular shape. Further, when seen in the axial direction (Y-axis direction), the pump body side convex portion 234b may have a shape other than the rectangular shape.

**[0102]** The car body side concave portion CB3a is arranged on an inner circumferential surface of the fitting portion BD3b, and recessed radially outward. When seen in the axial direction (Y-axis direction), an opening portion of the car body side concave portion CB3a has a rectangular or substantially rectangular shape.

**[0103]** The pump body side convex portion 234b radially faces the car body side concave portion CB3a. As shown in the example of FIG. 4, the pump body side convex portion 234b is fitted into the car body side con-

cave portion CB3a. With this, a relative circumferential position between the exposure portion 234 and the car body CB3 is determined by the position adjustment portion PA3. Further, when seen in the axial direction (Y-axis direction), the pump side convex portion 234b may have a shape other than the rectangular shape, as long as it can be fitted into the car body side concave portion CB3a. Other elements of the pump device 210 are identical to those of the pump device 10 shown in FIG. 1 and FIG. 2. Other elements of the car body CB3 are identical to those of the car body CB1 shown in FIG. 1 and FIG. 2.

#### <Second Embodiment>

**[0104]** When compared with the first embodiment, a difference in the second embodiment is that a flow channel, where oil passes through, is provided between the exposure portion and the fitting portion. In the following description, similar features from the previous description will be described with identical reference numbers, and they will not be explained in further detail.

**[0105]** FIG. 5 is a cross-sectional view of a portion of a pump device 310 according to this embodiment. FIG. 6 illustrates a portion of the pump device 310, and corresponds to a cross-sectional view taken along VI-VI shown in FIG. 5. As shown in FIG. 5, the pump device 310 is attached to a car body CB4. The pump device 310 preferably has a case 11, a motor portion 20 and a pump portion 330.

**[0106]** The pump portion 330 preferably has a pump body 331, a pump cover 32, an inner rotor 61 and an outer rotor 62. The pump body 331 has an exposure portion 334. The car body CB4 has a pump device accommodation portion BD4. The pump device accommodation portion BD4 preferably has an accommodation main body portion BD4a and a fitting portion BD4b. The exposure portion 334 is fitted into the fitting portion BD4b. The accommodation main body portion BD4a is identical to the accommodation main body portion BD1a of the first embodiment.

**[0107]** As shown in FIG. 6, a flow channel FC1, where oil passes through, is provided in a radial gap between the exposure portion 334 and the fitting portion BD4b. As shown in FIG. 5, the flow channel FC1 is connected to an inlet 32a. For this reason, the oil, which is introduced from the in-port portion IP into the inlet 32a, flows into the accommodation main body portion BD4a via the flow channel FC1. Specifically, the oil flows through a radial gap between the accommodation main body portion BD4a and a housing 12. With this, the oil cools down a portion inside the accommodation main body portion BD4a of the pump device 310. The portion inside the accommodation main body portion BD4a of the pump device 310 includes, for example, in this embodiment, a rotor 40 and a stator 50.

**[0108]** As in the pump device 110 shown in FIG. 1, in a state in which the pump body 310 is attached to the car body CB4, an O-ring 93 is arranged between a hous-

ing flange portion 15 and a car body surface CBS. For this reason, it is possible to prevent the oil introduced into the accommodation main body portion BD4a from leaking outside between the housing flange portion 15 and the car body surface CBS.

**[0109]** As shown in FIG. 6, in this embodiment, a flow channel FC2, where oil passes through, is provided in a radial gap between the exposure 334 and the fitting portion BD4b, separately from the flow channel FC1. That is, in this embodiment, two flow channels FC1, FC2 are provided in a radial gap between the exposure portion 334 and the fitting portion BD4b. For this reason, the oil introduced into the accommodation main body portion BD4a via the flow channel FC1 flows out of the accommodation main body portion BD4a via the flow channel FC2. With this, it is possible to circulate the oil introduced into the accommodation main body portion BD4a inside the pump device 310. As a result, it is possible to further cool down the pump device 310.

**[0110]** As shown in FIG. 6, the flow channel FC1 is arranged on a lower (-Z side) end portion in a radial gap between the exposure portion 334 and the fitting portion BD4b. The flow channel FC2 is arranged on an upper (+Z side) end portion in a radial gap between the exposure portion 334 and the fitting portion BD4b. That is, the two flow channels FC1, FC2 are arranged on a radially opposite side from each other on the center axis J.

**[0111]** For this reason, while the oil is introduced into the accommodation main body portion BD4a via the fluid channel FC1, and while the introduced oil is flown out of the accommodation main body portion BD4a via the flow channel FC2, it is possible to cool down the entire pump device 310 in the circumferential direction. Specifically, in the example shown in FIG. 5 and FIG. 6, the oil is introduced into the accommodation main body portion BD4a from the in-port portion IP via the flow channel FC1. Then, the oil introduced into the accommodation main body portion BD4a flows to the upper side (+Z side) along an outer circumferential surface of the housing 12, and flows out of the accommodation main body portion BD4a via the flow channel FC2. With this, it is possible to cool down the entire pump device 310 in the circumferential direction, with the oil introduced into the accommodation main body portion BD4a.

**[0112]** The outer circumferential surface 334a is surface on a radially outer side of the exposure portion 334. As shown in FIG. 6, radially inwardly recessed exposure portion side grooves 334b, 334c are provided on the outer circumferential surface 334a. As shown in FIG. 5, the exposure portion side grooves 334b, 334c extend in the axial direction (Y-axis direction). The exposure portion side grooves 334b, 334c have a shape that is, for example, identical to the pump body side concave portion 34b shown in FIG. 2.

**[0113]** As shown in FIG. 6, the exposure portion side groove 334b is arranged on a lower (-Z side) end portion of the outer circumferential surface 334a. The exposure portion side groove 334c is arranged on an upper (+Z

side) end portion of the outer circumferential surface 334a.

**[0114]** A surface on a radially inner side of the fitting portion BD4b is provided with radially outwardly recessed fitting portion side grooves CB4a, CB4b. As shown in FIG. 5, the fitting portion side grooves CB4a, CB4b extend in the axial direction (Y-axis direction). The fitting portion side grooves CB4a, CB4b have a shape that is, for example, identical to the car body side concave portion CB3a.

**[0115]** The fitting portion side groove CB4a is arranged on a lower (-Z side) end portion of a radially inner side surface of the fitting portion BD4b. The fitting portion side groove CB4b is arranged on an upper (+Z side) end portion of a radially inner side surface of the fitting portion BD4b.

**[0116]** The exposure side groove 334b radially faces the fitting portion side groove CB4a. Accordingly, the exposure portion side groove 334b and the fitting portion side groove CB4a define the flow channel FC1. That is, the exposure portion side groove 334b defines at least a portion of the flow channel FC1. The fitting portion side groove CB4a defines at least a portion of the flow channel FC1.

**[0117]** The exposure portion side groove 334c radially faces the fitting portion side groove CB4b. Accordingly, the exposure portion side groove 334c and the fitting portion side groove CB4b define the flow channel FC2. That is, the exposure portion side groove 334c defines at least a portion of the flow channel FC2. The fitting portion side groove CB4b defines at least a portion of the flow channel FC2.

**[0118]** According to this embodiment, grooves are provided to both the exposure portion 334 and the fitting portion BD4b, and the grooves radially face one another, thereby defining the flow channels FC1, FC2. For this reason, it is possible to increase a cross-sectional area of the flow channels FC1, FC2. Accordingly, it is possible for the oil to smoothly pass through the flow channels FC1, FC2.

**[0119]** In this embodiment, an X-axial width of the fitting portion side grooves CB4a, CB4b is bigger than an X-axial width of the exposure portion side grooves 334b, 334c. Other elements of the pump device 310 are identical to those of the pump device 10 described in the first embodiment. Other elements of the car body CB4 are identical to those of the car body CB1 described in the first embodiment.

**[0120]** Further, the following configuration may be employed in this embodiment.

**[0121]** The number of the flow channels FC1, FC2 employed may be one or may be three, or more. The shape of the flow channels FC1, FC2 is not particularly limited.

**[0122]** The flow channels FC1, FC2 may be defined by either the exposure portion side grooves 334b, 334c or the fitting portion side grooves CB4a, CB4b. In this case, the remaining one of either the exposure portion side grooves 334b, 334c or the fitting portion side grooves

CB4a, CB4b may not be provided.

**[0123]** Further, a method of mounting the pump device of this embodiment onto the car body is not particularly limited to the above-described method. The pump device of this embodiment may be, for example, mounted onto the car body in a state in which the exposure portion is not fitted into the fitting portion of the car body.

**[0124]** Features of the above-described preferred embodiments and the modifications thereof may be combined appropriately as long as no conflict arises.

**[0125]** While preferred embodiments of the present disclosure have been described above, it is to be understood that variations and modifications will be apparent to those skilled in the art without departing from the scope and spirit of the present disclosure. The scope of the present disclosure, therefore, is to be determined solely by the following claims.

**[0126]** While the description above refers to particular embodiments of the present invention, it will be understood that many modifications may be made without departing from the spirit thereof. The accompanying claims are intended to cover such modifications so that they would fall within the true scope and spirit of the present invention.

**[0127]** The presently disclosed embodiments are therefore to be considered in all respects as illustrative and not restrictive, the scope of the disclosure being indicated by the appended claims, rather than the foregoing description, and all changes which come within the meaning and range of equivalency of the claims are therefore intended to be embraced therein.

## Claims

1. A pump device (10, 110, 210, 310), comprising:

a motor portion (20) having a shaft (41) having its center on an axially extending center axis (J), a rotor (40) which is fixed to the shaft (41), and a stator (50) which is arranged on a radially outer side of the rotor (40);

a pump portion (30, 230, 330) which is arranged on one axial side of the motor portion (20), and driven by the motor portion (20); and a cylindrical housing (12) which holds the motor portion (20) and the pump portion (30, 230, 330), the pump portion (30, 130, 230, 330) including:

an inner rotor (61) which is attached to the shaft (41);

an annular outer rotor (62) which surrounds a radially outer side of the inner rotor (61); a pump body (31, 131, 231, 331) which accommodates the inner rotor (61) and the outer rotor (62); and

a pump cover (32) which is attached to one axial side of the pump body

- (31,131,231,331),  
 wherein the pump body (31,131,231,331)  
 has a pump chamber (33) which is recessed  
 from a surface on one axial side toward the  
 other axial side and accommodates the inner  
 rotor (61) and the outer rotor (62), and  
 a through-hole (31 a) which axially pene-  
 trates through the pump body  
 (31,131,231,331) and through which the  
 shaft (41) passes,  
 the pump cover (32) has an inlet (32a) and  
 an outlet (32b) which are in communication  
 with the pump chamber (33),  
 the housing (12) has a tube portion (14)  
 which covers at least a radially outer side  
 of the stator (50) and a flange portion (15)  
 which extends radially outward from an end  
 portion on the other axial side of the tube  
 portion (14),  
 the pump body (31, 131, 231, 331) has an  
 exposure portion (34, 134, 234, 334) which  
 is arranged on one axial side from the tube  
 portion (14) and exposed outside the hous-  
 ing (12), and  
 the exposure portion (34, 134, 234, 334) has  
 an outer circumferential surface (34a, 134a,  
 234a, 334a) which surrounds a radially out-  
 er side of the center axis (J).
2. The pump device (10, 110, 210, 310) according to  
 Claim 1,  
 wherein the exposure portion (34, 134, 234, 334)  
 radially overlaps with the pump chamber (33).
  3. The pump device (10, 110, 210, 310) according to  
 Claim 1 or 2,  
 wherein the pump body (31, 131, 231, 331) has a  
 stepped portion (35) where its radial dimension be-  
 comes smaller toward the one axial side,  
 the housing (12) has an extending portion (16) which  
 extends radially inward from an end portion of one  
 axial side of the tube portion (14), and  
 a stepped surface (35a), which intersects with the  
 axial direction (Y-axis direction) of the stepped por-  
 tion (35), is in contact with the extending portion (16).
  4. The pump device (10, 110, 210, 310) according to  
 any one of Claims 1 to 3,  
 wherein the pump body (31, 131, 231, 331) has a  
 bearing portion (36) which supports the shaft (41).
  5. The pump device (10, 110, 210, 310) according to  
 any one of Claims 1 to 4,  
 wherein the pump device (10, 110, 210, 310) is fixed  
 to a car body (CB1, CB2, CB3, CB4) via the flange  
 portion (15),  
 the car body (CB1, CB2, CB3, CB4) has a pump  
 device accommodation portion (BD1, BD2, BD3,  
 BD4) which accommodates the pump device (10,  
 110, 210, 310), an in-port portion (IP) which is con-  
 nected with the inlet (32a), and an out-port portion  
 (OP) which is connected with the outlet (32b), and  
 the pump device accommodation portion (BD1, BD2,  
 BD3, BD4) has a fitting portion (BD1b, BD2b, BD3b,  
 BD4b) which is fittingly engaged with the exposure  
 portion (34, 134, 234, 334).
  6. The pump device (10, 110, 210, 310) according to  
 Claim 5,  
 wherein a flow channel (FC1, FC2), where fluid pass-  
 es through, is provided in a radial gap between the  
 exposure portion (34, 134, 234, 334) and the fitting  
 portion (BD1b, BD2b, BD3b, BD4b), and  
 the flow channel (FC1, FC2) is connected with the  
 inlet (32a).
  7. The pump device (10, 110, 210, 310) according to  
 Claim 6,  
 wherein two flow channels (FC1, FC2) are provided  
 in a radial gap between the exposure portion (34,  
 134, 234, 334) and the fitting portion (BD1b, BD2b,  
 BD3b, BD4b), and  
 the two flow channels (FC1, FC2) are respectively  
 provided on opposite sides from each other relative  
 to the center axis (J).
  8. The pump device (10, 110, 210, 310) according to  
 Claim 6 or 7,  
 wherein radially inwardly recessed exposure portion  
 side grooves (334b, 334c) are provided on a surface  
 on a radially outer side of the exposure portion (34,  
 134, 234, 334), and  
 the exposure portion side grooves (334b, 334c) de-  
 fine at least a portion of the flow channel (FC1, FC2).
  9. The pump device (10, 110, 210, 310) according to  
 any one of Claims 6 to 8,  
 wherein radially inwardly recessed fitting portion side  
 grooves (CB4a, CB4b) are provided to a surface on  
 a radially outer side of the fitting portion (BD1b,  
 BD2b, BD3b, BD4b), and  
 the fitting portion side grooves (CB4a, CB4b) define  
 at least a portion of the flow channel (FC1, FC2).
  10. The pump device (10, 110, 210, 310) according to  
 any one of Claims 5 to 9,  
 wherein the exposure portion (34, 134, 234, 334)  
 has a columnar shape,  
 a surface on a radially inner side of the pump device  
 accommodation portion (BD1, BD2, BD3, BD4) has  
 a cylindrical shape,  
 the exposure portion (34, 134, 234, 334) and the car  
 body (CB1, CB2, CB3, CB4) are provided with a po-  
 sition adjustment portion (PA1, PA 2, PA 3) to deter-  
 mine a relative circumferential position between the  
 exposure portion (34, 134, 234, 334) and the car

body (CB1, CB2, CB3, CB4),  
 the position adjustment portion (PA1, PA2, PA3) has  
 a pump body side concave portion (34b, 134b) which  
 is disposed on an outer circumferential surface of  
 the exposure portion (34, 134, 234, 334) and re- 5  
 cessed radially inward, and a car body side convex  
 portion (CB1a, CB2a) which is disposed on an inner  
 circumferential surface of the fitting portion (BD1b,  
 BD2b, BD3b, BD4b) and protrudes radially inward,  
 and 10  
 the pump body side concave portion (34b, 134b) ra-  
 dially faces the car body side convex portion (CB1a,  
 CB2a).

11. The pump device (10, 110, 210, 310) according to 15  
 any one of Claims 5 to 10,  
 the exposure portion (34, 134, 234, 334) has a co-  
 lumnar shape,  
 a surface on a radially inner side of the pump device  
 accommodation portion (BD1, BD2, BD3, BD4) has 20  
 a cylindrical shape,  
 the exposure portion (34, 134, 234, 334) and the car  
 body (CB1, CB2, CB3, CB4) are provided with a po-  
 sition adjustment portion (PA1, PA 2, PA 3) to deter- 25  
 mine a relative circumferential position between the  
 exposure portion (34, 134, 234, 334) and the car  
 body (CB1, CB2, CB3, CB4),  
 the position adjustment portion (PA1, PA2, PA3) has  
 a pump body side convex portion (234b) which is 30  
 arranged on an outer circumferential surface of the  
 exposure portion (34, 134, 234, 334) and protrudes  
 radially outward, and a car body side concave portion  
 (CB3a) which is arranged on an inner circumferential  
 surface of the fitting portion (BD1b, BD2b, BD3b,  
 BD4b) and recessed radially outward, and 35  
 the pump body side convex portion (234b) radially  
 faces the car body side concave portion (CB3a).

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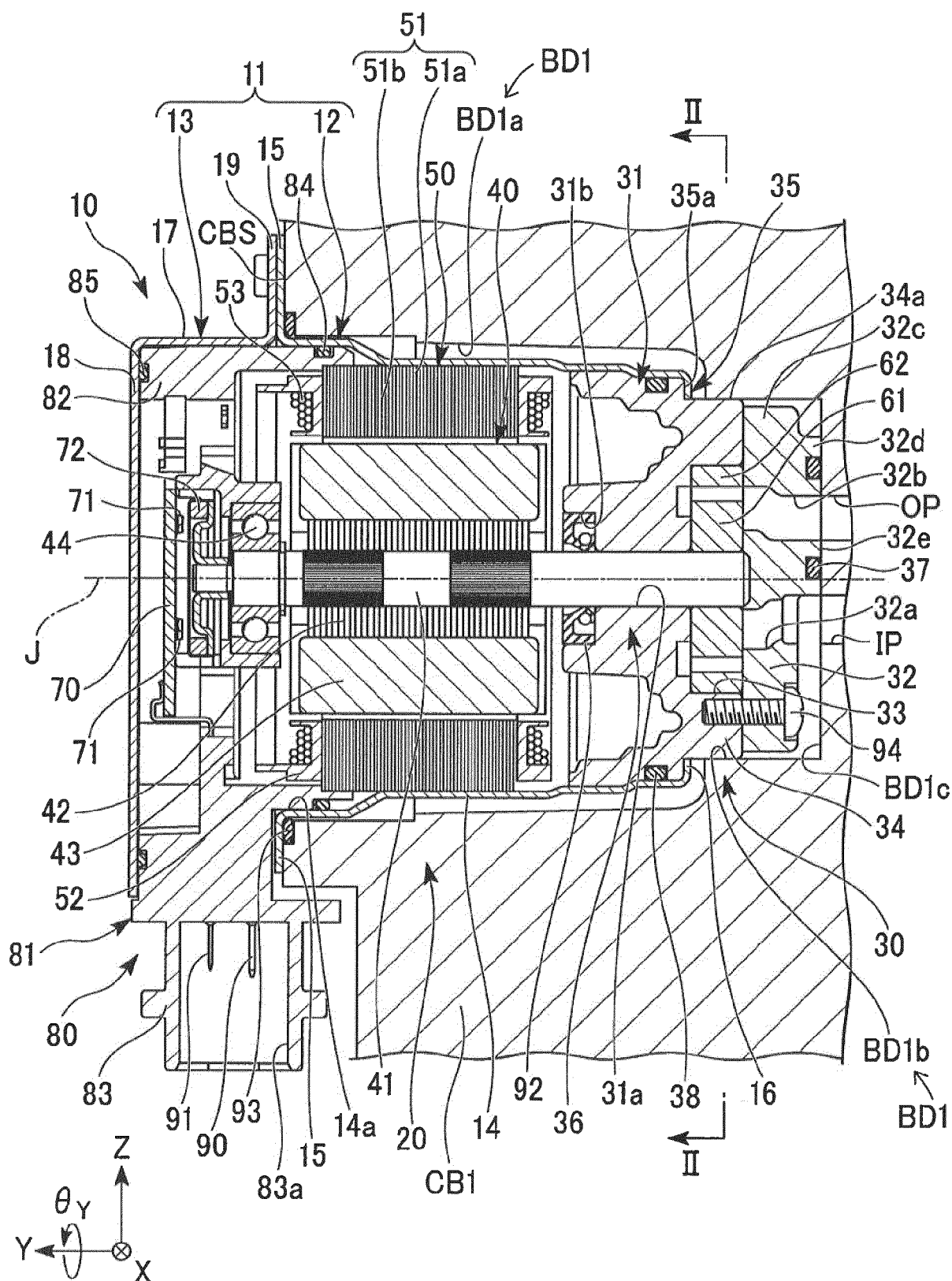


Fig.1

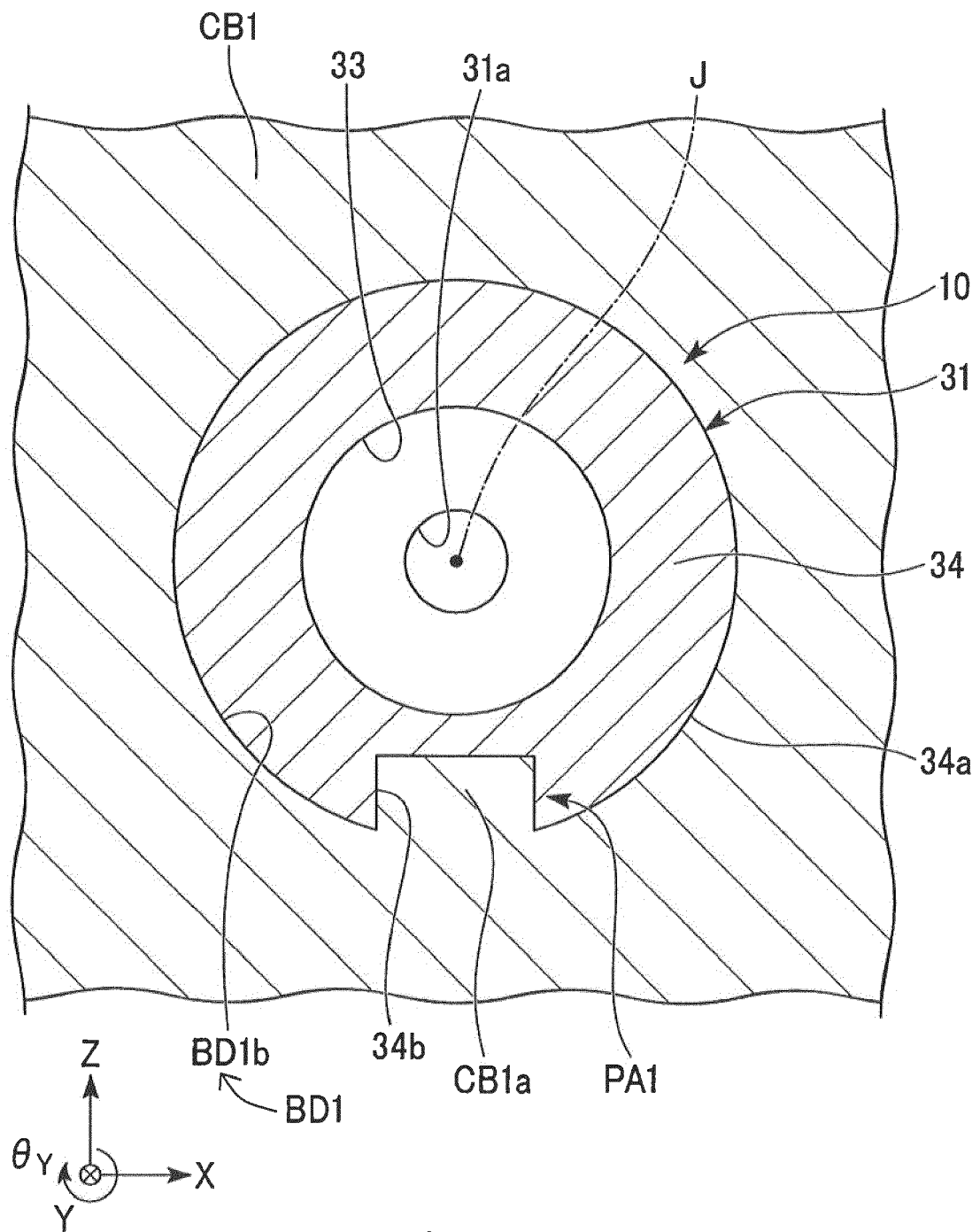


Fig.2

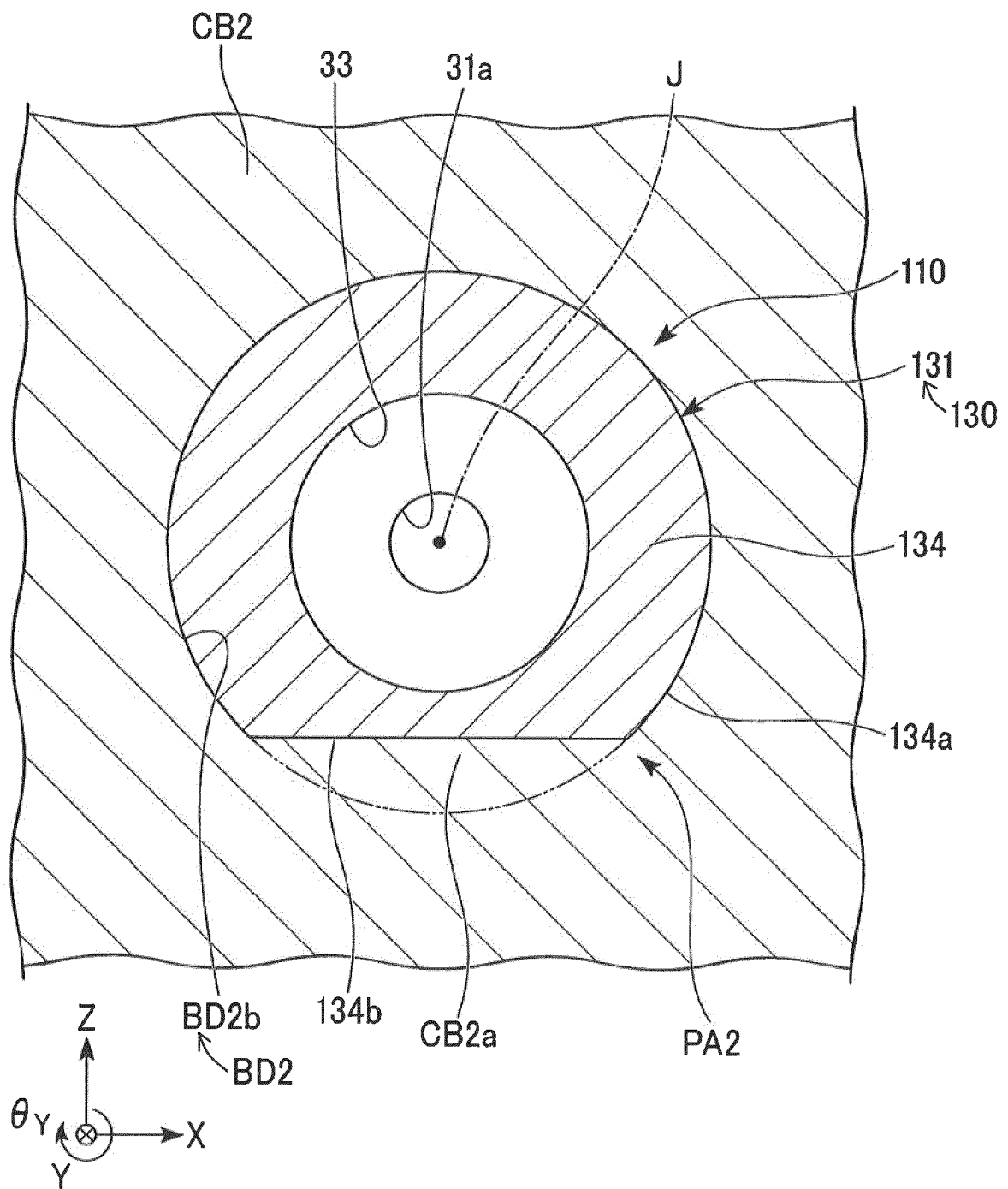


Fig.3



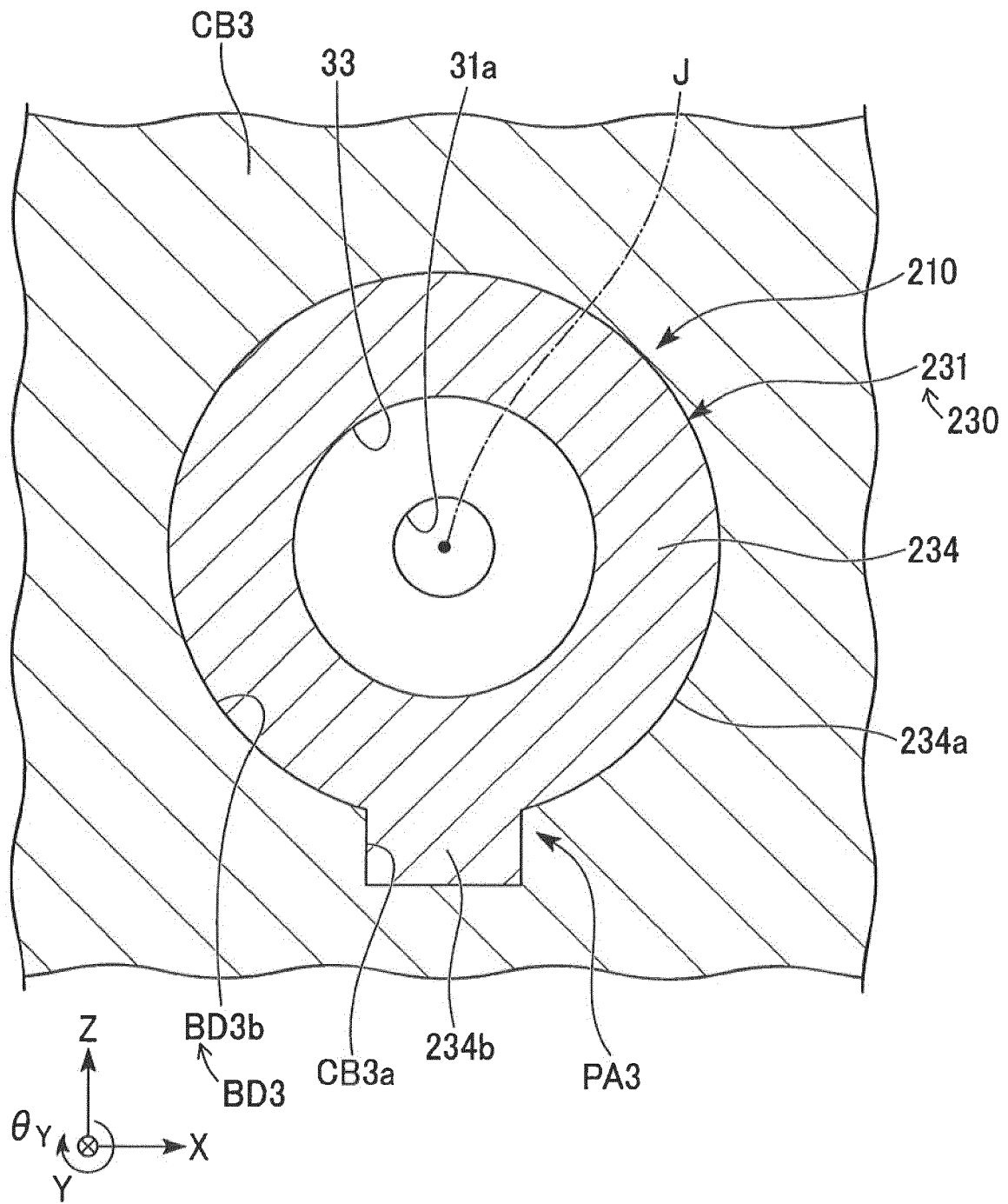


Fig.4

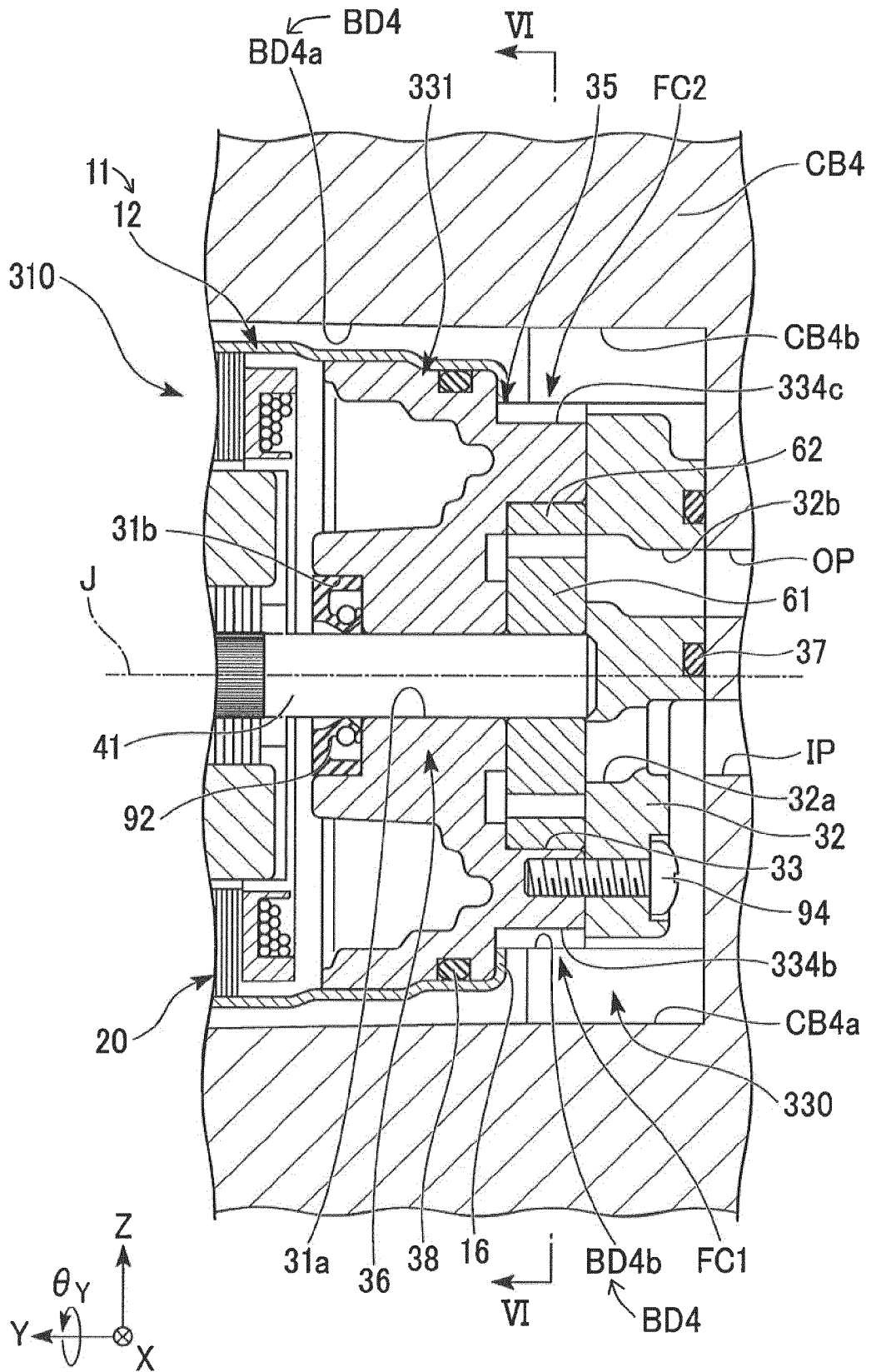


Fig.5

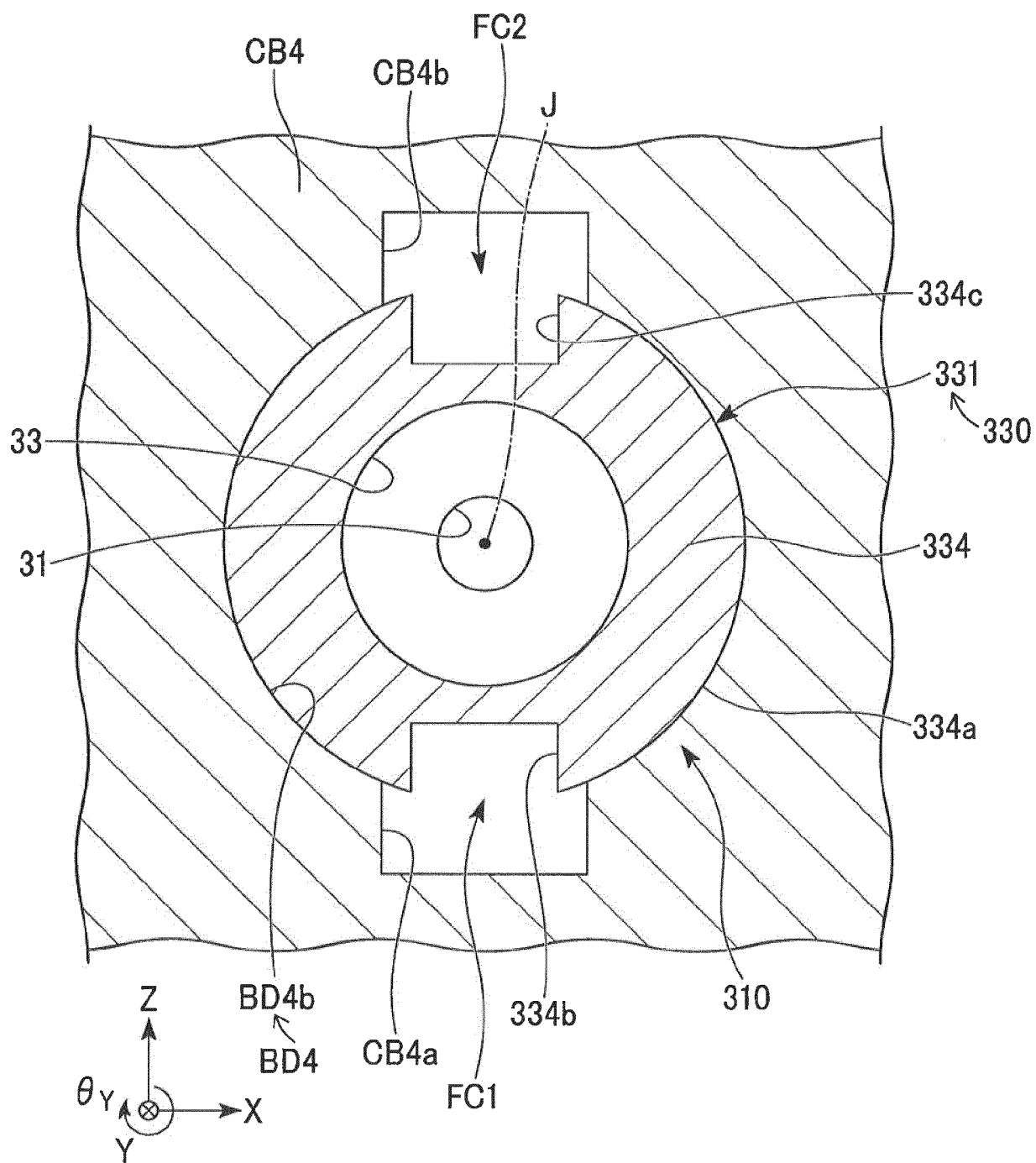


Fig.6



## EUROPEAN SEARCH REPORT

Application Number  
EP 16 16 8993

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DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	US 2013/189134 A1 (IRIE MASARU [JP] ET AL) 25 July 2013 (2013-07-25)	1-4	INV. F01C21/10 F04C2/10 F04C15/00
A	* the whole document * * figures 1,2,5 * * paragraph [0051] - paragraph [0056] *	5-11	
	-----		
X	US 2014/241917 A1 (SUZUKI MOTOTSUGU [JP] ET AL) 28 August 2014 (2014-08-28)	1-9	
Y	* the whole document * * figures 1,5,6 *	10,11	
	-----		
Y	US 2004/184942 A1 (PHILLIPS EDWARD H [US]) 23 September 2004 (2004-09-23)	10,11	
	* the whole document * * figures 2,3,5-8 * * paragraph [0035] *		
	-----		
The present search report has been drawn up for all claims			TECHNICAL FIELDS SEARCHED (IPC)
			F01C F04C
Place of search		Date of completion of the search	Examiner
Munich		21 September 2016	Sbresny, Heiko
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			

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**ANNEX TO THE EUROPEAN SEARCH REPORT  
ON EUROPEAN PATENT APPLICATION NO.**

EP 16 16 8993

5

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  
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21-09-2016

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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2013189134 A1	25-07-2013	CN 103206374 A	17-07-2013
		JP 2013167243 A	29-08-2013
		US 2013189134 A1	25-07-2013
US 2014241917 A1	28-08-2014	NONE	
US 2004184942 A1	23-09-2004	NONE	

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

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**Patent documents cited in the description**

- JP 2011094553 A [0002]