

Description

Technical Field

[0001] The present invention relates to a variable capacity piston pump.

Background Art

[0002] As a variable capacity piston pump in the related art, for example, as described in Patent Literature 1 (Japanese Unexamined Patent Publication No. 2006-348911), a variable capacity piston pump which is used as a hydraulic pressure generation source of a hydraulic circuit and changes a discharge capacity by adjusting the inclination of a swashplate is known.

[0003] The variable capacity piston pump described in Patent Literature 1 includes a control piston which presses the swashplate and a swashplate return spring which biases the swashplate from a side opposite to the control piston. As the control pressure of the control piston is changed, the magnitude of a pressing force exerted on the swashplate is changed. By controlling the magnitude of the pressing force, the inclination of the swashplate is adjusted. Specifically, when the pressing force of the control piston is decreased, the inclination of the swashplate is increased by the biasing force of the swashplate return spring. When the pressing force of the control piston is increased, the inclination of the swashplate is decreased.

Summary of Invention

Technical Problem

[0004] However, in the variable capacity piston pump described above, due to the displacement of the inclination of the swashplate, the position of a seat surface center in the swashplate return spring on the swashplate side deviates from the axial line of the swashplate return spring. That is, there is a possibility that, the end portion of the swashplate return spring on the swashplate side may be locally bent and buckled or may be damaged due to local stress, resulting in functional deterioration. In addition, as a result of the bending, there is a possibility that the swashplate return spring may come into contact with other components and may be damaged, resulting in functional deterioration.

[0005] Therefore, in the variable capacity piston pump described in Patent Literature 1, a member having a spherical surface on the swashplate side is disposed at the end portion of the swashplate return spring on the swashplate side. However, in the case where the member having a spherical surface on the swashplate side is disposed at the end portion of the swashplate return spring on the swashplate side, there is a problem of an increase in the number of components or an increase in costs due to a complex assembly process.

[0006] An object of various aspects of the present in-

vention is to provide a variable capacity piston pump capable of suppressing functional deterioration in a swashplate return spring.

Solution to Problem

[0007] According to an aspect of the present invention, there is provided a variable capacity piston pump performing suction and discharge of a hydraulic fluid by reciprocation of a piston in a cylinder block rotating integrally with a rotating shaft, the stroke of the reciprocation of the piston depending on an inclination of a swashplate, wherein the swashplate includes a sliding contact surface contacting slidably with one end portion of the piston via a shoe, the swashplate being disposed to enable to turn about a turning center to change the inclination that defines the stroke of the piston, the variable capacity piston pump comprising: a pressing portion disposed on one side with respect to the sliding contact surface of the swashplate, the pressing portion pressing a pressed portion of the swashplate to adjust the inclination of the swashplate between a maximum inclination and a minimum inclination, wherein a discharge capacity of the hydraulic fluid is maximized at the maximum inclination and the discharge capacity of the hydraulic fluid is minimized at the minimum inclination, and a swashplate return spring disposed on the other side with respect to the sliding contact surface of the swashplate, the swashplate return spring extending along one direction and biasing the pressed portion of the swashplate toward the one side of the sliding contact surface, wherein the swashplate return spring is capable of taking a first seat surface center position and a second seat surface center position, wherein the first seat surface center position is a position of a seat surface center on the swashplate side when the inclination of the swashplate is the maximum inclination and the second seat surface center position is a position of the seat surface center on the swashplate side when the inclination of the swashplate is the minimum inclination, and wherein there is a positional relationship in which a vertical reference line passes between the first seat surface center position and the second seat surface center position, the vertical reference line being a straight line perpendicular to a parallel reference line and passing through the turning center of the swashplate, the parallel reference line being a straight line parallel to an axial direction of the swashplate return spring and passing through the turning center of the swashplate.

[0008] In the variable capacity piston pump, there is a positional relationship in which the vertical reference line passes between the first seat surface center position which is the position of the seat surface center on the swashplate side when the inclination of the swashplate is the maximum inclination and the second seat surface center position which is the position of the seat surface center on the swashplate side when the inclination of the swashplate is the minimum inclination. When the position of the seat surface center on the swashplate side is on

the vertical reference line or near the vertical reference line, there is a small variation of the seat surface center positions in the directions of the vertical reference line. In the variable capacity piston pump according to the present invention, since the first seat surface center position and the second seat surface center position are positioned with the vertical reference line interposed therebetween, the position of the seat surface center on the swashplate side is on the vertical reference line or near the vertical reference line. Therefore, variation of the position of the seat surface center on the swashplate side in the directions of the vertical reference line can be reduced. Therefore, the swashplate return spring can be provided such that the deviation amount that the position of the seat surface center of the swashplate return spring deviates from the axial line of the swashplate return spring is decreased regardless of the inclination of the swashplate. Therefore, in a range from the maximum inclination to the minimum inclination of the swashplate, local bending of the end portion of the swashplate return spring on the swashplate side can be suppressed. Accordingly, functional deterioration in the swashplate return spring can be suppressed.

[0009] According to another aspect of the present invention, in the variable capacity piston pump, there may be a positional relationship in which the vertical reference line passes through a midpoint between the first seat surface center position and the second seat surface center position. In this case, the deviation amount of the position of the seat surface center on the swashplate side deviating from the axial line of the swashplate return spring when the inclination of the swashplate is the maximum inclination and the deviation amount of the position of the seat surface center on the swashplate side deviating from the axial line of the swashplate return spring when the inclination of the swashplate is the minimum inclination can be equal to each other. That is, the deviation amount of the position of the seat surface center on the swashplate side deviating from the axial line of the swashplate return spring does not excessively increase in any of cases where the inclination of the swashplate is the maximum inclination or the minimum inclination. Therefore, the deviation amount of the position of the seat surface center of the swashplate return spring deviating from the axial line of the swashplate return spring due to the displacement of the inclination of the swashplate can be minimized. Accordingly, local bending of the end portion of the swashplate return spring on the swashplate side due to the displacement of the inclination of the swashplate can be further suppressed.

[0010] According to another aspect of the present invention, in the variable capacity piston pump, the swashplate return spring may be disposed so that its axial direction thereof is parallel to the rotating shaft. In this case, assembly of the swashplate return spring in the variable capacity piston pump is facilitated.

Advantageous Effects of Invention

[0011] According to the various aspects of the present invention, a variable capacity piston pump capable of suppressing local bending of a swashplate return spring is provided.

Brief Description of Drawings

[0012]

FIG. 1 is a schematic sectional view illustrating a variable capacity piston pump according to an embodiment of the present invention.

FIG. 2 is a perspective view of a swashplate illustrated in FIG. 1.

FIG. 3 is a side view of the swashplate illustrated in FIG. 1 viewed from a side of a sliding contact surface.

FIG. 4 is a side view of the swashplate illustrated in FIG. 1 viewed on a side opposite to the sliding contact surface.

FIG. 5 is a view schematically illustrating the positional relationship between the sliding contact surface of the swashplate and a turning center of the swashplate.

FIG. 6 is a schematic view illustrating variation in the position of a seat surface center of a swashplate return spring.

FIG. 7 is a schematic view illustrating the position of a seat surface center of a swashplate return spring at a position different from that of FIG. 6.

FIG. 8 is a perspective view illustrating a swashplate according to a modification example.

Description of Embodiments

[0013] Hereinafter, an embodiment of the present invention will be described in detail with reference to the accompanying drawings. In the description, like elements which are the same or having the same function are denoted by like reference numerals, and overlapping description thereof will be omitted.

[0014] First, a variable capacity piston pump (hereinafter, "a pump") according to the embodiment will be described with reference to FIG. 1. A pump 1 includes a pump housing 10, a rotating shaft 20, and a cylinder block 14.

[0015] The pump housing 10 is configured by bonding a front housing 10a, a center housing 10b, and a rear housing 10c together, and has a crank chamber 12 therein.

[0016] Most of the rotating shaft 20 is accommodated in the crank chamber 12 of the pump housing 10, and only one end portion thereof protrudes from the pump housing 10. The rotating shaft 20 is rotatably held in the crank chamber 12 by a bearing. The end portion of the rotating shaft 20 protruding from the pump housing 10 is connected to a power take-off (not illustrated) such that

the entirety of the rotating shaft 20 is driven to rotate by an engine.

[0017] The cylinder block 14 is also accommodated in the crank chamber 12 of the pump housing 10. The cylinder block 14 is spline-fitted to the rotating shaft 20 so as to rotate integrally with the rotating shaft 20. In the cylinder block 14, a plurality of cylinder bores 14a, each including an opening on a side of the protruding end portion of the rotating shaft 20, are provided, and the plurality of cylinder bores 14a are disposed with intervals therebetween at a predetermined angle around the rotating shaft 20 in the cylinder block 14. In addition, in each of the plurality of cylinder bores 14a, a piston 16a having a head protruding toward the side of the protruding end portion of the rotating shaft 20 is accommodated.

[0018] A swashplate 30 is further accommodated in the crank chamber 12 of the pump housing 10. Hereinafter, the configuration of the swashplate 30 will be described with reference to FIGS. 2 to 4. FIG. 2 is a perspective view of the swashplate 30 illustrated in FIG. 1. FIG. 3 is a side view of the swashplate illustrated in FIG. 1 viewed from a side of a sliding contact surface. FIG. 4 is a side view of the swashplate illustrated in FIG. 1 viewed on a side opposite to the sliding contact surface.

[0019] As illustrated in FIGS. 2 to 4, the swashplate 30 includes a body portion 31, a pair of sliding portions 32, and a pressed portion 33.

[0020] The body portion 31 has a substantially plate shape, and the center portion thereof is provided with a through-hole 31a through which the above-described rotating shaft 20 is inserted. The pair of sliding portions 32 are provided at positions with the body portion 31 interposed therebetween to be integrated with the body portion 31.

[0021] The rear surface side of the body portion 31 and the sliding portions 32 become a flat surface 30a as illustrated in FIG. 3, and this surface is the sliding contact surface, which will be described later. On the other hand, the front surface side of the body portion 31 and the sliding portions 32 has a shape in which the sliding portions 32 protrude from the body portion 31 as illustrated in FIGS. 2 and 4. The section of the sliding portion 32 has a half-moon shape (D shape), and has a sliding surface 32a which is curved at a predetermined curvature so as to be convex toward the front surface side.

[0022] In addition, in the body portion 31, the pressed portion 33 which extends upward from the body portion 31 is provided. On the rear surface side in the pressed portion 33, an accommodation hole 33a is formed, and a cylindrical member 33b, which will be described later, is disposed in the accommodation hole 33a. In addition, the cylindrical member 33b may be disposed in a fixed state so as not to be turned, or may be disposed so as to be turned. In addition, on the front surface side in the pressed portion 33, at a position biased by the tip end portion of a swashplate return spring 60, a protruding portion 33c and a planar portion 33d with which the tip end portion of the swashplate return spring 60 is engaged

are formed.

[0023] Returning to FIG. 1, the position of the swashplate 30 is held by a swashplate receiving member 34 disposed on the front surface side thereof. The swashplate receiving member 34 has a support surface 34a having substantially the same curvature as that of the sliding surface 32a of the sliding portion 32 of the swashplate 30 described above. The swashplate 30 is disposed so as to cause the sliding surface 32a of the sliding portion 32 to come into contact with the support surface 34a of the swashplate receiving member 34 and is thus supported by the swashplate receiving member 34 to be oscillated along the curvature. More specifically, the swashplate 30 is capable of turning (regarded as tilting or regarded as rotating) about the center X of curvature of the support surface 34a of the swashplate receiving member 34 as the origin. The center X of curvature is also the center of curvature of the sliding surface 32a of the sliding portion 32 of the swashplate 30. In addition, the center X of curvature can be defined as a point at a constant distance (shortest distance) from the sliding contact surface 30a regardless of the turning position of the swashplate 30. In the following description, the center of curvature is referred to as a turning center X. In addition, in FIG. 1, the turning center X is denoted by a dot. However, the line of the turning center X extends in an inward direction (a direction perpendicular to the figure).

[0024] The swashplate 30 is disposed so as to turn about the turning center X and change the inclination that defines the stroke of the piston 16. For example, the inclination can be defined as an angle with respect to a straight line perpendicular to the axial line of the rotating shaft 20. In the embodiment, the inclination is defined as an angle of the sliding contact surface 30a with respect to the straight line perpendicular to the axial line of the rotating shaft 20.

[0025] The sliding contact surface 30a on the rear surface side of the swashplate 30 faces the cylinder block 14 side. The head (one end portion) of each piston 16 protruding from the cylinder block 14 comes into sliding contact with the sliding contact surface 30a via a shoe 36. The shoe 36 to which the head of the piston 16 attached is held in a disk-shaped retainer 35 having a hole into which the shoe 36 is inserted. When the cylinder block 14 is rotated along with the rotating shaft 20, each piston 16 rotates about the rotating shaft 20 while sliding on the sliding contact surface 30a via the shoe 36.

[0026] As the swashplate 30 is turned and inclined about the turning center X, the end portion of the head side (the left end portion in FIG. 1) of each piston 16 accommodated in the cylinder block 14 comes in pressing contact via the shoe 36, and the cylinder block 14 comes into pressing contact with a valve plate 40 fixed to the inner end wall surface of the rear housing 10c.

[0027] In addition, as the cylinder block 14 and the rotating shaft 20 rotate integrally with each other, the stroke of each piston 16 defined by the inclination of the swashplate 30 is reciprocated, and the cylinder bore 14a alter-

nately communicates with a suction port 40a and a discharge port 40b forming an arc shape, which are provided to penetrate through the valve plate 40. Accordingly, hydraulic oil is suctioned into the cylinder bore 14a from the suction port 40a, and the hydraulic oil in the cylinder bore 14a is discharged from the discharge port 40b due to a pump action. In addition, a suction passage 10d and a discharge passage 10e are formed in the rear housing 10c to respectively communicate with the suction port 40a and the discharge port 40b.

[0028] The pump 1 is further provided with a control piston 50 provided on the rear surface side of the swashplate 30, that is, on the cylinder block 14 side. The control piston 50 is provided at a side portion of the center housing 10b of the pump housing 10, and includes a housing 52 that communicates with the crank chamber 12 and a piston portion 58 that reciprocates in the housing 52. The housing 52 has a substantially cylindrical shape extending in a direction inclined with respect to the rotating shaft 20 so as to cause the piston portion 58 to face the pressed portion 33 of the swashplate 30.

[0029] One opening of the openings of the housing 52 distant from the swashplate 30 is blocked by a screw 54. Accordingly, a piston accommodation chamber 56 is defined in the housing 52, and the piston portion 58 is accommodated in the piston accommodation chamber 56.

[0030] The piston portion 58 has a columnar external shape. The diameter of the piston portion 58 is designed such that there is no gap from the inner wall surface of the piston accommodation chamber 56 and the piston portion 58 slides in the piston accommodation chamber 56. The end surface of the piston portion 58 on the swashplate 30 is a planar shape and can move to a position that comes into contact with the cylindrical member 33b in the pressed portion 33 of the swashplate 30. As illustrated in FIG. 1, the end surface of the piston portion 58 on the swashplate 30 side, which is a pressing portion, comes into contact with the cylindrical member 33b of the pressed portion 33 of the swashplate 30 to always press the cylindrical member 33b with a predetermined pressing force.

[0031] A space between the piston portion 58 and the screw 54 in the piston accommodation chamber 56 functions as a control chamber 56a into which the hydraulic oil flows. The pressure in the control chamber 56a (hereinafter, referred to as control pressure) is changed due to the inflow of the hydraulic oil. The control piston 50 causes the piston portion 58 to slide due to a change in the control pressure and press the swashplate 30 from the cylinder block 14 side. Accordingly, the control piston 50 adjusts the inclination of the swashplate 30 between the maximum inclination, at which the discharge capacity of the hydraulic oil is maximized, and the minimum inclination, at which the discharge capacity of the hydraulic oil is minimized.

[0032] The pump 1 further includes the swashplate return spring 60 which is a cylindrical spiral shape (coil spring) extending in one direction on the front surface

side of the swashplate 30. That is, the swashplate return spring 60 is disposed on the side opposite to the control piston 50 with respect to the sliding contact surface 30a of the swashplate 30. Specifically, the base end portion of the swashplate return spring 60 is accommodated in a spring chamber 70 formed in the front housing 10a of the pump housing 10.

[0033] In the embodiment, the spring chamber 70 is formed in parallel to the rotating shaft 20, and the swashplate return spring 60 extends toward the swashplate 30 from the spring chamber 70. As a result, the swashplate return spring 60 is disposed so that the axial direction thereof is parallel to the rotating shaft 20. The tip end portion of the swashplate return spring 60 abuts the front surface of the pressed portion 33 of the swashplate 30 described above and is engaged with the protruding portion 33c and the planar portion 33d formed on the front surface. The swashplate return spring 60 is not fixed to the spring chamber 70 and the swashplate 30 and the position and posture thereof are held in a state of being interposed between the spring chamber 70 and the pressed portion 33.

[0034] In other words, regarding the seat surfaces (spring end surfaces) of the swashplate return spring 60, a seat surface 60a of the base end portion abuts the bottom wall of the spring chamber 70, and a seat surface 60b of the tip end portion abuts the pressed portion 33 of the swashplate 30. Accordingly, the swashplate return spring 60 is compressed such that the swashplate 30 is biased toward the cylinder block side with respect to the sliding contact surface 30a. In addition, the swashplate return spring 60 is a wire spring formed by processing a metallic wire rod such as SWP-B.

[0035] Next, with reference to FIGS 5 and 6, the position of a seat surface center of the swashplate return spring 60 on the swashplate 30 side will be described in detail. Here, the seat surface center of the swashplate return spring 60 on the swashplate 30 side is the center in the seat surface 60b of the swashplate return spring 60 on the swashplate 30 side (tip end side), and for example, refers to a position at an equivalent distance from all the points on the outer circumference of the seat surface 60b. In the embodiment, since the swashplate return spring 60 has a cylindrical spiral shape, the shape of the seat surface 60b (that is, the sectional shape of the tip end portion of the swashplate return spring 60) is a circular shape, and the center of the circle may be defined as the seat surface center. Hereinafter, the center in the seat surface 60b of the swashplate return spring 60 on the swashplate 30 side is referred to as the seat surface center of the swashplate return spring 60.

[0036] First, references such as the turning center X, the vertical reference line and the parallel reference line for the position of the seat surface center of the swashplate return spring 60 will be described. FIG. 5 is a view schematically illustrating the positional relationship between the sliding contact surface 30a of the swashplate 30 and the turning center X of the swashplate 30. In ad-

dition, in FIG. 5, the turning center X is denoted by a dot. However, the line of the turning center X extends in an inward direction (a direction perpendicular to the figure).

[0037] As illustrated in FIG. 5, a distance d from the sliding contact surface 30a of the swashplate 30 to the turning center X at the maximum inclination indicated by "Max" and a distance d from the sliding contact surface 30a of the swashplate 30 to the turning center X at the minimum inclination indicated by "Min" are the same. That is, the distance of the turning center X from the sliding contact surface 30a is constant regardless of the inclination of the swashplate 30. In addition, in a section, an imaginary circle E that touches both the sliding contact surface 30a of the swashplate 30 at the maximum inclination and the sliding contact surface 30a of the swashplate 30 at the minimum inclination is drawn as a circle having the turning center X as its center. That is, the turning center X can be defined as a central axial line of a column having, as its section, the imaginary circle E that touches the sliding contact surface 30a of the swashplate 30 regardless of the inclination of the swashplate 30.

[0038] The parallel reference line Y is a straight line which is parallel to the axial direction of the swashplate return spring 60 and passes through the turning center X. In the embodiment, since the axial line of the swashplate return spring 60 is parallel to the rotating shaft 20, the parallel reference line Y is a line parallel to the rotating shaft 20. A straight line that is perpendicular to the parallel reference line Y and passes through the turning center X is defined as the vertical reference line Z.

[0039] FIG. 6 is a schematic view illustrating variation in the position of the seat surface center of the swashplate return spring 60 due to the displacement of the inclination of the swashplate 30 in the pump 1. In FIG. 6, the parallel reference line Y, the vertical reference line Z, and the turning center X shown in FIG. 5 are shown. In FIG. 6, furthermore, the axial line of the swashplate return spring 60 is indicated by axial line S.

[0040] In FIG. 6, variation in the position of the seat surface center of the swashplate return spring 60 in the pump 1 according to the embodiment is indicated by a double-headed arrow A. The double-headed arrow A represents that the position of the seat surface center of the swashplate return spring 60 varies between a position of the seat surface center of the swashplate return spring 60 when the inclination of the swashplate 30 is the maximum inclination (hereinafter, referred to as a first seat surface center position) A1, and a position of the seat surface center of the swashplate return spring 60 when the inclination of the swashplate 30 is the minimum inclination (hereinafter, referred to as a second seat surface center position) A2. The angular difference between the maximum inclination and the minimum inclination of the swashplate 30 is indicated by θ . As illustrated in FIG. 6, the position of the seat surface center of the swashplate return spring 60 moves between the first seat surface center position A1 and the second seat surface center

position A2 along an arc of the imaginary circle having the turning center X as its center. This is because the distance between the pressed portion 33 of the swashplate 30 at which the seat surface center of the swashplate return spring 60 is positioned and the turning center X is always constant regardless of the inclination.

[0041] As indicated by the double-headed arrow A of FIG. 6, in the pump 1 according to the embodiment, for example, when viewed in a direction perpendicular to a plane parallel to the parallel reference line Y and the vertical reference line Z (a direction perpendicular to the figure), the vertical reference line Z passes between the first seat surface center position A1 when the inclination of the swashplate 30 is the maximum inclination and the second seat surface center position A2 when the inclination of the swashplate 30 is the minimum inclination. That is, the vertical reference line Z is interposed between the first seat surface center position A1 when the inclination of the swashplate 30 is the maximum inclination and the second seat surface center position A2 when the inclination of the swashplate 30 is the minimum inclination.

[0042] In a case where the first seat surface center position A1, the second seat surface center position A2, and the vertical reference line Z have this positional relationship, as illustrated in FIG. 6, the position of the seat surface center of the swashplate return spring 60 moves just beside the position of the seat surface center in the range of the double-headed arrow A, and there is substantially no displacement in upward and downward directions (that is, directions of the vertical reference line Z) of FIG. 6. Therefore, even when the inclination of the swashplate 30 moves from the maximum inclination to the minimum inclination and accordingly the position of the seat surface center of the swashplate return spring 60 moves from the first seat surface center position A1 to the second seat surface center position A2, the position of the seat surface center of the swashplate return spring 60 barely changes in the directions of the vertical reference line Z.

[0043] Therefore, by disposing the swashplate return spring 60 so as to cause the axial line S to approach the first seat surface center position A1 and the second seat surface center position A2, the deviation amount of the position of the seat surface center of the swashplate return spring 60 deviating from the axial line S at the position of the maximum inclination (A1), at the position of the minimum inclination (A2), and the position of an arbitrary inclination therebetween is suppressed.

[0044] In FIG. 6, for comparison, cases where the vertical reference line Z does not pass between the first seat surface center position and the second seat surface center position of the swashplate return spring 60 are indicated by double-headed arrows B and C. In addition, in any case of the double-headed arrows B and C, the difference θ between the maximum inclination and the minimum inclination of the swashplate 30 is the same as the difference θ of the double-headed arrow A described

above.

[0045] The double-headed arrow B indicates the amount of variation in the position of the seat surface center of the swashplate return spring 60 in a case where both a first seat surface center position B1 and a second seat surface center position B2 of the swashplate return spring 60 are positioned on the swashplate return spring 60 side in relation to the vertical reference line Z. As illustrated in FIG. 6, when the inclination of the swashplate 30 changes from the maximum inclination to the minimum inclination and accordingly the position of the seat surface center of the swashplate return spring 60 moves from the first seat surface center position B 1 to the second seat surface center position B2, the position of the seat surface center of the swashplate return spring 60 gradually moves in a downward direction and significantly displaces in the directions of the vertical reference line Z. That is, in the case where both the first seat surface center position B1 and the second seat surface center position B2 are positioned on the swashplate return spring 60 side in relation to the vertical reference line Z, compared to the case where the vertical reference line Z passes between the first seat surface center position A1 and the second seat surface center position A2, displacement of the position of the seat surface center of the swashplate return spring 60 in the directions of the vertical reference line Z is increased.

[0046] Therefore, regard the case of the double-headed arrow B, even when the swashplate return spring 60 is disposed so as to cause the axial line S to be set closely to any of the position of the maximum inclination (B1) and the position of the minimum inclination (B2), the position of the seat surface center of the swashplate return spring 60 significantly deviates from the axial line S during the operation.

[0047] The double-headed arrow C indicates the amount of variation in the position of the seat surface center of the swashplate return spring 60 in a case where both a first seat surface center position C1 and a second seat surface center position C2 are positioned on the control piston 50 side in relation to the vertical reference line Z. As illustrated in FIG. 6, when the inclination of the swashplate 30 changes from the maximum inclination to the minimum inclination and accordingly the position of the seat surface center of the swashplate return spring 60 moves from the first seat surface center position C 1 to the second seat surface center position C2, the position of the seat surface center of the swashplate return spring 60 gradually moves in an upward direction and significantly displaces in the directions of the vertical reference line Z. That is, even in the case where both the first seat surface center position C1 and the second seat surface center position C2 are positioned on the control piston side in relation to the vertical reference line Z, compared to the case where the vertical reference line Z passes between the first seat surface center position A1 and the second seat surface center position A2, displacement of the position of the seat surface center of the swash-

plate return spring 60 in the directions of the vertical reference line Z is increased.

[0048] Therefore, regard the case of the double-headed arrow C, similarly to the case of the double-headed arrow B, even when the swashplate return spring 60 is disposed so as to cause the axial line S to be set closely to any of the position of the maximum inclination (C1) and the position of the minimum inclination (C2), the position of the seat surface center of the swashplate return spring 60 also significantly deviates from the axial line S during the operation.

[0049] As described above, in the pump 1 according to the embodiment, there is a positional relationship in which the vertical reference line Z passes between the first seat surface center position A1 of the swashplate return spring 60 and the second seat surface center position A2 of the swashplate return spring 60. When the position of the seat surface center of the swashplate return spring 60 on the swashplate 30 side is on the vertical reference line Z or near the vertical reference line Z, there is a small variation in the directions of the vertical reference line Z. In the pump 1 described above, since the first seat surface center position A1 and the second seat surface center position A2 are positioned with the vertical reference line Z interposed therebetween, the position of the seat surface center on the swashplate 30 side is on the vertical reference line Z or near the vertical reference line Z. Therefore, variation of the position of the seat surface center on the swashplate 30 side in the directions of the vertical reference line Z can be reduced. Therefore, the swashplate return spring 60 can be provided such that the amount of the position of the seat surface center of the swashplate return spring 60 deviating from the axial line S of the swashplate return spring 60 is decreased regardless of the inclination of the swashplate 30. Accordingly, functional deterioration in the swashplate return spring 60 can be suppressed.

[0050] In addition, the positional relationship in which the vertical reference line Z passes between the first seat surface center position A1 of the swashplate return spring 60 and the second seat surface center position A2 of the swashplate return spring 60, that is, the positional relationship in which the vertical reference line Z is interposed between the first seat surface center position A1 and the second seat surface center position A2 includes a positional relationship in which the vertical reference line Z overlaps the first seat surface center position A1 or the second seat surface center position A2.

[0051] In the pump 1 according to the embodiment, the swashplate return spring 60 is disposed so that the axial line thereof is parallel to the rotating shaft 20. The swashplate return spring 60 is assembled between the front housing 10a and the center housing 10b which are arranged in the direction of the rotating shaft 20. When the front housing 10a and the center housing 10b are joined to each other, a pressing force along the axial line of the rotating shaft 20 is exerted. Therefore, when the direction of the force is the same as the axial direction of the swash-

plate return spring 60, assembly of the swashplate return spring 60 is facilitated. Furthermore, the pump 1 is generally designed on the basis of the axial line of the rotating shaft 20. Therefore, when the spring chamber 70 provided in the front housing 10a or the swashplate return spring 60 extending from the spring chamber 70 are disposed in parallel to the rotating shaft 20, design is facilitated.

[0052] In addition, typically, in preparation of local bending of the tip end portion of the swashplate return spring, a region where movement of the bent end portion is expected is excessively secured. In this case, miniaturization of the pump is hindered, or an increase in the dimensions of the pump is incurred. Contrary to this, according to the pump 1 according to the embodiment, local bending of the swashplate return spring 60 can be suppressed. Therefore, there is no need to secure a large region, and miniaturization of the pump housing 10 can be realized.

[0053] In addition, as indicated by the double-headed arrow A of FIG. 7, the positional relationship between the first seat surface center position A1, the second seat surface center position A2, and the vertical reference line Z may be an embodiment in which the vertical reference line Z passes through a midpoint P which is the point that bisects a straight line that connects the first seat surface center position A1 and the second seat surface center position A2. In this case, the vertical reference line is coincident with the perpendicular bisector of the straight line that connects the first seat surface center position A1 and the second seat surface center position A2.

[0054] At this time, when the swashplate return spring 60 is disposed so as to cause the axial line S thereof to pass through the first seat surface center position A1, the axial line S also passes through the second seat surface center position A2 and the midpoint P. That is, the first seat surface center position A1, the second seat surface center position A2, and the midpoint P are arranged along the direction of the axial line S, and there is no positional offset in the directions of the vertical reference line Z.

[0055] Here, regarding the case of the double-headed arrow A of FIG. 6, when the radius of an imaginary circle on which the position of the seat surface center of the swashplate return spring 60 moves is referred to as r and the inclination of the straight line that connects the second seat surface center position A2 and the turning center X is referred to as θ' , the amount of the position of the seat surface center of the swashplate return spring 60 between the first seat surface center position A1 and the second seat surface center position A2 deviating from the axial line S becomes $r(1-\cos\theta')$. Contrary to this, regarding the double-headed arrow A of FIG. 7, the difference θ of the double-headed arrow A is bisected into the swashplate return spring 60 side and the control piston 50 side. Therefore, both the inclination of the straight line that connects the first seat surface center position A1 and the turning center X with respect to the vertical ref-

erence line Z and the inclination of the straight line that connects the second seat surface center position A2 and the turning center X become $\theta/2$, which is smaller than θ' . Therefore, the deviation amount of the seat surface center of the swashplate return spring 60 between the first seat surface center position A1 and the second seat surface center position A2 deviating from the axial line S is represented by $r(1-\cos(\theta/2))$. As described above, in the case where the vertical reference line Z passes through the midpoint P, the amount of the position of the position of the seat surface center of the swashplate return spring 60 deviating from the axial line S of the swashplate return spring 60 due to the displacement of the inclination of the swashplate 30 can be minimized. Accordingly, local bending of the end portion of the swashplate return spring 60 on the swashplate 30 side due to the displacement of the inclination of the swashplate 30 can be further suppressed.

[0056] While various embodiments of the present invention have been described, the present invention is not limited to the embodiments, and includes modifications without departing from the gist described in the appended claims and applications to other forms.

[0057] The swashplate 30 is not limited to that in the embodiment. For example, instead of the swashplate 30, a swashplate 130 having a shape illustrated in FIG. 8 may be employed.

[0058] The swashplate 130 includes a pair of rotating shaft portions 132 instead of the pair of sliding portions 32 of the swashplate 30. The above-described swashplate 30 has a form that rotates about the turning center X by cooperation between the sliding portions 32 and the swashplate receiving member 34. However, the swashplate 130 can rotate about the turning center X since the pair of rotating shaft portions 132 having a columnar shape extending along the turning center X are rotatably held in the crank chamber 12. The swashplate 130 also includes a disk-shaped body portion 131 having the same function as that of the body portion 31 of the swashplate 30 described above. The body portion 131 includes a sliding contact surface 130a, which is the same as the sliding contact surface 30a, on the rear surface side thereof and further includes a pressed portion 133 which is the same as the pressed portion 33 at the upper portion thereof. The swashplate 130 illustrated in FIG. 8 has functions which are the same as or equivalent to those of the swashplate 30 described above. Moreover, since the swashplate 130 includes the pair of rotating shaft portions 132, the swashplate receiving member 34 described above becomes unnecessary, and simplification of the configuration of the pump 1 can be achieved.

Reference Signs List

[0059]

1 variable capacity piston pump

14	cylinder block	
16	piston	
20	rotating shaft	
30, 130	swashplate	
30a	sliding contact surface	5
33, 133	pressed portion	
58	piston portion (pressing portion)	
60	swashplate return spring	
X	turning center	
Y	parallel reference line	10
Z	vertical reference line	
A1	first seat surface center position	
A2	second seat surface center position	

the first seat surface center position and the second seat surface center position, the vertical reference line being a straight line perpendicular to a parallel reference line and passing through the turning center of the swashplate, the parallel reference line being a straight line parallel to an axial direction of the swashplate return spring and passing through the turning center of the swashplate.

Claims

1. A variable capacity piston pump performing suction and discharge of a hydraulic fluid by reciprocation of a piston in a cylinder block rotating integrally with a rotating shaft, the stroke of the reciprocation of the piston depending on an inclination of a swashplate, wherein the swashplate includes a sliding contact surface contacting slidably with one end portion of the piston via a shoe, the swashplate being disposed to enable to turn about a turning center to change the inclination that defines the stroke of the piston, the variable capacity piston pump comprising:

a pressing portion disposed on one side with respect to the sliding contact surface of the swashplate, the pressing portion pressing a pressed portion of the swashplate to adjust the inclination of the swashplate between a maximum inclination and a minimum inclination, wherein a discharge capacity of the hydraulic fluid is maximized at the maximum inclination and the discharge capacity of the hydraulic fluid is minimized at the minimum inclination, and a swashplate return spring disposed on the other side with respect to the sliding contact surface of the swashplate, the swashplate return spring extending along one direction and biasing the pressed portion of the swashplate toward the one side of the sliding contact surface, wherein the swashplate return spring is capable of taking a first seat surface center position and a second seat surface center position, wherein the first seat surface center position is a position of a seat surface center on the swashplate side when the inclination of the swashplate is the maximum inclination and the second seat surface center position is a position of the seat surface center on the swashplate side when the inclination of the swashplate is the minimum inclination, and wherein there is a positional relationship in which a vertical reference line passes between

2. The variable capacity piston pump according to claim 1, wherein there is a positional relationship in which the vertical reference line passes through a midpoint between the first seat surface center position and the second seat surface center position.

3. The variable capacity piston pump according to claim 1 or 2, wherein the swashplate return spring is disposed so that the axial direction thereof is parallel to the rotating shaft.

Fig.1

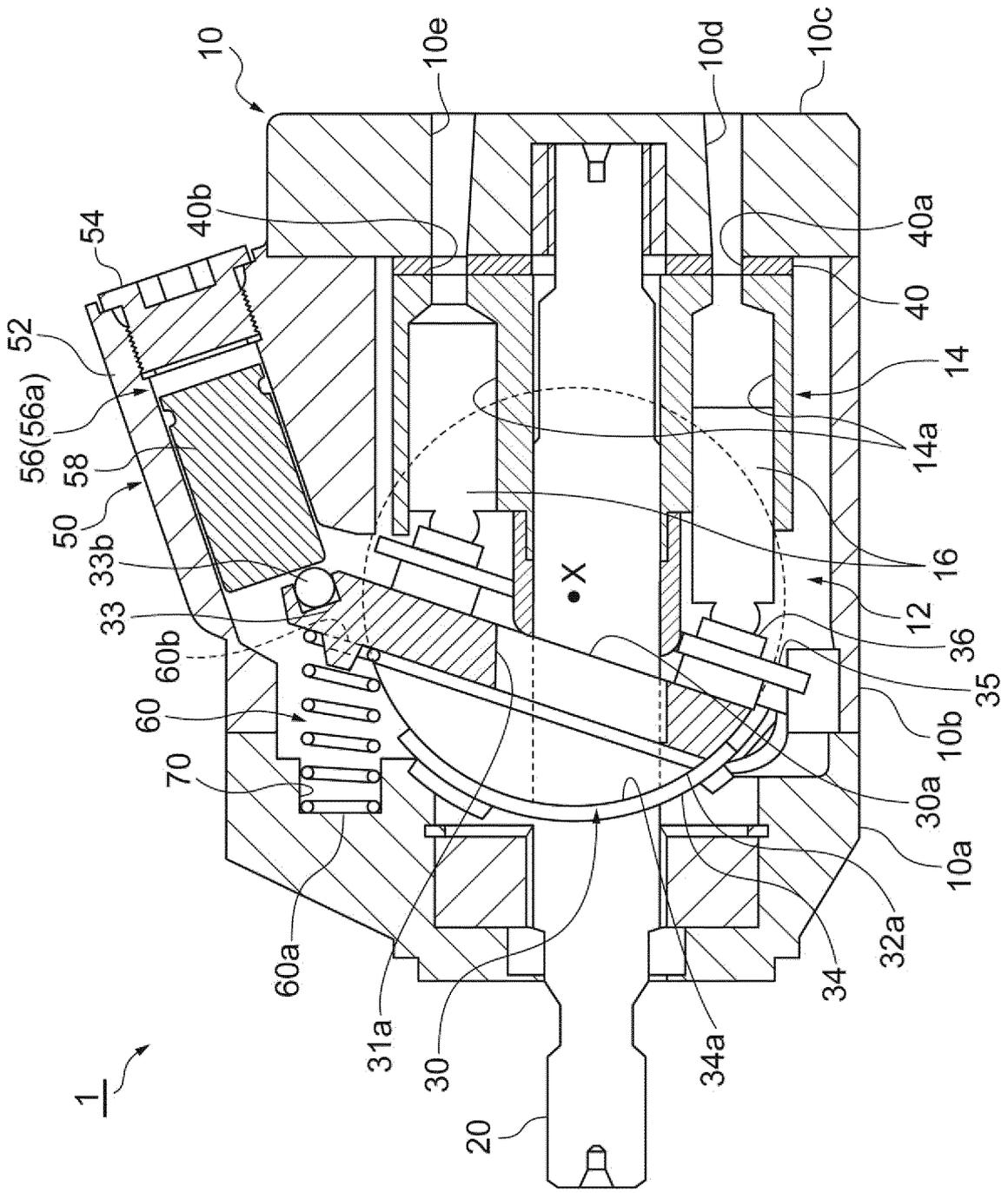


Fig.2

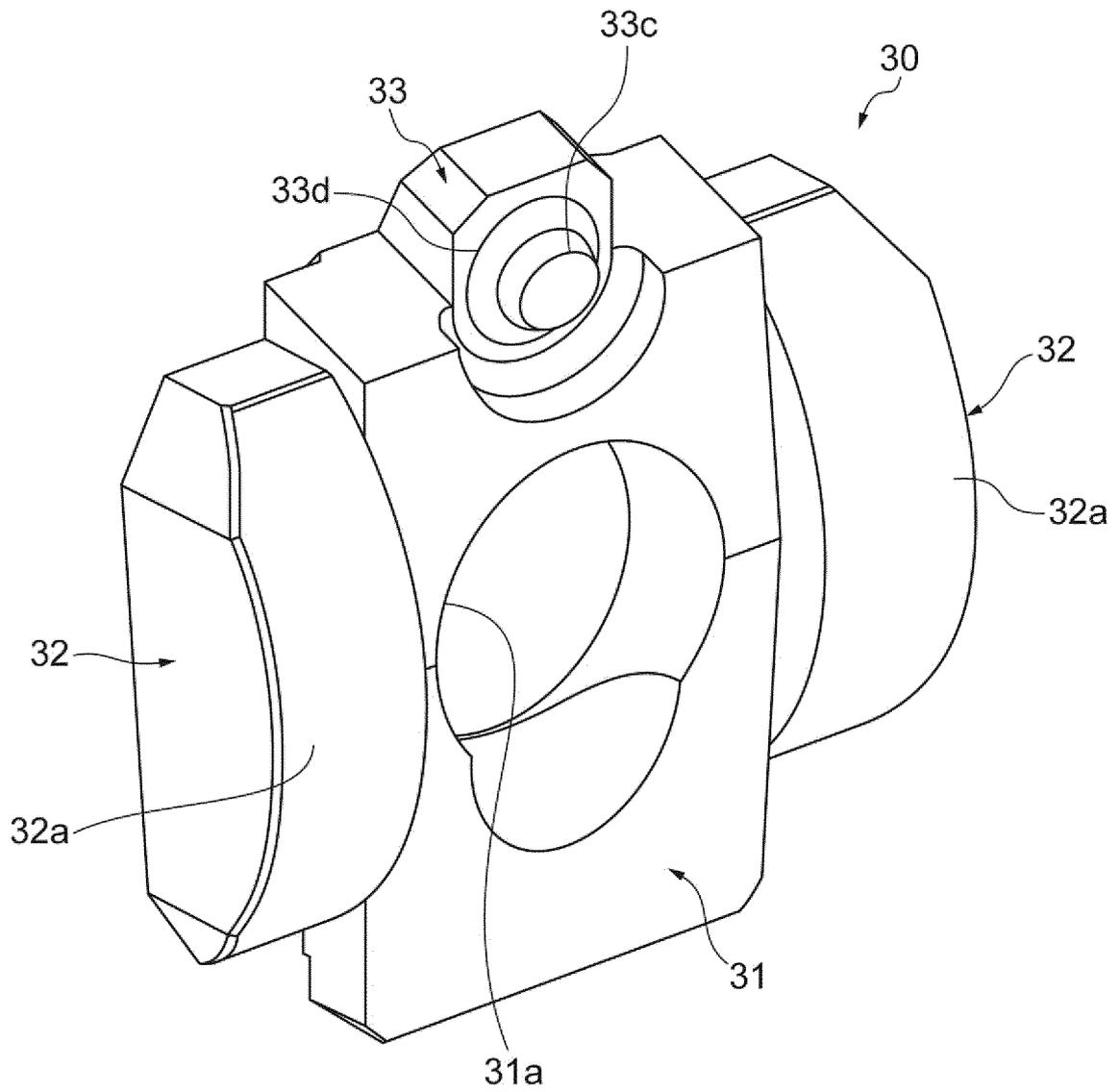


Fig.3

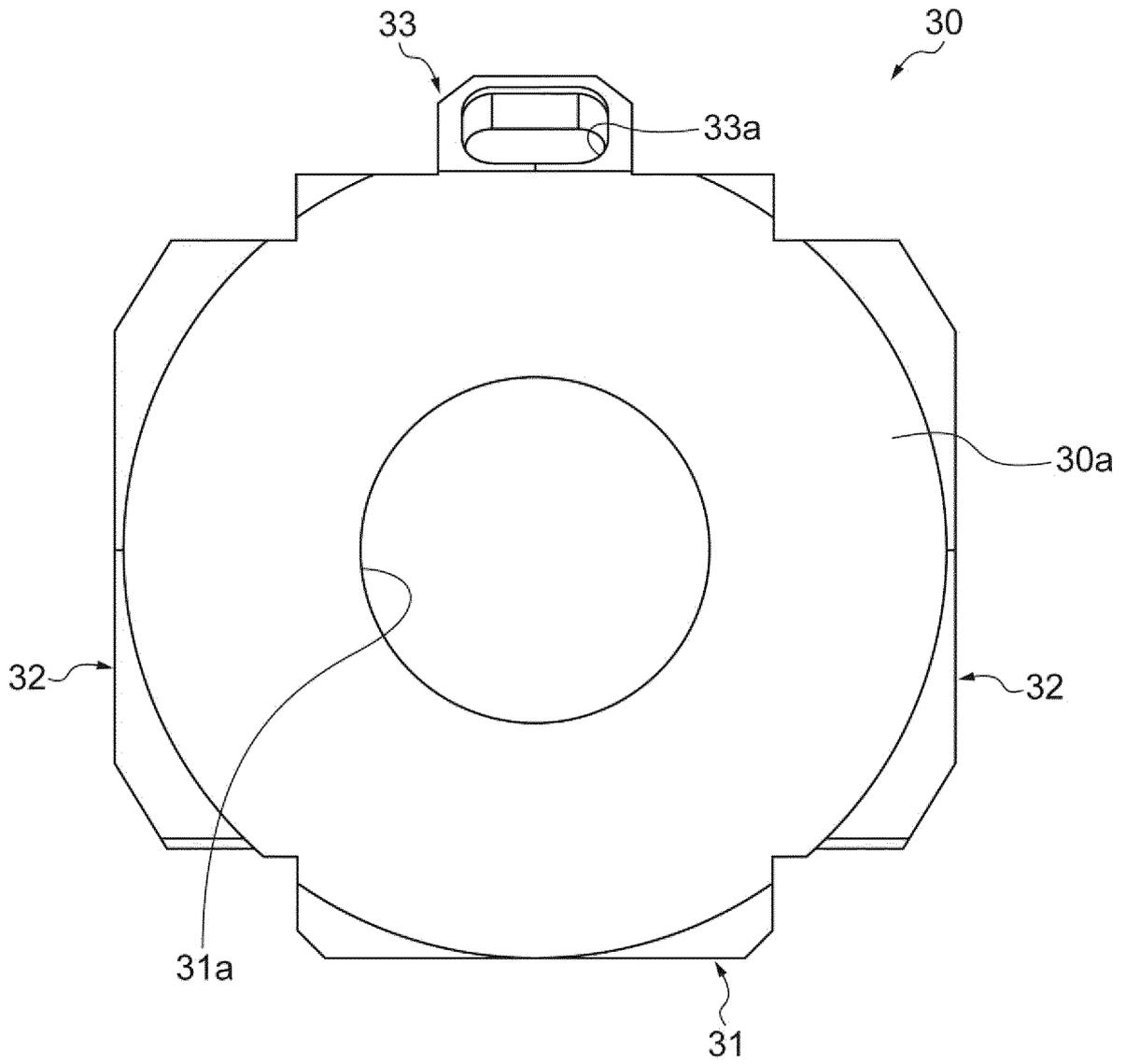


Fig.4

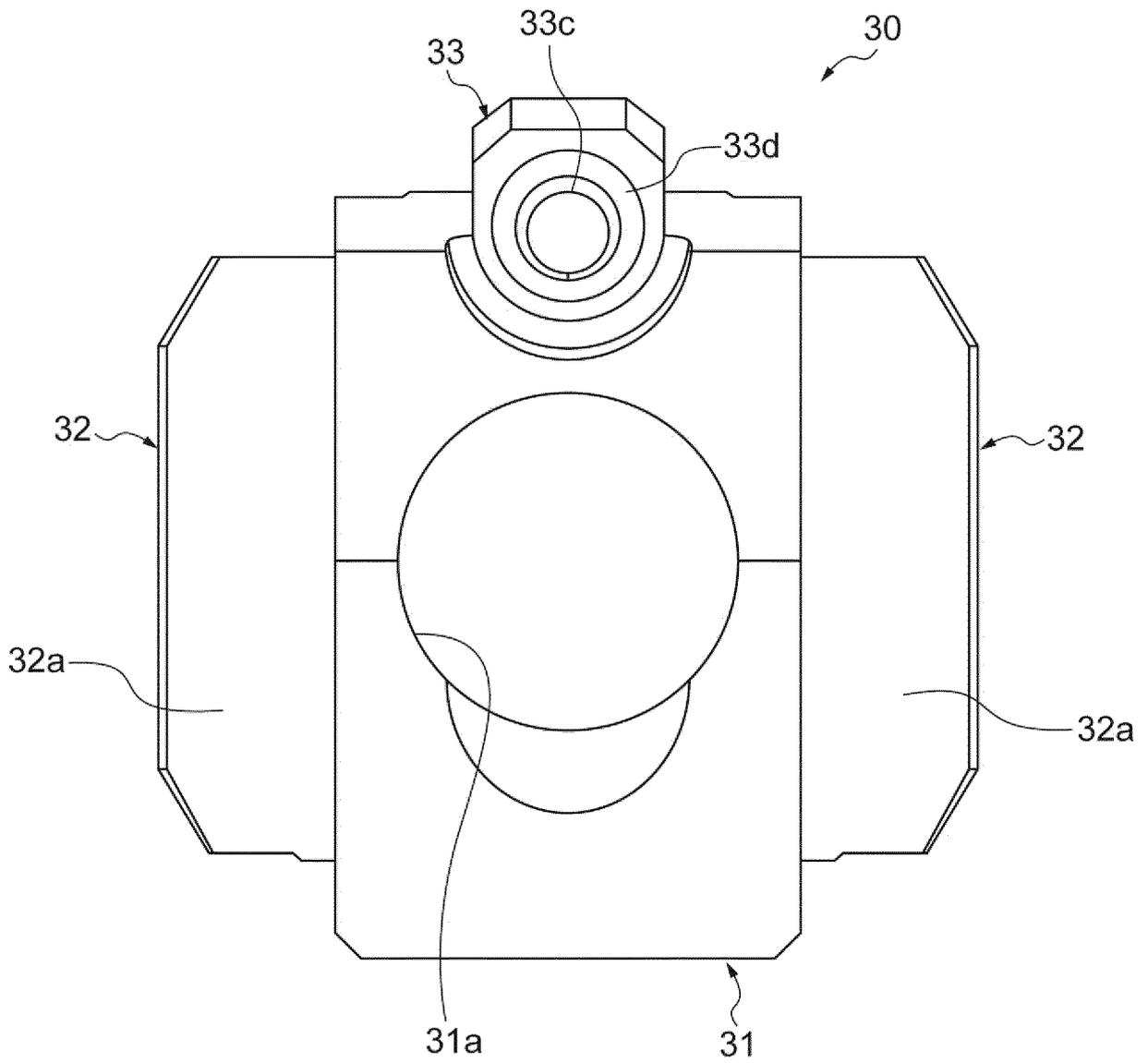


Fig.5

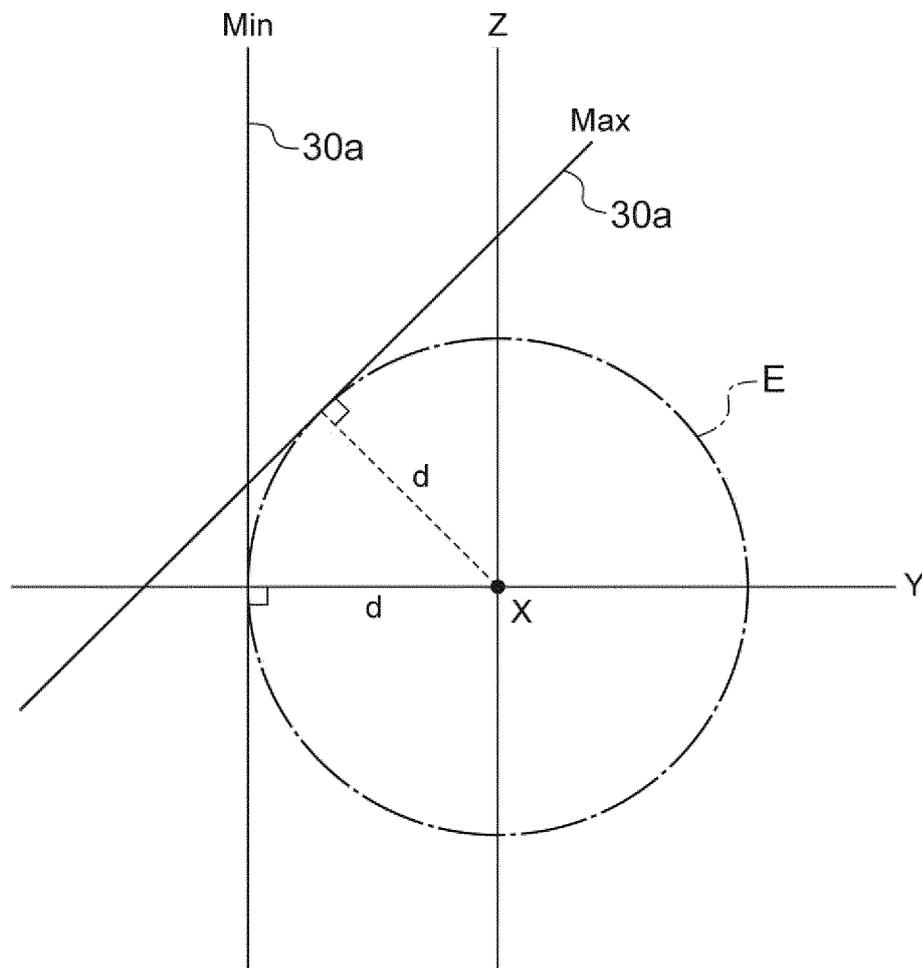


Fig.6

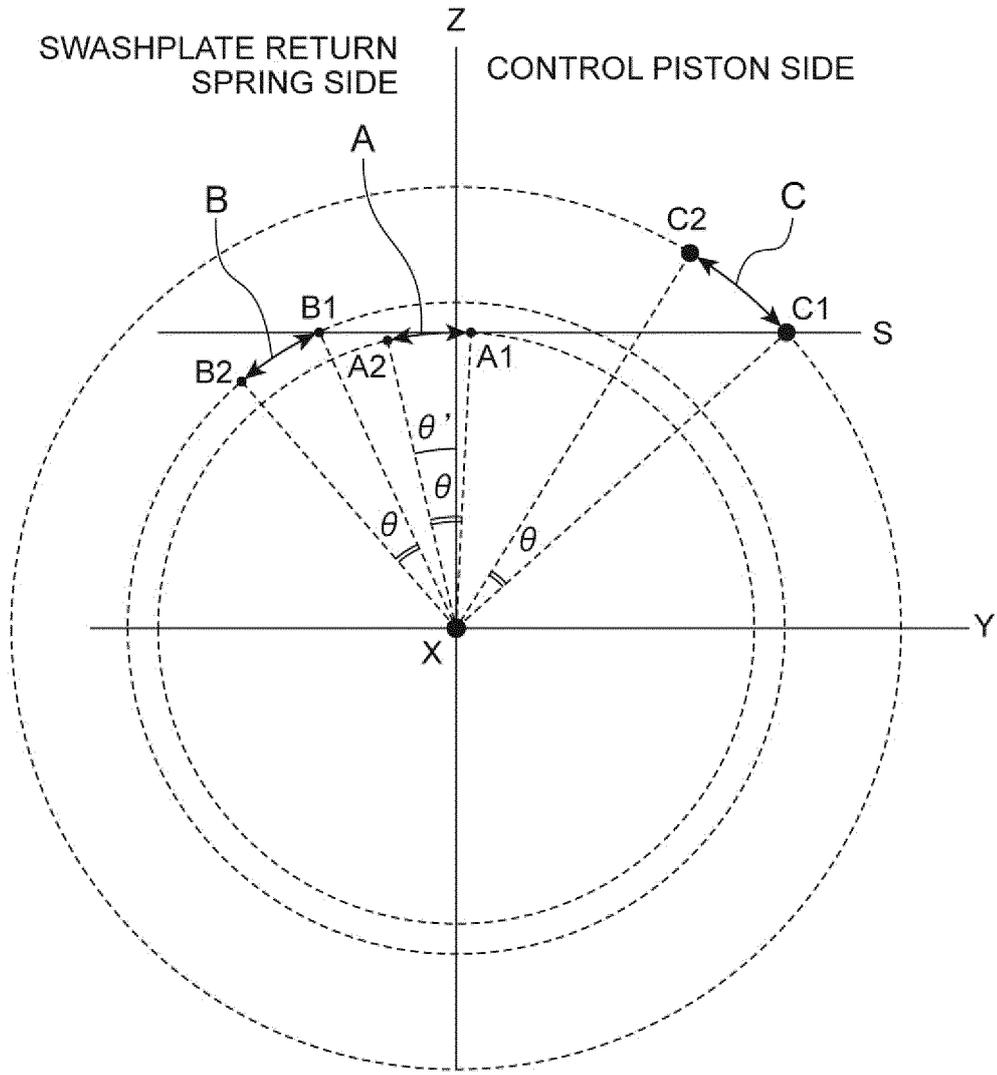


Fig.7

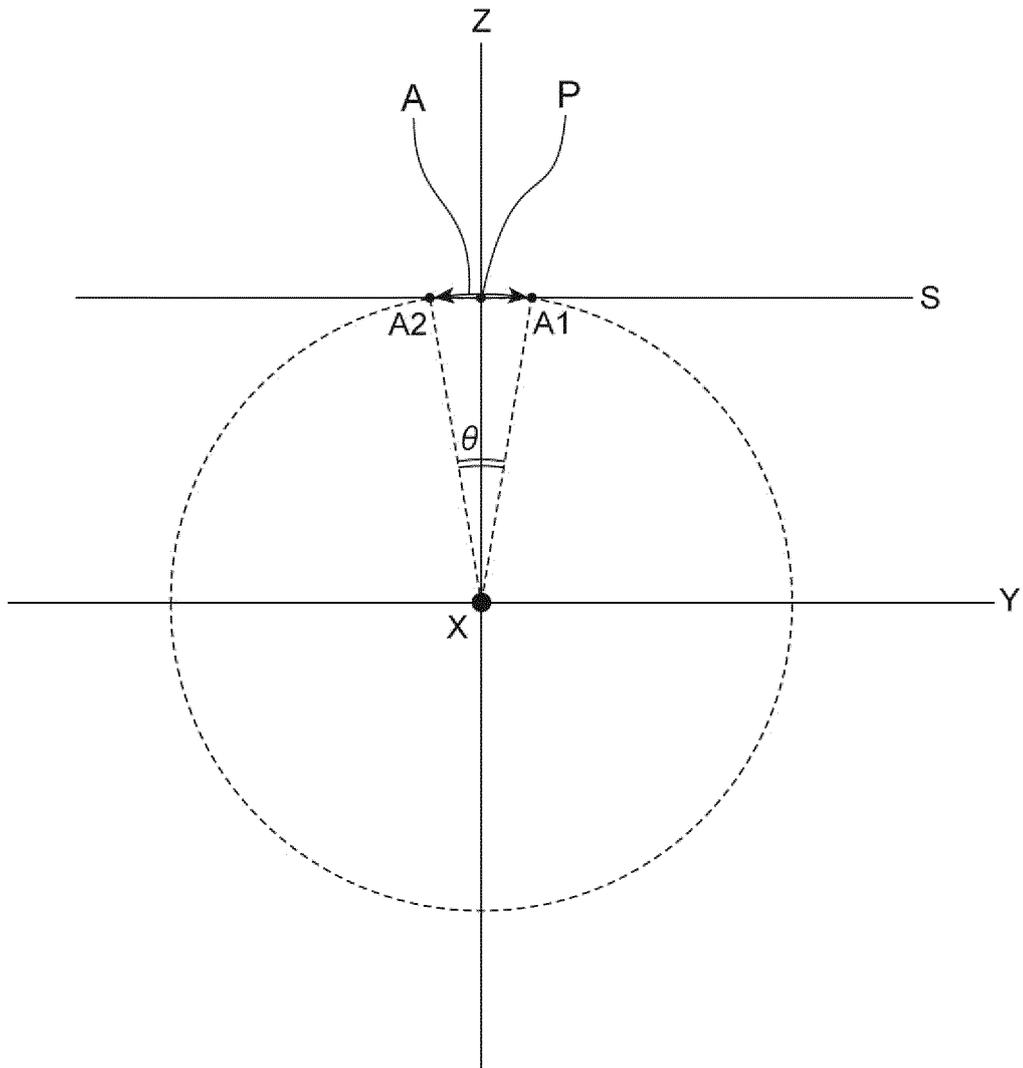
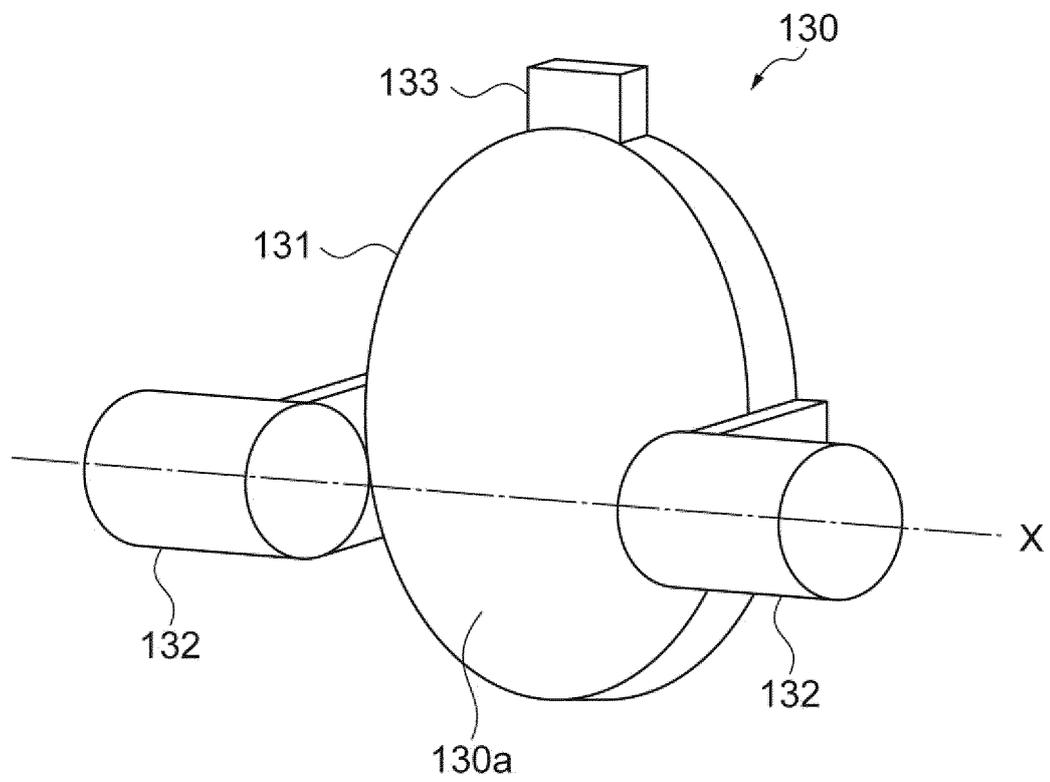


Fig.8



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2015/069137

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A. CLASSIFICATION OF SUBJECT MATTER
F04B1/32(2006.01) i

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

10

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
F04B1/32

15

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 1996-2015
Kokai Jitsuyo Shinan Koho 1971-2015 Toroku Jitsuyo Shinan Koho 1994-2015

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

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C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2009-542966 A (Robert Bosch GmbH), 03 December 2009 (03.12.2009), fig. 1 & JP 5232780 B2 & WO 2008/006508 A2 & DE 102006042677 A1 & CN 101443549 A	1-3
A	US 5515829 A (Jerry A. WEAR), 14 May 1996 (14.05.1996), fig. 6 to 7 (Family: none)	1-3

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Further documents are listed in the continuation of Box C. See patent family annex.

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* Special categories of cited documents:
 "A" document defining the general state of the art which is not considered to be of particular relevance
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 "&" document member of the same patent family

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Date of the actual completion of the international search
15 September 2015 (15.09.15)

Date of mailing of the international search report
06 October 2015 (06.10.15)

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Name and mailing address of the ISA/
Japan Patent Office
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Tokyo 100-8915, Japan

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INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2015/069137

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 10844/1987 (Laid-open No. 119885/1988) (Kayaba Industry Co., Ltd.), 03 August 1988 (03.08.1988), fig. 1 to 2 (Family: none)	1-3
A	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 56721/1987 (Laid-open No. 164575/1988) (Nachi-Fujikoshi Corp.), 26 October 1988 (26.10.1988), fig. 2 to 3 (Family: none)	1-3

REFERENCES CITED IN THE DESCRIPTION

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