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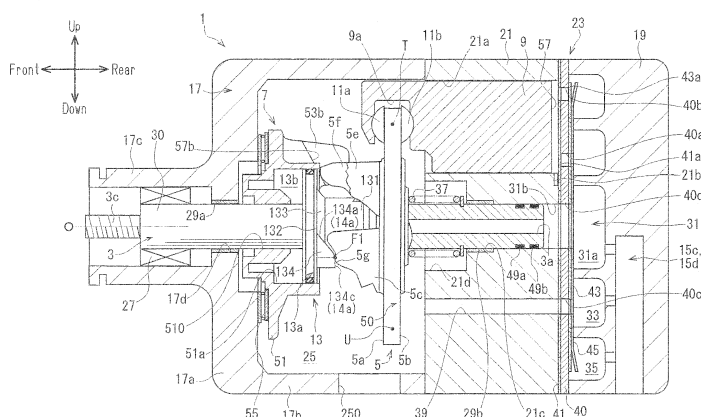
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(54) **VARIABLE DISPLACEMENT SWASH-PLATE COMPRESSOR**

(57) A variable displacement swash-plate compressor includes an actuator (13) that is configured to change the inclination angle of a swash plate (5). The actuator (13) includes a movable body (13a) that moves along a drive shaft axis (O). The movable body (13a) includes an acting portion (14a) that is configured to push the swash plate (5) with the pressure in a control pressure chamber (13b). The swash plate (5) includes a receiving portion (5g) that contacts and is pushed by the acting portion

(14a). The acting portion (14a) and the receiving portion (5g) contact each other at an acting position (F1). A bottom dead center associated part (U) for positioning the piston (9) at a bottom dead center is defined on the swash plate (5). When the inclination angle is minimized, the acting position (F1) is located at a position closer to the bottom dead center associated part (U) than the drive shaft axis (O).

Fig.1



Description

BACKGROUND OF THE INVENTION

[0001] The present invention relates to a variable displacement swash-plate compressor.

[0002] Japanese Laid-Open Patent Publication No. 52-131204 discloses a conventional variable displacement swash-plate compressor (hereinafter, referred to as a compressor). The compressor includes a swash plate chamber, cylinder bores, a suction chamber, and a discharge chamber, which are provided in the housing. A drive shaft is rotationally supported in the housing. The swash plate chamber accommodates a swash plate, which is rotational through rotation of the drive shaft. A link mechanism is located between the drive shaft and the swash plate. The link mechanism allows the inclination angle of the swash plate to be changed. The inclination angle is the angle of the swash plate in relation to a direction perpendicular to the axis of the drive shaft. Each cylinder bore reciprocally accommodates a piston. A conversion mechanism reciprocates each of the pistons in the associated one of the cylinder bores by the stroke corresponding to the inclination angle through rotation of the swash plate. A top dead center associated part for positioning each piston at the top dead center is defined on the swash plate. The inclination angle of the swash plate is changed by an actuator. The actuator is controlled by a control mechanism. The control mechanism includes a pressure regulation valve.

[0003] The link mechanism includes a lug member, a hinge ball, and a link. The lug member is located in the swash plate chamber and is fixed to the drive shaft. The hinge ball is fitted about the drive shaft to be arranged between the swash plate and the drive shaft. The hinge ball includes a spherical portion, which slidably contacts the swash plate, and a receiving portion, which faces the actuator. The receiving portion has a flat shape that is perpendicular to the drive shaft axis. The link is provided between the lug member and the swash plate. The link connects the swash plate to the lug member, so that the swash plate is permitted to pivot.

[0004] The actuator includes the lug member, a movable body, and a control pressure chamber. The movable body has a cylindrical shape that is coaxial with the drive shaft axis. The movable body is fitted about the drive shaft and changes the inclination angle of the swash plate by moving along the axis of the drive shaft. The movable body has an acting portion at a position facing the hinge ball. The acting portion has a flat shape perpendicular to the drive shaft axis and contacts the receiving portion at an acting position. Since the hinge ball and the movable body are both fitted about the drive shaft and the acting portion and the receiving portion both have a flat shape, the acting position is located about the drive shaft. When the acting portion and the receiving contact each other, the movable body is engaged with the swash plate via the hinge ball. The control pressure chamber, which is

defined by the lug member and the movable body, uses its internal pressure to move the movable body.

[0005] In this compressor, when the control mechanism connects the discharge chamber and the control pressure chamber with each other using the pressure regulation valve, the pressure in the control pressure chamber is increased. This moves the movable body along the axis of the drive shaft and causes the acting portion to press the receiving portion along the axis of the drive shaft. Accordingly, the hinge ball is moved along the axis of the drive shaft, and the swash plate slides on the hinge ball in the direction reducing the inclination angle. This allows the displacement of the compressor per rotation of the drive shaft to be reduced.

[0006] In this type of compressor, the swash plate receives reaction force from members such as pistons during operation. The reaction force is great at the top dead center associated part of the swash plate. However, in the compressor of the above described document, the acting position is located about the drive shaft and is close to the top dead center associated part. Thus, the movable body is easily influenced by the reaction force, which increases the load when reducing the inclination angle. Therefore, when reducing the inclination angle, the pressure difference between the swash plate chamber and the control pressure chamber (hereinafter, referred to as a variable pressure difference) needs to be increased to move the movable body with a greater thrust. In this case, the inclination angle cannot be quickly changed in response to changes in the driving state of machinery on which the compressor is mounted, such as a vehicle, and high controllability cannot be achieved.

[0007] Further, if the compressor has a small displacement per rotation of the drive shaft and the pressure in the control pressure chamber cannot be increased, the variable pressure difference cannot be increased. Thus, to move the movable body with a great thrust, the size of the movable body may be increased to enlarge the pressure receiving area. In this case, however, the size of the actuator and thus the size of the compressor would be increased, reducing the mountability of the compressor to the vehicle and the like.

SUMMARY OF THE INVENTION

[0008] An objective of the present invention is to provide a variable displacement swash-plate compressor that has a high controllability and an improved mountability.

[0009] To achieve the foregoing objective and in accordance with one aspect of the present invention, a variable displacement swash-plate compressor is provided that includes a housing having a swash plate chamber and a cylinder bore, a drive shaft that is rotationally supported by the housing, a swash plate that is supported in the swash plate chamber and is rotational by rotation of the drive shaft, a link mechanism, a piston, a conversion mechanism, an actuator, and a control mechanism.

The link mechanism is arranged between the drive shaft and the swash plate and allows an inclination angle of the swash plate to be changed with respect to a direction perpendicular to a drive shaft axis of the drive shaft. The piston is reciprocally received in the cylinder bore. The conversion mechanism causes the piston to reciprocate in the cylinder bore by a stroke corresponding to the inclination angle of the swash plate through rotation of the swash plate. The actuator is configured to change the inclination angle. The control mechanism controls the actuator. The link mechanism includes a lug member that is located in the swash plate chamber and is fixed to the drive shaft and a transmitting member that transmits rotation of the lug member to the swash plate. The actuator includes the lug member, a movable body that is configured to rotate integrally with the swash plate and to move along the drive shaft axis, thereby changing the inclination angle, and a control pressure chamber that is defined by the lug member and the movable body and is configured such that pressure in the control pressure chamber is changed by the control mechanism to move the movable body. The movable body includes an acting portion that is configured to push the swash plate with the pressure in the control pressure chamber. The swash plate includes a receiving portion that contacts and is pushed by the acting portion. The acting portion and the receiving portion contact each other at an acting position. A bottom dead center associated part for positioning the piston at a bottom dead center is defined on the swash plate. When the inclination angle is minimized, the acting position is located at a position shifted closer to the bottom dead center associated part than the drive shaft axis.

[0010] Other aspects and advantages of the present invention will become apparent from the following description, taken in conjunction with the accompanying drawings, illustrating by way of example the principles of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] The invention, together with objects and advantages thereof, may best be understood by reference to the following description of the presently preferred embodiments together with the accompanying drawings in which:

Fig. 1 is a cross-sectional view of a compressor according to a first embodiment at the minimum displacement;

Fig. 2 is a schematic diagram showing the control mechanism of the compressor according to the first embodiment;

Fig. 3 is a schematic front view of the swash plate of the compressor according to the first embodiment;

Fig. 4 is a rear view of the lug plate of the compressor according to the first embodiment;

Fig. 5 is an enlarged partial cross-sectional view showing the lug plate and the movable body of the

compressor according to the first embodiment;

Fig. 6 is a side view of the movable body of the compressor according to the first embodiment;

Fig. 7 is a rear view of the movable body of the compressor according to the first embodiment;

Fig. 8 is an enlarged partial cross-sectional view of an acting position when the displacement is minimized in the compressor according to the first embodiment;

Fig. 9 is an enlarged partial cross-sectional view of the acting position when the displacement is increased from the minimum displacement in the compressor according to the first embodiment;

Fig. 10 is an enlarged partial cross-sectional view of an acting position when the displacement is maximized in the compressor according to the first embodiment;

Fig. 11 is a graph showing the relationship between the inclination angle and the variable pressure difference;

Fig. 12 is an enlarged partial cross-sectional view of a compressor according to a second embodiment when the displacement is minimized;

Fig. 13 is a schematic front view of a swash plate of the compressor according to the second embodiment; and

Fig. 14 is an enlarged partial cross-sectional view of the compressor according to the second embodiment when the displacement is maximized.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0012] First and second embodiments will now be described with reference to the drawings. Compressors according to the first and second embodiments are variable displacement swash-plate compressors with single-headed pistons. These compressors are installed in vehicles and are each included in the refrigeration circuit in the air conditioner for the vehicle.

First Embodiment

[0013] As shown in Fig. 1, the compressor according to the first embodiment includes a housing 1, a drive shaft 3, a swash plate 5, a link mechanism 7, pistons 9, pairs of shoes 11a, 11b, an actuator 13, and a control mechanism 15, which is illustrated in Fig. 2.

[0014] As shown in Fig. 1, the housing 1 has a front housing member 17 at a front position in the compressor, a rear housing member 19 at a rear position in the compressor, and a cylinder block 21 and a valve assembly plate 23, which are arranged between the front housing member 17 and the rear housing member 19.

[0015] The front housing member 17 includes a front wall 17a, which extends in the vertical direction of the compressor on the front side, and a circumferential wall 17b, which is integrated with the front wall 17a and ex-

tends rearward from the front of the compressor. The front housing member 17 has a substantially cylindrical cup shape with the front wall 17a and the circumferential wall 17b. Furthermore, the front wall 17a and the circumferential wall 17b define a swash plate chamber 25 in the front housing member 17.

[0016] The front wall 17a has a boss 17c, which projects forward. The boss 17c accommodates a shaft sealing device 27. The boss 17c has a first shaft hole 17d, which extends in the front-rear direction of the compressor. The first shaft hole 17d accommodates a first slide bearing 29a.

[0017] The circumferential wall 17b has an inlet 250, which communicates with the swash plate chamber 25. The swash plate chamber 25 is connected to a non-illustrated evaporator through the inlet 250. Since low-pressure refrigerant gas that has passed through the evaporator flows into the swash plate chamber 25 via the inlet 250, the pressures in the swash plate chamber 25 is lower than the pressure in a discharge chamber 35, which will be discussed below.

[0018] A part of the control mechanism 15 is received in the rear housing member 19. The rear housing member 19 includes a first pressure regulation chamber 31a, a suction chamber 33, and the discharge chamber 35. The first pressure regulation chamber 31a is located in the central part of the rear housing member 19. The discharge chamber 35 has an annular shape and is located in a radially outer part of the rear housing member 19. Also, the suction chamber 33 has an annular shape between the first pressure regulation chamber 31a and the discharge chamber 35 in the rear housing member 19. The discharge chamber 35 is connected to a non-illustrated outlet.

[0019] The cylinder block 21 includes cylinder bores 21a, the number of which is the same as that of the pistons 9. The cylinder bores 21a are arranged at equal angular intervals in the circumferential direction. The front end of the each cylinder bore 21a communicates with the swash plate chamber 25. The cylinder block 21 also includes retainer grooves 21 b, which limit the lift of suction reed valves 41a, which will be discussed below.

[0020] The cylinder block 21 further includes a second shaft hole 21c, which communicates with the swash plate chamber 25 and extends in the front-rear direction of the compressor. The second shaft hole 21c accommodates a second slide bearing 29b. The first slide bearing 29a and the second slide bearing 29b may be replaced by rolling-element bearings.

[0021] The cylinder block 21 further has a spring chamber 21d. The spring chamber 21d is located between the swash plate chamber 25 and the second shaft hole 21c. The spring chamber 21d accommodates a restoration spring 37. The restoration spring 37 urges the swash plate 5 forward of the swash plate chamber 25 when the inclination angle is minimized. The cylinder block 21 also includes a suction passage 39, which communicates with the swash plate chamber 25.

[0022] The valve assembly plate 23 is located between the rear housing member 19 and the cylinder block 21. The valve assembly plate 23 includes a valve base plate 40, a suction valve plate 41, a discharge valve plate 43, and a retainer plate 45.

[0023] The valve base plate 40, the discharge valve plate 43, and the retainer plate 45 include suction ports 40a, the number of which is equal to that of the cylinder bores 21a. Furthermore, the valve base plate 40 and the suction valve plate 41 include discharge ports 40b, the number of which is equal to that of the cylinder bores 21a. The cylinder bores 21a communicate with the suction chamber 33 through the suction ports 40a and communicate with the discharge chamber 35 through the discharge ports 40b. Furthermore, the valve base plate 40, the suction valve plate 41, the discharge valve plate 43, and the retainer plate 45 include a first communication hole 40c and a second communication hole 40d. The first communication hole 40c connects the suction chamber 33 to the suction passage 39. This causes the swash plate chamber 25 to communicate with the suction chamber 33.

[0024] The suction valve plate 41 is provided on the front surface of the valve base plate 40. The suction valve plate 41 includes suction reed valves 41a, which are allowed to selectively open and close the suction ports 40a by elastic deformation. The discharge valve plate 43 is located on the rear surface of the valve base plate 40. The discharge valve plate 43 includes discharge reed valves 43a, which are allowed to selectively open and close the discharge ports 40b by elastic deformation. The retainer plate 45 is provided on the rear surface of the discharge valve plate 43. The retainer plate 45 limits the maximum opening degree of the discharge reed valves 43a.

[0025] The drive shaft 3 has a cylindrical outer circumferential surface 30. The drive shaft 3 is inserted in the boss 17c toward the rear of the housing 1. The front portion of the drive shaft 3 is supported by the shaft sealing device 27 in the boss 17c and is supported by the first slide bearing 29a in the first shaft hole 17d. The rear portion of the drive shaft 3 is supported by the second slide bearing 29b in the second shaft hole 21c. In this manner, the drive shaft 3 is supported by the housing 1 to be rotational about the drive shaft axis O. The second shaft hole 21c and the rear end of the drive shaft 3 define a second pressure regulation chamber 31 b. The second pressure regulation chamber 31b communicates with the first pressure regulation chamber 31a through the second communication hole 40d. The first and second pressure regulation chambers 31a, 31b constitute a pressure regulation chamber 31.

[0026] O-rings 49a, 49b are provided on the rear end of the drive shaft 3. The O-rings 49a, 49b are located between the drive shaft 3 and the second shaft hole 21c to seal off the swash plate chamber 25 and the pressure regulation chamber 31 from each other.

[0027] The link mechanism 7, the swash plate 5, and

the actuator 13 are mounted on the drive shaft 3. The link mechanism 7 includes first and second swash plate arms 5e, 5f provided on the swash plate 5 shown in Fig. 3, a lug plate 51 shown in Fig. 4, and first and second lug arms 53a, 53b provided on the lug plate 51. The first and second swash plate arms 5e, 5f correspond to transmitting members. The lug plate 51 corresponds to a lug member. For illustrative purposes, part of the first swash plate arm 5e is omitted by using a break line in Fig. 1. The same applies to Figs. 8 to 10, which will be discussed below.

[0028] As shown in Fig. 3, the swash plate 5 has a swash plate main portion 50, a swash plate weight 5c, and the first and second swash plate arms 5e, 5f.

[0029] The swash plate main portion 50 is shaped as a flat annular plate and has a front surface 5a and a rear surface 5b. A top dead center associated part T for positioning each piston 9 at the top dead center and a bottom dead center associated part U for positioning each piston 9 at the bottom dead center are defined on the swash plate main portion 50. Also, as shown in Fig. 3, an imaginary bottom dead center plane D is defined in this compressor. The bottom dead center plane D includes the top dead center associated part T, the bottom dead center associated part U, and the drive shaft axis O.

[0030] The swash plate main portion 50 includes a through hole 5d. The drive shaft 3 is inserted in the through hole 5d. Two flat guide surfaces 52a, 52b are provided in the through hole 5d. When the drive shaft 3 is inserted in the through hole 5d, the guide surfaces 52a, 52b contact the outer circumferential surface 30 of the drive shaft 3.

[0031] The swash plate weight 5c is provided on the front surface 5a at a position closer to the bottom dead center associated part U than the drive shaft axis O. That is, the swash plate weight 5c is located between the drive shaft axis O and the bottom dead center associated part U. The swash plate weight 5c has a substantially semi-circular cylindrical shape and extends from the front surface 5a toward the lug plate 51 as shown in Fig. 1. The swash plate weight 5c has, at its distal end, first and second protrusions 5g, 5h as shown in Fig. 3. The first and second protrusions 5g, 5h correspond to receiving portions.

[0032] The first protrusion 5g and the second protrusion 5h are provided on the swash plate weight 5c at positions on opposite sides of the bottom dead center plane D, and project forward from the swash plate 5, that is, toward the actuator 13. The first and second protrusions 5g, 5h each have an arcuate shape with a generatrix extending in a direction perpendicular to the bottom dead center plane D.

[0033] The first and second swash plate arms 5e, 5f are arranged on the front surface 5a at positions closer to the top dead center associated part T than the drive shaft axis O, that is, at positions on the opposite side of the drive shaft axis O to the bottom dead center associated part U. In other words, the first and second swash

plate arms 5e, 5f are located between the drive shaft axis O and the top dead center associated part T. The first swash plate arm 5e and the second swash plate arm 5f are arranged on the front surface 5a at positions on opposite sides of the bottom dead center plane D. As shown in Fig. 1, the first and second swash plate arms 5e, 5f extend from the front surface 5a toward the lug plate 51. For illustrative purposes, the shapes of the swash plate weight 5c and the first and second swash plate arms 5e, 5f are simplified in Fig. 3.

[0034] As shown in Fig. 4, the lug plate 51 has a substantially annular shape with a through hole 510. The drive shaft 3 is press-fitted in the through hole 510, so that the lug plate 51 rotates integrally with the drive shaft 3. As shown in Fig. 1, a thrust bearing 55 is located between the lug plate 51 and the front wall 17a.

[0035] As shown in Fig. 5, the lug plate 51 has a recessed cylinder chamber 51a, which has a cylindrical shape coaxial with and extending along the drive shaft axis O. The cylinder chamber 51a communicates with the swash plate chamber 25 at the rear.

[0036] As shown in Fig. 4, the first lug arm 53a and the second lug arm 53b are provided on the lug plate 51 at positions on opposite sides of the bottom dead center plane D. On the lug plate 51, the first and second lug arms 53a, 53b are located at positions closer to the top dead center associated part T on the swash plate main portion 50 than the drive shaft axis O and extend from the lug plate 51 toward the swash plate 5. That is, the first and second lug arms 53a, 53b are located between the drive shaft axis O and the top dead center associated part T on the lug plate 51.

[0037] The lug plate 51 has first and second guide surfaces 57a, 57b between the first and second lug arms 53a, 53b. The first guide surface 57a and the second guide surface 57b are also located on opposite sides of the bottom dead center plane D. As shown in Fig. 1, the second guide surface 57b is inclined such that the distance from the swash plate 5 gradually decreases from the outer circumference of the lug plate 51 toward the cylinder chamber 51a. The first guide surface 57a has the same shape as the second guide surface 57b.

[0038] In this compressor, the first and second swash plate arms 5e, 5f are inserted between the first and second lug arms 53a, 53b to mount the swash plate 5 to the drive shaft 3. The lug plate 51 and the swash plate 5 are thus coupled to each other with the first and second swash plate arms 5e, 5f located between the first and second lug arms 53a, 53b. When rotation of the lug plate 51 is transmitted from the first and second lug arms 53a, 53b to the first and second swash plate arms 5e, 5f, the swash plate 5 rotates with the lug plate 51 in the swash plate chamber 25.

[0039] Since the first and second swash plate arms 5e, 5f are located between the first and second lug arms 53a, 53b, the distal end of the first swash plate arm 5e contacts the first guide surface 57a, and the distal end of the second swash plate arm 5f contacts the second guide sur-

face 57b. The first and second swash plate arms 5e, 5f slide on the first and second guide surfaces 57a, 57b, respectively. Accordingly, the swash plate 5 is allowed to change its inclination angle relative to the direction perpendicular to the drive shaft axis O between the minimum inclination angle shown in Fig. 1 and the maximum inclination angle shown in Fig. 10, while substantially maintaining the position of the top dead center associated part T.

[0040] As shown in Fig. 5, the actuator 13 includes the lug plate 51, a movable body 13a, and a control pressure chamber 13b.

[0041] As shown in Fig. 6, the movable body 13a is fitted about the drive shaft 3 and located between the lug plate 51 and the swash plate 5 to move along the drive shaft axis O while sliding on the drive shaft 3. The movable body 13a has a substantially cylindrical shape coaxial with the drive shaft 3. Specifically, the movable body 13a includes a first cylindrical portion 131, a second cylindrical portion 132, a coupling portion 133, a movable body weight 134, and a rotation stopper 135.

[0042] The first cylindrical portion 131 is located at a position facing the swash plate 5 in the movable body 13a and extends along the drive shaft axis O. The first cylindrical portion 131 has the smallest outer diameter in the movable body 13a. As shown in Fig. 5, a ring groove 131a is provided in the inner circumferential surface of the first cylindrical portion 131. An O-ring 49c is fitted in the ring groove 131a. The second cylindrical portion 132 is located at a position on the movable body 13a that faces the lug plate 51. The second cylindrical portion 132 has a diameter larger than that of the first cylindrical portion 131 and has the largest outer diameter in the movable body 13a. The second cylindrical portion 132 has a ring groove 132a in the outer circumferential surface. An O-ring 49d is fitted in the ring groove 132a. The coupling portion 133 has an outer diameter that gradually increases from the first cylindrical portion 131 toward the second cylindrical portion 132 and couples the first cylindrical portion 131 and the second cylindrical portion 132 to each other.

[0043] As shown in Fig. 7, the movable body weight 134 is located closer to the bottom dead center associated part U of the swash plate main portion 50 than the drive shaft axis O. That is, the movable body weight 134 is located between the drive shaft axis O and the bottom dead center associated part U. The movable body weight 134 has a semi-columnar shape. As shown in Fig. 1, the movable body weight 134 extends from the second cylindrical portion 132 toward the swash plate 5. The movable body weight 134 displaces the center of gravity of the movable body 13a to a position closer to the bottom dead center associated part U than the drive shaft axis O.

[0044] As shown in Fig. 7, the movable body weight 134 has a symmetrical shape with respect to the bottom dead center plane D and has first and second inclined surfaces 134a, 134b and first and second vertical surfaces 134c, 134d. The first inclined surface 134a and the

first vertical surface 134c constitute a first acting portion 14a. The second inclined surface 134b and the second vertical surface 134d constitute a second acting portion 14b. Thus, in addition to achieving weight balance of the movable body 13a, the movable body weight 134 has functions of the first acting portion 14a and the second acting portion 14b, which are located on opposite sides of the bottom dead center plane D.

[0045] As shown in Fig. 1, the first inclined surface 134a is inclined such that the distance from the drive shaft axis O gradually decreases from the swash plate 5 toward the second cylindrical portion 132. The second inclined surface 134b, which is shown in Fig. 7, has the same structure as the first inclined surface 134a.

[0046] The first vertical surface 134c is connected to an end of the first inclined surface 134a that faces the swash plate 5 and vertically extends toward the bottom dead center associated part U. The second vertical surface 134d is connected to an end of the second inclined surface 134b that faces the swash plate 5 and vertically extends toward the bottom dead center associated part U. The first vertical surface 134c and the second vertical surface 134d are continuous with each other and located on opposite sides of the bottom dead center plane D.

[0047] In this compressor, the first inclined surface 134a and the first vertical surface 134c, that is, the first acting portion 14a contacts the first protrusion 5g shown in Fig. 3 at a first acting position F1 shown in Fig. 7. Since the first protrusion 5g has a cylindrical shape as described above, the first acting portion 14a and the first protrusion 5g make line contact at the first acting position F1. Likewise, the second acting portion 14b and the second protrusion 5h shown in Fig. 3 make line contact at a second acting position F2 shown in Fig. 7.

[0048] Fig. 7 shows a state in which the first acting position F1 is located on the first inclined surface 134a, and the second acting position F2 is located on the second inclined surface 134b. However, when the inclination angle of the swash plate 5 of this compressor changes, the first acting position F1 and the second acting position F2 are moved. That is, as shown in Figs. 8 to 10, when the swash plate 5 is moved from the minimum inclination angle to the maximum inclination angle, the first acting position F1 is moved from the first vertical surface 134c to a position on the first inclined surface 134a that is close to the second cylindrical portion 132. Likewise, the second acting position F2 is moved from the second vertical surface 134d to a position on the second inclined surface 134b that is close to the second cylindrical portion 132. In this compressor, not only when the swash plate 5 is at the minimum inclination angle, but also when at the maximum inclination angle, the first and second acting positions F1, F2 are located at positions shifted closer to the bottom dead center associated part U than the drive shaft axis O. That is, the first and second acting positions F1, F2 are located between the drive shaft axis O and the bottom dead center associated part U. Movement of the first and second acting positions F1, F2 will be de-

scribed below.

[0049] As shown in Fig. 6, the rotation stopper 135 is located at a position on the first cylindrical portion 131 that faces the swash plate 5. The rotation stopper 135 has a rectangular shape as shown in Fig. 7 and extends from the outer circumferential surface of the first cylindrical portion 131 toward the top dead center associated part T of the swash plate main portion 50. The rotation stopper 135 is located between the first swash plate arm 5e and the second swash plate arm 5f, which are shown in Fig. 3. As the swash plate 5 rotates, the rotation stopper 135 contacts the first swash plate arm 5e or the second swash plate arm 5f to restrict the movable body 13a from rotating about the drive shaft axis O. This allows the movable body 13a to be rotated integrally with the lug plate 51 and the swash plate 5 by rotation of the drive shaft 3.

[0050] As shown in Fig. 5, the control pressure chamber 13b is defined by the second cylindrical portion 132, the coupling portion 133, the cylinder chamber 51a, and the drive shaft 3. The control pressure chamber 13b and the swash plate chamber 25 are sealed off from each other by the O-rings 49c, 49d.

[0051] The drive shaft 3 has an axial passage 3a and a radial passage 3b. The axial passage 3a extends from the rear end of the drive shaft 3 toward the front end along the drive shaft axis O. The radial passage 3b extends in a radial direction from the front end of the axial passage 3a and opens in the outer circumferential surface of the drive shaft 3. As shown in Fig. 1, the rear end of the axial passage 3a communicates with the pressure regulation chamber 31. The radial passage 3b communicates with control pressure chamber 13b as shown in Fig. 5. The axial passage 3a and the radial passage 3b connect the pressure regulation chamber 31 to the control pressure chamber 13b.

[0052] As shown in Fig. 1, the drive shaft 3 has, at the front end, a threaded portion 3c. The drive shaft 3 is connected to a non-illustrated pulley or a non-illustrated electromagnetic clutch through the threaded portion 3c.

[0053] Each piston 9 is accommodated in the corresponding one of the cylinder bores 21a and is allowed to reciprocate in the cylinder bore 21a. Each piston 9 and the valve assembly plate 23 define a compression chamber 57 in the corresponding cylinder bore 21a.

[0054] Each piston 9 has an engaging portion 9a. Each engaging portion 9a accommodates a pair of hemispherical shoes 11a, 11b. The shoes 11a, 11b convert rotation of the swash plate 5 into reciprocation of the pistons 9. The shoes 11a, 11b correspond to a conversion mechanism. Each piston 9 thus reciprocates in the corresponding cylinder bore 21a by the stroke corresponding to the inclination angle of the swash plate 5. Instead of providing the shoes 11a, 11b, a wobble plate type conversion mechanism may be employed in which a wobble plate is provided on the rear surface 5b of the swash plate main portion 50 via a thrust bearing, and the wobble plate and the pistons 9 are connected to each other with connecting rods.

[0055] As shown in Fig. 2, the control mechanism 15 includes a low-pressure passage 15a, a high-pressure passage 15b, a control valve 15c, an orifice 15d, the axial passage 3a, and the radial passage 3b.

[0056] The low-pressure passage 15a is connected to the pressure regulation chamber 31 and the suction chamber 33. The low-pressure passage 15a, the axial passage 3a, and the radial passage 3b connect the control pressure chamber 13b, the pressure regulation chamber 31, and the suction chamber 33 to one another. The high-pressure passage 15b is connected to the pressure regulation chamber 31 and the discharge chamber 35. The high-pressure passage 15b, the axial passage 3a, and the radial passage 3b connect the control pressure chamber 13b, the pressure regulation chamber 31, and the discharge chamber 35 to one another.

[0057] The control valve 15c is arranged in the low-pressure passage 15a. The low-pressure control valve 15c is allowed to adjust the opening degree of the low-pressure passage 15a based on the pressure in the suction chamber 33. The high-pressure passage 15b also has the orifice 15d.

[0058] In this compressor, a pipe connected to the evaporator is connected to the inlet 250 shown in Fig. 1, and a pipe connected to the condenser is connected to the outlet. The condenser is connected to the evaporator via a pipe and an expansion valve. These components, which include the compressor, the evaporator, the expansion valve, and the condenser, constitute the refrigeration circuit in the air conditioner for a vehicle. The illustration of the evaporator, the expansion valve, the condenser, and the pipes is omitted.

[0059] In the compressor having the above-described configuration, the drive shaft 3 rotates to rotate the swash plate 5, thus reciprocating each piston 9 in the corresponding cylinder bore 21a. This varies the volume of each compression chamber 57 in accordance with the piston stroke. Thus, the refrigerant that has been drawn from the evaporator into the swash plate chamber 25 through the inlet 250 flows through the suction passage 39 and the suction chamber 33 and is compressed in the compression chambers 57. The refrigerant that is compressed in the compression chambers 57 is discharged to the discharge chamber 35 and is discharged to the condenser through the outlet.

[0060] The actuator 13 changes the inclination angle of the swash plate 5 to increase or decrease the stroke of the pistons 9, thereby varying the displacement of the compressor.

[0061] Specifically, when the control valve 15c of the control mechanism 15 shown in Fig. 2 reduces the opening degree of the low-pressure passage 15a, the pressure in the pressure regulation chamber 31 is increased, and the pressure in the control pressure chamber 13b is increased. This causes the movable body 13a to move along the drive shaft axis O toward the swash plate 5 as shown in Fig. 8, while moving away from the lug plate 51.

[0062] Accordingly, at the first acting position F1 of the

compressor, the first acting portion 14a shown in Fig. 7 pushes the first protrusion 5g shown in Fig. 3 toward the rear of the swash plate chamber 25. Likewise, at the second acting position F2, the second acting portion 14b shown in Fig. 7 pushes the second protrusion 5h shown in Fig. 3 toward the rear of the swash plate chamber 25. As described above, the first and second acting positions F1, F2 are located at positions shifted closer to the bottom dead center associated part U than the drive shaft axis O. That is, the first and second acting positions F1, F2 are located between the drive shaft axis O and the bottom dead center associated part U. Thus, the movable body 13a pushes the swash plate 5 at a position shifted closer to the bottom dead center associated part U than the drive shaft axis O via the first and second acting portions 14a, 14b and the first and second protrusions 5g, 5h. Therefore, the first and second swash plate arms 5e, 5f slide on the first and second guide surfaces 57a, 57b, respectively, toward the drive shaft axis O as shown in Fig. 8.

[0063] Accordingly, the swash plate 5 reduces the angle relative to the direction perpendicular to the drive shaft axis O, or the inclination angle, while substantially maintaining the position of the top dead center associated part T. This reduces the stroke of the pistons 9 and the displacement of the compressor per rotation of the drive shaft 3. The reduction in the inclination angle causes the swash plate 5 contact the restoration spring 37. The inclination angle of the swash plate 5 shown in Figs. 1 and 8 corresponds to the minimum inclination angle in the compressor.

[0064] In contrast, when the control valve 15c of the control mechanism 15 shown in Fig. 2 increases the opening degree of the low-pressure passage 15a, the pressure in the pressure regulation chamber 31 and thus the pressure in the control pressure chamber 13b become substantially equal to the pressure in the suction chamber 33. Thus, reaction force that acts on the swash plate 5 from components such as the pistons 9 causes the movable body 13a to move along the drive shaft axis O from the swash plate 5 toward the lug plate 51 as shown in Figs. 9 and 10. This causes the movable body 13a to move deeply into the cylinder chamber 51a.

[0065] The reaction force acting on the swash plate 5 and the urging force of the restoration spring 37 cause the first and second swash plate arms 5e, 5f to slide on the first and second guide surfaces 57a, 57b, respectively, to move away from the drive shaft axis O.

[0066] The swash plate 5 thus increases the inclination angle while substantially maintaining the position of the top dead center associated part T. This increases the stroke of the pistons 9 and thus increases the displacement of the compressor per rotation of the drive shaft 3. Fig. 9 illustrates a state in which the inclination angle of the swash plate 5 is slightly increased. The inclination angle of the swash plate 5 shown in Fig. 10 corresponds to the maximum inclination angle in the compressor.

[0067] As described above, in this compressor, the first

and second acting portions 14a, 14b and the first and second protrusions 5g, 5h are all located at positions shifted closer to the bottom dead center associated part U than the drive shaft axis O. The first acting position F1, where the first acting portion 14a and the first protrusion 5g make line contact, and the second acting position F2, where the second acting portion 14b and the second protrusion 5h make line contact, are located at positions shifted closer to the bottom dead center associated part U than the drive shaft axis O not only when the swash plate 5 is at the minimum inclination angle, but also when the swash plate 5 is at the maximum inclination angle. When decreasing the inclination angle of the swash plate 5, the movable body 13a pushes the swash plate 5 along the drive shaft axis O via the first and second acting positions F1, F2.

[0068] Since the reaction force acting on the swash plate 5 is small at a position between the drive shaft axis O and the bottom dead center associated part U, particularly at a position close to the bottom dead center associated part U, the movable body 13a is unlikely to be influenced by the reaction force. That is, the compressor reduces the load on the movable body 13a when minimizing the inclination angle. Thus, when reducing the inclination angle in the compressor, the movable body 13a is moved without increasing the variable pressure difference to obtain a large thrust. This allows the compressor to quickly change the inclination angle in response to changes in the driving state of the vehicle. Also, the configuration allows the size of the compressor to be reduced. These operations will be described based on comparison with examples.

[0069] The compressor of the comparative example includes partially modified versions of the swash plate 5 and the movable body 13a of the compressor according to the first embodiment. Specifically, the swash plate weight 5c does not have the first and second protrusions 5g, 5h, and the movable body 13a does not have the movable body weight 134. In this configuration of the comparative example, the rear end of the first cylindrical portion 131 of the movable body 13a contacts the front surface 5a of the swash plate main portion 50 at a position around the through hole 5d. Thus, in the comparative example, the movable body 13a and the swash plate 5 contact each other at a position substantially on the drive shaft axis O, and the acting position is located about the drive shaft 3.

[0070] The reaction force that acts on the swash plate 5 from components such as the pistons 9 increases on the swash plate main portion 50 as the distance from the top dead center associated part T decreases. More specifically, when the swash plate 5 rotates in the direction of the solid arrow in Fig. 13, a position slightly before the top dead center associated part T in the rotation direction is a maximum load position P1, where the reaction force from components such as the pistons 9 is maximized.

[0071] Thus, in the compressor of the comparison example, in which the acting position is located about the

drive shaft 3, the acting position is located close to the top dead center associated part T, and the movable body 13a is easily influenced by the reaction force. Therefore, as indicated by the graph of Fig. 11, in the compressor of the comparative example, the variable pressure difference needs to be increased to move the movable body 13a with a greater thrust as the inclination angle of the swash plate 5 is reduced.

[0072] Further, if the compressor of the comparison example has a small displacement per rotation of the drive shaft 3 and the pressure in the control pressure chamber 13b cannot be increased, the variable pressure difference cannot be increased. Thus, to move the movable body 13a with a great thrust, the size of the movable body 13a may be increased to enlarge the pressure receiving area. However, this would increase the size of the compressor.

[0073] In contrast, in the compressor according to the first embodiment, not only when the swash plate 5 is at the minimum inclination angle, but also at the maximum inclination angle, the first and second acting positions F1, F2 are located at positions shifted closer to the bottom dead center associated part U than the drive shaft axis O. Thus, the first and second acting positions F1, F2 are separated away from the top dead center associated part T, which makes the movable body 13a less prone to influence of the reaction force. That is, the load on the movable body 13a when decreasing the inclination angle is reduced, so that the movable body 13a is moved without increasing the variable pressure difference. Accordingly, in the compressor according to the first embodiment, the variable pressure difference is reduced over the entire range and made substantially constant as indicated by the graph of Fig. 11 when the inclination angle is changed.

[0074] As described above, in the compressor according to the first embodiment, the movable body 13a is moved without increasing the variable pressure difference. Thus, even if the displacement per rotation of the drive shaft is small, the movable body 13a is moved reliably. Therefore, the movable body 13a of the compressor does need to be enlarged to increase the pressure receiving area, and the compressor is reduced in size.

[0075] In the compressor according to the first embodiment, the first and second acting positions F1, F2 are shifted closer to the bottom dead center associated part U than the drive shaft axis O. Thus, compared to the compressor of the comparative example, in which the acting position is close to the top dead center associated part T, the stroke of the movable body 13a when the inclination angle of the swash plate 5 is changed is increased.

[0076] In the compressor of the comparative example, since the acting position is located about the drive shaft axis O, the distance between the acting position and the drive shaft axis O is constant even if the inclination angle of the swash plate 5 is changed. In contrast, in the compressor according to the first embodiment, the first and

second acting positions F1, F2 are moved in a direction from the bottom dead center associated part U toward the drive shaft axis O by moving the swash plate 5 from the minimum inclination angle to the maximum inclination angle as shown in Figs. 8 to 10. Hereinafter, the first acting position F1 will be described.

[0077] As described above, when the inclination angle of the swash plate 5 is reduced, the first acting portion 14a pushes the first protrusion 5g toward the rear of the swash plate chamber 25 at the first acting position F1. Thus, as the inclination angle of the swash plate 5 decreases, the first acting position F1 moves from the first inclined surface 134a toward the first vertical surface 134c. When the inclination angle of the swash plate 5 is minimized, the first acting position F1 is located on the first vertical surface 134c. That is, when the swash plate 5 is at the minimum inclination angle, the first vertical surface 134c and the first protrusion 5g make line contact at the first acting position F1. The position of the first acting position F1 at this time is defined as an initial position A.

[0078] When the pressure in the pressure regulation chamber 31 is lowered and the movable body 13a is slightly moved from the swash plate 5 toward the lug plate 51 along the drive shaft axis O as shown in Fig. 9, the inclination angle of the swash plate 5 is slightly increased. At this time, the first inclined surface 134a and the first protrusion 5g make line contact at the first acting position F1. More specifically, a part of the first inclined surface 134a that is close to the first vertical surface 134c and the first protrusion 5g make line contact. That is, when the inclination angle of the swash plate 5 is increased slightly from the minimum inclination angle, the first acting position F1 is moved from the initial position A toward the lug plate 51 along the drive shaft axis O by a distance X1. The first acting position F1 is also moved in a direction from the bottom dead center associated part U toward the drive shaft axis O by a distance Y1. In other words, due to a slight increase in the inclination angle of the swash plate 5, the first acting position F1 is moved from the initial position A by the distance Y1 in a direction from the bottom dead center associated part U toward the drive shaft axis O. For illustrative purposes, the initial position A is illustrated as a circle of a dashed line in Figs. 9 and 10.

[0079] Further, when the inclination angle of the swash plate 5 is increased, the first protrusion 5g slides on the first inclined surface 134a toward the second cylindrical portion 132. When the inclination angle of the swash plate 5 is maximized as shown in Fig. 10, a part of the first inclined surface 134a that is close to the second cylindrical portion 132 and the first protrusion 5g make line contact at the first acting position F1. That is, the first acting position F1 is moved from the initial position A toward the lug plate 51 along the drive shaft axis O by a distance X2, which is greater than the distance X1. The first acting position F1 is also moved in a direction from the bottom dead center associated part U toward the

drive shaft axis O by a distance Y2, which is greater than the distance Y1. Accordingly, due to the change of the inclination angle of the swash plate 5 from the minimum inclination angle to the maximum inclination angle, the first acting position F1 is moved from the initial position A by the distance Y2 in a direction from the bottom dead center associated part U toward the drive shaft axis O. The same applies to the second acting position F2.

[0080] Thus, in the compressor according to the first embodiment, if the range of the inclination angle of the swash plate 5 is the same, when the inclination angle is increased, the stroke of the movable body 13a along the drive shaft axis O is small compared to a case in which the distance between the acting position and the drive shaft axis O is constant even if the inclination angle is changed. Thus, in the compressor according to the first embodiment, although the movable body 13a pushes the swash plate 5 along the drive shaft axis O at a position relatively close to the bottom dead center associated part U via the first and second acting positions F1, F2, the stroke of the movable body 13a is minimized. The compressor according to the first embodiment thus prevents the shaft length from being increased.

[0081] Therefore, the compressor according to the first embodiment has a high controllability and an improved mountability.

[0082] Further, the reaction force that acts from the pistons 9 to the swash plate 5 during operation of the compressor generates moment that acts to rotate the swash plate 5 in a direction other than the direction in which the inclination angle is changed. This creates a warp in the swash plate 5. In this respect, the guide surfaces 52a, 52b in the through hole 5d of the compressor slide on the outer circumferential surface 30 of the drive shaft 3 in response to changes in the inclination angle of the swash plate 5. Then, the swash plate 5 is guided by the link mechanism 7 and the drive shaft 3 along the drive shaft axis O and in the direction of the inclination angle, so that the inclination angle is changed as described above. At this time, the guide surfaces 52a, 52b allow the swash plate 5 to easily contact the outer circumferential surface 30 of the drive shaft 3 at two points on opposite sides of the drive shaft axis O. Therefore, the compressor reliably prevents the swash plate 5 from being warped by the moment. Since the compressor has no sleeve, the number of components is reduced, and the manufacturing costs are reduced, accordingly.

[0083] Further, when the inclination angle of the swash plate 5 is reduced, the first acting portion 14a pushes the first protrusion 5g at the first acting position F1, and the second acting portion 14b pushes the second protrusion 5h at the second acting position F2. In this manner, the movable body 13a pushes the swash plate 5 along the drive shaft axis O and at two positions, which are the first acting position F1 and the second acting position F2 with reference to the bottom dead center plane D. This allows the movable body 13a of the compressor to decrease the inclination angle of the swash plate 5 rapidly.

[0084] Further, the swash plate main portion 50 has the swash plate weight 5c on the front surface 5a, and the movable body 13a has the movable body weight 134. The swash plate weight 5c and the movable body weight 134 are located at positions closer to the bottom dead center associated part U than the drive shaft axis O. Thus, even though the swash plate arms 5e, 5f are closer to the top dead center associated part T than the drive shaft axis O on the front surface 5a, the swash plate weight 5c and the movable body weight 134 reliably maintain the weight balance between the top dead center associated part T and the bottom dead center associated part U with the drive shaft axis O in between. Therefore, rotation of the drive shaft 3 reliably rotates the link mechanism 7, the actuator 13, and the swash plate 5, and vibration during operation is suppressed.

[0085] Also, the swash plate weight 5c and the movable body weight 134 eliminate the necessity for providing a weight for reliably maintaining the weight balance to the lug plate 51. This prevents the size of the lug plate 51 from being increased. Thus, the lug plate 51 is reliably prevented from agitating lubricant in the swash plate chamber 25. Therefore, the lubricity of the lubricant does not deteriorate because of heating of the lubricant that would be caused by such agitation. Accordingly, sliding parts in the compressor are prevented from being unduly worn.

[0086] Further, since the swash plate weight 5c has the first and second protrusions 5g, 5h, the swash plate 5 is easy to produce. Likewise, since the movable body weight 134 also functions as the first and second acting portions 14a, 14b, the movable body 13a is easy to produce.

35 Second Embodiment

[0087] In the compressor according to the second embodiment, the first and second protrusions 5g, 5h of the compressor according to the first embodiment are replaced by a single protrusion 5i on the swash plate weight 5c as shown in Fig. 12. The protrusion 5i also functions as a receiving portion. Also, the movable body weight 134 of the compressor according to the first embodiment is replaced by a movable body weight 136 on the movable body 13a.

[0088] The protrusion 5i is located on the front side of the swash plate weight 5c, that is, on the side of the swash plate weight 5c that faces the movable body 13a. Specifically, as shown in Fig. 13, the protrusion 5i is located at the distal end of the swash plate weight 5c and in an area between the bottom dead center associated part U and a position on the opposite side of the drive shaft axis O from the maximum load position P1 (hereinafter, referred to as an opposite position P2). The area is indicated by the arrow of a broken line. The protrusion 5i has a semispherical shape. As in Fig. 3, for illustrative purposes, the shapes of the swash plate weight 5c and the protrusion 5i are simplified in Fig. 10.

[0089] Like the above described movable body weight 134, the movable body weight 136 is arranged on the movable body 13a at a position that is closer to the bottom dead center associated part U of the swash plate main portion 50 than the drive shaft axis O as shown in Fig. 12. The movable body weight 136 extends from the second cylindrical portion 132 toward the swash plate 5. The movable body weight 136 has an inclined surface 136a and a vertical surface 136b. The inclined surface 136a is inclined such that the distance from the drive shaft axis O gradually decreases from the swash plate 5 toward the second cylindrical portion 132. The vertical surface 136b is connected to an end of the inclined surface 136a that faces the swash plate 5 and extends vertically toward the bottom dead center associated part U. The inclined surface 136a and the vertical surface 136b constitute an acting portion 16. Thus, the movable body weight 136 has a function of the acting portion 16 in addition to the function for creating weight balance in the movable body 13a.

[0090] The acting portion 16, which is constituted by the inclined surface 136a and the vertical surface 136b, and the protrusion 5i of the swash plate 5 make point contact at an acting position F3. When the inclination angle of the swash plate 5 is changed from the minimum inclination angle shown in Fig. 12 to the maximum inclination angle shown in Fig. 14, the acting position F3 is moved. Specifically, as shown in the drawings, when the swash plate 5 is at the minimum inclination angle, the acting position F3 is located on the vertical surface 136b. That is, when the swash plate 5 is at the minimum inclination angle, the vertical surface 136b and the protrusion 5i make point contact at the acting position F3. In contrast, when the swash plate 5 is at the maximum inclination angle as shown in Fig. 14, the acting position F3 is located on the inclined surface 136a. That is, when the swash plate 5 is at the maximum inclination angle, the inclined surface 136a and the protrusion 5i make point contact at the acting position F3.

[0091] As described above, due to the change of the inclination angle of the swash plate 5 from the minimum inclination angle to the maximum inclination angle, the third acting position F3 is moved in a direction from the bottom dead center associated part U toward the drive shaft axis O in this compressor. In this compressor also, not only when the swash plate 5 is at the minimum inclination angle, but also at the maximum inclination angle, the third acting position F3 is located at a position shifted closer to the bottom dead center associated part U than the drive shaft axis O. Since the protrusion 5i is located at a position between the opposite position P2 and the bottom dead center associated part U as shown in Fig. 13, the acting position F3 of this compressor is defined on the swash plate main portion 50 in an area between the opposite position P2 and the bottom dead center associated part U. The other components of the compressor of the second embodiment are configured identically with the corresponding components of the compressor

of the first embodiment. Accordingly, these components are identified by the same reference numbers, and detailed description thereof is omitted herein.

[0092] In the compressor of the second embodiment, the inclined surface 136a and the vertical surface 136b of the movable body weight 136, that is, the acting portion 16 and the protrusion 5i make point contact at the single acting position F3. Therefore, the acting portion 16 and the protrusion 5i, and thus, the movable body 13a and the swash plate 5 are easy to produce.

[0093] The acting position F3 is defined on the swash plate main portion 50 in an area between the opposite position P2 and the bottom dead center associated part U. In the swash plate main portion 50, the reaction force from components such as the pistons 9 is maximized at the maximum load position P1. In contrast, the reaction force acting on the swash plate 5 is small between the opposite position P2 and the bottom dead center associated part U. Thus, the load on the movable body 13a is reliably reduced when the inclination angle of the swash plate 5 is reduced. Accordingly, even though the movable body 13a has the single acting position F3, the movable body 13a reliably pushes the swash plate 5 along the drive shaft axis O via the acting position F3. The other operations of the compressor are the same as the corresponding operations of the compressor of the first embodiment.

[0094] Although only the first and second embodiments of the present invention have been described so far, the present invention is not limited to the first and second embodiments, but may be modified as necessary without departing from the scope of the invention.

[0095] For example, in the compressor according to the first embodiment, the shapes of the first and second acting portions 14a, 14b may be changed such that, when the swash plate 5 is at the maximum inclination angle, the first and second acting positions F1, F2 are shifted beyond the drive shaft axis O and reach positions on the swash plate main portion 50 that are close to the top dead center associated part T. The same modification may be applied to the compressor according to the second embodiment.

[0096] The compressor according to the first embodiment may be configured such that, while the inclination angle of the swash plate 5 is increased from the minimum inclination angle to a predetermined inclination angle, the first and second acting positions F1, F2 are moved in a direction from the bottom dead center associated part U toward the drive shaft axis O, and while the inclination angle of the swash plate 5 is increased from the predetermined inclination angle to the maximum inclination angle, the first and second acting positions F1, F2 do not move. The same modification may be applied to the compressor according to the second embodiment.

[0097] Further, in the compressor according to the first embodiment, the movable body 13a may include dedicated first and second acting portions 14a, 14b in addition to the movable body weight 134. The same modification

may be applied to the compressor according to the second embodiment.

[0098] In the compressor according to the first embodiment, the first and second acting portions 14a, 14b and the first and second protrusions 5g, 5h may be configured to make point contact. Likewise, in the compressor according to the second embodiment, the acting portion 16 and the protrusion 5i may be configured to make line contact.

[0099] Further, regarding the control mechanism 15 of the compressor according to the first and second embodiments, the control valve 15c may be provided in the high-pressure passage 15b, and the orifice 15d may be provided in the low-pressure passage 15a. In this case, the control valve 15c is allowed to adjust the flow rate of high-pressure refrigerant flowing through the high-pressure passage 15b. This allows the high-pressure in the discharge chamber 35 to promptly increase the pressure in the control pressure chamber 13b and to promptly reduce the displacement. Also, the control valve 15c may be replaced by a three-way valve connected to the low-pressure passage 15a and the high-pressure passage 15b. In this case, the opening degree of the three-way valve is adjusted to regulate the flow rate of refrigerant flowing through the low-pressure passage 15a and the high-pressure passage 15b.

[0100] Therefore, the present examples and embodiments are to be considered as illustrative and not restrictive and the invention is not to be limited to the details given herein, but may be modified within the scope and equivalence of the appended claims.

Claims

1. A variable displacement swash-plate compressor comprising:

a housing (1) having a swash plate chamber (25) and a cylinder bore (21a);
 a drive shaft (3) that is rotationally supported by the housing (1);
 a swash plate (5) that is supported in the swash plate chamber (25) and is rotational by rotation of the drive shaft (3);
 a link mechanism (7) arranged between the drive shaft (3) and the swash plate (5), wherein the link mechanism (7) allows an inclination angle of the swash plate (5) to be changed with respect to a direction perpendicular to a drive shaft axis (O) of the drive shaft (3);
 a piston (9) reciprocally received in the cylinder bore (21a);
 a conversion mechanism (11a, 11b) that causes the piston (9) to reciprocate in the cylinder bore (21a) by a stroke corresponding to the inclination angle of the swash plate (5) through rotation of the swash plate (5);

an actuator (13) configured to change the inclination angle; and
 a control mechanism (15) that controls the actuator (13), wherein
 the link mechanism (7) includes

a lug member (51) that is located in the swash plate chamber (25) and is fixed to the drive shaft (3), and
 a transmitting member (5e, 5f) that transmits rotation of the lug member (51) to the swash plate (5),

the actuator (13) includes

the lug member (51),
 a movable body (13a) that is configured to rotate integrally with the swash plate (5) and to move along the drive shaft axis (O), thereby changing the inclination angle, and
 a control pressure chamber (13b) that is defined by the lug member (51) and the movable body (13a) and is configured such that pressure in the control pressure chamber (13b) is changed by the control mechanism (15) to move the movable body (13a),

the variable displacement swash-plate compressor being **characterized in that**

the movable body (13a) includes an acting portion (14a, 14b; 16) that is configured to push the swash plate (5) with the pressure in the control pressure chamber (13b),
 the swash plate (5) includes a receiving portion (5g, 5h; 5i) that contacts and is pushed by the acting portion (14a, 14b; 16),
 the acting portion (14a, 14b; 16) and the receiving portion (5g, 5h; 5i) contact each other at an acting position (F1, F2; F3),
 a bottom dead center associated part (U) for positioning the piston (9) at a bottom dead center is defined on the swash plate (5), and
 when the inclination angle is minimized, the acting position (F1, F2; F3) is located at a position shifted closer to the bottom dead center associated part (U) than the drive shaft axis (O).

2. The variable displacement swash-plate compressor according to claim 1, wherein the transmitting member (5e, 5f) is located on the swash plate (5) and is positioned on an opposite side of the drive shaft axis (O) from the bottom dead center associated part (U), the swash plate (5) has a swash plate weight (5c) that is located at a position closer to the bottom dead center associated part (U) than the drive shaft axis (O) and protrudes toward the acting portion (14a, 14b; 16), and
 the receiving portion (5g, 5h; 5i) is located on the

swash plate weight (5c).

thereby changing the inclination angle.

3. The variable displacement swash-plate compressor according to claim 2, wherein the movable body (13a) has a movable body weight (134; 136) that is located a position closer to the bottom dead center associated part (U) than the drive shaft axis (O), and the movable body weight functions as the acting portion (14a, 14b; 16). 5 10
4. The variable displacement swash-plate compressor according to any one of claims 1 to 3, wherein the acting position is a first acting position (F1), a second acting position (F2) is defined that constitutes a pair with the first acting position (F1), wherein the first acting position (F1) and the second acting position (F2) are located on opposite sides of a bottom dead center plane (D), which includes the bottom dead center associated part (U) and the drive shaft axis (O), the acting portion is a first acting portion (14a) that contacts the receiving portion (5g) at the first acting position (F1), and a second acting portion (14b) is provided that contacts the receiving portion (5h) at the second acting position (F2). 15 20 25
5. The variable displacement swash-plate compressor according to claim 1 or 2, wherein the acting position (F3) is a single position. 30
6. The variable displacement swash-plate compressor according to claim 5, wherein, in relation to a maximum load position (P1), where reaction force acting from the piston (9) is maximized on the swash plate (5), the acting position (F3) is located in an area between the bottom dead center associated part (U) and a position on an opposite side of the drive shaft axis (O) from the bottom dead center associated part (U). 35 40
7. The variable displacement swash-plate compressor according to any one of claims 1 to 6, wherein, when the inclination angle is increased, the acting position (F1, F2; F3) is moved in a direction from the bottom dead center associated part (U) toward the drive shaft axis (O). 45
8. The variable displacement swash-plate compressor according to any one of claims 1 to 7, wherein the swash plate (5) has a through hole (5d), which slides on an outer circumference of the drive shaft (3) in response to changes in the inclination angle, and the swash plate (5) is guided by the link mechanism (7) and the through hole (5d) along the drive shaft axis (O) and in a direction of the inclination angle, 50 55

Fig.1

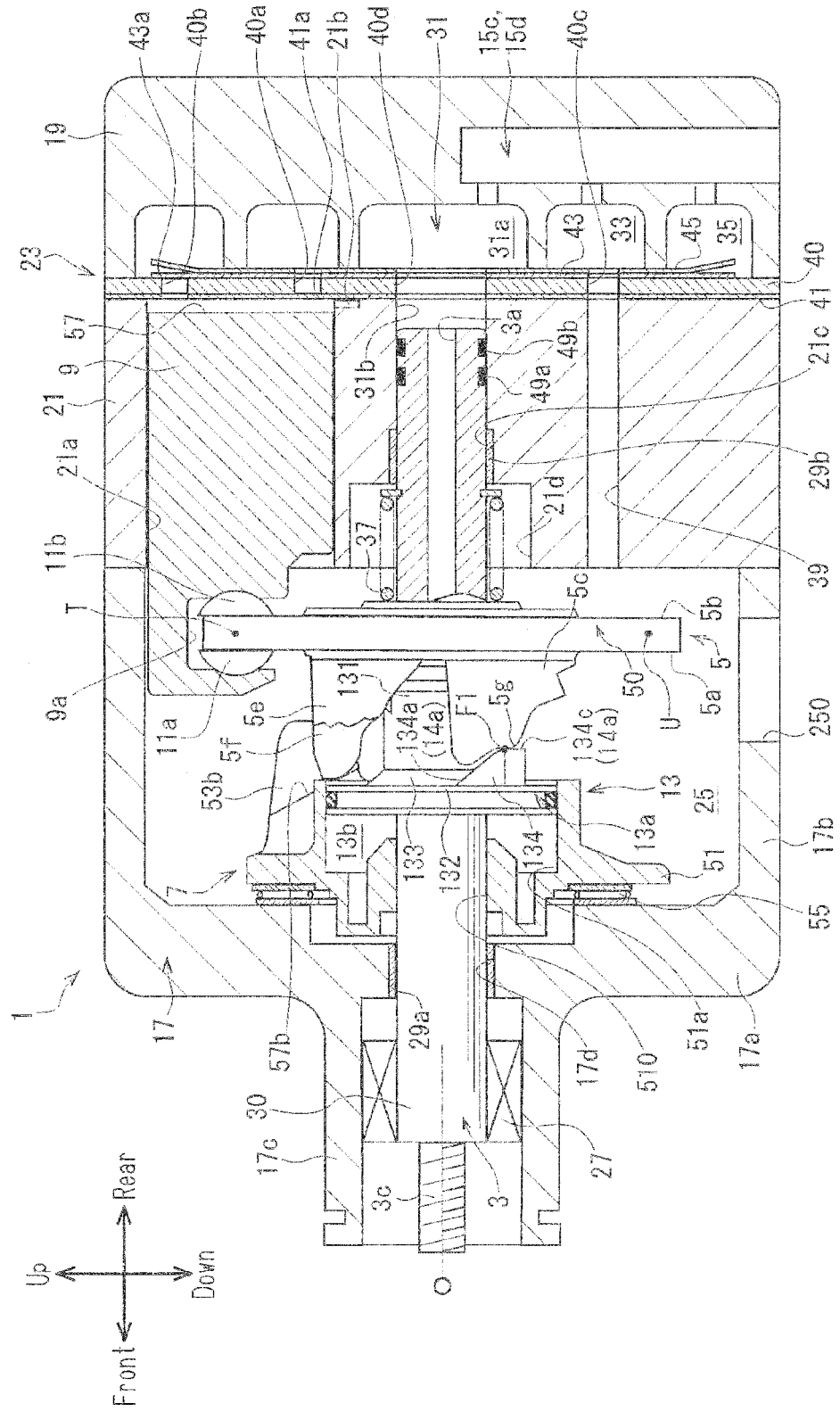


Fig.2

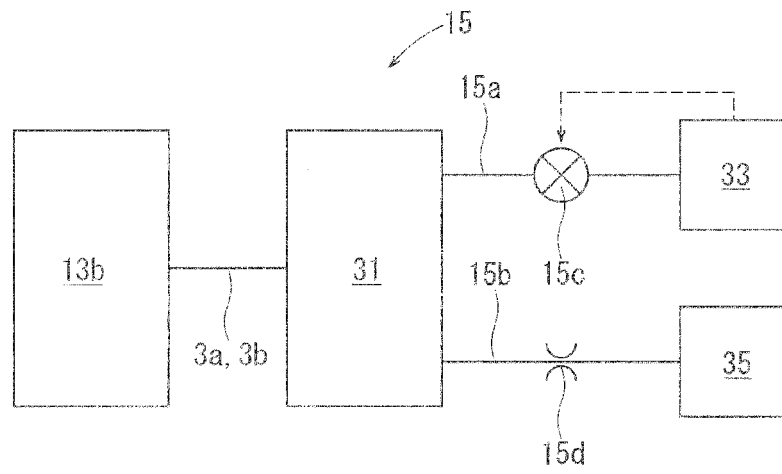


Fig.3

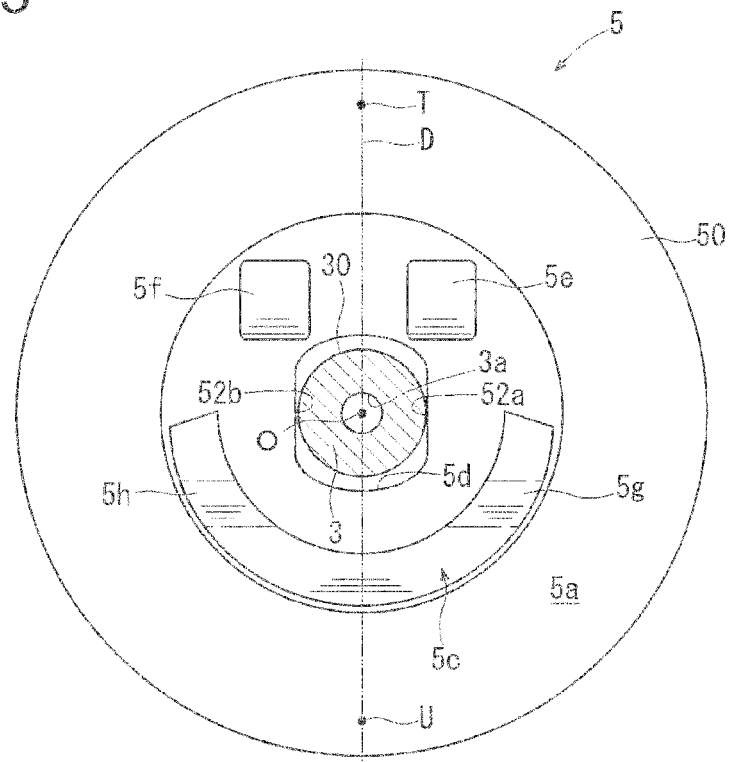


Fig.4

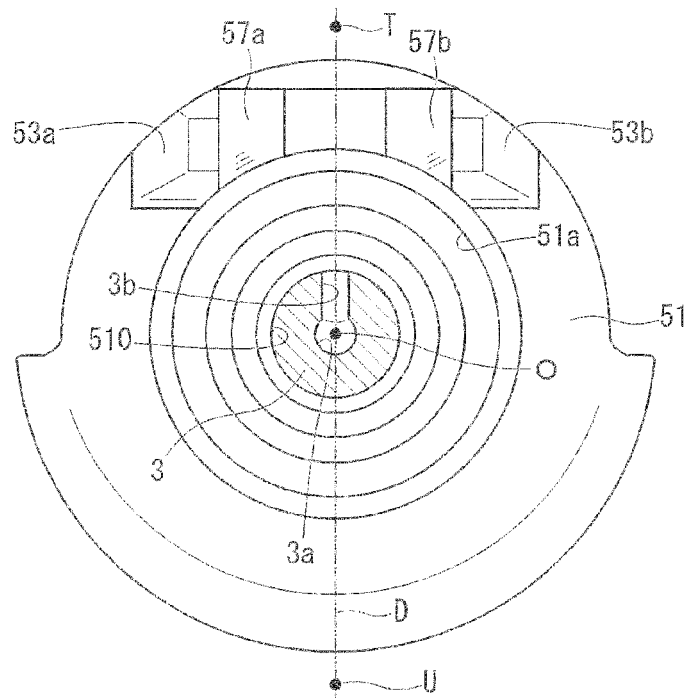


Fig.5

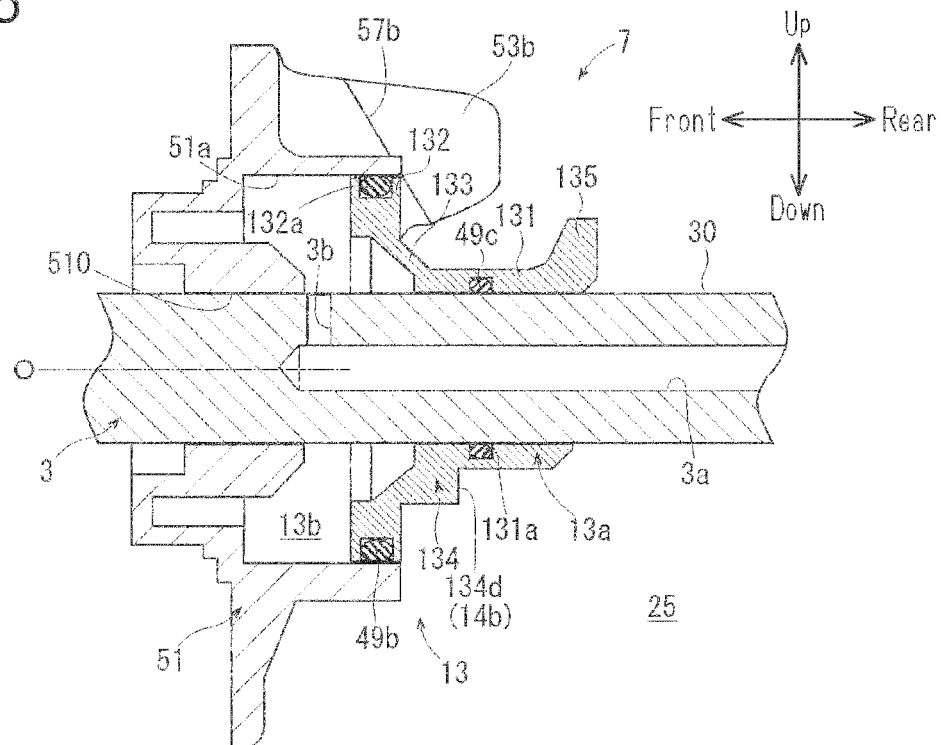


Fig.6

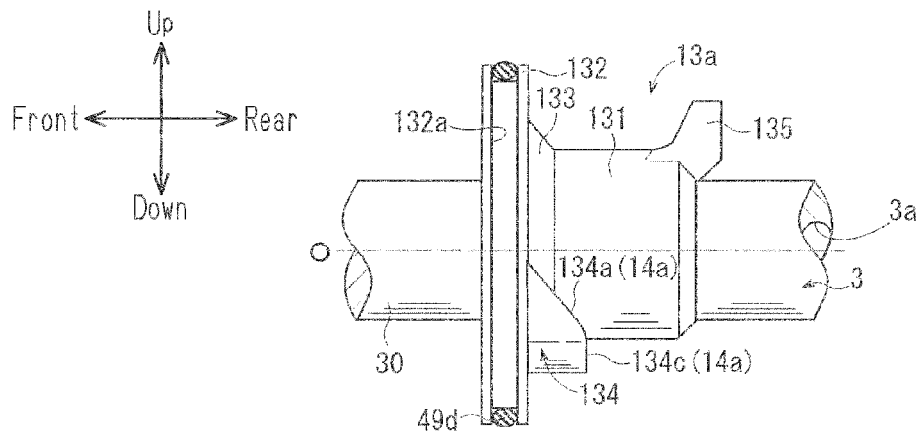


Fig.7

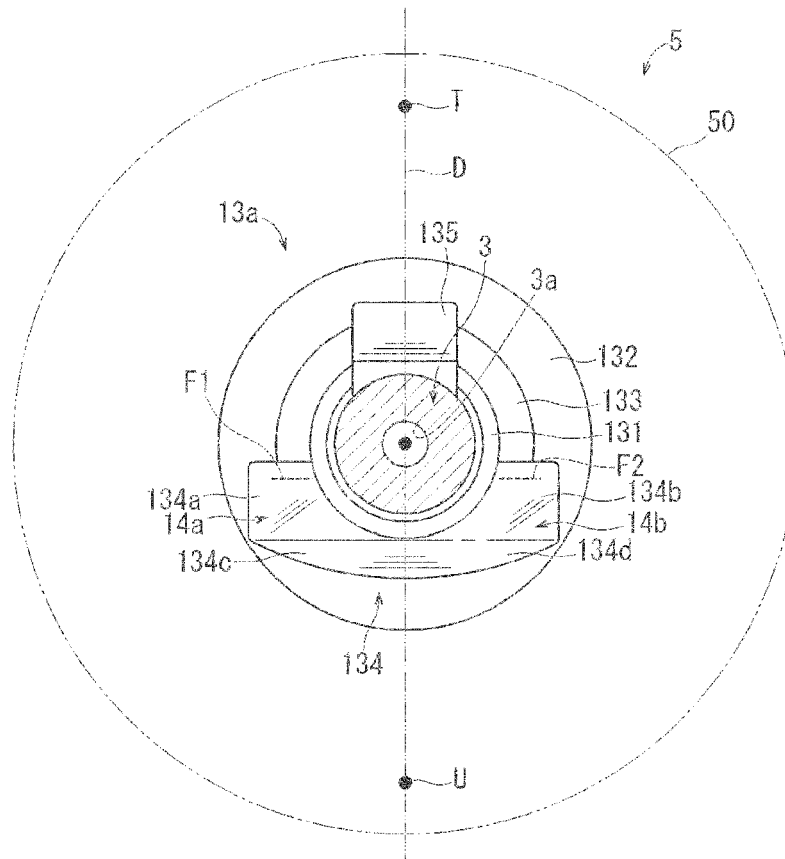


Fig. 8

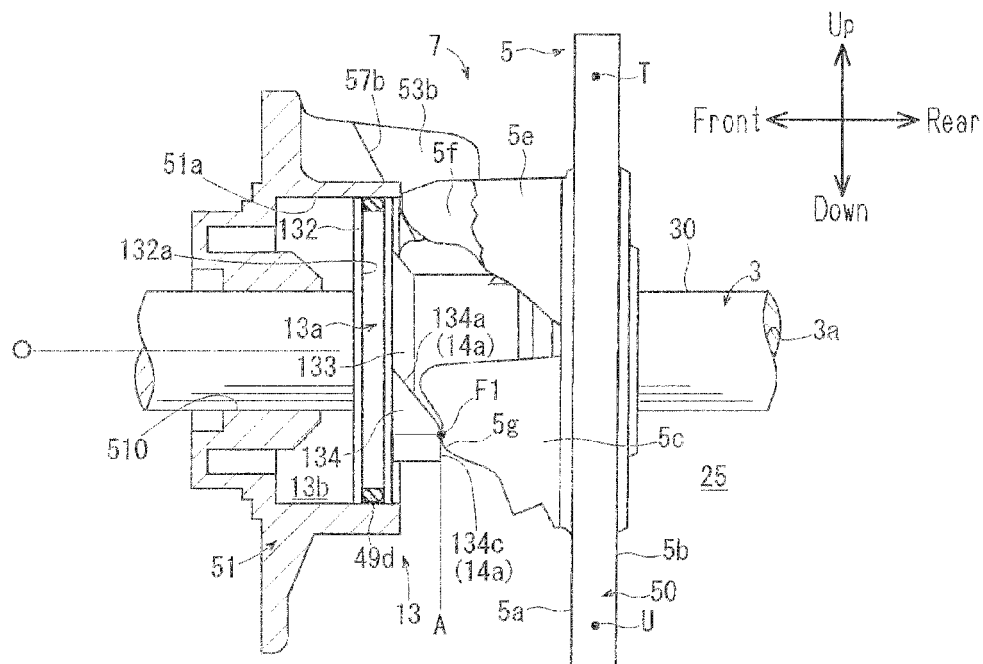


Fig. 9

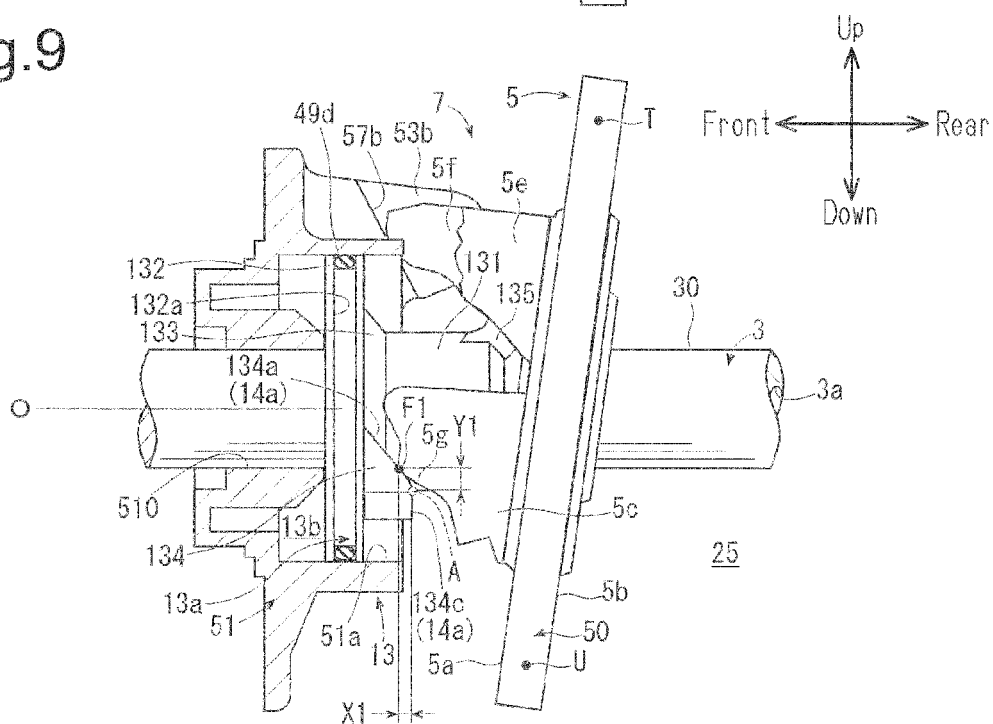


Fig.10

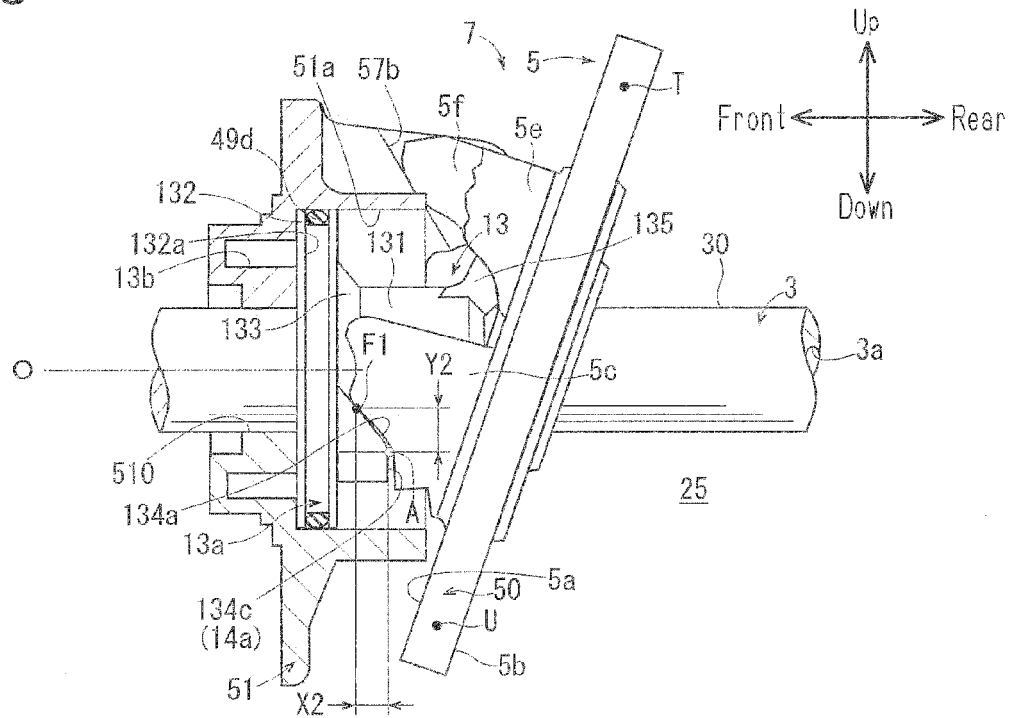


Fig.11

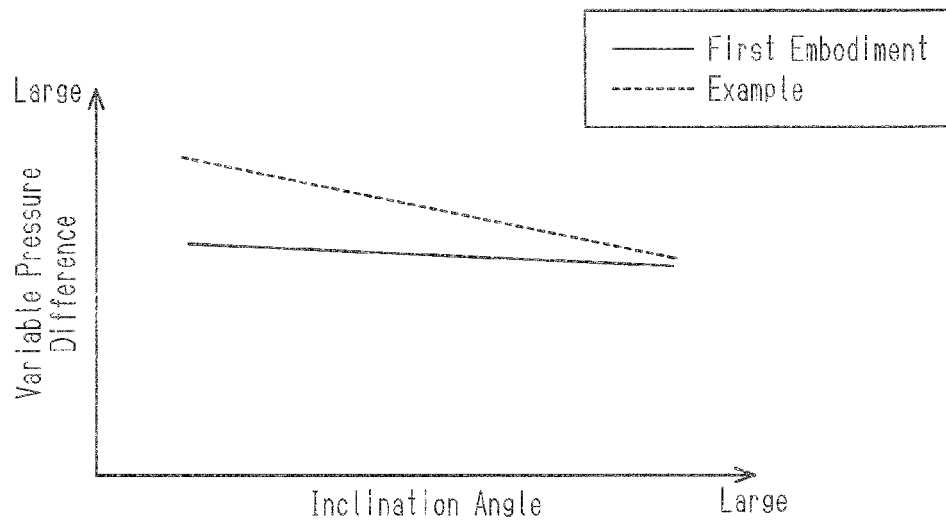


Fig.12

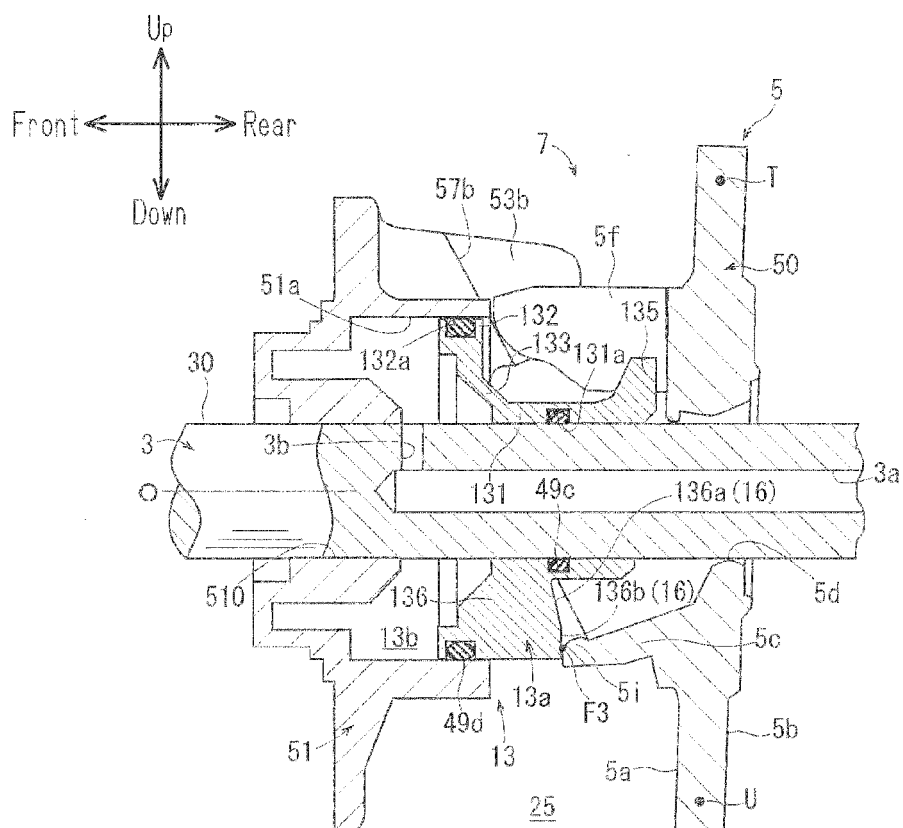


Fig.13

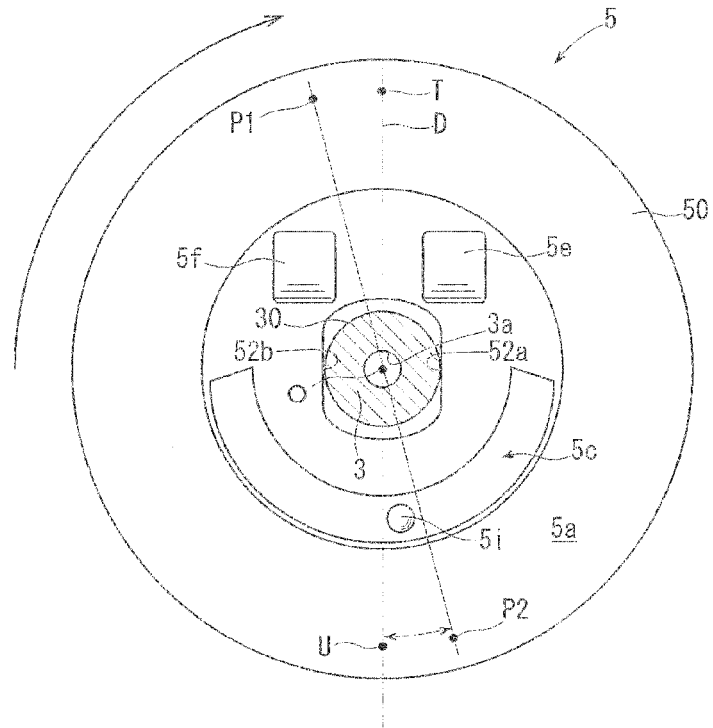
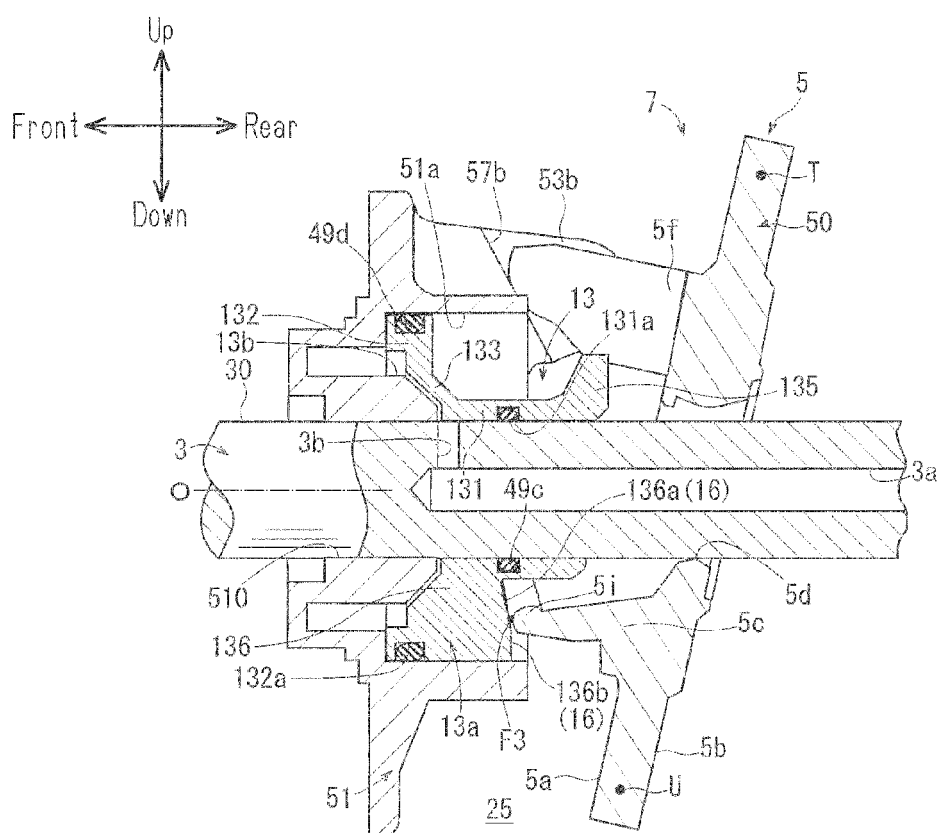


Fig. 14





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