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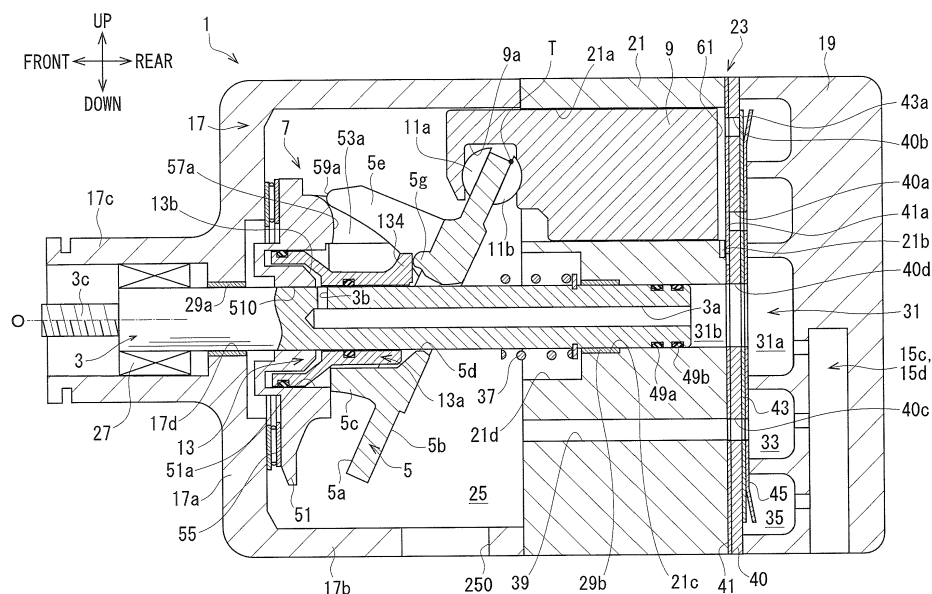
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(54) **Variable displacement swash plate type compressor**

(57) In the compressor of the present invention, guide surfaces 57a and 57b are formed on a lug plate 51 and guided surfaces 59a and 59b are formed on swash plate arms 5e and 5f. The guide surfaces 57a and 57b and the guided surfaces 59a and 59b are respectively in linear contact with one another at a first abutment position P1 when an inclination angle is maximum and are in linear contact with one another at a second abutment position

P2 when the inclination angle is minimum. The guide surfaces 57a and 57b are formed such that portions between the first abutment position P1 and the second abutment position P2 are convex toward the guided surfaces 59a and 59b. In the compressor, a contact angle θ_1 at the first abutment position P1 can be made large, and a contact angle θ_2 at the second abutment position P2 can be made small.

FIG. 1



Description

TECHNICAL FIELD

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

BACKGROUND ART

[0002] Japanese Patent Laid-Open No. 8-105384 discloses a conventional variable displacement swash plate type compressor (hereinafter, described as a compressor). In the compressor, suction chambers, discharge chambers, a swash plate chamber, center bores and a plurality of cylinder bores are formed in a housing. In the housing, a drive shaft is rotatably supported. In the swash plate chamber, a swash plate that is rotatable by rotation of the drive shaft is provided. Between the drive shaft and the swash plate, a link mechanism is provided. The link mechanism allows change of an inclination angle of the swash plate. Here, the inclination angle refers to an angle of the swash plate to the direction orthogonal to a drive shaft axis of the drive shaft. In the respective cylinder bores, pistons are accommodated reciprocally. Shoes that are made a pair for each of the pistons cause the respective pistons to reciprocate in the cylinder bores at a stroke corresponding to the inclination angle by rotation of the swash plate, as a conversion mechanism. An actuator changes the inclination angle. A control mechanism controls the actuator.

[0003] The link mechanism has a lug member, a first swash plate arm and a second swash plate arm. The lug member is fixed to the drive shaft, and is located at a front side in the swash plate chamber to face the swash plate. The first swash plate arm is provided at a front surface of the swash plate, and extends to a front part of the swash plate chamber. The first swash plate arm is pivotably connected to the lug member, and rotation of the drive shaft is transmitted to the first swash plate arm from the lug member. The second swash plate arm is provided at a rear surface of the swash plate, and extends to a rear part of the swash plate chamber. A guided surface is formed on the second swash plate arm. The guided surface is formed into a cylindrical shape.

[0004] The actuator is disposed at a rear side from the swash plate. The actuator has a first movable body, a second movable body and a control pressure chamber. The first movable body and the second movable body have the drive shaft inserted therethrough while the first movable body and the second movable body are aligned in an axial direction and are movable in a drive shaft axis direction. The first movable body is located in the center bore. The second movable body is provided with a flat guide surface which inclines at a fixed angle toward the swash plate side. The guide surface and the guided surface are in linear contact with each other. Further, the control pressure chamber moves the first movable body and the second movable body by an internal pressure.

[0005] In the compressor, the control mechanism introduces a refrigerant in the discharge chamber into the control pressure chamber, and thereby increases the pressure in the control pressure chamber. Thereby, the first movable body moves in the drive shaft axis direction in the center bore, and moves the second movable body to the front side of the swash plate chamber in the drive shaft axis direction. Therefore, the guided surface slides on the guide surface in a direction to be away from the drive shaft axis. Further, the first swash plate arm pivots with respect to the lug member. In this manner, in the compressor, the inclination angle of the swash plate increases, and a discharge capacity per one rotation of the drive shaft increases.

[0006] In the above described conventional compressor, the guided surface slides on the guide surface, and thereby change of the inclination angle of the swash plate is allowed. At this time, a compression load acts on the guide surface through the guided surface. The compression load has a component that causes the guide surface and the guided surface to slide in a direction to increase the inclination angle (hereinafter, the component will be called a capacity increasing component).

[0007] Here, if an angle that is formed by the guide surface and a virtual flat surface that is orthogonal to the drive shaft axis, that is, a contact angle of the guide surface and the guided surface, is made large, the capacity increasing component can be made large, and therefore a maximum discharge capacity is easily kept. Conversely, if the contact angle of the guide surface and the guided surface is made small, the capacity increasing component can be made small, and therefore, a minimum discharge capacity is easily kept.

[0008] However, in the conventional compressor, the guide surface is formed to be flat. Because of this, the guided surface slides on the guided surface while always keeping a fixed contact angle. Therefore, in the compressor, the maximum discharge capacity is difficult to keep, and the minimum discharge capacity is also difficult to keep.

[0009] The present invention is made in the light of the above described conventional circumstances, and it is an object of the present invention to provide a variable displacement swash plate type compressor capable of favorably keeping a maximum discharge capacity and also capable of favorably keeping a minimum discharge capacity, in a compressor that changes a discharge capacity by an actuator.

SUMMARY OF THE INVENTION

[0010] A variable displacement swash plate type compressor of the present invention comprises a housing in which a suction chamber, a discharge chamber, a swash plate chamber and a cylinder bore are formed, a drive shaft that is rotatably supported by the housing, a swash plate rotatable in the swash plate chamber by rotation of the drive shaft, a link mechanism that is provided between

the drive shaft and the swash plate and allows change of an inclination angle of the swash plate to a direction orthogonal to a drive shaft axis of the drive shaft, a piston that is accommodated in the cylinder bore to be capable of reciprocating, a conversion mechanism that causes the piston to reciprocate in the cylinder bore at a stroke corresponding to the inclination angle by rotation of the swash plate, an actuator capable of changing the inclination angle, and a control mechanism that controls the actuator, wherein the link mechanism has a lug member that is provided on the drive shaft in the swash plate chamber and faces the swash plate, and a swash plate arm to which rotation of the drive shaft is transmitted from the lug member, on the lug member, a guide surface that faces the swash plate arm is formed, on the swash plate arm, a guided surface that abuts on and is guided by the guide surface is formed, the actuator has the lug member, a movable body that is disposed between the lug member and the swash plate and is movable in a direction of the drive shaft axis, and a control pressure chamber that is provided between the lug member and the movable body and moves the movable body by an internal pressure, and the guide surface is formed such that a portion thereof between a first abutment position, where the guided surface abuts on the guide surface when the inclination angle is maximum, and a second abutment position, where the guided surface abuts on the guide surface when the inclination angle is minimum, is convex toward the guided surface.

[0011] Other aspects and advantages of the present invention will be apparent from the embodiments disclosed in the following description and in the attached drawings, the illustrations exemplified in the drawings, and the concept of the invention disclosed in the entire description and drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012]

FIG. 1 is a sectional view at a time of a maximum capacity in a compressor of Embodiment 1.

FIG. 2 is a schematic diagram showing a control mechanism, according to the compressor of Embodiment 1.

FIG. 3 is a schematic top view showing a link mechanism and the like, according to the compressor of Embodiment 1.

FIG. 4 is an essential part enlarged sectional view showing a lug plate, a movable body and the like, according to the compressor of Embodiment 1.

FIG. 5 is a sectional view at a time of a minimum capacity in the compressor of Embodiment 1.

FIG. 6 is a schematic view showing a state in which a guided surface abuts on a guide surface, and slides

from a first abutment position to a second abutment position while being guided, according to the compressor of Embodiment 1.

FIG. 7A is a schematic view showing a contact angle in a first abutment position of the guide surface and the guided surface, according to the compressor of Embodiment 1.

FIG. 7B is a schematic view showing a contact angle in a second abutment position of the guide surface and the guided surface, according to the compressor of Embodiment 1.

FIG. 8 is a graph showing a change ratio of a capacity increasing component, based on a change in a contact angle and a change in a variable differential pressure.

FIG. 9 is a schematic view showing a state in which a guided surface abuts on a guide surface and slides from a first abutment position to a second abutment position while being guided, according to a compressor of Embodiment 2.

FIG. 10 is a schematic view showing a contact angle of a guide surface and a guided surface, according to a compressor of a comparative example.

DETAILED DESCRIPTION OF EXEMPLARY EMBODIMENTS

[0013] Hereinafter, Embodiments 1 and 2 embodying the present invention will be described with reference to the drawings. Compressors in Embodiments 1 and 2 are variable displacement single head swash plate type compressors. These compressors are both mounted on vehicles, and configure refrigeration circuits of vehicle air-conditioning apparatuses.

(Embodiment 1)

[0014] As shown in FIG. 1, a compressor of Embodiment 1 includes a housing 1, a drive shaft 3, a swash plate 5, a link mechanism 7, a plurality of pistons 9, a pair of shoes 11a and 11b, an actuator 13, and a control mechanism 15 shown in FIG. 2.

[0015] As shown in FIG. 1, the housing 1 has a front housing 17 that is located at a front part of the compressor, a rear housing 19 that is located at a rear part of the compressor, a cylinder block 21 that is located between the front housing 17 and the rear housing 19, and a valve formation plate 23.

[0016] The front housing 17 has a front wall 17a that extends in an up and down direction of the compressor in the front part, and a circumferential wall 17b that is integrated with the front wall 17a and extends toward the rear part from the front part of the compressor. By the front wall 17a and the circumferential wall 17b, the front housing 17 forms a substantially cylindrical shape with a bottom. Further, by the front wall 17a and the circumferential wall 17b, a swash plate chamber 25 is formed in the front housing 17.

[0017] In the front wall 17a, a boss 17c that protrudes forward is formed. In the boss 17c, a shaft seal device 27 is provided. Further, in the boss 17c, a first shaft hole 17d that extends in a longitudinal direction of the compressor is formed. In the first shaft hole 17d, a first sliding bearing 29a is provided.

[0018] In the circumferential wall 17b, an inlet port 250 that communicates with the swash plate chamber 25 is formed. Through the inlet port 250, the swash plate chamber 25 is connected to an evaporator not illustrated. Thereby, a low pressure refrigerant gas that has passed through the evaporator flows into the swash plate chamber 25 through the inlet port 250. Therefore, a pressure in the swash plate chamber 25 is lower than a pressure in a discharge chamber 35 that will be described later.

[0019] In the rear housing 19, a part of the control mechanism 15 is provided. Further, in the rear housing 19, a first pressure regulation chamber 31a, a suction chamber 33 and a discharge chamber 35 are formed. The first pressure regulation chamber 31a is located in a center portion of the rear housing 19. The discharge chamber 35 is located annularly at an outer circumferential side of the rear housing 19. Further, the suction chamber 33 is formed annularly between the first pressure regulation chamber 31a and the discharge chamber 35, in the rear housing 19. The discharge chamber 35 is connected to an outlet port not illustrated.

[0020] In the cylinder block 21, cylinder bores 21a, the number of which is the same as the number of the pistons 9, are formed in a circumferential direction at equiangular intervals. Front end sides of the respective cylinder bores 21a communicate with the swash plate chamber 25. Further, in the cylinder block 21, a retainer groove 21b that regulates a maximum angle of a suction reed valve 41a that will be described later is formed.

[0021] Furthermore, in the cylinder block 21, a second shaft hole 21c that extends in the longitudinal direction of the compressor while communicating with the swash plate chamber 25 is provided to penetrate the cylinder block 21. In the second shaft hole 21c, a second sliding bearing 29b is provided. Note that in place of the first sliding bearing 29a and the second sliding bearing 29b described above, rolling bearings can be adopted respectively.

[0022] Further, in the cylinder block 21, a spring chamber 21d is formed. The spring chamber 21d is located between the swash plate chamber 25 and the second shaft hole 21c. In the spring chamber 21d, a return spring 37 is disposed. The return spring 37 urges the swash plate 5 the inclination angle of which is minimum toward a front part of the swash plate chamber 25. Further, in the cylinder block 21, a suction passage 39 that communicates with the swash plate chamber 25 is formed.

[0023] The valve formation plate 23 is provided between the rear housing 19 and the cylinder block 21. The valve formation plate 23 consists of a valve plate 40, a suction valve plate 41, a discharge valve plate 43 and a retainer plate 45.

[0024] In the valve plate 40, the discharge valve plate 43 and the retainer plate 45, suction ports 40a the number of which is the same as the number of the cylinder bores 21a are formed. Further, in the valve plate 40 and the suction valve plate 41, discharge ports 40b the number of which is the same as the number of the cylinder bores 21a are formed. The respective cylinder bores 21a communicate with the suction chamber 33 through the respective suction ports 40a, and communicate with the discharge chamber 35 through the respective discharge ports 40b. Further, in the valve plate 40, the suction valve plate 41, the discharge valve plate 43 and the retainer plate 45, a first communication hole 40c and a second communication hole 40d are formed. By the first communication hole 40c, the suction chamber 33 and the suction passage 39 communicate with each other. Thereby, the swash plate chamber 25 and the suction chamber 33 communicate with each other.

[0025] The suction valve plate 41 is provided on a front surface of the valve plate 40. At the suction valve plate 41, a plurality of suction reed valves 41a capable of opening and closing the respective suction ports 40a by elastic deformation are formed. Further, the discharge valve plate 43 is provided on a rear surface of the valve plate 40. At the discharge valve plate 43, a plurality of discharge reed valves 43a capable of opening and closing the respective discharge ports 40b by elastic deformation are formed. The retainer plate 45 is provided on a rear surface of the discharge valve plate 43. The retainer plate 45 restricts a maximum opening degree of the discharge reed valve 43a.

[0026] The drive shaft 3 is inserted toward a rear side of the housing 1 from a boss 17c side. The drive shaft 3 has a front end side inserted through the shaft seal device 27 in the boss 17c, and supported by the first sliding bearing 29a in the first shaft hole 17d. Further, a rear end side of the drive shaft 3 is supported by the second sliding bearing 29b in the second shaft hole 21c. In this manner, the drive shaft 3 is supported rotatably around a drive shaft axis O with respect to the housing 1. In the second shaft hole 21c, a second pressure regulation chamber 31b is defined in a space from a rear end of the drive shaft 3. The second pressure regulation chamber 31b communicates with the first pressure regulation chamber 31a through the second communication hole 40d. By these first and the second pressure regulation chambers 31a and 31b, a pressure regulation chamber 31 is formed.

[0027] At the rear end of the drive shaft 3, O-rings 49a and 49d are provided. Thereby, the respective O-rings 49a and 49b are located between the drive shaft 3 and the second shaft hole 21c to seal a space between the swash plate chamber 25 and the pressure regulation chamber 31.

[0028] Further, the link mechanism 7, the swash plate 5 and the actuator 13 are fitted to the drive shaft 3. As shown in FIG. 3, the link mechanism 7 has a lug plate 51, a pair of lug arms 53a and 53b that are formed at the

lug plate 51, and a pair of swash plate arms 5e and 5f that are formed at the swash plate 5. The lug plate 51 corresponds to a lug member in the present invention. Note that in FIG. 3, in order to facilitate explanation, shapes of the lug plate 51, the swash plate 5 and the like are illustrated by being simplified.

[0029] As shown in FIG. 1, the lug plate 51 is formed into a substantially annular ring shape in which an insertion hole 510 is provided to penetrate therethrough. The lug plate 51 is disposed forward of the swash plate 5, in the swash plate chamber 25. As shown in FIG. 4, the drive shaft 3 is press-fitted into the insertion hole 510, and the lug plate 51 is rotatable integrally with the drive shaft 3. Further, between the lug plate 51 and the front wall 17a, a thrust bearing 55 is provided.

[0030] In the lug plate 51, a cylindrical cylinder chamber 51a that extends in a longitudinal direction of the lug plate 51 is concavely provided coaxially with the drive shaft axis O. The cylinder chamber 51a opens to the swash plate chamber 25 at a rear end surface of the lug plate 51, and extends to a spot to be an inner side of the thrust bearing 55 in the lug plate 51, from the rear end surface of the lug plate 51.

[0031] As shown in FIG. 3, the respective lug arms 53a and 53b extend rearward respectively from the lug plate 51. Further, on the lug plate 51, a pair of guide surfaces 57a and 57b are formed at a position between the respective lug arms 53a and 53b. The lug arms 53a and 53b and the guide surfaces 57a and 57b are respectively formed on the lug plate 51 such that a top dead center surface X, which is an imaginary surface defined by a top dead center position T of the swash plate 5 and the drive shaft axis O, is interposed therebetween. Further, in the compressor, a first virtual plane Y1 that intersects the drive shaft axis O while being orthogonal to the top dead center surface X is assumed.

[0032] As shown in FIG. 1, the swash plate 5 forms an annular flat plate shape, and has a front surface 5a and a rear surface 5b. On the front surface 5a, a weight portion 5c that protrudes forward of the swash plate 5 is formed. The weight portion 5c abuts on the lug plate 51 when the inclination angle of the swash plate 5 becomes maximum. Further, in a center of the swash plate 5, an insertion hole 5d is formed. The drive shaft 3 is inserted through the insertion hole 5d.

[0033] As shown in FIG. 3, the respective swash plate arms 5e and 5f are formed respectively on a front surface 5a of the swash plate 5 with the top dead center surface X therebetween. The respective swash plate arms 5e and 5f extend forward from the front surface 5a. Further, at tip ends of the respective swash plate arms 5e and 5f, guided surfaces 59a and 59b are formed. As shown by the two-dot chain line in FIG. 4, the guided surface 59a is formed into a cylindrical shape having a generating line that extends in a direction orthogonal to the top dead center surface X. The same goes for the guided surface 59b.

[0034] Further, as shown in FIG. 1, in the swash plate

5, a substantially semispherical convex portion 5g is protrudingly provided on the front surface 5a, and is integrated with the front surface 5a. The convex portion 5g is located between the swash plate arm 5e and the swash plate arm 5f.

[0035] As shown in FIG. 3, in the compressor, the respective swash plate arms 5e and 5f are inserted between the respective lug arms 53a and 53b, whereby the lug plate 51 and the swash plate 5 are connected. Thereby, a rotational drive force of the lug plate 51 is transmitted to the respective swash plate arms 5e and 5f from the respective lug arms 53a and 53b. Thereby, the swash plate 5 is rotatable with the lug plate 51, in the swash plate chamber 25.

[0036] As above, the lug plate 51 and the swash plate 5 are connected, whereby the guided surface 59a of the swash plate arm 5e abuts on the guide surface 57a, and the guided surface 59b of the swash plate arm 5f abuts on the guide surface 57b. Here, the respective guided surfaces 59a and 59b of the respective swash plate arms 5e and 5f are formed into cylindrical shapes, and therefore, the respective guide surfaces 57a and 57b and the respective guided surfaces 59a and 59b are in linear contact with one another respectively. Subsequently, the respective guided surfaces 59a and 59b slide on the respective guide surfaces 57a and 57b while being guided by the guide surfaces 57a and 57b respectively. In this manner, the swash plate 5 can change an inclination angle of its own relative to a direction orthogonal to the drive shaft axis O, from a maximum inclination angle shown in FIG. 1 to a minimum inclination angle shown in FIG. 5, while substantially keeping the top dead center position T.

[0037] As described above, the respective guided surfaces 59a and 59b are formed into cylindrical shapes, and therefore, curvatures of the respective guided surfaces 59a and 59b are fixed. Therefore, as shown in FIG. 6, in both a first abutment position P1 and a second abutment position P2, distances from respective centers C1 of the guided surfaces 59a and 59b to the guide surfaces 57a and 57b are fixed.

[0038] As shown in FIG. 3 and FIG. 4, the guide surface 57a extends outward in a radial direction of the lug plate 51 from the drive shaft axis O side. The guide surface 57a is formed into a substantially cylindrical shape having a generating line that extends to be orthogonal to the top dead center surface X, and bends into a convex shape that protrudes rearward with respect to the first virtual plane Y1. More specifically, as shown in FIG. 6, the guide surface 57a is formed such that a portion between the first abutment position P1, where the guide surface 57a and the guided surface 59a are in linear contact with each other when the inclination angle of the swash plate 5 is maximum, and the second abutment position P2, where the guide surface 57a and the guided surface 59a are in linear contact with each other when the inclination angle is minimum, is convex toward the guided surface 59a. Further, in the guide surface 57a, a top portion P3 is

formed to be offset to the first abutment position P1 side from a middle between the first abutment position P1 and the second abutment position P2. The top portion P3 is present at a position that is the most separated from the first virtual plane Y1, in the generating line on the guide surface 57a. The guide surface 57b shown in FIG. 3 is similar to the above, and is formed into a convex shape toward the guided surface 59b.

[0039] As shown in FIG. 4, the actuator 13 consists of the lug plate 51, a movable body 13a and a control pressure chamber 13b.

[0040] The movable body 13a has the drive shaft 3 inserted therethrough, and is movable in the drive shaft axis O direction while sliding in contact with the drive shaft 3. The movable body 13a forms a cylindrical shape coaxial with the drive shaft 3. In more detail, the movable body 13a has a first cylinder portion 131, a second cylinder portion 132, and a connection portion 133. The first cylinder portion 131 is located at the swash plate 5 side in the movable body 13a, and is in sliding contact with the drive shaft 3. An O-ring 49c is provided on an inner circumferential surface of the first cylinder portion 131. The second cylinder portion 132 is located at a front part of the movable body 13a. The second cylinder portion 132 is formed to have a larger diameter than the first cylinder portion 131. An O-ring 49d is provided on an outer circumferential surface of the second cylinder portion 132. The connection portion 133 is located between the first cylinder portion 131 and the second cylinder portion 132, and extends while gradually enlarging a diameter toward the front part from a rear part of the movable body 13a. In the connection portion 133, a rear end continues to the first cylinder portion 131, and a front end continues to the second cylinder portion 132.

[0041] Further, an acting portion 134 is formed integrally with a rear end of the first cylinder portion 131. The acting portion 134 vertically extends toward a top dead center position T side of the swash plate 5 from the drive shaft axis O side, and abuts on the convex portion 5g. Thereby, the movable body 13a is rotatable integrally with the lug plate 51 and the swash plate 5.

[0042] Further, the cylinder chamber 51a can accommodate the second cylinder portion 132 and the connection portion 133 by causing the second cylinder portion 132 and the connection portion 133 to advance to an inside.

[0043] The control pressure chamber 13b is formed among the second cylinder portion 132, the connection portion 133, the cylinder chamber 51a and the drive shaft 3. A space between the control pressure chamber 13b and the swash plate chamber 25 is sealed by the O-rings 49c and 49d.

[0044] Further, in the drive shaft 3, an axial path 3a that extends in the drive shaft axis O direction toward the front end from the rear end of the drive shaft 3, and a radial path 3b that extends in a radial direction from a front end of the axial path 3a and opens to the outer circumferential surface of the drive shaft 3 are formed.

As shown in FIG. 1, a rear end of the axial path 3a opens to the pressure regulation chamber 31. Meanwhile, the radial path 3b opens to the control pressure chamber 13b. By the axial path 3a and the radial path 3b, the pressure regulation chamber 31 and the control pressure chamber 13b communicate with each other.

[0045] The drive shaft 3 is connected to a pulley or an electromagnetic clutch not illustrated, by a screw portion 3c that is formed at a tip end.

[0046] The respective pistons 9 are respectively accommodated in the respective cylinder bores 21a, and are capable of reciprocating in the respective cylinder bores 21a. By the respective pistons 9 and the valve formation plate 23, compression chambers 61 are defined in the respective cylinder bores 21a.

[0047] Further, in the respective pistons 9, engaging portions 9a are concavely provided respectively. In the engaging portion 9a, the semispherical shoes 11a and 11b are respectively provided. The respective shoes 11a and 11b convert rotation of the swash plate 5 into reciprocal movement of the respective pistons 9. The respective shoes 11a and 11b correspond to a conversion mechanism in the present invention. In this manner, the respective pistons 9 can reciprocate in the cylinder bores 21a respectively at a stroke corresponding to the inclination angle of the swash plate 5.

[0048] As shown in FIG. 2, the control mechanism 15 has a low-pressure passage 15a, a high-pressure passage 15b, a control valve 15c and an orifice 15d, and the axial path 3a and the radial path 3b.

[0049] The low-pressure passage 15a is connected to the pressure regulation chamber 31 and the suction chamber 33. Thereby, by the low-pressure passage 15a, the axial path 3a and the radial path 3b, the control pressure chamber 13b, the pressure regulation chamber 31 and the suction chamber 33 are brought into a state communicating to one another. The high-pressure passage 15b is connected to the pressure regulation chamber 31 and the discharge chamber 35. By the high-pressure passage 15b, the axial path 3a and the radial path 3b, the control pressure chamber 13b, the pressure regulation chamber 31 and the discharge chamber 35 communicate with one another. Further, the orifice 15d is provided in the high-pressure passage 15b.

[0050] The control valve 15c is provided in the low-pressure passage 15a. The control valve 15c can regulate an opening degree of the low-pressure passage 15a based on a pressure in the suction chamber 33.

[0051] In the compressor, piping connecting to the evaporator is connected to the inlet port 250 shown in FIG. 1, and piping connecting to a condenser is connected to the outlet port. The condenser is connected to the evaporator via piping and an expansion valve. By the compressor, the evaporator, the expansion valve, the condenser and the like, a refrigeration circuit of an air-conditioning apparatus for a vehicle is configured. Note that illustration of the evaporator, the expansion valve, the condenser and the respective pipings are omitted.

[0052] In the compressor which is configured as above, the drive shaft 3 rotates, whereby the swash plate 5 rotates, and the respective pistons 9 reciprocate in the respective cylinder bores 21a. Therefore, the compression chamber 61 changes a capacity in response to a piston stroke. Therefore, the refrigerant gas which is taken into the swash plate chamber 25 by the inlet port 250 from the evaporator passes through the suction chamber 33 from the suction passage 39 and is compressed in the compression chamber 61. Subsequently, the refrigerant gas which is compressed in the compression chamber 61 is discharged into the discharge chamber 35 and is discharged into the condenser from the outlet port. Further, by the weight portion 5c, an inertial force during rotation of the swash plate 5 is regulated.

[0053] During the above, in the compressor, a piston compression force that makes the inclination angle of the swash plate 5 small acts onto the swash plate 5, the lug plate 51 and the like. In the compressor, the inclination angle of the swash plate 5 is changed to increase or decrease the stroke of the piston 9, and thereby capacity control can be performed.

[0054] More specifically, when the control valve 15c shown in FIG. 2 makes the opening degree of the low-pressure passage 15a large, in the control mechanism 15, the pressure in the pressure regulation chamber 31, and by extension, the pressure in the control pressure chamber 13b becomes substantially equal to the pressure in the suction chamber 33. Therefore, a differential pressure (hereinafter, called a variable differential pressure) between the control pressure chamber 13b and the swash plate chamber 25 becomes small. Thereby, by the piston compression force which acts on the swash plate 5, in the actuator 13, the movable body 13a slides in the cylinder chamber 51a toward the lug plate 51 side from the swash plate 5 side in the drive shaft axis O direction, as shown in FIG. 1.

[0055] Further, at the same time, in the compressor, by the piston compression force and the urging force of the return spring 37 which act on the swash plate 5 itself, the guided surface 59a of the swash plate arm 5e slides on the guide surface 57a so as to be away from the drive shaft axis O. Similarly, the guided surface 59b of the swash plate arm 5f also slides on the guide surface 57b.

[0056] Therefore, in the swash plate 5, a bottom dead center side pivots in a clockwise direction while substantially keeping the top dead center position T. In this manner, in the compressor, the inclination angle of the swash plate 5 to the drive shaft axis O of the drive shaft 3 increases. Thereby, in the compressor, the stroke of the piston 9 increases, and the discharge capacity per one rotation of the drive shaft 3 becomes large. Note that the inclination angle of the swash plate 5 shown in FIG. 1 is a maximum inclination angle in the compressor. At this time, the guided surface 59a and the guide surface 57a are in linear contact with each other at the first position P1 as shown in FIG. 6. The same applies to the guided surface 59b and the guide surface 57b.

[0057] Meanwhile, when the control valve 15c shown in FIG. 2 makes the opening degree of the low-pressure passage 15a small, the pressure in the pressure regulation chamber 31 becomes high, and the pressure in the control pressure chamber 13b becomes high. Therefore, the variable differential pressure becomes large. Thereby, as shown in FIG. 5, the movable body 13a slides in the cylinder chamber 51a in the drive shaft axis O direction toward the swash plate 5 side while moving away from the lug plate 51.

[0058] Thereby, in the compressor, the acting portion 134 presses the convex portion 5g toward the rear part of the swash plate chamber 25. Therefore, the guided surface 59a of the swash plate arm 5e slides on the guide surface 57a so as to be close to the drive shaft axis O. Similarly, the guided surface 59b of the swash plate arm 5f also slides on the guide surface 57b.

[0059] Therefore, in the swash plate 5, the bottom dead center side pivots in a counterclockwise direction while substantially keeping the top dead center position T. In this manner, in the compressor, the inclination angle of the swash plate 5 to the drive shaft axis O of the drive shaft 3 is decreased. Thereby, in the compressor, the stroke of the piston 9 decreases, and the discharge capacity per one rotation of the drive shaft 3 becomes small. Further, the swash plate 5 abuts on the return spring 37 by the inclination angle decreasing. Note that the inclination angle of the swash plate 5 shown in FIG. 5 is a minimum inclination angle in the compressor. At this time, as shown in FIG. 6, the guided surface 59a and the guide surface 57a are in linear contact with each other at the second position P2. The same applies to the guided surface 59b and the guide surface 57b.

[0060] As above, in the compressor, the respective guided surfaces 59a and 59b of the respective swash plate arms 5e and 5f respectively slide on the respective guide surfaces 57a and 57b of the lug plate 51, whereby change of the inclination angle of the swash plate 5 is allowed. Here, in the compressor, the guide surfaces 57a and 57b are formed such that portions between the first abutment position P1 and the second abutment position P2 are convex toward the guided surfaces 59a and 59b, respectively. Therefore, in the compressor, the contact angle changes at the first abutment position P1 side and the second abutment position P2 side. More specifically, a radius of curvature becomes large at the first abutment position P1 side, and the radius of curvature becomes small at the second abutment position P2 side.

[0061] The radius of curvature changes as above, and thereby, a contact angle θ_1 , which is an angle formed by the guide surfaces 57a and 57b and the guided surfaces 59a and 59b when the inclination angle is maximum as shown in FIG. 7A, differs from a contact angle θ_2 , which is an angle formed by the guide surfaces 57a and 57b and the guided surfaces 59a and 59b when the inclination angle is minimum as shown in FIG. 7B in this compressor. Hereinafter, details will be described based on the guide surface 57a and the guided surface 59a.

[0062] The contact angle θ_1 refers to an angle formed by a contact surface S1, which is formed by the guide surface 57a and the guided surface 59a, and a second virtual plane Y2, which is a plane orthogonal to the drive shaft axis O, when the inclination angle of the swash plate 5 is maximum, i.e., at the first abutment position P1 as shown in FIG. 7A. Likewise, the contact angle θ_2 refers to an angle formed by a contact surface S2, which is formed by the guide surface 57a and the guided surface 59a, and the second virtual plane Y2, which is a plane orthogonal to the drive shaft axis O, when the inclination angle of the swash plate 5 is minimum, i.e., at the second abutment position P2 as shown in FIG. 7B.

[0063] FIG. 10 shows a compressor of a comparative example. In the compressor of the comparative example, a pair of guide surfaces 63 are formed on the lug plate 51. The respective guide surfaces 63 are formed to be flat downward inclinations toward a center side from an outer circumferential side of the lug plate 51 along the first virtual plane Y1. Thereby, in the compressor, a radius of curvature is fixed from the first abutment position P1 to the second abutment position P2. Therefore, either in the first abutment position P1, or in the second abutment position P2, contact angles θ_x of the respective guided surfaces 59a and 59b and the respective guide surfaces 63 are fixed without changing.

[0064] In this respect, in the present compressor, the radius of curvature is large at the first abutment position P1 side, and the radius of curvature is small at the second abutment position P2 side. Therefore, in this compressor, the contact angle changes from the contact angle θ_1 to the contact angle θ_2 while the inclination angle becomes minimum from the maximum.

[0065] As shown in a graph in FIG. 8, in the compressor, as the radius of curvature becomes larger, and the contact angle of the guide surfaces 57a and 57b and the guided surfaces 59a and 59b becomes larger, the capacity increasing component becomes larger. Meanwhile, as the radius of curvature becomes smaller, and the contact angle of the guide surfaces 57a and 57b and the guided surfaces 59a and 59b becomes smaller, the capacity increasing component becomes smaller.

[0066] Here, in this compressor, the contact angle θ_1 in the first abutment position P1 is an angle that is larger than the contact angle θ_x in the compressor of the comparative example. Meanwhile, the contact angle θ_2 in the second abutment position P2 is an angle that is smaller than the contact angle θ_x in the compressor of the comparative example.

[0067] Thereby, in this compressor, the capacity increasing component can be made large when the inclination angle of the swash plate 5 is maximum, and the maximum discharge capacity is easily kept, as compared with the compressor of the comparative example. Conversely, in this compressor, the capacity increasing component can be made small when the inclination angle of the swash plate 5 is minimum, and the minimum discharge capacity can be easily kept. Meanwhile, in the

compressor of the comparative example, the radius of curvature is fixed, and therefore, the capacity increasing component is fixed when the inclination angle of the swash plate 5 is maximum and when the inclination angle is minimum. Therefore, the maximum discharge capacity and the minimum discharge capacity are difficult to keep.

[0068] Consequently, according to the compressor of Embodiment 1, in the compressor which changes the discharge capacity by the actuator 13, the maximum discharge capacity can be favorably kept and the minimum discharge capacity also can be favorably kept.

[0069] In particular, in this compressor, the top portions P3 of the guide surfaces 57a and 57b are offset to the first abutment position P1 side from the middle between the first abutment position P1 and the second abutment position P2. Therefore, in this compressor, in changing the inclination angle of the swash plate 5, the respective guided surfaces 59a and 59b can favorably slide on the respective guide surfaces 57a and 57b, and the discharge capacity can be favorably changed from the maximum discharge capacity to the minimum discharge capacity.

(Embodiment 2)

[0070] A compressor in Embodiment 2 is provided with a pair of swash plate arms 67 shown in FIG. 9, in place of the swash plate arms 5e and 5f in the compressor of Embodiment 1. Though not illustrated, the respective swash plate arms 67 are also respectively formed on the front surface 5a of the swash plate 5 with the top dead center surface X interposed therebetween, and extend forward from the front surface 5a. Further, guided surfaces 67a are formed at tip ends of the respective swash plate arms 67. As shown by the two-dot chain lines in FIG. 9, the guided surface 67a is formed into an elliptical shape having a generating line that extends to be orthogonal to the top dead center surface X.

[0071] Thereby, in the compressor, a radius R1 of curvature of the guide surface 67a at the first abutment position P1 differs from a radius R2 of curvature of the guide surface 67a at the second abutment position P2. More specifically, the radius R1 of curvature of the guided surface 67a in the first abutment position P1 is smaller than the radius R2 of curvature of the guided surface 67a in the second abutment position P2. Note that the guided surface 67a may be formed into a parabolic shape or the like so that the radius of curvature of the guided surface 67a differs in the first abutment position P1 and the second abutment position P2. The other components in the compressor are similar to those in the compressor of Embodiment 1, and detailed explanation concerning the same components will be omitted by assigning the same reference signs to the same components.

[0072] In this compressor, the guide surface 57a and the guided surface 67a are in linear contact with each other at a contact angle θ_3 when an angle formed by a contact surface S3 of the guide surface 57a and the guid-

ed surface 67a and a second virtual plane Y2 at the first abutment position P1, i.e., the inclination angle of the swash plate 5, is maximum. Meanwhile, the guide surface 57a and the guided surface 67a are in linear contact with each other at a contact angle θ_4 when an angle formed by a contact surface S4 of the guide surface 57a and the guided surface 67a and the second virtual plane Y2 at the second abutment position P2, i.e., the inclination angle of the swash plate 5, is minimum. As described above, in the guide surfaces 57a and 57b, the radiuses of curvature are large on the side of the first abutment position P1 side, and the radiuses of curvature are small on the side of the second abutment position P2. Therefore, in this compressor, the contact angle θ_3 is larger than the contact angle θ_4 .

[0073] Here, as described above, the radius R1 of curvature of the guided surface 67a at the first abutment position P1 is smaller than the radius R2 of curvature at the second abutment position P2. Therefore, in this compressor, at the first abutment position P1, a distance from the center C2 of the guided surface 67a to the guide surface 57a is short, and conversely, in the second abutment position P2, the distance from the center C2 of the guided surface 67a to the guide surface 57a is long.

[0074] Thereby, even though the contact angles θ_3 and θ_4 differ from each other when the inclination angle of the swash plate 5 is maximum and when the inclination angle is minimum, change of the top dead center position of the piston 9 can be made small, in this compressor. The other operations in the compressor are similar to those of the compressor in Embodiment 1.

[0075] Although the present invention has been described above based on Embodiments 1 and 2, the present invention is not limited to the above described Embodiments 1 and 2, and it is needless to say that the present invention can be properly changed within the range without departing from the gist of the present invention.

[0076] For example, with respect to the control mechanism 15, 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 opening degree of the high-pressure passage 15b can be regulated by the control valve 15c. Thereby, the pressure in the control pressure chamber 13b can be made quickly high due to the pressure of the refrigerant gas in the first discharge chamber 29a, and the discharge capacity can be increased quickly.

[0077] In the compressor of the present invention, guide surfaces 57a and 57b are formed on a lug plate 51 and guided surfaces 59a and 59b are formed on swash plate arms 5e and 5f. The guide surfaces 57a and 57b and the guided surfaces 59a and 59b are respectively in linear contact with one another at a first abutment position P1 when an inclination angle is maximum and are in linear contact with one another at a second abutment position P2 when the inclination angle is minimum. The guide surfaces 57a and 57b are formed such that portions be-

tween the first abutment position P1 and the second abutment position P2 are convex toward the guided surfaces 59a and 59b. In the compressor, a contact angle θ_1 at the first abutment position P1 can be made large, and a contact angle θ_2 at the second abutment position P2 can be made small.

Claims

1. A variable displacement swash plate type compressor comprising:

a housing (1) in which a suction chamber (33), a discharge chamber (35), a swash plate chamber (25) and a cylinder bore (21a) are formed; a drive shaft (3) that is rotatably supported by the housing (1);

a swash plate (5) rotatable in the swash plate chamber (25) by rotation of the drive shaft (3); a link mechanism (7) that is provided between the drive shaft (3) and the swash plate (5) and allows change of an inclination angle of the swash plate (5) to a direction orthogonal to a drive shaft axis (O) of the drive shaft (3);

a piston (9) that is accommodated in the cylinder bore (21a) to be capable of reciprocating;

a conversion mechanism (11a, 11b) that causes the piston (9) to reciprocate in the cylinder bore (21a) at a stroke corresponding to the inclination angle by rotation of the swash plate (5);

an actuator (13) capable of changing the inclination angle; and

a control mechanism (15) that controls the actuator (13),

wherein the link mechanism (7) has a lug member (51) that is provided on the drive shaft (3) in the swash plate chamber (25) and faces the swash plate (5), and a swash plate arm (5e, 5f, 67) to which rotation of the drive shaft (3) is transmitted from the lug member (51),

on the lug member (51), a guide surface (57a, 57b, 65) that faces the swash plate arm (5e, 5f, 67) is formed,

on the swash plate arm (5e, 5f, 67), a guided surface (59a, 59b, 67a) that abuts on and is guided by the guide surface (57a, 57b, 65) is formed, the actuator (13) has the lug member (51), a movable body (13a) that is disposed between the lug member (51) and the swash plate (5) and is movable in a direction of the drive shaft axis (O), and a control pressure chamber (13b) that is provided between the lug member (51) and the movable body (13a) and moves the movable body (13a) by an internal pressure, and the guide surface (57a, 57b, 65) is formed such that a portion thereof between a first abutment position (P1), where the guided surface (57a,

57b, 65) abuts on the guide surface (57a, 57b, 65) when the inclination angle is maximum, and a second abutment position (P2), where the guided surface (59a, 59b, 67a) abuts on the guide surface (57a, 57b, 65) when the inclination angle is minimum, is convex toward the guided surface (59a, 59b, 67a). 5

2. The variable displacement swash plate type compressor according to claim 1, wherein a top portion (P3) of the guide surface (57a, 57b, 65) is offset to the first abutment position (P1) side from a middle of the first abutment position (P1) and the second abutment position (P2). 10 15

3. The variable displacement swash plate type compressor according to claim 1 or 2, wherein a radius of curvature (R1, R2) of the guided surface (59a, 59b, 67a) differs between the first abutment position (P1) and the second abutment position (P2). 20

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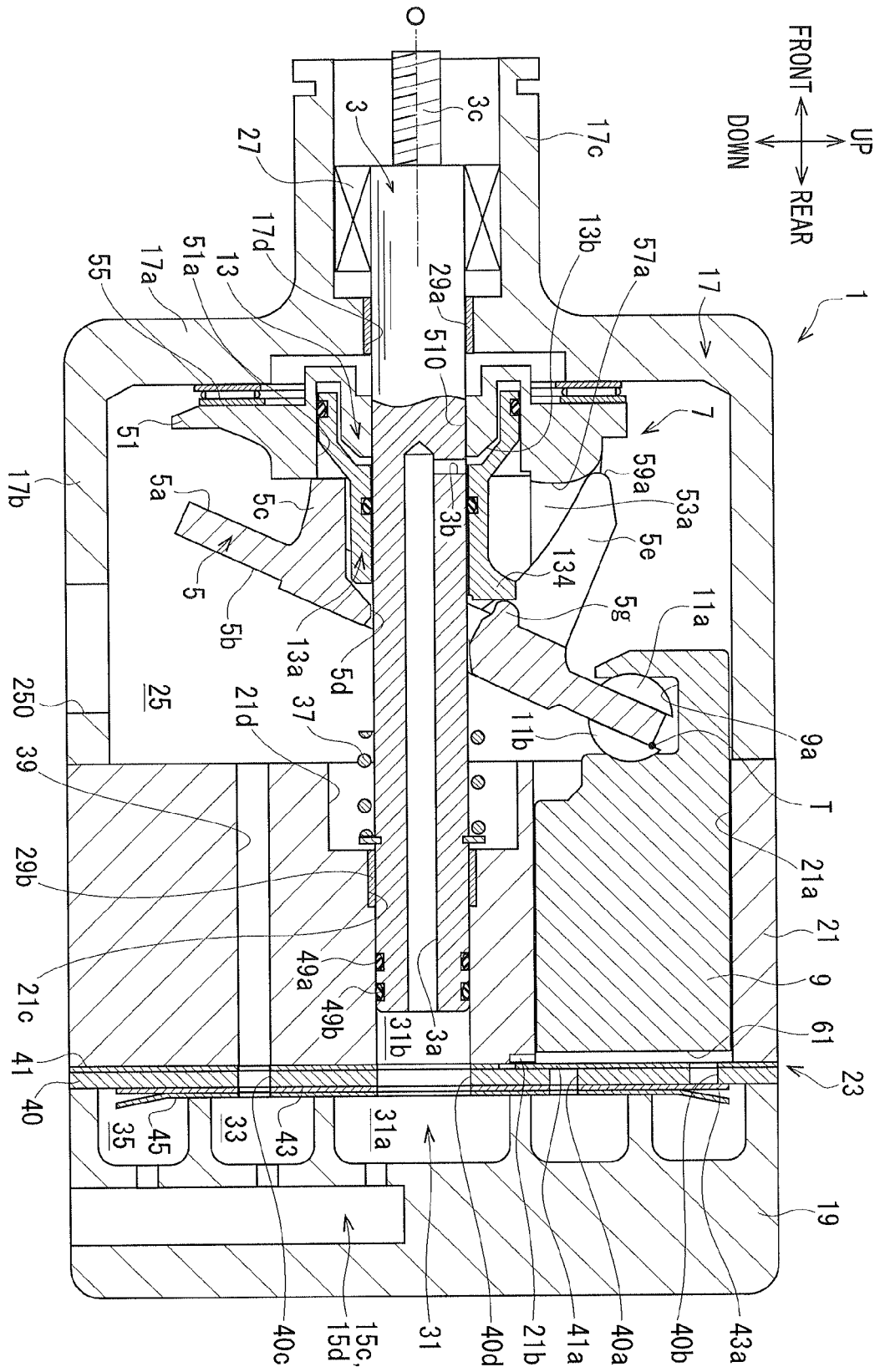


FIG. 2

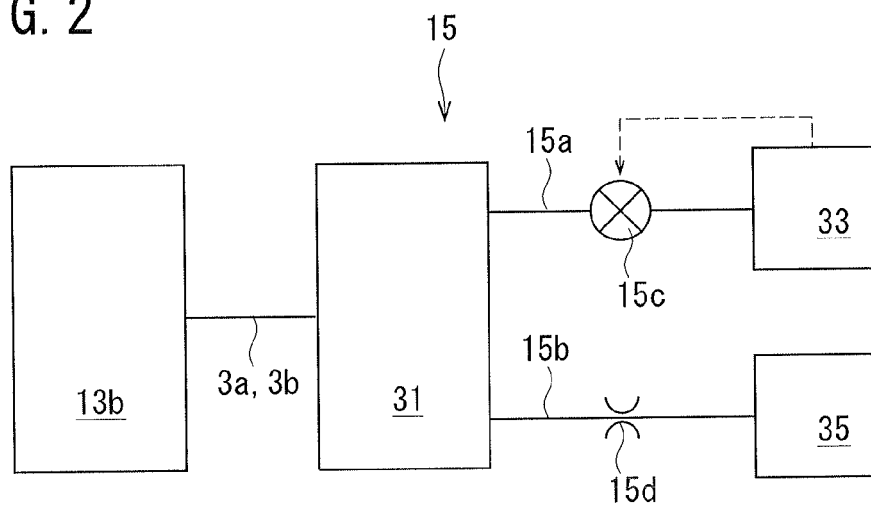


FIG. 3

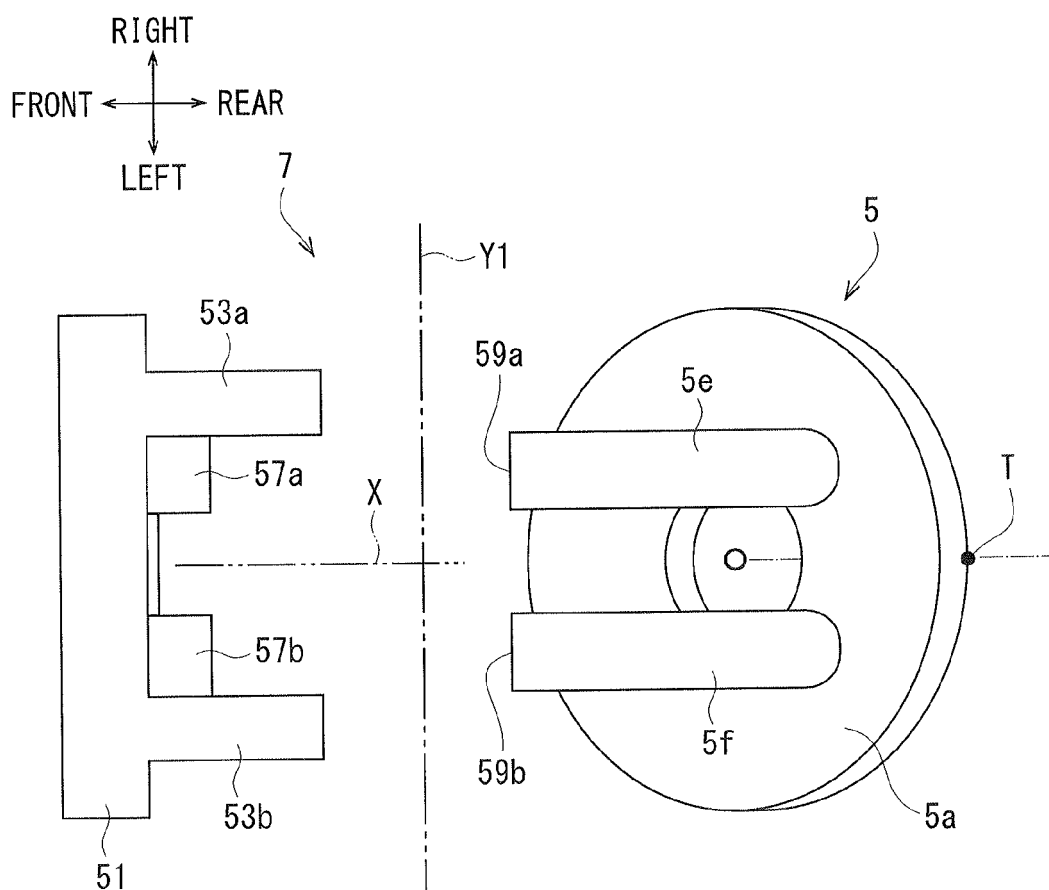


FIG. 4

FRONT $\longleftrightarrow$ REAR

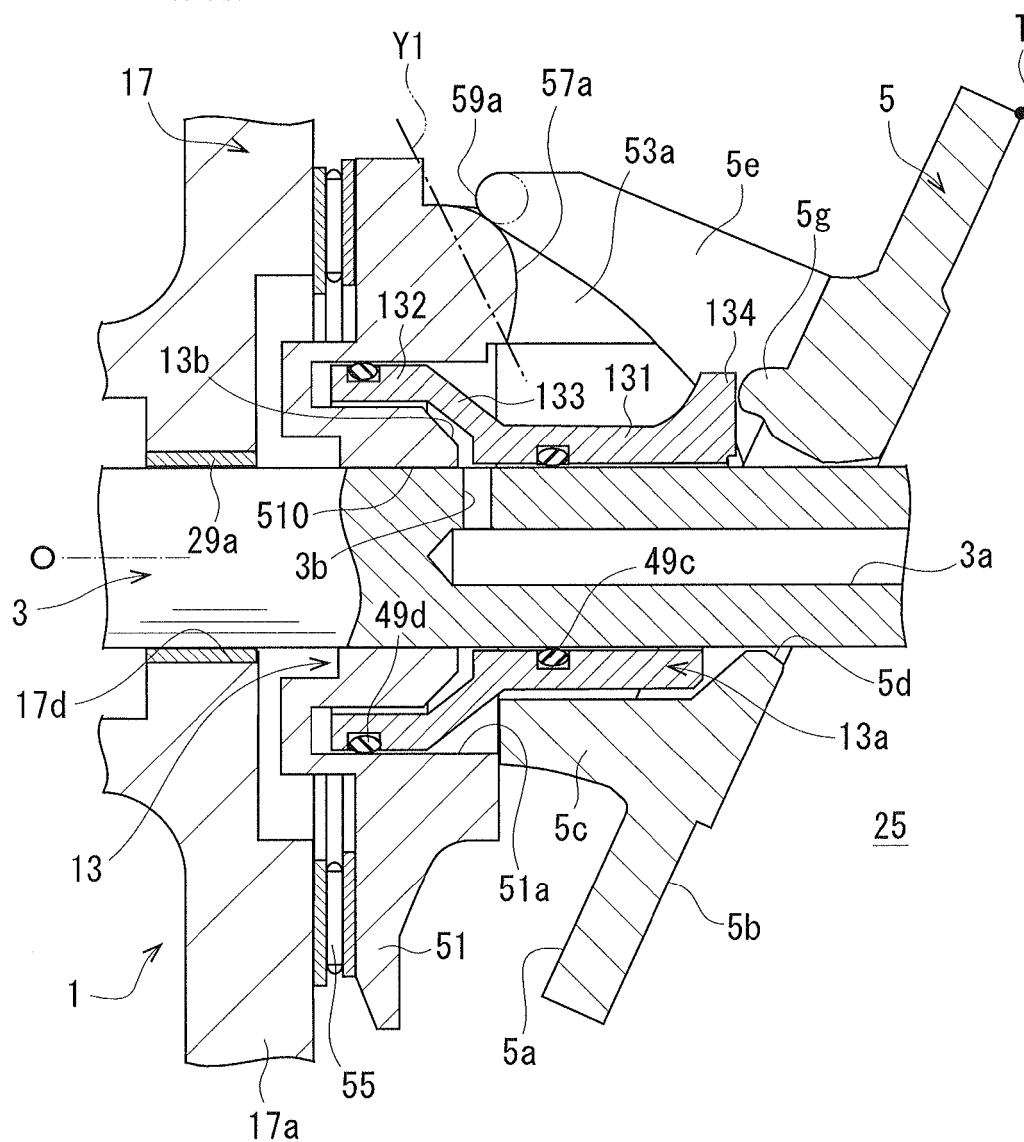


FIG. 5

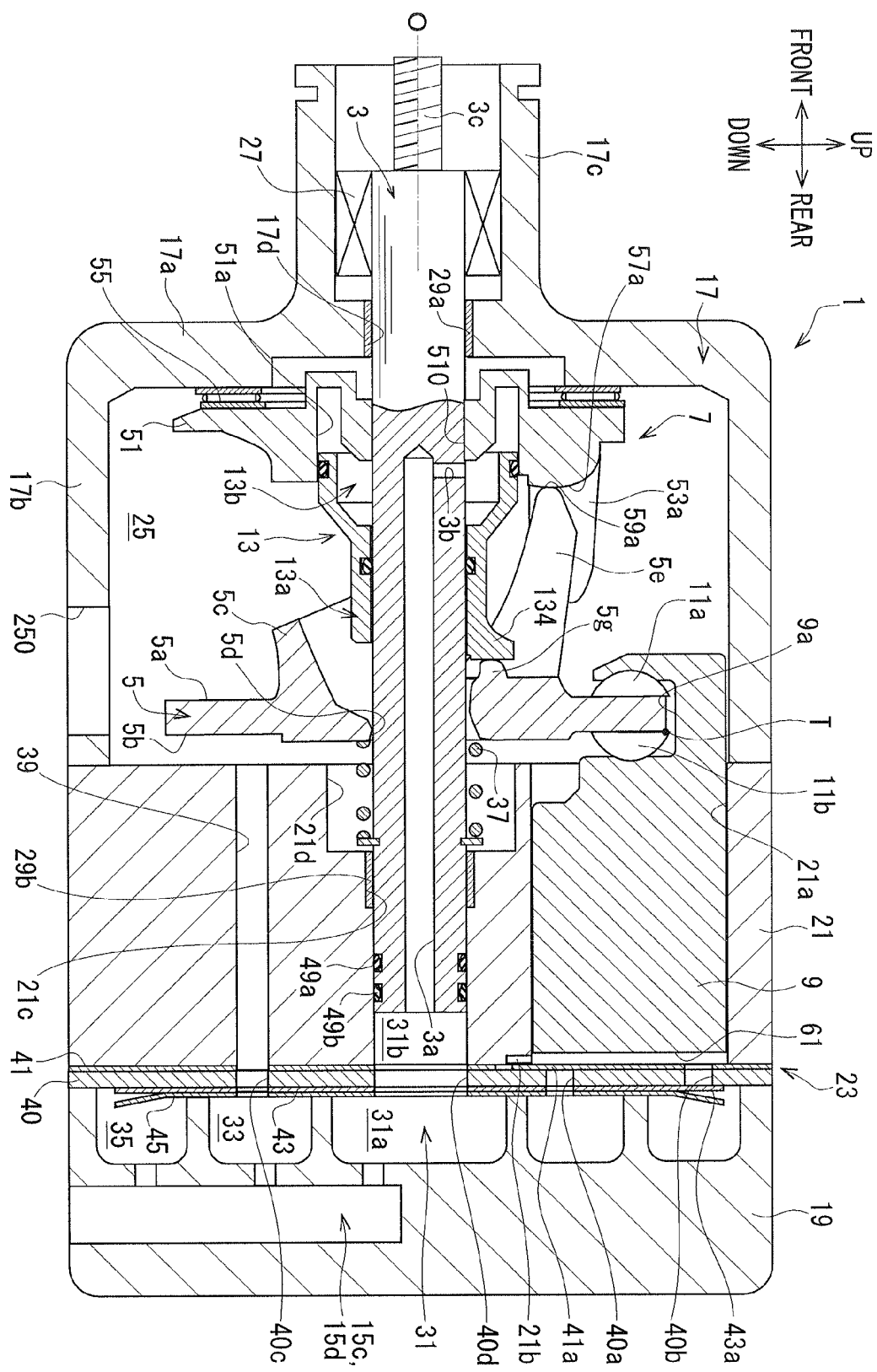
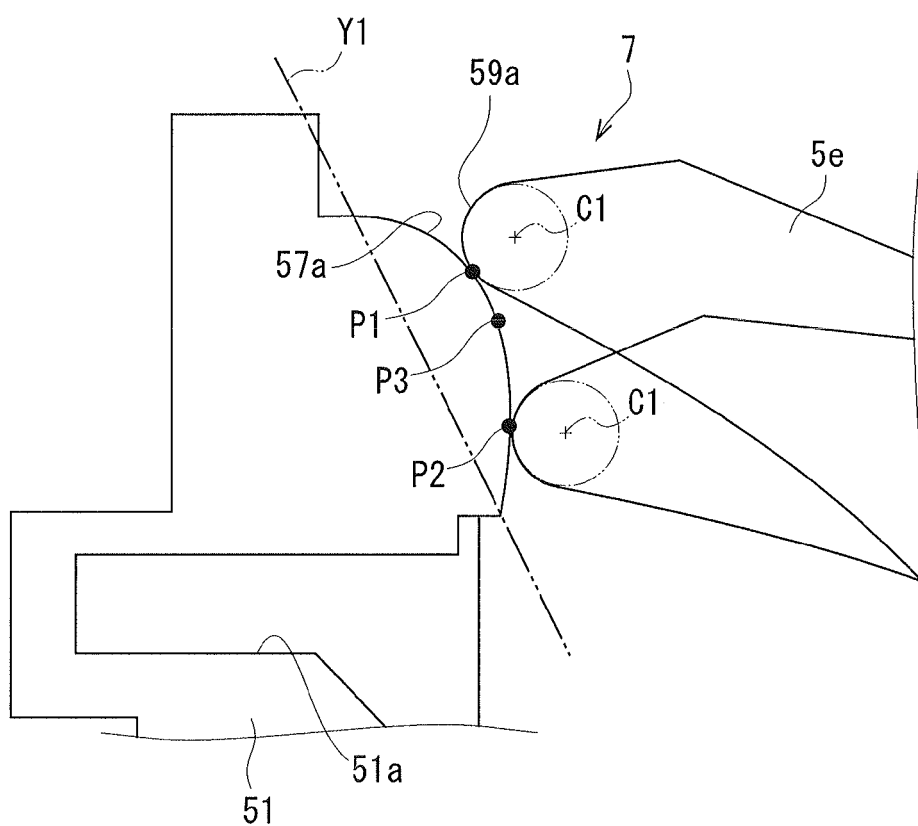


FIG. 6

FRONT $\longleftrightarrow$ REAR



O

FIG. 7A

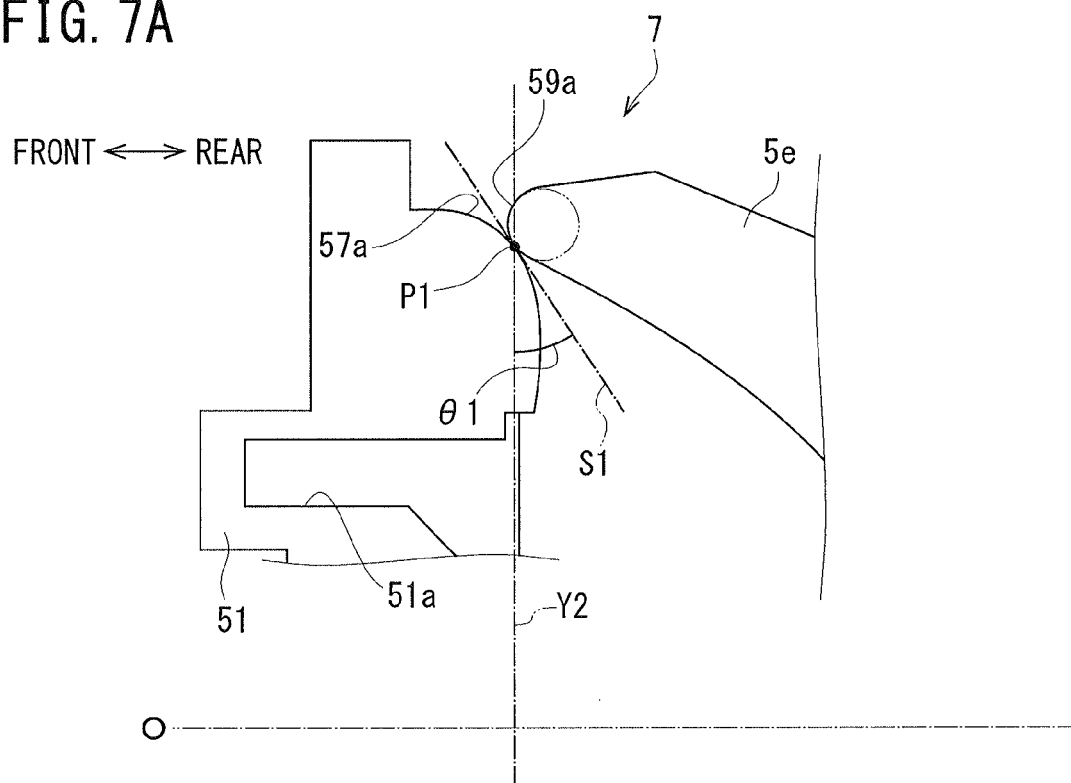


FIG. 7B

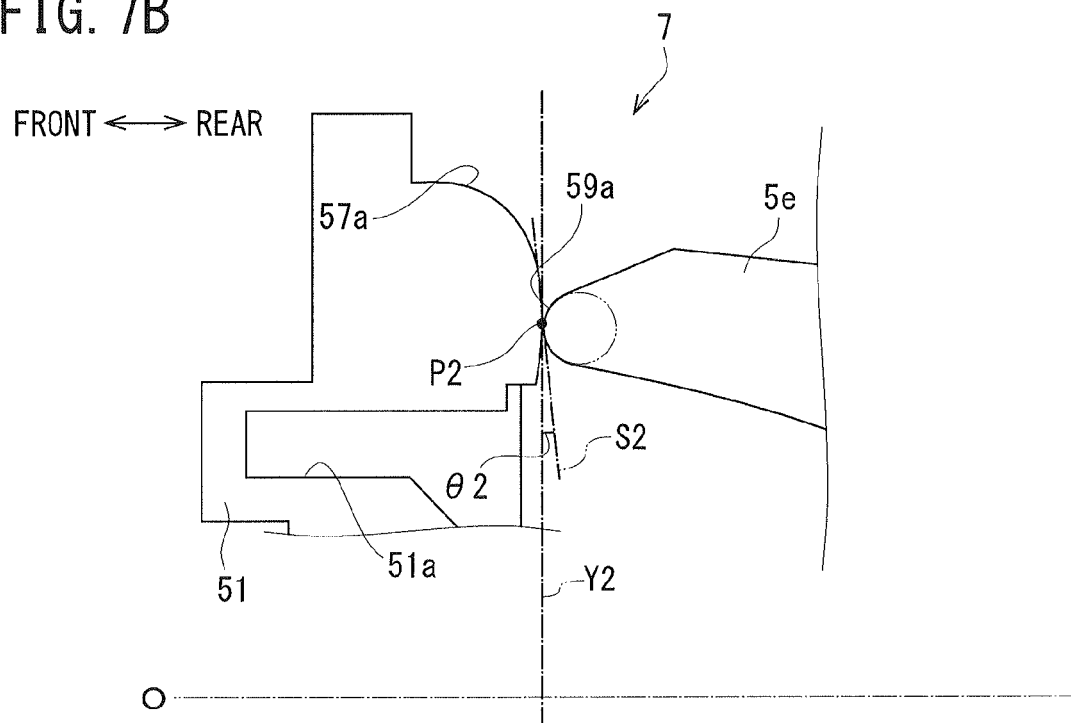


FIG. 8

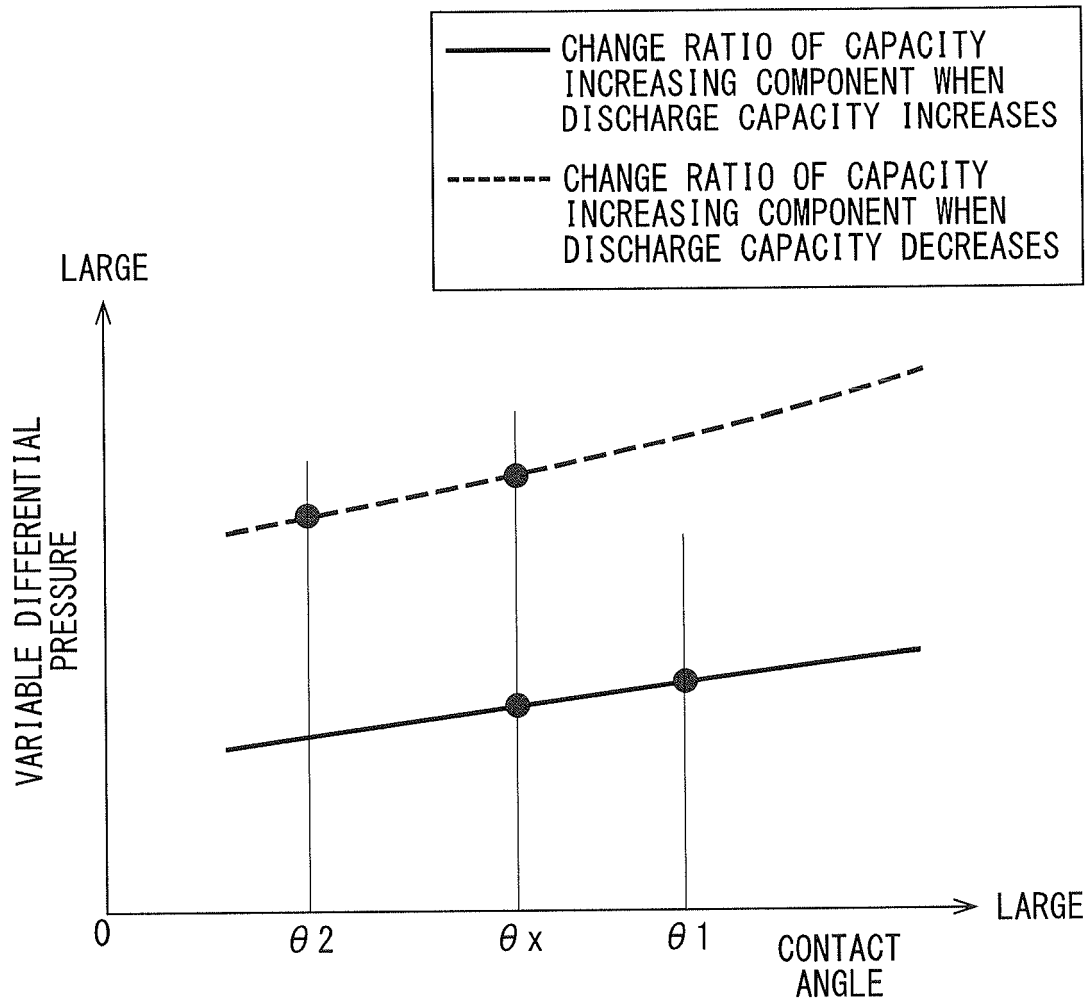


FIG. 9

FRONT $\longleftrightarrow$ REAR

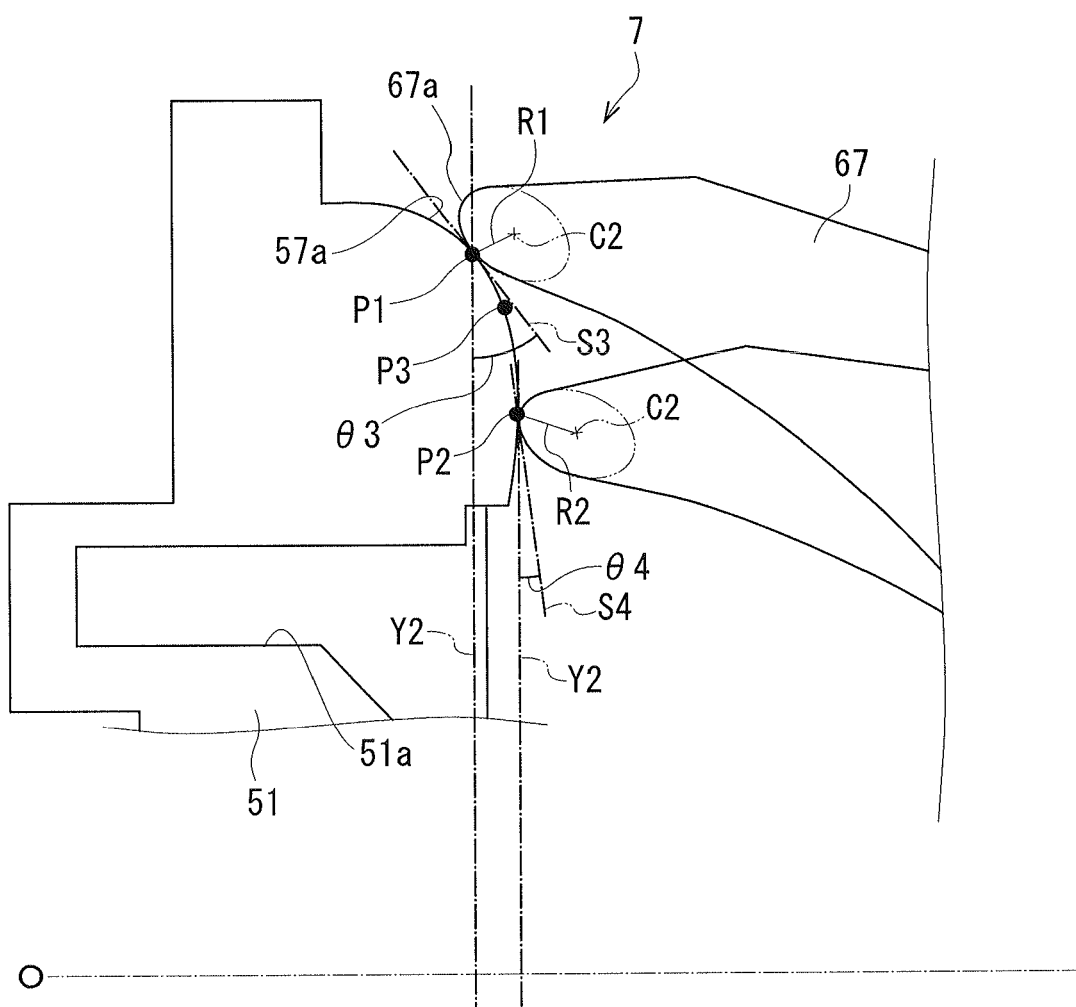
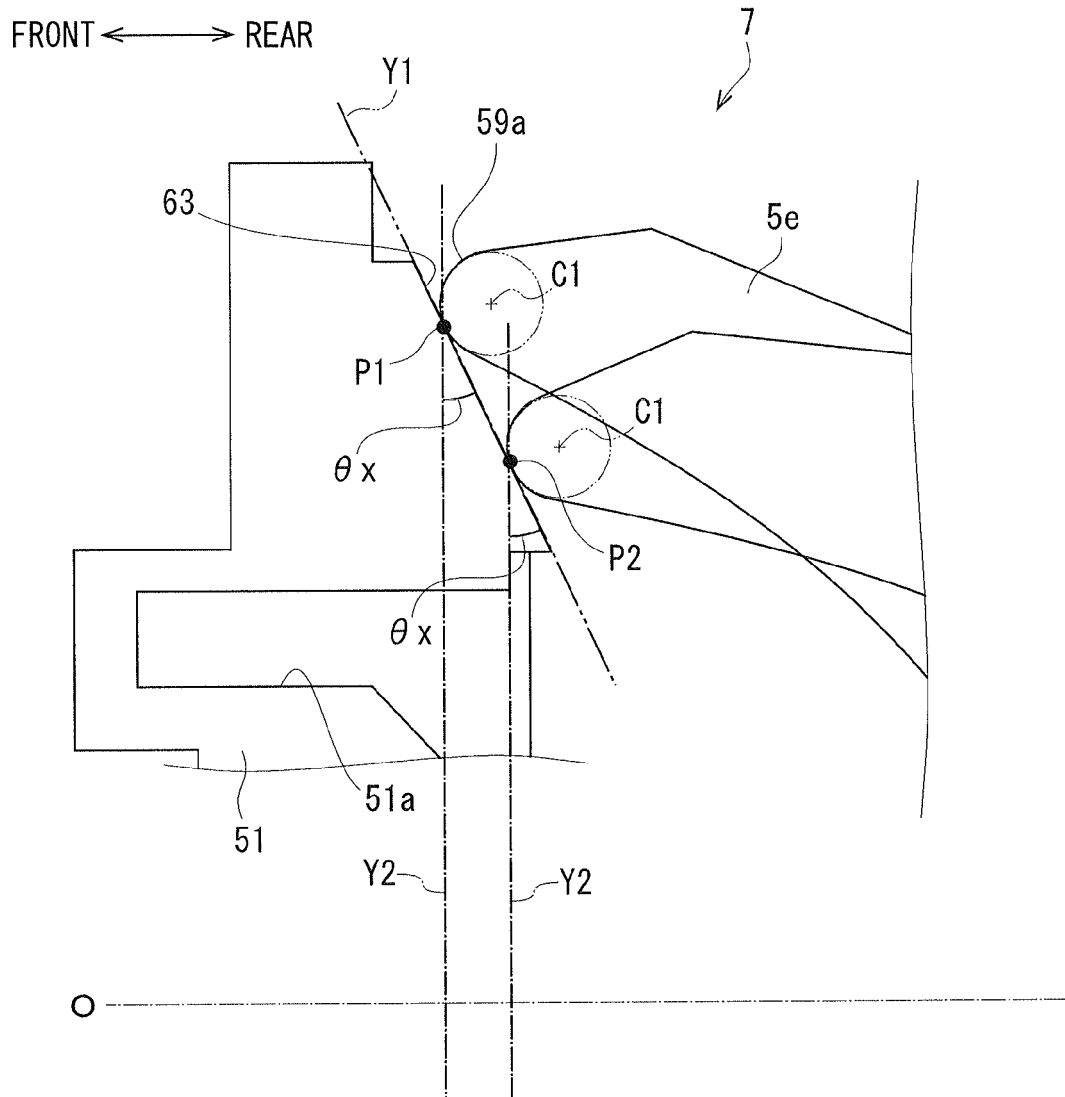


FIG. 10



REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 8105384 A [0002]