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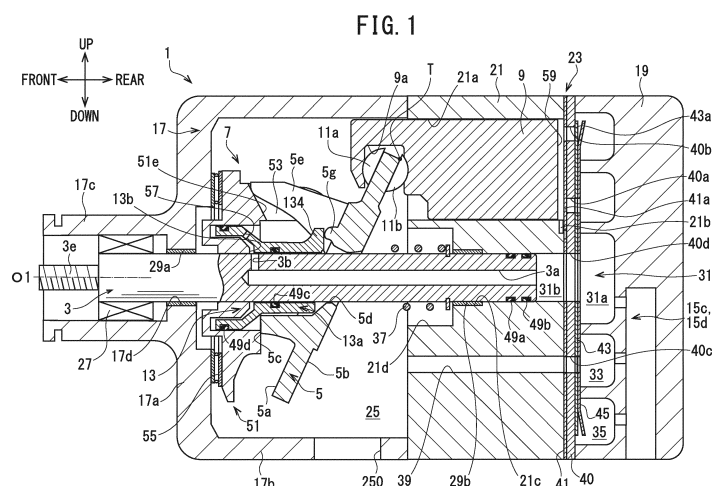
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(54) **VARIABLE DISPLACEMENT SWASH PLATE TYPE COMPRESSOR**

(57) A variable displacement swash plate type compressor comprises an actuator (13) for changing the inclination angle of the swash plate (5) inside the swash plate chamber (25). Said actuator (13) includes a defining body (51c) provided on the drive shaft (3), a movable body (134) movable in axial direction of the drive shaft (3) and a control pressure chamber (13b) defined by the defining body (51c) and the movable body (134). A control mechanism (15) is configured to control the actuator (13), wherein refrigerant is introduced into the control

pressure chamber (13b) via a supply passage (3a,3b) and discharged from the control pressure chamber (13b) via a bleed passage. Said bleed passage includes a throttle hole (57) formed in at least one of the defining body (51c) and the movable body (134). Lubricant is discharged through the throttle hole (57) together with the refrigerant gas. Consequently, in the compressor, the lubricant is less easily stored in the control pressure chamber (13b), and lubricant shortage in the swash plate chamber (25) less easily occurs.



Description

TECHNICAL FIELD

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

BACKGROUND ART

[0002] Japanese Patent Application Laid-Open No. H8-105384 discloses a conventional variable displacement swash plate type compressor (hereinafter referred to as compressor). In the compressor, a suction chamber, a discharge chamber, a swash plate chamber, a center bore, and a plurality of cylinder bores are formed in a housing. The swash plate chamber and the center bore communicate with each other. In the housing, a drive shaft is rotatably supported. In the swash plate chamber, a swash plate rotatable by the rotation of the drive shaft is provided. A link mechanism is provided between the drive shaft and the swash plate. The link mechanism allows a change in an inclination angle of the swash plate. Here, the inclination angle refers to an angle of the swash plate with respect to a direction orthogonal to the drive 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 actuator includes a first movable body, a second movable body, and a control pressure chamber. The drive shaft is inserted through the first movable body and the second movable body, which are aligned and movable in the axial direction of the drive shaft. The first movable body is located in the center bore. Further, a thrust bearing is provided between the first movable body and the second movable body. The swash plate is engaged with the second movable body to be capable of changing the inclination angle. The control pressure chamber moves the first movable body and the second movable body by an internal pressure.

[0004] The control mechanism performs communication control between the control pressure chamber and the suction chamber, and performs communication control between the control pressure chamber and the discharge chamber, thereby the pressure of a refrigerant in the control pressure chamber is regulated. Further, the control mechanism includes an O-ring and a pair of sealing rings. The O-ring and the respective sealing rings are located between the outer circumferential surface of the first movable body and the inner circumferential surface of the center bore. The control pressure chamber and the swash plate chamber are sealed from each other by the O-ring and the respective sealing rings.

[0005] In the compressor, the control mechanism in-

troduces the refrigerant in the discharge chamber into the control pressure chamber, thereby the pressure in the control pressure chamber raise. Consequently, the first movable body moves in axial direction of the drive shaft in the center bore, and moves the second movable body in the axial direction. The second movable body increases the inclination angle of the swash plate by the link mechanism. Consequently, in the compressor, it is possible to increase a discharge capacity per one rotation of the drive shaft.

[0006] In the conventional compressor, in changing the discharge capacity, the control mechanism regulates the pressure in the control pressure chamber through the communication controls between the suction chamber and the discharge chamber and the control pressure chamber while sealing the control pressure chamber and the swash plate chamber from each other. Therefore, in the compressor, processing or means for preventing leakage of the refrigerant from the control pressure chamber is necessary. As a result, manufacturing costs increase.

[0007] Further, in the compressor, when the refrigerant in the discharge chamber is introduced into the control pressure chamber, lubricant flows into the control pressure chamber together with the refrigerant. The lubricant flown into the control pressure chamber is stored in the control pressure chamber. Consequently, in the compressor, the lubricant in the swash plate chamber tends to run short. In the swash plate chamber, lubrication of the thrust bearing and the like tends to be insufficient. Therefore, in the compressor, it is difficult to maintain performance for a long period.

[0008] The present invention has been devised in view of the circumstances in the past and it is a problem to be solved by the invention to provide a compressor that changes a discharge capacity using an actuator, the compressor being a variable displacement swash plate compressor capable of displaying high performance for a long period while realizing a reduction in manufacturing costs.

SUMMARY OF THE INVENTION

[0009] A variable displacement swash plate type compressor according to 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 rotatably supported by the housing; a swash plate rotatable in the swash plate chamber according to the rotation of the drive shaft; a link mechanism provided between the drive shaft and the swash plate and configured to allow a change in an inclination angle of the swash plate with respect to a direction orthogonal to an axis of the drive shaft; a piston accommodated in the cylinder bore to be reciprocally movable; a conversion mechanism configured to reciprocally move, according to the rotation of the swash plate, the piston in the cylinder bore at a stroke corresponding to the in-

clination angle; an actuator capable of changing the inclination angle; and a control mechanism configured to control the actuator.

[0010] The swash plate chamber communicates with the suction chamber.

[0011] The actuator includes: a defining body provided on the drive shaft in the swash plate chamber; a movable body movable in axial direction of the drive shaft in the swash plate chamber; and a control pressure chamber defined by the defining body and the movable body and configured to move the movable body by an internal pressure in the control pressure chamber.

[0012] The control mechanism includes: a supply passage communicating with the discharge chamber and the control pressure chamber, and introducing a refrigerant in the discharge chamber into the control pressure chamber; and a bleed passage communicating with the control pressure chamber and the swash plate chamber, and discharging the refrigerant in the control pressure chamber to the swash plate chamber.

[0013] The bleed passage includes a communication path formed in at least one of the movable body and the defining body, and discharging lubricant from the control pressure chamber to the swash plate chamber together with the refrigerant.

[0014] Other aspects and advantages of the invention will be apparent from embodiments disclosed in the attached drawings, illustrations exemplified therein, and the concept of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015]

FIG. 1 is a sectional view at a state of a maximum capacity in compressor of embodiment 1.

FIG. 2 is a schematic diagram showing a control mechanism of the compressor in the embodiment 1.

FIG. 3 is an essential part enlarged sectional view showing an actuator of the compressor in the embodiment 1.

FIG. 4 is a sectional view at a state of a minimum capacity in compressor of embodiment 1.

FIG. 5 is an essential part enlarged sectional view showing an actuator of a compressor in an embodiment 2.

FIG. 6 is an essential part enlarged sectional view showing an actuator of a compressor in an embodiment 3.

FIG. 7 is an essential part enlarged sectional view showing an actuator of a compressor in an embodiment 4.

FIG. 8 is a sectional view at a state of a maximum capacity in compressor of embodiment 5.

FIG. 9 is a schematic diagram showing a control mechanism of the compressor in an embodiment 5.

FIG. 10 is an essential part enlarged sectional view showing an actuator of the compressor in the em-

bodiment 5.

FIG. 11 is a sectional view at a state of a minimum capacity in compressor of embodiment 5.

FIG. 12 is an essential part enlarged sectional view showing an actuator of a compressor in an embodiment 6.

DETAILED DESCRIPTION OF EXEMPLARY EMBODIMENTS

[0016] Embodiments 1 to 6 embodying the present invention are explained below with reference to the drawings. Compressors in the embodiments 1 to 4 are variable displacement single head swash plate type compressors. On the other hand, compressors in the embodiments 5 and 6 are variable displacement double head swash plate type compressors. All of the compressors are mounted on vehicles and configure a refrigeration circuit of an air-conditioning apparatus for the vehicle.

(Embodiment 1)

[0017] As shown in FIG. 1, the compressor in the 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.

[0018] As shown in FIG. 1, the housing 1 includes a front housing 17 located in the front of the compressor, a rear housing 19 located in the rear of the compressor, a cylinder block 21 located between the front housing 17 and the rear housing 19, and a valve formation plate 23.

[0019] The front housing 17 has a front wall 17a that extends in an up-down direction of the compressor in the front side and a circumferential wall 17b that is integrated with the front wall 17a, and extends toward the rear side from the front side of the compressor. The front housing 17 is formed in a bottomed substantially cylindrical shape by the front wall 17a and the circumferential wall 17b. Further, a swash plate chamber 25 is formed in the front housing 17 by the front wall 17a and the circumferential wall 17b.

[0020] In the front wall 17a, a boss 17c projecting forward is formed. In the boss 17c, a shaft seal device 27 that secures hermetic seal between the inside of the housing 1 and the outside is provided. Further, in the boss 17c, a first shaft hole 17d extending in the front-rear direction of the compressor is formed. A first plain bearing 29a is provided in the first shaft hole 17d. The first plain bearing 29a receives a radial force acting on the drive shaft 3. The first plain bearing 29a corresponds to the radial bearing in the present invention. Further, a rolling bearing can be adopted instead of the first plain bearing 29a.

[0021] In the circumferential wall 17b, an inlet port 250 communicating with the swash plate chamber 25 is formed. The swash plate chamber 25 is connected to a not-shown evaporator through the inlet port 250. Conse-

quently, a low-pressure refrigerant gas that passes through the evaporator flows into the swash plate chamber 25 through the inlet port 250. Therefore, the pressure in the swash plate chamber 25 is lower than the pressure in a discharge chamber 35 explained below.

[0022] 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 the center portion of the rear housing 19. The discharge chamber 35 is annularly located on the outer circumference side of the rear housing 19. Further, the suction chamber 33 is annularly formed between the first pressure regulation chamber 31a and the discharge chamber 35, in the rear housing 19. The discharge chamber 35 is connected to a not-shown discharge port.

[0023] In the cylinder block 21, cylinder bores 21a as many as the pistons 9 are provided at equal angle intervals in the circumferential direction. The front end sides of the cylinder bores 21a communicate with the swash plate chamber 25. Further, in the cylinder block 21, a retainer groove 21b that regulates maximum opening of a suction reed valve 41a explained below is formed.

[0024] Further, in the cylinder block 21, a second shaft hole 21c extending in the front-rear direction of the compressor while communicating with the swash plate chamber 25 is penetratingly provided. A second plain bearing 29b is provided in the second shaft hole 21c. Note that a rolling bearing can be adopted instead of the second plain bearing 29b.

[0025] Furthermore, 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. A return spring 37 is arranged in the spring chamber 21d. The return spring 37 urges the swash plate 5 inclined at a minimum inclination angle toward the front of the swash plate chamber 25. In the cylinder block 21, a suction passage 39 communicating with the swash plate chamber 25 is formed.

[0026] The valve formation plate 23 is provided between the rear housing 19 and the cylinder block 21. The valve formation plate 23 includes of a valve plate 40, a suction valve plate 41, a discharge valve plate 43, and a retainer plate 45.

[0027] In the valve plate 40, the discharge valve plate 43, and the retainer plate 45, suction ports 40a as many as the cylinder bores 21a are formed. In the valve plate 40 and the suction valve plate 41, discharge ports 40b as many as 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. The suction chamber 33 and the

suction passage 39 communicate with each other through the first communication hole 40c. Consequently, the swash plate chamber 25 and the suction chamber 33 communicate with each other.

[0028] The suction valve plate 41 is provided on the 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 suction ports 40a by elastic deformation are formed. Further, the discharge valve plate 43 is provided on the 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 discharge ports 40b by elastic deformation are formed. The retainer plate 45 is provided on the rear surface of the discharge valve plate 43. The retainer plate 45 regulates maximum opening degree of the discharge reed valves 43a.

[0029] The drive shaft 3 is inserted toward a rear side of the housing 1 from a boss 17c side. The front end side of the drive shaft 3 is inserted through the shaft seal device 27 in the boss 17c, and axially supported by the first plain bearing 29a in the first shaft hole 17d. Further, a rear end side of the drive shaft 3 is axially supported by the second plain bearing 29b in the second shaft hole 21c. In this way, the drive shaft 3 is rotatably supported around a drive axis O1 with respect to the housing 1. In the second shaft hole 21c, a second pressure regulation chamber 31b is defined in the second shaft hole 21c by the 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. The first and second pressure regulation chambers 31a and 31b formed a pressure regulation chamber 31.

[0030] O-rings 49a and 49b are provided at the rear end of the drive shaft 3. Consequently, the 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.

[0031] Further, The link mechanism 7, the swash plate 5, and the actuator 13 are attached to the drive shaft 3. The link mechanism 7 includes of a lug plate 51, a pair of lug arms 53 formed in the lug plate 51, and a pair of swash plate arms 5e formed in the swash plate 5. In the compressor, the lug plate 51 forms the link mechanism 7 and functions as the defining body in the present invention. Note that, in FIG. 1, only one lug arm 53 and one swash plate arm 5e are shown. The same applies to FIG. 4.

[0032] The lug plate 51 is formed in a substantial ring shape and arranged in the front of the swash plate 5. As shown in FIG. 3, the lug plate 51 includes a fixed portion 51a, a fixed flange portion 51b, and an outer sliding portion 51c. The fixed portion 51a is located in the center of the lug plate 51. In the fixed portion 51a, an insertion hole 51d is penetratingly provided. The drive shaft 3 is press-fitted in the insertion hole 51d. Consequently, the lug

plate 51 is fixed to the drive shaft 3 and is capable of rotating integrally with the drive shaft 3.

[0033] The fixed flange portion 51b is located at the front end of the lug plate 51 and extends in the radially outer direction from the fixed portion 51a. The outer sliding portion 51c is located on the outer circumference side of the fixed portion 51a, extends in the axial direction O1, which is the drive axis of the drive shaft 3 from the tip end of the fixed flange portion 51b, and is formed in a cylindrical shape concentric with the axial direction O1. The inside of the outer sliding portion 51c communicates with the swash plate chamber 25 and is a part of the swash plate chamber 25. Further, a thrust bearing 55 is provided between the lug plate 51 and the front wall 17a. The thrust bearing 55 receives a thrust force acting on the drive shaft 3. The thrust bearing 55 corresponds to the thrust bearing in the present invention.

[0034] The lug arms 53 extend rearward from the outer sliding portion 51c. In the outer sliding portion 51c, a guide surface 51e is provided in a position between the lug arms 53. The guide surface 51e is formed to incline downward from the front end side to the rear end side.

[0035] As shown in FIG. 1, the swash plate 5 is formed in an annular flat shape and includes a front surface 5a and a rear surface 5b. On the front surface 5a, a weight portion 5c projecting to the front of the swash plate 5 is formed. The weight portion 5c comes into contact with the lug plate 51 when the inclination angle of the swash plate 5 is the maximum. An insertion hole 5d is formed in the center of the swash plate 5. Further, the drive shaft 3 is inserted through the insertion hole 5d.

[0036] The swash plate arms 5e are formed on the front surface 5a. The swash plate arms 5e extend forward from the front surface 5a. Further, in the swash plate 5, a substantially semispherical convex portion 5g is protrudingly provided on the front surface 5a. The convex portion 5g is located between the swash plate arms 5e.

[0037] In the compressor, the swash plate arms 5e are inserted between the lug arms 53, whereby the lug plate 51 and the swash plate 5 are connected. Consequently, the swash plate 5 is rotatable in the swash plate chamber 25 together with the lug plate 51. The lug plate 51 and the swash plate 5 are connected in this way, whereby, in the swash plate arms 5e, the tip end sides of the swash plate arms 5e come into contact with the guide surface 51e. The swash plate arms 5e slide on the guide surface 51e, whereby the swash plate 5 is capable of changing the inclination angle of the swash plate 5 with respect to the direction orthogonal to the axial direction O1 from a maximum inclination angle shown in FIG. 1 to a minimum inclination angle shown in FIG. 4, while substantially maintaining a top dead center position T.

[0038] The actuator 13 includes of the lug plate 51, a movable body 13a, and a control pressure chamber 13b.

[0039] As shown in FIG. 3, the drive shaft 3 is inserted through the movable body 13a. The movable body 13a is capable of moving in the axial direction O1 while sliding in contact with the drive shaft 3. The movable body 13a

is formed in a cylindrical shape coaxial with the drive shaft 3. The movable body 13a includes a first cylinder portion 131, a second cylinder portion 132, and a connection portion 133. The first cylinder portion 131 is located near the swash plate 5 in the movable body 13a, and slidably provided with respect to the drive shaft 3. An O-ring 49c is provided on the inner circumferential surface of the first cylinder portion 131.

[0040] An acting portion 134 is integrally formed at the rear end of the first cylinder portion 131. As shown in FIG. 1, the acting portion 134 vertically extends from a position near the axial direction O1 toward the top dead center position T of the swash plate 5 and is in contact with the convex portion 5g. Consequently, the movable body 13a is rotatable integrally with the lug plate 51 and the swash plate 5.

[0041] As shown in FIG. 3, the second cylinder portion 132 is located in the front of the movable body 13a. The second cylinder portion 132 is formed in a diameter larger than the diameter of the first cylinder portion 131. An O-ring 49d is provided on the 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 from the rear to the front of the movable body 13a while gradually increasing in a diameter. The rear end of the connection portion 133 is connected with the first cylinder portion 131, and the front end of the connection portion 133 is connected with the second cylinder portion 132.

[0042] The outer sliding portion 51c of the lug plate 51 surrounds the movable body 13a by causing the second cylinder portion 132 and the connection portion 133 to enter the inside of the outer sliding portion 51c. The outer sliding portion 51c is capable of accommodating the second cylinder portion 132 and the connection portion 133 in its inside. Consequently, the second cylinder portion 132 is capable of sliding in the outer sliding portion 51c, that is, on an inner wall 510 of the outer sliding portion 51c.

[0043] The control pressure chamber 13b is formed by the second cylinder portion 132, the connection portion 133, and the drive shaft 3 in the outer sliding portion 51c and is separated from the swash plate chamber 25. The control pressure chamber 13b is sealed from the swash plate chamber 25 by the O-rings 49c and 49d.

[0044] A throttle hole 57 is bored on the front end side in the connection portion 133, that is, a side close to the second cylinder portion 132 in the connection portion 133. The throttle hole 57 corresponds to the communication path in the present invention.

[0045] The throttle hole 57 extends to incline upward from the front end side to the rear end side in the connection portion 133. More specifically, the throttle hole 57 extends such that the lubricant discharged from the throttle hole 57 together with the refrigerant gas is supplied to a sliding part between the second cylinder portion 132 and the inner wall 510 of the outer sliding portion 51c. As explained above, since the inside of the outer

sliding portion 51c communicates with the swash plate chamber 25, the control pressure chamber 13b and the swash plate chamber 25 communicate with each other through the throttle hole 57. Note that the throttle hole 57 may be formed in the second cylinder portion 132.

[0046] As shown in FIG. 1, in the drive shaft 3, an axial path 3a extending in the axial direction O1 from the rear end to the front end of the drive shaft 3 and a radial path 3b extending in the radial direction from the front end of the axial path 3a and opening to the outer circumferential surface of the drive shaft 3 are formed. The rear end of the axial path 3a opens to the pressure regulation chamber 31. On the other hand, the radial path 3b opens to the control pressure chamber 13b. The pressure regulation chamber 31 and the control pressure chamber 13b communicate with each other through the axial path 3a and the radial path 3b.

[0047] The drive shaft 3 is connected to a pulley or an electromagnetic clutch not shown in the figure by a screw portion 3e formed at the tip end.

[0048] The respective pistons 9 are respectively accommodated in the respective cylinder bores 21a and reciprocatingly movable in the respective cylinder bores 21a. Compression chambers 59 are defined in the respective cylinder bores 21a by the respective pistons 9 and the valve formation plate 23.

[0049] In the pistons 9, engaging portions 9a are recessed. In the engaging portions 9a, semispherical shoes 11a and 11b are respectively provided. The shoes 11a and 11b convert the rotation of the swash plate 5 into reciprocating movement of the pistons 9. The shoes 11a and 11b correspond to the conversion mechanism in the present invention. Consequently, the pistons 9 are reciprocatingly movable in the cylinder bores 21a at a stroke corresponding to the inclination angle of the swash plate 5.

[0050] As shown in FIG. 2, the control mechanism 15 is configured by a low-pressure passage 15a, a high-pressure passage 15b, a low-pressure control valve 15c, a high-pressure control valve 15d, the axial path 3a, the radial path 3b, and the throttle hole 57 explained above.

[0051] The low-pressure passage 15a is connected to the pressure regulation chamber 31 and the suction chamber 33. Consequently, the control pressure chamber 13b, the pressure regulation chamber 31, and the suction chamber 33 communicate with one another through the low-pressure passage 15a, the axial path 3a, and the radial path 3b. The bleed passage in the present invention is formed by the low-pressure passage 15a, the axial path 3a, the radial path 3b, and the throttle hole 57.

[0052] The high-pressure passage 15b is connected to the pressure regulation chamber 31 and the discharge chamber 35. The control pressure chamber 13b, the pressure regulation chamber 31, and the discharge chamber 35 communicate with one another through the high-pressure passage 15b, the axial path 3a, and the radial path 3b. The supply passage in the present inven-

tion is formed by the high-pressure passage 15b, the axial path 3a, and the radial path 3b.

[0053] The low-pressure control valve 15c is provided in the low-pressure passage 15a. The low-pressure control valve 15c is capable of adjusting the opening degree of the low-pressure passage 15a on the basis of the pressure in the suction chamber 33. Further, the high-pressure control valve 15d is provided in the high-pressure passage 15b. The high-pressure control valve 15d is capable of adjusting the opening degree of the high-pressure passage 15b on the basis of the pressure in the suction chamber 33.

[0054] In the compressor, a pipe connected to the evaporator is connected to the inlet port 250 shown in FIG. 1. A pipe connected to a condenser is connected to the outlet port. The condenser is connected to the evaporator via a pipe and an expansion valve. A refrigeration circuit of an air-conditioning apparatus for a vehicle is configured by the compressor, the evaporator, the expansion valve, the condenser, and the like. Note that illustration of the evaporator, the expansion valve, the condenser, and the respective pipes is omitted.

[0055] In the compressor configured as explained above, the drive shaft 3 rotates, whereby the swash plate 5 rotates and the respective pistons 9 reciprocatingly move in the respective cylinder bores 21a. Therefore, the compression chamber 59 changes the capacity according to a piston stroke. Therefore, the refrigerant gas sucked into the swash plate chamber 25 from the evaporator by the inlet port 250 is compressed in the compression chamber 59 through the suction passage 39 to the suction chamber 33. The refrigerant gas compressed in the compression chamber 59 is discharged to the discharge chamber 35 and is discharged to the condenser from the outlet port.

[0056] In the compressor, it is possible to change a discharge capacity by changing the inclination angle of the swash plate 5 with the actuator 13 and increasing or reducing the stroke of the pistons 9.

[0057] Specifically, in the compressor, in the control mechanism 15, the high-pressure control valve 15d shown in FIG. 2 adjusts opening degree of the high-pressure passage 15b, whereby the pressure in the pressure regulation chamber 31 and further, in the control pressure chamber 13b is increased by the refrigerant gas in the discharge chamber 35. Further, adjusted opening degree of the low-pressure passage 15a by the low-pressure control valve 15c is performed, whereby the pressure in the control pressure chamber 13b is reduced.

[0058] Further, in the compressor, the refrigerant gas in the control pressure chamber 13b is discharged to the inside of the outer sliding portion 51c and further, the swash plate chamber 25 through the throttle hole 57. In this way, in the compressor, the pressure in the control pressure chamber 13b is regulated by the respective opening degree adjustments of the high-pressure passage 15b and the low-pressure control valve 15c and the discharge of the refrigerant gas by the throttle hole 57.

[0059] If the high-pressure control valve 15d reduces the opening degree of the high-pressure passage 15b or the low-pressure control valve 15c increases the opening degree of the low-pressure passage 15a, the pressure in the control pressure chamber 13b decreases. In this case, as explained above, the refrigerant gas in the control pressure chamber 13b is discharged to the swash plate chamber 25 through the throttle hole 57. Therefore, a pressure difference between the control pressure chamber 13b and the swash plate chamber 25 decreases. Therefore, with a piston compression force acting on the swash plate 5, as shown in FIG. 1, in the actuator 13, the movable body 13a slides in the outer sliding portion 51c from a position near the swash plate 5 toward the lug plate 51 in the axial direction O1.

[0060] At the same time, in the compressor, the swash plate arms 5e slide on the guide surface 51e to move away from the axial direction O1. Therefore, in the swash plate 5, a bottom dead center side pivots in the clockwise direction while substantially keeping the top dead center position T. In this way, in the compressor, the inclination angle of the swash plate 5 with respect to the axial direction O1 of the drive shaft 3 increases. Consequently, in the compressor, the stroke of the pistons 9 increases, and a discharge capacity per one rotation of the drive shaft 3 increases. Note that the inclination angle of the swash plate 5 shown in FIG. 1 is a maximum inclination angle in the compressor.

[0061] On the other hand, if the high-pressure control valve 15d shown in FIG. 2 increases the opening degree of the high-pressure passage 15b or the low-pressure control valve 15c reduces the opening degree of the low-pressure passage 15a, the pressure in the control pressure chamber 13b increases. Therefore, a pressure difference between the control pressure chamber 13b and the swash plate chamber 25 increases. In this case, the refrigerant gas is discharged to the swash plate chamber 25 through the throttle hole 57. Consequently, as shown in FIG. 4, the movable body 13a slides in the outer sliding portion 51c in the axial direction O1 toward the swash plate 5 while moving away from the lug plate 51.

[0062] Consequently, in the compressor, the acting portion 134 presses the convex portion 5g toward the rear of the swash plate chamber 25. Consequently, the swash plate arms 5e slide on the guide surface 51e to approach the axial direction O1. Consequently, in the swash plate 5, the bottom dead center side pivots in the counterclockwise direction while substantially keeping the top dead center position T. In this way, in the compressor, the inclination angle of the swash plate 5 with respect to the axial direction O1 of the drive shaft 3 decreases. Consequently, in the compressor, the stroke of the pistons 9 decreases, and the discharge capacity per one rotation of the drive shaft 3 decreases. Note that the inclination angle of the swash plate 5 shown in FIG. 4 is a minimum inclination angle in the compressor.

[0063] As explained above, in the compressor, when the pressure in the control pressure chamber 13b is reg-

ulated, in addition to the respective opening degree adjustments of the high-pressure passage 15b and the low-pressure control valve 15c, the refrigerant gas is discharged from the inside of the control pressure chamber 13b to the swash plate chamber 25 through the throttle hole 57. Therefore, in the compressor, when the pressure in the control pressure chamber 13b is regulated, it is unnecessary to completely seal the control pressure chamber 13b. The control pressure chamber 13b is enough only to be sealed by the O-rings 49c and 49d.

[0064] The throttle hole 57 discharges the lubricant to the swash plate chamber 25 from the inside of a control pressure chamber 13b together with the refrigerant gas. Therefore, in the compressor, even if the lubricant flows into the control pressure chamber 13b together with the refrigerant gas when the refrigerant gas in the discharge chamber 35 is introduced into the control pressure chamber 13b, the lubricant is discharged from the inside of the control pressure chamber 13b to the swash plate chamber 25 together with the refrigerant gas through the throttle hole 57.

[0065] In the compressor, the throttle hole 57 is formed in the connection portion 133. Therefore, in the compressor, it is possible to suitably cause the lubricant to flow out from the throttle hole 57 with a centrifugal force generated when the movable body 13a rotates. Therefore, in the compressor, the lubricant is less easily stored in the control pressure chamber 13b. Lubricant shortage in the swash plate chamber 25 less easily occurs.

[0066] Here, in the compressor, the throttle hole 57 extends such that the lubricant discharged from the throttle hole 57 together with the refrigerant gas is supplied to the sliding part between the second cylinder portion 132 and the inner wall 510 of the outer sliding portion 51c. Therefore, in the compressor, when the inclination angle of the swash plate 5 decreases from a maximum state, that is, the movable body 13a slides in the outer sliding portion 51c in the axial direction O1 toward the swash plate 5, the sliding part between the second cylinder portion 132 and the inner wall 510 of the outer sliding portion 51c is suitably lubricated by the lubricant discharged from the throttle hole 57. Therefore, in the compressor, the second cylinder portion 132 is capable of suitably sliding on the inner wall 510 of the outer sliding portion 51c. Therefore, in the compressor, it is possible to suitably change the discharge capacity per one rotation of the drive shaft 3 for a long period.

[0067] Therefore, according to the compressor of embodiment 1, in the compressor which changes a discharge capacity using the actuator 13, the compressor displays high performance for a long period while realizing a reduction in manufacturing costs.

(Embodiment 2)

[0068] As shown in FIG. 5, in a compressor in the embodiment 2, a throttle hole 61 is provided instead of the throttle hole 57 in the compressor in the embodiment 1.

The throttle hole 61 is formed in the fixed flange portion 51b of the lug plate 51. The throttle hole 61 extends from the control pressure chamber 13b toward the front wall 17a such that lubricant discharged from the throttle hole 61 together with a refrigerant gas is supplied to the thrust bearing 55. The throttle hole 61 opens near the thrust bearing 55. Consequently, the control pressure chamber 13b and the swash plate chamber 25 communicate with each other through the throttle hole 61. Further, in the compressor, the bleed passage in the present invention is formed by the low-pressure passage 15a, the axial path 3a, the radial path 3b, and the throttle hole 61. Note that the throttle hole 61 may be formed in the fixed portion 51a. The other components in the compressor are the same as those of the compressor in the embodiment 1. The same components are denoted by the same reference numerals and signs. Detailed explanation concerning the components is omitted.

[0069] In the compressor, when the pressure in the control pressure chamber 13b is regulated, in addition to the respective opening degree adjustments of the high-pressure passage 15b and the low-pressure control valve 15c, the refrigerant gas is discharged from the inside of the control pressure chamber 13b to the swash plate chamber 25 through the throttle hole 61. Here, in the compressor, the throttle hole 61 is formed in the fixed flange portion 51b such that the lubricant discharged from the throttle hole 61 together with the refrigerant gas is supplied to the thrust bearing 55. Therefore, in the compressor, it is possible to lubricate the thrust bearing 55 with the lubricant discharged from the throttle hole 61. Therefore, in the compressor, seizure less easily occurs in the thrust bearing 55, and durability can be improved. The other kinds of action in the compressor are the same as those in the compressor in the embodiment 1.

(Embodiment 3)

[0070] As shown in FIG. 6, in a compressor in the embodiment 3, a throttle hole 63 is provided instead of the throttle hole 57 in the compressor in the embodiment 1. The throttle hole 63 is formed in the fixed flange portion 51b of the lug plate 51. The throttle hole 63 extends from the control pressure chamber 13b toward the drive shaft 3 such that lubricant discharged from the throttle hole 63 together with a refrigerant gas is supplied to the first plain bearing 29a. Consequently, the control pressure chamber 13b and the swash plate chamber 25 communicate with each other through the throttle hole 63. In the compressor, the bleed passage in the present invention is formed by the low-pressure passage 15a, the axial path 3a, the radial path 3b, and the throttle hole 63. Note that the throttle hole 63 may be formed in the fixed portion 51a. The other components in the compressor are the same as those of the compressor in the embodiment 1.

[0071] In the compressor, when the pressure in the control pressure chamber 13b is regulated, in addition to the respective opening degree adjustments of the high-

pressure passage 15b and the low-pressure control valve 15c, the refrigerant gas is discharged from the inside of the control pressure chamber 13b to the swash plate chamber 25 through the throttle hole 63. Here, in the compressor, the throttle hole 63 is formed in the fixed flange portion 51b such that the lubricant discharged from the throttle hole 63 together with the refrigerant gas is supplied to the first plain bearing 29a. Therefore, in the compressor, it is possible to lubricate the first plain bearing 29a with the lubricant discharged from the throttle hole 63. Therefore, in the compressor, seizure less easily occurs between the drive shaft 3 and the first plain bearing 29a, and durability can be improved. The other kinds of action in the compressor are the same as those in the compressor in the embodiment 1.

(Embodiment 4)

[0072] As shown in FIG. 7, in a compressor in the embodiment 4, the shapes of the front housing 17 and the lug plate 51 in the compressor in the embodiment 1 are partially changed and the arrangements of the shaft seal device 27 and the first plain bearing 29a are changed. Specifically, in the compressor, compared with the compressor in the embodiment 1, the first shaft hole 17d is formed to be expanded in diameter in the front housing 17, whereby the shaft seal device 27 is arranged in the first shaft hole 17d. Consequently, the shaft seal device 27 faces the swash plate chamber 25. In the compressor, compared with the compressor in the embodiment 1, the lug plate 51 is extended to the front, whereby the first plain bearing 29a is arranged between the front wall 17a and the fixed flange portion 51b.

[0073] In the compressor, a throttle hole 65 is provided instead of the throttle hole 57 in the compressor in the embodiment 1. The throttle hole 65 is formed in the fixed flange portion 51b of the lug plate 51. The throttle hole 65 extends from the control pressure chamber 13b toward the front housing 17 such that lubricant discharged from the throttle hole 65 together with a refrigerant gas is supplied to the shaft seal device 27. Consequently, the control pressure chamber 13b and the swash plate chamber 25 communicate with each other through the throttle hole 65. In the compressor, the bleed passage in the present invention is formed by the low-pressure passage 15a, the axial path 3a, the radial path 3b, and the throttle hole 65. The other components in the compressor are the same as those of the compressor in the embodiment 1.

[0074] In the compressor, when the pressure in the control pressure chamber 13b is regulated, in addition to the respective opening degree adjustments of the high-pressure passage 15b and the low-pressure control valve 15c, the refrigerant gas is discharged from the inside of the control pressure chamber 13b to the swash plate chamber 25 through the throttle hole 65. Here, in the compressor, the throttle hole 65 is formed in the fixed flange portion 51b such that the lubricant discharged from

the throttle hole 65 together with the refrigerant gas is supplied to the shaft seal device 27. Therefore, in the compressor, it is possible to lubricate the shaft seal device 27 with the lubricant discharged from the throttle hole 65. Therefore, in the compressor, a space between the shaft seal device 27 and the drive shaft 3 is suitably lubricated.

[0075] In the compressor, the first plain bearing 29a is arranged between the front wall 17a and the fixed flange portion 51b while the shaft seal device 27 is arranged in the first shaft hole 17d. Therefore, in the compressor, compared with the compressor in the embodiment 1, it is possible to arrange the shaft seal device 27 and the lug plate 51 close to each other. It is possible to reduce the length of the boss 17c. Consequently, in the compressor, compared with the compressor in the embodiment 1, it is possible to reduce the size of the compressor. The other kinds of action in the compressor are the same as those of the compressor in the embodiment 1.

(Embodiment 5)

[0076] As shown in FIG. 8, a compressor in the embodiment 5 includes a housing 10, a drive shaft 30, a swash plate 50, a link mechanism 70, a plurality of pistons 90, a pair of shoes 110a and 110b, an actuator 160, and a control mechanism 150 shown in FIG. 9.

[0077] As shown in FIG. 8, the housing 10 includes a front housing 117 located in the front of the compressor, a rear housing 119 located in the rear of the compressor, first and second cylinder blocks 121 and 123 located between the front housing 117 and the rear housing 119, and first and second valve formation plates 139 and 141.

[0078] In the front housing 117, a boss 117a projecting forward is formed. In the boss 117a, a shaft seal device 125 that secures hermetic seal between the inside and the outside of the housing 10 is provided. Further, in the front housing 117, a first suction chamber 127a and a first discharge chamber 129a are formed. The first suction chamber 127a is located radially inward with respect to the first discharge chamber 129a in the front housing 117. The first discharge chamber 129a is formed in an annular shape and located radially outside of the first suction chamber 127a in the front housing 117.

[0079] Further, in the front housing 117, a first front communication path 118a is formed. The front end side of the first front communication path 118a communicates with the first discharge chamber 129a. The rear end side of the first front communication path 118a opens to the rear end of the front housing 117.

[0080] In the rear housing 119, a part of the control mechanism 150 is provided. In the rear housing 119, a second suction chamber 127b, a second discharge chamber 129b, and a pressure regulation chamber 131 are formed. The pressure regulation chamber 131 is located in the center portion of the rear housing 119. The second suction chamber 127b is formed in an annular shape and located radially outside of the pressure regu-

lation chamber 131 in the rear housing 119. The second discharge chamber 129b is also formed in an annular shape and located radially outside of the second suction chamber 127b in the rear housing 119.

[0081] Further, in the rear housing 119, a first rear communication path 120a is formed. The rear end side of the first rear communication path 120a communicates with the second discharge chamber 129b. The front end side of the first rear communication path 120a opens to the front end of the rear housing 119.

[0082] A swash plate chamber 330 is formed between the first cylinder block 121 and the second cylinder block 123.

[0083] In the first cylinder block 121, a plurality of first cylinder bores 121a are formed in parallel to one another at equal angle intervals in the circumferential direction. Further, in the first cylinder block 121, a first shaft hole 121b, through which the drive shaft 30 is inserted, is formed. In the first shaft hole 121b, a first plain bearing 122a is provided.

[0084] Further, in the first cylinder block 121, a first recessed portion 121c communicating with the first shaft hole 121b and coaxial with the first shaft hole 121b is formed. The first recessed portion 121c communicates with the swash plate chamber 330 and is a part of the swash plate chamber 330. A first thrust bearing 135a is provided at the front end of the first recessed portion 121c. Further, in the first cylinder block 121, a first communication path 137a that allows the swash plate chamber 330 and the first suction chamber 127a to be communicated with each other is formed. Further, in the first cylinder block 121, a first retainer groove 121e that regulates maximum opening degree of respective first suction reed valves 691a explained below is recessed.

[0085] Further, in the first cylinder block 121, a second front communication path 118b is formed. The front end of the second front communication path 118b opens to the front end side of the first cylinder block 121. The rear end of the second front communication path 118b opens to the rear end side of the first cylinder block 121.

[0086] In the second cylinder block 123, as in the first cylinder block 121, a plurality of second cylinder bores 123a are formed. The respective second cylinder bores 123a form pairs with the respective first cylinder bores 121a in the front and the rear.

[0087] Further, in the second cylinder block 123, a second shaft hole 123b, through which the drive shaft 3 is inserted, is formed. The rear end of the second shaft hole 123b communicates with the pressure regulation chamber 131. Further, in the second shaft hole 123b, a second plain bearing 122b is provided. Note that rolling bearings may be respectively provided instead of the first plain bearing 122a and the second plain bearing 122b.

[0088] Further, in the second cylinder block 123, a second recessed portion 123c communicating with the second shaft hole 123b and coaxial with the second shaft hole 123b is formed. The second recessed portion 123c also communicates with the swash plate chamber 330

and is a part of the swash plate chamber 330. A second thrust bearing 135b is provided at the rear end of the second recessed portion 123c. The second thrust bearing 135b corresponds to the thrust bearing in the present invention. Further, in the second cylinder block 123, a second communication path 137b that allows the swash plate chamber 330 and the second suction chamber 127b to be communicated with each other is formed. Further, in the second cylinder block 123, a respective second retainer groove 123e that regulates maximum opening degree of second suction reed valves 711a explained below is recessed.

[0089] In the second cylinder block 123, an outlet port 126, a merging discharge chamber 128, a third front communication path 118c, a second rear communication path 120b, and an inlet port 330a are formed. The outlet port 126 and the merging discharge chamber 128 communicate with each other. The merging discharge chamber 128 is connected to a not-shown condenser, which configures a conduit, via the outlet port 126.

[0090] The front end side of the third front communication path 118c opens to the front end of the second cylinder block 123. The rear end side of the third front communication path 118c communicates with the merging discharge chamber 128. When the first cylinder block 121 and the second cylinder block 123 are joined, the third front communication path 118c communicates with the rear end side of the second front communication path 118b.

[0091] The not-shown evaporator, which configures the conduit, is connected to the inlet port 330a. Consequently, the swash plate chamber 330 and the evaporator are connected via the inlet port 330a.

[0092] The first valve formation plate 139 is provided between the front housing 117 and the first cylinder block 121. Further, the second valve formation plate 141 is provided between the rear housing 119 and the second cylinder block 123.

[0093] The first valve formation plate 139 includes a first valve plate 690, a first suction valve plate 691, a first discharge valve plate 692, and a first retainer plate 693. In the first valve plate 690, the first discharge valve plate 692, and the first retainer plate 693, first suction holes 690a as many as the first cylinder bores 121a are formed. Further, in the first valve plate 690 and the first suction valve plate 691, first discharge holes 690b as many as the first cylinder bores 121a are formed. Further, in the first valve plate 690, the first suction valve plate 691, the first discharge valve plate 692, and the first retainer plate 693, a first suction communication hole 690c are formed. Further, in the first valve plate 690 and the first suction valve plate 691, a first discharge communication hole 690d is formed.

[0094] The first cylinder bores 121a communicate with the first suction chamber 127a through the first suction holes 690a. The first cylinder bores 121a communicate with the first discharge chamber 129a through the first discharge holes 690b. The first suction chamber 127a

and the first communication path 137a communicate with each other through the first suction communication holes 690c. The first front communication path 118a and the second front communication path 118b communicate with each other through the first discharge communication hole 690d.

[0095] The first suction valve plate 691 is provided on the rear surface of the first valve plate 690. At the first suction valve plate 691, a plurality of first suction reed valves 691a capable of opening and closing the respective first suction holes 690a by elastic deformation are formed. Further, the first discharge valve plate 692 is provided on the front surface of the first valve plate 690. At the first discharge valve plate 692, a plurality of first discharge reed valves 692a capable of opening and closing the respective first discharge holes 690b by elastic deformation are formed. The first retainer plate 693 is provided on the front surface of the first discharge valve plate 692. The first retainer plate 693 regulates maximum opening degree of the respective first discharge reed valves 692a.

[0096] The second valve formation plate 141 includes a second valve plate 710, a second suction valve plate 711, a second discharge valve plate 712, and a second retainer plate 713. In the second valve plate 710, the second discharge valve plate 712, and the second retainer plate 713, second suction holes 710a as many as the second cylinder bores 123a are formed. Further, in the second valve plate 710 and the second suction valve plate 711, second discharge holes 710b as many as the second cylinder bores 123a are formed. Further, in the second valve plate 710, the second suction valve plate 711, the second discharge valve plate 712, and the second retainer plate 713, a second suction communication hole 710c are formed. Further, in the second valve plate 710 and the second suction valve plate 711, a second discharge communication hole 710d is formed.

[0097] The respective second cylinder bores 123a communicate with the second suction chamber 127b through the respective second suction holes 710a. Further, the respective second cylinder bores 123a communicate with the second discharge chamber 129b through the respective second discharge holes 710b. The second suction chamber 127b and the second communication path 137b communicate with each other through the second suction communication hole 710c. The first rear communication path 120a and the second rear communication path 120b communicate with each other through the second discharge communication hole 710d.

[0098] The second suction valve plate 711 is provided on the front surface of the second valve plate 710. At the second suction valve plate 711, a plurality of second suction reed valves 711a capable of opening and closing the respective second suction holes 710a by elastic deformation are formed. Further, the second discharge valve plate 712 is provided on the rear surface of the second valve plate 710. At the second discharge valve plate 712, a plurality of second discharge reed valves 712a capable

of opening and closing the respective second discharge holes 710b by elastic deformation are formed. The second retainer plate 713 is provided on the rear surface of the second discharge valve plate 712. The second retainer plate 713 regulates maximum opening degree of the respective second discharge reed valves 712a.

[0099] In the compressor, a first discharge communication path 118 is formed by the first front communication path 118a, the first discharge communication hole 690d, the second front communication path 118b, and the third front communication path 118c. Further, a second discharge communication path 120 is formed by the first rear communication path 120a, the second discharge communication hole 710d, and the second rear communication path 120b.

[0100] Further, in the compressor, the first and second suction chambers 127a and 127b and the swash plate chamber 330 communicate with each other through the first and second communication paths 137a and 137b and the first and second suction communication holes 690c and 710c. Therefore, the pressure in the first and second suction chambers 127a and 127b and the pressure in the swash plate chamber 330 are substantially equal. Further, a low-pressure refrigerant gas that passes through the evaporator flows into the swash plate chamber 330 through the inlet port 330a. Therefore, the respective pressures in the swash plate chamber 330 and in the first and second suction chambers 127a and 127b are lower than the respective pressures in the first and second discharge chambers 129a and 129b.

[0101] The drive shaft 30 is configured by a drive shaft main body 300, a first supporting member 143a, and a second supporting member 143b. The drive shaft main body 300 extends from the front side to the rear side of the housing 10 and is inserted rearward from the boss 117a through the first and second plain bearings 122a and 122b. Consequently, the drive shaft main body 300 and further, the drive shaft 30 are axially supported by the housing 10 to be rotatable around a drive axial direction 02. The front end of the drive shaft main body 300 is located in the boss 117a. The rear end of the drive shaft main body 300 projects into the pressure regulation chamber 131.

[0102] Further, in the drive shaft main body 300, the swash plate 50, the link mechanism 70, and the actuator 160 are provided. The swash plate 50, the link mechanism 70, and the actuator 160 are respectively arranged in the swash plate chamber 330.

[0103] The first supporting member 143a is press-fitted in the front end side of the drive shaft main body 300 and located in the first shaft hole 121b. Further, in the first supporting member 143a, a flange 430 in contact with the first thrust bearing 135a is formed. An attaching portion (not shown in the figure), through which a second pin 147b explained below is inserted, is formed in the first supporting member 143a. Further, the front end of a first return spring 144a is fixed to the first supporting member 143a. The first return spring 144a extends from

the first supporting member 143a toward the swash plate chamber 330 in the axial direction 02.

[0104] As shown in FIG. 10, the second supporting member 143b is press-fitted in the rear end side of the drive shaft main body 300, and located in the second shaft hole 123b. A flange 431 in contact with the second thrust bearing 135b is formed at the front end of the second supporting member 143b. Further, O-rings 73a and 73b are provided in the second supporting member 143b.

[0105] As shown in FIG. 8, the swash plate 50 is formed in an annular flat shape, and includes a front surface 50a and a rear surface 50b. The front surface 50a faces the front of the compressor in the swash plate chamber 330. Further, the rear surface 50b faces the rear of the compressor in the swash plate chamber 330.

[0106] The swash plate 50 is fixed to a ring plate 145. The ring plate 145 is formed in an annular flat shape. An insertion hole 145a is formed in the center portion of the ring plate 145. The drive shaft main body 300 is inserted through the insertion hole 145a in the swash plate chamber 330, whereby the swash plate 50 is attached to the drive shaft 30.

[0107] The link mechanism 70 includes a lug arm 149. The lug arm 149 is arranged further in the front than the swash plate 50 in the swash plate chamber 330, and located between the swash plate 50 and the first supporting member 143a. The lug arm 149 is formed to have a substantial L shape from the front end side to the rear end side. A weight portion 149a is formed on the rear end side of the lug arm 149. The weight portion 149a extends over an approximately half circumference in the circumferential direction of the actuator 160. Note that the shape of the weight portion 149a can be designed as appropriate.

[0108] The rear end side of the lug arm 149 is connected to one end side of the ring plate 145 by a first pin 147a. Consequently, the rear end side of the lug arm 149 is pivotably supported around a first pivot axis M1, which is the axis of the first pin 147a, with respect to one end side of the ring plate 145, that is, the swash plate 50. The first pivot axis M1 extends in a direction orthogonal to the axial direction 02 of the drive shaft 30.

[0109] The front end side of the lug arm 149 is connected to the first supporting member 143a by a second pin 147b. Consequently, the front end side of the lug arm 149 is pivotably supported around a second pivot axis M2, which is the axis of the second pin 147b, with respect to the first supporting member 143a, that is, the drive shaft 30. The second pivot axis M2 extends in parallel to the first pivot axis M1. The link mechanism 70 is configured by the lug arm 149 and the first and second pins 147a and 147b.

[0110] The weight portion 149a is provided on the rear end side of the lug arm 149, that is, on the opposite side of the second pivot axis M2 with respect to the first pivot axis M1. Therefore, since the lug arm 149 is supported on the ring plate 145 by the first pin 147a, the weight portion 149a is located rearward with respect to the ring

plate 145, that is, rearward of the rear surface 50b of the swash plate 50 through a groove portion 145b of the ring plate 145. A centrifugal force generated by the rotation of the swash plate 50 around the axial direction 02 also acts on the weight portion 149a at the rear side of the rear surface 50b of the swash plate 50.

[0111] In the compressor, the swash plate 50 and the drive shaft 30 are connected by the link mechanism 70, whereby the swash plate 50 and the drive shaft 30 are capable of rotating together. Further, both ends of the lug arms 149 respectively pivot around the first pivot axis M1 and the second pivot axis M2, whereby the swash plate 50 is capable of changing the inclination angle.

[0112] The respective pistons 90 include first head portions 90a on the front end sides and include second head portions 90b on the rear end sides. The respective first head portions 90a are accommodated to be reciprocatingly movable in the respective first cylinder bores 121a. Respective first compression chambers 121d are defined in the respective first cylinder bores 121a by the respective first head portions 90a and the respective first valve formation plate 139. The respective second head portions 90b are accommodated to be reciprocatingly movable in the respective second cylinder bores 123a. Respective second compression chambers 123d are defined in the respective second cylinder bores 123a by the respective second head portions 90b and the respective second valve formation plate 141.

[0113] Further, engaging portions 90c are formed in the centers of the respective pistons 90. Semispherical shoes 110a and 110b are provided in the respective engaging portions 90c. The rotation of the swash plate 50 is converted into reciprocating movement of the pistons 90 by the shoes 110a and 110b. The shoes 110a and 110b correspond to the conversion mechanism in the present invention. In this way, in the compressor, the respective first and second head portions 90a and 90b are reciprocatingly movable in the respective first and second cylinder bores 121a and 123a at a stroke corresponding to the inclination angle of the swash plate 50. As shown in FIG. 11, in the compressor, as the inclination angle of the swash plate 50 decreases, a top dead center position of the second head portions 90b moves larger than a top dead center position of the first head portions 90a.

[0114] The actuator 160 is arranged in the swash plate chamber 330. The actuator 160 is located rearward relative to the swash plate 50, and is capable of entering the inside of the second recessed portion 123c. As shown in FIG. 10, the actuator 160 includes a movable body 160a, a defining body 160b, and a control pressure chamber 160c. The control pressure chamber 160c is formed between the movable body 160a and the defining body 160b.

[0115] The movable body 160a includes an inner sliding portion 161, a bottom wall 162, a peripheral wall 163, and a coupling portion 164. The inner sliding portion 161 is located at the rear end of the movable body 160a. The

drive shaft main body 300 is inserted through the inner sliding portion 161. Consequently, the inner sliding portion 161 is slidably provided in the drive shaft main body 300. An O-ring 73c is provided in the inner sliding portion 161. The bottom wall 162 extends from the rear end of the peripheral wall 163 toward the drive shaft main body 300 at the rear end of the movable body 160a. The bottom wall 162 is connected with the inner sliding portion 161. The peripheral wall 163 extends from the tip end of the bottom wall 162 toward the front end in the axial direction 02. Consequently, the peripheral wall 163 is formed in a cylindrical shape concentric with the axial direction 02. As shown in FIG. 8, the coupling portion 164 is formed at the front end of the peripheral wall 163.

[0116] As shown in FIG. 10, the defining body 160b is formed in a disk shape having a diameter substantially the same as the inner diameter of the peripheral wall 163. A fixed portion 165 is provided on the center side of the defining body 160b. The drive shaft main body 300 is press-fitted in the fixed portion 165, whereby the fixed portion 165 is fixed with the drive shaft 30. Further, an O-ring 73d is provided on the outer circumferential surface of the defining body 160b. Note that the defining body 160b may be provided in the drive shaft 30 movably in the axial direction 02.

[0117] As shown in FIG. 8, a second return spring 144b is provided between the defining body 160b and the ring plate 145. Specifically, the rear end of the second return spring 144b is fixed to the defining body 160b. The front end of the second return spring 144b is fixed to the other end side of the ring plate 145.

[0118] The drive shaft main body 300 is inserted through the inner sliding portion 161 and the fixed portion 165 as explained above, whereby the movable body 160a is arranged to be opposed to the link mechanism 70 across the swash plate 50 in a state in which the movable body 160a is accommodated in the second recessed portion 123c. On the other hand, the defining body 160b is arranged in the movable body 160a further in the rear than the swash plate 50. An outer circumference surface the defining body 160b is surrounded by the peripheral wall 163. Consequently, the control pressure chamber 160c is formed between the movable body 160a and the defining body 160b. The control pressure chamber 160c is separated from the swash plate chamber 330 by the movable body 160a and the defining body 160b.

[0119] As shown in FIG. 10, a throttle hole 75 is formed in the defining body 160b. The throttle hole 75 extends from the control pressure chamber 160c toward the swash plate chamber 330. More specifically, the throttle hole 75 extends to incline upward from the control pressure chamber 160c toward the swash plate chamber 330 such that the lubricant discharged from the throttle hole 75 together with the refrigerant gas is supplied to a sliding part between an inner wall 163a of the peripheral wall 163 and the defining body 160b. The control pressure chamber 160c and the swash plate chamber 330 communicate with each other through the throttle hole 75.

[0120] As shown in FIG. 8, the other end side of the ring plate 145 is connected to the coupling portion 164 of the movable body 160a by a third pin 147c. Consequently, the other end side of the ring plate 145, that is, the swash plate 50 is pivotably supported by the movable body 160a around an action axis M3, which is the axis of the third pin 147c. The action axis M3 extends in parallel to the first and second pivot axes M1 and M2. In this way, the movable body 160a is connected to the swash plate 50.

[0121] Further, in the drive shaft main body 300, an axial path 30a that extends in the axial direction 02 from the rear end toward the front and a radial path 30b that extends in the radial direction from the front end of the axial path 30a and opens to the outer circumferential surface of the drive shaft main body 300, are formed. The rear end of the axial path 30a opens to the pressure regulation chamber 131. On the other hand, the radial path 30b opens to the control pressure chamber 160c. Consequently, the control pressure chamber 160c communicates with the pressure regulation chamber 131 through the radial path 30b and the axial path 30a.

[0122] A screw portion 30d is formed at the tip end of the drive shaft main body 300. The drive shaft 30 is connected to a pulley or an electromagnetic clutch not shown in the figure via the screw portion 30d.

[0123] As shown in FIG. 9, the control mechanism 150 is configured by a low-pressure passage 150a, a high-pressure passage 150b, a low-pressure control valve 150c, a high-pressure control valve 150d, the axial path 30a, the radial path 30b, and the throttle hole 75 explained above.

[0124] The low-pressure passage 150a is connected to the pressure regulation chamber 131 and the second suction chamber 127b. Consequently, the control pressure chamber 160c, the pressure regulation chamber 131, and the second suction chamber 127b communicate with one another through the low-pressure passage 150a, the axial path 30a, and the radial path 30b. The bleed passage in the present invention is formed by the low-pressure passage 150a, the axial path 30a, the radial path 30b, and the throttle hole 75.

[0125] The high-pressure passage 150b is connected to the pressure regulation chamber 131 and the second discharge chamber 129b. The control pressure chamber 160c, the pressure regulation chamber 131, and the second discharge chamber 129b communicate with one another through the high-pressure passage 150b, the axial path 30a, and the radial path 30b. The supply passage in the present invention is formed by the high-pressure passage 150b, the axial path 30a, and the radial path 30b.

[0126] The low-pressure control valve 150c is provided in the low-pressure passage 150a. The low-pressure control valve 150c is capable of adjusting the opening degree of the low-pressure passage 150a on the basis of the pressure in the second suction chamber 127b. Further, the high-pressure control valve 150d is provided in the high-pressure passage 150b. The high-pressure con-

trol valve 150d is capable of adjusting the opening degree of the high-pressure passage 150b on the basis of the pressure in the second suction chamber 127b.

[0127] In the compressor, a pipe connected to the evaporator is connected to the inlet port 330a shown in FIG. 8. A pipe connected to the condenser is connected to the outlet port 126. The condenser is connected to the evaporator via a pipe and an expansion valve.

[0128] In the compressor configured as explained above, the drive shaft 30 rotates, whereby the swash plate 50 rotates and the pistons 90 reciprocatingly move in the first and second cylinder bores 121a and 123a. Therefore, a capacity change occurs in the first and second compression chambers 121d and 123d according to a piston stroke. Therefore, the compressor repeatedly performs a suction stroke for sucking the refrigerant gas into the first and second compression chambers 121d and 123d, a compression stroke for compressing the refrigerant gas in the first and second compression chambers 121d and 123d, a discharge stroke for discharging the compressed refrigerant gas to the first and second discharge chambers 129a and 129b, and the like.

[0129] The refrigerant gas discharged to the first discharge chamber 129a reaches the merging discharge chamber 128 through the first discharge communication path 118. Similarly, the refrigerant gas discharged to the second discharge chamber 129b reaches the merging discharge chamber 128 through the second discharge communication path 120. The refrigerant gas reached the merging discharge chamber 128 is discharged from the outlet port 126 to the condenser.

[0130] While the suction stroke and the like are performed, a piston compression force for reducing the inclination angle of the swash plate 50 acts on a rotating body including of the swash plate 50, the ring plate 145, the lug arm 149, and the first pin 147a. Further, in the compressor, as in the compressors explained above, if the inclination angle of the swash plate 50 is changed, it is possible to perform capacity control by an increase and a decrease in the stroke of the pistons 90.

[0131] Specifically, in the control mechanism 150, the high-pressure control valve 150d shown in FIG. 9 performs the opening degree adjustment of the high-pressure passage 150b, whereby the pressure in the pressure regulation chamber 131 and further, in the control pressure chamber 160c is increased by the refrigerant gas in the second discharge chamber 129b. Further, the opening degree adjustment of the low-pressure passage 150a by the low-pressure control valve 150c is performed, whereby the pressure in the control pressure chamber 160b is reduced.

[0132] Further, in the compressor, as in the compressors explained above, the refrigerant gas in the control pressure chamber 160c is discharged to the swash plate chamber 330 through the throttle hole 75. In this way, by the respective opening degree adjustments of the high-pressure passage 150b and the low-pressure control valve 150c and the discharge of the refrigerant gas by

the throttle hole 75, in the compressor, the pressure in the control pressure chamber 160c is regulated.

[0133] Here, if the high-pressure control valve 150d reduces the opening degree of the high-pressure passage 150b or the low-pressure control valve 150c increases the opening degree of the low-pressure passage 150a, the pressure in the control pressure chamber 160c decreases. In this case, as explained above, the refrigerant gas in the control pressure chamber 160c is discharged to the swash plate chamber 330 through the throttle hole 75. Therefore, the pressure in the control pressure chamber 160c decreases, and a pressure difference between the control pressure chamber 160c and the swash plate chamber 330 decreases. Therefore, with a piston compression force acting on the swash plate 50, as shown in FIG. 11, in the actuator 160, the movable body 160a moves toward the front in the second recessed portion 123c.

[0134] Consequently, the other end side of the ring plate 145, that is, the other end side of the swash plate 50 pivots in the clockwise direction around the action axis M3 while resisting an urging force of the second return spring 144b. Further, the rear end of the lug arm 149 pivots in the clockwise direction around the first pivot axis M1. The front end of the lug arm 149 pivots in the counterclockwise direction around the second pivot axis M2. Therefore, the lug arm 149 approaches the flange 430 of a first supporting member 143a. Consequently, the swash plate 50 pivots with the action axis M3 as a point of action and with the first pivot axis M1 as a fulcrum. Therefore, the inclination angle of the swash plate 50 with respect to the axial direction 02 of the drive shaft 30 decreases. The stroke of the pistons 90 decreases. Therefore, in the compressor, a discharge capacity per one rotation of the drive shaft 30 decreases. Note that the inclination angle of the swash plate 50 shown in FIG. 11 is a minimum inclination angle in the compressor.

[0135] Here, in the compressor, the centrifugal force acting on the weight portion 149a is also applied to the swash plate 50. Therefore, in the compressor, the swash plate 50 is easily displaced in a direction for reducing the inclination angle of the swash plate 50.

[0136] Further, the inclination angle of the swash plate 50 decreases, whereby the ring plate 145 comes into contact with the rear end of the first return spring 144a. Consequently, the first return spring 144a is elastically deformed. The rear end of the first return spring 144a approaches the first supporting member 143a.

[0137] Here, in the compressor, the inclination angle of the swash plate 50 decreases and the stroke of the pistons 90 decreases, whereby a top dead center position of the second head portion 90b moves away from the second valve formation plate 141. Therefore, in the compressor, when the inclination angle of the swash plate 50 approaches a zero degree, compression work is slightly performed in the first compression chamber 121d. On the other hand, the compression work is not performed in the second compression chamber 123d.

[0138] On the other hand, if the high-pressure control valve 150d shown in FIG. 9 increases the opening degree of the high-pressure passage 150b or the low-pressure control valve 150c reduces the opening degree of the low-pressure passage 150a, the pressure in the control pressure chamber 160c increases. A pressure difference between the control pressure chamber 160c and the swash plate chamber 330 increases. In this case, as explained above, the refrigerant gas in the control pressure chamber 160c is discharged to the swash plate chamber 330 through the throttle hole 75. Therefore, as shown in FIG. 8, in the actuator 160, the movable body 160a moves toward the rear in the second recessed portion 123c while resisting a piston compression force acting on the swash plate 50.

[0139] Consequently, in the action axis M3, the movable body 160a drags the other end side of the swash plate 50 rearward within the swash plate chamber 330 through the coupling portion 164. Consequently, the other end side of the swash plate 50 pivots in the counterclockwise direction around the action axis M3. Further, the rear end of the lug arm 149 pivots in the counterclockwise direction around the first pivot axis M1. The front end of the lug arm 149 pivots in the clockwise direction around the second pivot axis M2. Therefore, the lug arm 149 separates from the flange 430 of the first supporting member 143a. Consequently, the swash plate 50 pivots, with the action axis M3 and the first pivot axis M1 respectively as a point of action and a fulcrum, in a direction opposite to the direction in which the inclination angle decreases. Therefore, the inclination angle of the swash plate 50 with respect to the axial direction 02 of the drive shaft 30 increases and the stroke of the pistons 90 increases. Consequently, the discharge capacity per one rotation of the drive shaft 30 increases. Note that the inclination angle of the swash plate 50 shown in FIG. 8 is a maximum inclination angle in the compressor.

[0140] As explained above, in the compressor, when the pressure in the control pressure chamber 160c is regulated, in addition to the respective opening degree adjustments of the high-pressure passage 150b and the low-pressure control valve 150c, the refrigerant gas is discharged from the inside of the control pressure chamber 160c to the swash plate chamber 330 through the throttle hole 75. Therefore, in the compressor, when the pressure in the control pressure chamber 160c is regulated, it is unnecessary to completely seal the control pressure chamber 160c. The control pressure chamber 160c is enough only to be sealed by the O-rings 73c and 73d.

[0141] Further, in the compressor, even if the lubricant flows into the control pressure chamber 160c together with the refrigerant gas when the refrigerant gas in the second discharge chamber 129b is introduced into the control pressure chamber 160c, the lubricant is discharged from the inside of the control pressure chamber 160c to the swash plate chamber 330 through the throttle hole 75 together with the refrigerant gas. Therefore, as

in the compressor in the embodiment 1, in the compressor, the lubricant is less easily stored in the control pressure chamber 160c. Lubricant shortage in the swash plate chamber 330 less easily occurs.

[0142] Here, as shown in FIG. 10, in the compressor, the throttle hole 75 extends to incline upward from the control pressure chamber 160c toward the swash plate chamber 330 such that the lubricant discharged from the throttle hole 75 together with the refrigerant gas is supplied to a sliding part between the inner wall 163a of the peripheral wall 163 and the defining body 160b. Therefore, in the compressor, when the inclination angle of the swash plate 50 increases from a minimum state, that is, when the movable body 160a moves rearward in the second recessed portion 123c, the lubricant flown out from the throttle hole 75 together with the refrigerant gas lubricates the inside of the peripheral wall 163. Here, in the peripheral wall 163, the front side of the defining body 160b communicates with the swash plate chamber 330. In the compressor, the inner wall 163a of the peripheral wall 163 is suitably lubricated by the lubricant. Therefore, the peripheral wall 163 is capable of suitably sliding on the outer circumferential surface of the defining body 160b. Therefore, in the compressor, it is possible to suitably change the discharge capacity per one rotation of the drive shaft 30 for a long period.

(Embodiment 6)

[0143] As shown in FIG. 12, in a compressor in the embodiment 6, a throttle hole 77 is provided instead of the throttle hole 75 in the compressor in the embodiment 5. The throttle hole 77 is formed in the bottom wall 162 in the movable body 160a. The throttle hole 77 extends from the control pressure chamber 160c toward the second thrust bearing 135b such that lubricant discharged from the throttle hole 77 together with a refrigerant gas is supplied to the second thrust bearing 135b. Consequently, the control pressure chamber 160c and the swash plate chamber 330 communicate with each other through the throttle hole 77. In the compressor, the bleed passage in the present invention is formed by the low-pressure passage 150a, the axial path 30a, the radial path 30b, and the throttle hole 77. The other components in the compressor are the same as those in the compressor in the embodiment 5.

[0144] In the compressor, when the pressure in the control pressure chamber 160c is regulated, in addition to the respective opening degree adjustments of the high-pressure passage 150b and the low-pressure control valve 150c, the refrigerant gas is discharged from the inside of the control pressure chamber 160c to the swash plate chamber 330 through the throttle hole 77. Here, in the compressor, the throttle hole 77 extends from the control pressure chamber 160c toward the second thrust bearing 135b such that the lubricant discharged from the throttle hole 77 together with the refrigerant gas is supplied to the second thrust bearing 135b. Therefore, in the

compressor, when the movable body 160a moves rearward in the second recessed portion 123c, the lubricant in the control pressure chamber 160c is discharged from the throttle hole 77 toward the second thrust bearing 135b together with the refrigerant gas. Here, in the compressor, the movable body 160a moves rearward in the second recessed portion 123c, whereby the movable body 160a and the second thrust bearing 135b gradually approach. Consequently, in the compressor, the second thrust bearing 135b can be suitably lubricated by the lubricant discharged from the throttle hole 77. Therefore, in the compressor, seizure less easily occurs in the second thrust bearing 135b, and durability can be improved. The other kinds of action in the compressor are the same as those in the compressor in the embodiment 5.

[0145] The present invention is explained above according to the embodiments 1 to 6. However, the present invention is not limited to the embodiments 1 to 6. It goes without saying that the present invention can be changed as appropriate and applied without departing from the gist of the present invention.

[0146] For example, a compressor may be configured by combining the compressors in the embodiments 1 to 4 as appropriate. Further, a compressor may be configured by combining the compressor in the embodiment 5 and the compressor in the embodiment 6.

[0147] Further, a three way valve may be adopted instead of the low-pressure control valves 15c and 150c and the high-pressure control valves 15d and 150d. In this case, the three way valve corresponds to the control valve in the present invention. The high-pressure control valves 15d and 150d may be arranged in only the high-pressure passages 15b and 150b.

[0148] Further, in the compressors in the embodiments 5 and 6, the compressors may be configured such that a compression chamber is formed only in one of the first cylinder block 121 and the second cylinder block 123.

Claims

1. A variable displacement swash plate type compressor comprising:

- a housing in which a suction chamber, a discharge chamber, a swash plate chamber, and a cylinder bore are formed;
- a drive shaft rotatably supported by the housing;
- a swash plate rotatable in the swash plate chamber according to the rotation of the drive shaft;
- a link mechanism provided between the drive shaft and the swash plate and configured to allow a change in an inclination angle of the swash plate with respect to a direction orthogonal to an axis of the drive shaft;
- a piston accommodated in the cylinder bore to be reciprocally movable;
- a conversion mechanism configured to reciprocally

catingly move, according to the rotation of the swash plate, the piston in the cylinder bore at a stroke corresponding to the inclination angle; an actuator capable of changing the inclination angle; and

a control mechanism configured to control the actuator, wherein the swash plate chamber communicates with the suction chamber, the actuator includes:

a defining body provided on the drive shaft in the swash plate chamber;
a movable body movable in axial direction of the drive shaft in the swash plate chamber; and
a control pressure chamber defined by the defining body and the movable body and configured to move the movable body by an internal pressure in the control pressure chamber,

the control mechanism includes:

a supply passage communicating with the discharge chamber and the control pressure chamber, and introducing a refrigerant in the discharge chamber into the control pressure chamber; and
a bleed passage communicating with the control pressure chamber and the swash plate chamber, and discharging the refrigerant in the control pressure chamber to the swash plate chamber, and

the bleed passage includes a communication path formed in at least one of the movable body and the defining body, and discharging lubricant from the control pressure chamber to the swash plate chamber together with the refrigerant.

2. The variable displacement swash plate type compressor according to claim 1, wherein the defining body includes an outer sliding portion extending in the axial direction of the drive shaft and surrounding slidably the movable body; the movable body includes:

a first cylinder portion arranged near the swash plate around the drive shaft;
a second cylinder portion formed in a cylindrical shape expanded to be larger in a diameter than the first cylinder portion; and
a connection portion connected the first cylinder portion and the second cylinder portion, and

the communication path is formed in the second cylinder portion or the coupling portion such that the

lubricant discharged from the communication path together with the refrigerant is supplied to a sliding part between the movable body and the outer sliding portion.

3. The variable displacement swash plate type compressor according to claim 1, wherein the defining body is fixed to the drive shaft, a thrust bearing that receives a thrust force acting on the drive shaft is provided between the defining body and the housing, a radial bearing that receives a radial force acting on the drive shaft is provided between the housing and the drive shaft, a shaft seal device that secures seal between an inside of the housing and an outside is provided between the housing and the drive shaft, and the communication path is formed in the defining body such that the lubricant discharged from the communication path together with the refrigerant is supplied to the thrust bearing, the radial bearing, or the shaft seal device.

4. The variable displacement swash plate type compressor according to claim 1, wherein the movable body includes a peripheral wall that extends in the axial direction of the drive shaft and surrounds the defining body while sliding with the defining body and a bottom wall that extends from the peripheral wall toward the drive shaft, and the communication path is formed in the defining body such that the lubricant discharged from the communication path together with the refrigerant is supplied to a sliding part between the peripheral wall and the defining body.

5. The variable displacement swash plate type compressor according to claim 1, wherein the movable body includes a peripheral wall that extends in the axial direction of the drive shaft and surrounds the defining body while sliding with the defining body and a bottom wall that extends from the peripheral wall toward the drive shaft, a thrust bearing that receives a thrust force acting on the drive shaft is provided between the movable body and the housing, and the communication path is formed in the movable body such that the lubricant discharged from the communication path together with the refrigerant is supplied to the thrust bearing.

FIG. 1

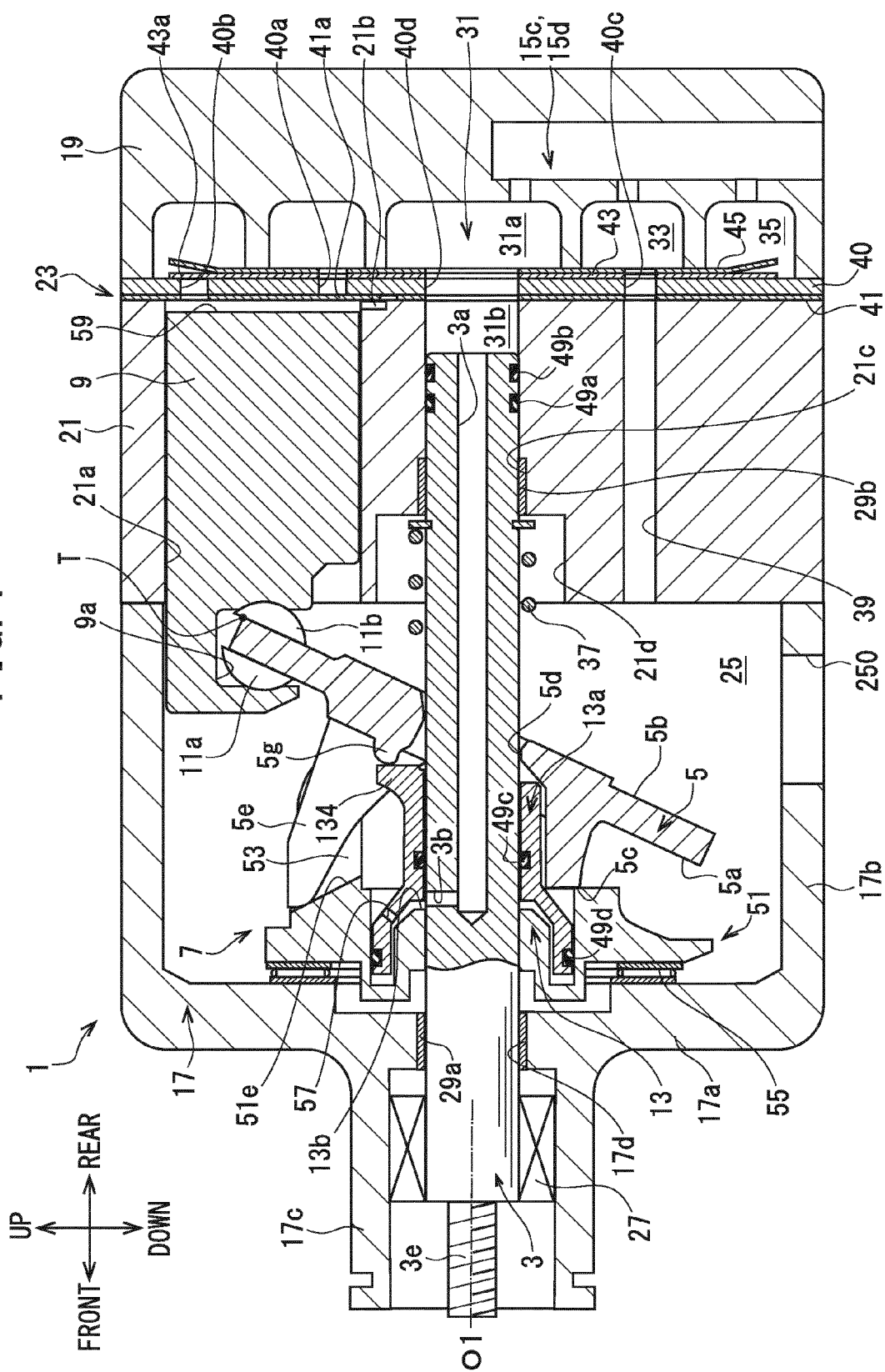


FIG. 2

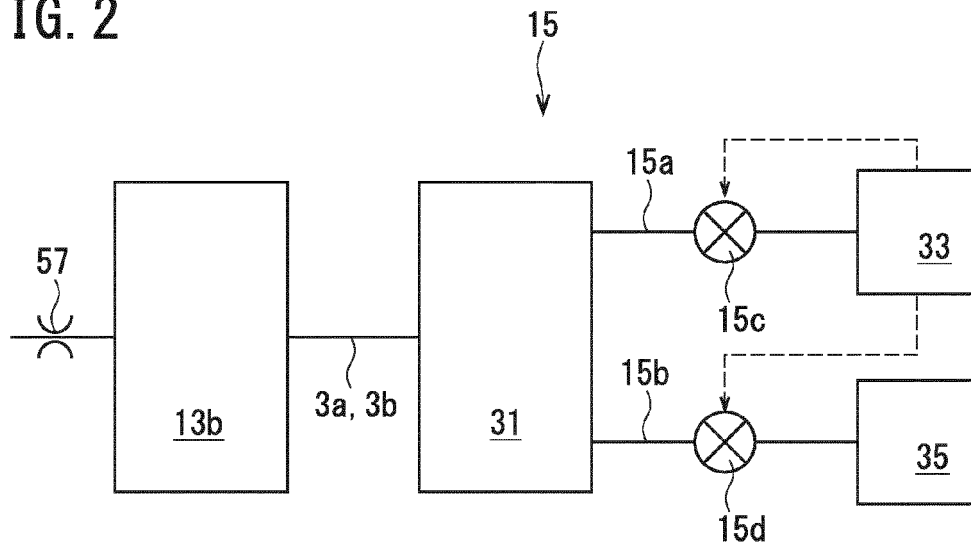


FIG. 3

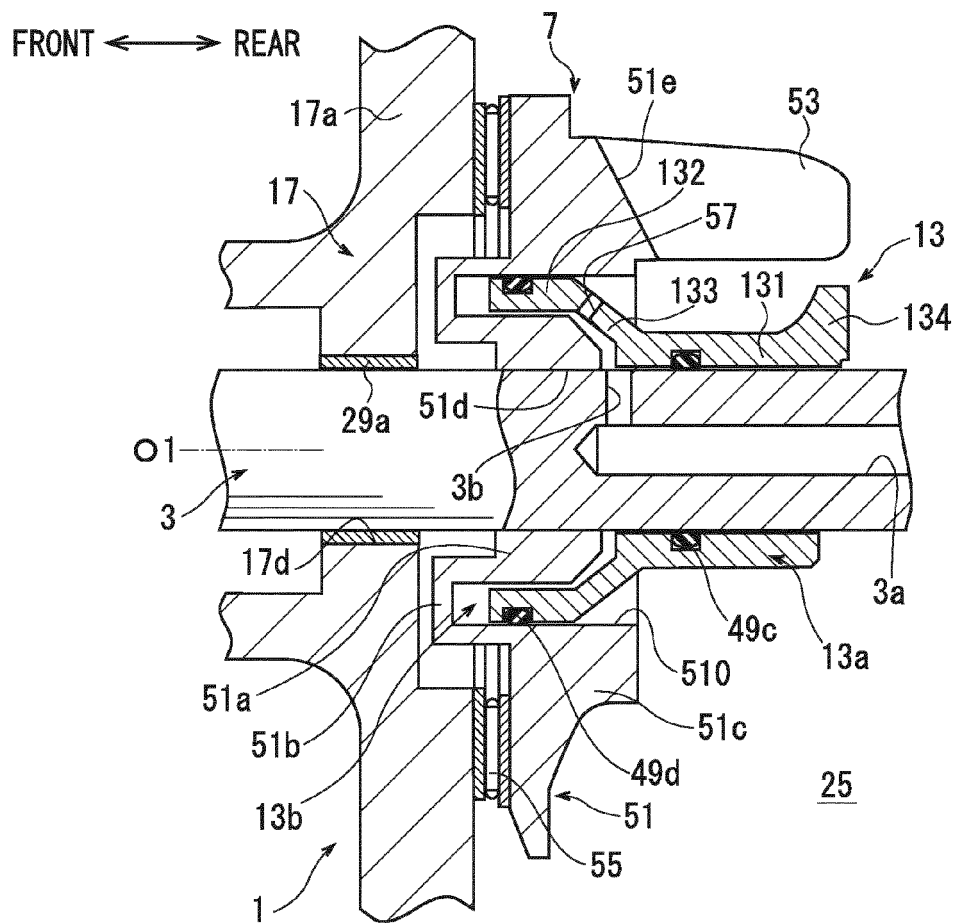


FIG. 4

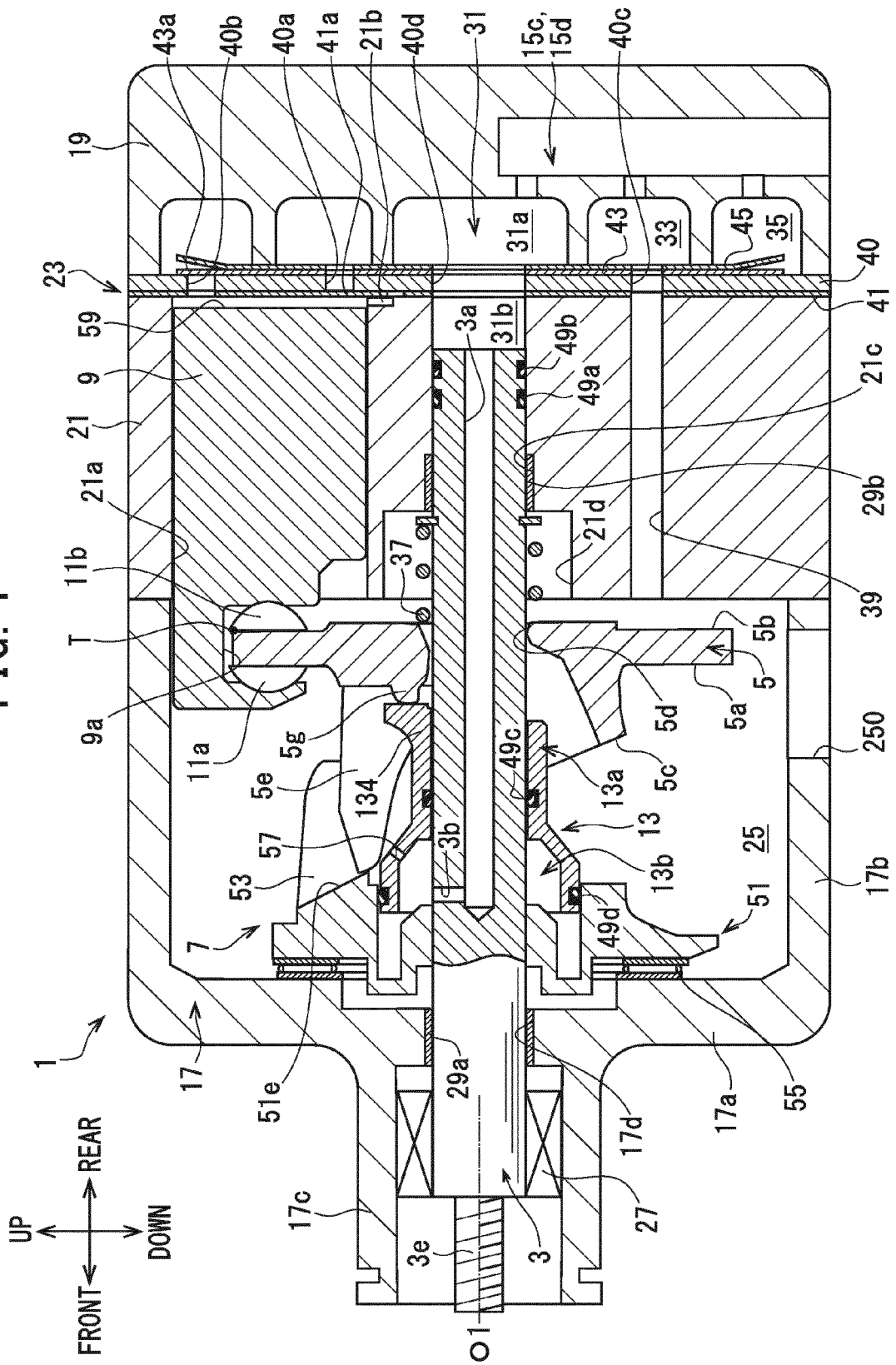


FIG. 5

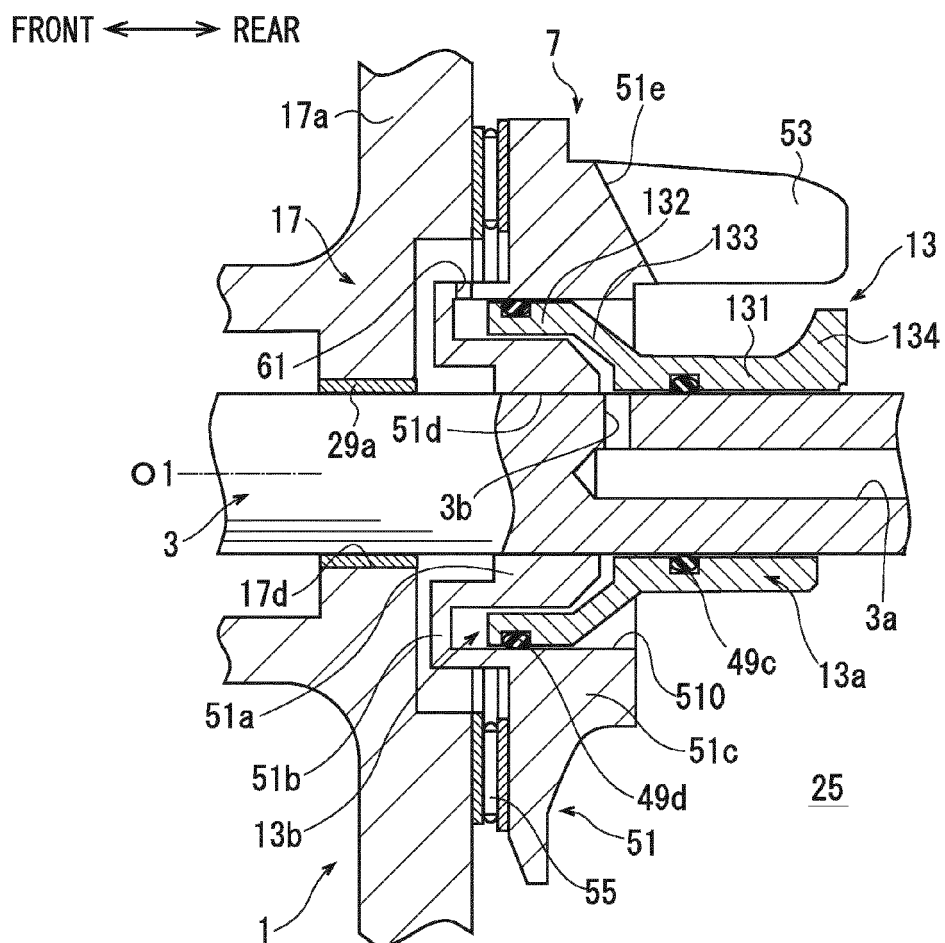


FIG. 6

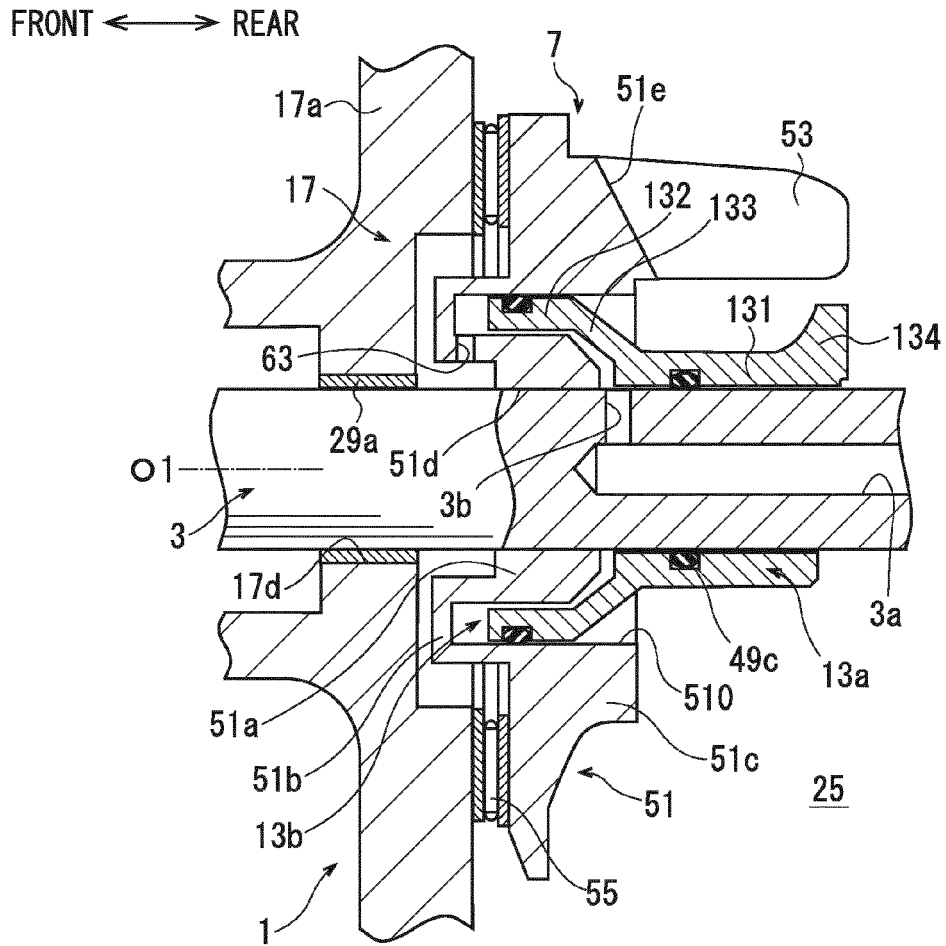


FIG. 7

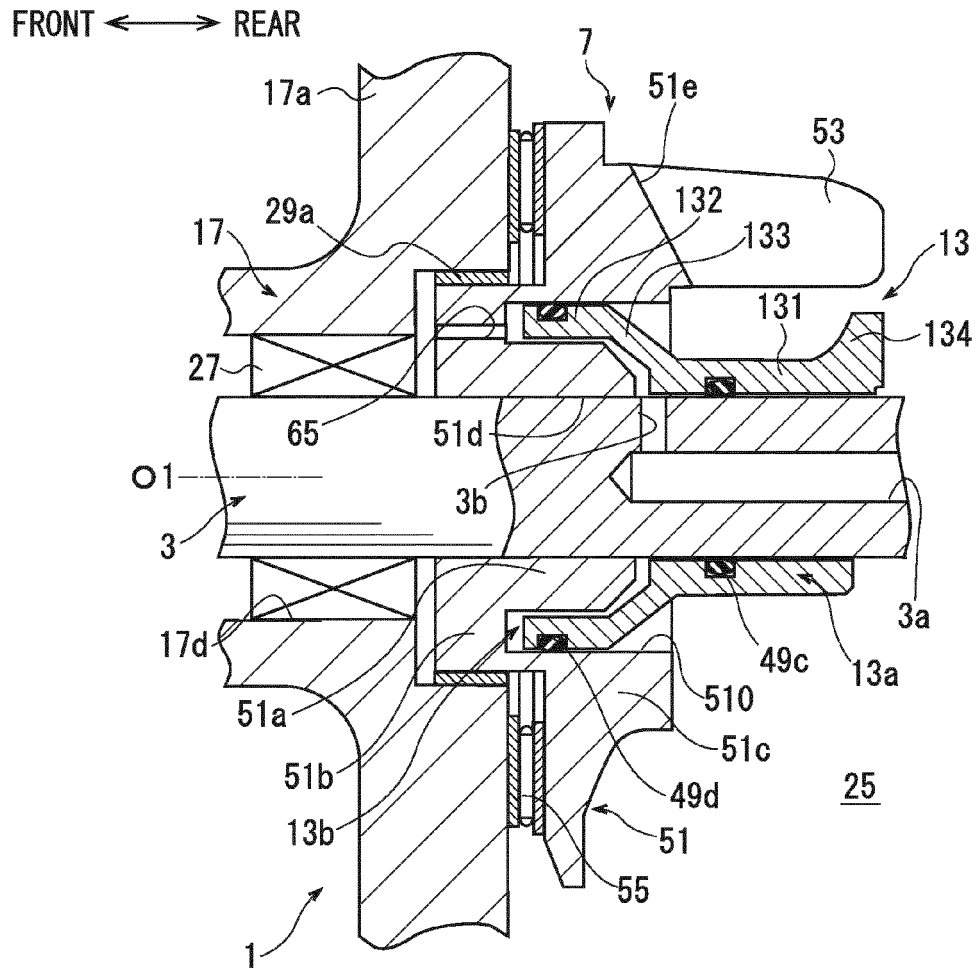


FIG. 8

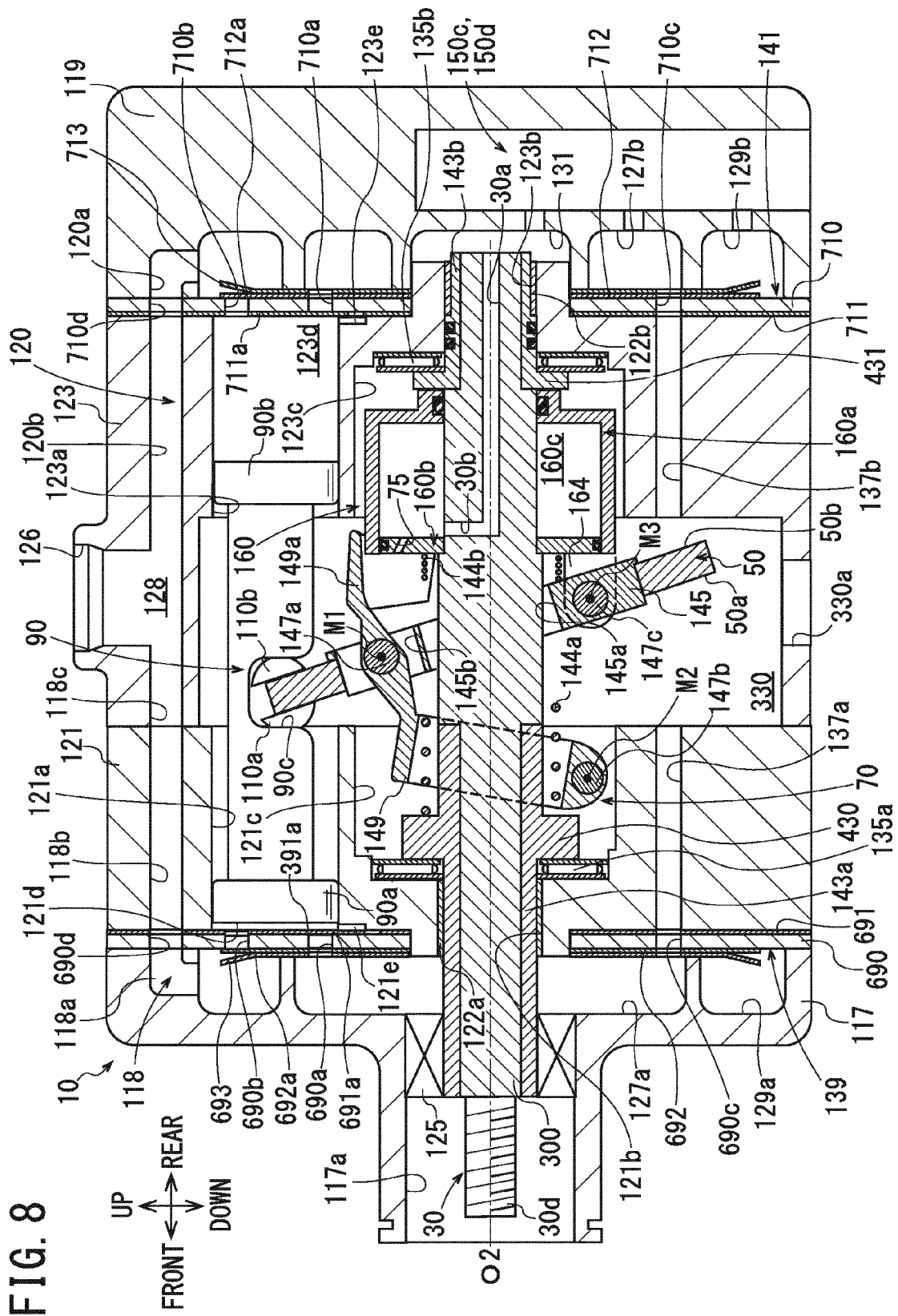


FIG. 9

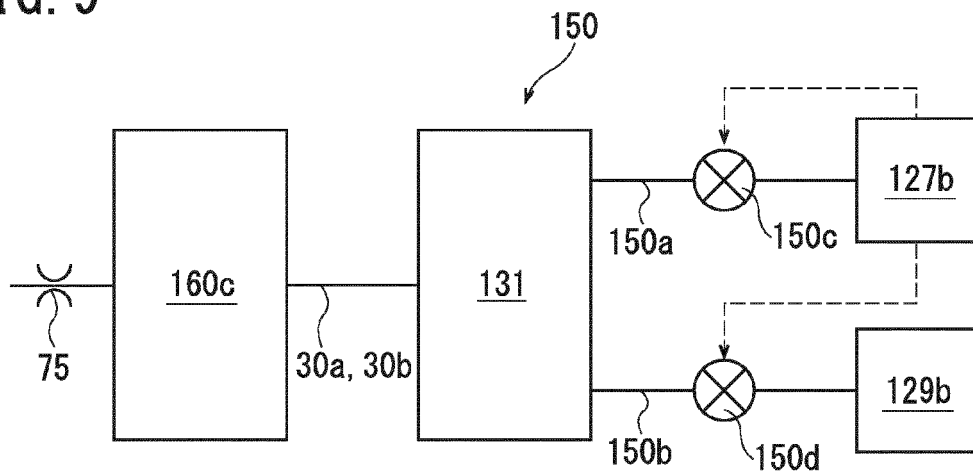
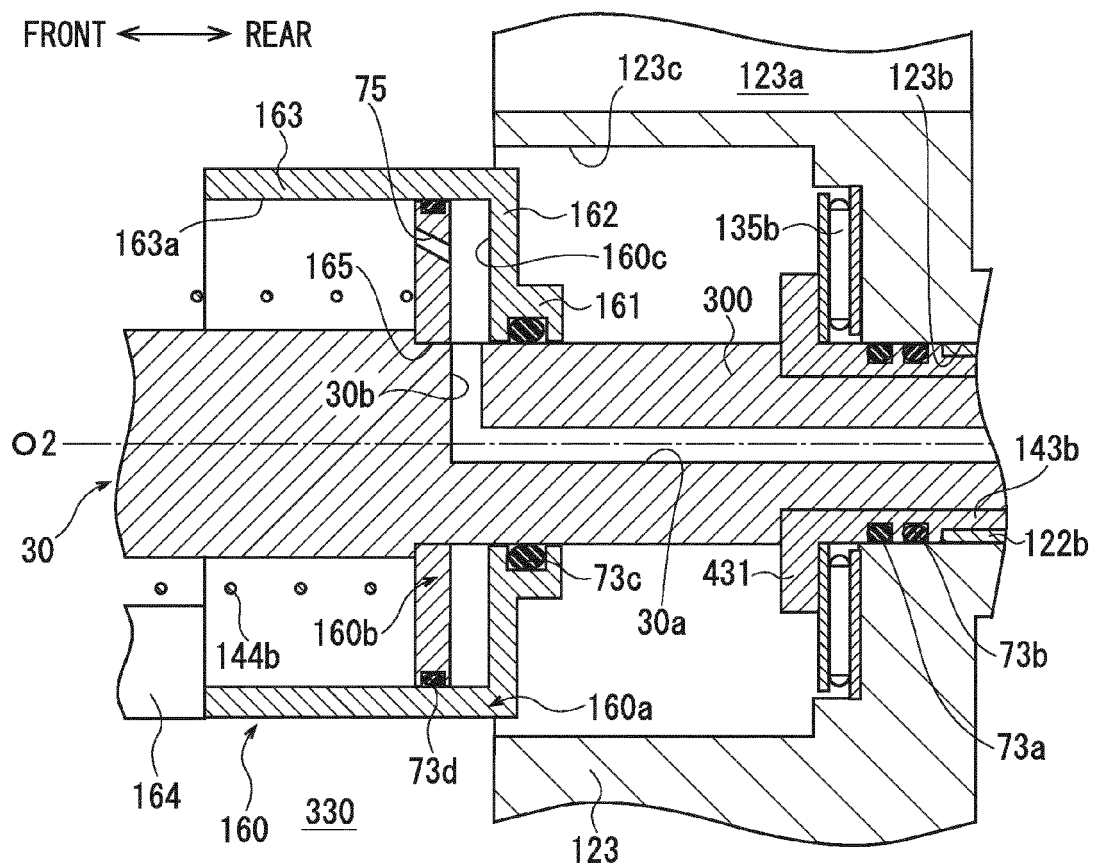


FIG. 10



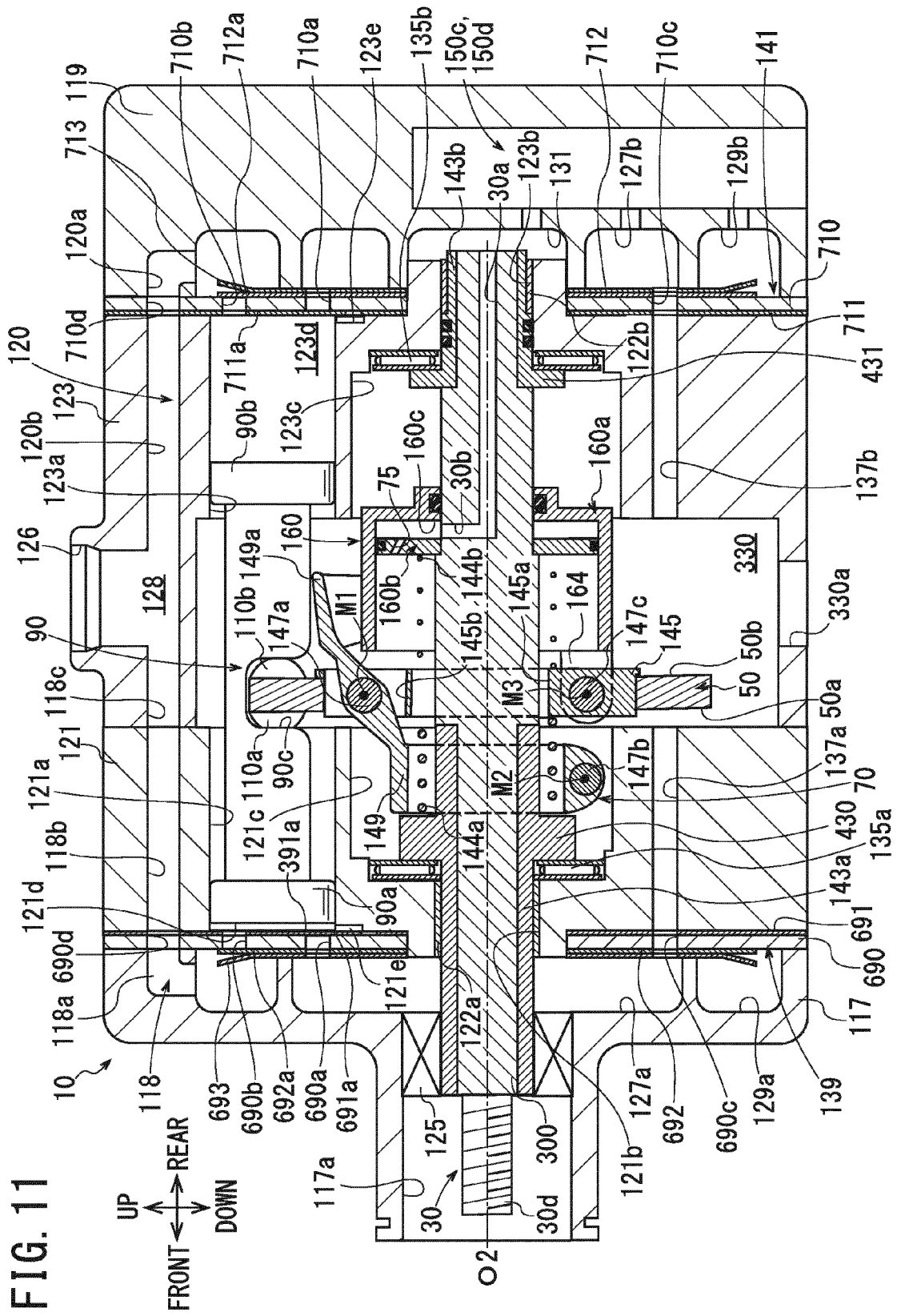
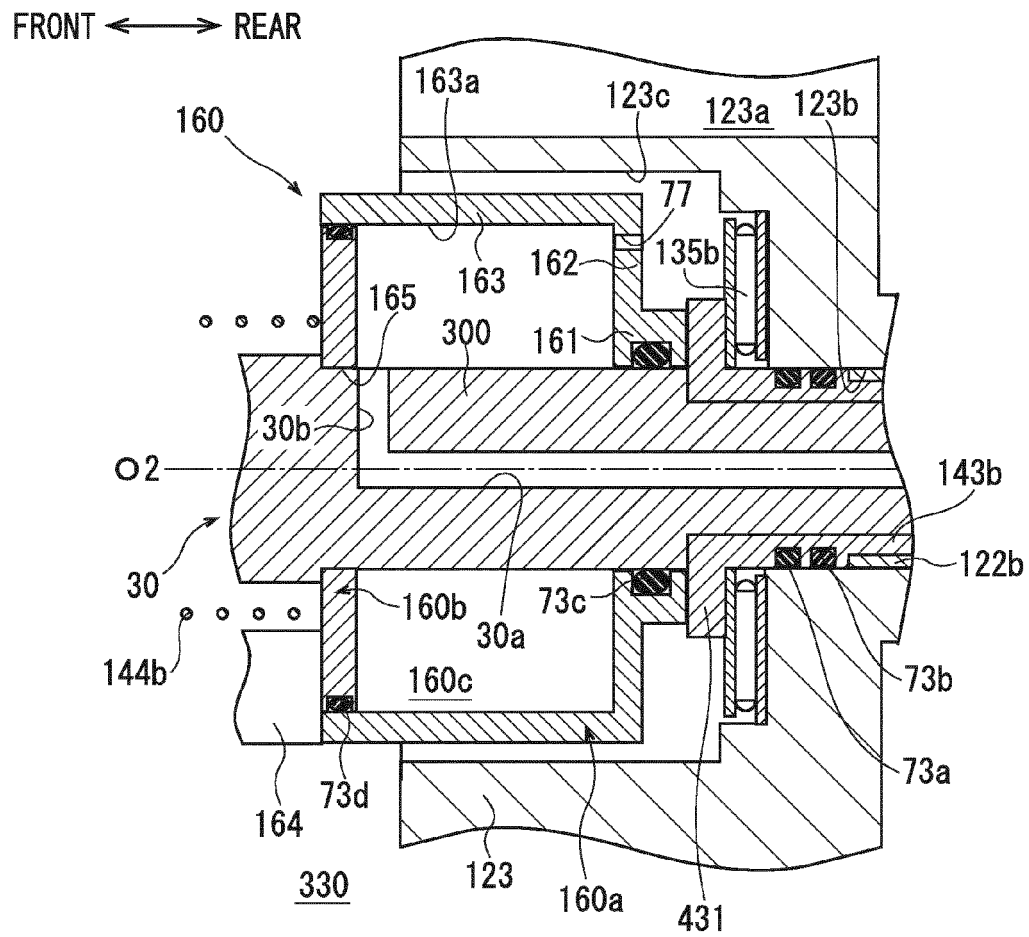


FIG. 12





EUROPEAN SEARCH REPORT

Application Number
EP 15 15 4313

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			F04B
The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 10 July 2015	Examiner Olona Laglera, C
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