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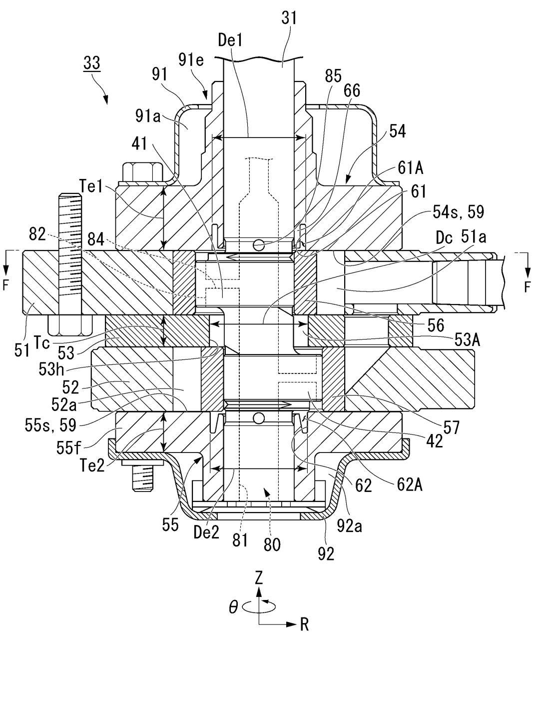
(54) ROTARY COMPRESSOR AND REFRIGERATION CYCLE DEVICE

(57) In a rotary compressor of the embodiment, a thickness of a partition plate in an axial direction is smaller than a thickness of a first flange part in the axial direction and a thickness of a second flange part in the axial direction. An area of a portion in which an end surface of a first roller on a partition plate side can be exposed to a shaft hole is Sc1. An area of a portion in which an end surface of the first roller on the first flange part side can be exposed to an inner region of an outer circumference of a first groove part is Se1. At this time, $1 < Scl/Sel \leq 1.6$ is established. An area of a portion in which an end surface of a second roller on the partition plate side can be exposed to the shaft hole is Sc2. An area of a portion in which an end surface of the second roller on the second flange part side can be exposed to an inner region of an outer circumference of a second groove part is Se2. At this time, $1 < Sc2/Se2 \leq 1.6$ is established. A solid lubricating film is formed on a first surface of the first flange part and a second surface of the second flange part.

FIG. 2



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Description

[Technical Field]

[0001] Embodiments of the present invention relate to a rotary compressor and a refrigeration cycle device.

[Background Art]

[0002] A rotary compressor is used in refrigeration cycle devices. A rotary compressor eccentrically rotates a roller inside a cylinder chamber to compress a gaseous refrigerant and sends it to the outside. The roller slides on a surface of a member (a bearing or a partition plate) forming an end surface of the cylinder chamber. When the member forming the end surface of the cylinder chamber becomes worn, the compression performance of the rotary compressor decreases. A rotary compressor in which decrease in compression performance is able to be curbed is required.

[Citation List]

[Patent Document]

[Patent Document 1]

[0003] Japanese Unexamined Patent Application, First Publication No. 2014-202200

[Summary of Invention]

[Technical Problem]

[0004] A problem to be solved by the present invention is to provide a rotary compressor and a refrigeration cycle device in which decrease in compression performance is able to be curbed.

[Solution to Problem]

[0005] A rotary compressor of the embodiment includes a compression mechanism unit compressing a gas to be compressed and a lubricating oil which are housed in a container. The compression mechanism unit includes a shaft, a first cylinder, a second cylinder, a partition plate, a first bearing, a second bearing, a first flange part, a second flange part, a first eccentric part, a second eccentric part, a first roller, and a second roller. The first cylinder forms a first cylinder chamber. The second cylinder is disposed to be aligned with the first cylinder in an axial direction of the shaft. The second cylinder forms a second cylinder chamber. The partition plate is disposed between the first cylinder and the second cylinder. The partition plate has a shaft hole through which the shaft is passed. The partition plate closes the first cylinder chamber and the second cylinder chamber. The first bearing is disposed on a side opposite to the partition plate with the first cylinder sandwiched therebetween. The first bearing supports the shaft. The second bearing is disposed on a side opposite to the partition plate with the second cylinder sandwiched therebetween. The second bearing supports the shaft. The first flange part is formed on the first cylinder side of the first bearing. The first flange part has a first surface which closes the first cylinder chamber. The second flange part is formed on the second cylinder side of the second bearing. The second flange part has a second surface which closes the second cylinder chamber. The first eccentric part is formed in a columnar shape. The first eccentric part is formed on the shaft. The first eccentric part is disposed at a position of the first cylinder in the axial direction. The second eccentric part is formed on the shaft. The second eccentric part is disposed at a position of the second cylinder in the axial direction. The first roller is disposed along an outer circumferential surface of the first eccentric part. The first roller moves along the first surface of the first flange part in accordance with rotation of the shaft. The second roller is disposed along an outer circumferential surface of the second eccentric part. The second roller moves along the second surface of the second flange part in accordance with rotation of the shaft. A thickness of the partition plate in the axial direction is smaller than a thickness of the first flange part in the axial direction and a thickness of the second flange part in the axial direction. The first bearing includes a first groove part formed in a ring shape on a surface of the first flange part and disposed coaxially with the shaft. The second bearing includes a second groove part formed in a ring shape on a surface of the second flange part and disposed coaxially with the shaft. An area of a portion in which an end surface of the first roller on the partition plate side is able to be exposed to the shaft hole according to movement of the first roller is defined as Sc1. An area of a portion in which an end surface of the first roller on the first flange part side is able to be exposed to an inner region of an outer circumference of the first groove part according to the movement of the first roller is defined as Sel. At this time, $1 < Scl/Sel \leq 1.6$ is established. An area of a portion in which an end surface of the second roller on the partition plate side is able to be exposed to the shaft hole according to movement of the second roller is defined as Sc2. An area of a portion in which an end surface of the second roller on the second flange part side is able to be exposed to an inner region of an outer circumference of the second groove part according to the movement of the second roller is defined as Se2. At this time, $1 < Sc2/Se2 \leq 1.6$ is established. A solid lubricating film is formed on the first surface of the first flange part and the second surface of the second flange part.

[Brief Description of Drawings]

[0006]

Fig. 1 is a schematic configuration view of a refrigeration cycle device including a cross-sectional view of a rotary compressor of the embodiment.

Fig. 2 is an enlarged view of a compression mechanism unit.

Fig. 3 is a cross-sectional view of a compression mechanism unit 33 along line F-F of Fig. 2.

Fig. 4 is a first explanatory view of a pressure receiving portion of a first roller.

Fig. 5 is a second explanatory view of a pressure receiving portion of the first roller.

Fig. 6 is a third explanatory view of a pressure receiving portion of the first roller.

Fig. 7 is a fourth explanatory view of a pressure receiving portion of the first roller.

Fig. 8 is an explanatory view of inner pressure receiving areas of the first roller and a second roller.

Fig. 9 is an explanatory view of outer pressure receiving areas of the first roller and the second roller.

Fig. 10 is a graph showing a transition of an amount of wear on a first surface of the first flange part.

[Description of Embodiments]

[0007] Hereinafter, a rotary compressor and a refrigeration cycle device of an embodiment will be described with reference to the drawings.

[0008] In the present application, a Z direction, an R direction and a θ direction of a polar coordinate system are defined as follows. The Z direction is an axial direction of a shaft 31. A +Z direction is a direction from a compression mechanism unit 33 toward an electric motor unit 32. For example, the Z direction may be a vertical direction, and the +Z direction may be vertically upward. Further, there are cases in which the Z direction is referred to as an axial direction Z. The R direction is a radial direction of the shaft 31. A +R side is an outer side in the radial direction and is a side away from a central axis of the shaft 31. Further, there are cases in which the R direction is referred to as a radial direction R. The θ direction is a circumferential direction around the central axis of the shaft 31. Further, there are cases in which the θ direction is referred to as a circumferential direction θ.

[0009] A refrigeration cycle device will be briefly described.

[0010] Fig. 1 is a schematic configuration view of a refrigeration cycle device including a cross-sectional view of a rotary compressor 2 of the present embodiment. A refrigeration cycle device 1 includes the rotary compressor 2, a radiator (for example, a condenser) 3 connected to the rotary compressor 2, an expansion device (for example, an expansion valve) 4 connected to the radiator 3, and a heat absorber (for example, a vaporizer) 5 connected to the expansion device 4. The refrigeration cycle device 1 contains a refrigerant such as carbon dioxide (CO_2). The refrigerant circulates in the refrigeration cycle device 1 while changing its phase.

[0011] The rotary compressor 2 is a so-called rotary type compressor. The rotary compressor 2, for example, compresses a low-pressure gaseous refrigerant (fluid) taken into the inside into a high-temperature and high-pressure gaseous refrigerant. Further, a specific configuration of the rotary compressor 2 will be described later.

[0012] The radiator 3 radiates heat from the high-temperature and high-pressure gaseous refrigerant discharged from the rotary compressor 2.

[0013] The expansion device 4 reduces a pressure of the high-pressure refrigerant sent from the radiator 3 to convert the high-pressure refrigerant into a low-temperature and low-pressure liquid refrigerant.

[0014] The heat absorber 5 vaporizes the low-temperature and low-pressure liquid refrigerant sent from the expansion device 4 to convert the low-temperature and low-pressure liquid refrigerant into a low-pressure gaseous refrigerant. In the heat absorber 5, vaporization of the low-pressure liquid refrigerant removes vaporization heat from the surroundings, and thus the surroundings are cooled. The low-pressure gaseous refrigerant that has passed through the heat absorber 5 is taken into the rotary compressor 2 described above.

[0015] As described above, in the refrigeration cycle device 1 of the present embodiment, a refrigerant serving as a working fluid circulates while changing its phase between a gaseous refrigerant and a liquid refrigerant, and heating, cooling, or the like is performed by utilizing such heat radiation and heat absorption.

[0016] A specific configuration of the rotary compressor 2 will be described.

[0017] The rotary compressor 2 of the present embodiment includes a compressor main body 11 and an accumulator 12.

[0018] The accumulator 12 is a so-called gas-liquid separator. The accumulator 12 is provided between the heat absorber 5 and the compressor main body 11 described above. The accumulator 12 is connected to the compressor main body 11 through a suction pipe 21. The accumulator 12 supplies a gaseous refrigerant vaporized by the heat absorber 5 to the compressor main body 11 through the suction pipe 21.

[0019] The compressor main body 11 includes the shaft 31, the electric motor unit 32 that rotates the shaft 31, the compression mechanism unit 33 that compresses the gaseous refrigerant by rotation of the shaft 31, and a cylindrical airtight container 34 accommodating the shaft 31, the electric motor unit 32, and the compression mechanism unit 33.

[0020] The shaft 31 and the airtight container 34 are disposed coaxially with respect to an axial center (axis) O of the shaft 31. Further, the axial center O of the shaft 31 means a center (rotation center) of the shaft 31. The electric motor unit 32 is disposed on the +Z side (upper side in Fig. 1) along the axial center O in the airtight container 34. The compression mechanism unit 33 is disposed on the -Z side (lower side in Fig. 1) along the axial center O in the airtight container 34.

[0021] The shaft 31 penetrates the electric motor unit 32 and extends inside the compression mechanism unit

33 in the axial direction Z.

[0022] The electric motor unit 32 is a so-called inner rotor type DC brushless motor. Specifically, the electric motor unit 32 includes a stator 36 and a rotor 37. The stator 36 is formed in a cylindrical shape and is fixed to an inner wall surface of the airtight container 34 by shrink-fitting or the like. The rotor 37 is disposed on an inner side of the stator 36. The rotor 37 is connected to an upper portion of the shaft 31. The rotor 37 rotationally drives the shaft 31 when a current is supplied to a coil provided in the stator 36.

[0023] Next, the compression mechanism unit 33 will be described.

[0024] Fig. 2 is an enlarged view of the compression mechanism unit. The compression mechanism unit 33 is a multi-cylinder compression mechanism unit having a plurality of cylinder chambers. For example, the compression mechanism unit 33 of the embodiment may be a two-cylinder compression mechanism unit having two cylinder chambers 51a and 52a. The compression mechanism unit 33 includes a plurality of cylinders 51 and 52, a partition plate 53, a main bearing (first bearing) 54, a sub bearing (second bearing) 55, a plurality of rollers 56 and 57, a main muffler member 91, and a sub muffler member 92.

[0025] The plurality of cylinders include a first cylinder 51 and a second cylinder 52. The first cylinder 51 and the second cylinder 52 are disposed to be aligned in the axial direction Z. The first cylinder 51 and the second cylinder 52 are formed in a cylindrical shape that opens in the axial direction Z. The first cylinder 51 and the second cylinder 52 are disposed coaxially with the shaft 31 on an outer side of the shaft in the radial direction R. Thereby, an internal space serving as a first cylinder chamber 51a is formed in the first cylinder 51. An inner circumferential surface of the first cylinder 51 forms an outer circumferential surface of the ring-shaped first cylinder chamber 51a. An internal space serving as a second cylinder chamber 52a is formed in the second cylinder 52. An inner circumferential surface of the second cylinder 52 forms an outer circumferential surface of the ring-shaped second cylinder chamber 52a.

[0026] In the present application, the partition plate 53 side of the first cylinder 51 and the second cylinder 52 in the axial direction Z may be referred to as an "inner side." Further, the main bearing 54 side of the first cylinder 51 and the sub bearing 55 side of the second cylinder 52 in the axial direction Z may be referred to as an "outer side."

[0027] The partition plate 53 is disposed between the first cylinder 51 and the second cylinder 52 in the axial direction Z and is sandwiched between the first cylinder 51 and the second cylinder 52. The partition plate 53 faces the internal space of the first cylinder chamber 51a in the axial direction Z to close the first cylinder chamber 51a. Similarly, the partition plate 53 faces the internal space of the second cylinder chamber 52a to close the second cylinder chamber 52a. Also, a shaft hole 53h through which the shaft 31 passes in the axial direction Z is provided in the partition plate 53. The shaft 31 described above penetrates the first cylinder 51, the second cylinder 52, and the partition plate 53.

[0028] As illustrated in Fig. 1, a first suction hole 76 extending in the radial direction R is formed in the first cylinder 51. An inner end portion of the first suction hole 76 in the radial direction R opens to the first cylinder chamber 51a. An outer end portion of the first suction hole 76 in the radial direction R is connected to the suction pipe 21 extending from the accumulator 12. Thereby, the first cylinder chamber 51a can suction the gaseous refrigerant from the accumulator 12. Also, a second suction hole 79 extending in the axial direction Z is formed in the first cylinder 51, the partition plate 53, and the second cylinder 52. An upper end portion of the second suction hole 79 in the axial direction Z opens to the first suction hole 76. That is, the second suction hole 79 is formed to be branched from the first suction hole 76. A lower end portion of the second suction hole 79 in the axial direction Z opens to the second cylinder chamber 52a. Thereby, the second cylinder chamber 52a can suction the gaseous refrigerant from the accumulator 12.

[0029] The main bearing 54 is positioned on a side opposite to the partition plate 53 with the first cylinder 51 sandwiched therebetween. The main bearing 54 rotatably supports the shaft 31. The main bearing 54 includes a first flange part 54f formed at an end portion on the first cylinder 51 side. The first flange part 54f has a first surface 54s that closes the first cylinder chamber 51a.

[0030] The sub bearing 55 is positioned on a side opposite to the partition plate 53 with the second cylinder 52 sandwiched therebetween. The sub bearing 55 rotatably supports the shaft 31. The sub bearing 55 includes a second flange part 55f formed at an end portion on the second cylinder 52 side. The second flange part 55f has a second surface 55s that closes the second cylinder chamber 52a.

[0031] A first eccentric part 41 and a second eccentric part 42 are provided to be aligned in the axial direction Z on the shaft 31 described above. The first eccentric part 41 is provided at a position corresponding to the first cylinder chamber 51a in the axial direction Z and is disposed inside the first cylinder chamber 51a. The second eccentric part 42 is provided at a position corresponding to the second cylinder chamber 52a in the axial direction Z and is disposed inside the second cylinder chamber 52a. The first eccentric part 41 and the second eccentric part 42 are each formed in a columnar shape in the axial direction Z and are eccentric with respect to the axial center O by the same amount in the radial direction R. The first eccentric part 41 and the second eccentric part 42 may be formed, for example, to have the same shape and the same size in a plan view from the axial direction Z and may be disposed, for example, with a phase difference of 180° in the circumferential direction θ.

[0032] The plurality of rollers include a first roller 56 and a second roller 57. The first roller 56 and the second roller 57 are each formed in a cylindrical shape in the axial direction Z. The first roller 56 is fitted along an outer circumferential surface of the first eccentric part 41 and is disposed in the first cylinder chamber 51a. Similarly, the second roller 57 is fitted along an outer circumferential surface of the second eccentric part 42 and is disposed in the second cylinder chamber 52a. Gaps for allowing relative rotation of the rollers 56 and 57 with respect to the eccentric parts 41 and 42 are respectively provided between inner circumferential surfaces of the rollers 56 and 57 and the eccentric parts 41 and 42. The first roller 56 and the second roller 57 eccentrically rotate inside the cylinder chambers 51a and 52a in accordance with rotation of the shaft 31 while outer circumferential surfaces of the rollers 56 and 57 are in sliding contact with inner circumferential surfaces of the cylinders 51 and 52.

[0033] Next, an internal configuration of the cylinder will be described.

[0034] An internal configuration of the first cylinder 51 and an internal configuration of the second cylinder 52 are substantially the same as each other except for portions that differ according to phase differences between the eccentric parts 41 and 42 and between the rollers 56 and 57. Therefore, here, the internal configuration of the first cylinder 51 will be described as a representative. Then, constituents of the second cylinder 52 having the same functions as those in the first cylinder 51 will be denoted by the same reference signs and description thereof will be omitted.

[0035] Fig. 3 is a cross-sectional view of the compression mechanism unit 33 along line F-F of Fig. 2.

[0036] As illustrated in Fig. 3, a vane groove 71 extending outward in the radial direction R is provided on the inner circumferential surface of the first cylinder 51. A vane 72 that is slidably movable in the radial direction R is inserted into the vane groove 71. The vane 72 is biased inward in the radial direction R by a biasing means (not illustrated), and a distal end thereof is brought into contact with the outer circumferential surface of the first roller 56 in the first cylinder chamber 51a. Thereby, the vane 72 partitions the inside of the first cylinder chamber 51a into a suction chamber 74 and a compression chamber 75. The vane 72 moves back and forth in the first cylinder chamber 51a as the first roller 56 rotates eccentrically. Thereby, a suction operation of suctioning the gaseous refrigerant into the suction chamber 74 and a compression operation of compressing the gaseous refrigerant in the compression chamber 75 are performed.

[0037] Also, the above-described first suction hole 76 and a discharge groove 77 are provided in the first cylinder 51. The inner end portion of the first suction hole 76 in the radial direction R opens to the suction chamber 74 of the first cylinder chamber 51a. The discharge groove 77 is provided in the compression chamber 75. The discharge groove 77 is provided on the inner circumferential surface of the first cylinder 51 in the axial direction Z and communicates with a main bearing discharge hole to be described later. The discharge groove 77 guides the gaseous refrigerant compressed in the compression chamber 75 to the main bearing discharge hole. On the other hand, a discharge groove 77 provided in the second cylinder 52 communicates with a sub bearing discharge hole to be described later. The discharge groove 77 of the second cylinder 52 guides the gaseous refrigerant compressed in a compression chamber 75 to the sub bearing discharge hole.

[0038] As illustrated in Fig. 2, the main muffler member 91 forms a main muffler chamber 91a between itself and the main bearing 44. The gaseous refrigerant compressed in the compression chamber 75 of the first cylinder chamber 51a is discharged to the main muffler chamber 91a from the main bearing discharge hole (not illustrated) formed in the first flange part 54f. The gaseous refrigerant discharged into the main muffler chamber 91a is discharged into the airtight container 34 from a main muffler chamber discharge port 91e. The sub muffler member 92 forms a sub muffler chamber 92a between itself and the sub bearing 55. The gaseous refrigerant compressed in the compression chamber 75 of the second cylinder 52 is discharged to the sub muffler chamber 92a from the sub bearing discharge hole (not illustrated) formed in the second flange part 55f. The sub muffler chamber 92a communicates with the main muffler chamber 91a through a through hole (not illustrated) formed in the second cylinder 52, the partition plate 53, and the first cylinder 51. Therefore, the gaseous refrigerant discharged to the sub muffler chamber 92a moves to the main muffler chamber 91a and is discharged from the main muffler chamber discharge port 91e into the airtight container 34.

[0039] The airtight container 34 includes a discharge pipe 35 on the +Z side of the rotor 37 of the electric motor unit 32. The discharge pipe 35 discharges the gaseous refrigerant discharged into the airtight container 34 to constituent units of the refrigeration cycle device outside the airtight container 34 such as the radiator 3.

[0040] The first flange part 54f of the main bearing 54 described above has a first groove part 61. The first groove part 61 is formed on a surface of the first flange part 54f on the first cylinder 51 side. The first groove part 61 is formed in a ring shape when viewed from the axial direction Z. The first groove part 61 is disposed coaxially with the shaft 31 on an outer side of the shaft 31 in the radial direction R. Thereby, a first collar 66 that supports the shaft 31 is formed between the shaft 31 and the first groove part 61.

[0041] Similarly, the second flange part 55f of the sub bearing 55 has a second groove part 62. A second collar 67 that supports the shaft 31 is formed between the shaft 31 and the second groove part 62.

[0042] In the multi-cylinder compression mechanism unit 33, since a plurality of cylinders are disposed between the main bearing 54 and the sub bearing 55, a distance between the main bearing 54 and the sub bearing 55 increases. Therefore, the shaft 31 is likely to be bent between the main bearing 54 and the sub bearing 55. Even when the shaft 31 rotates while being bent, the first collar 66 and the second collar 67 support the shaft 31 while bending together with the shaft 31. Thereby, wear of the main bearing 54 and the sub bearing 55 due to rotation of the shaft 31 is suppressed.

[0043] A thickness Tc of the partition plate 53 in the axial direction Z is smaller than a thickness Te1 of the first flange part 54f in the axial direction Z and a thickness Te2 of the second flange part 55f in the axial direction Z. Thereby, the distance between the main bearing 54 and the sub bearing 55 decreases. Accordingly, bending of the shaft 31 is suppressed.

[0044] Next, an oil supply passage 80 provided in the compression mechanism unit 33 will be described.

[0045] A lubricating oil is contained in the airtight container 34. A polyalkylene glycol (PAG) oil is contained as the lubricating oil (refrigerating machine oil). A PAG oil has a smaller decrease in viscosity when a refrigerant is dissolved compared to other lubricating oils such as a polyol ester (POE) oil and a polyvinyl ether (PVE) oil. Particularly, even when a carbon dioxide refrigerant is compressed to a high temperature, since the PAG oil has a small decrease in viscosity, a satisfactory lubrication state is maintained.

[0046] As illustrated in Fig. 2, the oil supply passage 80 includes a main passage 81 provided in the shaft 31, a sub-passage 82 and a communication passage 84 provided in the first eccentric part 41, and an end portion passage 85 provided in the +Z direction of the first eccentric part 41. Similarly, a sub-passage and a communication passage are also provided in the second eccentric part 42. Similarly, an end portion passage is also provided in the -Z direction of the second eccentric part 42. Here, the sub-passage 82, the communication passage 84, and the end portion passage 85 provided in the first eccentric part 41 will be described as representatives.

[0047] The main passage 81 is provided coaxially with the axial center O and is formed inside the shaft 31. The main passage 81 extends inside the shaft 31 in the axial direction Z. The main passage 81 opens inside the airtight container 34 at the end portion of the shaft 31 supported by the sub bearing 45. A part of the compression mechanism unit 33 is immersed in the lubricating oil contained in the airtight container 34. The lubricating oil flows into the main passage 81. A pumping means (not illustrated) such as a torsion plate for pumping up the lubricating oil into the main passage 81 in accordance with rotation of the shaft 31 is provided inside the main passage 81.

[0048] The sub-passage 82 is a groove provided on the outer circumferential surface of the first eccentric part 41. The sub-passage 82 is formed between the outer circumferential surface of the first eccentric part 41 and the inner circumferential surface of the first roller 56. The sub-passage 82 extends throughout the first eccentric part 41 in the axial direction Z. The communication passage 84 is provided inside the first eccentric part 41 in the radial direction R. The communication passage 84 is provided between the main passage 81 and the sub-passage 82 to connect the main passage 81 and the sub-passage 82. The lubricating oil pumped up into the main passage 81 flows into the sub-passage 82 through the communication passage 84 due to a centrifugal force according to rotation of the shaft 31. Further, the lubricating oil is supplied from the sub-passage 82 to various sliding portions of the compression mechanism unit 33.

[0049] An inner end portion of the end portion passage 85 in the radial direction R opens to the main passage 81. An outer end portion of the end portion passage 85 in the radial direction R opens to the outer circumferential surface of the shaft 31. The lubricating oil pumped up into the main passage 81 is supplied to the outer circumferential surface of the shaft 31 through the end portion passage 85 by the centrifugal force according to the rotation of the shaft 31. Further, the lubricating oil is supplied from the outer circumferential surface of the shaft 31 to various sliding portions of the compression mechanism unit 33.

[0050] A pressure received by each of the rollers 56 and 57 in the axial direction Z will be described. First, a pressure received by an inner end surface of each of the rollers 56 and 57 (end surface on the partition plate 53 side) will be described.

[0051] As described above, the gaseous refrigerant compressed by the compression mechanism unit 33 is discharged into the airtight container 34. The gaseous refrigerant and lubricating oil inside the airtight container 34 are in a high-pressure state. Similarly, a portion to which the lubricating oil is supplied through the oil supply passage 80 is also in a high-pressure state. The lubricating oil is supplied to a central portion region 53A, which is an inner region of the shaft hole 53h of the partition plate 53, via the sub-passage 82 of the oil supply passage 80. The lubricating oil is supplied to a first end portion region 61 A, which is an inner region of an outer circumference of the first groove part 61 of the first flange part 54f, via the sub-passage 82 and the end portion passage 85 of the oil supply passage 80. Further, a distal end of the first collar 66 in the -Z direction is disposed in the +Z direction with respect to a surface of the first flange part 54f on the first cylinder 51 side. Therefore, the first end portion region 61A is a region from the outer circumference of the shaft 31 to the outer circumference of the first groove part 61 in the radial direction R. Similarly, the lubricating oil is also supplied to a second end portion region 62A which is an inner region of an outer circumference of the second groove part 62 of the second flange part 55f. Accordingly, the central portion region 53A, the first end portion region 61A, and the second end portion region 62A are all in a high-pressure state.

[0052] Fig. 4 is a first explanatory view of a pressure receiving portion of the first roller. Similarly, Fig. 5 is a second explanatory view, Fig. 6 is a third explanatory view, and Fig. 7 is a fourth explanatory view. Figs, 4 to 7 are cross-sectional views of a main part along line F-F of Fig. 2.

[0053] It is necessary to suppress a direct inflow of the lubricating oil from the central portion region 53A to the first cylinder chamber 51a. Therefore, in the process of eccentric rotation of the first roller 56, an outer circumference of the central portion region 53A (inner circumference of the shaft hole 53h) is always disposed on an inner side of the outer circumference of the first roller 56. Also, the first eccentric part 41 is disposed in the first cylinder chamber 51a through the shaft hole 53h. Therefore, an outer diameter of the first eccentric part 41 is smaller than an inner diameter of the shaft hole 53h. Accordingly, in the process of the eccentric rotation of the first roller 56, a part of the outer circumference of the central portion region 53A (inner circumference of the shaft hole 53h) is disposed on an outer side of the inner circumference of the first roller 56 (outer circumference of the first eccentric part 41).

[0054] Thereby, as illustrated in Fig. 4, a part of the outer circumference of the central portion region 53A is disposed between the inner circumference and the outer circumference of the first roller 56. That is, a part of the inner end surface of the first roller 56 becomes an exposed region 56p exposed to the central portion region 53A.

[0055] Figs. 5 to 7 each illustrate a state in which the first roller 56 is eccentrically rotated by 90 degrees from Fig. 4. Due to the eccentric rotation of the first roller 56, each part of the inner end surface of the first roller 56 along the inner circumference can be an exposed region 56p.

[0056] Fig. 8 is an explanatory view of pressure receiving areas of inner end surfaces of the first roller and the second roller. Due to the eccentric rotation of the first roller 56, a ring-shaped region of the inner end surface of the first roller 56 along the inner circumference is a portion that can be exposed to the central portion region 53A. This ring-shaped region is a high-pressure region c1 that receives a high pressure from the central portion region 53A. An area (inner pressure receiving area) of the high-pressure region c1 on the inner end surface of the first roller 56 is defined as Sc1.

[0057] Similarly, a ring-shaped region of the inner end surface of the second roller 57 along the inner circumference can be exposed to the central portion region 53A. This ring-shaped region is a high-pressure region c2 that receives a high pressure from the central portion region 53A. An area (inner pressure receiving area) of the high-pressure region c2 on the inner end surface of the second roller 57 is defined as Sc2.

[0058] The internal configuration of the first cylinder 51 and the internal configuration of the second cylinder 52 are the same except that the eccentric parts 41 and 42 are disposed in different phases from each other in the circumferential direction θ. Also, an outer diameter of the central portion region 53A (inner diameter of the shaft hole 53h) is constant in the axial direction Z. Therefore, the inner pressure receiving area Sc1 of the first roller 56 and the inner pressure receiving area Sc2 of the second roller 57 are equivalent.

[0059] Next, a pressure received by an outer end surface of each of the rollers 56 and 57 (end surface on the main bearing 54 side or the sub bearing 55 side) will be described.

[0060] As illustrated in Fig. 2, it is necessary to suppress a direct inflow of the lubricating oil from the first end portion region 61A into the first cylinder chamber 51a. Therefore, in the process of the eccentric rotation of the first roller 56, an outer circumference of the first end portion region 61 A (outer circumference of the first groove part 61) is always disposed on an inner side of the outer circumference of the first roller 56. Also, in the process of the eccentric rotation of the first roller 56, a part of the outer circumference of the first end portion region 61A is disposed on an outer side of the inner circumference of the first roller 56. Accordingly, a part of the outer circumference of the first end portion region 61A is disposed between the inner circumference and the outer circumference of the first roller 56. A part of an outer end surface of the first roller 56 is exposed to the first end portion region 61A.

[0061] Fig. 9 is an explanatory view of outer pressure receiving areas of the first roller and the second roller.

[0062] Due to the eccentric rotation of the first roller 56, a ring-shaped region of the outer end surface of the first roller 56 along the inner circumference is a portion that can be exposed to the first end portion region 61A. This ring-shaped region is a high-pressure region e1 that receives a high pressure from the first end portion region 61A. An area of the high-pressure region e1 (outer pressure receiving area) on the outer end surface of the first roller 56 is defined as Se1.

[0063] Similarly, a ring-shaped region of the outer end surface of the second roller 57 along the inner circumference can be exposed to the second end portion region 62A. This ring-shaped region is a high-pressure region e2 that receives a high pressure from the second end portion region 62A. An area of the high-pressure region e2 (outer pressure receiving area) on the outer end surface of the second roller 57 is defined as Se2.

[0064] An outer diameter of the first end portion region 61A (outer diameter of the first groove part 61) and an outer diameter of the second end portion region 62A (outer diameter of the second groove part 62) may be the same as or different from each other. When both the outer diameters are the same as each other, the outer pressure receiving area Se1 of the first roller 56 and the outer pressure receiving area Se2 of the second roller 57 are the same. When both the outer diameters are different from each other, the outer pressure receiving area Se1 of the first roller 56 and the outer pressure receiving area Se2 of the second roller 57 are different.

[0065] Next, a force received by the inner end surface and a force received by the outer end surface of each of the rollers 56 and 57 are compared.

[0066] As illustrated in Fig. 2, an outer diameter (inner diameter of the shaft hole 53h) Dc of the central portion region 53A is larger than an outer diameter (outer diameter of the first groove part 61) De1 of the first end portion region 61A. Therefore, the inner pressure receiving area Sc1 of the first roller 56 is larger than the outer pressure receiving area Se1 of the first roller 56. That is, $1 < Scl/Sel$ is established. Further, a pressure in the central portion region 53A is equivalent to a pressure in the first end portion region 61A. Accordingly, a force received by the inner end surface of the first roller 56 in the +Z direction is larger than a force received by the outer end surface thereof in the -Z direction. Thereby, the first roller 56 is pressed toward the first flange part 54f of the main bearing 54.

[0067] Similarly, the outer diameter (inner diameter of the shaft hole 53h) Dc of the central portion region 53A is larger than an outer diameter (outer diameter of the second groove part 62) De2 of the second end portion region 62A. Therefore, the inner pressure receiving area Sc2 of the second roller 57 is larger than the outer pressure receiving area Se2 of the second roller 57. That is, $1 < Sc2/Se2$ is established. Further, a pressure in the central portion region 53A is equivalent to a pressure in the second end portion region 62A. Accordingly, a force received by the inner end surface of the second roller 57 in the -Z direction is larger than a force received by the outer end surface thereof in the +Z direction. Thereby, the second roller 57 is pressed toward the second flange part 55f of the sub bearing 55.

[0068] As described above, the thickness Tc of the partition plate 53 in the axial direction Z is smaller than the thickness Te1 of the first flange part 54f in the axial direction Z and the thickness Te2 of the second flange part 55f in the axial direction Z. In this case, since the partition plate 53 is likely to be bent, frictional forces of the partition plate 53 against the first roller 56 and the second roller 57 may increase. On the other hand, the first roller 56 is pressed toward the first flange part 54f, and the second roller 57 is pressed toward the second flange part 55f. Thereby, friction of the first roller 56 and the second roller 57 with the partition plate 53 is suppressed.

[0069] A solid lubricating film 59 is formed on the first surface 54s of the first flange part 54f that forms the outer end surface of the first cylinder chamber 51a. The solid lubricating film 59 may be formed only on the first surface 54s or may be formed on the entire surface of the main bearing 54. As the solid lubricating film 59, a manganese phosphate film or a molybdenum dioxide film is preferably formed. These solid lubricating films 59 have excellent wear resistance and contribute to reduction in initial friction with the first roller 56. Further, a manganese phosphate film may be formed on a lower layer that is in contact with the first surface 54s, and a molybdenum dioxide film may be formed on an upper layer that is in contact with the first roller 56. Since a manganese phosphate film has excellent wear resistance, reliability of the compressor is improved. Since a molybdenum dioxide film has a large effect in reducing initial friction, initial characteristics of the compressor are improved.

[0070] Similarly, the solid lubricating film 59 is also formed on the second surface 55s of the second flange part 55f that forms the outer end surface of the second cylinder chamber 52a.

[0071] As described above, the first roller 56 is pressed toward the first flange part 54f, and the second roller 57 is pressed toward the second flange part 55f. Accordingly, friction of the first roller 56 and the second roller 57 with the partition plate 53 is suppressed. Therefore, the solid lubricating film 59 may be formed only on the first flange part 54f and the second flange part 55f. It is not necessary to form the solid lubricating film 59 on the partition plate 53 and the rollers 56 and 57. Accordingly, costs of the rotary compressor 2 are reduced.

[0072] Fig. 10 is a graph showing a transition of an amount of wear on the first surface of the first flange part. In Fig. 10, an amount of wear is denoted by two types of marks according to a magnitude of a ratio of the inner pressure receiving area Sc1 to the outer pressure receiving area Se1 of the first roller 56. An amount of wear when $1 < Scl/Sel \leq 1.6$ is denoted by a mark of □. An amount of wear when $1.6 < Scl/Sel$ is denoted by a mark of ×. In Fig. 10, an amount of wear of a manganese phosphate film formed on the first surface 54s of the first flange part 54f is denoted.

[0073] When $1 < Scl/Sel \leq 1.6$, the first roller 56 is weakly pressed toward the first surface 54s of the first flange part 54f. In this case, in an initial stage of an operation of the rotary compressor 2, an amount of wear of the first surface 54s increases (initial wear). However, when the operating time exceeds t1, the amount of wear hardly increases due to an effect of initial adaptability (steady wear). That is, due to sliding between the first surface 54s and the first roller 56 in the initial stage of the operation, a contact state between the two is made uniform, and a sliding surface of the first surface 54s becomes smooth. Thereby, after t1 hour has elapsed, a frictional coefficient decreases, and the amount of wear is in a state in which it hardly increases.

[0074] On the other hand, in the case of $1.6 < Scl/Sel$, the first roller 56 is strongly pressed toward the first surface 54s. In this case, the amount of wear continues to increase even when the operating time exceeds t1. That is, the sliding surface has not been made smooth in the initial stage of the operation of the compressor, and the effect of initial adaptability cannot be obtained. Particularly, when the refrigerant of the refrigeration cycle device 1 is carbon dioxide, since the refrigerant is compressed to a high pressure, an internal pressure of the airtight container 34 increases. Thereby, since the first roller 56 is strongly pressed toward the first surface 54s, the effect of initial adaptability cannot be easily obtained.

[0075] As described above, it is desirable that a ratio of the inner pressure receiving area Sc1 to the outer pressure receiving area Se1 of the first roller 56 satisfy $1 < Scl/Sel \leq 1.6$. Similarly, it is desirable that a ratio of the inner pressure receiving area Sc2 to the outer pressure receiving area Se2 of the second roller 57 satisfy $1 < Sc2/Se2 \leq 1.6$.

[0076] As described in detail above, in the rotary compressor 2 of the embodiment, the thickness of the partition plate 53 in the axial direction Z is smaller than the thickness of the first flange part 54f in the axial direction Z and the thickness of the second flange part 55f in the axial direction Z. Thereby, a distance between the main bearing 54 and the sub bearing 55 decreases. Accordingly, bending of the shaft 31 between the main bearing 54 and the sub bearing 55 is suppressed.

[0077] 1 <Sc1/Se1 is established. Thereby, the first roller 56 is pressed against the first surface 54s of the first flange part 54f. Also, 1 < Sc2/Se2 ≤ 1.6 is established. Thereby, the second roller 57 is pressed against the second surface 55s of the second flange part 55f.

[0078] The solid lubricating film 59 is formed on the first surface 54s of the first flange part 54f and the second surface 55s of the second flange part 55f. Thereby, wear resistance of the first surface 54s is improved even when the first roller 56 is moved by being pressed against the first surface 54s. Also, wear resistance of the second surface 55s improves even when the second roller 57 is moved by being pressed against the second surface 55s.

[0079] Scl/Sel ≤ 1.6 and Sc2/Se2 ≤ 1.6 are established. Thereby, even when the gaseous refrigerant is compressed to a high pressure, the first roller 56 is weakly pressed against the first surface 54s of the first flange part 54f. Also, the second roller 57 is weakly pressed against the second surface 55s of the second flange part 55f. Accordingly, the effect of initial adaptability can be obtained. Therefore, an amount of wear on the first surface 54s and the second surface 55s is suppressed. Accordingly, a decrease in compression performance of the rotary compressor 2 is suppressed.

[0080] The solid lubricating film 59 is preferably a manganese phosphate film or a molybdenum dioxide film.

[0081] The solid lubricating film 59 preferably includes a manganese phosphate film on the lower layer and a molybdenum dioxide film on the upper layer.

[0082] Since a manganese phosphate film has excellent wear resistance, reliability of the rotary compressor 2 is improved. Since the molybdenum dioxide film has a large effect in reducing initial friction, initial characteristics of the rotary compressor 2 are improved.

[0083] The gas to be compressed in the rotary compressor 2 is carbon dioxide gas, and the lubricating oil is a polyalkylene glycol oil.

[0084] When the gas to be compressed is carbon dioxide, it is compressed to a high pressure. Even in this case, since Scl/Sel ≤ 1.6 and Sc2/Se2 ≤ 1.6 are established, an amount of wear on the first surface 54s and the second surface 55s is suppressed. Also, a polyalkylene glycol oil has a smaller decrease in viscosity when it is dissolved than other lubricating oils. Thereby, a satisfactory lubrication state is maintained even when the gas to be compressed is compressed to a high temperature. Accordingly, an amount of wear on the first surface 54s and the second surface 55s is suppressed.

[0085] The refrigeration cycle device 1 of the embodiment includes the rotary compressor 2 described above, the radiator 3 connected to the rotary compressor 2, the expansion device 4 connected to the radiator 3, and the heat absorber 5 connected to the expansion device 4.

[0086] In the rotary compressor 2 described above, a decrease in compression performance is suppressed. Accordingly, a refrigeration cycle device with excellent reliability is provided.

[0087] According to at least one embodiment described above, 1 < Scl/Sel ≤ 1.6 and 1 < Sc2/Se2 ≤ 1.6 are established. Thereby, a decrease in compression performance of the rotary compressor 2 can be suppressed.

[0088] While certain embodiments have been described, these embodiments have been presented by way of example only, and are not intended to limit the scope of the inventions. Indeed, the novel embodiments described herein may be embodied in a variety of other forms; furthermore, various omissions, substitutions and changes in the form of the embodiments described herein may be made without departing from the spirit of the inventions. The accompanying claims and their equivalents are intended to cover such forms or modifications as would fall within the scope and spirit of the inventions.

[Reference Signs List]

[0089]

R	Radial direction
Z	Axial direction
θ	Circumferential direction
1	Refrigeration cycle device
2	Rotary compressor
3	Radiator
4	Expansion device
5	Heat absorber
31	Shaft
33	Compression mechanism unit
34	Airtight container (container)
41	First eccentric part
42	Second eccentric part
51	First cylinder
51a	First cylinder chamber
52	Second cylinder
52a	Second cylinder chamber
53	Partition plate
53h	Shaft hole
54	Main bearing (first bearing)
54f	First flange part
54s	First surface
55	Sub bearing (second bearing)
55f	Second flange part
55s	Second surface
56	First roller
57	Second roller
59	Solid lubricating film
61	First groove part
62	Second groove part

Claims

1. A rotary compressor comprising a compression mechanism unit compressing a gas to be compressed and a lubricating oil which are housed in a container, wherein
the compression mechanism unit includes:

    a shaft;
    a first cylinder forming a first cylinder chamber;
    a second cylinder disposed to be aligned with the first cylinder in an axial direction of the shaft and forming a second cylinder chamber;
    a partition plate disposed between the first cylinder and the second cylinder, having a shaft hole through which the shaft is passed, and configured to close the first cylinder chamber and the second cylinder chamber;
    a first bearing disposed on a side opposite to the partition plate with the first cylinder sandwiched therebetween and configured to support the shaft;
    a second bearing disposed on a side opposite to the partition plate with the second cylinder sandwiched therebetween and configured to support the shaft;
    a first flange part formed on the first cylinder side of the first bearing and having a first surface which closes the first cylinder chamber;
    a second flange part formed on the second cylinder side of the second bearing and having a second surface which closes the second cylinder chamber;
    a first eccentric part formed on the shaft and disposed at a position of the first cylinder in the axial direction;
    a second eccentric part formed on the shaft and disposed at a position of the second cylinder in the axial direction;
    a first roller disposed along an outer circumferential surface of the first eccentric part and configured to move along the first surface of the first flange part in accordance with rotation of the shaft; and
    a second roller disposed along an outer circumferential surface of the second eccentric part and configured to move along the second surface of the second flange part in accordance with rotation of the shaft,
    a thickness of the partition plate in the axial direction is smaller than a thickness of the first flange part in the axial direction and a thickness of the second flange part in the axial direction,
    the first bearing includes a first groove part formed in a ring shape on a surface of the first flange part and disposed coaxially with the shaft,
    the second bearing includes a second groove part formed in a ring shape on a surface of the second flange part and disposed coaxially with the shaft,
    $1 < Scl/Sel \leq 1.6$ is established when an area of a portion in which an end surface of the first roller on the partition plate side is able to be exposed to the shaft hole according to movement of the first roller is defined as Sc1 and an area of a portion in which an end surface of the first roller on the first flange part side is able to be exposed to an inner region of an outer circumference of the first groove part according to the movement of the first roller is defined as Se1,
    $1 < Sc2/Se2 \leq 1.6$ is established when an area of a portion in which an end surface of the second roller on the partition plate side is able to be exposed to the shaft hole according to movement of the second roller is defined as Sc2 and an area of a portion in which an end surface of the second roller on the second flange part side is able to be exposed to an inner region of an outer circumference of the second groove part according to the movement of the second roller is defined as Se2, and
    a solid lubricating film is formed on the first surface of the first flange part and the second surface of the second flange part.

2. The rotary compressor according to claim 1, wherein the solid lubricating film is a manganese phosphate film or a molybdenum dioxide film.

3. The rotary compressor according to claim 1, wherein the solid lubricating film includes a manganese phosphate film of a lower layer and a molybdenum dioxide film of an upper layer.

4. The rotary compressor according to any one of claims 1 to 3, wherein the gas to be compressed is carbon dioxide and the lubricating oil is a polyalkylene glycol oil.

5. A refrigeration cycle device comprising:

    the rotary compressor according to any one of claims 1 to 4;
    a radiator connected to the rotary compressor;
    an expansion device connected to the radiator; and
    a heat absorber connected to the expansion device.

FIG. 1

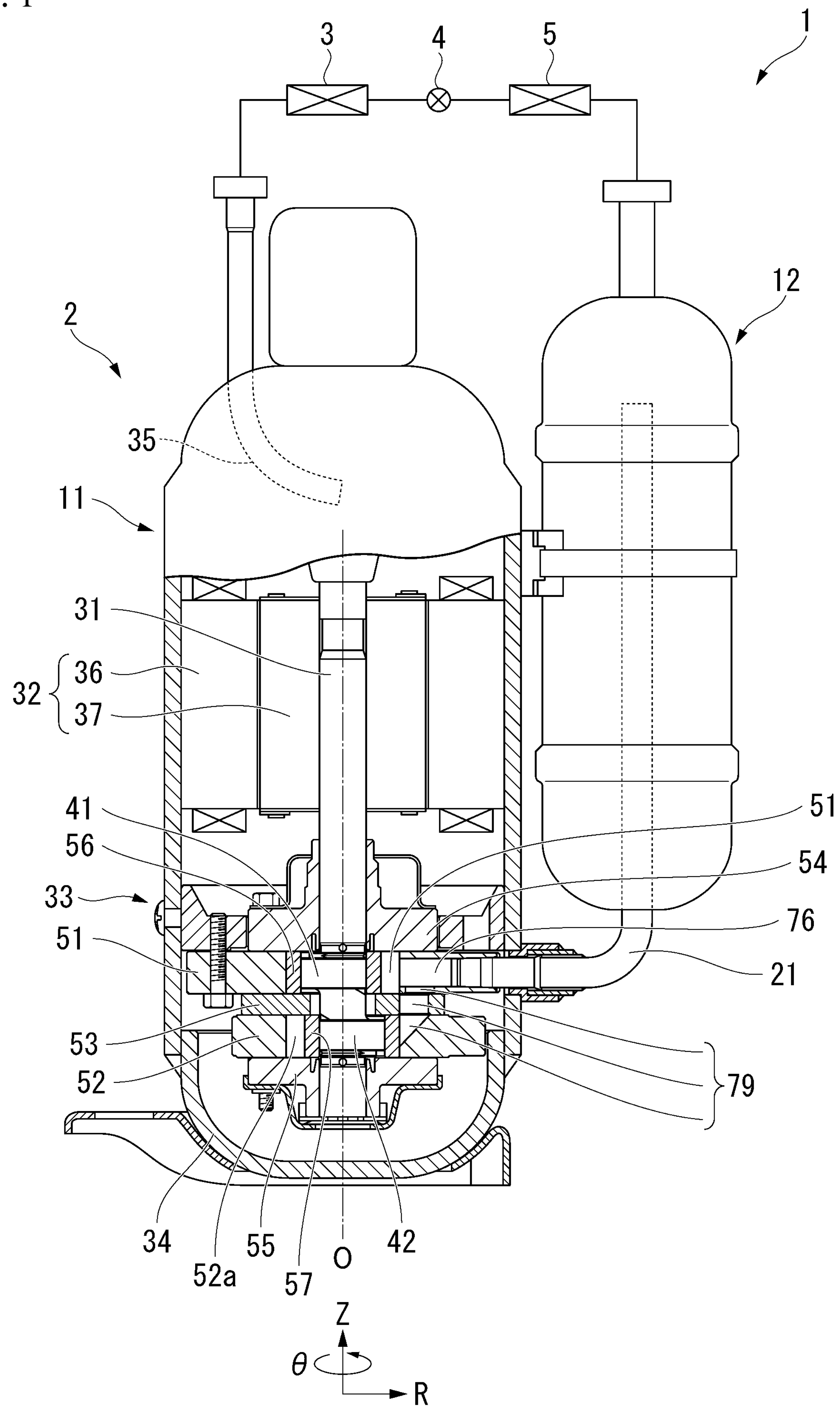
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FIG. 2

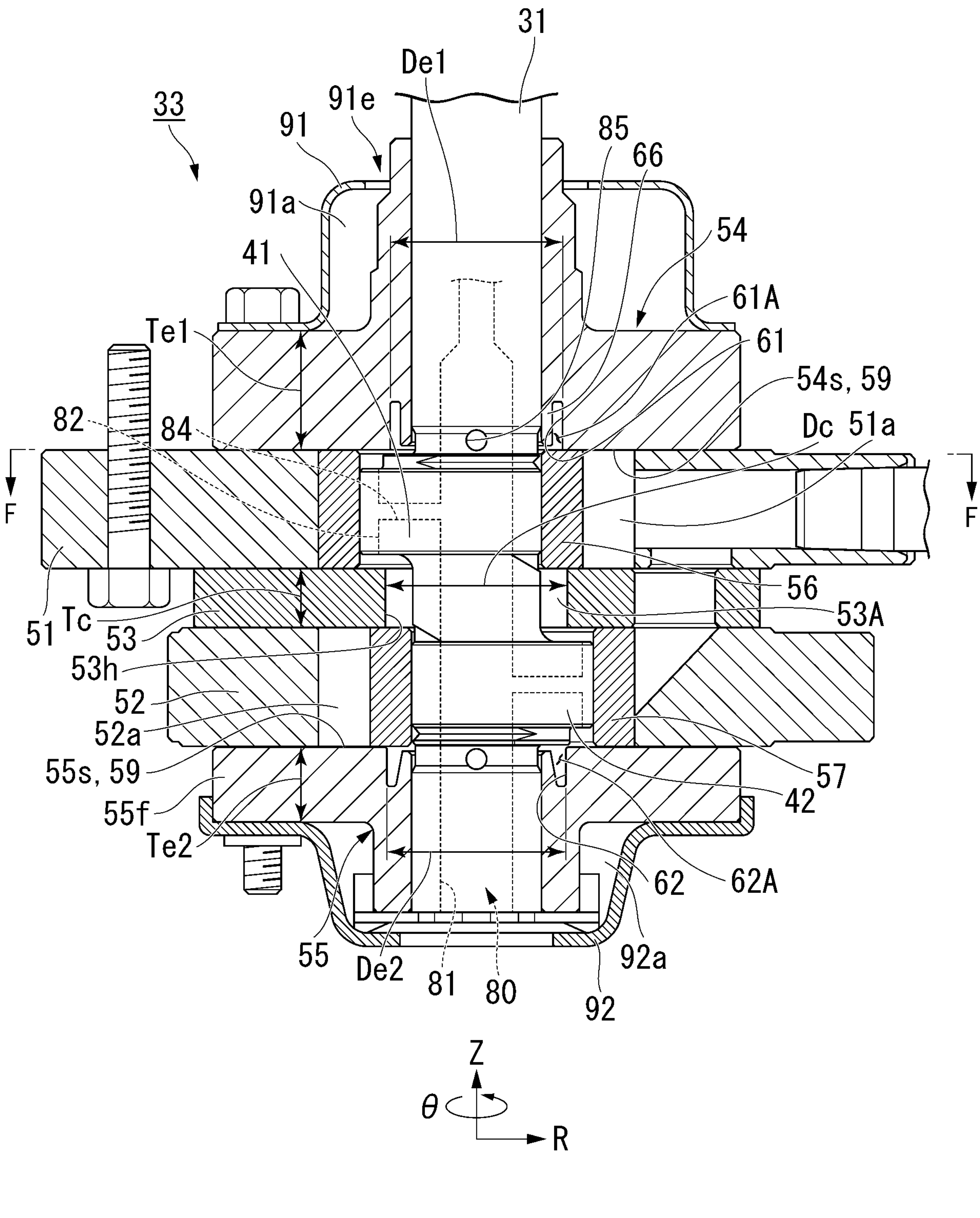
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FIG. 3

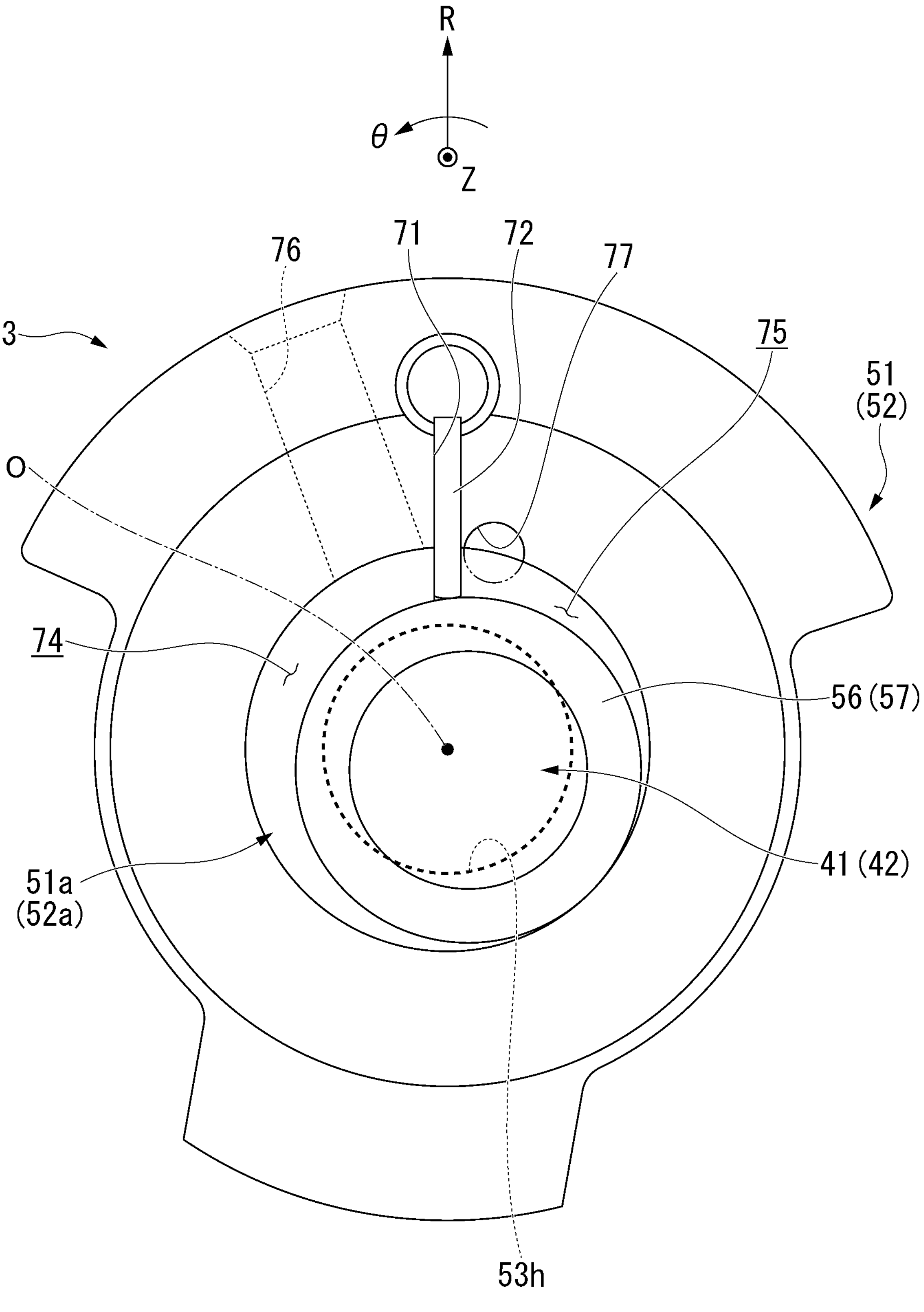


FIG. 4

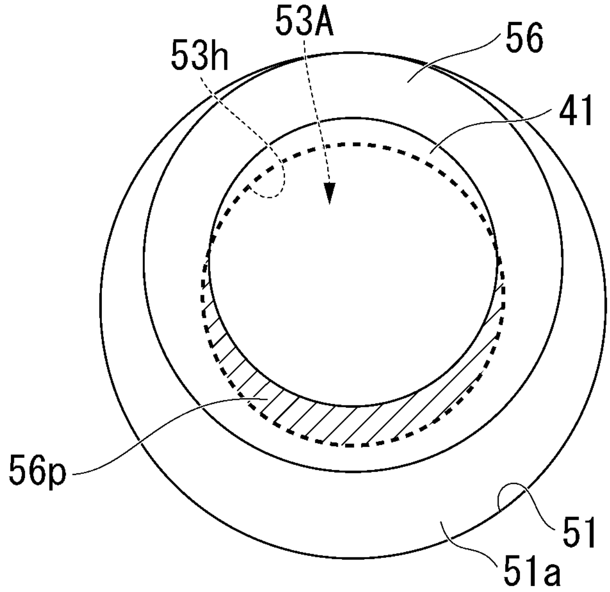


FIG. 5

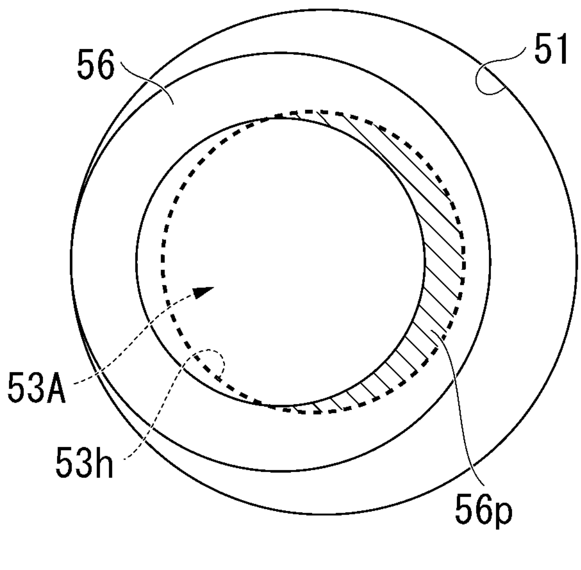


FIG. 6

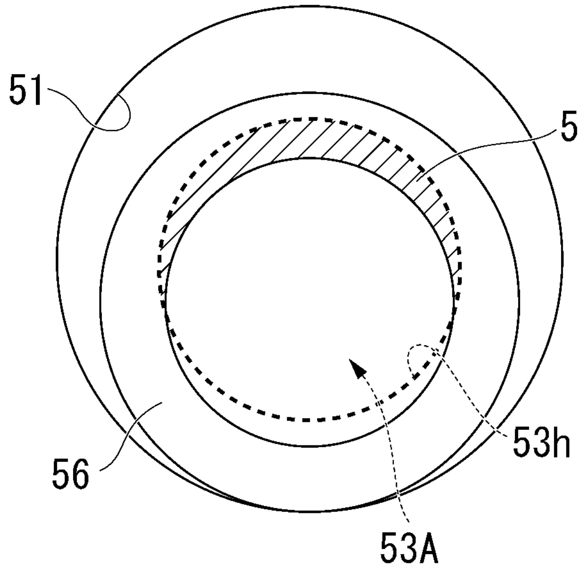


FIG. 7

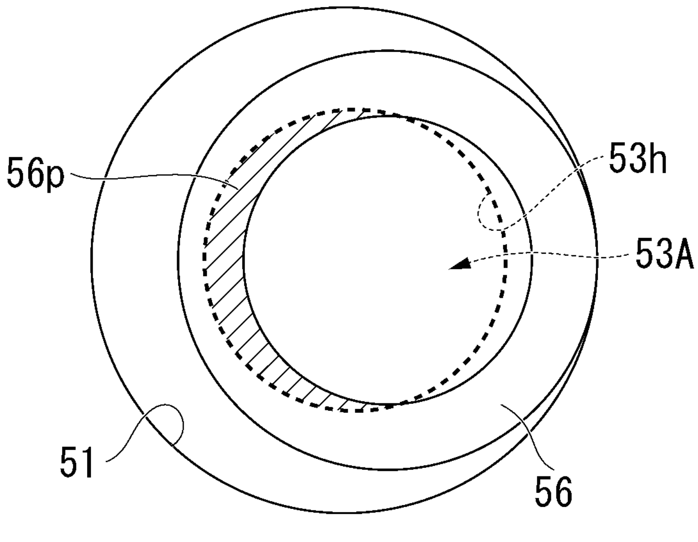


FIG. 8

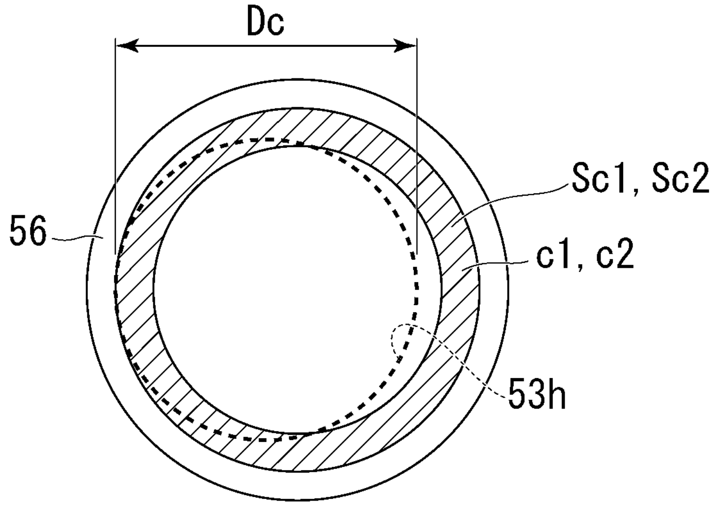


FIG. 9

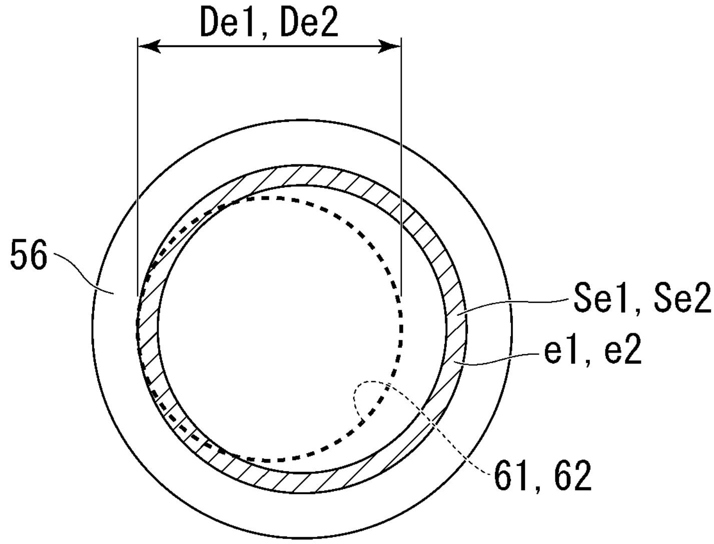
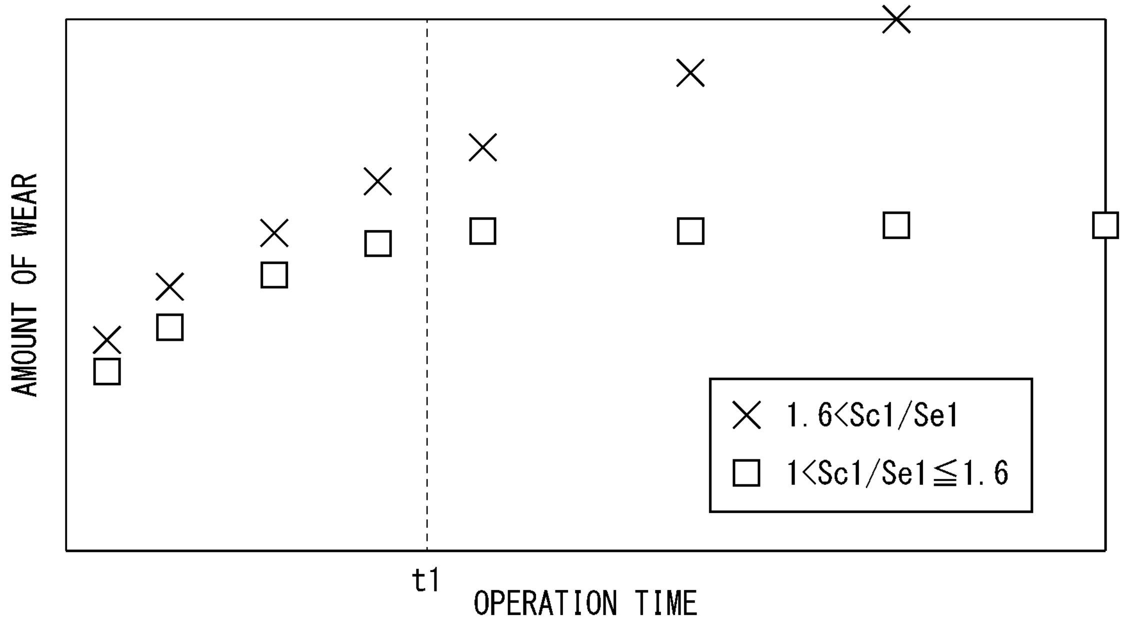


FIG. 10



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2018/045713

A. CLASSIFICATION OF SUBJECT MATTER
Int. Cl. F04C23/00(2006.01)i, F04C18/356(2006.01)i, F04C29/00(2006.01)i

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
Int. Cl. F04C23/00, F04C18/356, F04C29/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Published examined utility model applications of Japan	1922-1996
Published unexamined utility model applications of Japan	1971-2019
Registered utility model specifications of Japan	1996-2019
Published registered utility model applications of Japan	1994-2019

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	WO 2018/116912 A1 (TOSHIBA CARRIER CORP.) 28 June 2018, fig. 1, 3 (Family: none)	1 2-5
X Y	JP 2018-135780 A (TOSHIBA CARRIER CORP.) 30 August 2018, paragraph [0026], fig. 1, 3 & US 2018/0238596 A1, paragraph [0034], fig. 1, 3	1 2-5
X Y	US 2007/0071628 A1 (NEWLAND, Joseph A.) 29 March 2007, fig. 1 & US 2006/0220518 A1	1 2-5
X Y	JP 2013-072362 A (DAIKIN INDUSTRIES, LTD.) 22 April 2013, paragraphs [0036], [0041], fig. 1 (Family: none)	1 2-5

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

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Date of the actual completion of the international search	Date of mailing of the international search report
22.02.2019	05.03.2019

Name and mailing address of the ISA/	Authorized officer
Japan Patent Office 3-4-3, Kasumigaseki, Chiyoda-ku, Tokyo 100-8915, Japan	Telephone No.

Form PCT/ISA/210 (second sheet) (January 2015)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2018/045713

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y A	JP 2016-100944 A (FANUC LTD.) 30 May 2016, paragraphs [0046], [0047], [0055], [0070], [0072] & US 2016/0141931 A1, paragraphs [0058], [0059], [0067], [0082]	2-5 1
Y A	JP 2017-133474 A (DAIKIN INDUSTRIES, LTD.) 03 August 2017, paragraphs [0025], [0027] (Family: none)	4-5 1-3
A	JP 2018-105243 A (HITACHI JOHNSON CONTROLS AIR CONDITIONING INC.) 05 July 2018, paragraphs [00335]-[0037], fig. 1-5 & CN 108240332 A	1-5

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REFERENCES CITED IN THE DESCRIPTION

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- JP 2014202200 A **[0003]**