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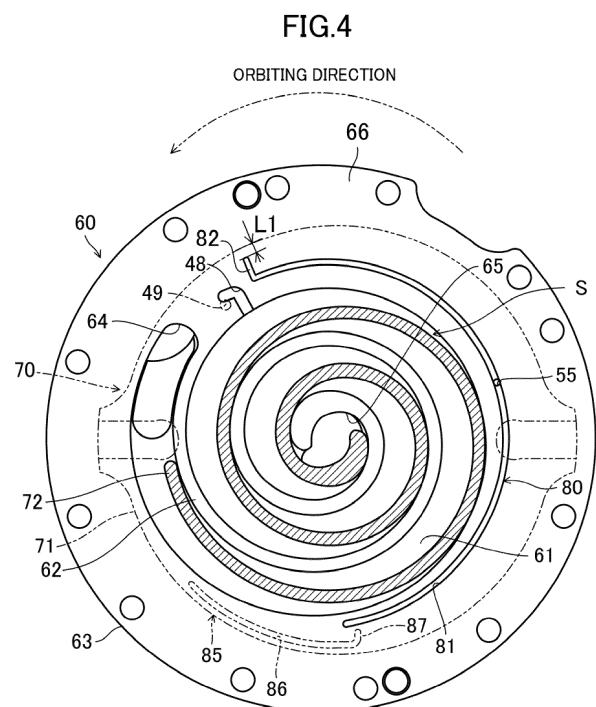
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(54) **SCROLL COMPRESSOR AND REFRIGERATING DEVICE**

(57) A compression mechanism (40) of a scroll compressor (10) includes a fixed scroll (60) and an orbiting scroll (70). An outer circumferential wall (63) of the fixed scroll (60) has a facing surface (66) that faces the front surface of an orbiting end plate (71) of the orbiting scroll (70), and the facing surface (66) has an oil groove (80) to which a lubricant with a high pressure equivalent to a discharge pressure of the compression mechanism (40) is supplied. The oil groove (80) has a circumferential groove portion (81) extending in a circumferential direction, and a radial groove portion (82) extending outward in a radial direction of the fixed scroll (60) and communicating with the circumferential groove portion (81).



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Description

TECHNICAL FIELD

[0001] The present disclosure relates to a scroll compressor and a refrigeration apparatus.

BACKGROUND ART

[0002] Patent Document 1 discloses a scroll compressor including a compression mechanism that has a fixed scroll and a movable scroll (orbiting scroll) and that forms a compression chamber between the scrolls.

[0003] The compression mechanism of Patent Document 1 includes an introduction mechanism and an auxiliary introduction mechanism both configured to supply a fluid in the compression chamber to a back pressure chamber formed on the back side of the movable scroll. The auxiliary introduction mechanism includes an auxiliary introduction passage that allows communication between the compression chamber and the back pressure chamber, and a check valve that allows the fluid to flow from the compression chamber toward the back pressure chamber and disallows the flow of the fluid from the back pressure chamber toward the compression chamber. In Patent Document 1, at the start or during a transitional operation of the compressor, the movable scroll may overturn. If an overturn occurs, the auxiliary introduction mechanism operates to recover the movable scroll from the overturned state.

CITATION LIST

PATENT DOCUMENTS

[0004] Patent Document 1: Japanese Unexamined Patent Publication No. 2015-105642

SUMMARY OF THE INVENTION

TECHNICAL PROBLEM

[0005] The scroll compressor of Patent Document 1 may not be able to reduce the state of overturn of the orbiting scroll, depending on the operating conditions.

[0006] It is an object of the present disclosure to reduce overturn of an orbiting scroll.

SOLUTION TO THE PROBLEM

[0007] A first aspect is directed to a scroll compressor (10). The scroll compressor (10) includes: a casing (20); and a compression mechanism (40) housed in the casing (20) and including a fixed scroll (60) and an orbiting scroll (70), the fixed scroll (60) including a fixed end plate (61), an outer circumferential wall (63) provided on an outer edge of the fixed end plate (61), and a fixed wrap (62) that is spiral and provided inside the outer circumferential wall

(63), the orbiting scroll (70) including an orbiting end plate (71) with which distal ends of the fixed end plate (61) and the outer circumferential wall (63) are in sliding contact, and an orbiting wrap (72) that is spiral, provided on a front surface of the orbiting end plate (71), and meshing with the fixed wrap (62), the outer circumferential wall (63) having a facing surface (66) that faces the front surface of the orbiting end plate (71), the facing surface (66) having an oil groove (80) to which a lubricant with a high pressure equivalent to a discharge pressure of the compression mechanism (40) is supplied, the oil groove (80) having a circumferential groove portion (81) extending in a circumferential direction of the fixed scroll (60), and a radial groove portion (82) extending outward in a radial direction of the fixed scroll (60) and communicating with the circumferential groove portion (81).

[0008] The gap between the orbiting scroll (70) and the fixed scroll (60) is generally uniform when the behavior of the orbiting scroll (70) is stable. In contrast, in the event of unstable behavior of the orbiting scroll (70), a relatively narrow portion and a relatively wide portion are formed in the gap between the orbiting scroll (70) and the fixed scroll (60) due to the tilt of the orbiting scroll (70).

[0009] According to the first aspect, the oil groove (80) has the radial groove portion (82). Thus, when the orbiting scroll (70) starts tilting, a force that separates the orbiting scroll (70) from the fixed scroll (60) acts on a portion where the gap between the orbiting scroll (70) and the fixed scroll (60) is narrow, due to the pressure of the radial groove portion (82) to which the high-pressure lubricant is being supplied. At this moment, the high pressure acts on a portion of the orbiting scroll (70) far from the center of gravity of the orbiting scroll (70) since the radial groove portion (82) extends outward in the radial direction of the fixed scroll (60). This can increase the moment of separation of the orbiting scroll (70) from the fixed scroll (60) and keep the gap between the orbiting scroll (70) and the fixed scroll (60) uniform. As a result, it is possible to maintain the stable behavior of the orbiting scroll (70) and reduce the state of overturn of the orbiting scroll (70).

[0010] A second aspect is an embodiment of the first aspect. In the second aspect, the scroll compressor further includes: a housing (50) disposed on a back surface of the orbiting scroll (70), the housing (50) forming a back pressure space (90) between the housing (50) and the orbiting scroll (70), the housing (50) having an annular ring groove (56) in a surface facing the orbiting scroll (70); and a sealing ring (57) housed in the ring groove (56), the sealing ring (57) being in contact with the back surface of the orbiting scroll (70) to partition the back pressure space (90) into a first back pressure space (91) on an inner circumference side of the ring groove (56) and a second back pressure space (92) on an outer circumference of the ring groove (56), wherein the first back pressure space (91) has a pressure equivalent to the discharge pressure of the compression mechanism (40), the second back pressure space (92) has a pressure

equal to or higher than a pressure of a fluid sucked into the compression mechanism (40) and lower than a pressure of a fluid discharged from the compression mechanism (40), and the radial groove portion (82) communicates with the second back pressure space (92) when the orbiting scroll (70) tilts.

[0011] Here, the orbiting scroll (70) overturns when the force pushing up the back surface of the orbiting scroll (70) and pressing the orbiting scroll (70) onto the fixed scroll (60) is insufficient relative to the force separating the orbiting scroll (70) and the fixed scroll (60) from each other.

[0012] According to the second aspect, the radial groove portion (82) communicates with the second back pressure space (92) when the orbiting scroll (70) tilts. Thus, in the event of the overturn of the orbiting scroll (70), the high-pressure lubricant is supplied from the end of the radial groove portion (82) to the second back pressure space (92). Accordingly, the pressure of the second back pressure space (92) increases, which results in an increase in the force pushing up the back surface of the orbiting scroll (70) and pressing the orbiting scroll (70) onto the fixed scroll (60). As a result, the orbiting scroll (70) can recover from its overturned state at an early stage.

[0013] A third aspect is an embodiment of the first or second aspect. In the third aspect, the radial groove portion (82) is located at an end of the circumferential groove portion (81).

[0014] According to the third aspect, the radial groove portion (82) formed at an end of the circumferential groove portion (81) allows the lubricant to be supplied sufficiently to the end of the circumferential groove portion (81).

[0015] A fourth aspect is an embodiment of any one of the first to third aspects. In the fourth aspect, a seal length (L1) that is a length of a portion of the facing surface (66) from an end of the radial groove portion (82) to an outer edge of the orbiting scroll (70) is equal to or greater than 2 mm.

[0016] According to the fourth aspect, since the seal length (L1) is equal to or greater than 2 mm, it is possible to keep the high-pressure lubricant from leaking out of the oil groove (80) while the orbiting scroll (70) is operating stably.

[0017] A fifth aspect is directed to a refrigeration apparatus including: the scroll compressor (10) of any one of the first to fourth aspects; and a refrigerant circuit (1a) through which a refrigerant compressed by the scroll compressor (10) flows.

[0018] According to the fifth aspect, it is possible to provide the refrigeration apparatus (1) that includes the scroll compressor (10) configured to reduce the state of overturn of the orbiting scroll (70).

BRIEF DESCRIPTION OF THE DRAWINGS

[0019]

FIG. 1 is a refrigerant circuit diagram showing a configuration of a refrigeration apparatus according to an embodiment.

FIG. 2 is a vertical sectional view illustrating a configuration of a scroll compressor.

FIG. 3 is an enlarged vertical sectional view of a compression mechanism and its surrounding area.

FIG. 4 is a bottom view of a fixed scroll.

FIG. 5 is a bottom view of the fixed scroll, and is a diagram illustrating the locations of sensors for measurement of the behavior of an orbiting scroll.

FIG. 6 shows the results of the measurement of the behavior of the orbiting scroll.

FIG. 7 shows the results of a tipping limit test.

DESCRIPTION OF EMBODIMENTS

<<Embodiment>>

[0020] Embodiments of the present disclosure will be described in detail below with reference to the drawings. The present disclosure is not limited to the embodiments shown below, and various changes can be made within the scope without departing from the technical concept of the present disclosure. Each of the drawings is intended to illustrate the present disclosure conceptually, and dimensions, ratios, or numbers may be exaggerated or simplified as necessary for the sake of ease of understanding.

(1) Overview of Refrigeration Apparatus

[0021] As illustrated in FIG. 1, a scroll compressor (10) is provided in a refrigeration apparatus (1). The refrigeration apparatus (1) includes a refrigerant circuit (1a) filled with a refrigerant. The refrigerant circuit (1a) includes the scroll compressor (10), a radiator (3), a decompression mechanism (4), and an evaporator (5). The decompression mechanism (4) is, for example, an expansion valve. The refrigerant circuit (1a) performs a vapor compression refrigeration cycle.

[0022] The refrigeration apparatus (1) is an air conditioner. The air conditioner may be any of a cooling-only apparatus, a heating-only apparatus, or an air conditioner switchable between cooling and heating. In this case, the air conditioner has a switching mechanism (e.g., a four-way switching valve) configured to switch the direction of circulation of the refrigerant. The refrigeration apparatus (1) may be a water heater, a chiller unit, or a cooling apparatus configured to cool air in an internal space. The cooling apparatus cools air in a refrigerator, a freezer, a container, or the like.

(2) Compressor

[0023] The scroll compressor (10) includes a casing (20), an electric motor (30), a drive shaft (11), a compression mechanism (40), and a housing (50). As illustrated in

FIG. 2, the casing (20) houses the electric motor (30), the drive shaft (11), the compression mechanism (40), and the housing (50).

[0024] In the following description, an "axial direction" refers to a direction in which the drive shaft (11) extends, a "radial direction" refers to a direction orthogonal to the axis of the drive shaft (11), and a "circumferential direction" refers to a circumferential direction about the axis of the drive shaft (11). A "radially inner side" is a side closer to the axis of the drive shaft (11), and a "radially outer side" is a side farther from the axis of the drive shaft (11).

(2-1) Casing

[0025] The casing (20) is configured as a vertically long closed container. The casing (20) has a cylindrical barrel (20a) extending vertically and two lids (20b) closing both ends of the barrel (20a). The casing (20) has, at its bottom, an oil reservoir (21). The oil reservoir (21) stores a lubricant. A suction pipe (12) is connected to an upper portion of the casing (20). A discharge pipe (13) is connected to the barrel (20a) of the casing (20).

(2-2) Electric Motor

[0026] The electric motor (30) is disposed in a central portion of the casing (20). The electric motor (30) has a stator (31) and a rotor (32). The stator (31) is fixed to the inner circumferential surface of the casing (20). The rotor (32) is disposed inside the stator (31). The drive shaft (11) passes through the rotor (32). The rotor (32) is fixed to the drive shaft (11).

(2-3) Drive Shaft

[0027] The drive shaft (11) extends vertically along the center axis of the casing (20). The drive shaft (11) has a main shaft portion (14) and an eccentric portion (15).

[0028] The eccentric portion (15) is provided at an upper end of the main shaft portion (14). The outer diameter of the eccentric portion (15) is smaller than that of the main shaft portion (14). The eccentric portion (15) has an axis decentered by a predetermined distance with respect to the axis of the main shaft (14).

[0029] The main shaft portion (14) has an upper portion passing through the housing (50) and rotatably supported by an upper bearing (51) of the housing (50). The main shaft portion (14) has a lower portion rotatably supported by a lower bearing (22) to be described later.

(2-4) Compression Mechanism

[0030] The compression mechanism (40) is disposed in an upper portion of the casing (20). As illustrated in FIGS. 2 and 3, the compression mechanism (40) includes a fixed scroll (60) and an orbiting scroll (70). The fixed scroll (60) is fixed to the upper surface of the housing (50). The orbiting scroll (70) is arranged between the fixed

scroll (60) and the housing (50). The orbiting scroll (70) meshes with the fixed scroll (60).

(2-4-1) Fixed Scroll

[0031] The fixed scroll (60) includes a fixed end plate (61), a fixed wrap (62), and an outer circumferential wall (63).

[0032] The fixed end plate (61) is in the shape of a disk. The fixed wrap (62) is spiral. The fixed wrap (62) protrudes downward from the front surface (the lower surface in FIG. 2) of the fixed end plate (61). The fixed wrap (62) is disposed on a portion of the fixed end plate (61) inside the outer circumferential wall (63).

[0033] The outer circumferential wall (63) is substantially tubular. The outer circumferential wall (63) protrudes downward from the outer edge of the front surface (the lower surface in FIG. 2) of the fixed end plate (61). The outer circumferential wall (63) surrounds the outer periphery of the fixed wrap (62).

[0034] The distal end surface (the lower surface in FIG. 2) of the fixed wrap (62) and the distal end surface (the lower surface in FIG. 2) of the outer circumferential wall (63) are generally flush with each other. The outer circumferential wall (63) of the fixed scroll (60) is fixed to the upper surface of the housing (50).

(2-4-2) Orbiting Scroll

[0035] The orbiting scroll (70) includes an orbiting end plate (71), an orbiting wrap (72), and a boss (73). The orbiting end plate (71) is in the shape of a disk. The distal ends of the fixed end plate (61) and the outer circumferential wall (63) are in sliding contact with the orbiting end plate (71).

[0036] The orbiting wrap (72) is spiral. The orbiting wrap (72) protrudes upward from the front surface (the upper surface in FIG. 2) of the orbiting end plate (71). The orbiting wrap (72) meshes with the fixed wrap (62).

[0037] The boss (73) is formed on a central portion of the back surface (the lower surface in FIG. 2) of the orbiting end plate (71). The eccentric portion (15) of the drive shaft (11) is inserted into the boss (73). Thus, the drive shaft (11) is coupled to the orbiting scroll (70). In other words, the drive shaft (11) is connected to the compression mechanism (40).

(2-4-3) Suction Port, Outlet

[0038] The outer circumferential wall (63) of the fixed scroll (60) has a suction port (64). The suction port (64) is open near the winding end of the fixed wrap (62). A downstream end of the suction pipe (12) is connected to the suction port (64).

[0039] The fixed end plate (61) of the fixed scroll (60) has, at its center, an outlet (65). The outlet (65) is open to the upper surface of the fixed end plate (61) of the fixed scroll (60). The high-pressure gas refrigerant discharged

from the outlet (65) flows into an upper space (23) in the casing (20) and flows out of the upper space (23) through a discharge path (not shown) formed in the housing (50) into a lower space (24).

(2-4-4) Fluid Chamber

[0040] The compression mechanism (40) has a fluid chamber (F) into which the refrigerant flows. The fluid chamber (F) is formed between the fixed scroll (60) and the orbiting scroll (70). The orbiting wrap (72) of the orbiting scroll (70) is positioned to mesh with the fixed wrap (62) of the fixed scroll (60). The fixed wrap (62) and the orbiting wrap (72) meshing with each other form the fluid chamber (F). The fluid chamber (F) fully closed forms a compression chamber (S). In the compression chamber (S), the gas refrigerant is compressed.

[0041] Here, the distal end surface (the lower surface in FIG. 2) of the outer circumferential wall (63) of the fixed scroll (60) serves as a facing surface (66) of the fixed scroll (60) which faces the front surface of the orbiting scroll (70). The front surface (the upper surface in FIG. 2) of the orbiting end plate (71) of the orbiting scroll (70) serves as a facing surface of the orbiting scroll (70) which faces the distal end surface of the fixed scroll (60).

(2-5) Housing

[0042] The housing (50) is disposed below the compression mechanism (40). Specifically, the housing (50) is disposed on the back side of the orbiting scroll (70). The housing (50) is located above the electric motor (30). An inflow end of the discharge pipe (13) is located between the housing (50) and the electric motor (30).

[0043] The housing (50) has a cylindrical shape extending in the axial direction (vertically). The outer diameter of the housing (50) at an upper portion is larger than the outer diameter of the housing (50) at a lower portion. The inner diameter of the housing (50) at an upper portion is larger than the inner diameter of the housing (50) at a lower portion.

[0044] The housing (50) includes an annular portion (52), a recess (53), and an upper bearing (51). The annular portion (52) is an upper portion of the housing (50). The annular portion (52) forms the outer circumference of the housing (50). The recess (53) is formed in the center of the upper portion of the housing (50). The recess (53) has a dish shape recessed downward. The recess (53) forms a crank chamber (54) that houses the boss (73) of the orbiting scroll (70). In the crank chamber (54), the eccentric portion (15) rotates eccentrically. The upper bearing (51) forms a lower portion of the housing (50). Specifically, the upper bearing (51) is formed below the recess (53).

[0045] The housing (50) is fixed to the inside of the casing (20) by press fitting. Specifically, the outer circumferential surface of the annular portion (52) of the housing (50) is fixed to the inner circumferential surface of the

barrel (20a) of the casing (20). The outer circumferential surface of the annular portion (52) and the inner circumferential surface of the barrel (20a) are in gastight contact with each other throughout the entire circumference. The housing (50) partitions the interior of the casing (20) into the upper space (23) for housing the compression mechanism (40) and the lower space (24) for housing the electric motor (30).

[0046] A back pressure space (90) is formed between the annular portion (52) of the housing (50) and the orbiting end plate (71) of the orbiting scroll (70). The back pressure space (90) is a space on which a back pressure pressing the orbiting scroll (70) onto the fixed scroll (60) acts.

[0047] The upper surface (the surface near the orbiting scroll (70)) of the annular portion (52) has a ring-shaped ring groove (56). The ring groove (56) is formed on the radially outer side of the recess (53). The ring groove (56) houses a ring-shaped sealing ring (57). The sealing ring (57) is fitted into the ring groove (56), and is held in contact with the back surface of the orbiting end plate (71) of the orbiting scroll (70).

[0048] The sealing ring (57) is in contact with the back surface of the orbiting end plate (71) of the orbiting scroll (70) to seal the gap between the housing (50) and the orbiting end plate (71). In other words, the sealing ring (57) partitions the back pressure space (90) into a first back pressure space (91) on the inner circumference side of the ring groove (56) and a second back pressure space (92) on the outer circumference side of the ring groove (56).

[0049] The first back pressure space (91) is configured as the crank chamber (54). The housing (50) has an oil discharge path (not shown) that is open to the bottom of the first back pressure space (91). This oil discharge path allows the first back pressure space (91) to communicate with the lower space (24) so that the lubricant in the first back pressure space (91) is discharged to the lower space (24). The second back pressure space (92) is formed between the upper surface of the annular portion (52) and the back surface of the orbiting scroll (70).

(2-6) Oldham Coupling

[0050] An Oldham coupling (45) is provided at an upper portion of the housing (50). As illustrated in FIGS. 2 and 3, the Oldham coupling (45) is disposed in the second back pressure space (92). The Oldham coupling (45) blocks the orbiting scroll (70), which is revolving, from rotating on its own axis. The Oldham coupling (45) is provided with a key (46). The key (46) protrudes toward the back surface (the lower surface in FIG. 2) of the orbiting end plate (71) of the orbiting scroll (70). The back surface of the orbiting end plate (71) of the orbiting scroll (70) has a keyway (47). The key (46) of the Oldham coupling (45) is slidably fitted to the keyway (47).

[0051] Although not shown, a key is provided in a portion of the Oldham coupling (45) toward the housing

(50). The key toward the housing (50) is slidably fitted to a keyway (not shown) of the housing (50).

(2-7) Lower Bearing

[0052] The lower bearing (22) is an auxiliary bearing member that rotatably supports the drive shaft (11). The lower bearing (22) supports an end portion (a lower end portion in FIG. 2) of the drive shaft (11) on the opposite side from the compression mechanism (40). The lower bearing (22) is housed in the casing (20). The lower bearing (22) is located below the electric motor (30). The lower bearing (22) is fixed to the inner circumferential surface of the casing (20).

(2-7) Oil Supply Passage

[0053] An oil supply passage (16) is formed inside the drive shaft (11). The oil supply passage (16) extends vertically from the lower end to the upper end of the drive shaft (11). A pump (25) is connected to the lower end of the drive shaft (11). The pump (25) is a positive-displacement pump, for example. A lower end portion of the pump (25) is immersed in the oil reservoir (21).

[0054] The pump (25) sucks up the lubricant from the oil reservoir (21) as the drive shaft (11) rotates, and transfers the lubricant to the oil supply passage (16). The oil supply passage (16) supplies the lubricant in the oil reservoir (21) to the sliding surfaces between the lower bearing (22) and the drive shaft (11) and the sliding surfaces between the upper bearing (51) and the drive shaft (11), and to the sliding surfaces between the boss (73) and the drive shaft (11). The oil supply passage (16) is open to the upper end surface of the drive shaft (11) and supplies the lubricant to above the drive shaft (11).

[0055] The recess (53) of the housing (50) communicates with the oil supply passage (16) of the drive shaft (11) via the inside of the boss (73) of the orbiting scroll (70). The high-pressure lubricant is supplied to the crank chamber (54) formed by the recess (53). Thus, a high pressure equivalent to the discharge pressure of the compression mechanism (40) acts on the crank chamber (54). In other words, the pressure in the first back pressure space (91) is equivalent to the discharge pressure of the compression mechanism (40).

(2-8) Primary Path and Secondary Path

[0056] As illustrated in FIG. 4, the lower surface of the outer circumferential wall (63) of the fixed scroll (60) has a primary path (48). The radially inner end of the primary path (48) is open to the inner circumferential surface of the outer circumferential wall (63) and communicates with the compression chamber (S) at intermediate pressure.

[0057] An outer circumferential portion of the orbiting end plate (71) of the orbiting scroll (70) has a secondary path (49). The secondary path (49) is configured as a

through hole passing vertically through the orbiting end plate (71). The secondary path (49) has an upper end that intermittently communicates with the radially outer end of the primary path (48), and a lower end that communicates with the second back pressure space (92) between the orbiting scroll (70) and the housing (50). In other words, the intermediate-pressure refrigerant is intermittently supplied from the compression chamber (S) at intermediate pressure to the second back pressure space (92). The second back pressure space (92) therefore has a predetermined intermediate pressure. The intermediate pressure is equal to or higher than the pressure of the fluid (refrigerant) sucked into the compression mechanism (40) and lower than the pressure of the fluid (refrigerant) discharged from the compression mechanism (40).

(2-9) Oil Path

[0058] An oil path (55) is provided in the housing (50) and the fixed scroll (60). The oil path (55) has an inflow end that communicates with the recess (53) of the housing (50). The oil path (55) has an outflow end open to the facing surface (66) of the fixed scroll (60). Through the oil path (55), the high-pressure lubricant in the recess (53) is supplied to the facing surfaces of the orbiting end plate (71) of the orbiting scroll (70) and the outer circumferential wall (63) of the fixed scroll (60).

(2-10) Fixed Oil Groove and Movable Oil Groove

[0059] As illustrated in FIG. 4, a fixed oil groove (80) is formed in the facing surface (66) (the lower surface in FIG. 2), of the outer circumferential wall (63) of the fixed scroll (60), which faces the orbiting end plate (71) of the orbiting scroll (70).

[0060] The fixed oil groove (80) has a fixed circumferential groove portion (81) and a fixed radial groove portion (82). The fixed circumferential groove portion (81) extends in a circumferential direction along the inner circumferential surface of the outer circumferential wall (63) of the fixed scroll (60). The oil path (55) communicates with the fixed circumferential groove portion (81). Accordingly, the lubricant with the high pressure equivalent to the discharge pressure of the compression mechanism (40) is supplied through the oil path (55) to the fixed circumferential groove portion (81).

[0061] The fixed radial groove portion (82) extends radially outward and communicates with the fixed circumferential groove portion (81). In this embodiment, the fixed radial groove portion (82) is formed at one end portion of the fixed circumferential groove portion (81) (the end portion in the counterclockwise direction in FIG. 4). The fixed radial groove portion (82) is bent from the one end portion of the fixed circumferential groove portion (81) and extends toward the outer periphery of the fixed scroll (60).

[0062] In this embodiment, the fixed radial groove portion (82) communicates with a forward end portion, in the

orbiting direction of the orbiting scroll (70), of the fixed circumferential groove portion (81). The fixed radial groove portion (82) communicates with an end portion of the fixed circumferential groove portion (81) near the suction port (64). The fixed radial groove portion (82) formed at the one end portion of the fixed circumferential groove portion (81) allows the lubricant to be supplied sufficiently to the one end portion of the fixed circumferential groove portion (81).

[0063] The fixed radial groove portion (82) communicates with the second back pressure space (92) when the orbiting scroll (70) overturns and tilts significantly. Specifically, a large gap is formed partially between the orbiting scroll (70) and the fixed scroll (60) when the orbiting scroll (70) overturns. The portion where the gap is large causes loss of the sealing function of the lubricant. Thus, the fixed radial groove portion (82) and the second back pressure space (92) communicate with each other.

[0064] The fixed radial groove portion (82) may be formed at an intermediate portion of the fixed circumferential groove portion (81) other than the end portions thereof. The fixed oil groove (80) corresponds to an oil groove of the present disclosure. The fixed circumferential groove portion (81) corresponds to a circumferential groove portion of the present disclosure. The fixed radial groove portion (82) corresponds to a circumferential groove portion of the present disclosure.

[0065] As illustrated in FIG. 4, the facing surface of the orbiting scroll (70) which faces the fixed scroll (60) has an orbiting oil groove (85). The orbiting oil groove (85) has an orbiting circumferential groove portion (86) and an orbiting radial groove portion (87). The orbiting circumferential groove portion (86) extends in the circumferential direction along the outer circumferential surface of the orbiting wrap (72).

[0066] The orbiting radial groove portion (87) extends radially to communicate with one end portion of the orbiting circumferential groove portion (86) (the end portion in the counterclockwise direction in FIG. 4). The orbiting radial groove portion (87) is bent from the one end portion of the orbiting circumferential groove portion (86) and extends toward the center of the orbiting scroll (70). In other words, the orbiting radial groove portion (87) extends radially inward on the orbiting end plate (71) of the orbiting scroll (70). Thus, the orbiting radial groove portion (87) has a radially inner end portion that can communicate with the fluid chamber (F).

[0067] The state of communication of the inner end portion of the orbiting radial groove portion (87) with the fixed oil groove (80) and the fluid chamber (F) changes as the orbiting scroll (70) rotates eccentrically. Accordingly, the high-pressure lubricant in the fixed oil groove (80) is supplied to the compression chamber (S), the facing surfaces of the fixed scroll (60) and the orbiting scroll (70), the keyway (47), and other components.

[0068] As illustrated in FIG. 4, a seal length (L1) is the length of a portion of the facing surface (66) of the fixed

scroll (60) that faces the orbiting scroll (70) from the outer end (radially outer end) of the fixed radial groove portion to the outer edge of the orbiting scroll (70), and the seal length (L1) is equal to or greater than 2 mm. In this embodiment, the seal length (L1) is 2 mm. This can keep the high-pressure lubricant from leaking out of the fixed oil groove (80) when the orbiting scroll (70) is operating stably (unless the orbiting scroll (70) is overturned).

10 (3) Operation

[0069] An operation of the scroll compressor (10) will be described below.

[0070] In FIG. 2, when the electric motor (30) is activated, the drive shaft (11) is driven to rotate. The orbiting scroll (70) makes an orbiting motion as the drive shaft (11) rotates. Since the Oldham coupling (45) blocks the rotation of the orbiting scroll (70) on its own axis, the orbiting scroll (70) rotates eccentrically about the axis of the drive shaft (11).

[0071] Due to the orbiting motion of the orbiting scroll (70), the gas refrigerant that has flowed into the suction port (64) through the suction pipe (12) is compressed in the compression chamber (S). Specifically, when the orbiting scroll (70) orbits, the gas refrigerant is gradually sucked into an outermost portion of the fluid chamber (F) through the suction port (64); thereafter, the fluid chamber (F) is fully closed, thereby defining the compression chamber (S). As the drive shaft (11) further rotates, the volume of an outermost portion of the compression chamber (S) decreases, and the compression chamber (S) gradually approaches the outlet (65).

[0072] At this moment, the primary path (48) and the secondary path (49) communicate with each other as the orbiting scroll (70) orbits due to the rotation of the drive shaft (11). Thus, the gas refrigerant that is being compressed in the compression chamber (S) passes sequentially through the primary path (48) and the secondary path (49) and starts being introduced into the second back pressure space (92). When the orbiting scroll (70) further orbits from this state, the area of a portion of the primary path (48) that is open to the secondary path (49) becomes maximum. The second back pressure space (92) is maintained at a predetermined target pressure in this manner, and a predetermined pressing force therefore acts on the back surface of the orbiting end plate (71) of the orbiting scroll (70). The pressing force as used herein refers to a force which pushes up the back surface of the orbiting scroll (70) and presses the orbiting scroll (70) onto the fixed scroll (60). When the orbiting scroll (70) further orbits from this state, the primary path (48) and the secondary path (49) are isolated from each other, and the gas refrigerant introduction into the second back pressure space (92) ends.

[0073] Thereafter, as the orbiting scroll (70) orbits due to further rotation of the drive shaft (11), the compression chamber (S) closer to the center of the orbiting scroll (70) communicates with the outlet (65). The high-pressure

gas refrigerant compressed in the compression chamber (S) is discharged from the outlet (65) and flows into the upper space (23) of the casing (20). The gas refrigerant in the upper space (23) flows into the lower space (24) through the discharge path (not shown) formed in the housing (50). The high-pressure gas refrigerant in the lower space (24) is discharged outside the casing (20) via the discharge pipe (13).

(4) Oil Supply Operation

[0074] Next, an oil supply operation of the scroll compressor (10) for supplying the lubricant will be described.

[0075] The rotation of the drive shaft (11) causes the high-pressure lubricant in the oil reservoir (21) to be sucked up by the pump (25). The lubricant sucked up flows upward through the oil supply passage (16) of the drive shaft (11) and flows out from the opening at the upper end of the eccentric portion (15) of the drive shaft (11) into the inside of the boss (73) of the orbiting scroll (70).

[0076] The lubricant supplied to the boss (73) flows out into the recess (53) of the housing (50) through the gap between the eccentric portion (15) of the drive shaft (11) and the boss (73). Accordingly, the crank chamber (54) (first back pressure space (91)) of the housing (50) has a high pressure equivalent to the discharge pressure of the compression mechanism (40). The orbiting scroll (70) is pressed onto the fixed scroll (60) by the high pressure that acts on the first back pressure space (91) and the intermediate pressure that acts on the second back pressure space (92).

[0077] The high-pressure lubricant accumulated in the recess (53) flows out through the oil path (55) into the fixed oil groove (80). The lubricant that has flowed in through the oil path (55) flows through the fixed circumferential groove portion (81) in the circumferential direction to both ends, and flows into the fixed radial groove portion (82) at one of the ends. The lubricant that has flowed into the fixed radial groove portion (82) flows radially outward. Accordingly, the lubricant with the high pressure equivalent to the discharge pressure of the compression mechanism (40) is supplied to the fixed oil groove (80). The high-pressure lubricant that has flowed into the fixed oil groove (80) is supplied to the sliding surfaces between the fixed scroll (60) and the orbiting scroll (70) and is then returned to the oil reservoir (21).

[0078] Here, while the scroll compressor (10) is in a normal state of the operation, a separation force separating the orbiting scroll (70) from the fixed scroll (60) (a force separating the scrolls from each other) acts on the orbiting scroll (70) due to the internal pressure of the compression chamber (S). On the other hand, the orbiting scroll (70) is pressed toward the fixed scroll (60) by the high pressure that acts on the first back pressure space (91) and the intermediate pressure that acts on the second back pressure space (92). Accordingly, while

the scroll compressor (10) is in the normal state, the separation force and the pressing force that act on the orbiting scroll (70) are balanced, and the behavior of the orbiting scroll (70) is stabilized. When the behavior of the orbiting scroll (70) is stabilized, the gap between the orbiting scroll (70) and the fixed scroll (60) is generally uniform, thereby ensuring the hermeticity of the compression chamber (S).

[0079] However, various factors, such as the pressure state of the compression chamber (S) and the centrifugal force acting on the orbiting scroll (70), may lead to an imbalance between the separation force and the pressing force that act on the orbiting scroll (70) and cause an unstable behavior of the orbiting scroll (70). In the event of such an unstable behavior, the orbiting scroll (70) tilts to be in a state in which part of the orbiting scroll (70) separates from the fixed scroll (60) (so-called "overturned state").

[0080] The orbiting scroll (70) exhibits such an unstable behavior as described above when, for example, the pressure state of the compression chamber (S) changes. A change in the pressure state of the compression chamber (S) causes differences in the separation force acting on the orbiting scroll (70) in a plurality of regions on the orbiting end plate (71). As a result, the separation force and the pressing force that act on the orbiting scroll (70) are partially unbalanced. In such a case, the orbiting scroll (70) tilts, and a relatively narrow portion and a relatively wide portion are formed in the gap between the orbiting scroll (70) and the fixed scroll (60).

[0081] In this embodiment, the high-pressure lubricant is supplied to the fixed radial groove portion (82). Thus, when the orbiting scroll (70) starts tilting, the separation force acts on the narrow portion of the gap due to the high pressure of the fixed radial groove portion (82). At this moment, the high pressure acts on a portion of the orbiting scroll (70) far from the center of gravity of the orbiting scroll (70) because the fixed radial groove portion (82) extends radially outward. This can increase the moment of separation of the fixed scroll (60) from the orbiting scroll (70) and keep the gap between the orbiting scroll (70) and the fixed scroll (60) uniform. As a result, it is possible to maintain the stable behavior of the orbiting scroll (70) and reduce the state of overturn of the orbiting scroll (70).

[0082] If the pressure of the refrigerant to be introduced into the second back pressure space (92) is lower than the predetermined target pressure, the pressing force that acts on the orbiting scroll (70) is relatively small (insufficient) with respect to the separation force. As a result, the separation force and the pressing force that act on the orbiting scroll (70) are unbalanced. This may lead to an unstable behavior of the orbiting scroll (70), resulting in the overturn of the orbiting scroll (70).

[0083] To address this problem, in this embodiment, the fixed radial groove portion (82) communicates with the second back pressure space (92) when the orbiting scroll (70) overturns and tilts. Thus, the high-pressure lubricant is supplied from the outer end of the fixed radial

groove portion (82) to the second back pressure space (92). The pressure of the second back pressure space (92) increases accordingly, resulting in an increase in the pressing force acting on the back surface of the orbiting scroll (70). As a result, the orbiting scroll (70) can recover from its overturned state at an early stage. Further, at this moment, the lubricant comes out from between the facing surfaces (sliding surfaces) of the orbiting scroll (70) and the fixed scroll (60) and is supplied to the second back pressure space (92) as the orbiting scroll (70) makes an orbiting motion. Since the high-pressure lubricant is supplied to the second back pressure space (92), the pressing force acting on the back surface of the orbiting scroll (70) increases. Thus, the orbiting scroll (70) can recover from its overturned state at an early stage.

(5) Measurement of Behavior of Orbiting Scroll

[0084] Next, the measurement of the behavior of the orbiting scroll (70) will be described with reference to FIGS. 5 and 6.

[0085] In this measurement, the behavior of an orbiting scroll (70) in the operation of a known scroll compressor (10) that does not include the fixed radial groove portion (82) of this embodiment was measured. More specifically, a plurality of distance sensors were attached to an outer circumferential wall (63) of a fixed scroll (60) of a compression mechanism (40) to measure the displacement of the orbiting scroll (70). In other words, in this measurement, the size of the gap (displacement) between the fixed scroll (60) and the orbiting scroll (70) at each of the sensor locations was measured during the operation of the scroll compressor (10).

[0086] In this measurement, the distance sensors were arranged at three locations, which are a point A, a point B, and a point C shown in FIG. 5. The measurement results at the sensor locations are shown in FIG. 6. In FIG. 6, the measurement result at the point A is indicated by the solid line, the measurement result at the point B is indicated by the dash-dot line, and the measurement result at the point C is indicated by the broken line.

[0087] When a range of the crank angle from 135 deg. to 220 deg. in FIG. 6 is focused on, the displacement at the point A in this range decreases sharply, and the displacement at the point B in this range increases sharply. Thus, it can be said that the orbiting scroll (70) in this range suddenly moves toward the fixed scroll (60) near the point A, and suddenly moves away from the fixed scroll (60) near the point B.

[0088] This seems to occur because the refrigerant gas is discharged from the compression chamber (S) at a crank angle of about 114 deg., and due to this discharge, the pressure relation in the compression chamber (S) changes; this change causes an imbalance of the separation force acting on the orbiting scroll (70) at the point A and the point B at a crank angle of about 135 deg.; and as a result, the size of the gap at each location changes (i.e., the tilt of the orbiting scroll (70) changes).

From this, it is found that the crank angle of about 135 deg. is the timing when the orbiting scroll (70) starts overturning, and at this moment, the orbiting scroll (70) approaches the fixed scroll (60) near the point A.

[0089] Then, from a crank angle of about 220 deg. in FIG. 6, the displacement at the point A increases gently, and the displacement at the point B decreases gently. Thereafter, the fluctuation range of the displacement at both of the point A and the point B becomes narrower. From this, it is found that if the crank angle exceeds around 220 deg., the orbiting scroll (70) has recovered from its overturned state.

[0090] In this embodiment, the fixed scroll (60) has the fixed radial groove portion (82) extending radially outward near the point A in view of the measurement results of the behavior of the orbiting scroll (70). Since the fixed radial groove portion (82) is provided at a portion of the fixed scroll (60) near the point A, the high pressure acts on a portion of the orbiting scroll (70) far from the center of gravity of the orbiting scroll (70). This can increase the moment of separation of the fixed scroll (60) from the orbiting scroll (70) at the timing when the orbiting scroll (70) starts overturning, and can keep the orbiting scroll (70) from approaching the fixed scroll (60). This can reduce the behavior of tilt of the orbiting scroll (70) and keep the gap between the orbiting scroll (70) and the fixed scroll (60) uniform. As a result, it is possible to reduce the state of overturn of the orbiting scroll (70).

(6) Tipping Limit Test

[0091] Next, a tipping limit test will be described with reference to FIG. 7.

[0092] In the tipping limit test, the second back pressure space (92) is set to have a low pressure (the pressure equivalent to the suction pressure of the compression mechanism (40)) so that the orbiting scroll (70) is intentionally overturned. Thereafter, in order to reduce the difference between the low pressure and the high pressure of the compression mechanism (40), the high pressure is adjusted, thereby making the orbiting scroll (70) recover from the overturned state. FIG. 7 is a graph showing the ratio Pr (H_p/L_p) between the high pressure H_p and the low pressure L_p when the orbiting scroll (70) recovered from its overturned state at each rotational speed.

[0093] In FIG. 7, the test results of the known scroll compressor (10) without the fixed radial groove portion (82) are indicated by the circles, and the test results of the scroll compressor (10) of this embodiment with the fixed radial groove portion (82) are indicated by the triangles.

[0094] As shown in FIG. 7, the value of Pr for the scroll compressor (10) of this embodiment is lower than that for the known scroll compressor (10) in the rotational speed equal to or greater than 20 rps. This means that the scroll compressor (10) of this embodiment has recovered from the overturned state at a smaller difference between the high pressure and the low pressure as compared to the

known scroll compressor (10). It is thus demonstrated that the scroll compressor (10) of this embodiment can recover from the overturned state earlier than the known scroll compressor (10).

(7) Features

(7-1) Feature 1

[0095] The fixed oil groove (80) has the fixed radial groove portion (82) extending outward in the radial direction of the fixed scroll (60) and communicating with the fixed circumferential groove portion (81).

[0096] Thus, when the orbiting scroll (70) starts tilting, a force that separates the orbiting scroll (70) from the fixed scroll (60) acts on a portion where the gap between the orbiting scroll (70) and the fixed scroll (60) is narrow, due to the pressure of the fixed radial groove portion (82) to which the high-pressure lubricant is being supplied. At this moment, the high pressure acts on a portion of the orbiting scroll (70) far from the center of gravity of the orbiting scroll (70) since the fixed radial groove portion (82) extends outward in the radial direction of the fixed scroll (60). This can increase the moment of separation of the orbiting scroll (70) from the fixed scroll (60) and keep the gap between the orbiting scroll (70) and the fixed scroll (60) uniform. As a result, it is possible to maintain the stable behavior of the orbiting scroll (70) and reduce the state of overturn of the orbiting scroll (70).

(7-2) Feature 2

[0097] The fixed radial groove portion (82) communicates with the second back pressure space (92) when the orbiting scroll (70) tilts.

[0098] Thus, in the event of the overturn of the orbiting scroll (70), the high-pressure lubricant is supplied from the end of the fixed radial groove portion (82) to the second back pressure space (92). Accordingly, the pressure of the second back pressure space (92) increases, which results in an increase in the force pushing up the back surface of the orbiting scroll (70) and pressing the orbiting scroll (70) onto the fixed scroll (60). As a result, the orbiting scroll (70) can recover from its overturned state at an early stage.

(7-3) Feature 3

[0099] The fixed radial groove portion (82) is formed at an end portion of the fixed circumferential groove portion (81). It is thus possible to supply the lubricant sufficiently to the end portion of the fixed circumferential groove portion (81).

(7-4) Feature 4

[0100] The seal length (L1) that is the length of a portion of the facing surface (66) of the fixed scroll (60) from the

end portion of the radial groove portion (82) to the outer edge of the orbiting scroll (70) is equal to or greater than 2 mm.

[0101] This can keep the high-pressure lubricant from leaking out of the oil groove (80) while the orbiting scroll (70) is operating stably.

(7-5) Feature 5

[0102] The refrigeration apparatus (1) includes the scroll compressor (10) of this embodiment and the refrigerant circuit (1a) through which the refrigerant compressed by the scroll compressor (10) flows.

[0103] It is thus possible to provide the refrigeration apparatus (1) that includes the scroll compressor (10) configured to reduce the state of overturn of the orbiting scroll (70).

[0104] While the embodiment and variations thereof have been described above, it will be understood that various changes in form and details may be made without departing from the spirit and scope of the claims. The elements according to embodiments, the variations thereof, and the other embodiments may be combined and replaced with each other.

[0105] The expressions of "first," "second," . . . described above are used to distinguish the terms to which these expressions are given, and do not limit the number and order of the terms.

30 INDUSTRIAL APPLICABILITY

[0106] As can be seen from the foregoing description, the present disclosure is useful for a scroll compressor and a refrigeration apparatus.

35

DESCRIPTION OF REFERENCE CHARACTERS

[0107]

- | | | |
|----|----|---|
| 40 | 1 | Refrigeration Apparatus |
| | 1a | Refrigerant Circuit |
| | 10 | Scroll Compressor |
| | 20 | Casing |
| | 40 | Compression Mechanism |
| 45 | 50 | Housing |
| | 56 | Ring Groove |
| | 57 | Sealing Ring |
| | 60 | Fixed Scroll |
| | 61 | Fixed End Plate |
| 50 | 62 | Fixed Wrap |
| | 63 | Outer Circumferential Wall |
| | 66 | Facing Surface |
| | 70 | Orbiting Scroll |
| | 71 | Orbiting End Plate |
| 55 | 72 | Orbiting Wrap |
| | 80 | Fixed Oil Groove (Oil Groove) |
| | 81 | Fixed Circumferential Groove Portion (Circumferential Groove Portion) |

- 82 Fixed Radial Groove Portion (Radial Groove Portion)
- 90 Back Pressure Space
- 91 First Back Pressure Space
- 92 Second Back Pressure Space
- L1 Seal Length

Claims

1. A scroll compressor comprising: 10

a casing (20); and
 a compression mechanism (40) housed in the casing (20) and including a fixed scroll (60) and an orbiting scroll (70),
 the fixed scroll (60) including a fixed end plate (61), an outer circumferential wall (63) provided on an outer edge of the fixed end plate (61), and a fixed wrap (62) that is spiral and provided inside the outer circumferential wall (63),
 the orbiting scroll (70) including an orbiting end plate (71) with which distal ends of the fixed end plate (61) and the outer circumferential wall (63) are in sliding contact, and an orbiting wrap (72) that is spiral, provided on a front surface of the orbiting end plate (71), and meshing with the fixed wrap (62),
 the outer circumferential wall (63) having a facing surface (66) that faces the front surface of the orbiting end plate (71), the facing surface (66) having an oil groove (80) to which a lubricant with a high pressure equivalent to a discharge pressure of the compression mechanism (40) is supplied,
 the oil groove (80) having
 a circumferential groove portion (81) extending in a circumferential direction of the fixed scroll (60), and
 a radial groove portion (82) extending outward in a radial direction of the fixed scroll (60) and communicating with the circumferential groove portion (81).

2. The scroll compressor of claim 1 further comprising: 45

a housing (50) disposed on a back surface of the orbiting scroll (70), the housing (50) forming a back pressure space (90) between the housing (50) and the orbiting scroll (70), the housing (50) having an annular ring groove (56) in a surface facing the orbiting scroll (70); and
 a sealing ring (57) housed in the ring groove (56), the sealing ring (57) being in contact with the back surface of the orbiting scroll (70) to partition the back pressure space (90) into a first back pressure space (91) on an inner circumference side of the ring groove (56) and a second back pressure space (92) on an outer circum-

ference of the ring groove (56), wherein the first back pressure space (91) has a pressure equivalent to the discharge pressure of the compression mechanism (40),
 the second back pressure space (92) has a pressure equal to or higher than a pressure of a fluid sucked into the compression mechanism (40) and lower than a pressure of a fluid discharged from the compression mechanism (40), and
 the radial groove portion (82) communicates with the second back pressure space (92) when the orbiting scroll (70) tilts.

3. The scroll compressor of claim 1 or 2, wherein the radial groove portion (82) is located at an end of the circumferential groove portion (81).

4. The scroll compressor of any one of claims 1 to 3, wherein
 a seal length (L1) that is a length of a portion of the facing surface (66) from an end of the radial groove portion (82) to an outer edge of the orbiting scroll (70) is equal to or greater than 2 mm.

5. A refrigeration apparatus comprising:

the scroll compressor (10) of any one of claims 1 to 4; and
 a refrigerant circuit (1a) through which a refrigerant compressed by the scroll compressor (10) flows.

FIG.1

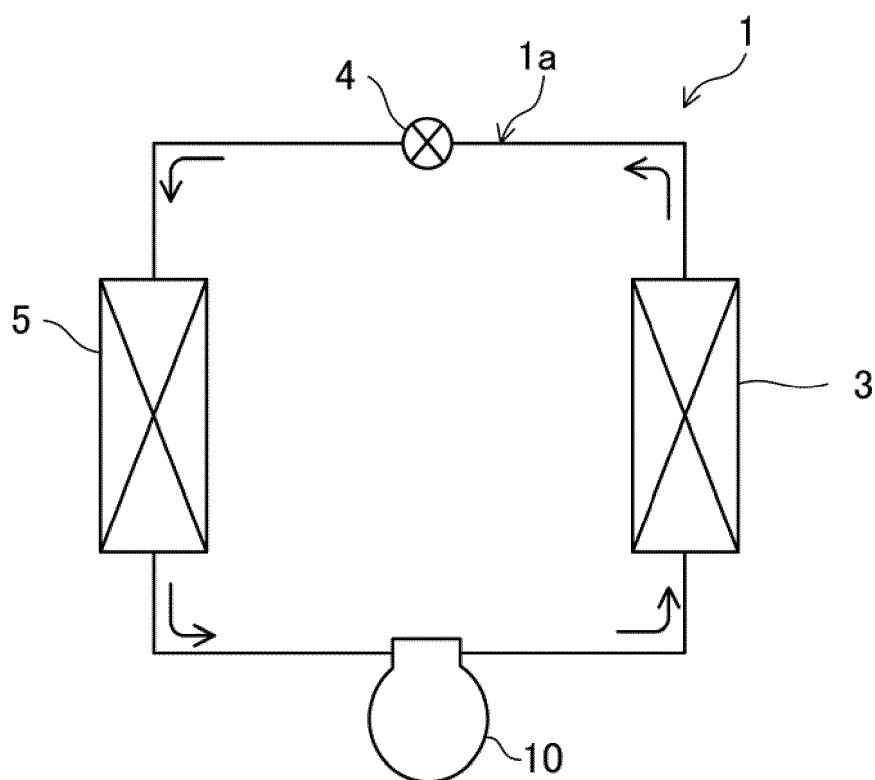


FIG.2

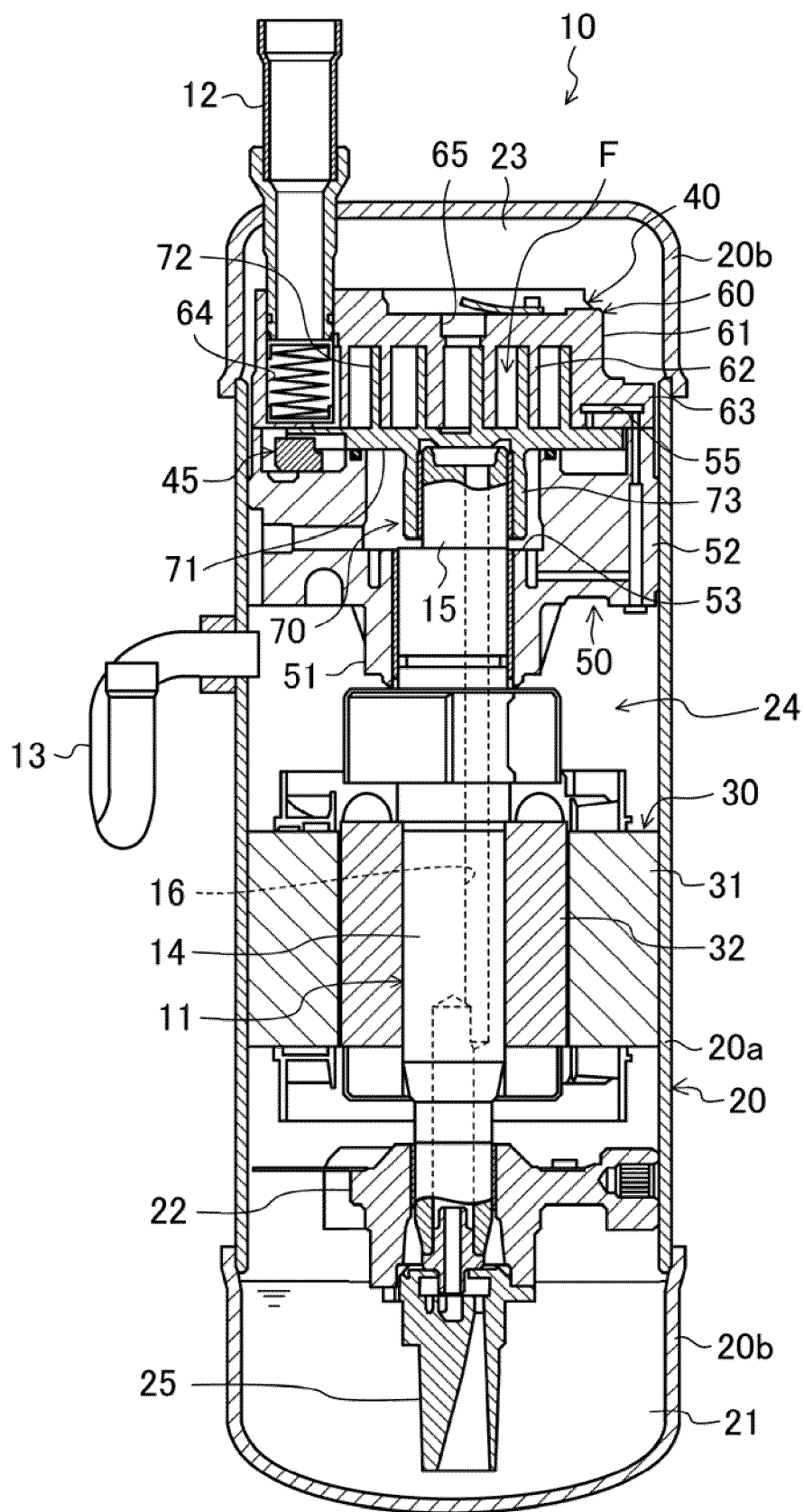


FIG.3

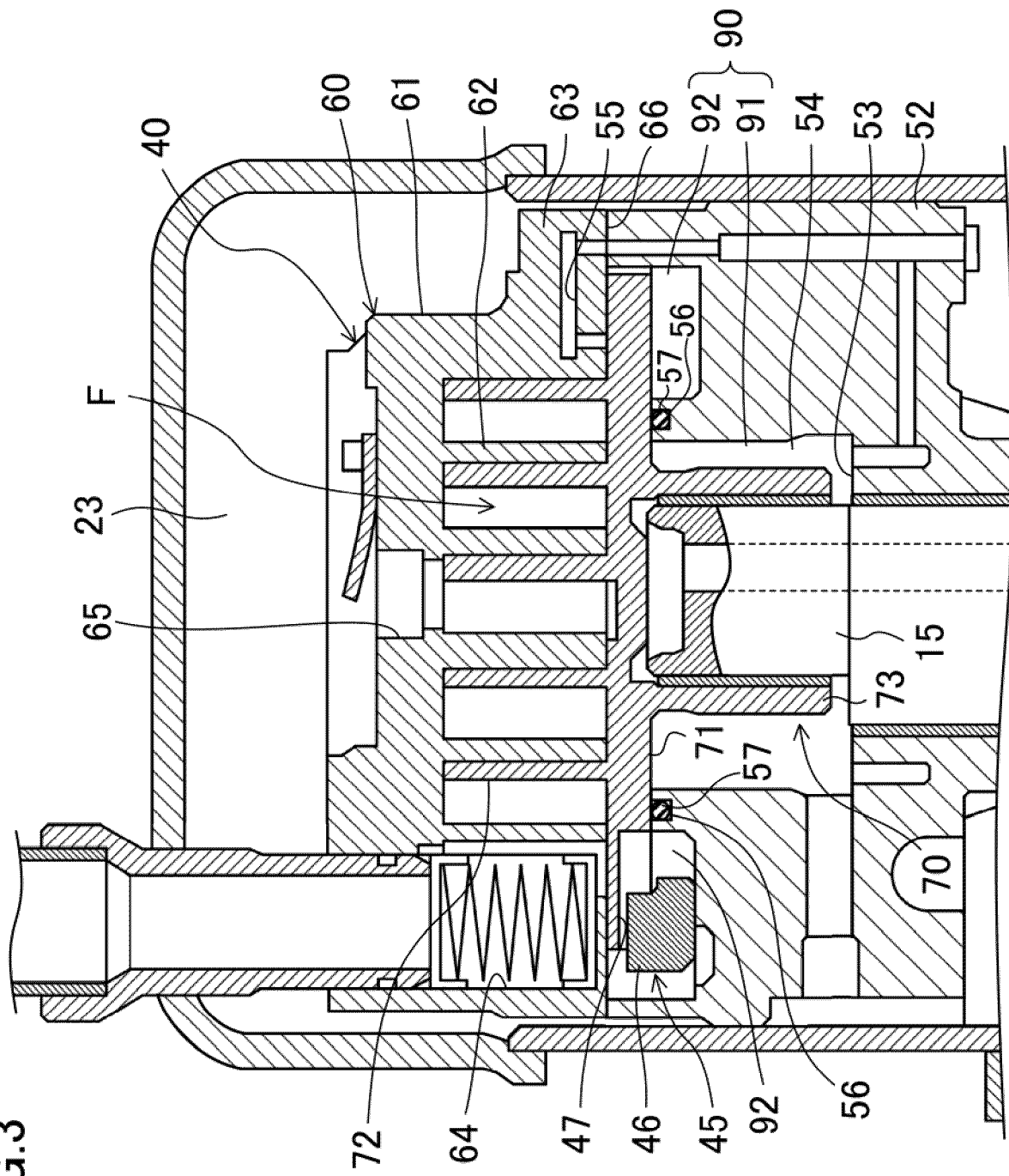


FIG.4

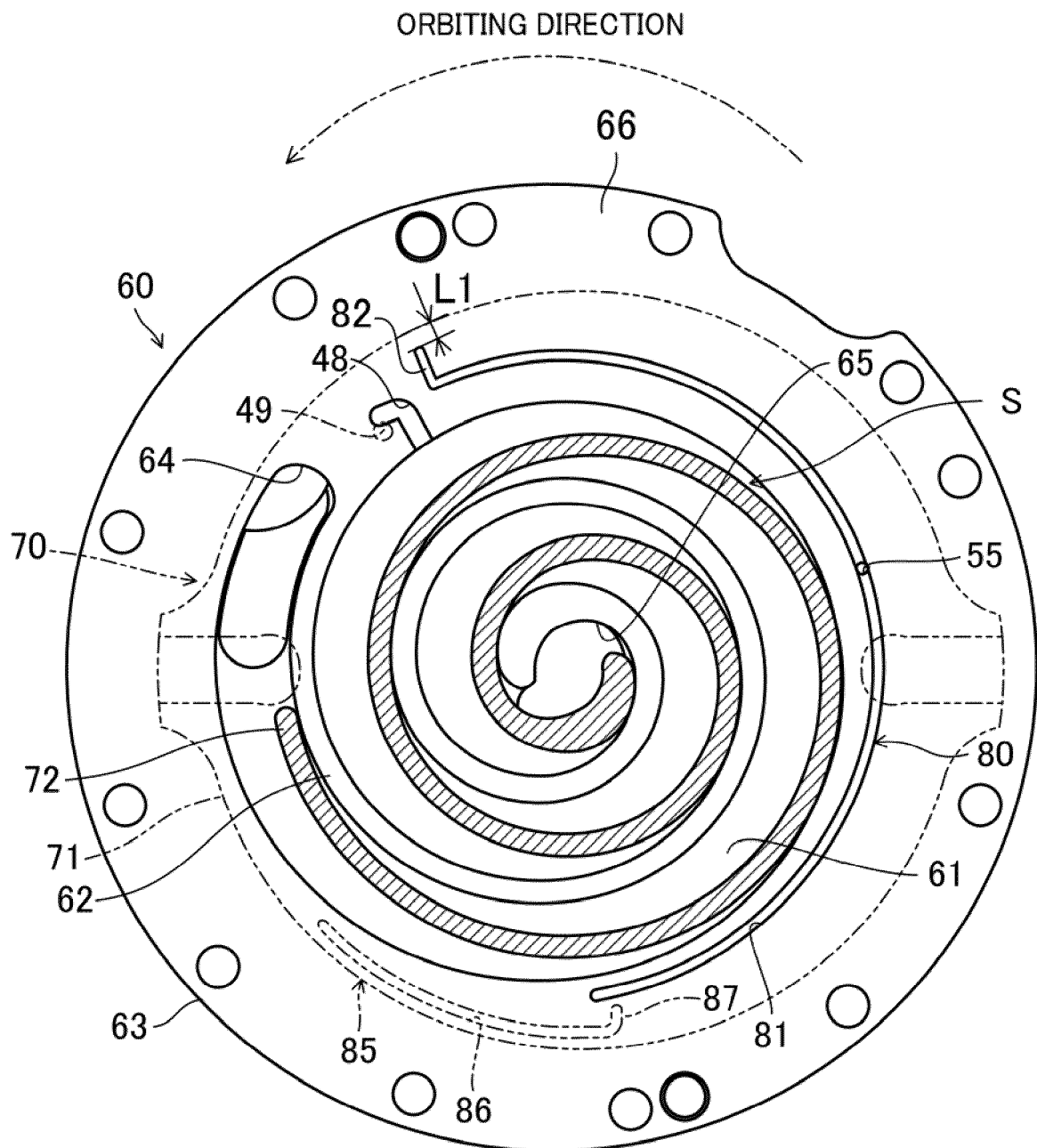


FIG.5

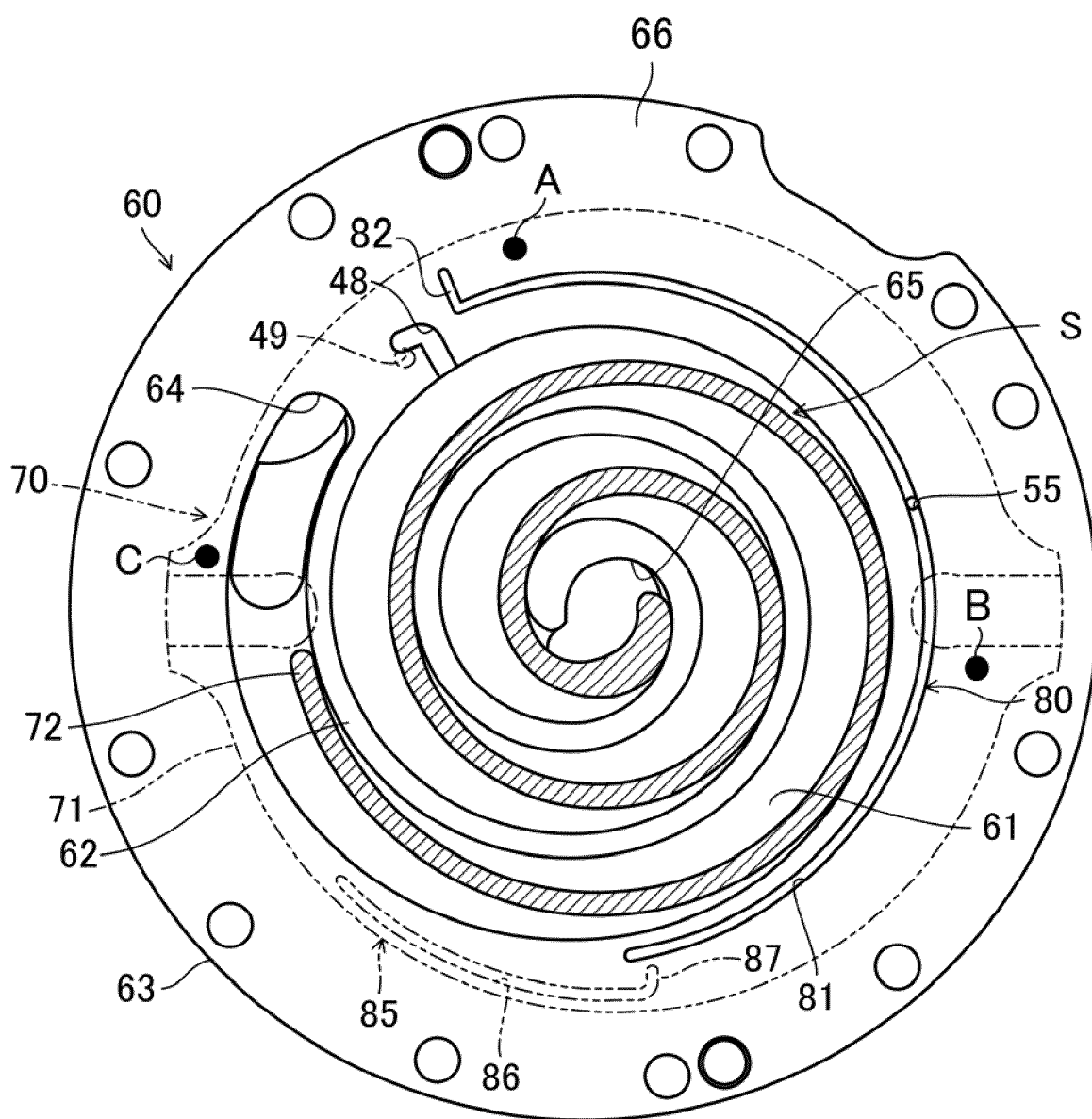


FIG.6

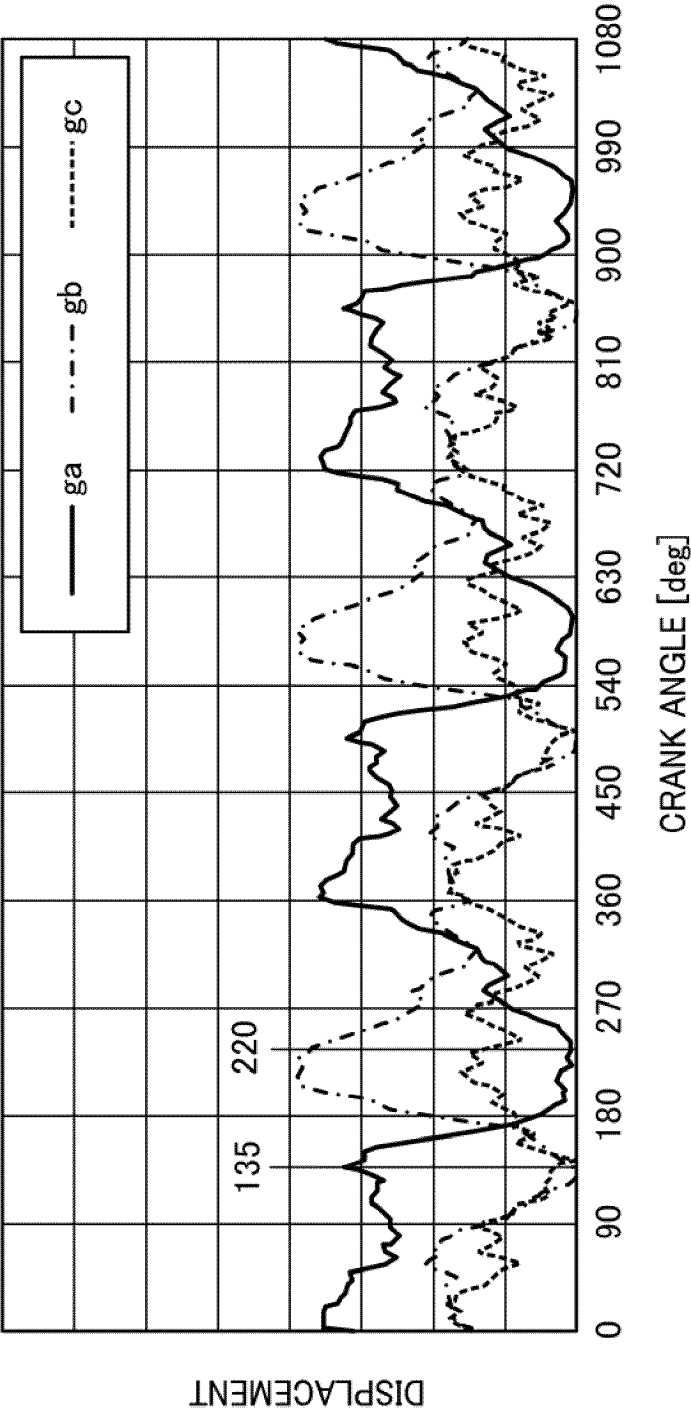
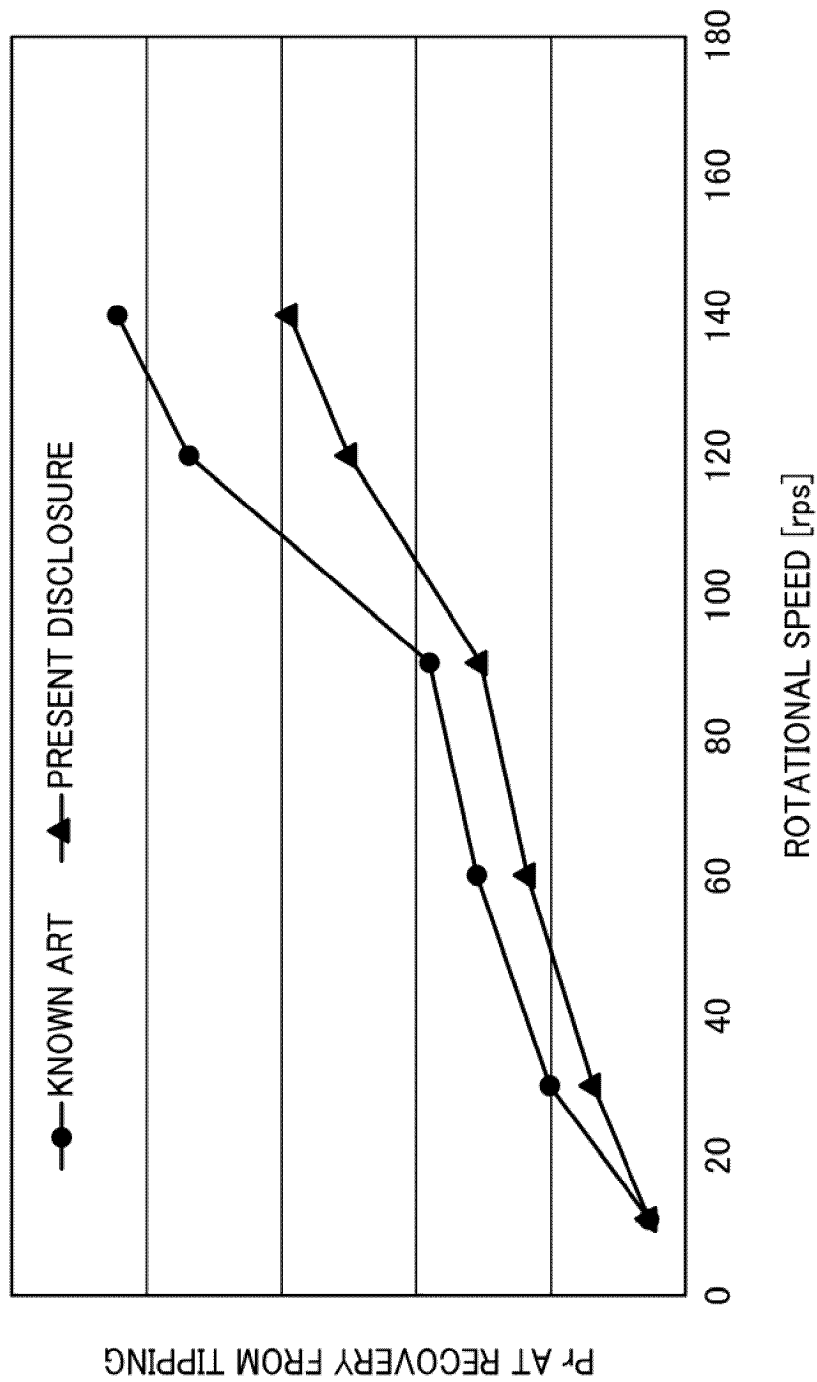


FIG.7



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2023/020160

A. CLASSIFICATION OF SUBJECT MATTER**F04C 18/02**(2006.01)i

FI: F04C18/02 311W; F04C18/02 311G

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)

F04C18/02

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 1971-2023
 Registered utility model specifications of Japan 1996-2023
 Published registered utility model applications of Japan 1994-2023

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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A		2, 4
A	JP 2000-110751 A (SANYO ELECTRIC CO LTD) 18 April 2000 (2000-04-18) paragraphs [0017]-[0021], [0027], fig. 1-2	1-5
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☒ Further documents are listed in the continuation of Box C.
 ☒ See patent family annex.

* Special categories of cited documents:	"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
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"E" earlier application or patent but published on or after the international filing date	"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"&" document member of the same patent family
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Date of the actual completion of the international search 07 August 2023	Date of mailing of the international search report 15 August 2023
Name and mailing address of the ISA/JP Japan Patent Office (ISA/JP) 3-4-3 Kasumigaseki, Chiyoda-ku, Tokyo 100-8915 Japan	Authorized officer Telephone No.

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

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2023/020160

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.

PCT/JP2023/020160

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