



(11)

EP 4 826 250 A1

(12)

EUROPEAN PATENT APPLICATION
published in accordance with Art. 153(4) EPC

(43) Date of publication:
21.10.2026 Bulletin 2026/43

(51) International Patent Classification (IPC):
F04C 18/02 (2006.01)

(21) Application number: **24920274.8**

(52) Cooperative Patent Classification (CPC):
F04C 18/02

(22) Date of filing: **17.10.2024**

(86) International application number:
PCT/JP2024/037007

(87) International publication number:
WO 2025/158726 (31.07.2025 Gazette 2025/31)

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC ME MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA
Designated Validation States:
GE KH MA MD TN

(71) Applicant: **DAIKIN INDUSTRIES, LTD.**
Osaka-shi, Osaka 530-0001 (JP)

(72) Inventor: **NAGAHARA, Kenji**
Osaka-shi, Osaka 530-0001 (JP)

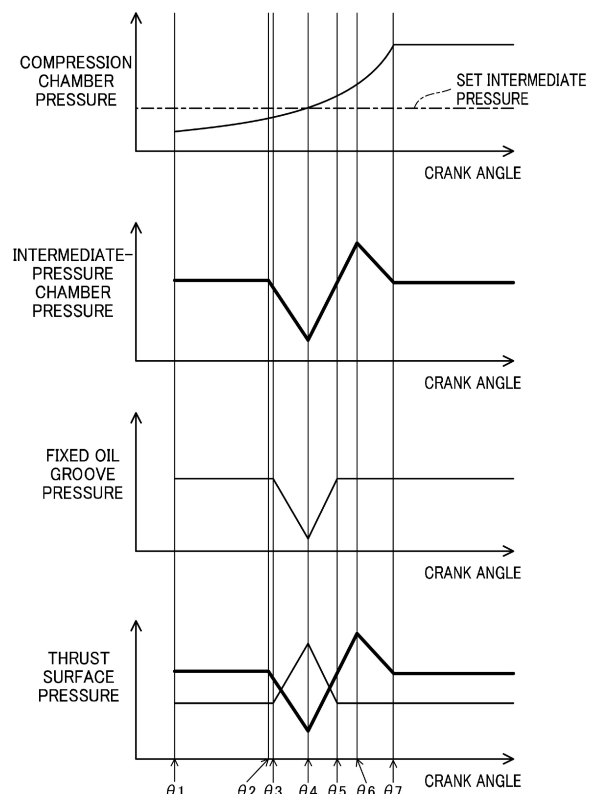
(74) Representative: **Goddard, Heinz J.**
Boehmert & Boehmert
Anwaltpartnerschaft mbB
Pettenkoferstrasse 22
80336 München (DE)

(30) Priority: **26.01.2024 JP 2024010077**

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

(57) As viewed in an axial direction, an intermediate-pressure port (49) overlaps an intermediate-pressure path (48) in a predetermined angular range of an orbiting motion of a movable scroll (70). As viewed in the axial direction, a movable oil groove (85) communicates with a compression chamber (S) in a predetermined angular range of the orbiting motion of the movable scroll (70). A state in which the movable oil groove (85) and the compression chamber (S) communicate with each other ends before an end of a communication section in which the intermediate-pressure port (49) communicates with the intermediate-pressure path (48).

FIG.6



EP 4 826 250 A1

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 having a fixed scroll and a movable scroll; and an intermediate-pressure portion that applies an intermediate pressure to a portion of the back surface of the movable scroll.

[0003] In Patent Document 1, a movable oil groove of the movable scroll communicates with a fixed oil groove; and when a wrap groove of the fixed scroll is in a refrigerant-sucking state, the movable oil groove communicates with the outermost circumferential portion of the wrap groove, and when the wrap groove forms a compression chamber, the movable oil groove is blocked from the wrap groove.

CITATION LIST

PATENT DOCUMENT

[0004] PATENT DOCUMENT 1: Japanese Patent No. 5691352

SUMMARY OF THE INVENTION

TECHNICAL PROBLEM

[0005] Here, the thrust surface pressure may locally increase, which may result in deterioration of the sliding conditions, when a section in which the push-back force caused by the pressure of the fixed oil groove is reduced by the communication of the movable oil groove with the compression chamber coincides with a section in which the pressing force is increased due to an increase in the pressure in the intermediate-pressure chamber during the second half of the intermediate-pressure communication section.

[0006] It is an object of the present disclosure to suppress an increase in thrust surface pressure by appropriately setting the timing of pressure fluctuations in an intermediate-pressure chamber and the timing of pressure fluctuations in a fixed oil groove.

SOLUTION TO THE PROBLEM

[0007] A first aspect of the present disclosure is directed to a scroll compressor including: a fixed scroll (60) including a fixed wrap (62) and a fixed end plate (61); and a movable scroll (70) including a movable wrap (72) and a movable end plate (71), the fixed wrap (62) and the movable wrap (72) meshing with each

other to form a compression chamber (S), wherein the fixed end plate (61) has a fixed oil groove (80) in a surface facing the movable end plate (71), and an intermediate-pressure path (48) that communicates with a space in the compression chamber (S), in which space a refrigerant having an intermediate pressure higher than a pressure of a suction refrigerant and lower than a pressure of a discharge refrigerant flows, the movable end plate (71) has a movable oil groove (85) in a surface facing the fixed end plate (61), and an intermediate-pressure port (49) that communicates with an intermediate-pressure chamber (43) provided on a side of the movable end plate (71) opposite the fixed end plate (61), as viewed in an axial direction, the intermediate-pressure port (49) overlaps the intermediate-pressure path (48) in a predetermined angular range of an orbiting motion of the movable scroll (70), as viewed in the axial direction, the movable oil groove (85) communicates with the compression chamber (S) in a predetermined angular range of the orbiting motion of the movable scroll (70), and a state in which the movable oil groove (85) and the compression chamber (S) communicate with each other ends before an end of a communication section in which the intermediate-pressure port (49) communicates with the intermediate-pressure path (48).

[0008] According to the first aspect, an increase in the thrust surface pressure can be suppressed by causing the timing at which the pressing force pressing the movable scroll (70) toward the fixed scroll (60) increases due to pressure fluctuations in the intermediate-pressure chamber (43) to coincide with the timing at which the push-back force pushing the movable scroll (70) back so as to separate from the fixed scroll (60) increases due to pressure fluctuations in the fixed oil groove (80).

[0009] A second aspect of the present disclosure is an embodiment of the scroll compressor of the first aspect. In the second aspect, the state in which the movable oil groove (85) and the compression chamber (S) communicate with each other starts after a start of the communication section in which the intermediate-pressure port (49) communicates with the intermediate-pressure path (48).

[0010] According to the second aspect, an increase in the thrust surface pressure can be suppressed at an appropriate timing.

[0011] A third aspect of the present disclosure is an embodiment of the scroll compressor of the first or second aspect. In the third aspect, the movable oil groove (85) and the compression chamber (S) communicate with each other in an angular range of 50% or more of the communication section.

[0012] According to the third aspect, an increase in the thrust surface pressure can be suppressed in a predetermined angular range in the communication section.

[0013] A fourth aspect of the present disclosure is an

embodiment of the scroll compressor of any one of the first to third aspects. In the fourth aspect, the state in which the movable oil groove (85) and the compression chamber (S) communicate with each other ends in an angular range greater than 0° and less than or equal to 30° before the end of the communication.

[0014] According to the fourth aspect, an increase in the thrust surface pressure can be suppressed in a predetermined angular range before the end of the communication.

[0015] A fifth aspect of the present disclosure is an embodiment of the scroll compressor of any one of the second to fourth aspects. In the fifth aspect, the state in which the movable oil groove (85) and the compression chamber (S) communicate with each other starts in an angular range greater than or equal to 0° and less than or equal to 10° after the start of the communication.

[0016] According to the fifth aspect, an increase in the thrust surface pressure can be suppressed in a predetermined angular range after the start of the communication.

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

[0018] According to the sixth aspect, it is possible to provide a refrigeration apparatus including the scroll compressor (10) and the refrigerant circuit (1a).

BRIEF DESCRIPTION OF THE DRAWINGS

[0019]

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

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

[FIG. 3] FIG. 3 is a diagram illustrating a bottom view of a configuration of a fixed scroll.

[FIG. 4] FIG. 4 is a diagram illustrating a plan view of a configuration of a movable scroll.

[FIG. 5] FIG. 5 is a diagram illustrating a plan view showing the timing of the suction shutoff of a space outside the movable scroll.

[FIG. 6] FIG. 6 is a graph showing a relationship between the crank angle of the drive shaft and each of the pressure in a compression chamber, the pressure in an intermediate-pressure chamber, the pressure in a fixed oil groove, and the thrust surface pressure.

[FIG. 7] FIG. 7 is a diagram illustrating a plan view showing the timing immediately before an intermediate-pressure port communicates with an intermediate-pressure path.

[FIG. 8] FIG. 8 is a diagram illustrating a plan view showing the timing after part of the intermediate-

pressure port communicates with the intermediate-pressure path.

[FIG. 9] FIG. 9 is a diagram illustrating a plan view showing the timing at which the entire intermediate-pressure port communicates with the intermediate-pressure path.

[FIG. 10] FIG. 10 is a diagram illustrating a plan view showing the timing before the end of the intermediate-pressure communication section and at which part of the intermediate-pressure port communicates with the intermediate-pressure path.

[FIG. 11] FIG. 11 is a diagram illustrating a plan view showing the timing immediately after the intermediate-pressure port separates from the intermediate-pressure path.

[FIG. 12] FIG. 12 is a graph showing a relationship between the crank angle of the drive shaft and each of the groove pressure and the intermediate pressure.

[FIG. 13] FIG. 13 is a graph showing a relationship between the crank angle of the drive shaft and each of the pressure in a compression chamber, the pressure in an intermediate-pressure chamber, the pressure in a fixed oil groove, and the thrust surface pressure according to a comparative example.

[FIG. 14] FIG. 14 is a graph showing a relationship between the crank angle of the drive shaft and each of the groove pressure and the intermediate pressure according to the comparative example.

DESCRIPTION OF EMBODIMENTS

[0020] 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.

[0021] 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 the air in an internal space of a refrigerator, a freezer, a container, or the like.

[0022] As illustrated in FIG. 2, the scroll compressor (10) includes a casing (20), an electric motor (30), and a compression mechanism (40). The casing (20) has a vertically oriented cylindrical shape, and is configured

as a closed dome. The casing (20) houses the electric motor (30) and the compression mechanism (40).

[0023] The electric motor (30) includes 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). A drive shaft (11) passes through the rotor (32). The rotor (32) is fixed to the drive shaft (11).

[0024] The casing (20) has, at its bottom, an oil reservoir (21). The oil reservoir (21) stores oil. A suction pipe (12) is connected to an upper portion of the casing (20). A discharge pipe (13) is connected to a barrel of the casing (20).

[0025] A housing (50) is fixed to the casing (20). The housing (50) is fixed to the inside of the casing (20) by, for example, shrink fitting. The housing (50) is located above the electric motor (30). The compression mechanism (40) is located above the housing (50). The discharge pipe (13) has an inflow end between the electric motor (30) and the housing (50).

[0026] The housing (50) has a recess (53). The recess (53) is a recessed portion of the upper surface of the housing (50). An upper bearing (51) is located below the recess (53).

[0027] The drive shaft (11) extends in the up-and-down direction 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 main shaft portion (14) has a lower portion rotatably supported by a lower bearing (22). The lower bearing (22) is fixed to the inner circumferential surface of the casing (20). The lower bearing (22) is provided with a positive-displacement pump (25), for example. The main shaft portion (14) has an upper portion passing through the housing (50) and rotatably supported by the upper bearing (51) of the housing (50).

[0029] The compression mechanism (40) includes a fixed scroll (60) and a movable scroll (70). The fixed scroll (60) is fixed to the upper surface of the housing (50). The movable scroll (70) is arranged between the fixed scroll (60) and the housing (50).

[0030] The fixed scroll (60) includes a fixed end plate (61), a fixed wrap (62), and an outer peripheral wall (63). The outer peripheral wall (63) is substantially tubular. The outer peripheral wall (63) is erected at an outer edge of the front surface (the lower surface in FIG. 2) of the fixed end plate (61).

[0031] The fixed wrap (62) is spiral. The fixed wrap (62) is erected on a portion of the fixed end plate (61) inside the outer peripheral wall (63).

[0032] The fixed end plate (61) is located on an outer side and is continuous with the fixed wrap (62). The distal end surface of the fixed wrap (62) and the distal end surface of the outer peripheral wall (63) are substantially flush with each other. The fixed scroll (60) is fixed to the housing (50).

[0033] The movable scroll (70) includes a movable end plate (71), a movable wrap (72), and a boss (73). The movable wrap (72) is spiral. The movable wrap (72) is provided on the upper surface of the movable end plate (71). The movable wrap (72) meshes with the fixed wrap (62).

[0034] The boss (73) is formed on a central portion of the lower surface of the movable end plate (71). The eccentric portion (15) of the drive shaft (11) is inserted into the boss (73), whereby the drive shaft (11) is connected.

[0035] An Oldham coupling (45) is provided at an upper portion of the housing (50). The Oldham coupling (45) blocks the rotation of the movable scroll (70) on its axis. The Oldham coupling (45) is provided with a key (46). The key (46) protrudes toward the lower surface of the movable end plate (71) of the movable scroll (70). The lower surface of the movable end plate (71) of the movable scroll (70) has a keyway (47). The key (46) of the Oldham coupling (45) is slidably fitted to the keyway (47).

[0036] Although not shown, a key is also 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).

[0037] The compression mechanism (40) has a compression chamber (S) into which the refrigerant flows. The compression chamber (S) is formed between the fixed scroll (60) and the movable scroll (70). The movable scroll (70) is placed so that the movable wrap (72) meshes with the fixed wrap (62) of the fixed scroll (60). Here, the lower surface of the outer peripheral wall (63) of the fixed scroll (60) serves as a thrust surface with respect to the movable scroll (70). On the other hand, the upper surface of the movable end plate (71) of the movable scroll (70) serves as a thrust surface with respect to the fixed scroll (60).

[0038] The outer peripheral 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 an outlet (65) at its center. 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 a lower space (24) via a passage (not shown) formed in the housing (50).

[0040] An oil supply passage (16) is formed inside the drive shaft (11). The oil supply passage (16) extends in the up-and-down direction from the lower end to the upper end of the drive shaft (11). A lower end portion of the drive shaft (11) is connected to the pump (25). A lower end portion of the pump (25) is immersed in the oil reservoir (21). The pump (25) sucks up the oil from the oil reservoir (21) as the drive shaft (11) rotates, and transfers the oil to the oil supply passage (16). The

oil supply passage (16) supplies the oil 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 oil to above the drive shaft (11).

[0041] 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 movable scroll (70). The high-pressure oil is supplied to the recess (53), so that a high pressure equivalent to the discharge pressure of the compression mechanism (40) acts on the recess (53). The movable scroll (70) is pressed onto the fixed scroll (60) by the high pressure in the recess (53) and the intermediate pressure in an intermediate-pressure chamber (43), which will be described later.

[0042] 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 thrust surface of the fixed scroll (60). Through the oil path (55), the high-pressure oil in the recess (53) is supplied to the thrust surfaces of the movable end plate (71) of the movable scroll (70) and the outer peripheral wall (63) of the fixed scroll (60).

[0043] The lower surface of the outer peripheral wall (63) of the fixed scroll (60) has an intermediate-pressure path (48) and a fixed oil groove (80) (see FIG. 3). The inner end of the intermediate-pressure path (48) is open to the inner circumferential surface of the outer peripheral wall (63). The intermediate-pressure path (48) communicates with a space in the compression chamber (S), in which space a refrigerant having an intermediate pressure higher than the pressure of the suction refrigerant and lower than the pressure of the discharge refrigerant flows.

[0044] The fixed oil groove (80) is formed in the thrust surface of the outer peripheral wall (63) of the fixed end plate (61) facing the movable end plate (71). The fixed oil groove (80) extends in a circumferential direction along the inner circumferential surface of the outer peripheral wall (63) of the fixed scroll (60). The oil path (55) communicates with the fixed oil groove (80), and oil is supplied to the fixed oil groove (80) from the oil path (55).

[0045] The intermediate-pressure chamber (43) is formed between the movable scroll (70) and the housing (50). The intermediate-pressure chamber (43) is formed on the side of the movable end plate (71) opposite the fixed end plate (61). The intermediate-pressure chamber (43) is provided radially outward of the recess (53) of the housing (50).

[0046] An outer circumferential portion of the movable end plate (71) of the movable scroll (70) has an intermediate-pressure port (49) (see FIG. 4). The inter-

mediate-pressure port (49) is configured as a through hole passing through the movable end plate (71) in the up-and-down direction. As viewed in the axial direction, the intermediate-pressure port (49) overlaps the intermediate-pressure path (48) in a predetermined angular range of the orbiting motion of the movable scroll (70).

[0047] The intermediate-pressure port (49) has an upper end that intermittently communicates with the outer end portion of the intermediate-pressure path (48), and a lower end that communicates with the intermediate-pressure chamber (43) between the movable scroll (70) and the housing (50). That is, the intermediate-pressure refrigerant is intermittently supplied from the compression chamber (S) at intermediate pressure to the intermediate-pressure chamber (43). The intermediate-pressure chamber (43) therefore has a predetermined intermediate pressure.

[0048] The thrust surface of the movable end plate (71) facing the fixed end plate (61) has a movable oil groove (85). As viewed in the axial direction, the movable oil groove (85) communicates with the fixed oil groove (80) and the compression chamber (S) in a predetermined angular range of the orbiting motion of the movable scroll (70).

-Operation-

[0049] A basic operation of the scroll compressor (10) will be described. In FIG. 2, when the electric motor (30) is activated, the drive shaft (11) to which the rotor (32) is fixed is driven to rotate. Since the rotation of the movable scroll (70) on its own axis is blocked by the Oldham coupling (45), the movable scroll (70) makes an orbiting motion about the axis of the drive shaft (11).

[0050] The orbiting motion of the movable scroll (70) causes the refrigerant to be compressed in the compression chamber (S). The high-pressure gas refrigerant compressed in the compression chamber (S) is discharged from the outlet (65), and flows into the lower space (24) via the passage (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).

[0051] The rotation of the drive shaft (11) causes the high-pressure oil in the oil reservoir (21) to be sucked up by the pump (25). The oil 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 movable scroll (70).

[0052] The oil 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 recess (53) of the housing (50) has a high pressure equivalent to the discharge pressure of the compression mechanism (40). The movable scroll (70) is pressed onto the fixed

scroll (60) by the high pressure in the recess (53) and the intermediate pressure in the intermediate-pressure chamber (43).

[0053] The high-pressure oil accumulated in the recess (53) flows out through the oil path (55) to the fixed oil groove (80). Accordingly, the oil with the high pressure equivalent to the discharge pressure of the compression mechanism (40) is supplied to the fixed oil groove (80).

<Thrust Surface Pressure>

[0054] A thrust surface pressure that acts on the sliding surfaces of the fixed scroll (60) and the movable scroll (70) is determined by the difference between a load that pushes the movable scroll (70) back downward and a load that presses the movable scroll (70) upward.

[0055] Specifically, the load that pushes the movable scroll (70) back downward is the sum of the push-back force caused by the pressure in the compression chamber (S) and the push-back force caused by the fixed oil groove (80). The load that presses the movable scroll (70) upward is the sum of the pressing force caused by the high pressure in the recess (53) of the housing (50) and the pressing force caused by the intermediate pressure in the intermediate-pressure chamber (43).

[0056] Here, during the orbiting motion of the movable scroll (70), the thrust surface pressure may locally increase, which may result in deterioration of the sliding conditions, when a section in which the push-back force caused by the pressure of the fixed oil groove (80) is reduced by the communication of the movable oil groove (85) with the compression chamber (S) coincides with a section in which the pressing force is increased due to an increase in the pressure in the intermediate-pressure chamber (43) during the second half of the intermediate-pressure communication section.

[0057] To address this, in this embodiment, an increase in thrust surface pressure is suppressed by appropriately setting the timing of pressure fluctuations in the intermediate-pressure chamber (43) and the timing of pressure fluctuations in the fixed oil groove (80).

[0058] Specifically, a case will be described in which the movable scroll (70) is rotated counterclockwise, with the suction shutoff angle of a space outside the movable wrap (72) in the compression chamber (S) set to be 0° as illustrated in FIG. 5.

[0059] As illustrated in FIG. 6, angle θ_1 is the timing at which the suction into the space outside the movable scroll (70) is shut off (see FIG. 5). At angle θ_1 , the intermediate-pressure port (49) does not communicate with the intermediate-pressure path (48). In addition, the movable oil groove (85) does not communicate with the compression chamber (S).

[0060] Angle θ_2 is the timing immediately before the intermediate-pressure port (49) communicates with the intermediate-pressure path (48) (see FIG. 7). At angle

θ_2 , the intermediate-pressure port (49) does not communicate with the intermediate-pressure path (48). In addition, the movable oil groove (85) does not communicate with the compression chamber (S). The intermediate-pressure port (49) communicates with the intermediate-pressure path (48) from angle θ_2 to angle θ_3 .

[0061] Angle θ_3 is the timing after part of the intermediate-pressure port (49) communicates with the intermediate-pressure path (48) (see FIG. 8). At angle θ_3 , the intermediate-pressure port (49) communicates with the intermediate-pressure path (48). In addition, the movable oil groove (85) does not communicate with the compression chamber (S). The movable oil groove (85) communicates with the compression chamber (S) from angle θ_3 to angle θ_4 .

[0062] In this manner, the state in which the movable oil groove (85) and the compression chamber (S) communicate with each other starts after the start of a communication section in which the intermediate-pressure port (49) communicates with the intermediate-pressure path (48). Here, the pressure in the compression chamber (S) is lower than a set intermediate pressure in the first half of the intermediate-pressure communication section, i.e., from angle θ_3 to angle θ_4 . Accordingly, the pressure in the intermediate-pressure chamber (43) is lower than the set intermediate pressure from angle θ_3 to angle θ_4 .

[0063] Angle θ_4 is the timing at which the entire intermediate-pressure port (49) communicates with the intermediate-pressure path (48) (see FIG. 9). At angle θ_4 , the intermediate-pressure port (49) communicates with the intermediate-pressure path (48). In addition, the movable oil groove (85) communicates with the compression chamber (S). The amount of oil to be supplied from the fixed oil groove (80) to the compression chamber (S) through the movable oil groove (85) increases from angle θ_3 to angle θ_4 . Accordingly, the pressure in the fixed oil groove (80) decreases from angle θ_3 to angle θ_4 .

[0064] Angle θ_5 is the timing before the end of the intermediate-pressure communication section and at which part of the intermediate-pressure port (49) communicates with the intermediate-pressure path (48) (see FIG. 10). At angle θ_5 , the intermediate-pressure port (49) communicates with the intermediate-pressure path (48). In addition, the movable oil groove (85) does not communicate with the compression chamber (S). Accordingly, the state in which the movable oil groove (85) and the compression chamber (S) communicate with each other ends before the end of the communication section in which the intermediate-pressure port (49) communicates with the intermediate-pressure path (48).

[0065] The amount of oil to be supplied from the fixed oil groove (80) to the compression chamber (S) through the movable oil groove (85) decreases from angle θ_4 to angle θ_5 . Accordingly, the pressure in the fixed oil

groove (80) increases from angle $\theta 4$ to angle $\theta 5$. As a result, the pressure in the fixed oil groove (80) becomes high in the angular range after angle $\theta 5$.

[0066] Angle $\theta 6$ is the timing immediately after the intermediate-pressure port (49) separates from the intermediate-pressure path (48) (see FIG. 11). At angle $\theta 6$, the intermediate-pressure port (49) does not communicate with the intermediate-pressure path (48). In addition, the movable oil groove (85) does not communicate with the compression chamber (S). At angle $\theta 6$, the pressure in the intermediate-pressure chamber (43) is higher than the set intermediate pressure. Thereafter, the pressure is lowered to the set intermediate pressure from angle $\theta 6$ to angle $\theta 7$.

[0067] As described above, the pressure in the intermediate-pressure chamber (43) increases in the second half of the intermediate-pressure communication section in the angular range of the orbiting motion of the movable scroll (70), i.e., from angle $\theta 4$ to angle $\theta 6$, thereby increasing the pressing force applied upward to the movable scroll (70) from angle $\theta 4$ to angle $\theta 6$.

[0068] On the other hand, the pressure in the fixed oil groove (80) increases from angle $\theta 4$ to angle $\theta 5$, thereby increasing the push-back force applied downward to the movable scroll (70) from angle $\theta 4$ to angle $\theta 5$. The pressure in the fixed oil groove (80) is substantially constant from angle $\theta 5$ to angle $\theta 6$.

[0069] Thus, an increase in the thrust surface pressure can be suppressed by causing the timing at which the pressing force pressing the movable scroll (70) toward the fixed scroll (60) increases due to pressure fluctuations in the intermediate-pressure chamber (43) to coincide with the timing at which the push-back force pushing the movable scroll (70) back so as to separate from the fixed scroll (60) increases due to pressure fluctuations in the fixed oil groove (80), as shown in FIG. 12.

[0070] It is preferable that the movable oil groove (85) and the compression chamber (S) communicate with each other in an angular range of 50% or more of the intermediate-pressure communication section. In the example shown in FIG. 6, it is preferable that the angular range from angle $\theta 3$ to angle $\theta 5$, which is a section in which the movable oil groove (85) and the compression chamber (S) communicate with each other, be set to be 50% or more with respect to the angular range from angle $\theta 2$ to angle $\theta 6$, which is a section in which the intermediate-pressure port (49) and the intermediate-pressure path (48) communicate with each other.

[0071] It is preferable that angle $\theta 5$ at which the state of communication between the movable oil groove (85) and the compression chamber (S) ends be set, relative to angle $\theta 6$ before the end of the communication section in which the intermediate-pressure port (49) communicates with the intermediate-pressure path (48), within an angular range greater than 0° and less than or equal to 30° before the end of the communication.

tion.

[0072] It is also preferable that angle $\theta 3$ at which the state of communication between the movable oil groove (85) and the compression chamber (S) starts be set, relative to angle $\theta 2$ after the start of the communication section in which the intermediate-pressure port (49) communicates with the intermediate-pressure path (48), within an angular range greater than or equal to 0° and less than or equal to 10° after the start of the communication.

[0073] As a comparative example, the following case will be described below with reference to FIG. 13, in which during the orbiting motion of the movable scroll (70), a section in which the push-back force caused by the pressure of the fixed oil groove (80) is reduced by the communication of the movable oil groove (85) with the compression chamber (S) coincides with a section in which the pressing force is increased due to an increase in the pressure in the intermediate-pressure chamber (43) during the second half of the intermediate-pressure communication section.

[0074] As illustrated in FIG. 13, angle $\theta 1'$ is the timing at which the suction into the space outside the movable scroll (70) is shut off. At angle $\theta 1'$, the intermediate-pressure port (49) does not communicate with the intermediate-pressure path (48). In addition, the movable oil groove (85) does not communicate with the compression chamber (S).

[0075] Angle $\theta 2'$ is the timing immediately before the intermediate-pressure port (49) communicates with the intermediate-pressure path (48). At angle $\theta 2'$, the intermediate-pressure port (49) does not communicate with the intermediate-pressure path (48). In addition, the movable oil groove (85) does not communicate with the compression chamber (S). The intermediate-pressure port (49) communicates with the intermediate-pressure path (48) from angle $\theta 2'$ to angle $\theta 3'$.

[0076] Angle $\theta 3'$ is the timing at which the entire intermediate-pressure port (49) communicates with the intermediate-pressure path (48). At angle $\theta 3'$, the intermediate-pressure port (49) communicates with the intermediate-pressure path (48). In addition, the movable oil groove (85) does not communicate with the compression chamber (S).

[0077] Angle $\theta 4'$ is the timing immediately before the movable oil groove (85) communicates with the compression chamber (S). At angle $\theta 4'$, the intermediate-pressure port (49) communicates with the intermediate-pressure path (48). In addition, the movable oil groove (85) does not communicate with the compression chamber (S). The movable oil groove (85) communicates with the compression chamber (S) from angle $\theta 4'$ to angle $\theta 5'$. At this moment, the amount of oil to be supplied from the fixed oil groove (80) to the compression chamber (S) through the movable oil groove (85) increases. Accordingly, the pressure in the fixed oil groove (80) decreases from angle $\theta 4'$ to angle $\theta 5'$.

[0078] Angle $\theta 5'$ is the timing immediately after the

intermediate-pressure port (49) separates from the intermediate-pressure path (48). At angle $\theta 5'$, the intermediate-pressure port (49) does not communicate with the intermediate-pressure path (48). In addition, the movable oil groove (85) communicates with the compression chamber (S). At angle $\theta 5'$, the pressure in the intermediate-pressure chamber (43) is higher than the set intermediate pressure. Thereafter, the pressure is lowered to the set intermediate pressure from angle $\theta 5'$ to angle $\theta 7'$.

[0079] Angle $\theta 6'$ is the timing at which the state of communication between the movable oil groove (85) and the compression chamber (S) ends. At angle $\theta 6'$, the intermediate-pressure port (49) does not communicate with the intermediate-pressure path (48). In addition, the movable oil groove (85) does not communicate with the compression chamber (S).

[0080] Accordingly, in the comparative example, the pressure in the intermediate-pressure chamber (43) increases from angle $\theta 3'$ to angle $\theta 5'$, thereby increasing the pressing force applied upward to the movable scroll (70) from angle $\theta 3'$ to angle $\theta 5'$.

[0081] On the other hand, the pressure in the fixed oil groove (80) decreases from angle $\theta 4'$ to angle $\theta 5'$, thereby decreasing the push-back force applied downward to the movable scroll (70) from angle $\theta 4'$ to angle $\theta 5'$.

[0082] Thus, a section in which the push-back force caused by the pressure of the fixed oil groove (80) is reduced by the communication of the movable oil groove (85) with the compression chamber (S) coincides with a section in which the pressing force is increased due to an increase in the pressure in the intermediate-pressure chamber (43) during the second half of the intermediate-pressure communication section; and the thrust surface pressure may locally increase, which may result in deterioration of the sliding conditions (see FIG. 14).

[0083] To address this, in the scroll compressor (10) of this embodiment, an increase in thrust surface pressure is suppressed by appropriately setting the timing of pressure fluctuations in the intermediate-pressure chamber (43) and the timing of pressure fluctuations in the fixed oil groove (80).

-Advantages of Embodiment-

[0084] According to a feature of the present embodiment, an increase in the thrust surface pressure can be suppressed by causing the timing at which the pressing force pressing the movable scroll (70) toward the fixed scroll (60) increases due to pressure fluctuations in the intermediate-pressure chamber (43) to coincide with the timing at which the push-back force pushing the movable scroll (70) back so as to separate from the fixed scroll (60) increases due to pressure fluctuations in the fixed oil groove (80).

[0085] According to a feature of this embodiment, the

state in which the movable oil groove (85) and the compression chamber (S) communicate with each other starts after the start of a communication section in which the intermediate-pressure port (49) communicates with the intermediate-pressure path (48), thereby making it possible to suppress an increase in the thrust surface pressure at an appropriate timing.

[0086] According to a feature of this embodiment, an increase in the thrust surface pressure can be suppressed in a predetermined angular range in the communication section.

[0087] According to a feature of this embodiment, an increase in the thrust surface pressure can be suppressed in a predetermined angular range before the end of the communication.

[0088] According to a feature of this embodiment, an increase in the thrust surface pressure can be suppressed in a predetermined angular range after the start of the communication.

[0089] According to a feature of this embodiment, a refrigeration apparatus includes the scroll compressor (10) and the refrigerant circuit (1a) through which the refrigerant compressed by the scroll compressor (10) flows. Thus, it is possible to provide a refrigeration apparatus including the scroll compressor (10) and the refrigerant circuit (1a).

<<Other Embodiments>>

[0090] The above-described embodiment may be modified as follows.

[0091] In this embodiment, with respect to the movable scroll (70), the thickness of a portion of the movable end plate (71) where the movable oil groove (85) is formed has not been specifically described; however, the portion of the movable end plate (71) where the movable oil groove (85) is formed may have a smaller thickness than the other portion. This configuration allows a portion of the movable end plate (71) around the movable oil groove (85) to be elastically deformed, thereby suppressing an increase in thrust surface pressure.

[0092] It will be understood that the embodiments and variations described above can be modified with various changes in form and detail without departing from the spirit and scope of the claims. The elements according to the embodiment, the variations thereof, and the other embodiments may be combined and replaced with each other. In addition, the expressions of "first," "second," "third," . . . , in the specification and claims are used to distinguish the terms to which these expressions are given, and do not limit the number and order of the terms.

INDUSTRIAL APPLICABILITY

[0093] As described above, the present disclosure is useful for a scroll compressor and a refrigeration appa-

ratus.

DESCRIPTION OF REFERENCE CHARACTERS

[0094]

- 1 Refrigeration Apparatus
- 1a Refrigerant Circuit
- 10 Scroll Compressor
- 43 Intermediate-Pressure Chamber
- 48 Intermediate-Pressure Path
- 49 Intermediate-Pressure Port
- 60 Fixed Scroll
- 61 Fixed End Plate
- 62 Fixed Wrap
- 70 Movable Scroll
- 71 Movable End Plate
- 72 Movable Wrap
- 80 Fixed Oil Groove
- 85 Movable Oil Groove
- S Compression Chamber

Claims

1. A scroll compressor comprising: a fixed scroll (60) including a fixed wrap (62) and a fixed end plate (61); and a movable scroll (70) including a movable wrap (72) and a movable end plate (71), the fixed wrap (62) and the movable wrap (72) meshing with each other to form a compression chamber (S), wherein
 - the fixed end plate (61) has a fixed oil groove (80) in a surface facing the movable end plate (71), and an intermediate-pressure path (48) that communicates with a space in the compression chamber (S), in which space a refrigerant having an intermediate pressure higher than a pressure of a suction refrigerant and lower than a pressure of a discharge refrigerant flows,
 - the movable end plate (71) has a movable oil groove (85) in a surface facing the fixed end plate (61), and an intermediate-pressure port (49) that communicates with an intermediate-pressure chamber (43) provided on a side of the movable end plate (71) opposite the fixed end plate (61),
 - as viewed in an axial direction, the intermediate-pressure port (49) overlaps the intermediate-pressure path (48) in a predetermined angular range of an orbiting motion of the movable scroll (70),
 - as viewed in the axial direction, the movable oil groove (85) communicates with the compression chamber (S) in a predetermined angular range of the orbiting motion of the movable scroll (70), and

a state in which the movable oil groove (85) and the compression chamber (S) communicate with each other ends before an end of a communication section in which the intermediate-pressure port (49) communicates with the intermediate-pressure path (48).

2. The scroll compressor of claim 1, wherein the state in which the movable oil groove (85) and the compression chamber (S) communicate with each other starts after a start of the communication section in which the intermediate-pressure port (49) communicates with the intermediate-pressure path (48).
3. The scroll compressor of claim 1 or 2, wherein the movable oil groove (85) and the compression chamber (S) communicate with each other in an angular range of 50% or more of the communication section.
4. The scroll compressor of any one of claims 1 to 3, wherein the state in which the movable oil groove (85) and the compression chamber (S) communicate with each other ends in an angular range greater than 0° and less than or equal to 30° before the end of the communication.
5. The scroll compressor of any one of claims 2 to 4, wherein the state in which the movable oil groove (85) and the compression chamber (S) communicate with each other starts in an angular range greater than or equal to 0° and less than or equal to 10° after the start of the communication.
6. A refrigeration apparatus comprising:
 - the scroll compressor (10) of any one of claims 1 to 5; and
 - a refrigerant circuit (1a) through which a refrigerant compressed by the scroll compressor (10) flows.

FIG.1

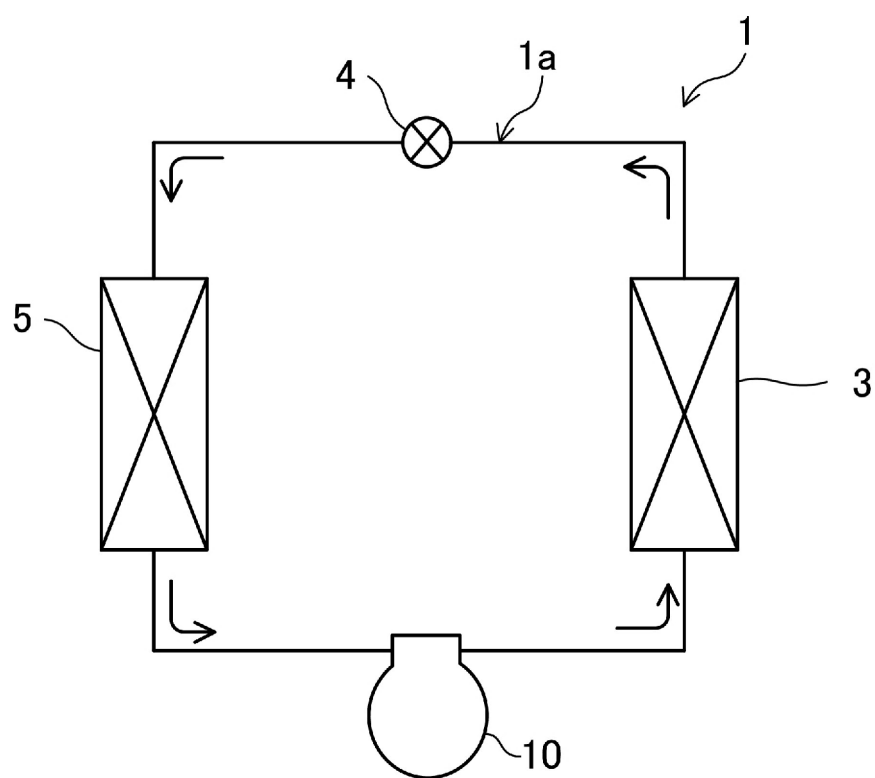


FIG.2

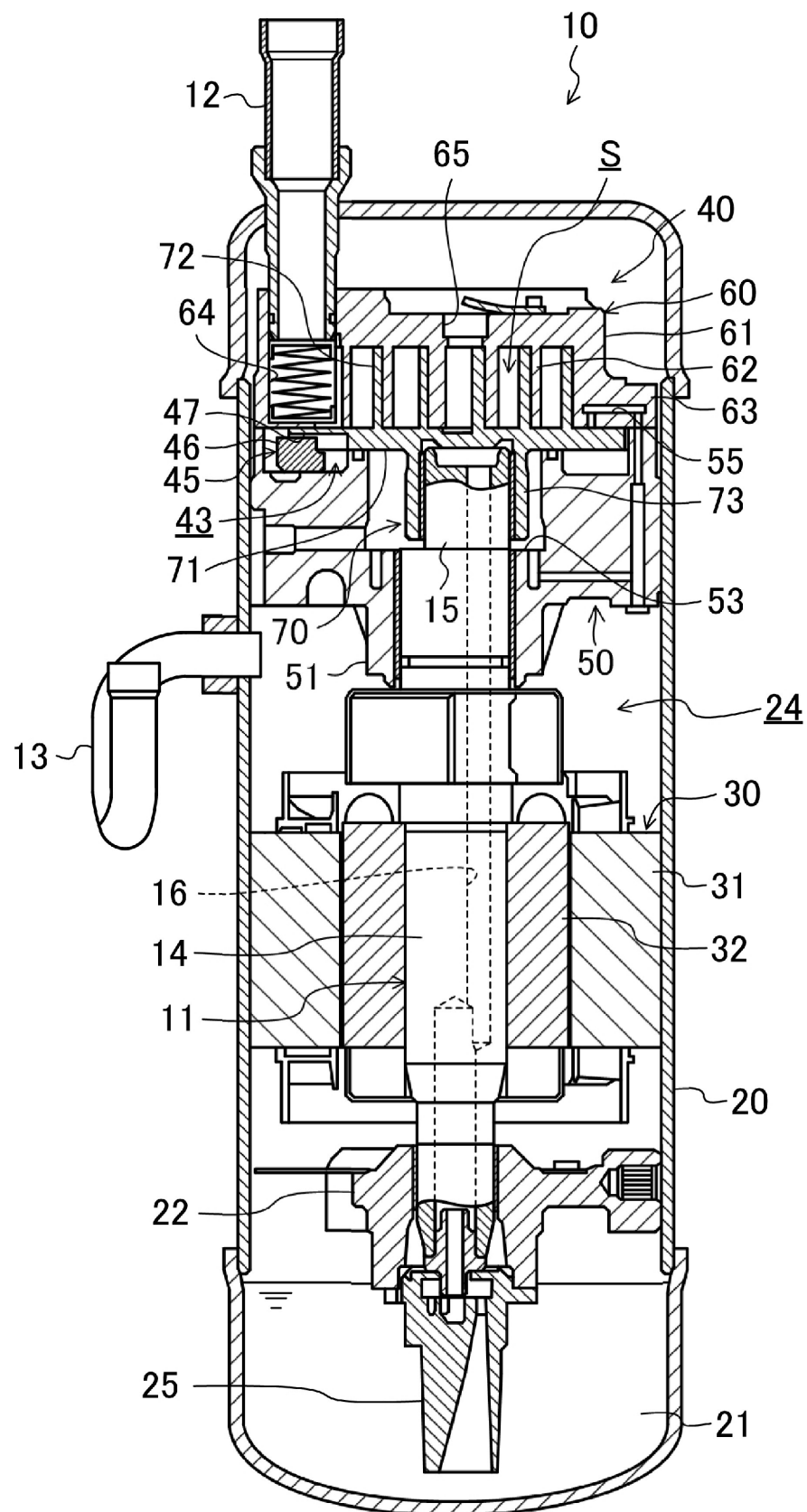


FIG.3

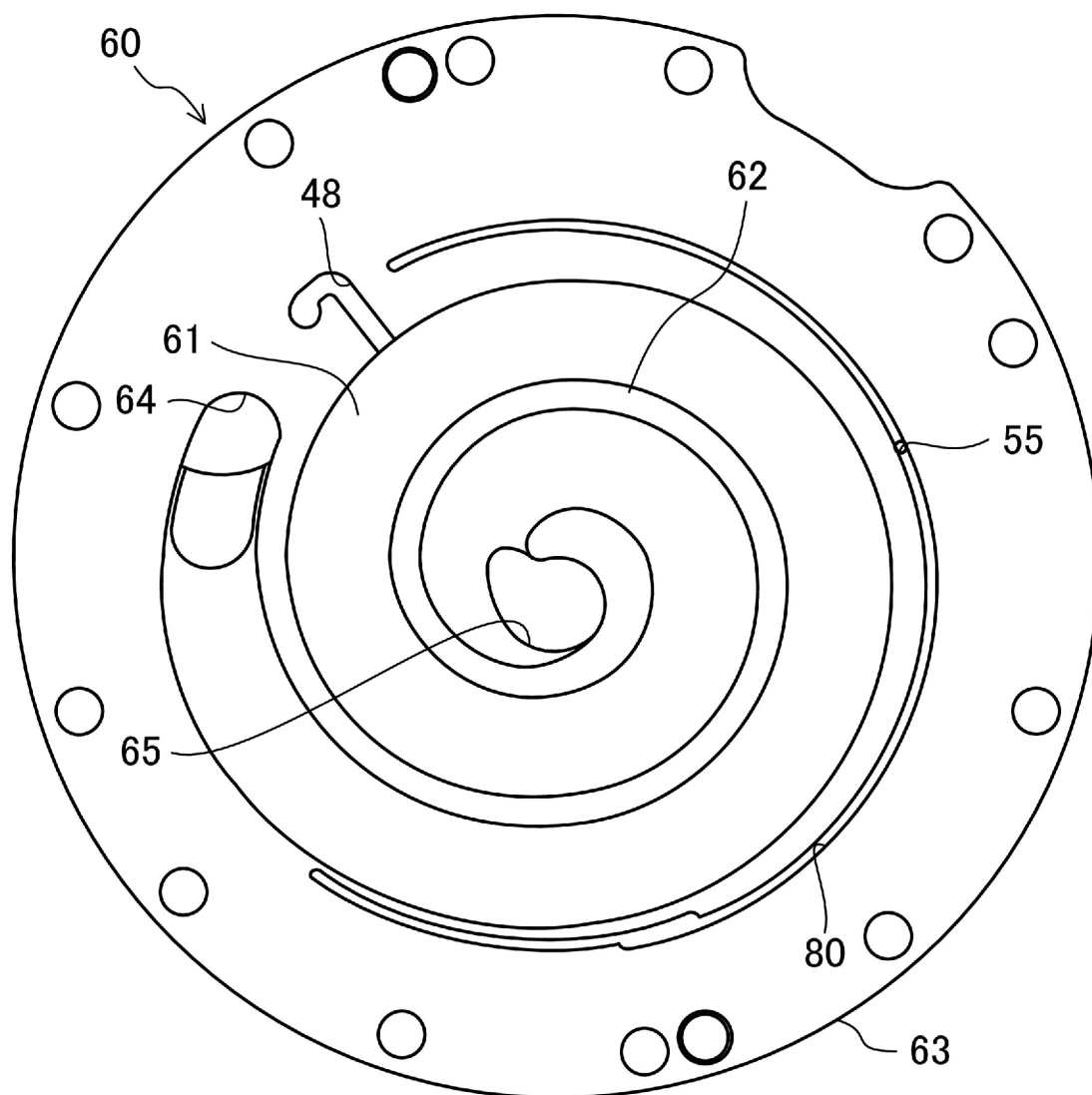


FIG.4

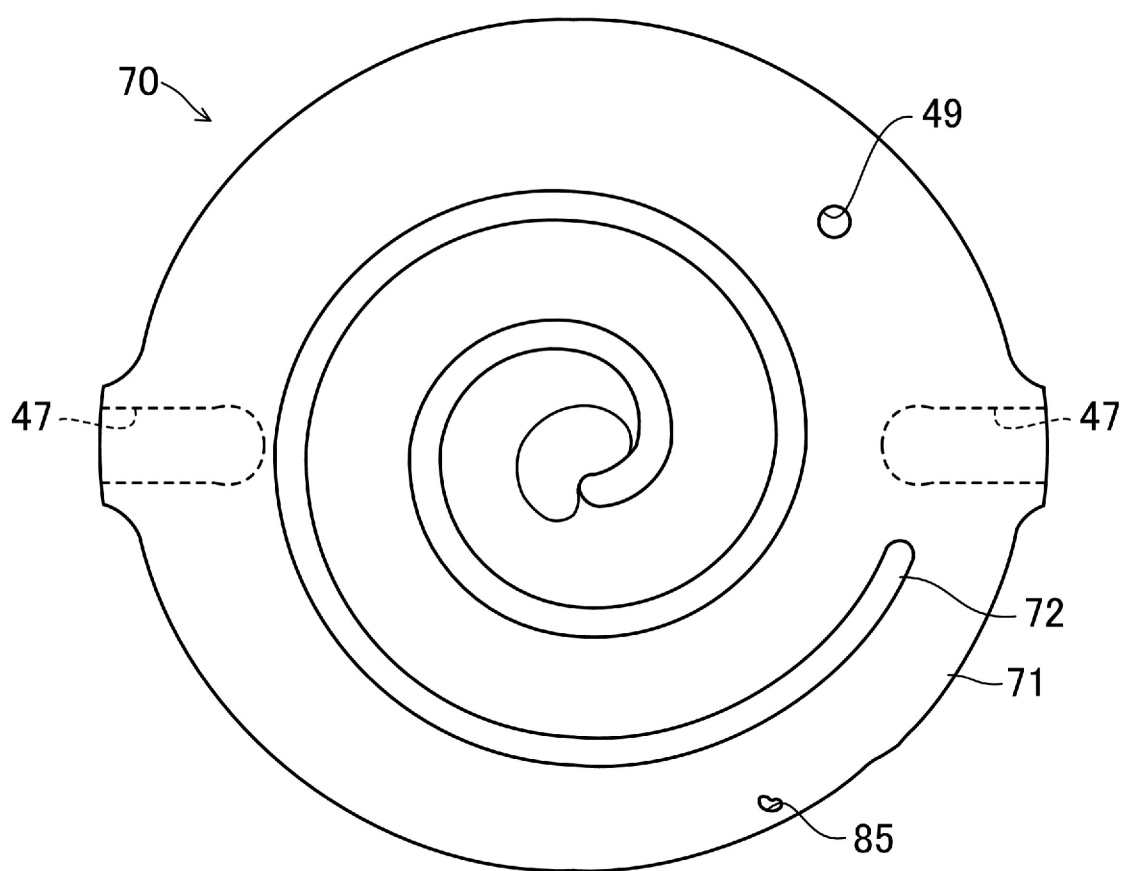


FIG.5

ANGLE $\theta 1$

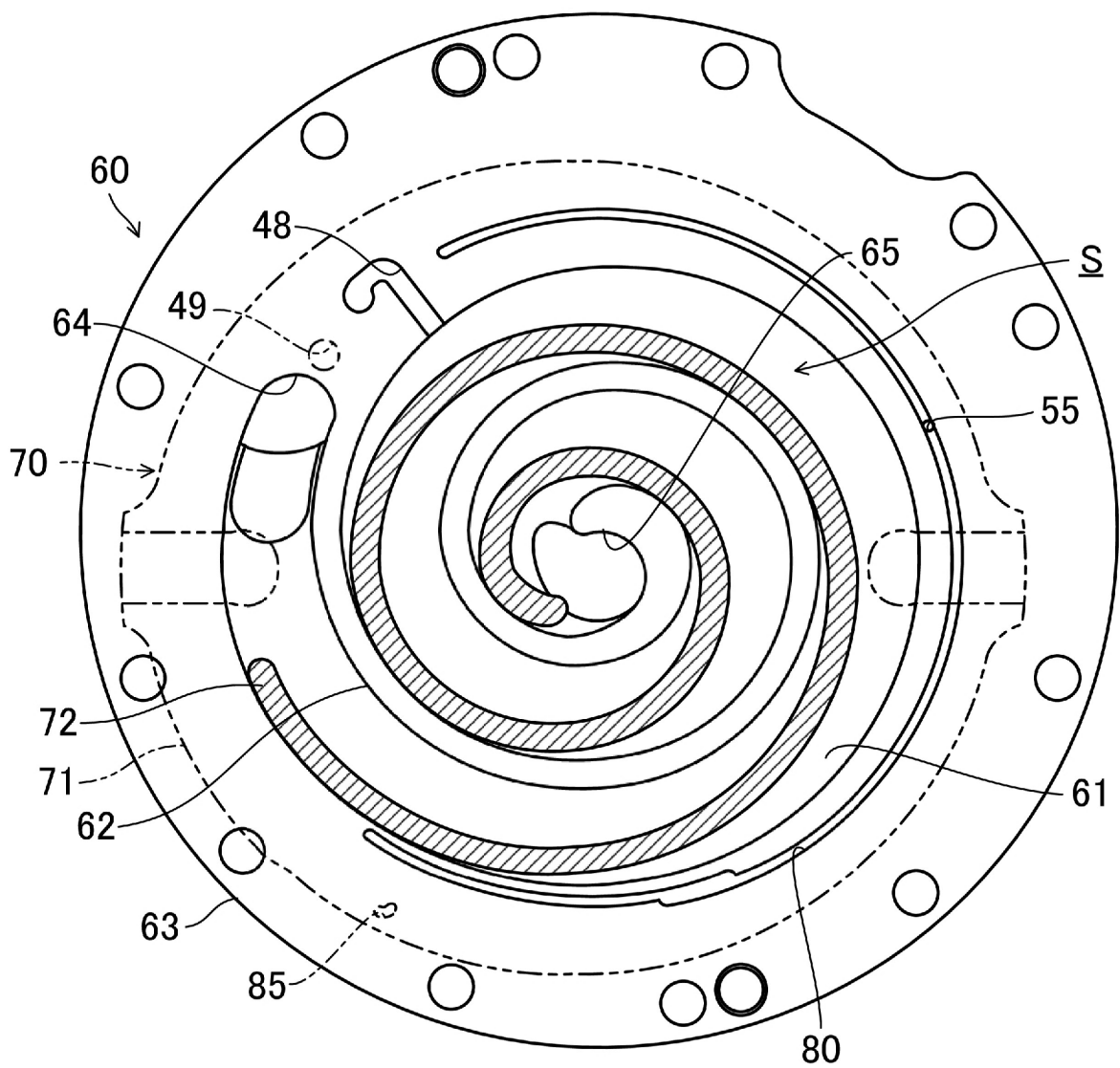


FIG.6

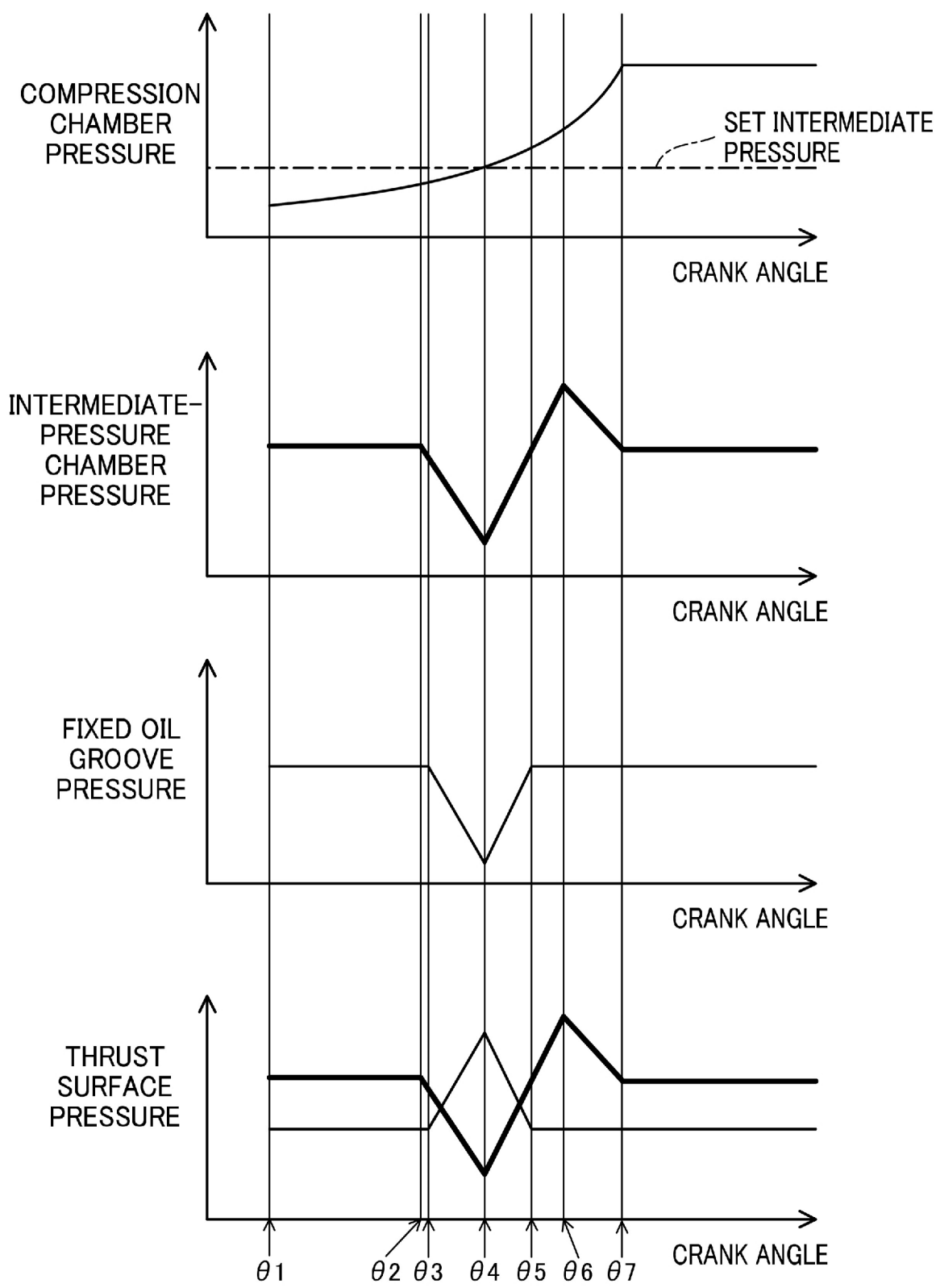


FIG.7

ANGLE $\theta 2$

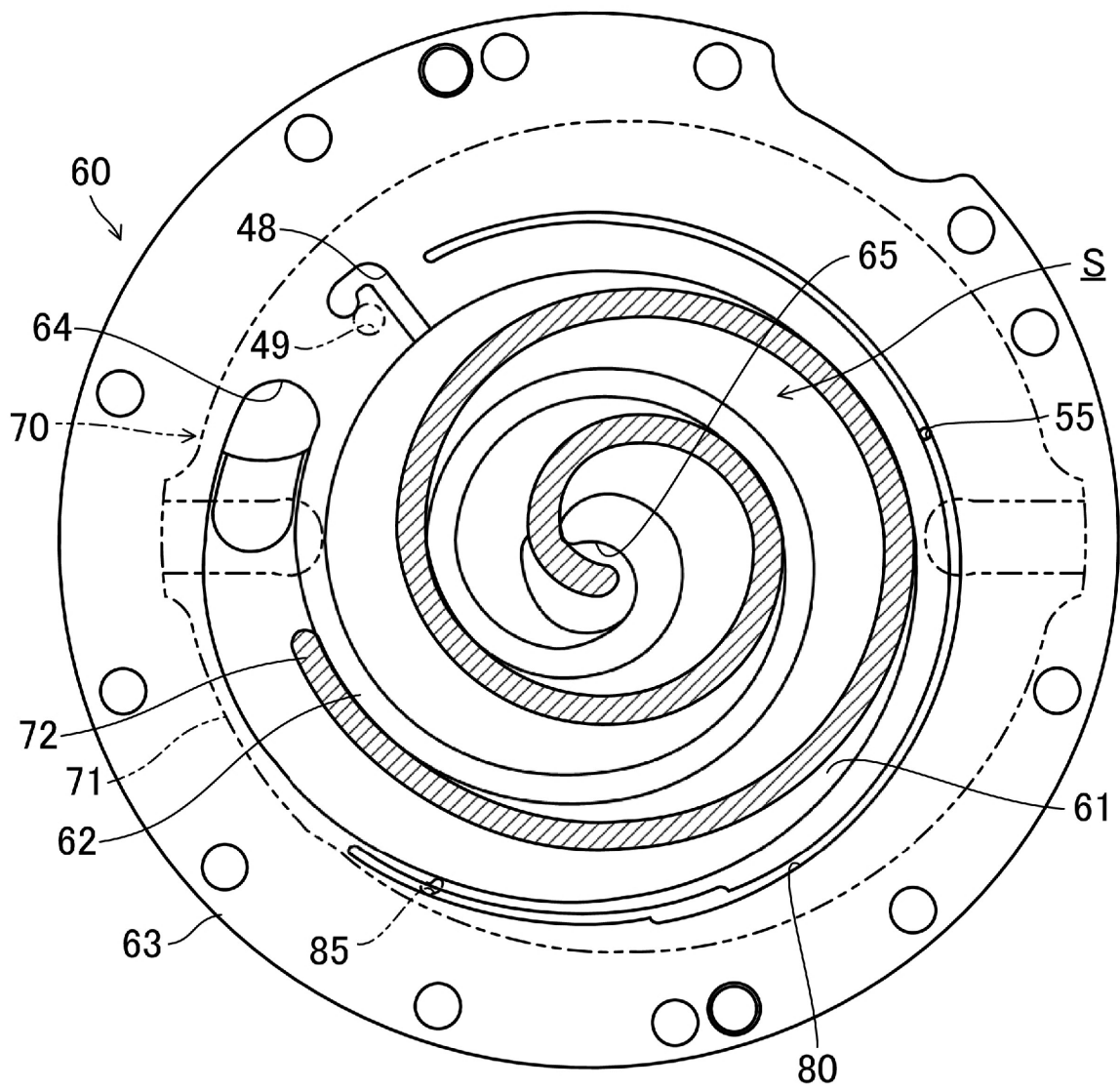


FIG.8

ANGLE $\theta 3$

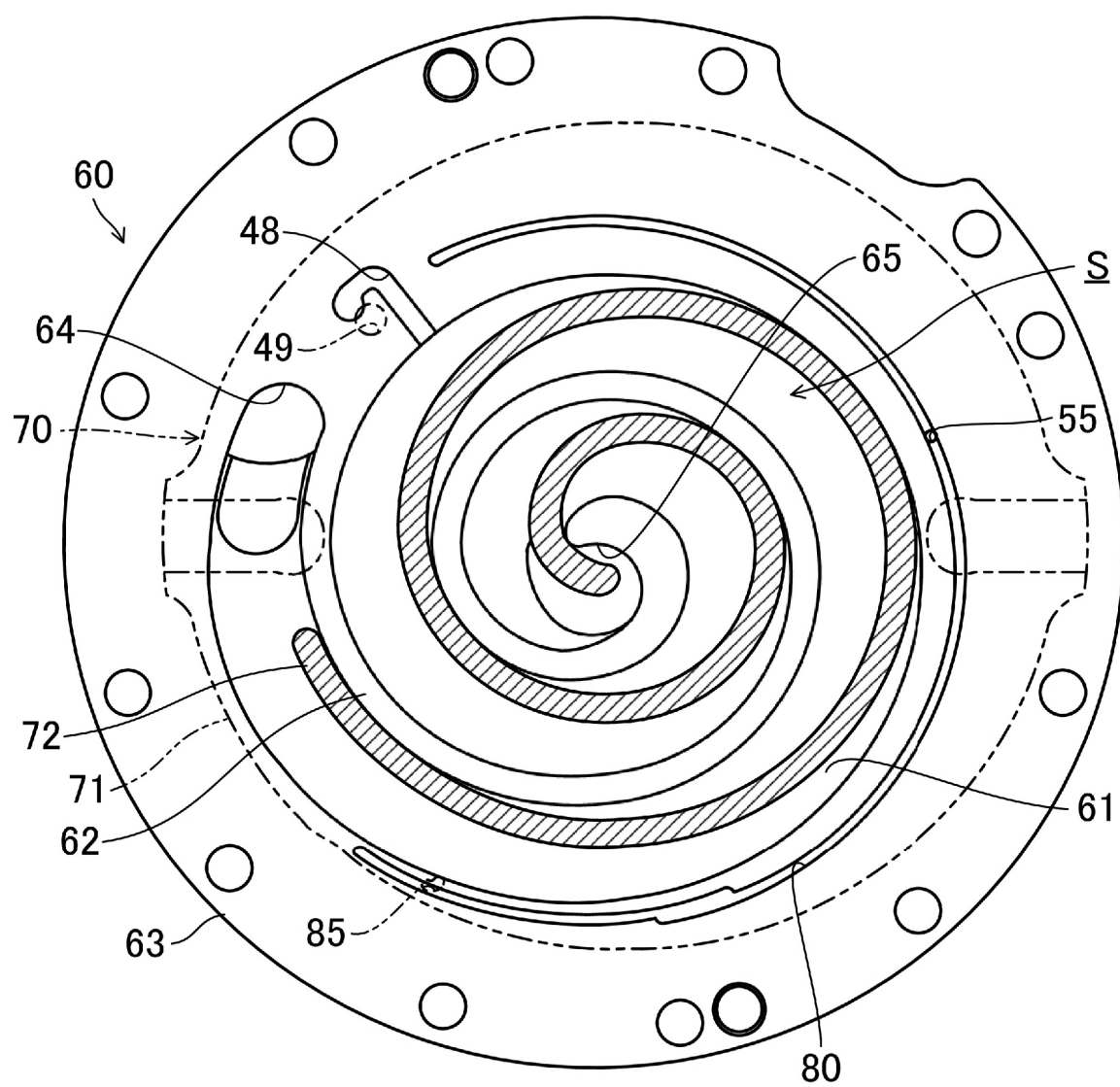


FIG.9

ANGLE $\theta 4$

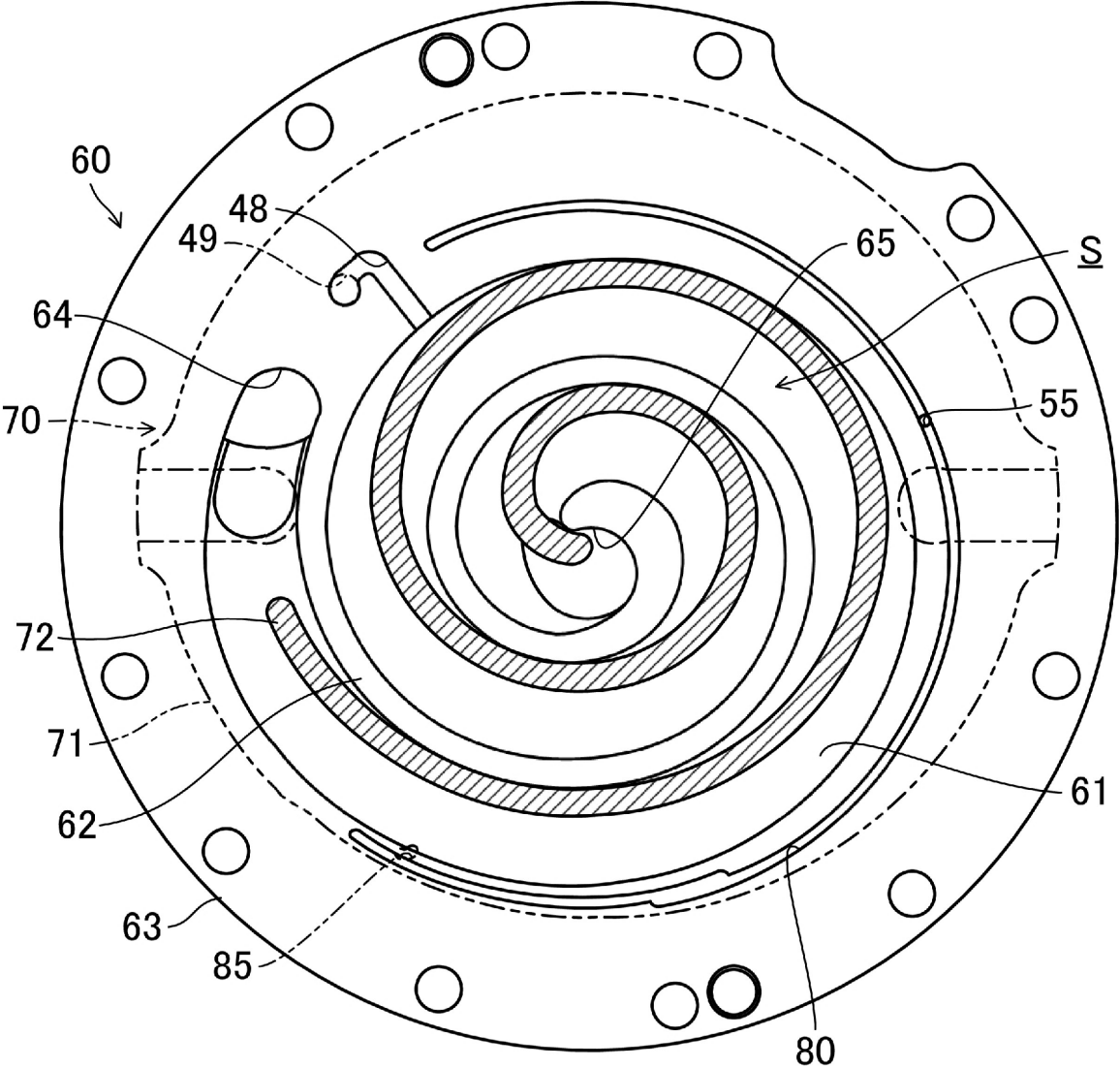


FIG.10

ANGLE $\theta 5$

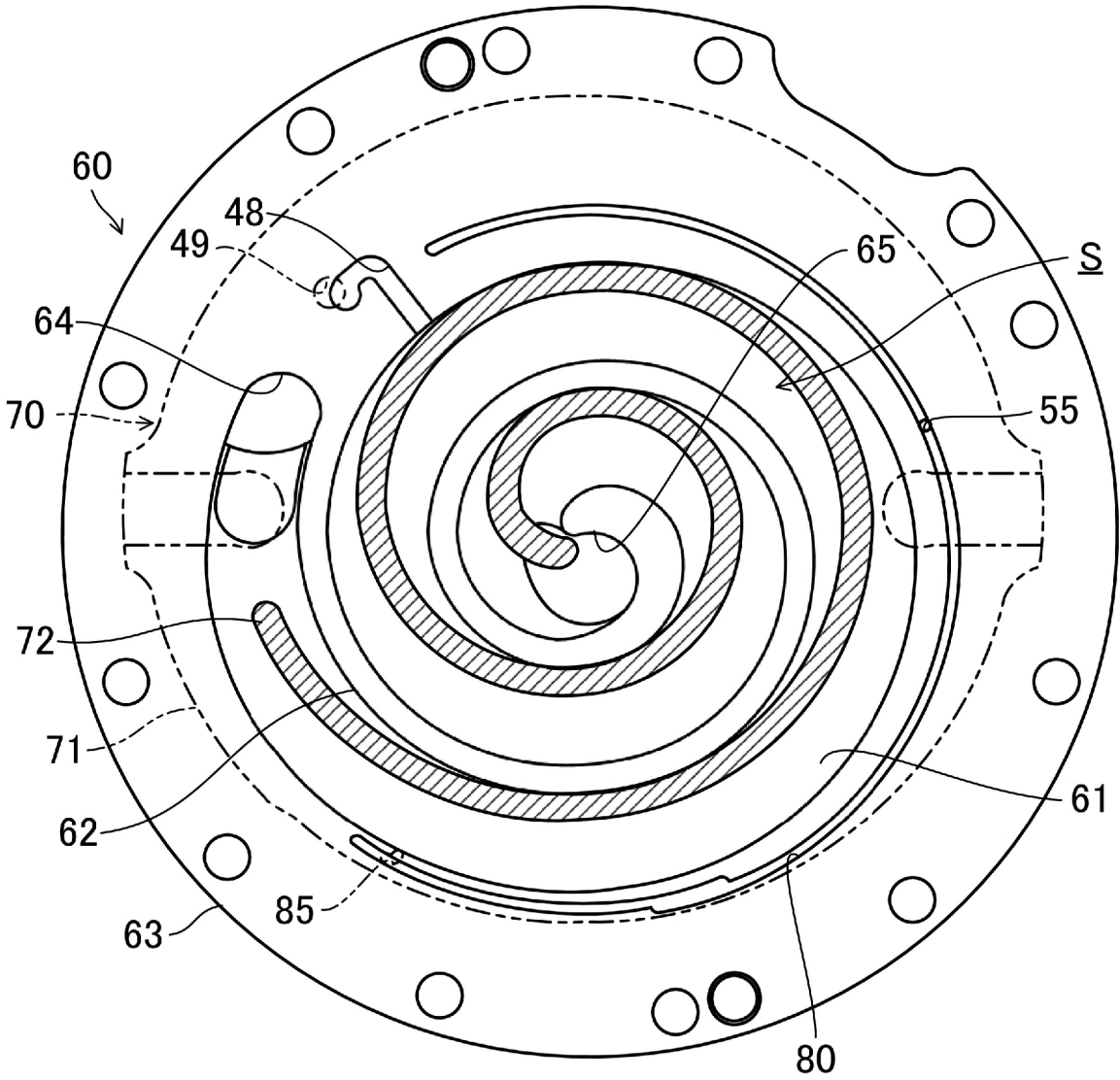


FIG.11

ANGLE θ_6

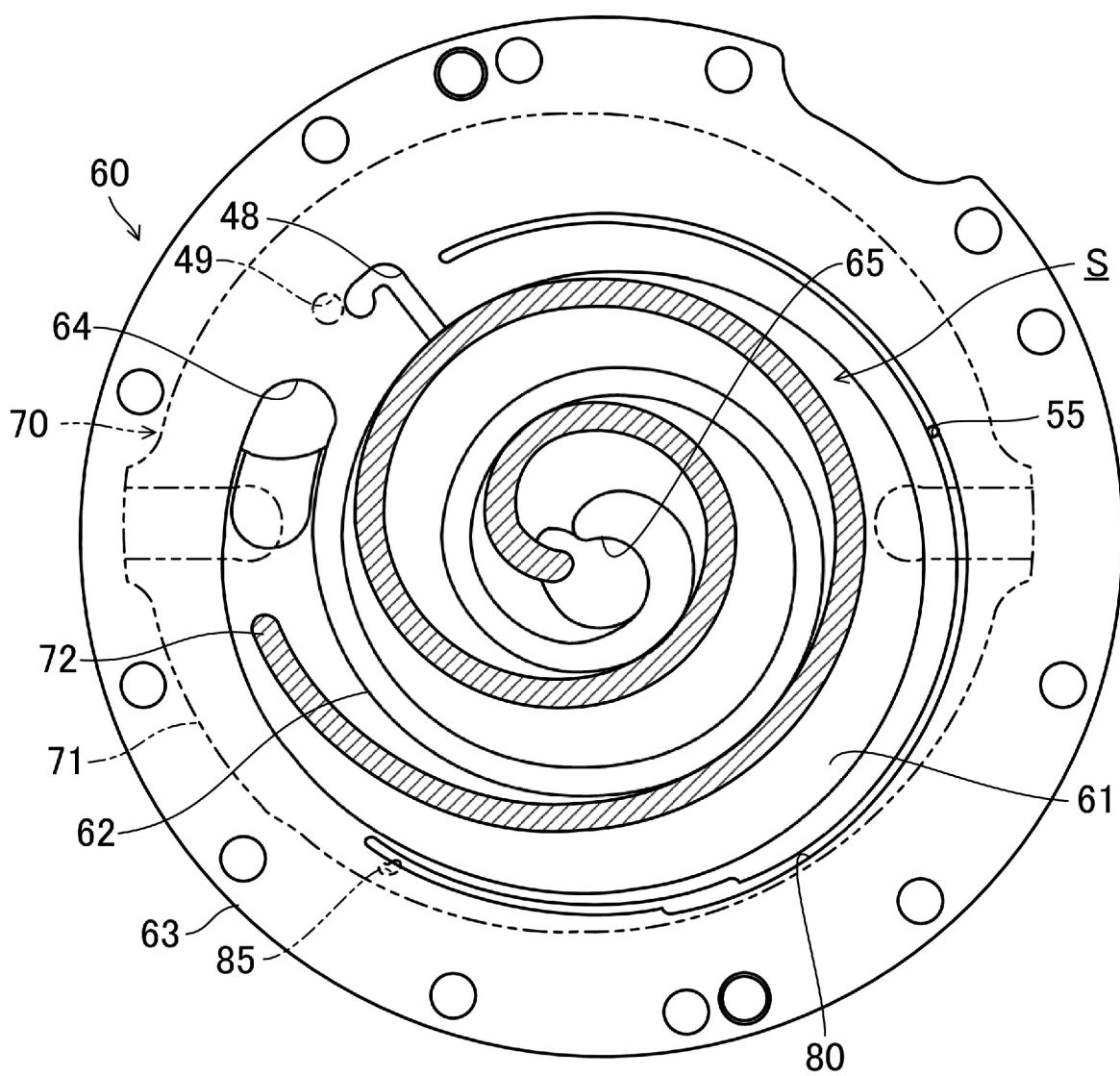


FIG.12

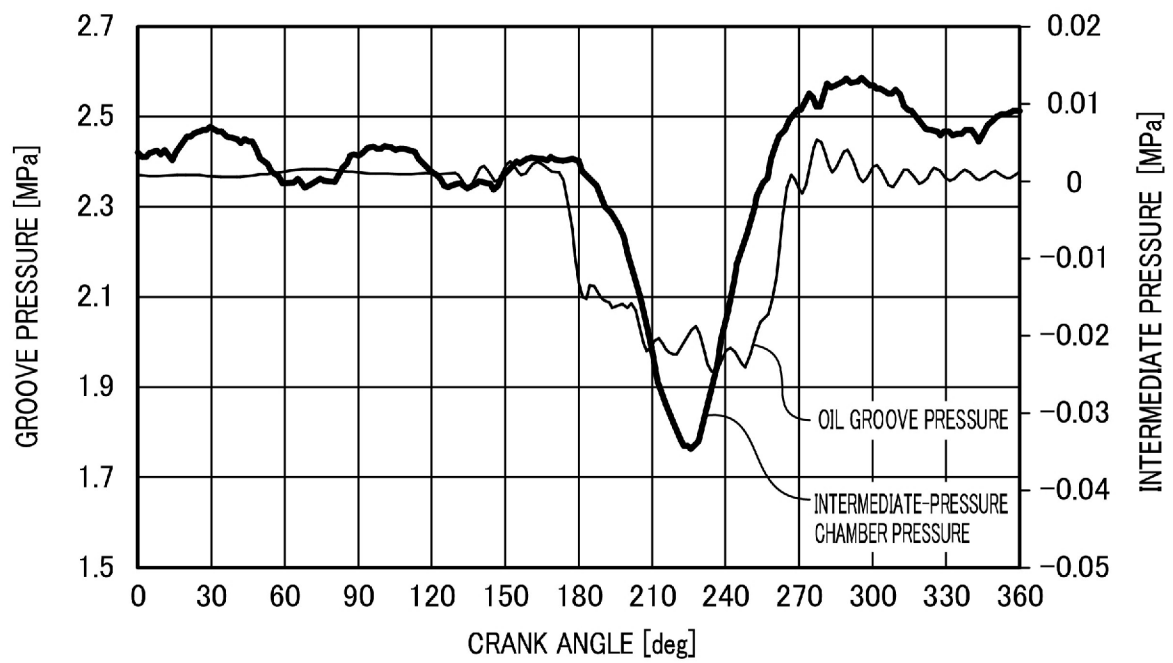


FIG.13

COMPARATIVE EXAMPLE

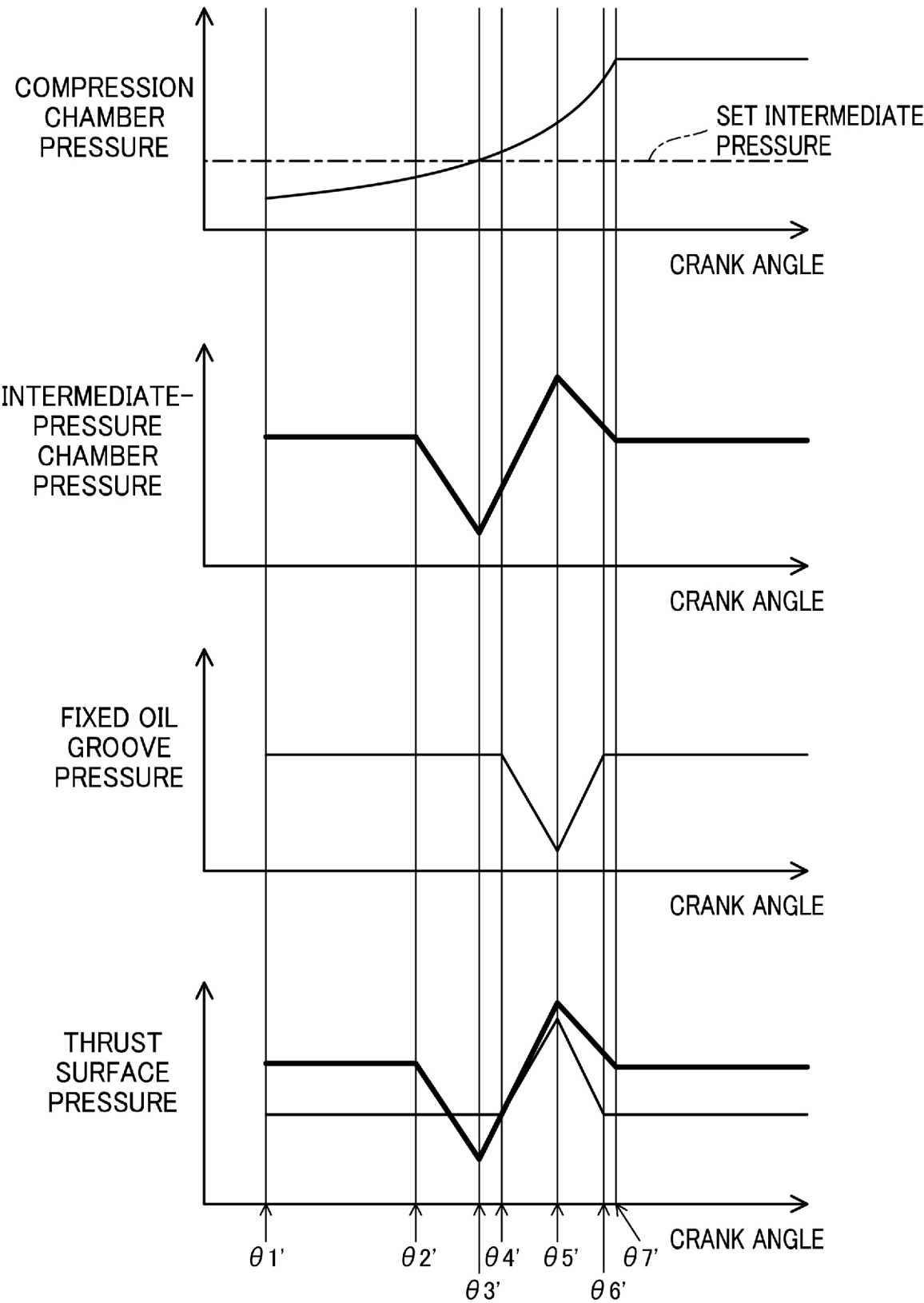
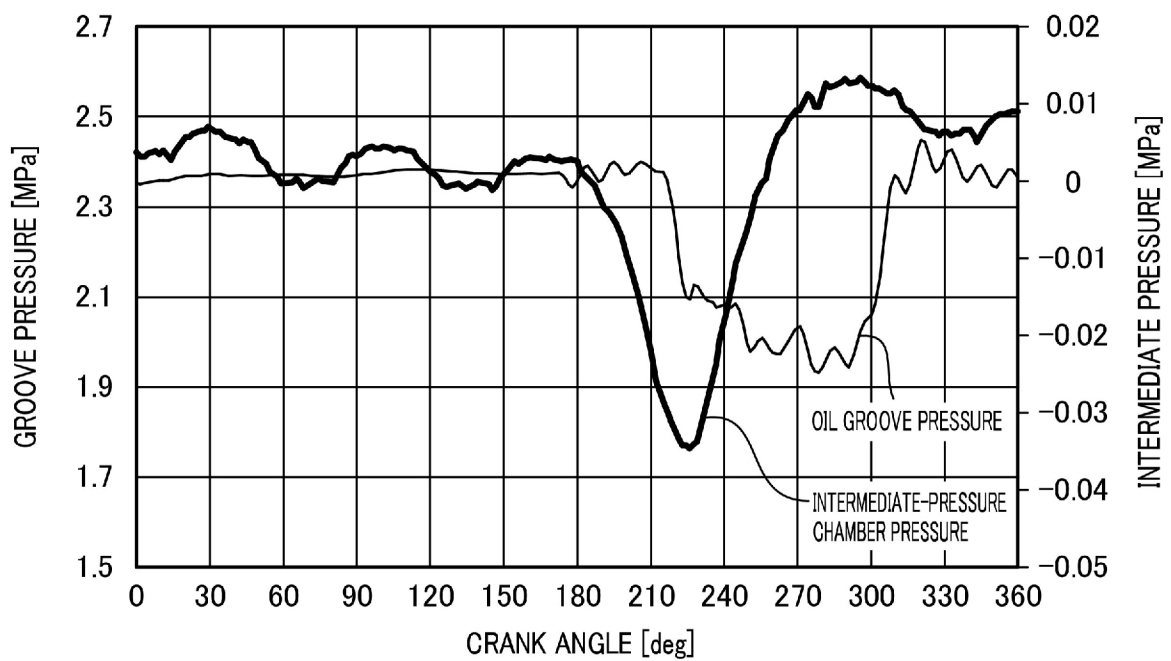


FIG.14

COMPARATIVE EXAMPLE

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2024/037007

A. CLASSIFICATION OF SUBJECT MATTER

F04C 18/02(2006.01)i

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

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 1971-2024

Registered utility model specifications of Japan 1996-2024

Published registered utility model applications of Japan 1994-2024

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.
A	JP 2019-196708 A (DAIKIN INDUSTRIES, LTD.) 14 November 2019 (2019-11-14) paragraphs [0030], [0033]-[0060], fig. 1-10	1-6
A	JP 2023-172727 A (HITACHI-JOHNSON CONTROLS AIR CONDITIONING, INC.) 06 December 2023 (2023-12-06) paragraphs [0028]-[0042], fig. 1-6	1-6
A	JP 2014-125914 A (DAIKIN INDUSTRIES, LTD.) 07 July 2014 (2014-07-07) paragraphs [0074]-[0079], fig. 1-6	1-6

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

* Special categories of cited documents:

“A” document defining the general state of the art which is not considered to be of particular relevance

“D” document cited by the applicant in the international application

“E” earlier application or patent but published on or after the international filing date

“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)

“O” document referring to an oral disclosure, use, exhibition or other means

“P” document published prior to the international filing date but later than the priority date claimed

“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

“X” document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

“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

“&” document member of the same patent family

Date of the actual completion of the international search

09 December 2024

Date of mailing of the international search report

17 December 2024

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.

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/JP2024/037007

5

10

15

20

25

30

35

40

45

50

55

Patent document cited in search report			Publication date (day/month/year)	Patent family member(s)			Publication date (day/month/year)
JP	2019-196708	A	14 November 2019	US	2021/0025395	A1	
				paragraphs [0028], [0031]-[0059], fig. 1-10			
				WO	2019/216098	A1	
				EP	3754199	A1	
JP	2023-172727	A	06 December 2023	CN	117108502	A	
JP	2014-125914	A	07 July 2014	(Family: none)			

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- JP 5691352 B [0004]