(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 4 464 896 A1

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

(43) Date of publication:
**20.11.2024 Bulletin 2024/47**

(21) Application number: **24739997.5**

(22) Date of filing: **26.03.2024**

(51) International Patent Classification (IPC):
***F04C 18/52*** ^(2006.01) ***F04C 29/00*** ^(2006.01)

(86) International application number:
**PCT/JP2024/012005**

(87) International publication number:
**WO 2024/204226 (03.10.2024 Gazette 2024/40)**

(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**

(30) Priority: **31.03.2023 JP 2023058790**

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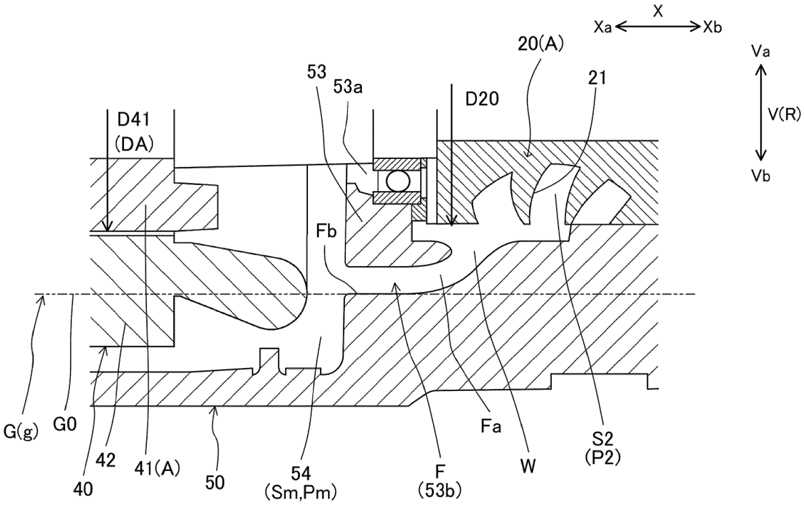
(54) **SCREW COMPRESSOR**

(57) A screw compressor includes a screw rotor having a screw groove, a gate rotor having a gate that meshes with the screw groove, and a casing rotatably holding the screw rotor and covering the screw rotor from radially outside. The screw rotor, the gate rotor, and the casing form a first compression chamber that compresses a fluid at a first pressure to an intermediate pressure and a second compression chamber that compresses the fluid at the intermediate pressure to a second pressure. The casing is provided with an intermediate chamber that communicates with the second compression chamber. The screw rotor and the casing are provided with a seal that seals the intermediate chamber and the first compression chamber. The first compression chamber is located above a center axis of the screw rotor.

FIG.12

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# Description

## TECHNICAL FIELD

**[0001]** The present disclosure relates to a screw compressor.

## BACKGROUND ART

**[0002]** Various techniques about a screw compressor are disclosed as in Patent Document 1, for example.

## CITATION LIST

## PATENT DOCUMENT

**[0003]** Patent Document 1: Japanese Unexamined Patent Publication No. 2014-025435

## SUMMARY OF THE INVENTION

## TECHNICAL PROBLEM

**[0004]** A screw compressor of this type includes a screw rotor, a gate rotor, and a casing. The screw rotor extends in an axial direction and has screw grooves formed in its outer periphery. The gate rotor is provided with a gate. The gate of the gate rotor meshes with the screw groove of the screw rotor. The casing rotatably holds the screw rotor and covers the screw rotor from radially outside.

**[0005]** A multistage screw compressor is a type of the screw compressor. The multistage screw compressor can compress a fluid in two or more stages. Such a multistage screw compressor includes a first compression chamber and a second compression chamber formed by the screw rotor, the gate rotor, and the casing. The first compression chamber compresses a fluid at a first pressure to an intermediate pressure higher than the first pressure. The second compression chamber compresses the fluid at the intermediate pressure to a second pressure higher than the intermediate pressure. A seal is provided for the casing and the screw rotor. The seal seals an intermediate chamber and the first compression chamber. The seal blocks the flow of the fluid from the intermediate chamber to the first compression chamber.

**[0006]** An oil sump may be formed in the intermediate chamber. The intermediate chamber has a higher pressure than the first compression chamber, and the oil in the oil sump in the intermediate chamber is likely to pass through the seal to enter the first compression chamber. When the oil enters the first compression chamber, the screw rotor stirs the oil in the first compression chamber, causing a stirring loss.

**[0007]** An object of the present disclosure is to reduce an oil stirring loss in a screw compressor.

## SOLUTION TO THE PROBLEMS

**[0008]** A first aspect of the present disclosure is directed to a screw compressor (1). The screw compressor (1) includes: a screw rotor (20) having a screw groove (21); a gate rotor (30, 35) having a gate (32, 37) that meshes with the screw groove (21); and a casing (50) rotatably holding the screw rotor (20) and covering the screw rotor (20) from radially outside (R1), wherein The screw rotor (20), the gate rotor (30, 35), and the casing (50) form a first compression chamber (S1) that compresses a fluid (W) at a first pressure (P1) to an intermediate pressure (Pm) higher than the first pressure (P1) and a second compression chamber (S2) that compresses the fluid (W) at the intermediate pressure (Pm) to a second pressure (P2) higher than the intermediate pressure (Pm). The casing (50) has an intermediate chamber (Sm) that communicates with the second compression chamber (S2). The screw rotor (20) and the casing (50) are provided with a seal (55a, 22) that seals the intermediate chamber (Sm) and the first compression chamber (S1). The first compression chamber (S1) is located above (Va) a center axis (O) of the screw rotor (20).

**[0009]** According to the first aspect, the first compression chamber (S1) is located above (Va) the center axis (O) of the screw rotor (20). The first compression chamber (S1) is likely to be located above (Va) the level of oil in an oil sump formed in the intermediate chamber (Sm).

**[0010]** The oil in the oil sump in the intermediate chamber (Sm) is less likely to enter the first compression chamber (S1) through the seal (55a, 22). This can keep the screw rotor (20) from stirring the oil in the first compression chamber (S1). Thus, the oil stirring loss in the screw compressor (1) can be reduced.

**[0011]** A second aspect of the present disclosure is an embodiment of the first aspect. In the second aspect, the casing (50) is provided with a communication passage (F) that allows the intermediate chamber (Sm) and the second compression chamber (S2) to communicate with each other, and a lower end (Fb) of the communication passage (F) is located below (Vb) an outermost diameter (DA) of a rotor (A) including the screw rotor (20).

**[0012]** According to the second aspect, the height of the oil level in the oil sump in the intermediate chamber (Sm) substantially coincides with the lower end (Fb) of the communication passage (F). The lower end (Fb) of the communication passage (F) is located below (Vb) the outermost diameter (DA) of the rotor (A), keeping the rotor (A) including the screw rotor (20) from stirring the oil.

**[0013]** A third aspect of the present disclosure is an embodiment of the second aspect. In the third aspect, the intermediate chamber (Sm) is a motor chamber (54) that houses a motor rotor (41), and the lower end (Fb) of the communication passage (F) is located below (Fb) the outermost diameter (DA) of the rotor (A) including the screw rotor (20) and the motor rotor (41).

**[0014]** According to the third aspect, the height of the oil level of the oil sump in the motor chamber (54) substantially coincides with the lower end (Fb) of the communication passage (F). The lower end (Fb) of the communication passage (F) is located below (Vb) the outermost diameter (DA) of the rotor (A), advantageously keeping the rotor (A) including the screw rotor (20) and the motor rotor (41) from stirring the oil.

**[0015]** A fourth aspect of the present disclosure is an embodiment of the second or third aspect. In the fourth aspect, the communication passage (F) includes a hole (53b) formed in a wall (53) of the casing (50).

**[0016]** According to the fourth aspect, the communication passage (F) can be suitably formed in the casing (50).

**[0017]** A fifth aspect of the present disclosure is an embodiment of any one of the second to fourth aspects. In the fifth aspect, the communication passage (F) includes an inclined portion (Fa) that is inclined upward from the intermediate chamber (Sm) toward the second compression chamber (S2) or a constricted portion that constricts a flow passage area of the communication passage (F).

**[0018]** According to the fifth aspect, the flow velocity of the fluid (W) flowing through the communication passage (F) is increased, keeping the oil from easily accumulating in the intermediate chamber (Sm).

## BRIEF DESCRIPTION OF THE DRAWINGS

**[0019]**

FIG. 1 is a right side view of a screw compressor according to a first embodiment.
FIG. 2 is a left side view of a screw compressor (1).
FIG. 3 is a front view of the screw compressor (1).
FIG. 4 is a right side sectional view of the screw compressor (1) taken along line IV-IV in FIG. 3.
FIG. 5 is a front sectional view of the screw compressor (1) taken along line V-V in FIG. 4.
FIG. 6 is a front sectional view of the screw compressor (1) taken along line VI-VI in FIG. 4.
FIG. 7 is a sectional view of the vicinity of a first discharge port (65) taken along line VII-VII in FIG. 6.
FIG. 8 is a sectional view illustrating the positional relationship between a first case outlet (63) and a first discharge port (65), with a first slide valve (87) removed.
FIG. 9 is a sectional view in the direction of arrows on line IX-IX in FIG. 6, illustrating the positional relationship between the first case outlet (63) and a first gate opening (60).
FIG. 10 is a front sectional view of the screw compressor (1) taken along line X-X in FIG. 4.
FIG. 11 is a front sectional view of the screw compressor (1) taken along line XI-XI in FIG. 4.
FIG. 12 is a right side sectional view illustrating the positional relationship between a rotor (A) and a communication passage (F).

## DESCRIPTION OF EMBODIMENTS

### <First Embodiment>

### (Screw Compressor)

**[0020]** A screw compressor (1) according to a first embodiment will be described below. The screw compressor (1) is applied to a refrigeration apparatus such as an air conditioner. The refrigeration apparatus includes a refrigerant circuit in which a refrigerant circulates. The screw compressor (1) compresses the refrigerant in the refrigerant circuit. The refrigerant circulates in the refrigerant circuit to cause a vapor compression refrigeration cycle.

FIGS. 1 to 5 show the screw compressor (1) of the first embodiment. In the following description, the left side of FIG. 1 may be referred to as the front side, the right side of FIG. 1 as the rear side, the upper side of FIG. 1 as the upper side, the lower side of FIG. 1 as the lower side, the back side of the sheet in FIG. 1 as the left side, and the front side of the sheet in FIG. 1 as the right side. FIG. 1 is a right side view, FIG. 2 a left side view, FIG. 3 a front view, FIG. 4 a right side sectional view taken along line IV-IV in FIG. 3, and FIG. 5 a front sectional view taken along line V-V in FIG. 4. The front-back direction and the left-right direction are the horizontal directions. The up-down direction is the vertical direction (V).

**[0021]** The screw compressor (1) includes a shaft (10), a screw rotor (20), a first gate rotor (30), a second gate rotor (35), a motor (40), and a casing (50).

**[0022]** The screw compressor (1) includes a front cover (70), a front bearing (71), a front bearing holder (72), a rear bearing holder (73), a rear bearing (74), a spacer (75), a snap ring (76), a holding member (77), an intermediate bearing (78), a first proximal gate bearing (79), a first distal gate bearing (80), a first proximal gate bearing holder (81), a first distal gate bearing holder (82), a second proximal gate bearing (83), a second distal gate bearing (84), a second proximal gate bearing holder (85), and a second distal gate bearing holder (86).

**[0023]** The screw compressor (1) includes a first slide valve (87), a first valve movement mechanism (88), a second slide valve (89), a second valve movement mechanism (90), a first cap (91), a gasket (92) as a first seal member, a second cap (93), a first cap-side discharge passage (94), a first discharge pipe (95), a silencer (96), a second cap-side discharge passage (97), and a second discharge pipe (98).

### (Shaft)

**[0024]** As illustrated in FIG. 4, a center axis (O) of the shaft (10) extends horizontally in the front-back direction. A direction in which the center axis (O) of the shaft (10) extends will be referred to as an axial direction (X). The axial direction (X) is the front-back direction. The screw compressor (1) is placed horizontally. A front side in the axial direction (X) is referred to as a front side (Xa) which is a first side in the axial direction (X). A rear side in the axial direction (X) is referred to as a rear side (Xb) which is a second side in the axial direction (X). The rear side (Xb) in the axial direction (X) is opposite to the front side (Xa) in the axial direction (X).

**[0025]** A radial direction (R) of the screw compressor (1) is orthogonal to the axial direction (X). A side far from the center axis (O) in the radial direction (R) is referred to as a radially outer side or outside (Ra) in the radial direction (R). A side closer the center axis (O) in the radial direction (R) is referred to as a radially inner side or inside (Rb) in the radial direction (R). The up-down direction, which is parallel to the radial direction (R), coincides with the vertical direction (V). An upper side in the vertical direction (V) is referred to as an upper side (above) (Va). A lower side in the vertical direction (V) is referred to as a lower side (below) (Vb). A circumferential direction (θ) of the screw compressor (1) is a direction about the center axis (O).

(Screw Rotor)

**[0026]** The screw rotor (20) is coupled to the shaft (10) and rotates together with the shaft (10). The screw rotor (20) extends in the axial direction (X), like the shaft (10). The screw rotor (20) includes a plurality of screw grooves (21), a front rotary seal (22), and a rear rotary seal (23). The screw rotor (20) is made of, for example, metal.

**[0027]** The screw grooves (21) are provided in the middle of the outer periphery of the screw rotor (20) in the axial direction (X). The screw grooves (21) are arranged in the axial direction (X). The screw grooves (21) are helical grooves.

**[0028]** A front end of the outer periphery of the screw rotor (20) in the axial direction (X) serves as the front rotary seal (22). A rear end of the outer periphery of the screw rotor (20) in the axial direction (X) serves as the rear rotary seal (23). The front rotary seal (22) and the rear rotary seal (23) have no screw grooves (21).

(First Gate Rotor)

**[0029]** As illustrated in FIG. 5, the first gate rotor (30) is arranged outward of the screw rotor (20) in the radial direction (R). The first gate rotor (30) is disposed on the left of the screw rotor (20).

**[0030]** The first gate rotor (30) includes a first gate shaft (31) and a first gate (32). The first gate rotor (30) is made of, for example, resin. The first gate shaft (31) extends in the vertical direction (V). The first gate (32) is fixed to the middle of the first gate shaft (31). The first gate (32) is substantially disc-shaped and concentric with the first gate shaft (31). The first gate (32) has a plurality of first gate teeth on the outer periphery. The first gate teeth of the first gate (32) of the first gate rotor (30) mesh with the screw grooves (21) of the screw rotor (20).

**[0031]** The first gate (32) has a gate radius (r). The gate radius (r) is a radius of the first gate (32). The gate radius (r) is half the diameter of the first gate (32). The gate radius (r) is a distance from the center to outer periphery of the first gate (32).

(Second Gate Rotor)

**[0032]** As illustrated in FIG. 5, the second gate rotor (35) is arranged radially outside (Ra) of the screw rotor (20). The second gate rotor (35) is disposed on the lower (Vb) right side of the screw rotor (20).

**[0033]** The second gate rotor (35) includes a second gate shaft (36) and a second gate (37). The second gate rotor (35) is made of, for example, resin. The second gate shaft (36) extends obliquely to the vertical direction (V). The second gate shaft (36) extends to the right as it goes upward (Va). The second gate (37) is fixed to the middle of the second gate shaft (36). The second gate (37) is substantially disc-shaped and concentric with the second gate shaft (36). The second gate (37) has a plurality of second gate teeth on the outer periphery. The second gate teeth of the second gate (37) of the second gate rotor (35) mesh with the screw grooves (21) of the screw rotor (20).

**[0034]** The second gate (37) has a gate radius (r). The gate radius (r) is a radius of the second gate (37). The gate radius (r) is half the diameter of the second gate (37). The gate radius (r) is a distance from the center to outer periphery of the second gate (37).

(Motor)

**[0035]** As illustrated in FIG. 4, the motor (40) includes a motor rotor (41) and a motor stator (42). The motor rotor (41) is coupled to the shaft (10) and rotates together with the shaft (10). The motor rotor (41) is disposed on the front side (Xa) of the screw rotor (20) in the axial direction (X). The motor stator (42) is fixed to an inner wall of a casing (50), which will be described later, with a fastener (not shown). The motor rotor (41) and the motor stator (42) face each other in the radial direction (R) with a predetermined gap between them.

(Casing)

**[0036]** As illustrated in FIGS. 1 to 4, the casing (50) has a substantially cylindrical shape. As illustrated in FIG. 4, a front opening (50a) is provided at the front end of the casing (50). A rear opening (50b) is provided at the rear end of the casing (50). The casing (50) is divided in the axial direction (X) into a motor housing (51) on the front side (Xa) in the axial direction (X) and a compression chamber forming portion (52) on the rear side (Xb) in the axial direction (X) by a partition wall (53).

**[0037]** As illustrated in FIG. 4, the motor housing (51) of the casing (50) has a motor chamber (54). The motor chamber (54) is a cavity formed in the casing (50). The motor chamber (54) houses the shaft (10) and the motor

(40). The motor chamber (54) houses the motor rotor (41) and motor stator (42) of the motor (40). The front end of the shaft (10) and the front end of the motor (40) protrude forward (Xa) of the motor chamber (54) through the front opening (50a).

**[0038]** The front cover (70) covers the front opening (50a) of the casing (50). An inner protrusion (70a) is provided to protrude radially inward (Rb) from the inner wall of the front cover (70). The front bearing (71) is held by the inner protrusion (70a) of the front cover (70). The front bearing (71) rotatably supports the front end of the shaft (10) on the front cover (70). The front bearing holder (72) holds the front bearing (71) on the front cover (70).

**[0039]** As illustrated in FIG. 4, the compression chamber forming portion (52) of the casing (50) has a cylindrical wall (55). The screw rotor (20) is disposed in a front space in the cylindrical wall (55) in the axial direction (X). A rear bearing holder (73), which will be described later, is disposed in a rear space in the cylindrical wall (55) in the axial direction (X).

**[0040]** As illustrated in FIG. 5, an inner peripheral surface of the cylindrical wall (55) of the casing (50) covers the screw grooves (21) of the screw rotor (20) from outside (Ra) in the radial direction (R). The inner diameter of the cylindrical wall (55) is slightly larger than the outer diameter of the screw rotor (20). The cylindrical wall (55) is provided with a first slit (56) through which the first gate (32) passes. The cylindrical wall (55) is provided with a second slit (57) through which the second gate (37) passes.

**[0041]** As illustrated in FIG. 4, a portion (55a) of the inner peripheral surface of the cylindrical wall (55) of the casing (50) facing the front rotary seal (22) of the screw rotor (20) serves as a front stationary seal (hereinafter referred to as a "front stationary seal (55a)"). A portion (55b) of the inner peripheral surface of the cylindrical wall (55) of the casing (50) facing the rear rotary seal (23) of the screw rotor (20) serves as a rear stationary seal (hereinafter referred to as a "rear stationary seal (55b)").

**[0042]** As described above, the rear bearing holder (73) is disposed in the rear space in the cylindrical wall (55) in the axial direction (X) as illustrated in FIG. 4. The rear bearing holder (73) is held on the inner peripheral surface of the cylindrical wall (55). The rear bearing holder (73) is substantially cylindrical. The rear bearing holder (73) includes a first portion (73a) extending in the axial direction (X) and a second portion (73b) extending inward (Rb) in the radial direction (R) from a front end of the first portion (73a).

**[0043]** There are two rear bearings (74). The two rear bearings (74) are arranged side by side in the axial direction (X). The rear bearings (74) are disposed between the first portion (73a) of the rear bearing holder (73) and the rear end of the shaft (10) in the radial direction (R). The rear bearing holder (73) holds the rear bearings (74). Specifically, an inner peripheral surface of the first portion (73a) of the rear bearing holder (73) holds outer peripheral surfaces of the rear bearings (74).

**[0044]** The rear bearings (74) support the rear end of the shaft (10) so that the shaft (10) is rotatable relative to the cylindrical wall (55) of the casing (50). The rear bearings (74) rotatably support the screw rotor (20) via the shaft (10).

**[0045]** The spacer (75) is disposed between the second portion (73b) of the rear bearing holder (73) and the front one of the rear bearings (74). A snap ring (76) is disposed at the rear end of the rear one of the rear bearings (74). The snap ring (76) positions the rear bearings (74) in the axial direction (X).

**[0046]** The holding member (77) covers the rear opening (50b) of the casing (50). The holding member (77) is plate-shaped. The holding member (77) has a thickness direction (t) in the axial direction (X). The holding member (77) is substantially disc-shaped. The holding member (77) is shorter in the axial direction (X) than in the radial direction (R).

**[0047]** A front surface of the holding member (77) is in contact with the rear end of the first portion (73a) of the rear bearing holder (73). The holding member (77) presses the rear bearing holder (73) forward (Xa) in the axial direction (X). The holding member (77) holds the rear bearing holder (73) with respect to the cylindrical wall (55) of the casing (50).

**[0048]** As described above, the partition wall (53) divides the casing (50) in the axial direction (X) into the motor housing (51) and the compression chamber forming portion (52) as illustrated in FIG. 4. The partition wall (53) extends in the radial direction (R). The partition wall (53) is disposed on the front side (Xa) of the cylindrical wall (55) in the axial direction (X). A front surface of the partition wall (53) faces the motor chamber (54). A rear surface of the partition wall (53) faces the front end of the screw rotor (20).

**[0049]** The partition wall (53) has a shaft through hole (53a). The shaft through hole (53a) penetrates the partition wall (53) in the axial direction (X). The shaft (10) passes the shaft through hole (53a) in the axial direction (X).

**[0050]** The intermediate bearing (78) is disposed on the partition wall (53) in the shaft through hole (53a). The intermediate bearing (78) supports the shaft (10) so that the shaft (10) is rotatable relative to the partition wall (53) of the casing (50).

**[0051]** The front bearing (71), the rear bearing (74), and the intermediate bearing (78) support the shaft (10) so that the shaft (10) is rotatable relative to the casing (50). The casing (50) rotatably holds the shaft (10). The casing (50) rotatably holds the screw rotor (20). The casing (50) rotatably holds the motor rotor (41).

(Case Outer Wall)

**[0052]** As illustrated in FIGS. 3 to 5, the casing (50) has a case outer wall (58) on the outside (Ra) in the radial direction (R). The case outer wall (58) is a wall on the outside (Ra) of the casing (50) in the radial direction (R).

(Gate Rotor Chamber)

**[0053]** As illustrated in FIG. 5, the casing (50) has a first gate rotor chamber (59). The first gate rotor chamber (59) is formed outside (Ra) the cylindrical wall (55) of the casing (50) in the radial direction (R). The first gate rotor chamber (59) is formed on the left of the cylindrical wall (55) of the casing (50). The first gate rotor chamber (59) and a first compression chamber (S1) communicate with each other via the first slit (56).

**[0054]** The first gate rotor (30) is housed in the first gate rotor chamber (59). The first gate rotor chamber (59) further houses the first proximal gate bearing (79), the first distal gate bearing (80), the first proximal gate bearing holder (81), and the first distal gate bearing holder (82).

**[0055]** The first proximal gate bearing (79) is a single first proximal gate bearing (79). The first proximal gate bearing (79) rotatably supports a proximal end portion (an upper end portion) of the first gate shaft (31) of the first gate rotor (30). There are two first distal gate bearings (80). The first distal gate bearings (80) rotatably support a distal end portion (a lower end portion) of the first gate shaft (31) of the first gate rotor (30).

**[0056]** The first proximal gate bearing holder (81) is disposed above (Va) the first gate rotor (30). The first proximal gate bearing holder (81) holds the first proximal gate bearing (79) with respect to the casing (50). The first proximal gate bearing holder (81) is detachable from the upper side (Va) of the first gate rotor chamber (59) of the casing (50).

**[0057]** The first distal gate bearing holder (82) is disposed below (Vb) the first gate rotor (30). The first distal gate bearing holder (82) holds the first distal gate bearing (80). The first distal gate bearing holder (82) is detachable from the lower side (Vb) of the first gate rotor chamber (59) of the casing (50).

**[0058]** A first gate opening (60) is formed in a left part of the case outer wall (58) of the casing (50). The first gate opening (60) communicates with the first gate rotor chamber (59).

**[0059]** As illustrated in FIG. 5, the casing (50) has a second gate rotor chamber (61). The second gate rotor chamber (61) is formed outside (Ra) the cylindrical wall (55) of the casing (50) in the radial direction (R). The second gate rotor chamber (61) is formed on the lower (Vb) right side of the cylindrical wall (55) of the casing (50). The second gate rotor chamber (61) and a second compression chamber (S2) communicate with each other via the second slit (57).

**[0060]** The second gate rotor (35) is housed in the second gate rotor chamber (61). The second gate rotor chamber (61) further houses the second proximal gate bearing (83), the second distal gate bearing (84), the second proximal gate bearing holder (85), and the second distal gate bearing holder (86).

**[0061]** There is a single second proximal gate bearing (83). The second proximal gate bearing (83) rotatably supports a proximal end portion (a lower left end portion) of the second gate shaft (36) of the second gate rotor (35). There are three second distal gate bearings (84). The second distal gate bearings (84) rotatably support a distal end portion (an upper right end portion) of the second gate shaft (36) of the second gate rotor (35).

**[0062]** The second proximal gate bearing holder (85) is disposed on the lower (Vb) left side of the second gate rotor (35). The second proximal gate bearing holder (85) holds the second proximal gate bearings (83). The second proximal gate bearing holder (85) is detachable from the lower (Vb) left side of the second gate rotor chamber (61) of the casing (50).

**[0063]** The second distal gate bearing holder (86) is disposed on the upper (Va) right side of the second gate rotor (35). The second distal gate bearing holder (86) holds the second distal gate bearings (84). The second distal gate bearing holder (86) is detachable from the upper (Va) right side of the second gate rotor chamber (61) of the casing (50).

**[0064]** A second gate opening (62) is formed in a lower (Vb) right part of the case outer wall (58) of the casing (50). The second gate opening (62) communicates with the second gate rotor chamber (61).

(Compression Chamber)

**[0065]** As illustrated in FIG. 5, a first compression chamber (S1) is formed by the screw grooves (21) of the screw rotor (20), the first gate (32) of the first gate rotor (30), and the cylindrical wall (55) of the casing (50). The first compression chamber (S1) compresses a working fluid (W). A second compression chamber (S2) is formed by the screw grooves (21) of the screw rotor (20), the second gate (37) of the second gate rotor (35), and the cylindrical wall (55) of the casing (50). The second compression chamber (S2) compresses the working fluid (W). The working fluid (W) is, for example, a refrigerant gas.

**[0066]** The first compression chamber (S1) is located above (Va) the center axis (O) of the screw rotor (20) (the shaft (10)) in the vertical direction (V). Specifically, suppose the first compression chamber (S1) is represented by a first range (S1a) in the circumferential direction ($\theta$) around the center axis (O), a major part of the whole first compression chamber (S1) (the first range (S1a)) is located above (Va) the center axis (O) in the vertical direction (V) (see FIG. 6).

**[0067]** The second compression chamber (S2) is located below (Vb) the center axis (O) of the screw rotor (20) (the shaft (10)) in the vertical direction (V). Specifically, suppose the second compression chamber (S2) is represented by a second range (S2a) in the circumferential direction ($\theta$) around the center axis (O), a major part of the whole second compression chamber (S2) (the second range (S2a)) is located below (Vb) the center axis (O) in the vertical direction (V) (see FIG. 6).

(Case Outlet)

**[0068]** FIG. 6 shows the screw compressor (1) in a front sectional view taken along line VI-VI in FIG. 4. A first case outlet (63) is formed in the left part of the case outer wall (58) of the casing (50). The working fluid (W) is discharged outside the casing (50) through the first case outlet (63). A second case outlet (64) is formed in a lower (Vb) right part of the case outer wall (58) of the casing (50). The working fluid (W) is discharged outside the casing (50) through the second case outlet (64).

(Discharge Port)

**[0069]** As illustrated in FIG. 6, a first discharge port (65) is formed in a portion (55c) of the cylindrical wall (55) of the casing (50) facing the first compression chamber (S1). The first discharge port (65) is arranged on the upper (Va) left side of the screw rotor (20). The first discharge port (65) is formed in the inner peripheral surface of the cylindrical wall (55). The first discharge port (65) is formed in a substantially semicircular shape when viewed in the axial direction (X). The first discharge port (65) communicates with the first compression chamber (S1).

**[0070]** A second discharge port (66) is formed in a portion (55d) of the cylindrical wall (55) of the casing (50) facing the second compression chamber (S2). The second discharge port (66) is arranged on the lower (Vb) right side of the screw rotor (20). The second discharge port (66) is formed in the inner peripheral surface of the cylindrical wall (55). The second discharge port (66) is formed in a substantially semicircular shape when viewed in the axial direction (X). The second discharge port (66) communicates with the second compression chamber (S2).

**[0071]** As illustrated in FIG. 6, the first case outlet (63) and the second case outlet (64) are located at different positions in the circumferential direction ($\theta$) of the screw rotor (20) (in the direction around the center axis (O)).

(Connection Passage)

**[0072]** As illustrated in FIG. 6, the casing (50) is provided with a first connection passage (67). The first connection passage (67) is formed by opening a hole in the wall of the casing (50). The first connection passage (67) crosses the first gate rotor chamber (59) of the casing (50) in the left-right direction. The first connection passage (67) connects the first case outlet (63) and the first discharge port (65). The first discharge port (65) communicates with the first case outlet (63) via the first connection passage (67). The first connection passage (67) extends straight.

**[0073]** The casing (50) is provided with a second connection passage (68). The second connection passage (68) is formed by opening a hole in the wall of the casing (50). The second connection passage (68) crosses the second gate rotor chamber (61) in the casing (50) obliquely with respect to the up-down direction and the left-right direction. The second connection passage (68) connects the second case outlet (64) and the second discharge port (66). The second discharge port (66) communicates with the second case outlet (64) via the second connection passage (68). The second connection passage (68) extends straight.

(Slide Valve)

**[0074]** FIG. 7 is a sectional view of the vicinity of the first discharge port (65) taken along line VII-VII in FIG. 6. As described above, the first discharge port (65) is formed in the portion (55c) of the cylindrical wall (55) of the casing (50) facing the first compression chamber (S1). The first slide valve (87) moves in the axial direction (X) in the first discharge port (65).

**[0075]** When the first slide valve (87) moves in the axial direction (X), the position of the first slide valve (87) relative to the first compression chamber (S1) changes. The first slide valve (87) moves in the axial direction (X) to adjust the opening degree (C) of the first discharge port (65). When the first slide valve (87) comes to a front end position (Ja), the first slide valve (87) blocks a gap between the first compression chamber (S1) and the first discharge port (65), reducing the opening degree (C) of the first discharge port (65). When the first slide valve (87) comes to a rear end position (Jb) (indicated by the two dot chain line), the gap is generated between the first compression chamber (S1) and the first discharge port (65), increasing the opening degree (C) of the first discharge port (65).

**[0076]** The first valve movement mechanism (88) causes the first slide valve (87) to move in the axial direction (X). The first valve movement mechanism (88) is a cylinder and piston mechanism. The first valve movement mechanism (88) includes a cylinder (88a), a piston (88b), and a rod (88c). The piston (88b) is disposed in the cylinder (88a). The rod (88c) extends from the front surface of the piston (88b) toward the front side (X) in the axial direction (X) and is connected to the rear end of the first slide valve (87).

**[0077]** A pressure control chamber (88d) is formed in the cylinder (88a) on the rear side (Xb) of the piston (88b) in the axial direction (X). When a high pressure is introduced into the pressure control chamber (88d), the first slide valve (87) moves to the front side (Xa) in the axial direction (X) together with the piston (88b) and the rod (88c). Although not shown, the first valve movement mechanism (88) biases the first slide valve (87) to the rear side (Xb) in the axial direction (X) with a spring.

**[0078]** Although not described in detail, the second slide valve (89) (see FIG. 6) moves in the axial direction (X) in the second discharge port (66). The second slide valve (89) moves in the axial direction (X) to adjust the opening degree (C) of the second discharge port (66). The second valve movement mechanism (90) (see FIGS.

1 and 2) causes the second slide valve (89) to move in the axial direction (X). The detailed structures of the second slide valve (89) and the second valve movement mechanism (90) are the same as those of the first slide valve (87) and the first valve movement mechanism (88).

(Positional Relationship between Case Outlet and Discharge Port)

**[0079]** FIG. 8 is a sectional view illustrating the positional relationship between the first case outlet (63) and the first discharge port (65), with the first slide valve (87) removed.

**[0080]** As illustrated in FIG. 8, the first discharge port (65) includes a front end (65a) as a first end and a rear end (65b) as a second end. The front end (65a) is an end of the first discharge port (65) on the front side (Xa) in the axial direction (X). The rear end (65b) is an end of the first discharge port (65) on the rear side (Xb) in the axial direction (X).

**[0081]** A position away from the front end (65a) of the first discharge port (65) toward the front side (Xa) in the axial direction (X) by the gate radius (r) of the first gate (32) is referred to as a front position (Ka) which is a first position. A position away from the rear end (65b) of the first discharge port (65) toward the rear side (Xb) in the axial direction (X) by the gate radius (r) of the first gate (32) is referred to as a rear position (Kb) which is a second position.

**[0082]** The first case outlet (63) is located between the front position (Ka) and the rear position (Kb) in the axial direction (X). The first case outlet (63) is located to overlap with the first discharge port (65) in the axial direction (X).

**[0083]** At least part of the opening width (B) of the first case outlet (63) in the axial direction (X) is within a range between the front position (Ka) and the rear position (Kb) in the axial direction (X).

**[0084]** As illustrated in FIG. 6, the first case outlet (63) is located closer to the first discharge port (65) than to the screw rotor (20) in the radial direction (R). A distance between the first case outlet (63) and the first discharge port (65) in the radial direction (R) is shorter than a distance between the first case outlet (63) and the screw rotor (20) in the radial direction (R).

**[0085]** The positional relationship between the second case outlet (64) and the second discharge port (66) is substantially the same as the positional relationship between the first case outlet (63) and the first discharge port (65). The positional relationship between the second case outlet (64) and the second discharge port (66) is indicated by reference numerals in parentheses in FIG. 8 for the sake of simplicity, although it is slightly different in a strict sense. In the description of the positional relationship between the second case outlet (64) and the second discharge port (66), the same matters as those in the positional relationship between the first case outlet (63) and the first discharge port (65) may not be described in detail.

**[0086]** As illustrated in FIG. 8, the second discharge port (66) includes a front end (66a) as a first end and a rear end (66b) as a second end. The front end (66a) is an end of the second discharge port (66) on the front side (Xa) in the axial direction (X). The rear end (66b) is an end of the second discharge port (66) on the rear side (Xb) in the axial direction (X).

**[0087]** A position away from the front end (66a) of the second discharge port (66) toward the front side (Xa) in the axial direction (X) by the gate radius (r) of the second gate (37) is referred to as a front position (Ka) which is a first position. A position away from the rear end (66b) of the second discharge port (66) toward the rear side (Xb) in the axial direction (X) by the gate radius (r) of the second gate (37) is referred to as a rear position (Kb) which is a second position.

**[0088]** The second case outlet (64) is located between the front position (Ka) and the rear position (Kb) in the axial direction (X). The second case outlet (64) is located to overlap with the second discharge port (66) in the axial direction (X).

**[0089]** As illustrated in FIG. 6, the second case outlet (64) is located closer to the second discharge port (66) than to the screw rotor (20) in the radial direction (R).

(Positional Relationship between Case Outlet and Gate Opening)

**[0090]** FIG. 9 is a sectional view taken along line IX-IX in FIG. 6, illustrating the positional relationship between the first case outlet (63) and the first gate opening (60).

**[0091]** As illustrated in FIGS. 6 and 9, the first gate shaft (31) and the first gate (32) of the first gate rotor (30) are visible through the first gate opening (60). The first case outlet (63) is arranged inside the first gate opening (60).

**[0092]** The first case outlet (63) and the first gate opening (60) are covered with a common first cap (91). The first cap (91) is also referred to as a side cap. The first cap (91) is substantially disc-shaped. A first case-side mounting surface (58a) is provided on a peripheral portion of the first gate opening (60) of the case outer wall (58). The first cap (91) is mounted on the first case-side mounting surface (58a). The first case outlet (63) is flush with the first case-side mounting surface (58a) of the case outer wall (58) on which the first cap (91) is mounted.

**[0093]** The first case outlet (63) being flush with the first case-side mounting surface (58a) means that the outer peripheral end of the first case outlet (63) and the first case-side mounting surface (58a) have almost no level difference. The level difference is preferably 1 mm or less, more preferably 0.5 mm or less, still more preferably 0.1 mm or less.

**[0094]** As illustrated in FIG. 6, a gasket (92) is disposed between the first case-side mounting surface (58a) and the first cap (91). The gasket (92) may be a sheet gasket or a spiral gasket. An O-ring may be used as the gasket (92). The first case-side mounting surface (58a) and the first cap (91) are sealed with the gasket (92).

**[0095]** The positional relationship between the second case outlet (64) and the second gate opening (62) is substantially the same as the positional relationship between the first case outlet (63) and the first gate opening (60). The positional relationship between the second case outlet (64) and the second gate opening (62) is indicated by reference numerals in parentheses in FIG. 9 for the sake of simplicity, although it is slightly different in a strict sense. In the description of the positional relationship between the second case outlet (64) and the second gate opening (62), the same matters as those in the positional relationship between the first case outlet (63) and the first gate opening (60) may not be described in detail.

**[0096]** The second case outlet (64) and the second gate opening (62) are covered with a common second cap (93). The second case outlet (64) is flush with a second case-side mounting surface (58b) of the case outer wall (58) on which the second cap (93) is mounted. The second case-side mounting surface (58b) and the second cap (93) are sealed with a gasket (92).

(Cap)

**[0097]** As illustrated in FIG. 6, the first cap (91) is provided with a first cap-side discharge passage (94). The first cap-side discharge passage (94) includes a hole (94a) and a pipe portion (94b). The hole (94a) of the first cap-side discharge passage (94) penetrates the first cap (91) in the radial direction (R). The hole (94a) of the first cap-side discharge passage (94) is connected to the first case outlet (63). The first cap-side discharge passage (94) communicates with the first case outlet (63). The pipe portion (94b) of the first cap-side discharge passage (94) is located outside (Ra) of the first cap (91) in the radial direction (R) and extends in the radial direction (R). The first cap (91) and the first cap-side discharge passage (94) are formed integrally.

**[0098]** One end of the first discharge pipe (95) is connected to an end of the first cap-side discharge passage (94). In other words, the first discharge pipe (95) is connected to the first case outlet (63) via the first cap-side discharge passage (94). The first discharge pipe (95) communicates with the first cap-side discharge passage (94). That is, the first discharge pipe (95) communicates with the first case outlet (63) via the first cap-side discharge passage (94). The other end of the first discharge pipe (95) is connected to a second inlet (69c) described later.

**[0099]** The first discharge pipe (95) is provided with a silencer (96). Specifically, the silencer (96) is wound around the outer periphery of the first discharge pipe (95). The silencer (96) is made of, for example, a sponge or polyurethane.

**[0100]** As illustrated in FIG. 6, the second cap (93) is provided with a second cap-side discharge passage (97). The second cap-side discharge passage (97) includes a hole (97a) and a pipe portion (97b). The hole (97a) of the second cap-side discharge passage (97) penetrates the second cap (93) in the radial direction (R). The hole (97a) of the second cap-side discharge passage (97) is connected to the second case outlet (64). The second cap-side discharge passage (97) communicates with the second case outlet (64). The pipe portion (97b) of the second cap-side discharge passage (97) is located outside (Ra) of the second cap (93) in the radial direction (R) and extends in the radial direction (R). The second cap (93) and the second cap-side discharge passage (97) are formed integrally.

**[0101]** One end of the second discharge pipe (98) is connected to an end of the second cap-side discharge passage (97). In other words, the second discharge pipe (98) is connected to the second case outlet (64) via the second cap-side discharge passage (97). The second discharge pipe (98) communicates with the second cap-side discharge passage (97). That is, the second discharge pipe (98) communicates with the second case outlet (64) via the second cap-side discharge passage (97). The other end of the second discharge pipe (98) is connected to, for example, a condenser in the refrigerant circuit. The second discharge pipe (98) is provided with a silencer (96). Specifically, the silencer (96) is wound around the outer periphery of the second discharge pipe (98).

(Inlet)

**[0102]** As illustrated in FIG. 4, a first inlet (69a) is provided in an upper portion of the case outer wall (58) of the compression chamber forming portion (52) of the casing (50). The first inlet (69a) communicates with the first compression chamber (S1) via a first suction passage (69b) provided in the cylindrical wall (55).

**[0103]** As illustrated in FIG. 4, the case outer wall (58) of the motor housing (51) of the casing (50) is provided with a second inlet (69c). The second inlet (69c) communicates with the motor chamber (54) via the second suction passage (69d).

(Two Stage Compression)

**[0104]** The screw compressor (1) is a two-stage screw compressor. The first compression chamber (S1) compresses the working fluid (W) at a first pressure (P1) to an intermediate pressure (Pm) higher than the first pressure (P1). The second compression chamber (S2) compresses the working fluid (W) at the intermediate pressure (Pm) to a second pressure (P2) higher than the intermediate pressure (Pm). The first compression chamber (S1) is also referred to as a low-stage compression chamber. The second compression chamber (S2) is also referred to as a high-stage compression chamber. The first pressure (P1) is also referred to as a low pressure. The second pressure (P2) is also referred to as a high pressure.

**[0105]** The working fluid (W) flows through the first inlet (69a), the first suction passage (69b), the first compression chamber (S1), the first discharge port (65), the first connection passage (67), the first case outlet (63), the first cap-side discharge passage (94), the first discharge pipe (95), the second inlet (69c), the second suction passage (69d), the motor chamber (54) as an intermediate chamber (Sm), the second compression chamber (S2), the second discharge port (66), the second connection passage (68), the second case outlet (64), the second cap-side discharge passage (97), and the second discharge pipe (98) in this order.

(Seal)

**[0106]** FIG. 10 shows the screw compressor (1) in a front sectional view taken along line X-X in FIG. 4. As illustrated in FIGS. 4 and 10, the front stationary seal (55a) on the inner peripheral surface of the cylindrical wall (55) of the casing (50) and the front rotary seal (22) of the screw rotor (20) slide against each other with a minute clearance left between them in the radial direction (R). As illustrated in FIG. 10, the front stationary seal (55a) is disposed above (Va) the center axis (O) in the vertical direction (V). The front stationary seal (55a) and the front rotary seal (22) slide against each other above (Va) the center axis (O) in the vertical direction (V).

**[0107]** As illustrated in FIG. 4, the front stationary seal (55a) and the front rotary seal (22) seal the motor chamber (54) (the intermediate chamber (Sm)) and the first compression chamber (S1). The motor chamber (54) sealed with the front stationary seal (55a) and the front rotary seal (22) does not communicate with the first compression chamber (S1).

**[0108]** As described above, the working fluid (W) is required to flow from the motor chamber (54) to the second compression chamber (S2), not from the motor chamber (54) to the first compression chamber (S1). The front stationary seal (55a) and the front rotary seal (22) block the flow of the working fluid (W) from the motor chamber (54) to the first compression chamber (S1).

(Communication Passage)

**[0109]** FIG. 11 shows the screw compressor (1) in a front sectional view taken along line XI-XI in FIG. 4. As illustrated in FIGS. 4 and 11, the partition wall (53) of the casing (50) has a communication hole (53b). The communication hole (53b) penetrates the partition wall (53) in the axial direction (X).

**[0110]** The communication hole (53b) constitutes a communication passage (F). In other words, the communication passage (F) includes the communication hole (53b). The communication passage (F) is disposed below (Vb) the center axis (O) in the vertical direction (V).

**[0111]** The communication passage (F) allows the motor chamber (54) and the second compression chamber (S2) to communicate with (be connected to) each other. The motor chamber (54) communicates with the second compression chamber (S2) via the communication passage (F).

**[0112]** The communication passage (F) includes an inclined portion (Fa). The inclined portion (Fa) is inclined upward from the motor chamber (54) on the front side (Xa) in the axial direction (X) toward the second compression chamber (S2) on the rear side (Xb) in the axial direction (X).

(Positional Relationship between Rotor and Communication Passage)

**[0113]** FIG. 12 illustrates the positional relationship between a rotor (A) and the communication passage (F) in a sectional view. The rotor (A) includes the shaft (10), the screw rotor (20), and the motor rotor (41). The outermost diameter (DA) of the rotor (A) is the larger one of the outermost diameter (D20) of the screw rotor (20) and the outermost diameter (D41) of the motor rotor (41). In this example, the outermost diameter (D41) of the motor rotor (41) is larger than the outermost diameter (D20) of the screw rotor (20), and thus, the outermost diameter (DA) of the rotor (A) is the outermost diameter (D41) of the motor rotor (41).

**[0114]** A lower end (Fb) of the communication passage (F) is located below (Vb) the outermost diameter (DA) of the rotor (A) in the vertical direction (V).

(Oil Sump)

**[0115]** As illustrated in FIG. 12, an oil sump (G) is formed by an inner bottom surface (50c) of the casing (50) on the lower side (Vb) in the vertical direction (V). Oil (g) is stored in the oil sump (G). The oil (g) is contained in the working fluid (W) as mist and is separated by an oil separator (disposed outside the screw compressor (1), not shown) to be stored in the oil sump (G). When the working fluid (W) flows at a sufficient flow rate, the height of the oil level (G0) of the oil (g) in the oil sump (G) in the vertical direction (V) substantially coincides with the lower end (Fb) of the communication passage (F).

(Advantages)

**[0116]** According to this embodiment, the first compression chamber (S1) is located above (Va) the center axis (O) of the screw rotor (20) as illustrated in FIG. 6. The first compression chamber (S1) is likely to be located above (Va) the oil level (G0) of the oil sump (G) formed in the intermediate chamber (Sm) (the motor chamber (54)).

**[0117]** The oil (g) in the oil sump (G) in the intermediate chamber (Sm) (the motor chamber (54)) is less likely to enter the first compression chamber (S1) through the seal (55a, 22). This can keep the screw rotor (20) from stirring the oil (g) in the first compression chamber (S1). Thus, the stirring loss of the oil (g) in the screw compressor (1) can be reduced.

**[0118]** The second compression chamber (S2) is located below (Vb) the center axis (O) of the screw rotor (20). The second pressure (P2) in the second compression chamber (S2) is higher than the intermediate pressure (Pm) in the intermediate chamber (Sm) (the motor chamber (54)). The oil (g) in the oil sump (G) in the low pressure intermediate chamber (Sm) (the motor chamber (54)) is less likely to enter the high pressure second compression chamber (S2).

**[0119]** The height of the oil level (G0) in the oil sump (G) in the motor chamber (54) (intermediate chamber (Sm)) substantially coincides with the lower end (Fb) of the communication passage (F). The lower end (Fb) of the communication passage (F) is located below (Va) the outermost diameter (DA) of the rotor (A), advantageously keeping the rotor (A) including the screw rotor (20) and the motor rotor (41) from stirring the oil.

**[0120]** The communication passage (F) can be suitably formed in the casing (50) by forming the hole (53b) in the partition wall (53).

**[0121]** The inclined portion (Fa) increases the flow velocity of the fluid (W) flowing through the communication passage (F). The oil (g) can be kept from easily accumulating in the intermediate chamber (Sm).

<Other Embodiments>

**[0122]** Although not shown, the communication passage (F) may have a constricted portion. In this case, the constricted portion constricts a flow passage area of the communication passage (F).

**[0123]** The communication passage (F) may include a member (e.g., a pipe) separate from the casing (50).

**[0124]** In the above embodiment, a two stage compressor has been described as the screw compressor (1) including the first compression chamber (S1) and the second compression chamber (S2), but the present disclosure is not limited to this example. A third compression chamber may be provided between the first compression chamber (S1) and the second compression chamber (S2). In this case, the first compression chamber (S1) compresses the working fluid (W) at the first pressure (P1) to a first intermediate pressure higher than the first pressure (P1). The third compression chamber compresses the working fluid (W) at the first intermediate pressure to a second intermediate pressure higher than the first intermediate pressure. The second compression chamber (S2) compresses the working fluid (W) at the second intermediate pressure to a second pressure (P2) higher than the second intermediate pressure.

**[0125]** In the above embodiment, most of the first compression chamber (S1) (a first range (S1a)) is located above (Va) the center axis (O) in the vertical direction (V) as illustrated in FIG. 6, but the present disclosure is not limited to this example. 51% of the first compression chamber (S1) (the first range (S1a)) may be located above (Va) the center axis (O) in the vertical direction (V).

**[0126]** While the embodiments have been described above, it will be understood that various changes in form and details can be made without departing from the spirit and scope of the claims. The elements of the above-described embodiments, variations, and other embodiments may be appropriately combined or replaced.

DESCRIPTION OF REFERENCE CHARACTERS

**[0127]**

| | |
|---|---|
| O | Center Axis |
| X | Axial Direction |
| Xa | Front Side (First Side) |
| Xb | Rear Side (Second Side) |
| R | Radial Direction |
| Ra | Radially Outer Side (Outside) |
| Rb | Radially Inner Side (Inside) |
| V | Vertical Direction |
| Va | Upper Side (Above) |
| Vb | Lower Side (Below) |
| θ | Circumferential Direction |
| r | Gate Radius |
| t | Thickness Direction |
| W | Working Fluid (Fluid) |
| S1 | First Compression Chamber |
| S2 | Second Compression Chamber |
| Sm | Intermediate Chamber |
| P1 | First Pressure |
| P2 | Second Pressure |
| Pm | Intermediate Pressure |
| C | Opening Degree |
| Ka | Front Position (First Position) |
| Kb | Rear Position (Second Position) |
| F | Communication Passage |
| Fa | Inclined Portion |
| Fb | Lower End |
| A | Rotor |
| DA | Outermost Diameter |
| D20 | Outermost Diameter |
| D41 | Outermost Diameter |
| G | Oil Sump |
| G0 | Oil Level |
| g | Oil |
| U | Pulsation |
| 1 | Screw Compressor |
| 10 | Shaft |
| 20 | Screw Rotor |
| 21 | Screw Groove |
| 22 | Front Rotary Seal |
| 23 | Rear Rotary Seal |
| 30 | First Gate Rotor |
| 32 | First Gate |
| 35 | Second Gate Rotor |
| 37 | Second Gate |
| 40 | Motor |
| 41 | Motor Rotor |
| 42 | Motor Stator |

| | |
|---|---|
| 50 | Casing |
| 53 | Partition Wall (Wall) |
| 53b | Communication Hole |
| 54 | Motor Chamber |
| 55 | Cylindrical Wall |
| 55a | Front Stationary Seal (Portion) |
| 55b | Rear Stationary Seal (Portion) |
| 55c | Portion |
| 55d | Portion |
| 56 | First Slit |
| 57 | Second Slit |
| 58 | Case Outer Wall |
| 58a | First Case-Side Mounting Surface |
| 58b | Second Case-Side Mounting Surface |
| 59 | First Gate Rotor Chamber |
| 60 | First Gate Opening |
| 61 | Second Gate Rotor Chamber |
| 62 | Second Gate Opening |
| 63 | First Case Outlet |
| 64 | Second Case Outlet |
| 65 | First Discharge Port |
| 65a | Front End (First End) |
| 65b | Rear End (Second End) |
| 66 | Second Discharge Port |
| 66a | Front End (First End) |
| 66b | Rear End (Second End) |
| 67 | First Connection Passage |
| 68 | Second Connection Passage |
| 69a | First Inlet |
| 69c | Second Inlet |
| 73 | Rear Bearing Holder (Bearing Holder) |
| 74 | Rear Bearing (Bearing) |
| 77 | Holding Member |
| 87 | First Slide Valve |
| 89 | Second Slide Valve |
| 91 | First Cap |
| 92 | Gasket (First Seal Member) |
| 93 | Second Cap |
| 94 | First Cap-Side Discharge Passage |
| 94c | Cap-Side Insertion Pipe |
| 95 | First Discharge Pipe |
| 96 | Silencer |
| 97 | Second Cap-Side Discharge Passage |
| 97c | Cap-side Insertion Pipe |
| 98 | Second Discharge Pipe |
| 99 | Merge Portion |
| 100 | Merge Pipe |
| 101 | O-ring (Second Seal Member) |

## Claims

**1.** A screw compressor, comprising:

a screw rotor (20) having a screw groove (21);
a gate rotor (30, 35) having a gate (32, 37) that meshes with the screw groove (21); and
a casing (50) rotatably holding the screw rotor (20) and covering the screw rotor (20) from radially outside (R1),
the screw rotor (20), the gate rotor (30, 35), and the casing (50) forming a first compression chamber (S1) that compresses a fluid (W) at a first pressure (P 1) to an intermediate pressure (Pm) higher than the first pressure (P1) and a second compression chamber (S2) that compresses the fluid (W) at the intermediate pressure (Pm) to a second pressure (P2) higher than the intermediate pressure (Pm),
the casing (50) having an intermediate chamber (Sm) that communicates with the second compression chamber (S2),
the screw rotor (20) and the casing (50) being provided with a seal (55a, 22) that seals the intermediate chamber (Sm) and the first compression chamber (S 1),
the first compression chamber (S1) being located above (Va) a center axis (O) of the screw rotor (20).

**2.** The screw compressor of claim 1, wherein

the casing (50) is provided with a communication passage (F) that allows the intermediate chamber (Sm) and the second compression chamber (S2) to communicate with each other, and
a lower end (Fb) of the communication passage (F) is located below (Vb) an outermost diameter (DA) of a rotor (A) including the screw rotor (20).

**3.** The screw compressor of claim 2, wherein

the intermediate chamber (Sm) is a motor chamber (54) that houses a motor rotor (41), and
the lower end (Fb) of the communication passage (F) is located below (Fb) the outermost diameter (DA) of the rotor (A) including the screw rotor (20) and the motor rotor (41).

**4.** The screw compressor of claim 2 or 3, wherein the communication passage (F) has a hole (53b) formed in a wall (53) of the casing (50).

**5.** The screw compressor of any one of claims 2 to 4, wherein the communication passage (F) includes an inclined portion (Fa) that is inclined upward from the intermediate chamber (Sm) toward the second compression chamber (S2) or a constricted portion that constricts a flow passage area of the communication passage (F).

FIG.1

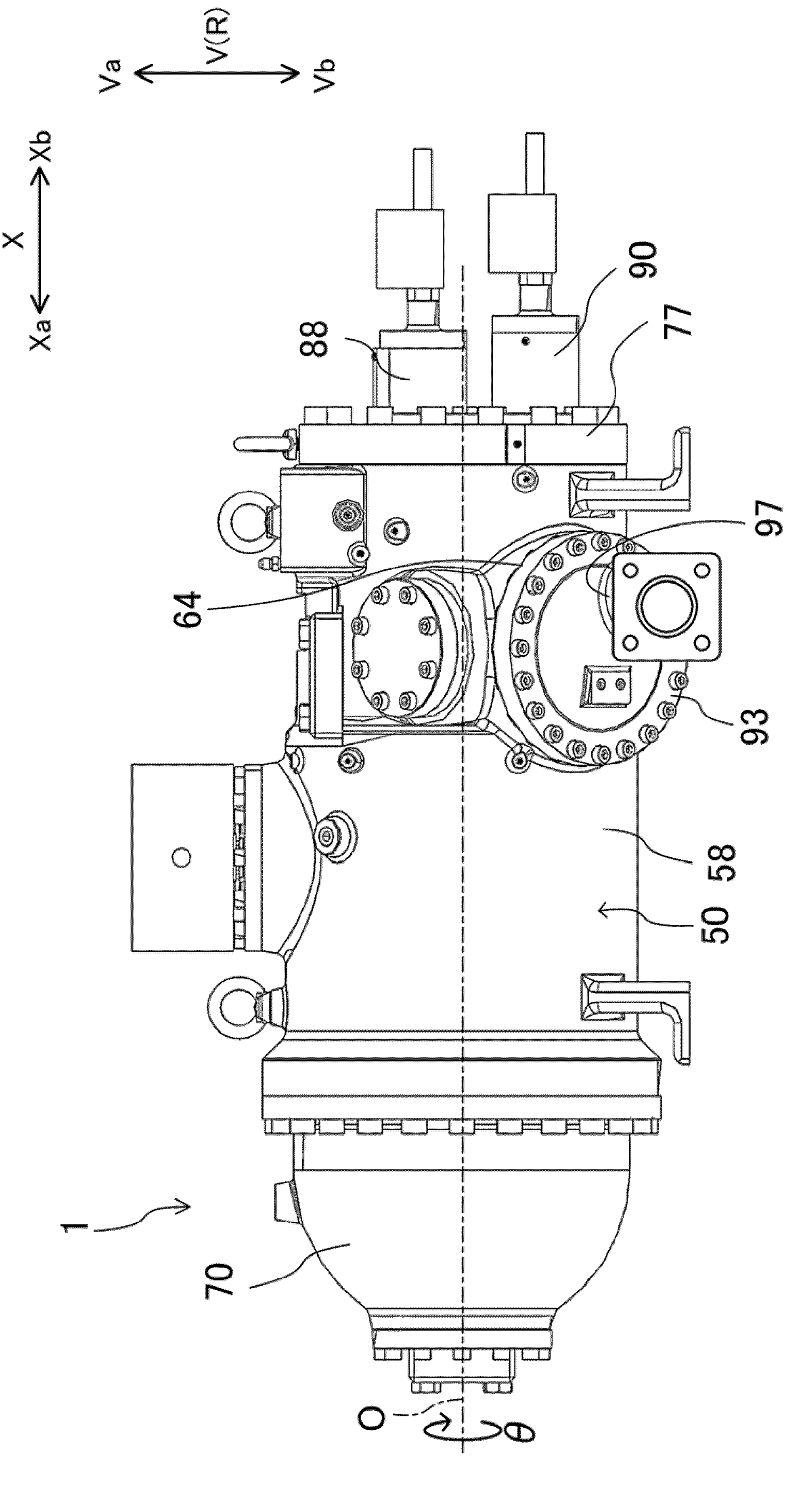


FIG.2

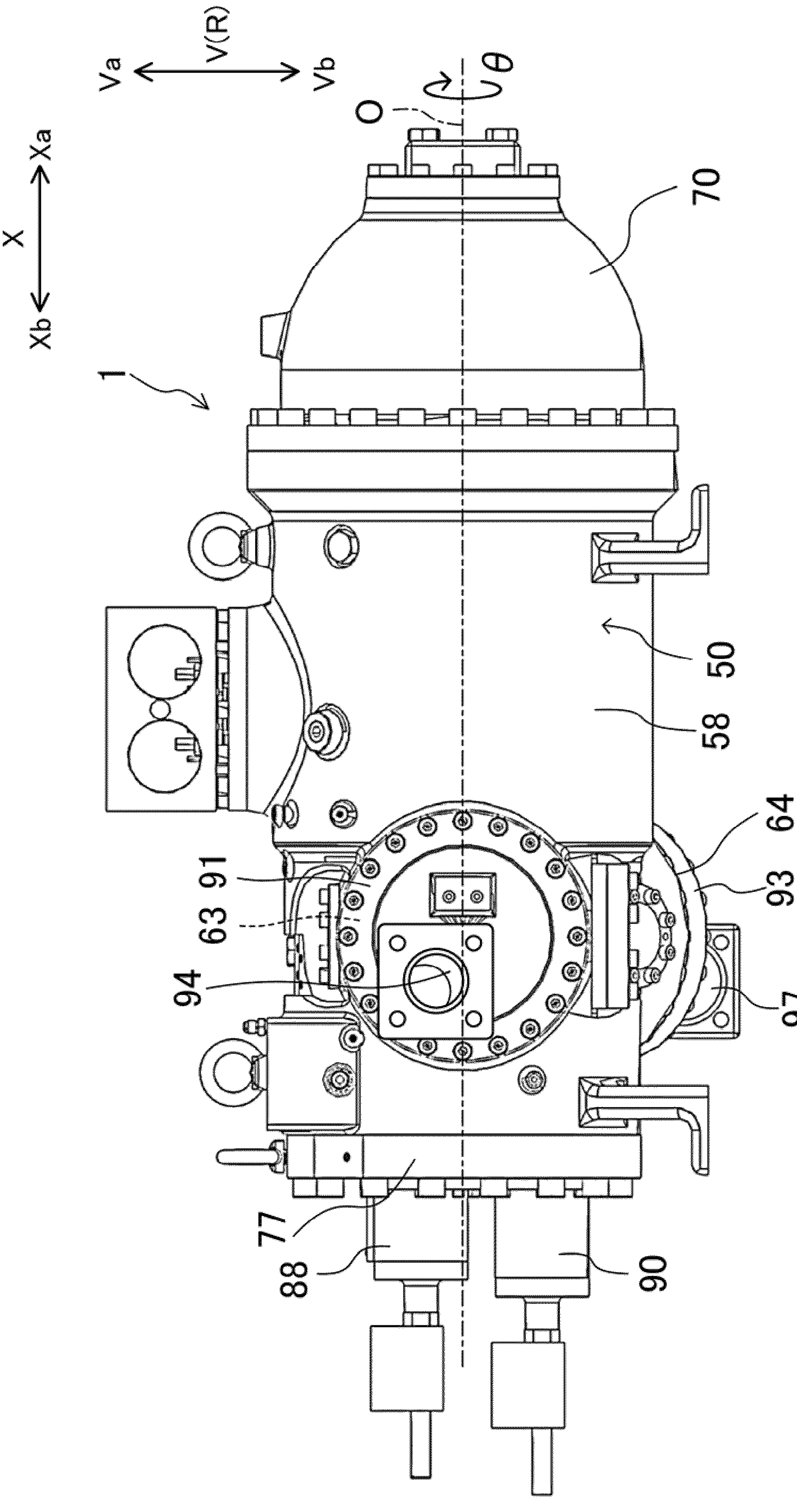
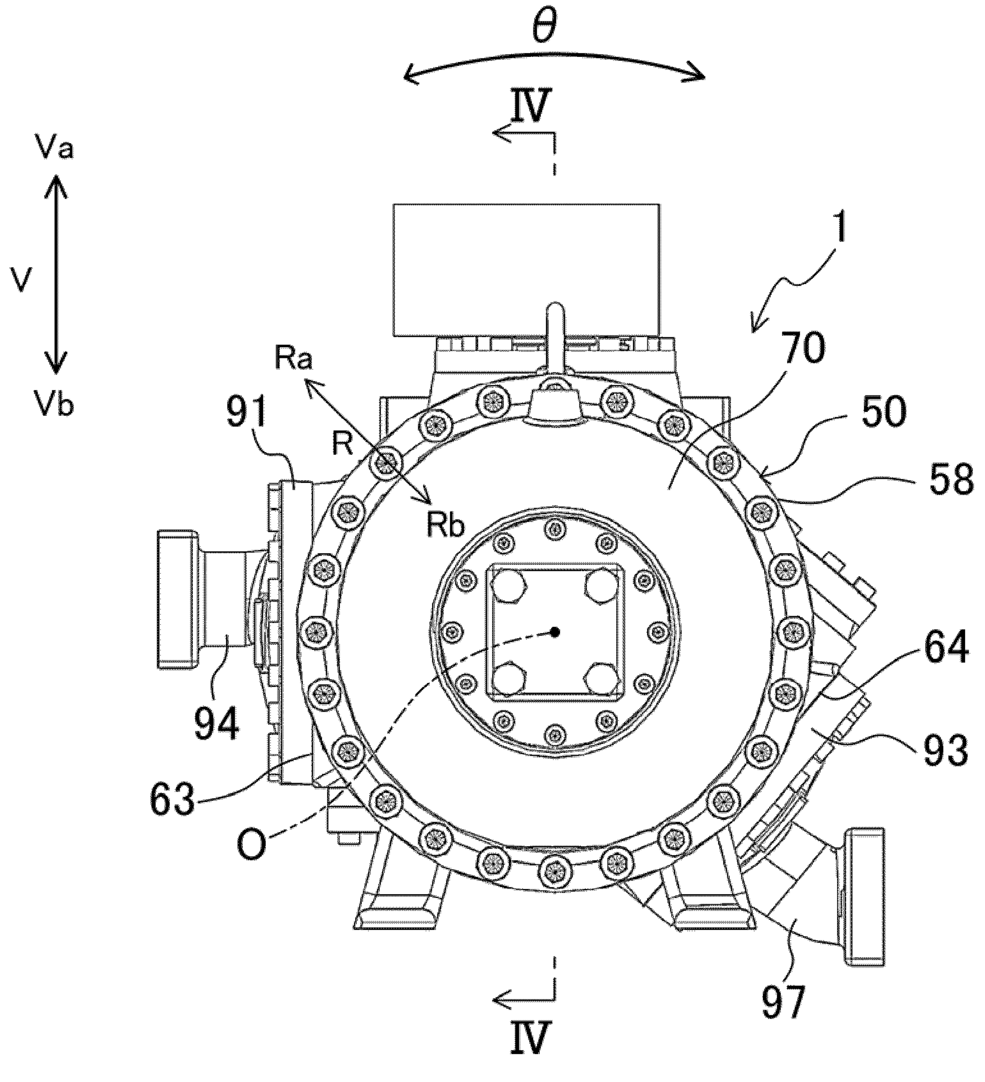


FIG.3



# FIG.4

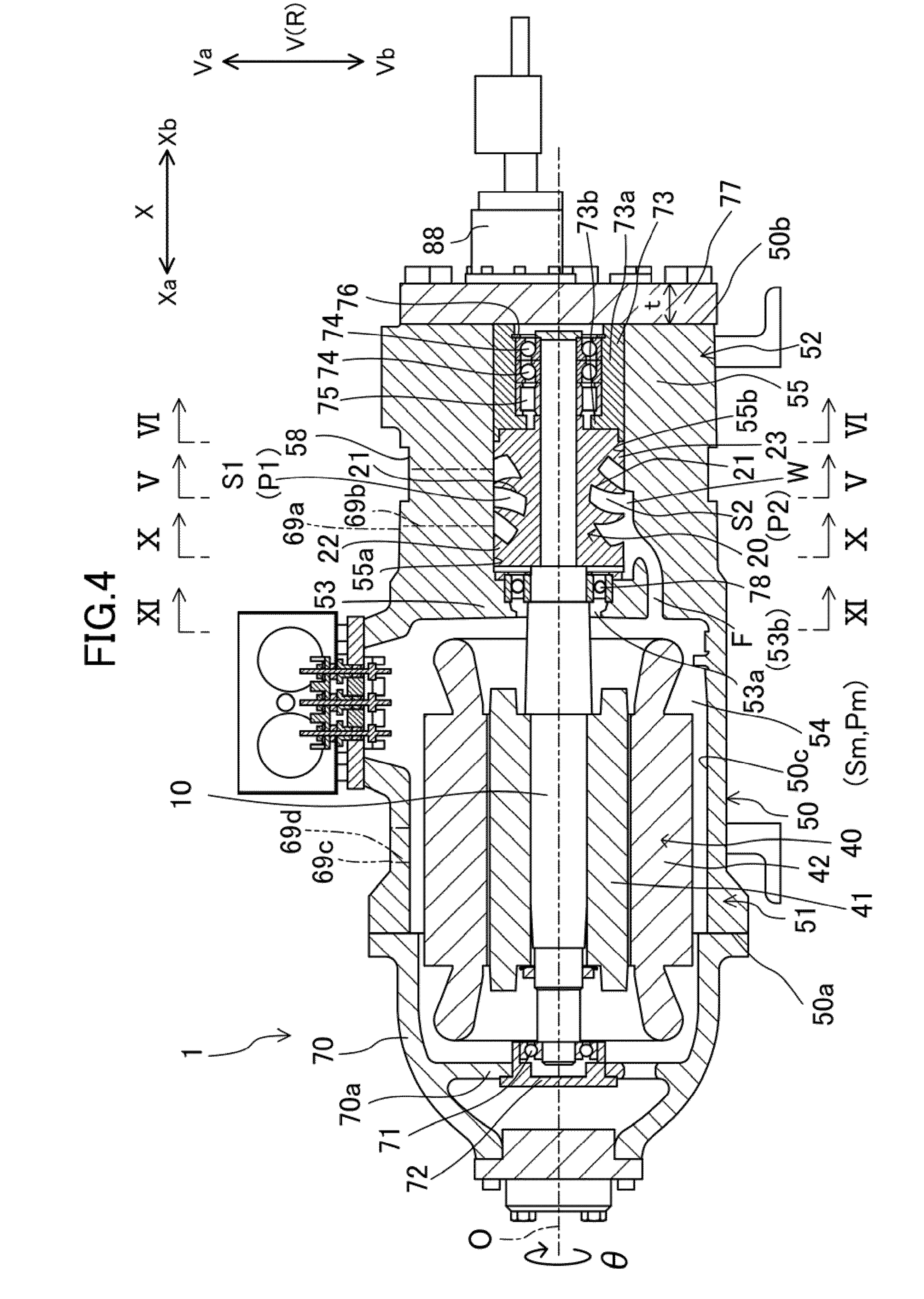

V(R)
Va
Vb
X
Xa
Xb
88
73b
73a
73
77
50b
76
74
74
75
t
52
55
55b
VI
VI
58
23
S1
(P1)
21
21
W
V
V
69b
69a
S2
(P2)
X
X
22
20
55a
78
53
XI
XI
F
(53b)
53a
54
50c
(Sm,Pm)
10
50
40
69d
69c
42
41
51
50a
1
70
70a
71
72
O
θ

FIG.5

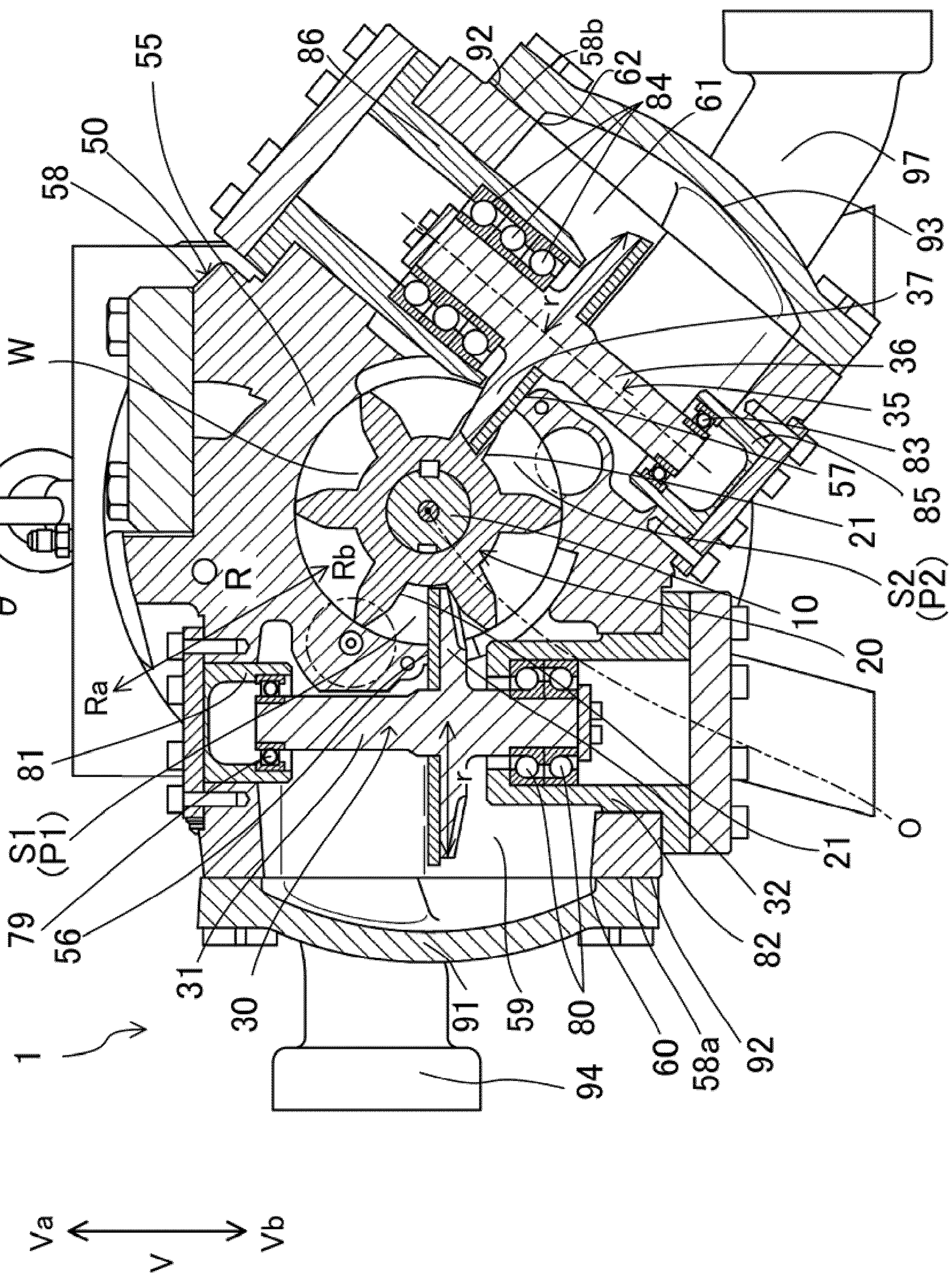

Va
V
Vb
θ
1
94
91
59
80
60
58a
92
82
32
21
O
20
10
S2
(P2)
21
85
57
83
35
36
37
93
97
61
84
62
58b
92
86
55
50
58
W
R
Rb
Ra
81
S1
(P1)
79
56
31
30
r

FIG.6

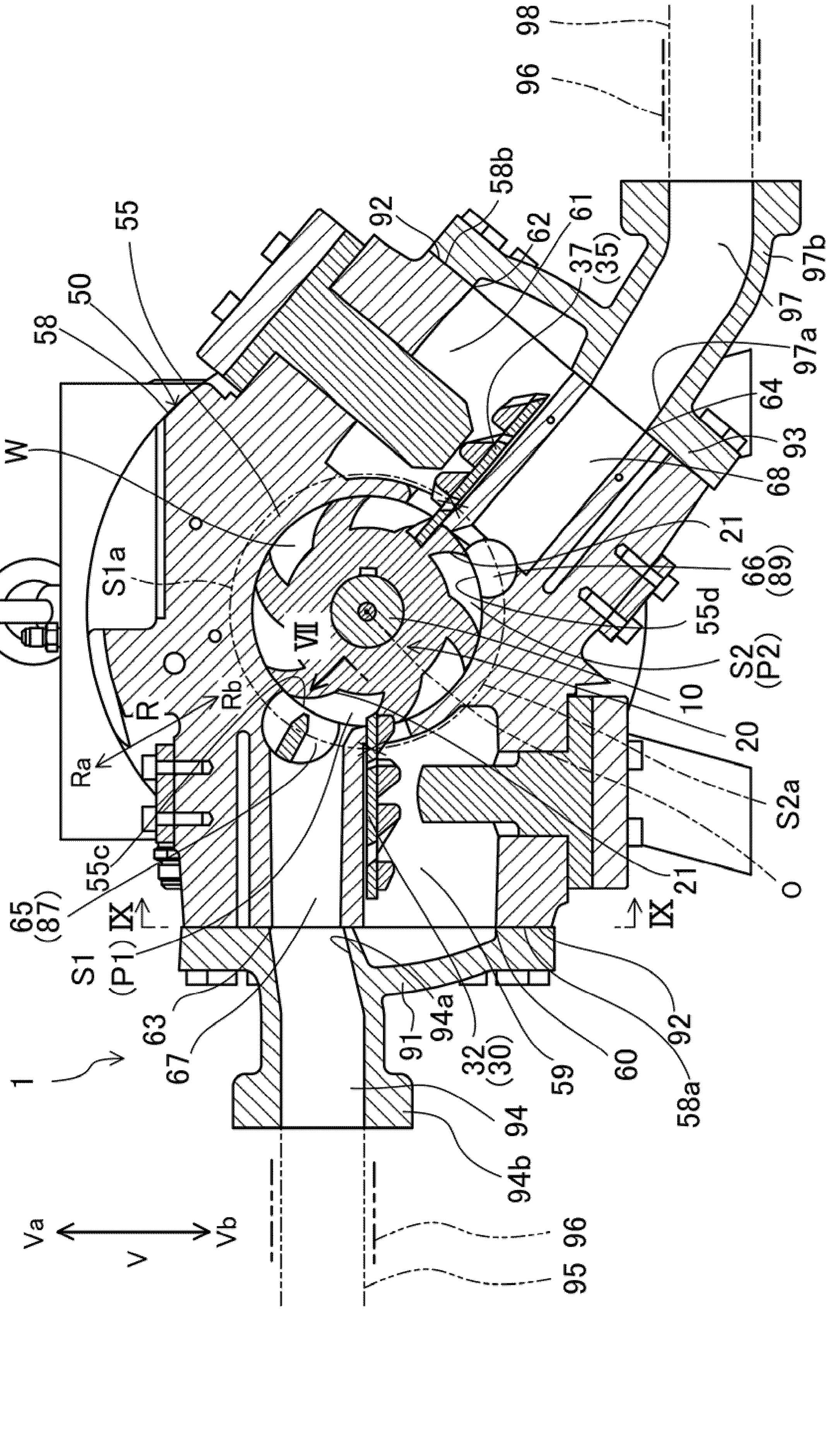
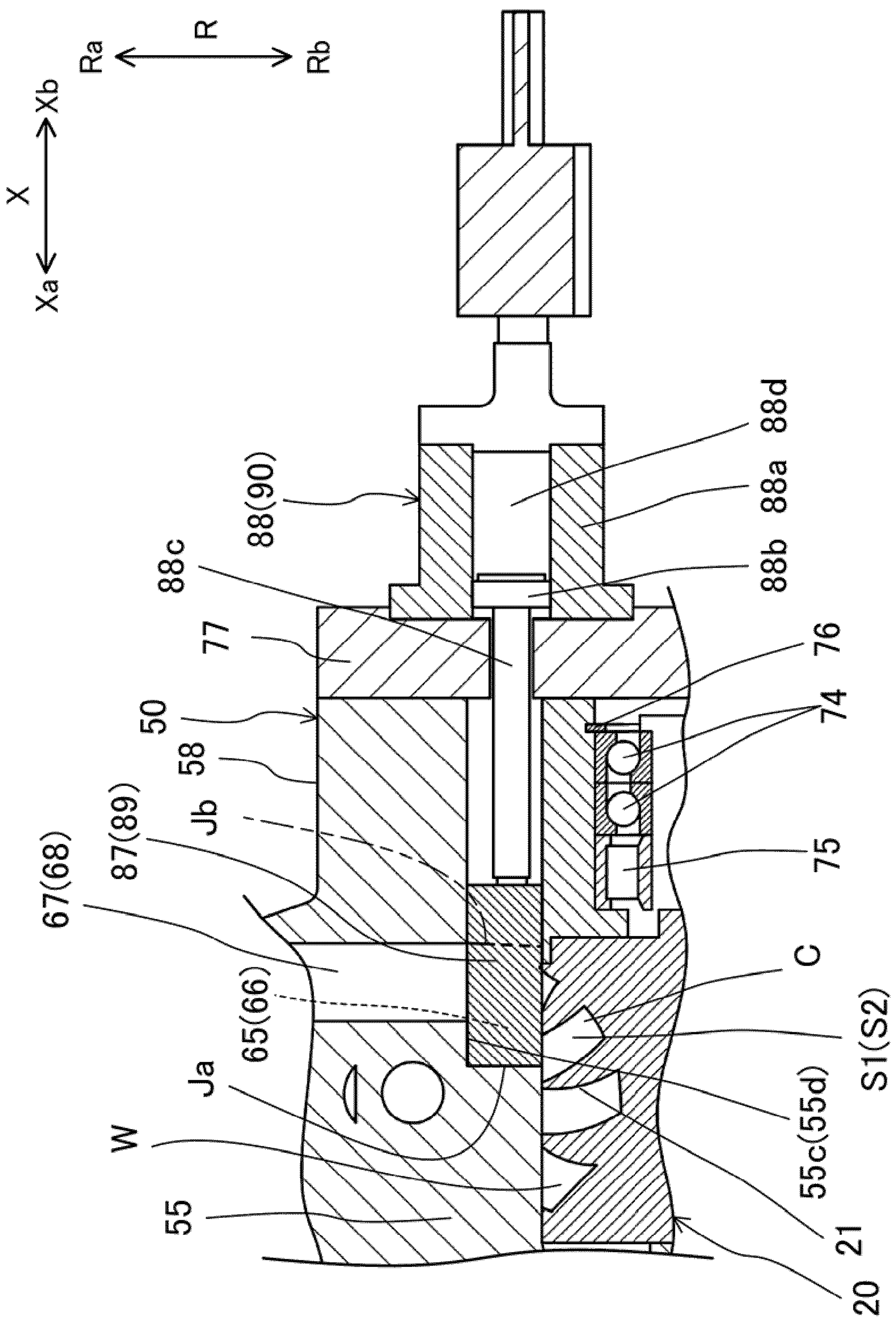

1
63
67
S1
(P1)
65
(87)
55c
Ra
R
Rb
θ
W
S1a
58
50
55
92
58b
62
61
37
(35)
97
97a
97b
64
93
68
21
66
(89)
55d
S2
(P2)
10
20
S2a
21
O
IX
IX
91
94a
32
(30)
59
60
92
58a
94
94b
95
96
96
98
VII
Va
V
Vb

FIG.7



Ra
R
Rb
Xa
X
Xb
88(90)
88c
88d
88a
88b
77
76
50
58
74
Jb
87(89)
75
67(68)
C
65(66)
S1(S2)
Ja
55c(55d)
W
55
21
20

FIG.8

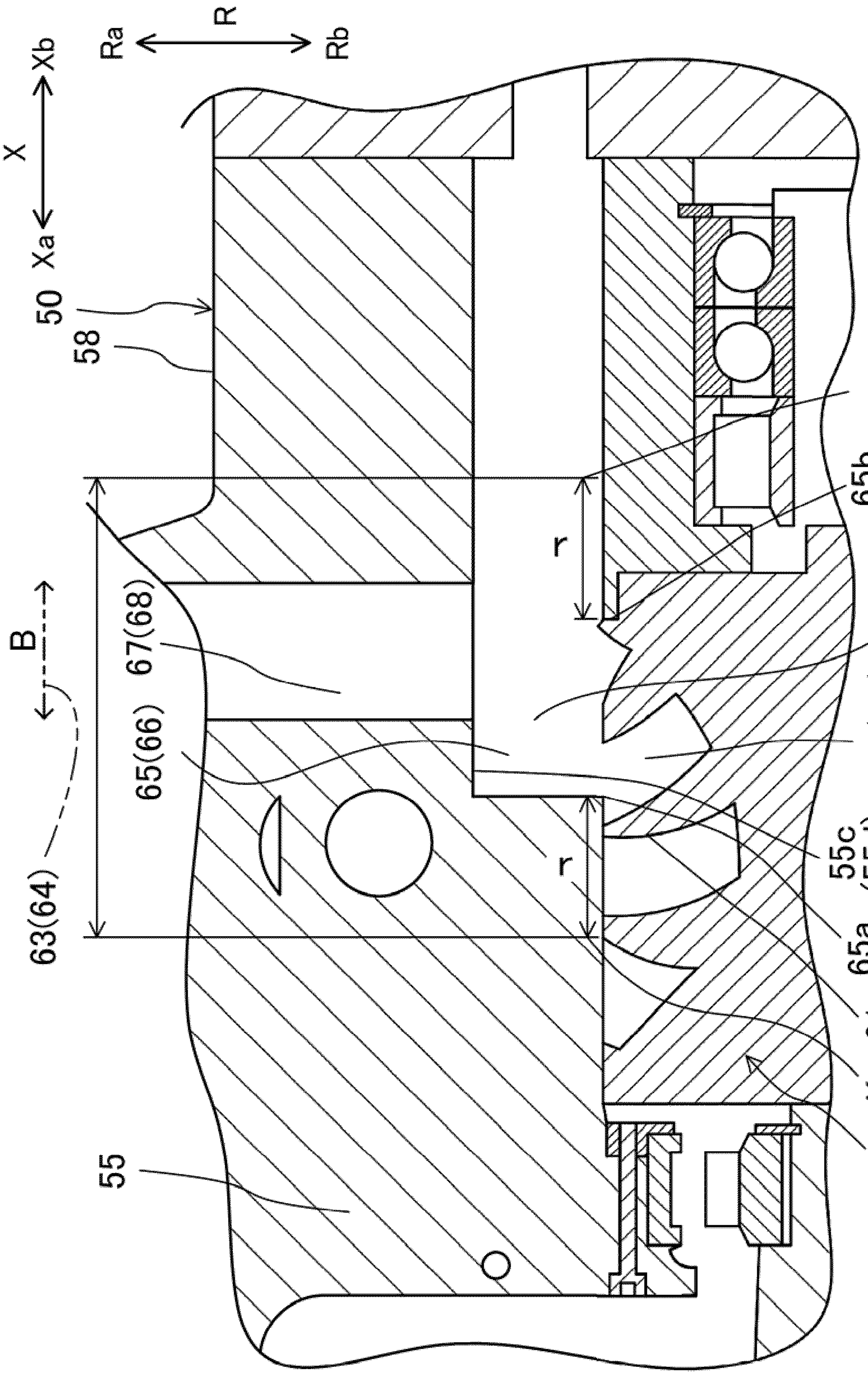
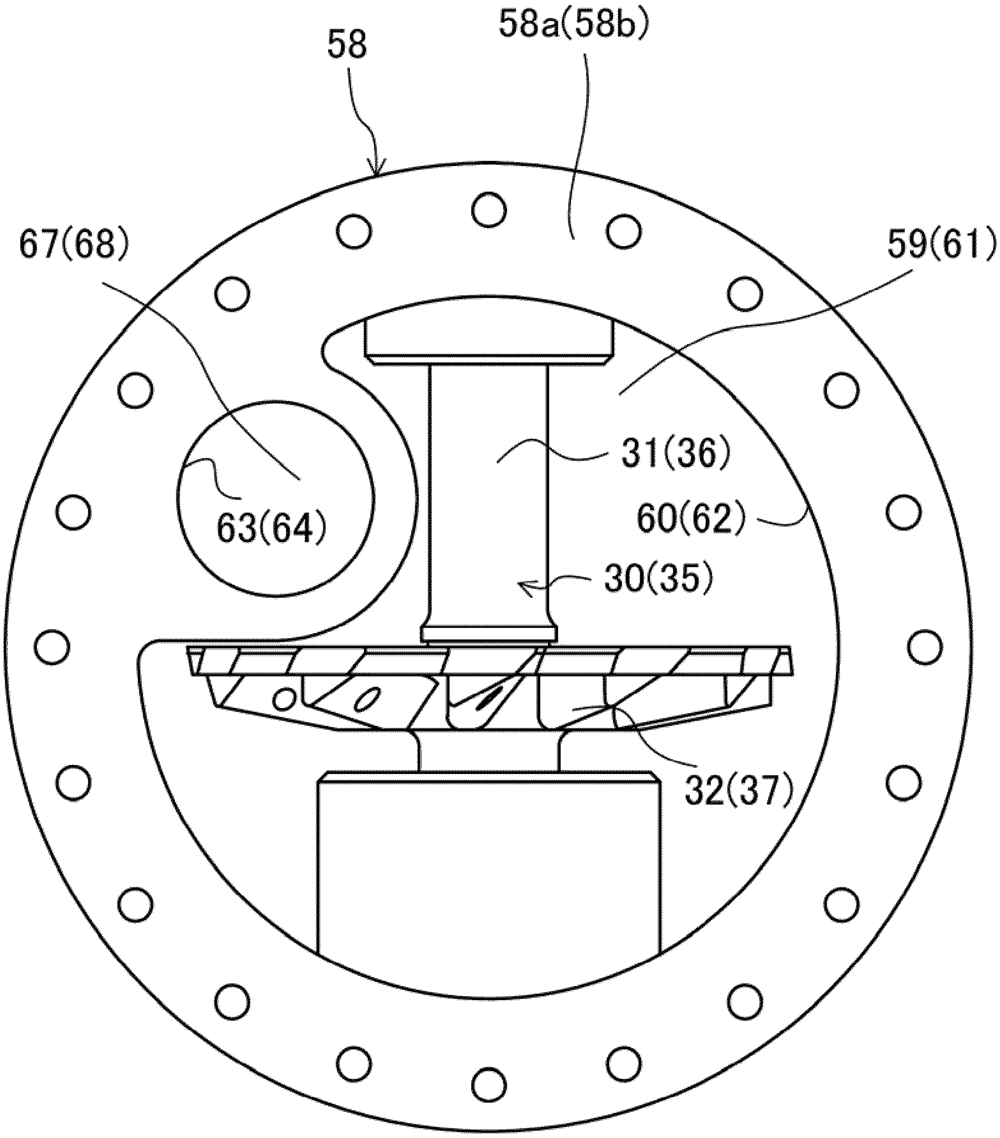

X
Xa
Xb
R
Ra
Rb
B
50
58
67(68)
65(66)
63(64)
r
r
Kb
65b
(66b)
W
S1(S2)
55c
(55d)
65a
(66a)
21
Ka
20
55

FIG.9



# FIG.10

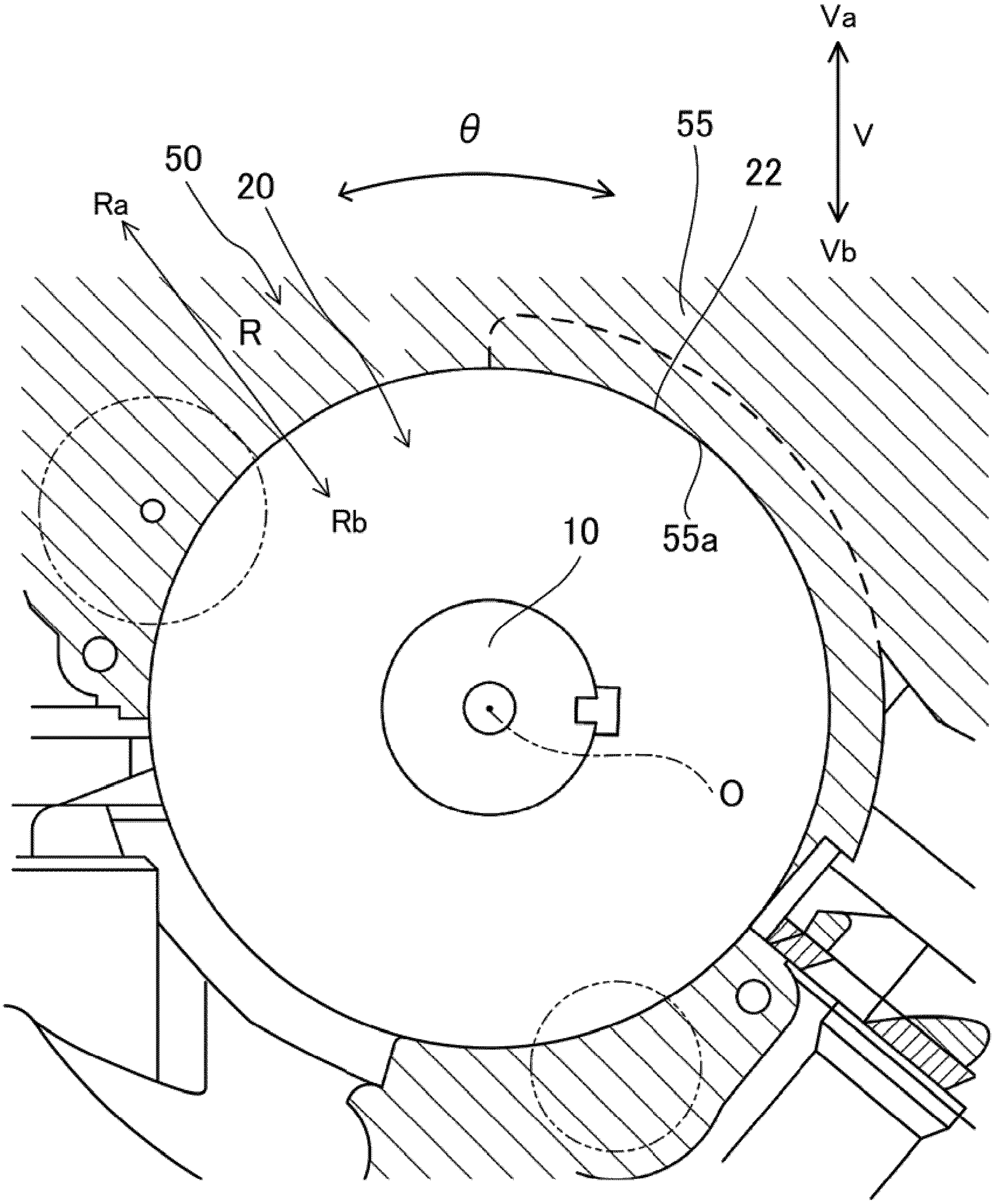


FIG.11

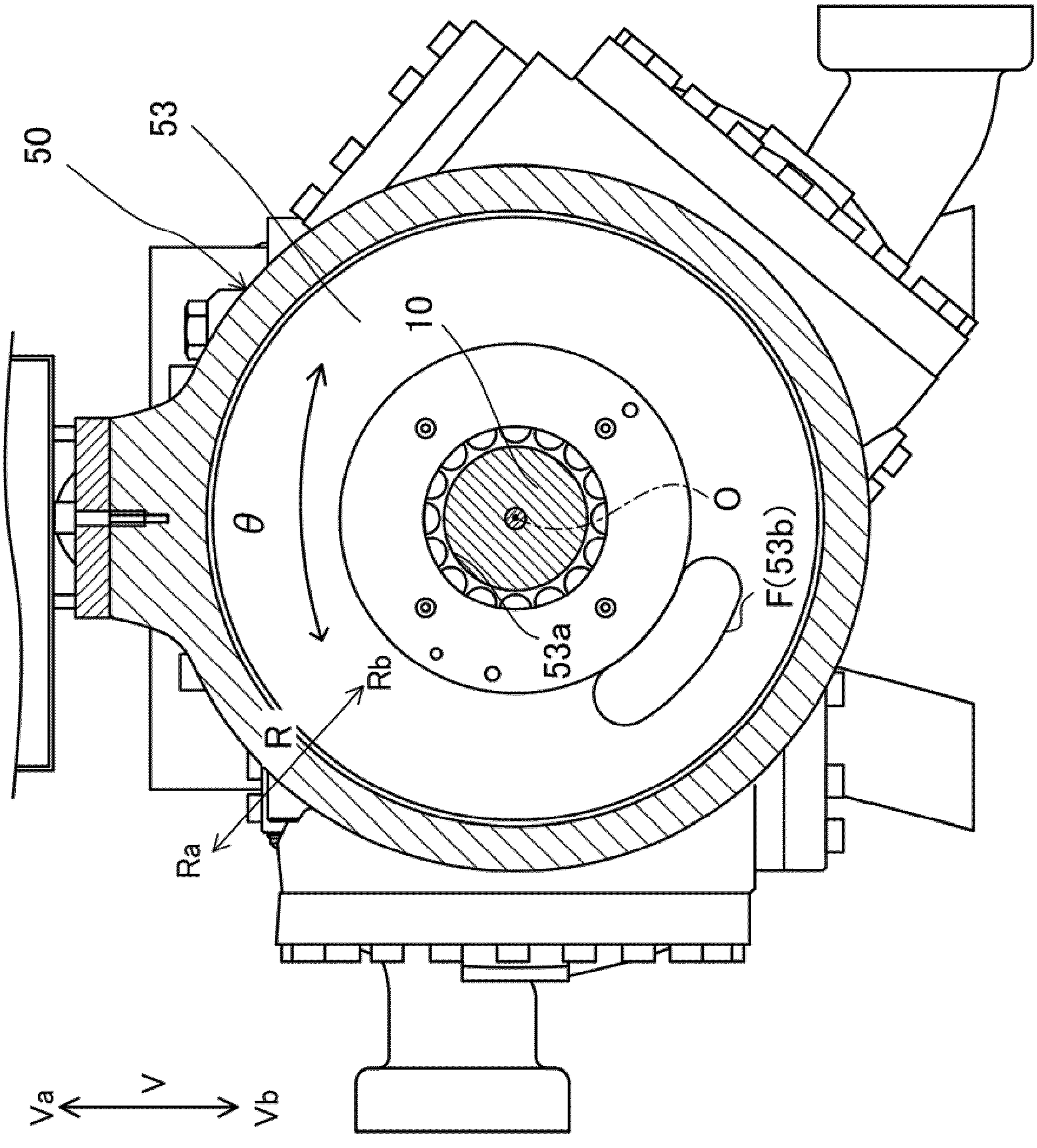
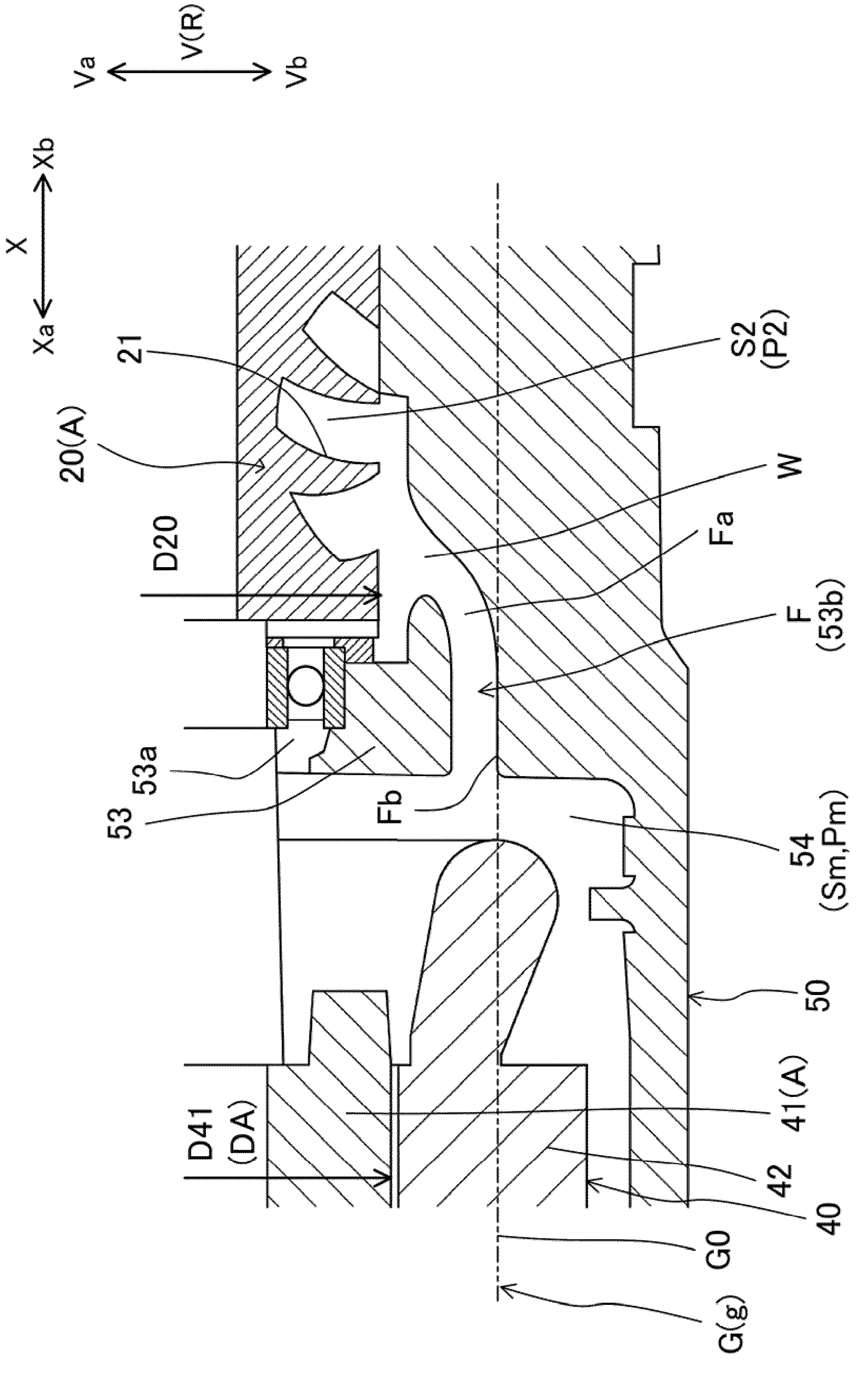


FIG.12



V(R)
Va
Vb
X
Xa
Xb
21
20(A)
D20
S2
(P2)
W
Fa
F
(53b)
53a
53
Fb
54
(Sm,Pm)
50
D41
(DA)
41(A)
42
40
G0
G(g)

## INTERNATIONAL SEARCH REPORT

International application No. **PCT/JP2024/012005**

**A. CLASSIFICATION OF SUBJECT MATTER**

***F04C 18/52***(2006.01)i; ***F04C 29/00***(2006.01)i
FI: F04C18/52; F04C29/00 C; F04C29/00 D

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)

F04C18/52; F04C29/00

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

Published examined utility model applications of Japan 1922-1996
Published unexamined utility model applications of Japan 1971-2024
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. |
|---|---|---|
| X | JP 2021-162021 A (DAIKIN INDUSTRIES, LTD.) 11 October 2021 (2021-10-11) paragraphs [0080], [0092], [0131]-[0147], [0206], fig. 1-3, 13-17 | 1-4 |
| A | | 5 |

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

* Special categories of cited documents:
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"D" document cited by the applicant in the international application
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"&" document member of the same patent family

| Date of the actual completion of the international search | Date of mailing of the international search report |
|---|---|
| **07 June 2024** | **18 June 2024** |

| Name and mailing address of the ISA/JP | Authorized officer |
|---|---|
| **Japan Patent Office (ISA/JP)**<br>**3-4-3 Kasumigaseki, Chiyoda-ku, Tokyo 100-8915**<br>**Japan** | Telephone No. |

Form PCT/ISA/210 (second sheet) (July 2022)

**INTERNATIONAL SEARCH REPORT**
**Information on patent family members**

International application No.
**PCT/JP2024/012005**

| Patent document cited in search report | Publication date (day/month/year) | Patent family member(s) | Publication date (day/month/year) |
|---|---|---|---|
| JP 2021-162021 A | 11 October 2021 | US 2023/0015175 A1<br>paragraphs [0052], [0064], [0103]-[0119], [0178], fig. 1-3, 13-17<br>WO 2021/200858 A1<br>EP 4105486 A1<br>CN 115244302 A | |

Form PCT/ISA/210 (patent family annex) (July 2022)

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- JP 2014025435 A **[0003]**