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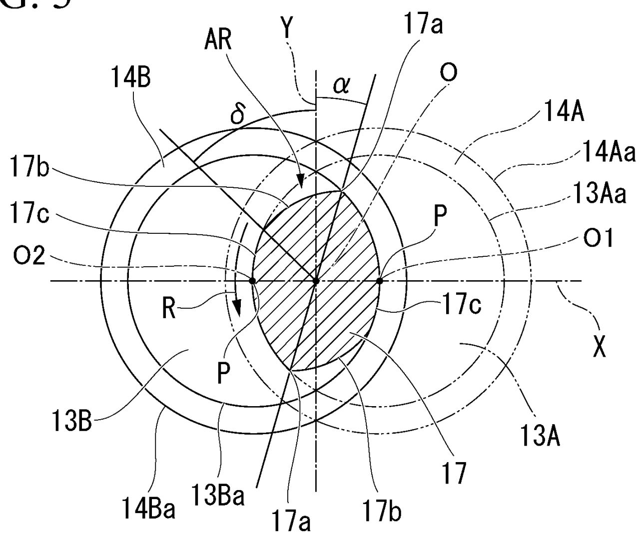
(54) ROTATING SHAFT OF ROTARY COMPRESSOR AND ROTARY COMPRESSOR

(57) An intermediate part (17) of a rotating shaft protrudes in a direction intersecting an eccentric direction of a main shaft piston rotor (14A) and a sub-shaft piston rotor (14B) as viewed in a cross section orthogonal to an axis (O), and has an apex (17a) where a distance between the outer peripheral surface and the axis (O) is maximized on an outer peripheral surface of the intermediate shaft part (17), and the apex (17a) is disposed at a position shifted at an angle (a) larger than 0 degrees and smaller than 45 degrees toward a backward side in a rotational direction (R) with respect to an imaginary line (Y) passing through the axis (O) orthogonally to the eccentric direction.

FIG. 3



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Description

TECHNICAL FIELD

[0001] The present invention relates to a rotating shaft of a rotary compressor that compresses a fluid and a rotary compressor including the same.

[0002] Priority is claimed on Japanese Patent Application No. 2017-201554, filed October 18, 2017, the content of which is incorporated herein by reference.

BACKGROUND ART

[0003] A rotary compressor applied to a refrigeration cycle such as an air conditioner previously has been known. In such a rotary compressor, a rotating shaft, a bearing for supporting the rotating shaft, a piston rotor eccentrically mounted on the rotating shaft, and a cylinder in which a piston rotor is disposed are mainly provided in a casing. In the rotary compressors, a fluid (refrigerant), which has flowed into the cylinder, is compressed by the rotation of the piston rotor.

[0004] In recent years, the demand for high efficiency has increased in the rotary compressor. For this reason, attempts have been made to reduce the size of a piston in order to increase the displacement of the piston. However, in this case, there is a problem in that a load acting on the piston increases and deflection easily occurs in the rotating shaft.

Citation List

Patent Literature

[0005] [Patent Document 1] Japanese Unexamined Patent Application, First Publication No. 2013-181420

DISCLOSURE OF INVENTION

Technical Problem

[0006] For example, in Patent Document 1 the deflection of a rotating shaft is suppressed using a technique, such as making the span between a main shaft part and a sub-shaft part of the rotating shaft. However, the technique of suppressing the deflection of a rotating shaft by optimizing the sectional shape of the rotating shaft is also considered.

[0007] The invention provides a rotating shaft of a rotary compressor and a rotary compressor capable of suppressing deflection of the rotating shaft to increase efficiency.

Solution to Problem

[0008] A rotating shaft of a rotary compressor according to an aspect of the invention is a rotating shaft of a rotary compressor that is rotatably supported with respect to a casing having a compression chamber therein and is rotationally driven around an axis to allow a fluid to be compressed with lubricating oil. The rotating shaft includes a shaft main body that extends in a rod shape around the axis; a main shaft piston rotor that is eccentrically provided at the shaft main body and is accommodated in a first compression chamber in the compression chamber; a sub-shaft piston rotor that is disposed apart in a direction of the axis from the main shaft piston rotor, is provided eccentrically with respect to the shaft main body in a direction different in phase by 180 degrees from the main shaft piston rotor, and is accommodated in a second compression chamber in the compression chamber; and an intermediate shaft part around which the lubricating oil is present and which is provided at a position sandwiched between the main shaft piston rotor and the sub-shaft piston rotor in the shaft main body. The intermediate shaft part protrudes in a direction intersecting an eccentric direction of the main shaft piston rotor and the sub-shaft piston rotor as viewed in a cross section orthogonal to the axis, and has an apex where a distance between the outer peripheral surface and the axis is maximized on an outer peripheral surface of the intermediate shaft part. The apex is disposed at a position shifted at an angle larger than 0 degrees and smaller than 45 degrees toward a backward side in a rotational direction with respect to an imaginary line passing through the axis orthogonally to the eccentric direction.

[0009] According to such rotating shaft of a rotary compressor, the apex of the intermediate shaft part is disposed at a position shifted at an angle larger than 0 degrees and smaller than 45 degrees toward a backward side in a rotational direction with respect to an imaginary line passing through the axis orthogonally to the eccentric direction. That is, the apex is not disposed on the imaginary line passing through the axis orthogonally to the eccentric direction, and the diameter of the intermediate shaft part is maximized at the position shifted toward the backward side in the rotational direction with respect to the imaginary line. Therefore, the second moment of area of the intermediate shaft part can be increased at this position where the apex is provided, and the rigidity of the intermediate shaft part can be improved.

[0010] Here, the knowledge that the maximum load during compression acts in a range larger than 5 degrees and smaller than 41 degrees on the backward side in the rotational direction from the imaginary line with respect to the intermediate shaft part was obtained. In the present aspect, the apex is disposed at the position shifted at an angle larger than 0 degrees and smaller than 45 degrees toward the backward side in the rotational direction with respect to the imaginary line, and the rigidity is high at this position. Thus, even if the thickness of the intermediate shaft part on the forward side in the rotational direction from the apex is smaller than that of a columnar shape, the strength can be sufficiently secured. Therefore, it is possible to secure the strength while reducing the weight of the intermediate shaft part. Therefore, even when the load during compression from each piston rotor acts on the rotating shaft, it is possible to suppress deflection deformation of the rotating shaft.

[0011] Additionally, in the rotating shaft of the rotary compressor, the outer peripheral surface of the intermediate shaft part may be disposed within one region where an outer peripheral edge of the main shaft piston rotor and an outer peripheral edge of the sub-shaft piston rotor overlap each other as viewed in the cross section orthogonal to the axis.

[0012] According to such a configuration, the apex is formed such that the outer peripheral surface of the intermediate shaft part is cut off on the forward side in the rotational direction of the apex. Hence, when the rotating shaft rotates, the lubricating oil around the intermediate shaft part is smoothly guided toward the apex of the intermediate shaft part, and smoothly flows along the outer peripheral surface of the intermediate shaft part toward the backward side in the rotational direction. Therefore, the stirring loss of the lubricating oil can be reduced.

[0013] Additionally, in the rotating shaft of the rotary compressor, the apex may be disposed at a position shifted at an angle larger than 0 degrees and smaller than 5 degrees toward the backward side in the rotational direction with respect to the imaginary line.

[0014] According to such a configuration, the apex is formed such that the outer peripheral surface of the intermediate shaft part is cut off on the forward side in the rotational direction of the apex. However, even in this case, the diameter of the intermediate shaft part does not extremely decrease on the forward side in the rotational direction of the apex, and the strength of the intermediate shaft part can be sufficiently secured.

[0015] Additionally, in the rotating shaft of the rotary compressor, the outer peripheral surface of the intermediate shaft part may have an apex-side curved surface that is disposed inside an outer edge of the one region and extends to be curved in a convex shape in a direction away from the axis from the apex toward a forward side in the rotational direction, and an eccentric-side curved surface that is smoothly continuous with the apex-side curved surface and is provided at a position including an intersection point between the imaginary line extending in the eccentric direction and the outer edge of the one region to extend along the outer edge of the one region.

[0016] By providing the apex-side curved surface and the eccentric-side curved surface as the outer peripheral surface of the intermediate shaft part, a smooth curved surface in more forward side than the apex on the rotation direction is formed toward the outer peripheral surface of the intermediate shaft part. Therefore, when the lubricating oil is stirred by the rotating shaft, the lubricating oil is from the eccentric-side curved surface toward the apex-side curved surface by these surfaces and flows smoothly. Therefore, even in the intermediate shaft part having the apex, the stirring loss of the lubricating oil can be reduced.

[0017] Additionally, in the rotating shaft of the rotary compressor, a pair of the apexes may be provided at positions symmetrical to each other with respect to the axis.

[0018] In this way, by providing the apexes at the symmetrical positions, the lubricating oil can be smoothly guided while securing the strength of the intermediate shaft part, and the stirring loss of the lubricating oil during the rotation of the rotating shaft can be further reduced. Moreover, during rotation, centrifugal forces acting on the positions of the apexes of the intermediate shaft part can be canceled between the apexes, and the stability during the rotation of the rotating shaft can be improved.

[0019] Additionally, in the rotating shaft of the rotary compressor, the pair of apexes may be different from each other in shift amount of an angle toward the backward side in the rotational direction with respect to a direction orthogonal to the eccentric direction.

[0020] Even in such a case, the lubricating oil can be smoothly guided while securing the strength of the intermediate shaft part, and the stirring loss of the lubricating oil during the rotation of the rotating shaft can be reduced.

[0021] Additionally, a rotary compressor according to one aspect of the invention includes the rotating shaft, a drive unit that is configured to rotationally drive the rotating shaft, and a casing that accommodates the rotating shaft and the drive unit and has a first compression chamber and a second compression chamber therein.

[0022] According to such a rotary compressor, by including the above rotating shaft, when the rotating shaft rotates, the lubricating oil around the intermediate shaft part can be smoothly guided toward the apex of the intermediate shaft part, can smoothly flow along the outer peripheral surface of the intermediate shaft part toward the backward side in the rotational direction, and the stirring loss of the lubricating oil can be reduced. It is possible to increase the second moment of area of the intermediate shaft part compared to a case where the apex is not provided, and it is possible to suppress the deflection deformation of the rotating shaft.

Advantageous Effects of Invention

[0023] According to the rotating shaft of the rotary compressor, and the rotary compressor, by virtue of the above configuration, it is possible to suppress the deflection of the rotating shaft to increase efficiency.

BRIEF DESCRIPTION OF DRAWINGS

[0024]

FIG. 1 is a longitudinal sectional view of a rotary compressor according to an embodiment of the invention.
FIG. 2 is a view showing a rotating shaft of the rotary compressor according to the embodiment of the invention.
FIG. 3 is a sectional view showing an intermediate shaft part in the rotating shaft of the rotary compressor according to the embodiment of the invention and is a view showing cross section A-A of FIG. 2.
FIG. 4A is a graph of experimental results showing a relationship between a load direction (maximum gas load direction) of a refrigerant gas and a load (maximum gas load) caused by the refrigerant gas during the compression of acting on the rotating shaft of the rotary compressor according to the embodiment of the invention.
FIG. 4B is a graph of experimental results showing a relationship between an angle α formed with an imaginary line Y at the apex and a pressure ratio HP/LP according to the embodiment of the invention.
FIG. 5 is a sectional view showing an intermediate shaft part in the rotating shaft of a rotary compressor according to the first modification example of the embodiment of the invention.
FIG. 6 is a sectional view showing an intermediate shaft part in a rotating shaft of a rotary compressor according to the second modification example of the embodiment of the invention.

BEST MODE FOR CARRYING OUT THE INVENTION

[0025] Hereinafter, a rotary compressor 1 according to an embodiment of the invention will be described.
[0026] As shown in FIG. 1, the rotary compressor 1 includes a drive unit 18, a rotating shaft 15 rotationally driven by the drive unit 18, and a casing 11 that accommodates the drive unit 18 and the rotating shaft 15. The rotary compressor 1 is a so-called two-cylinder type rotary compressor 1 in which compression chambers S are provided in two upper and lower stages at an inner lower part of the casing 11.
[0027] The casing 11 has a cylindrical shape centered on an axis O, and two disk-shaped cylinders 12A and 12B are provided at a distance in an upward-and-downward direction at an inner lower part of the casing 11. An upper cylinder is referred to a main-shaft-side cylinder 12A, and a lower cylinder is referred to as a sub-shaft-side cylinder 12B.
[0028] Cylindrical cylinder inner wall surfaces 12S1 and 12S2 are formed inside the cylinders 12A and 12B, respectively. The first compression chamber S1 is defined by the cylinder inner wall surface 12S1 of the main-shaft-side cylinder 12A, and the second compression chamber S2 is defined by the cylinder inner wall surface 12S2 of the sub-shaft-side cylinder 12B. A disk-shaped partition plate 10 is provided between the upper and lower cylinders 12A and 12B. The first compression chamber S1 and the second compression chamber S2 are partitioned by the partition plate 10.
[0029] Openings 22A and 22B are formed at the positions of a side surface, i.e., an outer peripheral surface of the casing 11, which face outer peripheral surfaces of the main-shaft-side cylinder 12A and the sub-shaft-side cylinder 12B. Suction ports 23A and 23B communicating with the first compression chamber S1 and the second compression chamber S2 are respectively formed at the positions of the cylinders 12A and 12B facing the openings 22A and 22B.
[0030] An accumulator 24, which performs gas-liquid separation of the refrigerant taken in from the upper suction inlet 24a before the refrigerant (fluid) is introduced into the casing 11, is fixed to the casing 11 via a stay 25. The accumulator 24 is provided with suction pipes 26A and 26B for introducing a gaseous phase of the refrigerant separated into gas and liquid in the accumulator 24 into the first compression chamber S 1 and the second compression chamber S2 in the casing 11. Distal end parts of the suction pipes 26A and 26B are connected to the suction ports 23A and 23B through the openings 22A and 22B.
[0031] Additionally, an upper part of the casing 11 is provided with discharge port 27 through which the refrigerant compressed in the first compression chamber S1 and the second compression chamber S2 is discharged.
[0032] The drive unit 18 is an electric motor and has a stator 20 fixed to an inner surface of the casing 11 above the main-shaft-side cylinder 12A, and a rotor 19 disposed so as to face the stator 20 inside the stator 20.
[0033] As shown in FIG. 2, the rotating shaft 15 includes a shaft main body 16 having a rod shape that extends in the direction of the axis O around the axis O, a main shaft piston rotor 14A and a sub-shaft piston rotor 14B that are provided in the shaft main body 16, and an intermediate shaft part 17 that is disposed at the position sandwiched between the main shaft piston rotor 14A and the sub-shaft piston rotor 14B in the direction of the axis O.
[0034] The shaft main body 16 is provided so as to be fitted into the rotor 19 of the drive unit 18 and is rotated around the axis O together with the rotor 19 by supplying electric power to the drive unit 18. The shaft main body 16 is rotatably

supported on the casing 11 by an upper bearing 17A provided at an upper part of the main-shaft-side cylinder 12A, and a lower bearing 17B provided at a lower part of the sub-shaft-side cylinder 12B.

[0035] The main shaft piston rotor 14A is provided in the shaft main body 16, is accommodated in the first compression chamber S1, and is rotated around the axis O together with the shaft main body 16. The main shaft piston rotor 14A is formed integrally with the shaft main body 16, is externally fitted to a main-shaft-side shaft part 13A having a columnar shape centered on an eccentric axis O1 parallel to the axis O, and has an annular shape. Accordingly, the main shaft piston rotor 14A rotates eccentrically with respect to the shaft main body 16 if the shaft main body 16 rotates.

[0036] The sub-shaft piston rotor 14B is provided in the shaft main body 16, is accommodated in the second compression chamber S2, and is rotated around the axis O together with the shaft main body 16. The sub-shaft piston rotor 14B is formed integrally with the shaft main body 16, is externally fitted to a sub-shaft-side eccentric shaft part 13B having a columnar shape centered on an eccentric axis O2 parallel to the axis O and the eccentric axis O1, and has an annular shape. The eccentric axis O2 is disposed at a position symmetrical to the eccentric axis O1 with respect to the axis O.

[0037] That is, the main shaft piston rotor 14A and the sub-shaft piston rotor 14B are rotated in a state where 180 degrees phases are eccentric in different directions with respect to the shaft main body 16.

[0038] Here, the rotating shaft 15 may be formed such that a main shaft portion provided with the main shaft piston rotor 14A and a sub-shaft portion provided with the sub-shaft piston rotor 14B are separately manufactured and these portions are joined together, or may be integrally formed. The main shaft portion and the sub-shaft portion may have mutually different external diameters.

[0039] Next, the intermediate shaft part 17 will be described.

[0040] As shown in FIG. 2, the intermediate shaft part 17 is provided at the position sandwiched between the main shaft piston rotor 14A and the sub-shaft piston rotor 14B in the direction of the axis O. That is, the intermediate shaft part 17 is disposed between the main-shaft-side cylinder 12A and the sub-shaft-side cylinder 12B within the casing 11.

[0041] As shown in FIG. 3, when the intermediate shaft part 17 is viewed in a cross section orthogonal to the axis O, an outer peripheral surface of the intermediate shaft part 17 is disposed within one region AR where an outer peripheral edge 14Aa of the main shaft piston rotor 14A and an outer peripheral edge 14Ba of the sub-shaft piston rotor 14B overlap each other. More specifically, in the present embodiment, the outer peripheral surface of the intermediate shaft part 17 is disposed within a region where an outer peripheral edge 13Aa of the main-shaft-side shaft part 13A and an outer peripheral edge 13Ba of the sub-shaft-side eccentric shaft part 13B overlap each other.

[0042] That is, the sectional shape of the intermediate shaft part 17 is a substantially elliptical shape, rugby ball shape, or almond shape. Accordingly, the intermediate shaft part 17 has a pair of apexes 17a that protrudes toward both sides in a direction intersecting an eccentric direction that is a direction in which an imaginary line X connecting the eccentric axes O1 and O2 and the axis O over the entire area in the direction of the axis O extend.

[0043] The pair of apexes 17a is provided at positions symmetrical to each other with respect to the axis O. Each apex 17a is disposed at a position by an angle α toward a backward side in a rotational direction R of the rotating shaft 15 with respect to an imaginary line Y that extends in the direction orthogonal to the eccentric direction, and thereby, the external diameter dimension of the intermediate shaft part 17 is the largest at the position of the angle α. Additionally, the external diameter dimension of the intermediate shaft part 17 is the smallest in the eccentric direction.

[0044] An outer peripheral surface of the apex 17a has an arcuate apex-side curved surface 17b that is disposed at a position apart from the outer peripheral edge 13Aa or 13Ba that is an outer edge of the one region AR, that is, radially inward of the outer edge and is curved in a convex shape from the apex 17a in a direction away from the axis O toward a forward side in the rotational direction R, and the arcuate eccentric-side curved surface 17c continuous with the apex 17a.

[0045] Since the pair of apexes 17a is provided in the present embodiment, a pair of apex-side curved surfaces 17b is provided at positions symmetrical to each other with respect to the axis O.

[0046] Here, the curvature radius of the apex-side curved surface 17b is preferably as large as possible in order to keep the second moment of area of the intermediate shaft part 17.

[0047] The eccentric-side curved surface 17c is smoothly continuous with the apex-side curved surface 17b in a state where there is no angle on the forward side in the rotational direction of the apex 17a. Also, the eccentric-side curved surface 17c is provided at a position including an intersection point P between the imaginary line X extending in the above eccentric direction, and an outer edge of the one region AR, and extends on the outer edge along the outer edge.

[0048] Since the pair of apexes 17a is provided in the present embodiment, a pair of the eccentric-side curved surfaces 17c of the positions symmetrical to each other with respect to the axis O is provided. Accordingly, one eccentric-side curved surface 17c extends along the outer edges of one region AR continuously on the forward side in the rotational direction R with one apex-side curved surface 17b extending toward the forward side in the rotational direction from one apex 17a, and is connected to the other apex 17a. Additionally, the other eccentric-side curved surface 17c is continuous on the forward side in the rotational direction R with the other apex-side curved surface 17b extending toward the forward side in the rotational direction R from the other apex 17a, extends along the outer edge of the one region AR, and is connected to the one apex 17a.

[0049] In other words, the intermediate shaft part 17 has a shape in which a portion of a forward portion in the rotational direction of the apex 17a is cut off radially inward from the substantially elliptical shape, rugby ball shape, or almond shape by the apex-side curved surface 17b.

[0050] Here, when the apex-side curved surface 17b is machined, in order to machine the apex-side curved surface while suppressing the amount of cutting, for example, it is possible to dispose the center of a machining circle on the backward side in the rotational direction R of the rotating shaft 15 with respect to the imaginary line Y to shave the intermediate shaft part 17 in an arcuate shape. Moreover, although an angle δ from the imaginary line Y to a connection point between the apex-side curved surface 17b and the eccentric-side curved surface 17c continuous toward the forward side in the rotational direction with the apex-side curved surface 17b is a value larger than the angle α ($\alpha < \delta$), δ may be a value that is as close to α as possible.

[0051] Here, the value of the above angle α is, for example, a value larger than 0 degrees and smaller than 5 degrees in the present embodiment.

[0052] As shown in FIG. 4A, FIG. 4B, and Table 1, under any condition (HP (discharge-side pressure)/LP (suction-side pressure)), it could be confirmed from experimental results that the maximum gas load acts in a range larger than 5 degrees and smaller than 41 degrees toward the backward side in the rotational direction R with reference to the imaginary line Y that extends in the direction orthogonal to the eccentric direction in the intermediate shaft part 17. That is, the range where the maximum gas load acts is a range of α= 5 degrees to 41 degrees.

[Table 1]

Maximum Gas Load	[N]	X	1.18X	1.25X	1.16X
Maximum Gas Load Direction	[deg]	96	110	128	142
Angle Formed With Imaginary Line: α	[deg]	5	14	29	41
Pressure Ratio: HP/LP	[-]	2.8	4.1	8.6	21.5
Additionally, the value of HP/LP in Table 1 was set assuming HP/LP in general air conditioners.					

[0053] According to the rotary compressor 1 of the present embodiment described above, the apex 17a of the intermediate shaft part 17 is disposed at a position shifted at an angle larger than 0 degrees and smaller than 5 degrees toward the backward side in the rotational direction R with respect to the direction orthogonal to the eccentric direction. That is, the apex 17a is not disposed on the imaginary line Y that extends in the direction orthogonal to the eccentric direction.

[0054] Therefore, since the diameter of the intermediate shaft part 17 is maximized at a position where the apex 17a is provided, the second moment of area of the intermediate shaft part 17 can be increased at this position, and the rigidity of the intermediate shaft part 17 can be improved. Therefore, even when the load during compression acts on each of the piston rotors 14A and 14B, it is possible to suppress deflection deformation of the rotating shaft 15.

[0055] Particularly, as shown in the above FIG. 4A, FIG. 4B, and Table 1, the knowledge that the maximum load during compression acts in a range of 5 degrees or more and 41 degrees or less toward the backward side in the rotational direction R with respect to the intermediate shaft part 17 was obtained. Therefore, the maximum load during compression does not act on the forward side in the rotational direction R from the apex 17a.

[0056] In this regard, in the present embodiment, the apex 17a is disposed at the position shifted by the angle α larger than 0 degrees and smaller than 5 times toward the backward side in the rotational direction R with respect to the direction orthogonal to the eccentric direction. Thus, the thickness of the intermediate shaft part 17 on the forward side in the rotational direction R from the apex 17a is smaller than that of a columnar shape.

[0057] However, in the portion in which the thickness of this intermediate shaft part 17 is smaller, as described above, the load acting during compression is smaller than the maximum load. Therefore, even if the apex 17a is provided at the above position, the strength of the intermediate shaft part 17 can be sufficiently secured. Also, the weight of the intermediate shaft part 17 can also be reduced.

[0058] Additionally, in the present embodiment, the outer peripheral surface of the intermediate shaft part 17 is disposed within the one region AR where the outer peripheral edge of the main shaft piston rotor 14A and the outer peripheral edge of the sub-shaft piston rotor 14B overlap each other, and the apex 17a is formed such that the outer peripheral surface of the intermediate shaft part 17 is cut off on the forward side in the rotational direction R of the apex 17a. For this reason, when the rotating shaft 15 rotates, the lubricating oil present around the intermediate shaft part 17 is smoothly guided toward the apex 17a of the intermediate shaft part 17, and smoothly flows along the outer peripheral surface of the intermediate shaft part 17 toward the backward side in the rotational direction R. Therefore, the stirring loss when the lubricating oil is stirred by the intermediate shaft part 17 during rotation can be reduced.

[0059] Particularly, in the present embodiment, by providing the apex-side curved surface 17b and the eccentric-side curved surface 17c as the outer peripheral surfaces of the intermediate shaft part 17, a smooth curved surface having no angle from the above intersection point P toward the apex 17a is formed on the outer peripheral surface of the intermediate shaft part 17 on the forward side in the rotational direction R from the apex 17a. Hence, when the lubricating oil is stirred by the rotating shaft 15, the lubricating oil is guided from the eccentric-side curved surface 17c toward the apex-side curved surface 17b by these surfaces and flows smoothly. Therefore, even in the intermediate shaft part 17 having the apex 17a, the stirring loss of the lubricating oil can be reduced.

[0060] Moreover, by providing a pair of apexes 17a at the positions symmetrical to each other with respect to the axis O, the lubricating oil can be smoothly guided on the outer peripheral surface of the intermediate shaft part 17 while securing the strength of the intermediate shaft part 17, and the stirring loss of the lubricating oil can be further reduced. Moreover, during rotation, centrifugal forces acting on the positions of the apexes 17a of the intermediate shaft part 17 can be canceled between the apexes 17a, and the stability during the rotation of the rotating shaft 15 can be improved.

[0061] Although the embodiments of the invention have been described in detail with reference to the drawings, the respective configurations and combinations thereof in the respective embodiments are examples, additions, omissions, substitutions, and other modifications of components can be made without departing from the concept of the invention. Additionally, the invention is not limited by the embodiment, and is limited only by the claims.

[0062] For example, as shown in FIG. 5, the apex 17a may be provided only at one point. The apex 17a is disposed at a position shifted by an angle β larger than 0 degrees and smaller than 5 degrees toward the backward side in the rotational direction R with respect to the imaginary line Y orthogonal to the eccentric direction.

[0063] Moreover, as shown in FIG. 6, the pair of apexes 17a is provided, and the positions at which the respective apexes 17a are disposed are disposed at positions shifted by $\theta 1$ and $\theta 2$ toward the backward side in the rotational direction R with respect to the imaginary line Y orthogonal to the eccentric direction. $\theta 1$ and $\theta 2$ are mutually different angles, and both are angles larger than 0 degrees and smaller than 5 toward the backward side in the rotational direction R with respect to the imaginary line Y orthogonal to the eccentric direction.

[0064] Additionally, the apex-side curved surface 17b of the intermediate shaft part 17 may be formed, for example, in a planar shape without being limited to the arcuate curved surface.

[0065] Additionally, the apex 17a may be disposed outside the one region AR.

[0066] Additionally, although the above angles α, β, $\theta 1$, and $\theta 2$ are, for example, values larger than 0 degrees and smaller than 5 degrees, the angles are not limited to this. That is, since the apex 17a to where the distance from the axis O is maximized may be located at the position where the maximum load acts on the intermediate shaft part 17, the values of α, β, $\theta 1$, and $\theta 2$ may be larger than 0 degrees and smaller than 45 degrees. Particularly, in a case where the apex 17a is disposed outside the one region AR, the diameter of the intermediate shaft part 17 does not extremely decreases on the backward side in the rotational direction R of the apex 17a. Thus, in consideration of this point, α, β, $\theta 1$, and $\theta 2$ may not be limited to the value larger than 0 degrees and smaller than 5 degrees as described above.

Industrial Applicability

[0067] According to the rotating shaft of the rotary compressor, and the rotary compressor, by virtue of the above configuration, it is possible to suppress the deflection of the rotating shaft to increase efficiency.

Reference Signs List

[0068]

1:	rotary compressor
10:	partition plate
11:	casing
12A:	main-shaft-side cylinder
12B:	sub-shaft-side cylinder
12S1, 12S2:	cylinder inner wall surface
13A:	main-shaft-side shaft part
13B:	sub-shaft-side eccentric shaft part
13Aa, 13Ba:	outer peripheral edge
14A:	main shaft piston rotor
14B:	sub-shaft piston rotor
14Aa, 14Ba:	outer peripheral edge
15:	rotating shaft
16:	shaft main body

18:	drive unit
17:	intermediate shaft part
17a:	apex
17b:	apex-side curved surface
17c:	eccentric-side curved surface
19:	rotor
20:	stator
22A:	opening
22B:	opening
23A:	suction port
23B:	suction port
24:	accumulator
24a:	suction inlet
25:	stay
26A:	suction pipe
26B:	suction pipe
27:	discharge port
S:	compression chamber
S1:	first compression chamber
S2:	second compression chamber
R:	rotational direction
O:	axis
O1:	eccentric axis
O2:	eccentric axis
AR:	one region
X:	imaginary line
P:	intersection point

Claims

1. A rotating shaft of a rotary compressor that is rotatably supported with respect to a casing having a compression chamber therein and is rotationally driven around an axis to allow a fluid to be compressed with lubricating oil, the rotating shaft comprising:

    a shaft main body that extends in a rod shape around the axis;
    a main shaft piston rotor that is eccentrically provided at the shaft main body and is accommodated in a first compression chamber in the compression chamber;
    a sub-shaft piston rotor that is disposed apart in a direction of the axis from the main shaft piston rotor, is provided eccentrically with respect to the shaft main body in a direction different in phase by 180 degrees from the main shaft piston rotor, and is accommodated in a second compression chamber in the compression chamber; and
    an intermediate shaft part around which the lubricating oil is present and which is provided at a position sandwiched between the main shaft piston rotor and the sub-shaft piston rotor in the shaft main body,
    wherein the intermediate shaft part protrudes in a direction intersecting an eccentric direction of the main shaft piston rotor and the sub-shaft piston rotor as viewed in a cross section orthogonal to the axis, and has an apex where a distance between the outer peripheral surface and the axis is maximized on an outer peripheral surface of the intermediate shaft part, and
    wherein the apex is disposed at a position shifted at an angle larger than 0 degrees and smaller than 45 degrees toward a backward side in a rotational direction with respect to an imaginary line passing through the axis orthogonally to the eccentric direction.

2. The rotating shaft of a rotary compressor according to claim 1,
    wherein the outer peripheral surface of the intermediate shaft part is disposed within one region where an outer peripheral edge of the main shaft piston rotor and an outer peripheral edge of the sub-shaft piston rotor overlap each other as viewed in the cross section orthogonal to the axis.

3. The rotating shaft of a rotary compressor according to claim 2,
    wherein the apex is disposed at a position shifted at an angle larger than 0 degrees and smaller than 5 degrees

toward the backward side in the rotational direction with respect to the imaginary line.

4. The rotating shaft of a rotary compressor according to claim 2 or 3,
wherein the outer peripheral surface of the intermediate shaft part includes an apex-side curved surface that is disposed inside an outer edge of the one region and extends to be curved in a convex shape in a direction away from the axis toward a forward side in the rotational direction from the apex, and
an eccentric-side curved surface that is smoothly continuous with the apex-side curved surface and is provided at a position including an intersection point between the imaginary line extending in the eccentric direction and the outer edge of the one region to extend along the outer edge of the one region.

5. The rotating shaft of a rotary compressor according to any one of claims 1 to 4,
wherein a pair of the apexes is provided at positions symmetrical to each other with respect to the axis.

6. The rotating shaft of a rotary compressor according to claim 5,
wherein the pair of apexes is different from each other in shift amount of an angle toward the backward side in the rotational direction with respect to a direction orthogonal to the eccentric direction.

7. A rotary compressor comprising:

the rotating shaft according to any one of claims 1 to 6;
a drive unit that is configured to rotationally drive the rotating shaft; and
a casing that accommodates the rotating shaft and the drive unit and has a first compression chamber and a second compression chamber therein.

FIG. 1

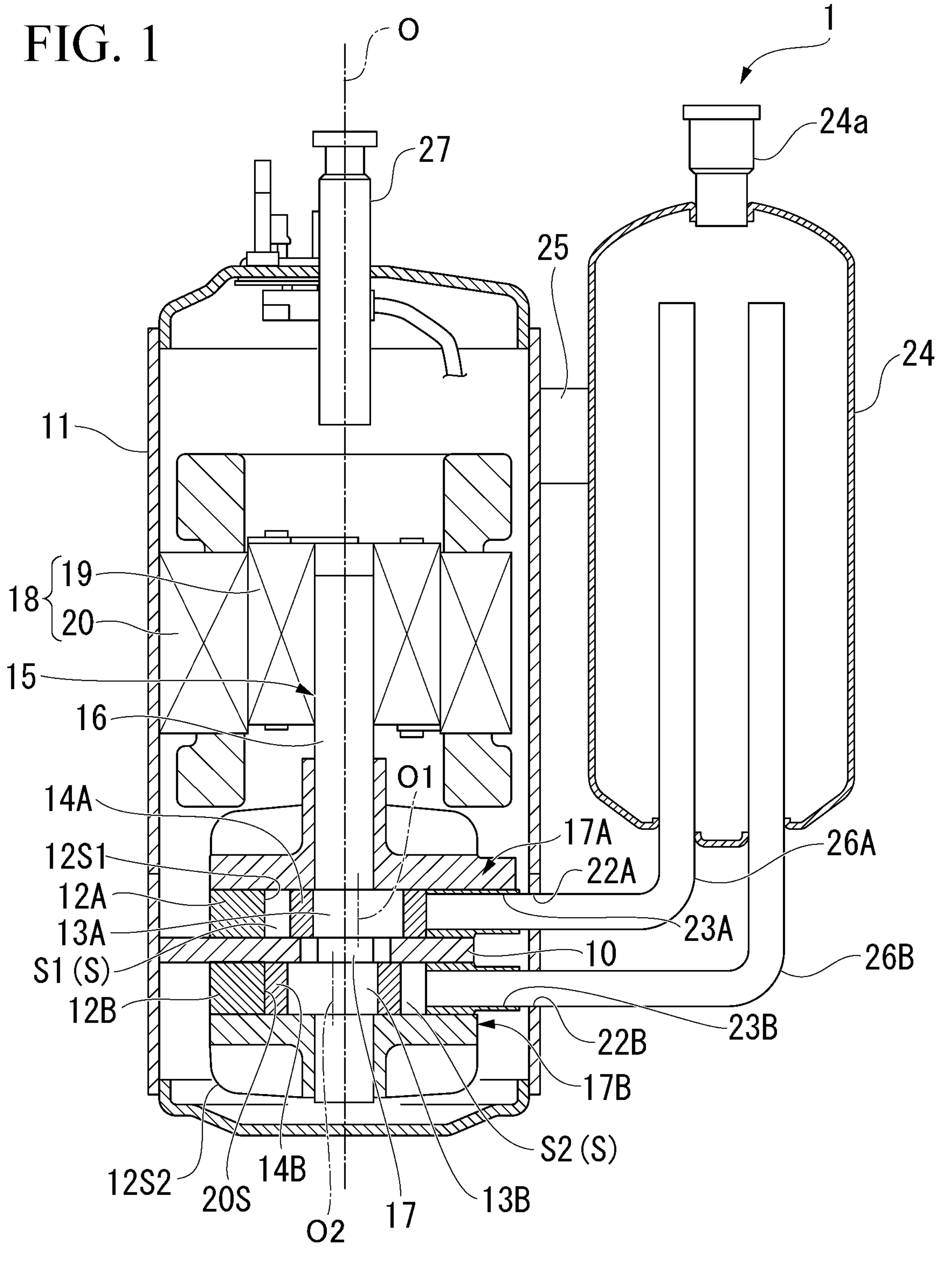

O
1
24a
27
25
24
11
18
19
20
15
16
O1
14A
17A
12S1
22A
26A
12A
13A
23A
S1 (S)
10
26B
12B
23B
22B
17B
S2 (S)
12S2
20S
14B
O2
17
13B

FIG. 2

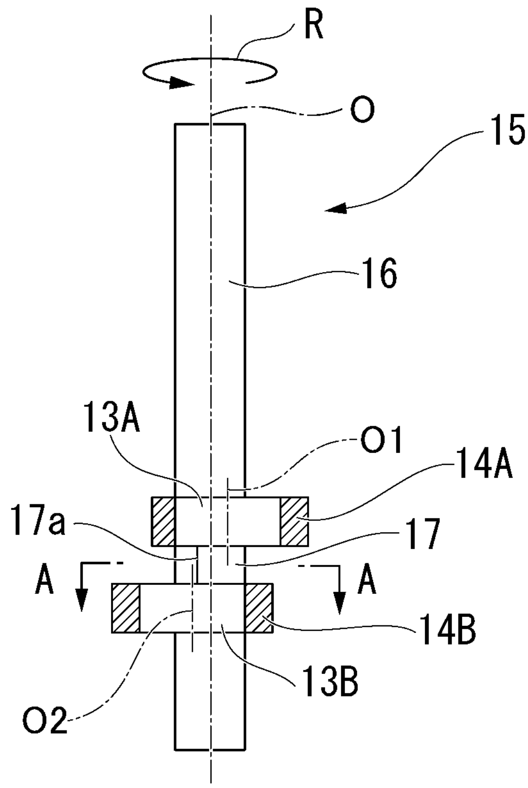

R
O
15
16
13A
O1
14A
17a
17
A
A
14B
13B
O2

FIG. 3

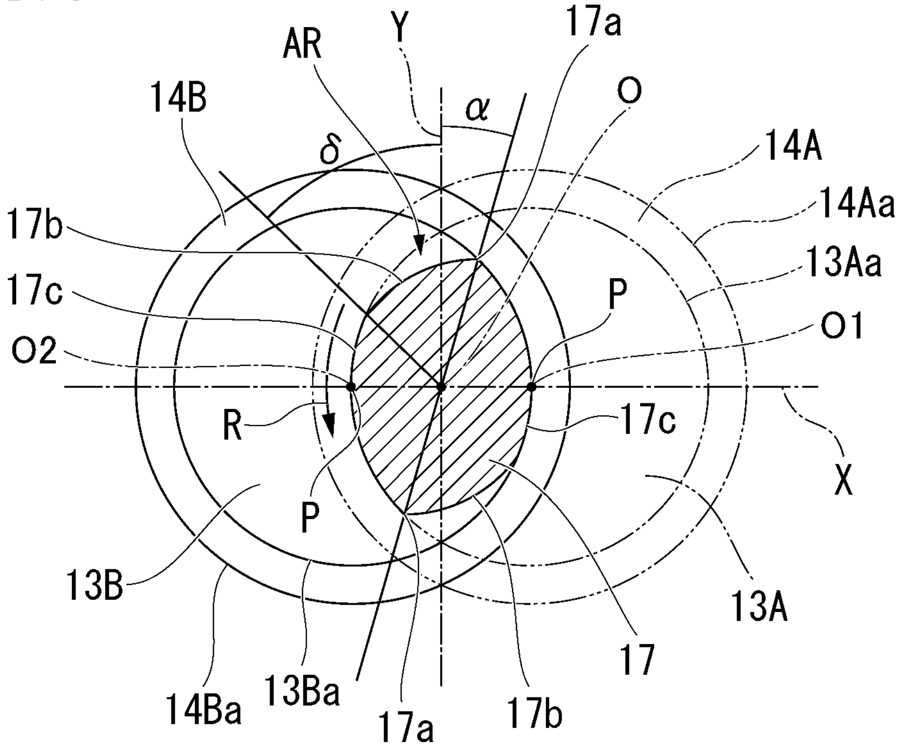

AR
Y
17a
α
O
14B
δ
14A
14Aa
17b
13Aa
17c
P
O1
O2
R
17c
X
P
13B
13A
17
14Ba
13Ba
17a
17b

FIG. 4A

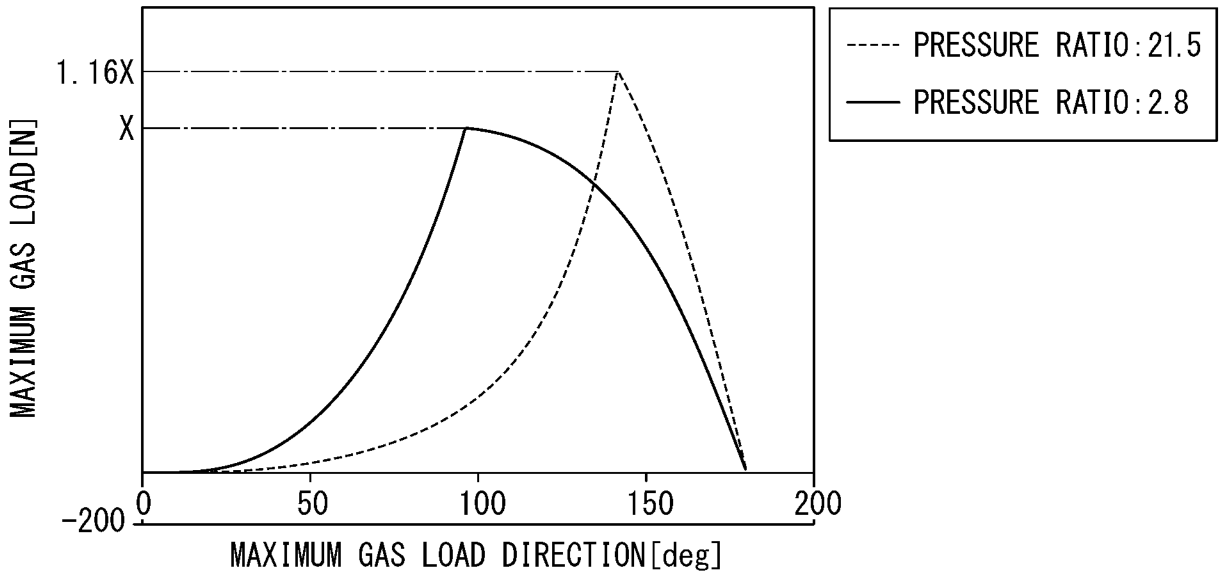

1.16X
X
MAXIMUM GAS LOAD[N]
-200
0
50
100
150
200
MAXIMUM GAS LOAD DIRECTION[deg]
PRESSURE RATIO:21.5
PRESSURE RATIO:2.8

FIG. 4B

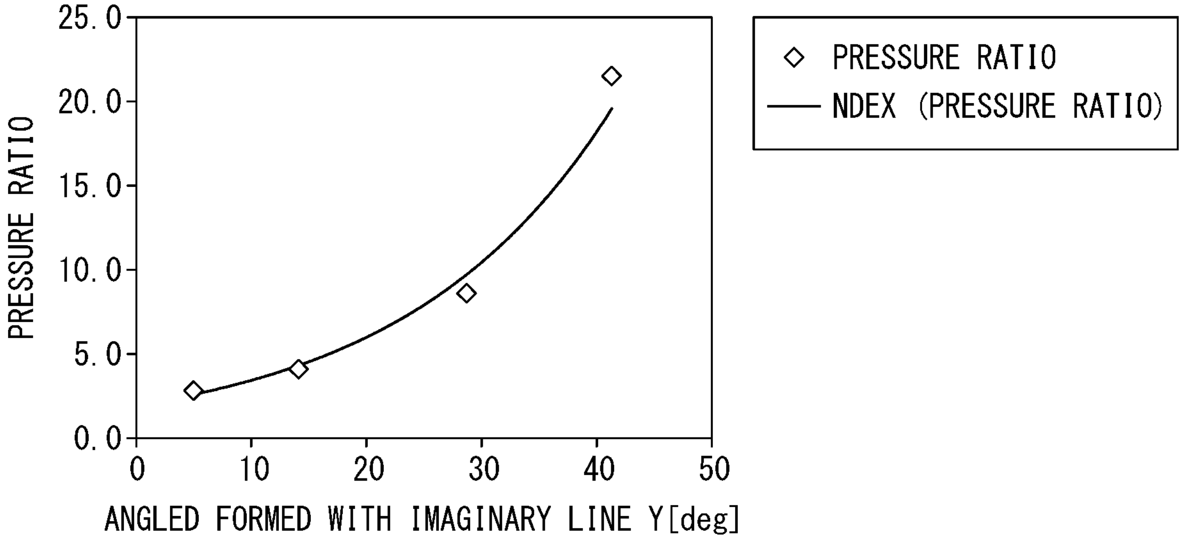

25.0
20.0
15.0
10.0
5.0
0.0
PRESSURE RATIO
0
10
20
30
40
50
ANGLED FORMED WITH IMAGINARY LINE Y[deg]
PRESSURE RATIO
NDEX (PRESSURE RATIO)

FIG. 5

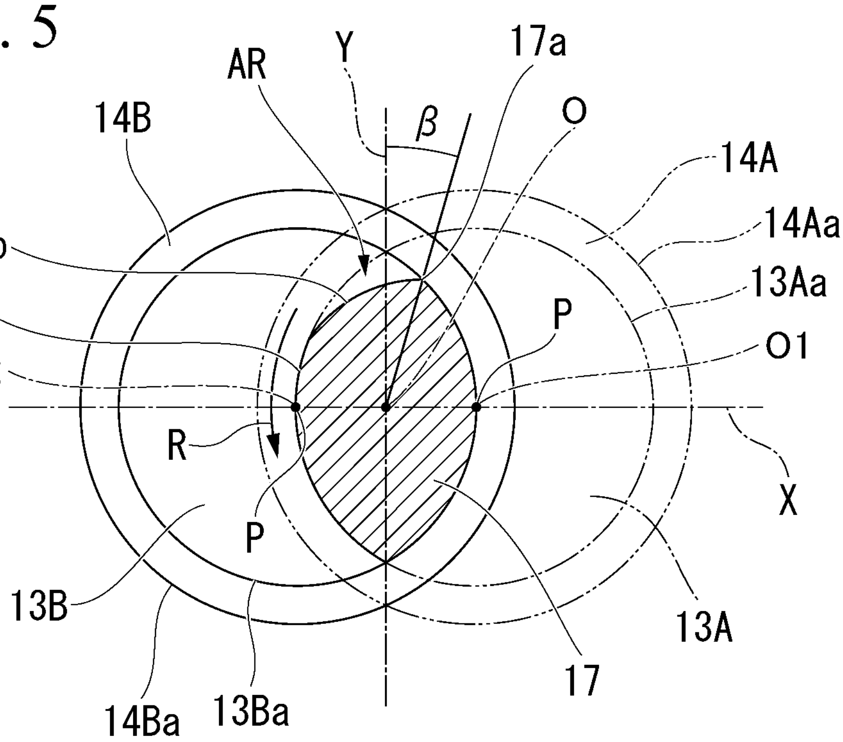
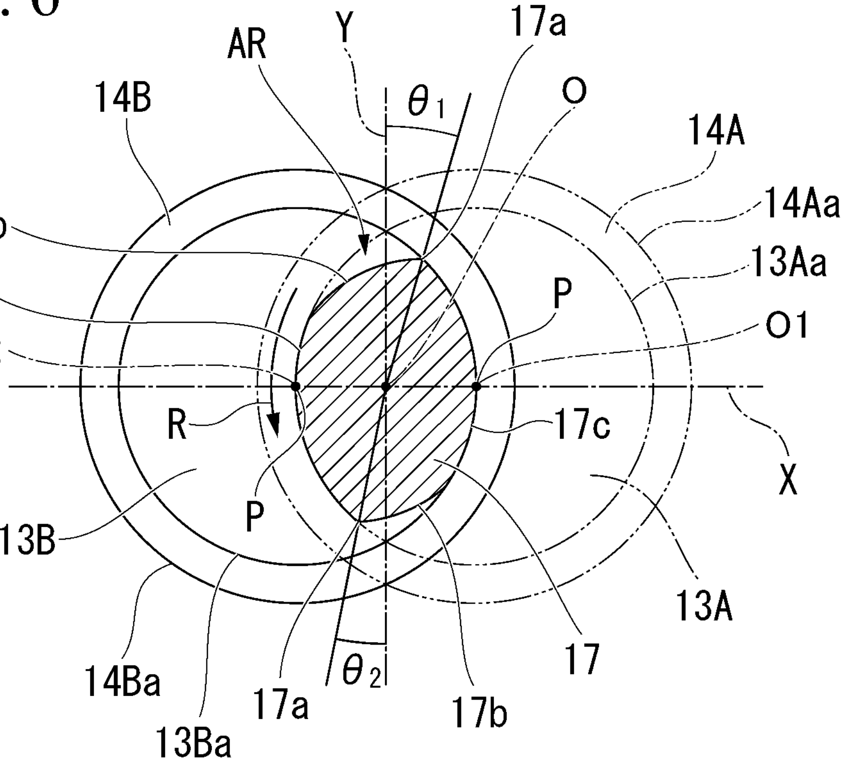

AR
Y
17a
β
O
14B
14A
14Aa
17b
13Aa
17c
P
O2
O1
R
X
P
13B
13A
17
14Ba
13Ba

FIG. 6


AR
Y
17a
θ1
O
14B
14A
14Aa
17b
13Aa
17c
P
O2
O1
R
17c
X
P
13B
13A
17
14Ba
θ2
17a
17b
13Ba

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2018/038818

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

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

B. FIELDS SEARCHED

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

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	1971-2018
Registered utility model specifications of Japan	1996-2018
Published registered utility model applications of Japan	1994-2018

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 A	JP 2013-96280 A (MITSUBISHI ELECTRIC CORP.) 20 May 2013, paragraphs [0035]-[0042], fig. 1-2 & CN 103089631 A & KR 10-2013-0047569 A	1-2, 4-5, 7 3, 6
X A	WO 2009/028633 A1 (TOSHIBA CARRIER CORPORATION) 05 March 2009, paragraphs [0070]-[0089], fig. 6-7 & US 2010/0147013 A1, paragraphs [0106]-[0127], fig. 6-7 & CN 101688535 A	1-2, 4-5, 7 3, 6

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

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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 December 2018 (07.12.2018)	25 December 2018 (25.12.2018)

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

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Patent documents cited in the description

- JP 2017201554 A **[0002]**
- JP 2013181420 A **[0005]**