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

(11) EP 3 318 760 A1

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

(43) Date of publication:
09.05.2018 Bulletin 2018/19

(21) Application number: **16817893.7**

(22) Date of filing: **28.06.2016**

(51) Int Cl.:
F04C 18/344 *(2006.01)* ***F04C 29/00*** *(2006.01)*

(86) International application number:
PCT/JP2016/069083

(87) International publication number:
WO 2017/002785 (05.01.2017 Gazette 2017/01)

(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 MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
MA MD

(30) Priority: **30.06.2015 JP 2015130554**

(71) Applicant: **Valeo Japan Co., Ltd.**
Saitama 360-0193 (JP)

(72) Inventors:
- **HIROTA, Yoshio**
  Kumagaya-shi
  Saitama 360-0193 (JP)
- **YOSHIDA, Yukio**
  Kumagaya-shi
  Saitama 360-0193 (JP)
- **TAKAHASHI, Tomoyasu**
  Kumagaya-shi
  Saitama 360-0193 (JP)
- **OSAWA, Jin**
  Kumagaya-shi
  Saitama 360-0193 (JP)
- **NAKAMURA, Takaaki**
  Kumagaya-shi
  Saitama 360-0193 (JP)

(74) Representative: **Tran, Chi-Hai**
Valeo Systèmes Thermiques
8, rue Louis Lormand
CS 80517 La Verrière
78322 Le Mesnil Saint Denis Cedex (FR)

(54) VANE COMPRESSOR

(57) [Object]

To provide a vane compressor in which the structure of the lower end portion of a vane is changed so that the shoulder portions of the lower end portion of the vane have difficulty in overriding on the arc surface on the side of the back pressure chamber and the rotation of the rotor is thereby prevented from being restricted by the vane protruding from the outer peripheral surface of the rotor.

[Solution]

A back pressure chamber 10 having a concave arc surface 101 is formed on the bottom of the vane groove 5, a lower end portion 61 in the forward or backward travel direction of the vane 6 has a convex arc surface 611a facing a bottom side arc surface 101c of the concave arc surface 101 of the bottom of the vane groove 5, and voids D are generated between the lower end portion 61 of the vane 6 and the concave arc surface 101 on the bottom of the vane groove 5 on both sides in the thickness direction of the vane 6 when the lower end portion 61 of the vane 6 makes contact with the bottom side arc surface 101c of the concave arc surface 101 of the bottom of the vane groove 5.

Printed by Jouve, 75001 PARIS (FR)

(Cont. next page)

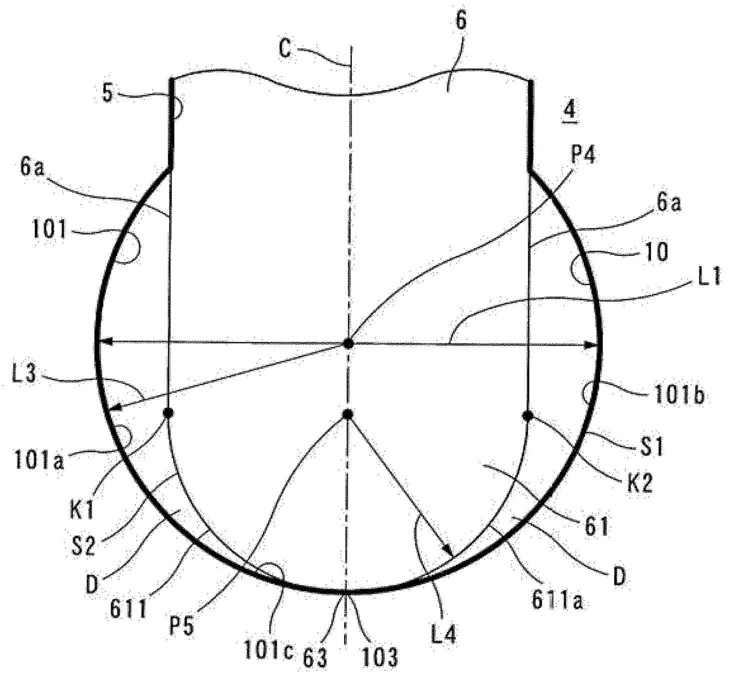

C
6
5
4
6a
P4
101
6a
10
L1
L3
101b
101a
S1
K1
K2
S2
61
D
D
611
611a
P5
L4
101c
63
103

Fig.3(a)

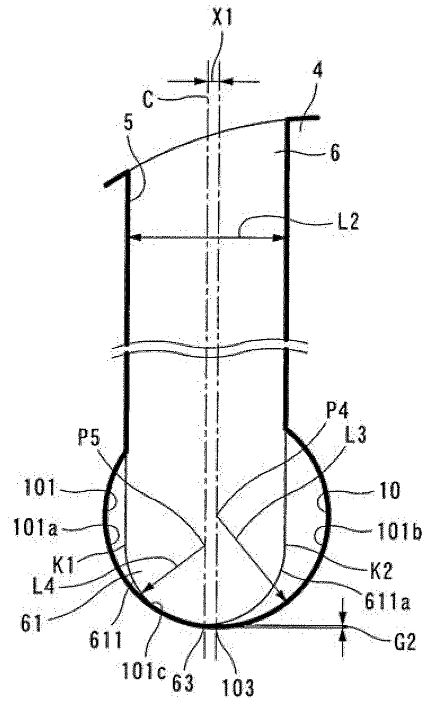

X1
C
4
5
6
L2
P4
P5
L3
101
10
101a
101b
K1
K2
L4
611a
61
G2
611
101c
63
103

Fig.3(b)

Description

Technical Field

[0001] The present invention relates to a vane compressor suitable for a refrigeration cycle using, for example, a working fluid as a refrigerant, more particularly to the structure of a lower end portion in the forward or backward travel direction of the vane of a vane compressor.

Background Art

[0002] As described in, for example, PTL 1, PTL 2, and the like, a vane compressor includes a cylinder having both ends closed by side blocks or the like, a rotor, rotatably housed in the cylinder, that has a perfect circular cross section, a vane groove formed radially inward from an outer peripheral surface of the rotor, and a vane housed in the vane groove movably forward and backward. In addition, the vane compressor has the structure in which the vane is brought into slidable contact with the inner peripheral surface of the cylinder by a centrifugal force caused by the rotation of the rotor or a back pressure from a back pressure chamber provided on the bottom of the vane groove.

[0003] In the vane compressor proposed in PTL 1, the bottom of the vane groove of the rotor has an arc-shaped cross section and the lower end portion of the vane is arc-shaped so as to match the shape of the bottom of the vane groove. Accordingly, even when the lower end portion of the vane collides with the bottom of the vane groove, impact sound is reduced because arcs make contact with each other.

[0004] In addition, since the bottom of the vane groove and the lower end portion of the vane are arc-shaped so as to become close to each other, the vane can reach the bottom of the vane groove until the centers in the arcs coincide. In consideration of this, the length of the vane along the vane groove is formed so as not to project from the vane groove even when the vane enters the deepest part of the vane groove. Accordingly, even when the vane moves in the vane groove so as to follow the shape of the inner peripheral surface of the cylinder as the rotor rotates and passes through the radial seal portion on the inner peripheral surface of the cylinder, the vane can enter the cylinder groove without interfering with the bottom of the vane groove.

Citation List

Patent Literature

[0005]

PTL 1: JP-A-10-18984
PTL 2: JP-A-11-230068

Summary of Invention

Technical Problem

[0006] The material of the vane compressor can be formed by, for example, forging as described in PTL 2. In the material of the rotor formed by forging, the vane groove including the back pressure chamber, a through hole into which a shaft is inserted, and the like are formed in advance. When the completed product of the rotor is created from such rotor materials formed as described above by forging or molding, the vane groove in which the vane slides and which requires dimensional accuracy is polished, but the back pressure chamber in which no member slides or to which no member is fitted is not machined.

[0007] When the rotor of the vane compressor described in PTL 1 is made from materials formed by forging or molding, the vane groove of the rotor is polished at high accuracy, but the back pressure chamber provided on the bottom of the vane groove has the shape formed by forging as is. Accordingly, when the vane groove is polished, the position of the vane groove deviates from the position of the back pressure chamber and the center of the vane groove in which the vane slides may deviate from the center of the back pressure chamber.

[0008] When the center of the vane groove in which the vane slides deviates from the center of the back pressure chamber, as illustrated in Fig. 8, even if the vane enters the deepest part of the vane groove, the center of the arc surface of the lower end portion of the vane does not coincide with the center of the arc surface of the vane groove, and the shoulder portion of the lower end portion of the vane overrides the arc surface on the side of the bottom of the vane groove. Accordingly, the lower end portion of the vane cannot enter the deepest part of the vane groove, the upper end portion projects from the outer peripheral surface of the rotor and the vane interferes with the inner peripheral surface of the cylinder, possibly disabling the rotation of the rotor.

[0009] The invention addresses the above problems with an object of providing a vane compressor in which the structure of the lower end side in the forward or backward travel direction of a vane is changed so that the shoulder portion of the lower end portion of the vane has difficulty in overriding the arc surface on the side of the concave arc surface of the back pressure chamber and the rotation of the rotor is thereby prevented from being restricted by the vane protruding from the outer peripheral surface of the rotor.

Solution to Problem

[0010] A vane compressor according to the invention includes a cylinder having both ends closed by side block members, a rotor rotatably provided in the cylinder, a vane groove formed radially inward from an outer peripheral surface of the rotor, and a vane housed in the vane groove movably forward and backward, one end portion of the vane making slidable contact with an inner peripheral surface of the cylinder as the rotor rotates, in which a back pressure chamber having a concave arc surface is formed on a bottom of the vane groove, the other end portion of the vane has a convex arc surface facing the concave arc surface of the vane groove, and voids are generated between the vane and the bottom of the vane groove on both sides in a thickness direction of the vane when the other end portion of the vane makes contact with the bottom of the vane groove. In a vane compressor according to the second aspect, the convex arc surface of the other end portion of the vane has a curvature radius smaller than the concave arc surface on the bottom of the vane groove and the voids are thereby generated on both sides of a contact portion between the other end portion of the vane and the bottom of the vane groove.

[0011] Accordingly, if the center of the vane groove in the thickness direction of the vane deviates from the center of the back pressure chamber in the thickness direction of the vane, voids are formed between the lower end portion of the vane and the bottom of the vane groove on both sides in the thickness direction of the vane when the lower end portion of the vane makes contact with the concave arc surface of the back pressure chamber. Accordingly, when the vane enters the deepest part of the vane groove, the shoulder portion of the lower end portion of the vane has difficulty in overriding the arc surface on the side of the back pressure chamber of the concave arc surface on the bottom of the vane groove. Accordingly, it is possible to prevent a defect that causes the upper end portion of the vane to project from the outer peripheral surface of the rotor, interfere with the inner peripheral surface of the cylinder, and inhibit the rotation of the rotor.

[0012] In a vane compressor according to the third aspect, tangential flat surfaces continued to the convex arc surface are formed on both sides in the thickness direction of the other end portion of the vane.

[0013] Accordingly, when the entire surface of the other end of vane facing the concave arc surface on the bottom of the vane groove is the convex arc surface, since the position of the shoulder portion of the vane is raised toward the outer peripheral surface of the rotor, the width of the sliding surface of the vane is narrowed. However, since the tangential flat surfaces are present, the position of the shoulder portion of the vane is prevented from being raised toward the outer peripheral surface of the rotor more than necessary, thereby preventing the width of the sliding surface of the vane from being narrowed.

[0014] In addition, since the radius of the convex arc surface of the other end portion of the vane can be reduced as compared with the case in which the entire surface facing the concave arc surface on the bottom of the vane groove is the convex arc surface, contact can be concentrated on the position at which the other end portion of the vane makes contact with the bottom of the vane groove. Accordingly, even when, for example, fine foreign matter enters the back pressure chamber, the foreign matter is sandwiched between the other end portion of the vane and the bottom of the vane groove, thereby preventing the possibility that the vane cannot enter the deep part of the bottom of the vane groove.

[0015] In a vane compressor according to the fourth aspect, sliding contact surfaces in slidable contact with the vane groove are formed on both sides in the thickness direction of the vane, chamfering for partially removing the sliding contact surfaces and the convex arc surface is performed between the sliding contact surfaces and the convex arc surface of the other end portion of the vane, and the voids are thereby provided.

[0016] Accordingly, it is possible to shave the shoulder portion of the vane or enlarge voids formed between the other end portion of the vane and the bottom of the vane groove on both sides in the thickness direction of the vane when the other end portion of the vane makes contact with the concave arc surface of the vane groove. Accordingly, when the vane enters the deepest part of the vane groove, the shoulder portion of the other end portion of the vane has more difficulty in overriding the arc surface on the side of the concave arc surface of the back pressure chamber.

Advantageous Effects of Invention

[0017] As described above, in the invention, even if the center of the vane groove in the thickness direction of the vane deviates from the center of the back pressure chamber in the thickness direction of the vane, voids are formed between the lower end portion of the vane and the concave arc surface of the back pressure chamber on both sides in the thickness direction of the vane when the lower end portion of the vane makes contact with the concave arc surface of the back pressure chamber. Accordingly, when the vane enters the deepest part of the vane groove, it is possible to prevent the shoulder portion of the lower end portion of the vane from overriding the arc surface on the side of the concave arc surface of the back pressure chamber. Accordingly, it is possible to prevent a defect that causes the upper end portion of the vane to project from the outer peripheral surface of the rotor, interfere with the inner peripheral surface of the cylinder, and inhibit the rotation of the rotor.

[0018] According to particularly the third aspect of the invention, when the entire surface of the other end portion of the vane facing the concave arc surface on the bottom of the vane groove is the convex arc surface, since the position of the shoulder portion of the vane is raised toward the outer peripheral surface of the rotor, the width of the sliding surface of the vane is narrowed. However, since the tangential flat surfaces are present, the position of the shoulder portion of the vane is prevented from being raised toward the outer peripheral surface of the rotor more than necessary, thereby preventing the width of the sliding surface of the vane from being narrowed.

[0019] In addition, according to particularly the third aspect of the invention, since the radius of the convex arc surface of the other end portion of the vane can be reduced as compared with the case in which the entire surface facing the concave arc surface on the bottom of the vane groove is the convex arc surface, contact can be concentrated on the position at which the other end portion of the vane makes contact with the bottom of the vane groove. Accordingly, even when, for example, fine foreign matter enters the back pressure chamber, the foreign matter is sandwiched between the other end portion of the vane and the bottom of the vane groove, thereby preventing the possibility that the vane cannot enter the deep part of the bottom of the vane groove.

[0020] According to particularly the fourth aspect of the invention, it is possible to shave the shoulder portion of the vane or enlarge voids formed between the lower end portion of the vane and the bottom of the vane groove on both sides in the thickness direction of the vane when the lower end portion of the vane makes contact with the concave arc surface of the back pressure chamber. Accordingly, when the vane enters the deepest part of the vane groove, the shoulder portion of the lower end portion of the vane has more difficulty in overriding the arc surface on the side of the concave arc surface of the back pressure chamber.

Brief Description of Drawings

[0021]

[Fig. 1 (a)] Fig. 1(a) is a cross sectional view illustrating an example of a vane compressor according to the invention, and a cross sectional view cut so that a discharge port can be seen.

[Fig. 1(b)] Fig. 1(b) is a cross sectional view illustrating an example of a vane compressor according to the invention, and a cross sectional view cut so that an intake port can be seen.

[Fig. 2] Fig. 2 is a cross sectional view taken along line A-A in Fig. 1(b).

[Fig. 3(a)] Fig. 3(a) is a schematic view illustrating the structures of a vane, a vane groove, and a back pressure chamber according to embodiment 1 of the invention, and an enlarged view illustrating the vane and the back pressure chamber when the vane groove does not deviate from the back pressure chamber in the thickness direction of the vane.

[Fig. 3(b)] Fig. 3(b) is a schematic view illustrating the structures of a vane, a vane groove, and a back pressure chamber according to embodiment 1 of the invention, and an overall view illustrating the vane, the vane groove, and the back pressure chamber when the vane groove deviates from the back pressure chamber in the thickness direction of the vane.

[Fig. 4(a)] Fig. 4(a) is a schematic view illustrating the structures of a vane, a vane groove, and a back pressure chamber according to the other example of embodiment 1 of the invention, and an enlarged view illustrating the vane and the back pressure chamber when the vane groove does not deviate from the back pressure chamber in the thickness direction of the vane.

[Fig. 4(b)] Fig. 4(b) is a schematic view illustrating the structures of a vane, a vane groove, and a back pressure chamber according to the other example of embodiment 1 of the invention, and an overall view illustrating the vane, the vane groove, and the back pressure chamber when the vane groove deviates from the back pressure chamber in the thickness direction of the vane.

[Fig. 5(a)] Fig. 5(a) is a schematic view illustrating the structures of a vane, a vane groove, and a back pressure chamber according to embodiment 2 of the invention, and an enlarged view illustrating the vane and the back pressure chamber when the vane groove does not deviate from the back pressure chamber in the thickness direction of the vane.

[Fig. 5(b)] Fig. 5(b) is a schematic view illustrating the structures of a vane, a vane groove, and a back pressure chamber according to embodiment 2 of the invention, and an overall view illustrating the vane, the vane groove, and the back pressure chamber when the vane groove deviates from the back pressure chamber in the thickness direction of the vane.

[Fig. 6] Fig. 6 is an explanatory diagram illustrating an example of setting the angle of the tangential flat surfaces of the other end portion of the vane according to embodiment 2 of the invention illustrated in Fig. 5(a) and Fig. 5(b).

[Fig. 7(a)] Fig. 7(a) is a schematic view illustrating the structures of a vane, a vane groove, and a back pressure chamber according to embodiment 3 of the invention, and an enlarged view illustrating the vane and the back pressure chamber when the vane groove does not deviate from the back pressure chamber in the thickness direction of the vane.

[Fig. 7(b)] Fig. 7(b) is a schematic view illustrating the structures of a vane, a vane groove, and a back pressure chamber according to embodiment 3 of the invention, and an overall view illustrating the vane, the vane groove, and the back pressure chamber when the vane groove deviates from the back pressure chamber in the thickness direction of the vane.

[Fig. 8(a)] Fig. 8(a) is a schematic view illustrating the structures of a vane, a vane groove, and a back pressure chamber according to a comparative example (to be compared with the embodiment 1, the other example of embodiment 1, embodiment 2, and embodiment 3 of the invention) having a problem in the lower end portion of the vane, and an enlarged view illustrating the vane and the back pressure chamber when the vane groove does not deviate from the back pressure chamber in the thickness direction of the vane.

[Fig. 8(b)] Fig. 8(b) is a schematic view illustrating the structures of a vane, a vane groove, and a back pressure chamber according to a comparative example (to be compared with the embodiment 1, the other example of embodiment 1, embodiment 2, and embodiment 3 of the invention) having a problem in the lower end portion of the vane, and an overall view illustrating the vane, the vane groove, and the back pressure chamber when the vane groove deviates from the back pressure chamber in the thickness direction of the vane.

Description of Embodiments

[0022] Embodiments of the invention will be described below with reference to the attached drawings.

[0023] Figs. 1 and 2 illustrate an example of a vane compressor used for the refrigeration cycle of, for example, an in-vehicle air conditioner. A vane compressor 1 includes a shaft 3, a rotor 4, fixed to the shaft 3, that rotates as the shaft 3 rotates, and first and second housing members 8 and 9 that define a compression space 18 (described later) together with the rotor 4. The first housing member 8 and the second housing member 9 constitute a housing 2.

[0024] In the embodiment, the first housing member 8 includes a cylinder 8a in which the rotor 4 is housed and a rear side block 8b positioned on the rear side in the shaft direction of the shaft 3 with respect to the cylinder 8a, integrally molded with the cylinder 8a, and closing the rear side of the cylinder 8a.

[0025] The rotor 4 housed in the cylinder 8a is a cylinder having a perfect circular cross section and a center point P1 of the perfect circle is provided with a through hole 4a to which the shaft 3 can be press-fitted, as illustrated in Fig. 2. In addition, the rotor 4 has two vanes 6 to be inserted into two vane grooves 5 opened in the outer peripheral surface of the rotor 4.

[0026] Although the structures of the vanes 6 in the examples illustrated in Figs. 3 to 8 will be described later, any of the vanes 6 includes one end portion having sliding contact surfaces 6a and 6a (described later) in slidable contact with the inner peripheral surface of the vane groove 5 described below on both sides in the thickness direction of the vane 6 and the other end portion having a convex arc surface 611a (described later) and slides on the inner peripheral surface of the cylinder 8a by moving forward or backward from the vane groove 5.

[0027] In any of the examples illustrated in Figs. 3 to 8, the vane groove 5 extends radially inward from the outer peripheral surface of the rotor 4. In addition, a back pressure chamber 10 having a concave arc surface 101, which will be described later, is formed on the bottom of the vane groove 5. The vane groove 5 and the back pressure chamber 10 are formed so as to penetrate from front side to the rear side along the shaft direction of the rotor 4.

[0028] As illustrated in Fig. 2, in the embodiment, the inner peripheral surface of the cylinder 8a has an inner diameter larger than the outer diameter of the rotor 4 and is formed in a perfect circle about a center point P2. The rotor 4 is housed in the cylinder 8a so that the outer peripheral surface of the rotor 4 and the inner peripheral surface of the cylinder 8a form a fine clearance (radial seal portion P3 at which the cylinder 8a is closest to the rotor 4) at one position in the peripheral direction. Since the rotor 4 about the center point P1 is housed in the cylinder 8a as described above, a compression space 18 is defined between the inner peripheral surface of the cylinder 8a and the outer peripheral surface of the rotor 4. This compression space 18 is partitioned by the two vanes 6 housed in the two vane grooves 5 formed in the rotor 4 into two compression chambers 19 and the volumes of the compression chambers 19 are changed as the rotor 4 rotates.

[0029] The second housing member 9 is configured by integrating a front side block 9a in contact with the front side end surface of the cylinder 8a with a shell 9b, extending in the shaft direction of the shaft 3 from the front side block 9a, that surrounds the outer peripheral surfaces of the cylinder 8a and the rear side block 8b. In addition, the second housing member 9 is coupled to the first housing member 8 via a coupling tool 7 such as a bolt. By inserting the first housing member 8 from a rear side opening 9d of the shell 9b and fitting the first housing member 8 to the shell 9b, the front side of the cylinder 8a is closed by the front side block 9a and the rear side opening 9d of the shell 9b is closed by the rear side block 8b.

[0030] In addition, in the second housing member 9, a pulley 20 to which rotational power is transmitted from the power source (not illustrated) of a vehicle via a belt (not illustrated) is rotatably mounted onto a boss section 9c integrated with the front side block 9a and the rotational power is transmitted from the pulley 20 to the shaft 3 via an electromagnetic clutch 21. In addition, the second housing member 9 is provided with an intake port 11 and a discharge port 12 of the working fluid (refrigerant gas) and the intake port 11 communicates with an intake space 14 including a space 14a formed in the second housing member 9 and a concavity 14b formed in the cylinder 8a.

[0031] The shaft 3 is rotatably supported via plain bearings 23 and 24 that are bearing portions held and formed by the front side block 9a of the second housing member 9 and the rear side block 8b of the first housing member 8. In addition, a seal member 13 is present between the shaft 3 and the inner side surface of the second housing member 9 in the part close to the base end of the boss section 9C of the second housing member 9 to prevent the working fluid from leaking externally from the opening of the boss section 9c.

[0032] The peripheral surface of the cylinder 8a is provided with an intake port 25 communicating with the intake space 14 so as to correspond to the compression space 18 and a discharge port 26 communicating with a discharge space 15. Accordingly, when the cylinder 8a is fitted to the shell 9b, the intake space 14 communicates with the compression chambers 19 via the intake port 25, the discharge space 15 having both ends separated by flange sections 8c and 8d is formed between the outer peripheral surface of the cylinder 8a and the inner side surface of the shell 9b, and the discharge space 15 can communicate with the compression chambers 19 via the discharge port 26. The discharge port 26 is opened or closed by a discharge valve 27 housed in the discharge space 15. In addition, the discharge space 15 communicates with an oil separator 16 via a passing hole 28 formed in the flange section 8d. In addition, the oil separator 16 communicates with the discharge port 12.

[0033] In the structure described above, in the vane compressor 1, the rotational power from the power source (not illustrated) is transmitted to the shaft 3 via the pulley 20 and the electromagnetic clutch 21 and, when the rotor 4 rotates, the working fluid having flowed to the intake space 14 from the intake port 11 is sucked by the compression space 18 via the intake port 25. Since the volumes of the compression chambers 19 partitioned by the vanes 6 in the compression space 18 are changed as the rotor 4 rotates, the working fluid between the vanes 6 is compressed and discharged from the discharge port 26 to the discharge space 15 via the discharge valve 27. The working fluid discharged to the discharge space 15 moves in the peripheral direction along the outer peripheral surface (inner side surface of the shell 9b) of the cylinder 8a and is introduced to the oil separating chamber of the oil separator 16 formed in the rear side block 8b via the passing hole 28 formed in the flange section 8d. After that, oil is separated from the working fluid during rotation in the oil separating chamber of the oil separator 16 and then the working fluid is discharged to an external circuit through the discharge port 12.

[0034] By the way, Fig. 3 illustrates embodiment 1 of the invention, Fig. 4 illustrates the other example of embodiment 1 of the invention, Figs. 5 and 6 illustrate embodiment 2 of the invention, Fig. 7 illustrates embodiment 3 of the invention, and Fig. 8 illustrates a comparative example to be compared with embodiment 1, the other example of embodiment 1, embodiment 2, and embodiment 3. Embodiment 1, the other example of embodiment 1, embodiment 2, and embodiment 3 will be described while being compared with the comparative example.

Embodiment 1

[0035] The vane groove 5 in embodiment 1 extends radially inward from the outer peripheral surface of the rotor 4 as described above and has the inner side surfaces in contact with the sliding contact surfaces 6a and 6a of the vane 6 on both sides in the thickness direction of the vane 6. Fig. 3 (a) illustrates a center line C passing through the center in the thickness direction of the vane 6.

[0036] As illustrated in Fig. 3, the back pressure chamber 10 in embodiment 1 includes two side arc surfaces 101a and 101b and one bottom side arc surface 101c positioned between the two side arc surfaces 101a and 101b.

[0037] The side arc surface 101a, the bottom side arc surface 101c, and the side arc surface 101b that form the back pressure chamber 10 are disposed along an arc S1 assumed about a center point P5 of the back pressure chamber 10 and constitute the concave arc surface 101 of the back pressure chamber 10. A diameter L1 of the back pressure chamber 10 is larger than a dimension L2 (illustrated in Fig. 3(b)) of the vane groove 5 in the thickness direction of the vane 6. Reference numeral 103 in Fig. 3 indicates the center in the arc of the arc S1 that forms the concave arc surface 101 of the back pressure chamber 10.

[0038] Also in the comparative example illustrated in Fig. 8, the back pressure chamber 10 has the concave arc surface 101, reference numeral 103 indicates the center in the arc of the arc S1 that forms the concave arc surface 101 of the back pressure chamber 10, and the center line C passing through the center in the thickness direction of the vane 6 is illustrated.

[0039] The vane 6 in embodiment 1 has a lower end portion 61 close to the lower end in the forward or backward travel direction of the vane 6 as the other end portion described above. The lower end portion 61 has the convex arc surface 611a in which an entire contact surface 611 facing a bottom side arc surface 102c of the back pressure chamber 10 is along an arc S2. Accordingly, shoulder portions K1 and K2 of the lower end portion 61 coincide with the start end and the terminal end of the arc S2 about the center point P5. A curvature radius L4 of the arc S2 forming the convex arc surface 611a of the lower end portion 61 is smaller than a curvature radius L3 of the arc S1 forming the concave arc surface 101 of the back pressure chamber 10. Reference numeral 63 in Fig. 3 indicates the center in the arc of the arc S2 forming the convex arc surface 611a of the lower end portion 61. In Fig. 3, for example, the curvature radius L4 of the arc S2 forming the convex arc surface 611a is substantially half the dimension L2 in the thickness direction of the vane 6. Accordingly, the convex arc surface 611a of the lower end portion 61 is a half peripheral surface and the center point P5 of the arc S2 and the shoulder portions K1 and K2 of the lower end portion 61 are positioned in a single line. When the position of the vane groove 5 does not deviate from the position of the back pressure chamber 10, a center point P4 of the arc S1 does not deviate from the center point P5 of the arc S2 as illustrated in Fig. 3(a), these points are present in the center line C of the same vane groove 5, and the center 63 in the arc of the convex arc surface 611a of the lower end portion 61 can coincide with the center 103 in the arc of the concave arc surface 101 of the back pressure chamber 10.

[0040] Although the entire contact surface 611 facing a bottom side arc surface 102 of the back pressure chamber 10 is the convex arc surface 611a along the arc S2 in the lower end portion 61 of the vane 6 in the comparative example, the curvature radius L4 of the arc S2 forming the convex arc surface 611a of the lower end portion 61 is the same as the curvature radius L3 of the arc S1 forming the concave arc surface 101 of the back pressure chamber 10. Also in this case, when the position of the vane groove 5 does not deviate from the position of the back pressure chamber 10, the center point P4 of the arc S1 does not deviate from the center point P5 of the arc S2 as illustrated in Fig. 8 (a), these points are present in the center line C of the same vane groove 5, and the center 63 in the arc of the convex arc surface 611a of the lower end portion 61 can coincide with the center 103 in the arc of the concave arc surface 101 of the back pressure chamber 10.

[0041] However, in the comparative example, even when the convex arc surface 611a of the lower end portion 61 is brought into contact with the bottom side arc surface 101c of the back pressure chamber 10 so that the center 63 in the arc of the convex arc surface 611a of the lower end portion 61 coincides with the center 103 in the arc of the concave arc surface 101 of the back pressure chamber 10, voids D are not formed between the vane 6 and the concave arc surface 101 of the back pressure chamber 10, as illustrated in Fig. 8(a). In contrast, in embodiment 1, when the convex arc surface 611a of the lower end portion 61 is brought into contact with the bottom side arc surface 101c of the back pressure chamber 10 so that the center 63 in the arc of the convex arc surface 611a of the lower end portion 61 coincides with the center 103 in the arc of the concave arc surface 101 of the back pressure chamber 10, the voids D are formed between the vane 6 and the concave arc surface 101 of the back pressure chamber 10 on both sides in the thickness direction of the vane, as illustrated in Fig. 3(a).

[0042] On the other hand, in manufacturing the rotor 4 of the invention using the manufacturing method described above, when the vane groove 5 is polished, the position of the vane groove 5 deviates from the position of the back pressure chamber 10, the center line C of the vane groove 5 in the thickness direction of the vane 6 and the center point P5 of the back pressure chamber 10 may deviate by approximately a predetermined dimension X1 along the thickness direction of the vane 6 from a set position, as illustrated in Figs. 3 (b) and 8 (b). In addition, the center 63 in the arc of the convex arc surface 611a of the contact surface 611 and the center 103 in the arc of the concave arc surface 101 of the back pressure chamber 10 also deviate by the predetermined dimension X1 along the thickness direction of the vane 6, as illustrated in Figs. 3(b) and 8(b).

[0043] Since the voids D are not formed between the vane 6 and the concave arc surface of the back pressure chamber 10 on both sides in the thickness direction of the vane in the comparative example in Fig. 8, the shoulder portions K1 and K2 of the lower end portion 61 override the side arc surfaces 101a and 101b of the back pressure chamber 10 as illustrated in Fig. 8(b) when the vane 6 enters the deepest part of the vane groove 5. A clearance G1 is generated between the center 63 in the arc of the convex arc surface 611a of the lower end portion 61 and the center 103 in the arc of the concave arc surface 101 of the back pressure chamber 10 along the forward or backward travel direction of the vane 6. Since this clearance G1 is large, the upper end portion of the vane 6 projects from the outer peripheral surface of the rotor 4, the vane 6 interferes with the inner peripheral surface of the cylinder 8a, possibly disabling the rotation of the rotor 4.

[0044] In contrast, since the voids D are formed between the vane 6 and the concave arc surface 101 of the back pressure chamber 10 on both sides in the thickness direction of the vane in embodiment 1, the shoulder portions K1 and K2 of the lower end portion 61 have difficulty in overriding the arc surface on the side arc surfaces 101a and 101b of the back pressure chamber 10 as illustrated in Fig. 3(b). Since the convex arc surface 611a of the lower end portion 61 is raised along the arc of the concave arc surface 101 of the back pressure chamber 10, a clearance G2 is generated along the forward or backward travel direction of the vane 6 between the center 63 of the arc surface of the lower end portion 61 and the center 103 of the arc surface of the concave arc surface 101 of the back pressure chamber 10, as illustrated in Fig. 3(b). However, since this clearance G2 is small, the upper end portion of the vane 6 does not project from the outer peripheral surface of the rotor 4 in embodiment 1, the vane 6 does not interfere with the inner peripheral surface of the cylinder 8a, thereby preventing the rotation of the rotor 4 from being disabled.

[0045] Fig. 4 illustrates the other example of embodiment 1 illustrated in Fig. 3. The other example of embodiment 1 will be described below with reference to Fig. 3. However, the same components as in embodiment 1 are given the same reference numerals in principle and descriptions are omitted.

[0046] The lower end portion 61 of the vane 6 in the other example of embodiment 1 is the same as the lower end portion 61 illustrated in Fig. 3 in that the entire contact surface 611 facing the bottom side arc surface 101c of the back pressure chamber 10 is the convex arc surface 611a along the arc S2. In contrast, in the lower end portion 61 of the vane 6 in the other example of embodiment 1, the curvature radius L4 of the arc S2 forming the convex arc surface 611a is larger than substantially the half of the dimension L2 in the thickness direction of the vane 6 and smaller than the curvature radius L3 of the arc S1 forming the concave arc surface 101 of the back pressure chamber 10. Accordingly, the convex arc surface 611a of the lower end portion 61 is smaller than a half peripheral surface and the center point P5 of the arc S2 is disposed closer to the sliding contact surface 6a of the vane 6 than the shoulder portions K1 and K2 of the lower end portion 61.

[0047] Also in the other example of embodiment 1, when the position of the vane grooves 5 does not deviate from the position of the back pressure chamber 10, as illustrated in Fig. 4(a), the center point P4 of the arc S1 does not deviate from the center point P5 of the arc S2, these center points are present in the center line C of the same vane groove 5, and the center 63 in the arc of the convex arc surface 611a of the lower end portion 61 can coincide with the center 103 in the arc of the concave arc surface 101 of the back pressure chamber 10.

[0048] In addition, also in the other example of embodiment 1, when the convex arc surface 611a of the lower end portion 61 is brought into contact with the bottom side arc surface 101c of the back pressure chamber 10 so that the center 63 in the arc of the convex arc surface 611a of the lower end portion 61 coincides with the center 103 in the arc of the concave arc surface 101 of the back pressure chamber 10 as illustrated in Fig. 4(a), the voids D are formed between the vane 6 and the concave arc surface of the back pressure chamber 10 on both sides in the thickness direction of vane, unlike the comparative example in Fig. 8.

[0049] Accordingly, even when the vane groove 5 deviates from the back pressure chamber 10 along the thickness direction of the vane, since the voids D are generated between the vane 6 and the concave arc surface 101 of the back pressure chamber 10 on both sides in the thickness direction of the vane, the shoulder portions K1 and K2 of the lower end portion 61 have difficulty in overriding the side arc surfaces 101a and 101b of the back pressure chamber 10 as illustrated in Fig. 4(b). In addition, the clearance G2 in Fig. 4(b) generated because the convex arc surface 611a of the lower end portion 61 is raised along the arc of the concave arc surface 101 of the back pressure chamber 10 is small as in embodiment 1 in Fig. 3, so the upper end portion of the vane 6 does not project from the outer peripheral surface of the rotor 4 also in the other example of embodiment 1, the vane 6 does not interfere with the inner peripheral surface of the cylinder 8a, thereby preventing the rotation of the rotor 4 from being disabled.

Embodiment 2

[0050] Figs. 5 and 6 illustrate embodiment 2 as described above. Embodiment 2 will be described below with reference to Figs. 5 and 6. However, the same components as in embodiment 1 and the other example of embodiment 1 are given the same reference numerals in principle and descriptions are omitted.

[0051] In the lower end portion 61 of the vane 6 in embodiment 2, the contact surface 611 includes the convex arc surface 611a and two tangential flat surfaces 611b continued to the convex arc surface 611a.

[0052] As illustrated in Fig. 5, the convex arc surface 611a is formed along an arc S3a of a circle S3, centered at P6, that has a radius L5 smaller than the radius L3 of the arc S1 forming the concave arc surface 101 of the back pressure chamber 10, the arc S3a facing the bottom side arc surface 101c. The tangential flat surfaces 611b are formed so as to make contact with the arc S3a forming the convex arc surface 611a in embodiment 2 and the contact flat surfaces 611b are flat surfaces extending from both ends of the arc S3 toward the shoulder portions K1 and K2 while being inclined toward the sliding contact surfaces 6a of the vane 6.

[0053] As illustrated in Fig. 6, the shape of the lower end portion 61 of the vane 6 in embodiment 2 can also be formed by, for example, providing the flat surfaces 611b on both sides in the thickness direction of the lower end portion 61 at the same angle as the oblique angle of the tangential flat surface of the arc surface (arc S1) passing through a point P7 at which the arc S1 forming the concave arc surface 101 of the back pressure chamber 10 and a virtual line V extending from the inner side surface of the vane groove 5 intersect and by connecting the intersection of the flat surface 611b and the flat surface 611b via the arc S3a of the contact circle S3 having the curvature radius L5 smaller than the curvature radius L3 of the arc S1 forming the concave arc surface of the back pressure chamber 10. It should be noted that the flat surface 611b may be slightly inclined toward the shaft line of the vane groove 5 from the same angle as the oblique angle of the tangential flat surface of the arc surface (arc S1) passing through the point P7, which is not illustrated.

[0054] Also in embodiment 2, when the position of the vane grooves 5 does not deviate from the position of the back pressure chamber 10, the center point P4 of the arc S1 does not deviate from the center point P6 of the circle S3 (arc S3a) as illustrated Fig. 5(a), these center points are present in the center line C in the same vane groove 5, and the center 63 in the arc of the convex arc surface 611a of the lower end portion 61 can coincide with the center 103 in the arc of the concave arc surface 101 of the back pressure chamber 10.

[0055] In addition, also in embodiment 2, as illustrated in Fig. 5 (a), when the convex arc surface 611a of the lower end portion 61 makes contact with the bottom side arc surface 101c of the back pressure chamber 10 so that the center 63 in the arc of the convex arc surface 611a of the lower end portion 61 coincides with the center 103 in the arc of the concave arc surface 101 of the back pressure chamber 10, the voids D are formed between the vane 6 and the concave arc surface of the back pressure chamber 10 on both sides in the thickness direction of the vane, unlike the comparative example in Fig. 8.

[0056] Accordingly, even when the vane groove 5 deviates from the back pressure chamber 10 along the thickness direction of the vane, since the voids D are generated between the vane 6 and the concave arc surface 101 of the back pressure chamber 10 on both sides in the thickness direction of the vane, the shoulder portions K1 and K2 of the lower end portion 61 have difficulty in overriding the side arc surfaces 101a and 101b of the back pressure chamber 10 as illustrated in Fig. 5(b). In addition, the clearance G2 in Fig. 5(b) generated because the convex arc surface 611a of the lower end portion 61 is raised along the arc of the concave arc surface

101 of the back pressure chamber 10 is small as in the above embodiments, so the upper end portion of the vane 6 does not project from the outer peripheral surface of the rotor 4 also in embodiment 2, the vane 6 does not interfere with the inner peripheral surface of the cylinder 8a, thereby preventing the rotation of the rotor 4 from being disabled.

Embodiment 3

[0057] Fig. 7 illustrate embodiment 3 as described above. Embodiment 3 will be described below with reference to Fig. 7. However, the same components as in the embodiments described above are given the same reference numerals in principle and descriptions are omitted.

[0058] The lower end portion 61 of the vane 6 in embodiment 3 is tapered by partially removing the sliding contact surface 6a and a part of the convex arc surface 611a of the vane 6 and forming the chamfered oblique surface 101c with respect to the convex arc surface 611a (the curvature radius L4 of the arc S2 is the same as the curvature radius L3 of the arc S1 forming the concave arc surface 101 of the back pressure chamber 10) having the entire contact surface 611 facing the bottom side arc surface 101c of the back pressure chamber 10 disposed along the arc S2 about the center point P5. However, although not illustrated, the curvature radius L4 of the arc S2 may be smaller than the curvature radius L3 of the arc S1 forming the concave arc surface 101 of the back pressure chamber 10. In addition, the chamfered oblique surface 101c may be formed by partially removing the sliding contact surface 6a of the vane 6 or the convex arc surface 611a.

[0059] When the position of the vane grooves 5 does not deviate from the position of the back pressure chamber 10, the center point P4 of the arc S1 does not deviate from the center point P5 of the circle S2 as illustrated in Fig. 7(a), these center points are present in the center line C in the same vane groove 5, and the center 63 in the arc of the convex arc surface 611a of the lower end portion 61 can coincide with the center 103 in the arc of the concave arc surface 101 of the back pressure chamber 10.

[0060] In addition, also in embodiment 3, as illustrated in Fig. 7 (a), when the convex arc surface 611a of the lower end portion 61 makes contact with the bottom side arc surface 101c of the back pressure chamber 10 so that the center 63 in the arc of the convex arc surface 611a of the lower end portion 61 coincides with the center 103 in the arc of the concave arc surface 101 of the back pressure chamber 10, the voids D are formed between the vane 6 and the concave arc surface of the back pressure chamber 10 on both sides in the thickness direction of the vane, unlike the comparative example in Fig. 8.

[0061] Accordingly, even when the vane groove 5 deviates from the back pressure chamber 10 along the thickness direction of the vane, since the voids D are generated between the vane 6 and the concave arc surface 101 of the back pressure chamber 10 on both sides in the thickness direction of the vane, the shoulder portions K1 and K2 of the lower end portion 61 have difficulty in overriding the side arc surfaces 101a and 101b of the back pressure chamber 10 as illustrated in Fig. 7(b). In addition, the clearance G2 in Fig. 7(b) generated because the convex arc surface 611a of the lower end portion 61 is raised along the arc of the concave arc surface 101 of the back pressure chamber 10 is small as in the above embodiments, so the upper end portion of the vane 6 does not project from the outer peripheral surface of the rotor 4 also in embodiment 3, the vane 6 does not interfere with the inner peripheral surface of the cylinder 8a, thereby preventing the rotation of the rotor 4 from being disabled.

Reference Signs List

[0062]

1:	vane compressor
4:	rotor
5:	vane groove
6:	vane
6a:	sliding contact surface
61:	lower end portion (other end portion)
611:	contact surface
611a:	convex arc surface
611b:	tangential flat surface, flat surface
611c:	chamfered oblique surface
63:	center in arc of convex arc surface
8a:	cylinder
10:	back pressure chamber
101:	concave arc surface
101a, 101b:	side arc surface
101c:	bottom side arc surface
103:	center in arc of concave arc surface
K1, K2:	shoulder portion of vane
D:	void

Claims

1. A vane compressor comprising:

a cylinder having both ends closed by side block members;
a rotor rotatably provided in the cylinder;
a vane groove formed radially inward from an outer peripheral surface of the rotor; and
a vane housed in the vane groove movably forward and backward, one end portion of the vane making slidable contact with an inner peripheral surface of the cylinder as the rotor rotates,
wherein a back pressure chamber having a concave arc surface is formed on a bottom of the vane groove, the other end portion of the vane

has a convex arc surface facing the concave arc surface of the vane groove, and voids are generated between the other end portion of the vane and the bottom of the vane groove on both sides in a thickness direction of the vane when the other end portion of the vane makes contact with the bottom of the vane groove.

2. The vane compressor according to claim 1, wherein the convex arc surface of the other end portion of the vane has a curvature radius smaller than the concave arc surface on the bottom of the vane groove and
the voids are thereby generated on both sides of a contact portion between the other end portion of the vane and the bottom of the vane groove.

3. The vane compressor according to claim 2, wherein tangential flat surfaces continued to the convex arc surface are formed on both sides in the thickness direction of the other end portion of the vane.

4. The vane compressor according to claim 1 or 2, wherein sliding contact surfaces in slidable contact with the vane groove are formed on both sides in the thickness direction of the vane,
chamfering for partially removing the sliding contact surfaces and the convex arc surface is performed between the sliding contact surfaces and the convex arc surface of the other end portion of the vane, and the voids are thereby provided.

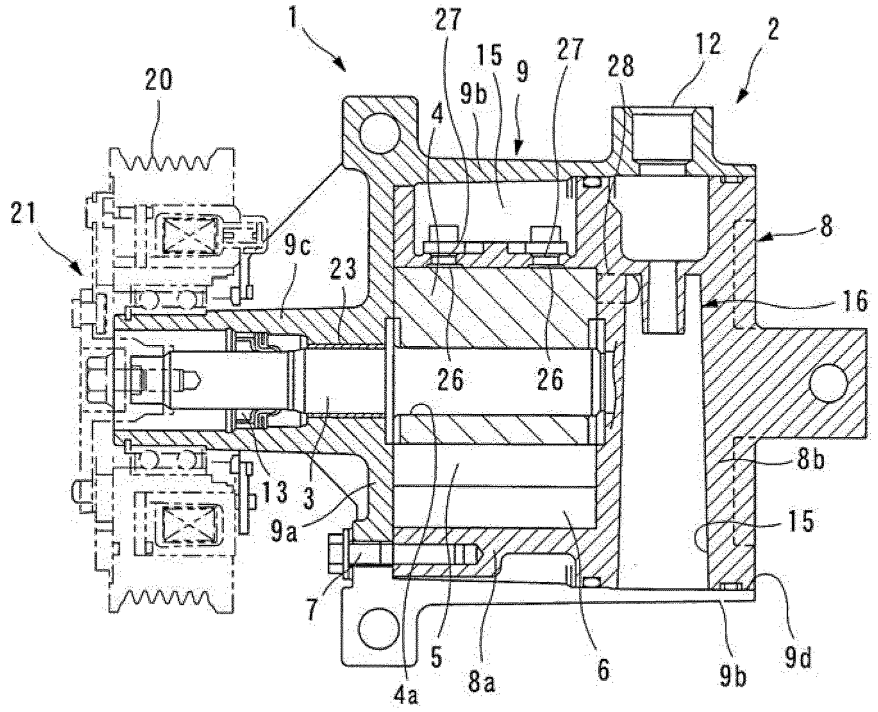

1
2
20
21
27
15
9b
9
27
28
12
4
8
9c
23
16
26
26
8b
13
3
9a
15
7
5
8a
6
9b
9d
4a

Fig.1(a)

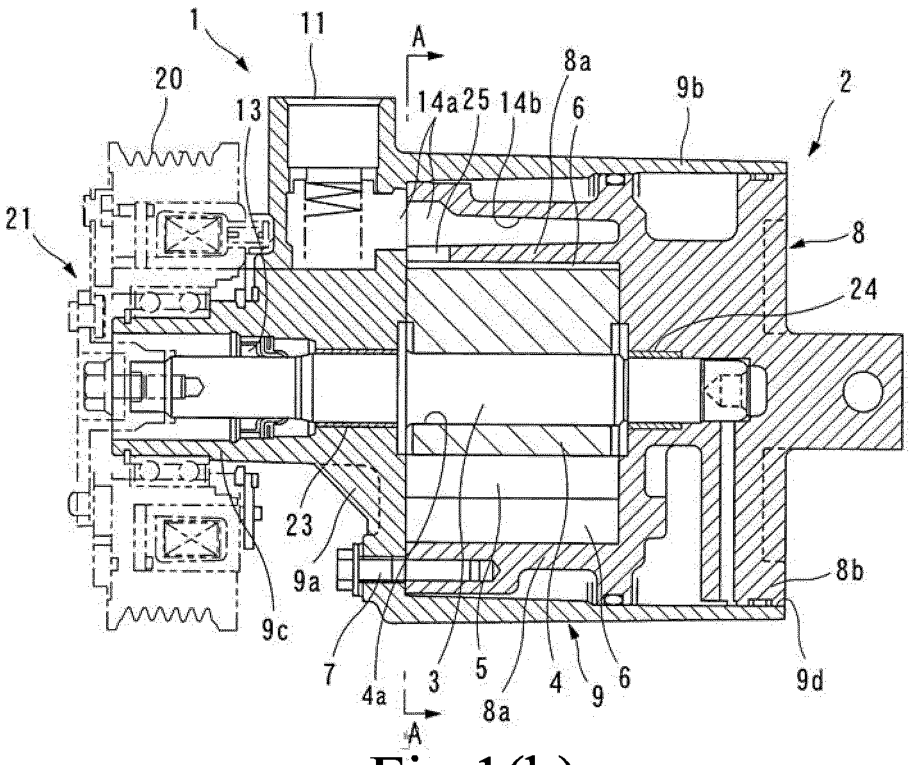
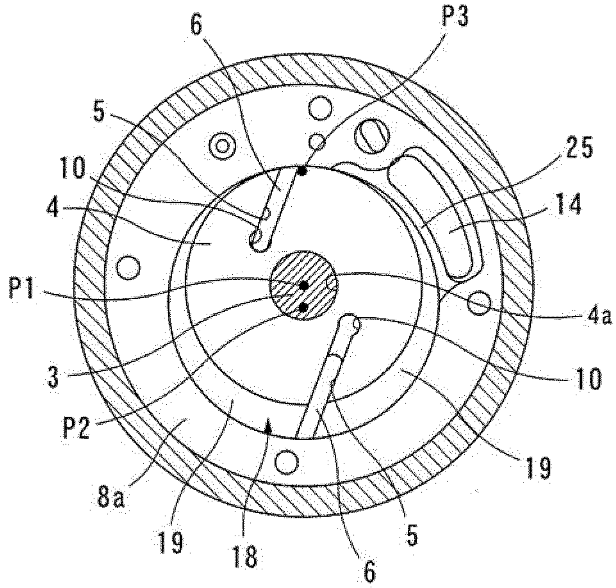

1
11
A
8a
20
13
14a
25
14b
6
9b
2
21
8
24
23
9a
8b
9c
7
4a
3
5
8a
4
9
6
9d
A

Fig.1(b)



line A-A Cross Section

Fig.2

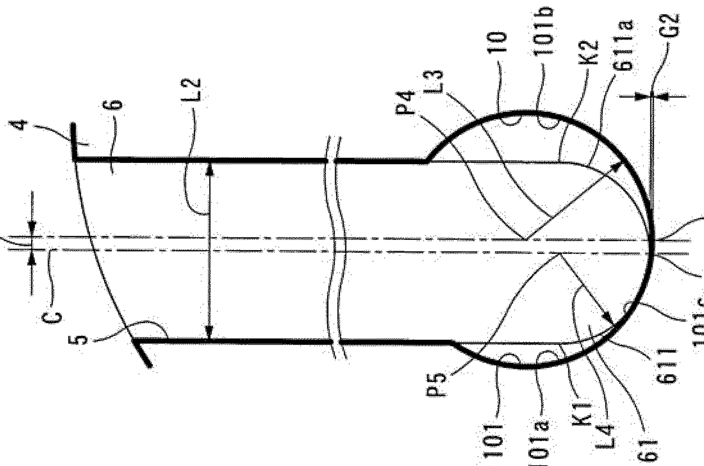

X1
C
5
4
6
L2
P4
L3
10
101b
K2
611a
G2
103
63
101c
611
P5
101
101a
K1
L4
61

Fig.3(b)

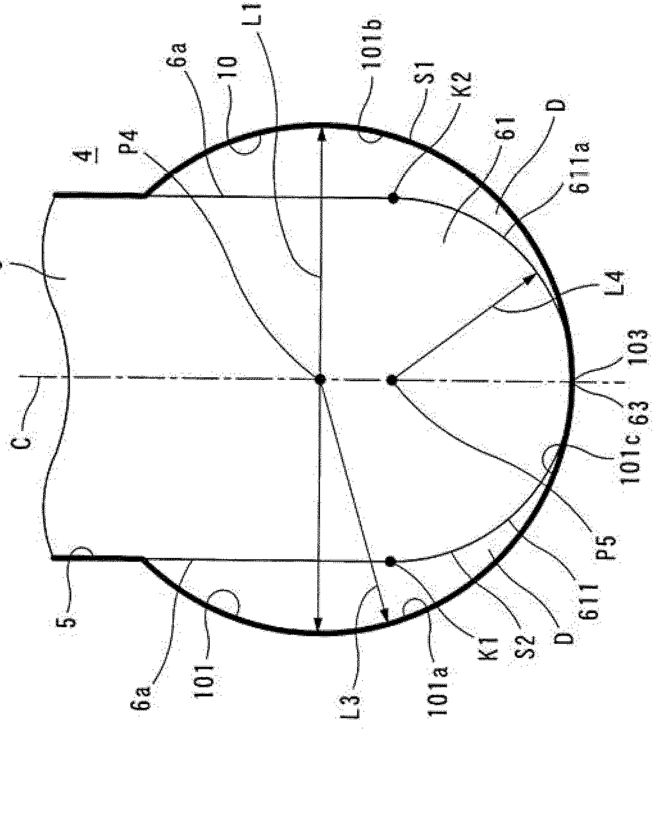

4
6
C
5
6a
P4
10
L1
101b
S1
K2
61
D
611a
L4
103
63
101c
P5
611
D
S2
K1
101a
L3
101
6a

Fig.3(a)

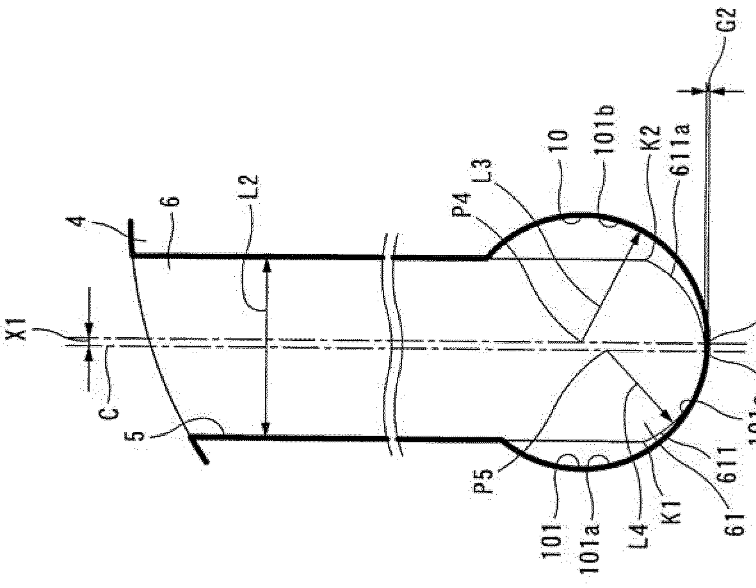

X1
C
5
4
6
L2
P4
L3
10
101b
K2
611a
G2
103
63
101c
611
61
K1
L4
101a
101
P5

Fig.4(b)

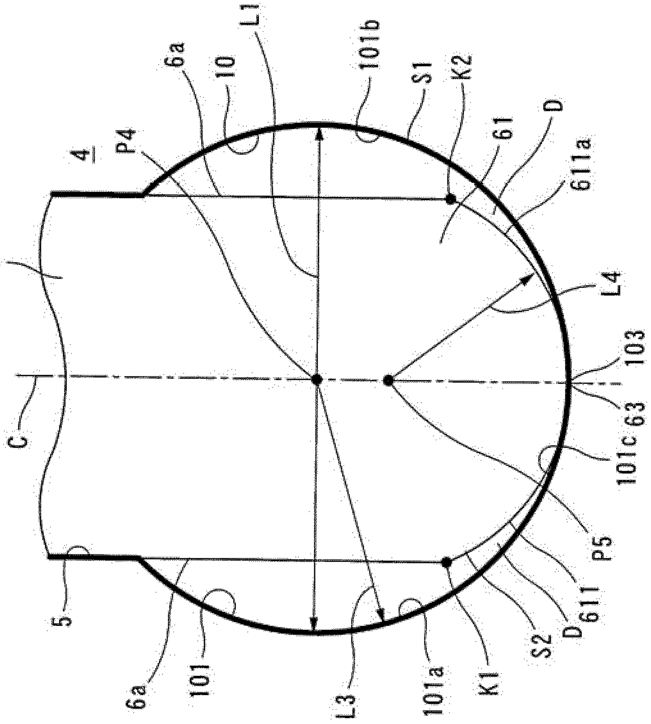

4
6
C
5
6a
101
L3
101a
K1
S2
D
611
P5
101c
63
103
L4
D
611a
61
K2
S1
101b
L1
10
6a
P4

Fig.4(a)

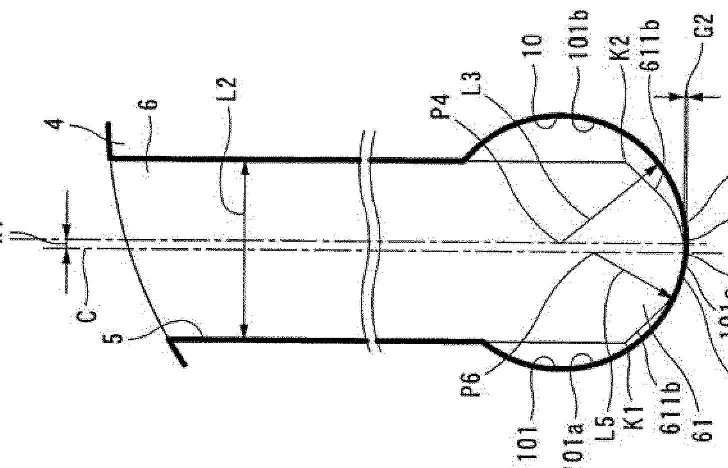

X1
C
5
4
6
L2
P4
L3
10
101b
K2
611b
G2
611
103
63
101c
611a
61
611b
K1
L5
101a
101
P6

Fig.5(b)

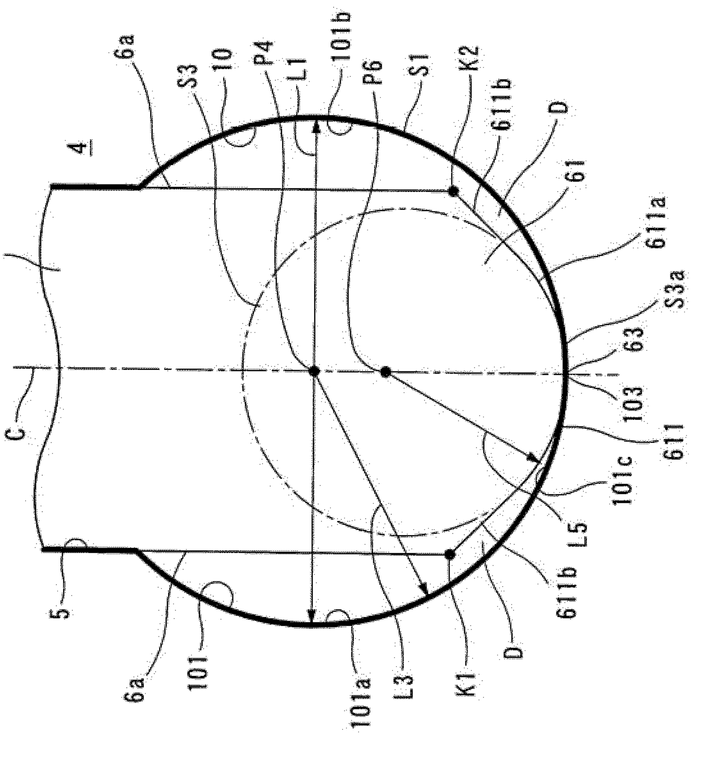

4
6
6a
S3
10
P4
L1
101b
P6
S1
K2
611b
D
61
611a
S3a
63
103
611
101c
L5
611b
D
K1
L3
101a
101
6a
5
C

Fig.5(a)

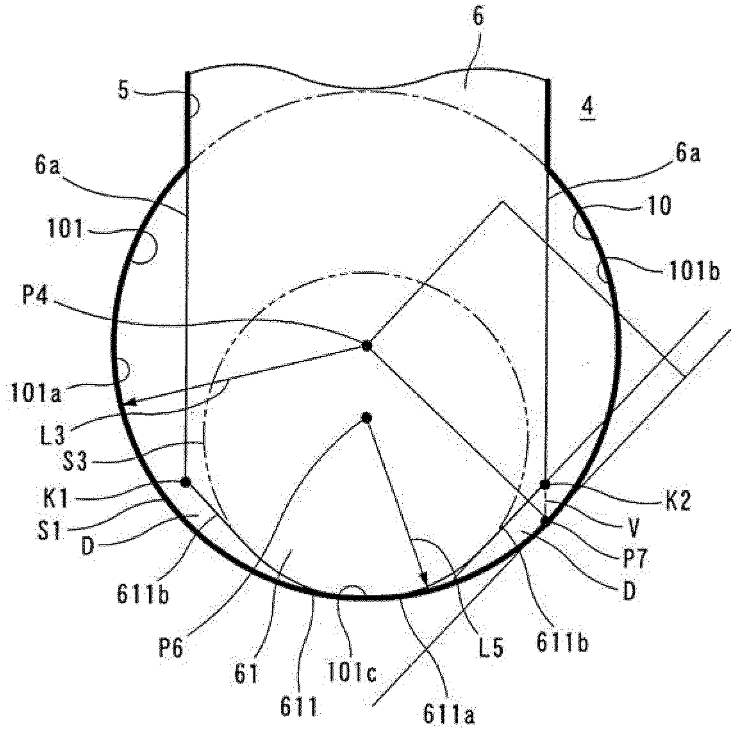

6
5
4
6a
6a
10
101
101b
P4
101a
L3
S3
K1
K2
S1
V
D
P7
D
611b
P6
61
611
101c
L5
611b
611a

Fig.6

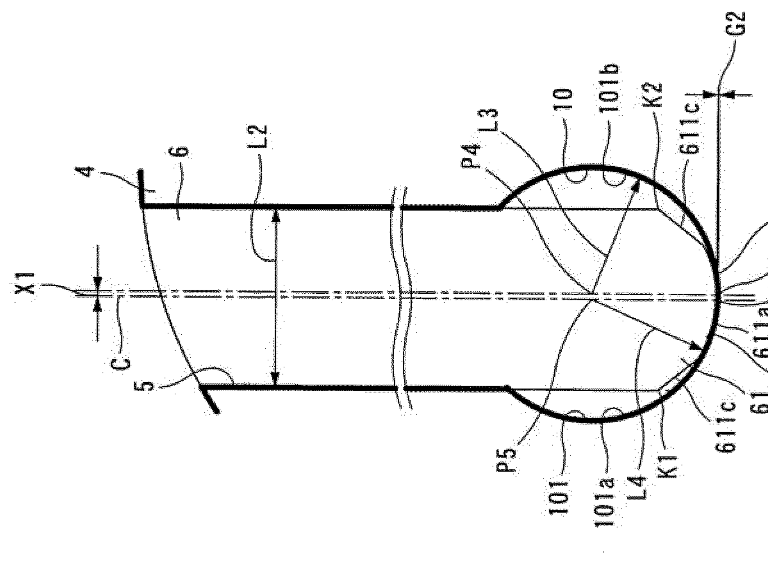

X1
C
5
4
6
L2
P4
L3
10
101b
K2
611c
G2
611
103
63
611a
101c
61
611c
K1
L4
101a
101
P5

Fig.7(b)

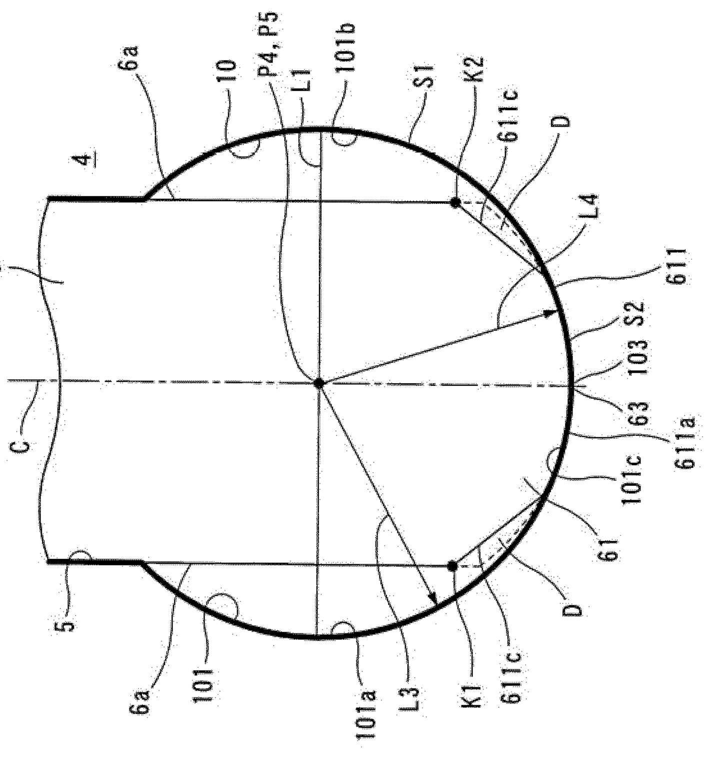

5
C
6
4
6a
10
P4, P5
L1
101b
S1
K2
611c
D
L4
611
S2
103
63
611a
101c
61
D
611c
K1
L3
101a
101
6a

Fig.7(a)

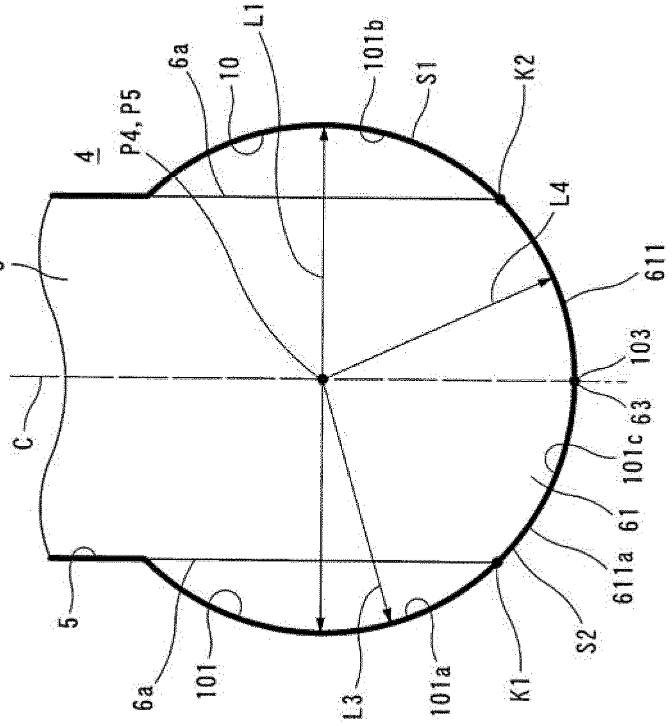

C
6
5
4
P4, P5
6a
10
L1
101b
S1
K2
L4
611
103
63
101c
61
611a
S2
K1
101a
L3
101
6a

Fig.8(a)

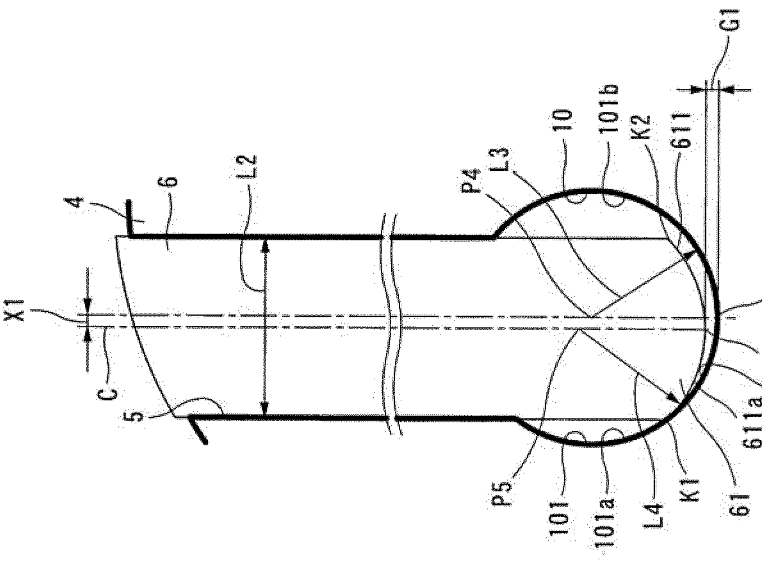

X1
C
5
4
6
L2
P4
L3
10
101b
K2
611
G1
103
63
101c
611a
61
K1
L4
101a
101
P5

Fig.8(b)

INTERNATIONAL SEARCH REPORT

International application No. PCT/JP2016/069083

A. CLASSIFICATION OF SUBJECT MATTER
F04C18/344(2006.01)i, *F04C29/00*(2006.01)i

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
F04C18/344, F04C29/00

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

Jitsuyo Shinan Koho	1922-1996	Jitsuyo Shinan Toroku Koho	1996-2016
Kokai Jitsuyo Shinan Koho	1971-2016	Toroku Jitsuyo Shinan Koho	1994-2016

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	JP 10-18984 A (Calsonic Corp.), 20 January 1998 (20.01.1998), paragraphs [0019] to [0025]; fig. 1 to 4 (Family: none)	1-2 3-4
Y A	CD-ROM of the specification and drawings annexed to the request of Japanese Utility Model Application No. 88640/1991(Laid-open No. 38379/1993) (Calsonic Corp.), 25 May 1993 (25.05.1993), paragraphs [0009] to [0013]; fig. 1 to 4 (Family: none)	3-4 1-2

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

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
16 September 2016 (16.09.16)	27 September 2016 (27.09.16)

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

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

REFERENCES CITED IN THE DESCRIPTION

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

Patent documents cited in the description

- JP 10018984 A **[0005]**
- JP 11230068 A **[0005]**