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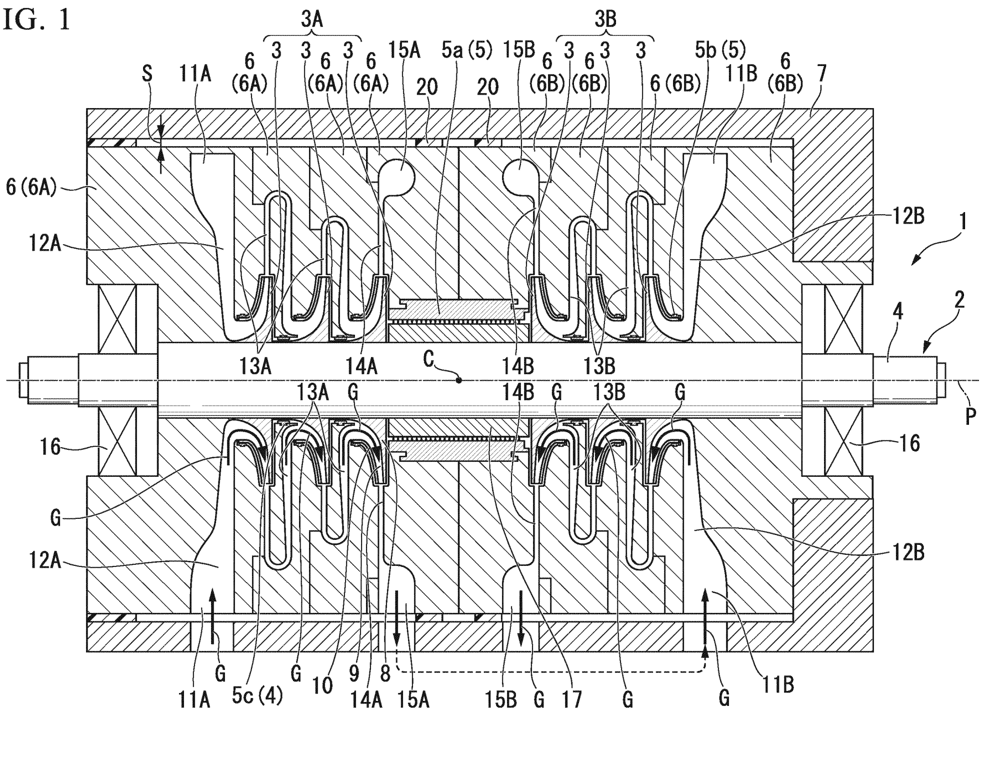
(54) **CENTRIFUGAL ROTARY MACHINE**

(57) Provided is the centrifugal rotary machine including: a rotor (2) having a rotary shaft (4) rotating around an axis (P) and impellers (3) rotating together with the rotary shaft (4); a casing (7) surrounding the rotor (2) from an outer peripheral side; a plurality of diaphragms (6) stacked between the rotor (2) and the casing (7) in a direction of the axis (P) and configured to define a flow channel of a fluid (G) fed under pressure using the impellers (3); and the restraining members (20) configured to restrain the diaphragms (6) from the outer peripheral side.

FIG. 1



EP 3 171 037 A1

Description

[Technical Field]

[0001] The present invention relates to a centrifugal rotary machine having a plurality of vane wheels.

[0002] Priority is claimed on Japanese Patent Application No. 2014-164735, filed August 13,2014, the content of which is incorporated herein by reference.

[Background Art]

[0003] In centrifugal rotary machines such as centrifugal compressors, generally, there are gaps between rotating bodies such as rotary shaft and impellers (vane wheels), and stationary bodies such as diaphragms in the vicinity of the rotating bodies. For this reason, sealing devices configured to prevent a working fluid from flowing into the gaps between the rotating bodies and the stationary bodies may be provided in some cases. In the case of a centrifugal compressor, sealing devices are provided at ferrule portions of inlets of impellers, portions between stages of multi-stage impellers, a balance piston portion provided at the last stage of multi-stage impellers, and the like. For example, a damper seal, a labyrinth seal, or the like is used for such sealing devices.

[0004] In order to minimize a leakage in sealing devices, gaps between seal members such as seal fins and rotating bodies are set to a small dimension (for example, 0.1 mm to several mm). When a centrifugal compressor is operated, deformation occurs in internal components such as diaphragms, impellers, and the like of the centrifugal compressor due to heat, stress, or a centrifugal force. Thus, the rotating bodies may come into contact with a stationary body in accordance with gaps between the sealing devices, which causes unstable vibration of a rotary shaft.

[0005] In recent years, for example, in a centrifugal compressor for a gas field, a discharge pressure has significantly increasingly become higher. For example, a high pressure compressor of which a discharge pressure is 20 MPa or more may be required. For this reason, deformation of the stationary body or the rotating bodies has tended to increase.

[0006] Also, for example, an absolute value of a differential pressure of a pressure distribution occurring in the vicinity of internal components such as diaphragms also increases along with an increase in pressure of a centrifugal compressor. Thus, the internal components are likely to be displaced. When gaps between sealing devices are enlarged in consideration of such deformation or displacement so that contact is prevented, this leads to deterioration of performance of the centrifugal compressor. Thus, it is difficult to set the gaps between the sealing devices.

[0007] Patent Literature 1 describes a centrifugal compressor including anti-deformation rings of the sealing devices to suppress deformation of the sealing devices.

[Citation List]

[Patent Literature]

[Patent Literature 1]

[0008] Japanese Unexamined Patent Application, First Publication No. 2011-32908

[Summary of Invention]

[Technical Problem]

[0009] However, in the structure disclosed in Patent Literature 1, deformation or displacement of diaphragms cannot be suppressed. Thus, gaps between sealing devices become non-uniform due to the deformation or displacement of the diaphragms, which causes unstable vibration of a rotary shaft.

[0010] An objective of the present invention is to provide a centrifugal rotary machine in which deformation or displacement of diaphragms is suppressed and thus unstable vibration of a rotary shaft of the centrifugal rotary machine can be prevented.

[Solution to Problem]

[0011] According to a first aspect of the present invention, a centrifugal rotary machine includes: a rotor having a rotary shaft rotating around an axis and impellers rotating together with the rotary shaft; a casing surrounding the rotor from an outer peripheral side; a plurality of diaphragms stacked between the rotor and the casing in an axial direction and configured to form a flow channel of a fluid fed under pressure using the impellers; and restraining members configured to restrain the diaphragms from the outer peripheral side.

[0012] With such a constitution, restraining members serve to suppress deformation or displacement of diaphragms so that a change in relative position of a stationary body and a rotating body along with deformation or displacement of the diaphragms is suppressed, and thus contact between the stationary body and the rotating body can be prevented.

[0013] In the centrifugal rotary machine, the restraining members may be annular rings fitted to outer peripheral surfaces of the diaphragms, and outer peripheral surfaces of the rings may be formed to come into contact with an inner peripheral surface of the casing.

[0014] With such a constitution, gaps between the diaphragms and the casing can be kept constant. In other words, the diaphragms can be prevented from being displaced in a radial direction. Also, deformation of the diaphragms can also be suppressed. Thus, when sealing devices are provided at diaphragms, the sealing devices can be prevented from coming into contact with the rotating body at the gaps.

[0015] In the centrifugal rotary machine, the restraining members may be made of a resin.

[0016] With such a constitution, slidability between the casing and the restraining members can be improved.

[0017] In the centrifugal rotary machine, concave grooves formed at regular intervals in a circumferential direction may be formed in outer peripheral surfaces of the restraining members.

[0018] With such a constitution, slidability between the casing and the restraining members can be improved.

[0019] In the centrifugal rotary machine, the restraining members may be key grooves formed to continue to the diaphragms which are adjacent to each other and key members fitted into the key grooves.

[0020] With such a constitution, the diaphragms joined in an axial direction can be firmly coupled using the key members. Thus, displacement of the diaphragms can be suppressed. In addition, when sealing devices are provided at the diaphragms, the sealing devices can be prevented from coming into contact with the rotating body at the gaps.

[0021] In the centrifugal rotary machine, the impellers may include: a first impeller group disposed at a first side in an axial direction and causing the fluid to flow toward a central position in an axial direction of the rotary shaft; a second impeller group disposed at a second side opposite to the first side in the axial direction and causing the fluid to flow toward the central position in the axial direction of the rotary shaft; and bearings provided at both sides of the rotary shaft and configured to rotatably support the rotary shaft, wherein the restraining members may be provided at positions of the diaphragms near the central position.

[0022] With such a constitution, deformation or displacement of diaphragms near the central position farthest away from the bearings serving as supporting portions of the rotary shaft can be effectively suppressed.

[Advantageous Effects of Invention]

[0023] According to the present invention, restraining members serve to suppress deformation or displacement of diaphragms so that a deformation or change in relative position of a stationary body and a rotating body along with displacement of the diaphragms is suppressed, and thus contact between the stationary body and the rotating body can be prevented.

[Brief Description of Drawings]

[0024]

Fig. 1 is a schematic cross-sectional view of a centrifugal compressor of a first embodiment of the present invention.

Fig. 2 is a partially enlarged view of the centrifugal compressor of the first embodiment of the present invention.

Fig. 3 is a view when a deformation restraining ring of a modified example of the first embodiment of the present invention is viewed in an axial direction thereof.

Fig. 4 is a view when a spacer of the modified example of the first embodiment of the present invention is viewed in an axial direction thereof.

Fig. 5 is a partially enlarged view of a centrifugal compressor of a second embodiment of the present invention.

[Description of Embodiments]

(First embodiment)

[0025] Hereinafter, a centrifugal compressor serving as a centrifugal rotary machine related to a first embodiment of the present invention will be described.

[0026] As shown in Fig. 1, a centrifugal compressor 1 in this embodiment is a single axis multistage type centrifugal compressor including a plurality of impellers 3 (vane wheels).

[0027] The centrifugal compressor 1 has a rotor 2 rotating around an axis P, a cylindrical casing 7 surrounding the rotor 2 from an outer peripheral side, and a plurality of diaphragms 6 stacked between the rotor 2 and the casing 7 in an axial direction and configured to form a flow channel of a process gas G (a fluid) fed under pressure using impellers 3.

[0028] The rotor 2 has a rotary shaft 4 and the plurality of impellers 3 rotating together with the rotary shaft 4. The impellers 3 are vane wheels attached to the rotary shaft 4 and configured to compress the process gas G using a centrifugal force.

[0029] A driver (not shown) such as a motor is coupled to the rotary shaft 4, and the rotor 2 is rotatably driven by the driver.

[0030] The rotary shaft 4 has a columnar shape and extends in an axial direction P. The rotary shaft 4 is rotatably supported by bearings 16 at both ends thereof in the axial direction P. Sealing devices 5 are appropriately provided between the rotary shaft 4 and the plurality of impellers 3 constituting the rotating bodies and the diaphragms 6.

[0031] The plurality of impellers 3 are arranged between the bearings 16 provided at both ends of the rotary shaft 4 in the axial direction P. Furthermore, the plurality of impellers 3 constitute two-set three-stage impeller groups 3A and 3B in which directions of blades face opposite sides in the axial direction P of the rotary shaft 4. A first impeller group 3A and a second impeller group 3B are attached to the rotary shaft 4 in a state in which rear sides thereof face a central position C in the axial direction P.

[0032] The first impeller group 3A is disposed at a first side (the left side of Fig. 1) in the axial direction. The second impeller group 3B is disposed at a second side (the right side of Fig. 1) opposite to the first side in the axial direction. The impeller groups 3A and 3B include three-stage compressor stages to correspond to the impellers 3 arranged in the axial direction.

[0033] The impellers 3 include a substantially discoid disk 8 of which a diameter gradually increases outward in a radial direction with respect to the axis P toward the central position C of the rotary shaft 4 in the axial direction P, a plurality of blades 9 radially provided at the disk 8 at intervals in a circumferential direction with respect to the axis P, and a shroud 10 provided to face the disk 8 and covering the plurality of blades 9.

[0034] The process gas G is compressed when it flows through the first impeller group 3A and the second impeller group 3B toward the central position C in the axial direction P.

[0035] The bearings 16 are provided at both ends of the rotary shaft 4 one by one, and rotatably support the rotary shaft 4. As the bearings 16, for example, journal bearings having a plurality of bearing pads can be adopted.

[0036] The casing 7 is formed in a cylindrical shape, and a central axis thereof coincides with the axis P. The casing 7 accommodates the plurality of diaphragms 6 therein. The plurality of diaphragms 6 are provided to be stacked in the axial direction.

[0037] The plurality of diaphragms 6 are provided to correspond to the compressor stages of the centrifugal compressor 1. To be specific, the plurality of diaphragms 6 are constituted of a plurality of diaphragms 6A corresponding to the first impeller group 3A and a plurality of diaphragms 6B corresponding to the second impeller group 3B. The plurality of diaphragms 6A corresponding to the first impeller group 3A are connected via step portions. The plurality of diaphragms 6B corresponding to the second impeller group 3B are also connected via step portions. Note that the diaphragms 6A and the diaphragms 6B, which are adjacent to each other near the central position C, are in contact with each other, but are not connected via the step portions.

[0038] Predetermined gaps S are formed between the cylindrical casing 7 and the plurality of diaphragms 6. In other words, an inner peripheral surface of the casing 7 and outer peripheral surfaces of the plurality of diaphragms 6 are spaced apart from each other via the predetermined gaps S. The gaps S are uniformly provided in the axial direction and the peripheral direction.

[0039] Annular suction ports 11A formed at an outside in the radial direction of an end at the first side in the axial direction are formed inside the stacked diaphragms 6. Furthermore, connection flow channels 12A are formed between the suction ports 11A and flow channels of the impellers 3 positioned at one side of the three-stage impeller group 3A and connect the flow channels of the impellers 3 and the suction ports 11A. Thus, the process gas G can be introduced from the outside into the three-stage impeller group 3A.

[0040] Connection flow channels 14A connected to the flow channels of the impellers 3 positioned at the second side of the three-stage impeller group 3A and extending outward in the radial direction are formed inside the diaphragms 6. Annular discharge ports 15A connected to the connection flow channels 14A and formed on an outside in the radial direction of the central position C in the axial direction are formed inside the diaphragms 6.

[0041] Also at a position at which the three-stage impeller group 3B is attached, casing flow channels 13B, suction ports 11B, connection flow channels 12B and 14B, and discharge ports 15B are formed inside the diaphragms 6. Furthermore, the casing flow channels 13B, the suction ports 11B, the connection flow channels 12B and 14B, and the discharge ports 15B are disposed at positions symmetrical with casing flow channels 13A, the suction ports 11A, the connection flow channels 12A and 14A, and the discharge ports 15A, respectively, in the axial direction using the central position C in the axial direction as a boundary.

[0042] A balance piston 17 configured to adjust thrust of the impellers 3 is provided at an outer peripheral surface of the rotary shaft 4 and between the three-stage impeller group 3A and the three-stage impeller group 3B. In the centrifugal compressor 1 in this embodiment, the rotor 2 is constituted of the rotary shaft 4, the plurality of impellers 3, and the balance piston 17.

[0043] The process gas G is compressed in the three-stage impeller group 3A and reaches a position near the central position C of the rotary shaft 4. After that, the process gas G is introduced into the three-stage impeller group 3B, is further compressed, and reaches the position near the central position C again (refer to a dotted line of Fig. 1). Therefore, a pressure difference occurs at a position between the three-stage impeller group 3A and the three-stage impeller group 3B serving as the central position C of the rotary shaft 4.

[0044] The three types of sealing devices 5 are provided at the centrifugal compressor 1 in this embodiment.

[0045] A first sealing device 5 is a first sealing device 5a configured to seal gaps between an outer peripheral surface of the balance piston 17 and the diaphragms 6. A second sealing device 5 is a second sealing device 5b configured to seal gaps between outer peripheral surfaces of the shrouds 10 of the impellers 3 and the diaphragms 6. A third sealing device 5 is a third sealing device 5c configured to seal gaps between the outer peripheral surface of the rotary shaft 4 and the diaphragms 6 between the impellers 3.

[0046] Here, the sealing devices 5 in this embodiment will be described using the first sealing device 5a. The first sealing device 5a prevents the process gas G from flowing from the three-stage impeller group 3B to the three-stage impeller group 3A along the axis P at the central position C using the pressure difference between the three-stage impeller group 3A and the three-stage impeller group 3B.

[0047] The sealing devices 5 has a sealing device main body attached to the diaphragms 6 and a plurality of seal fins extending from the sealing device main body toward the rotor 2. The plurality of seal fins are directed toward the rotor 2, extend from the sealing device main body to an inner peripheral side, and extend in the peripheral direction. These seal fins form micro-gaps with respect to the rotor 2 in the radial direction.

[0048] The sealing devices 5 forms a so-called labyrinth seal using the plurality of seal fins. Note that a sealing structure used for the sealing devices 5 can also adopt a damper seal (a hole pattern seal or a honeycomb seal) without being limited to a labyrinth seal.

[0049] The centrifugal compressor 1 in this embodiment includes annular deformation restrain rings 20 configured to restrain the diaphragms 6 from the outer peripheral side. In other words, the deformation restrain rings 20 are cylindrical restraining members with a predetermined thickness in the radial direction. In the case of the deformation restrain rings 20, inner diameters of the deformation restrain rings 20 are formed to be substantially the same as or slightly smaller than diameters of the diaphragms 6. In other words, the deformation restrain rings 20 have inner diameters such that they are able to be fitted to the outer peripheral surfaces of the diaphragms 6.

[0050] As shown in Fig. 2, in the case of the deformation restrain rings 20, outer peripheral surfaces of the deformation restrain rings 20 are formed to correspond to the inner peripheral surface of the casing 7. In other words, in the case of the deformation restrain rings 20, inner peripheral sides thereof are fixed to the outer peripheral surfaces of the diaphragms 6, and outer peripheral sides thereof are in contact with the inner peripheral surface of the casing 7.

[0051] The deformation restrain rings 20 are disposed at the outer peripheral surfaces of the diaphragms 6 along grooves for rings 21 formed on the outer peripheral surfaces of the diaphragms 6 in the peripheral direction. Groove widths of the grooves for ring 21 correspond to widths of the deformation restrain rings 20.

[0052] The deformation restrain rings 20 are formed of a resin with high slidability such as, for example, polytetrafluoroethylene (PTFE). Materials forming the deformation restrain rings 20 are not limited thereto, and any materials which have high slidability and have lower rigidity than a material forming the casing 7 may be adopted. For example, a polyacetal resin or the like can also be adopted.

[0053] The deformation restrain rings 20 in this embodiment are attached to two diaphragms 6 farthest away from the bearings 16 serving as a support point of the rotary shaft 4 among the plurality of diaphragms 6. That is to say, the deformation restrain rings 20 are attached to the diaphragms 6 near the discharge ports 15A and 15B. In other words, the deformation restrain rings 20 are attached to the diaphragms 6A closest to the central position C side among the plurality of diaphragms 6A corresponding to the first impeller group 3A and the diaphragms 6B closest to the central position C side among the plurality of diaphragms 6B corresponding to the second impeller group 3B.

[0054] According to the above-described embodiment, the deformation restrain rings 20 serving as the restraining members disposed at the gaps S serve to suppress deformation or displacement of the diaphragms 6. Thus, a change in relative position of a stationary body and a rotating body such as the rotor 2 along with displacement of the diaphragms 6 is suppressed, and thus contact between the stationary body and the rotating body can be prevented.

[0055] The restraining members are the annular deformation restrain rings 20 fitted to the outer peripheral surfaces of the diaphragms 6, and the outer peripheral surfaces of the deformation restrain rings 20 are formed to come into contact with the inner peripheral surface of the casing 7. Thus, the gaps S between the diaphragms 6 and the casing 7 can be kept constant. Also, deformation of the diaphragms 6 can also be suppressed. In other words, the diaphragms 6 can be prevented from being displaced in the radial direction. Thus, the sealing devices 5 can be prevented from coming into contact with the rotating body at the gaps.

[0056] The deformation restrain rings 20 are formed of a resin so that slidability between the casing 7 and the deformation restrain rings 20 can be improved.

[0057] The deformation restrain rings 20 are disposed near the central position C so that displacement of the diaphragms 6 near the central position C farthest away from the bearings 16 serving as supporting portions of the rotary shaft 4 can be effectively suppressed.

[0058] The deformation restrain rings 20 are disposed along the grooves for ring 21 formed in the outer peripheral surfaces of the diaphragms 6 so that the deformation restrain rings 20 can be prevented from being shifted in the axial direction.

[0059] Note that it is assumed that the deformation restrain rings 20 in the above-described embodiment have the same cross-sectional shape in the peripheral direction, but the present invention is not limited thereto. For example, as in a modified example shown in Fig. 3, concave grooves 24 formed at regular intervals in the peripheral direction may be formed in outer peripheral surfaces of deformation restrain rings 20B.

[0060] As in a modified example shown in Fig. 4, a plurality of spacers 20C may be intermittently disposed in the peripheral direction. For example, the spacers 20C may be adhered to the diaphragms 6 such that the spacers 20C can be disposed at the gaps between the diaphragms 6 and the casing 7.

[0061] According to the above-described modified examples, slidability between the casing 7 and the restraining members 20B and 20C can be improved.

(Second embodiment)

[0062] Hereinafter, restraining members of a second embodiment of the present invention will be described on the basis of the drawings. Note that this embodiment will be described focusing on differences from the above-described first embodiment and descriptions of portions which are the same as those of the first embodiment will be omitted.

[0063] As shown in Fig. 5, the restraining members in this embodiment are key grooves 22 formed to continue to neighboring diaphragms 6A and 6B disposed closest to a central position C and key members 20D fitted into the key grooves 22. The two key grooves 22 and key members 20D are provided at both ends of diaphragms 6.

[0064] The key grooves 22 are grooves which extend in the axial direction and of which cross-sectional shapes are rectangular shapes.

[0065] The key members 20D are fitted into the key grooves 22 formed to continue to the diaphragms 6A and 6B. The key members 20D may be fixed to the diaphragms 6 using fastening members such as screws. Furthermore, the key members 20D.are not limited to key members in which both ends thereof have square shapes shown in Fig. 5. Key members in which at least one of both ends thereof has a rounded shape may be adopted as the key members 20D. Shapes of the key grooves 22 need not coincide with those of the key members 20D, and lengths thereof in a longitudinal direction may be longer than those of the key members 20D.

[0066] The two key grooves 22 and key members 20D are provided at both ends of the diaphragms 6, but the present invention is not limited thereto. In addition, they may be further provided at an upper portion. Only one key groove 22 and one key member 20D may be provided.

[0067] According to the above-described embodiments, the diaphragms 6 joined in the axial direction can be firmly coupled using the key members 20D. Thus, displacement of the diaphragms 6 can be suppressed. In addition, when sealing devices 5 are provided at the diaphragms 6, the sealing devices 5 can be prevented from coming into contact with the rotating body at the gaps.

[0068] Note that the technical scope of the present invention is not limited to the above-described embodiments, and various modifications are possible without departing from the gist of the present invention.

[0069] For example, although the restraining members are applied to the centrifugal compressor in the above-described embodiments, any centrifugal rotary machines which have a rotor having impellers, a casing surrounding the rotor from an outer peripheral side, and diaphragms configured to define a flow channel of a fluid fed under pressure using the impellers may be adopted. For example, the restraining members in the above-described embodiments may be applied to a centrifugal pump.

[Industrial Applicability]

[0070] According to this centrifugal rotary machine, a change in relative position of a stationary body and a rotating body along with deformation or displacement of diaphragms is suppressed, and thus contact between the stationary body and the rotating body can be prevented.

[Reference Signs List]

[0071]

1 Centrifugal compressor
2 Rotor
3 Impeller
4 Rotary shaft
5 Sealing device
6, 6A, 6B Diaphragm
7 Casing
8 Disk
9 Blade
10 Shroud
11A, 11B Suction port
12A, 12B, 14A, 14B Connection flow channel (flow channel)
13A, 13B Casing flow channel (flow channel)
15A, 15B Discharge port
16 Bearing
17 Balance piston
20, 20B Deformation restrain ring (restraining member)
20C Spacer (restraining member)
20D Key member
21 Grooves for ring
22 Key groove
24 Concave groove
G Process gas (fluid)
P Axis
S Gap

Claims

1. A centrifugal rotary machine comprising:

a rotor having a rotary shaft rotating around an axis and impellers rotating together with the rotary shaft;
a casing surrounding the rotor from an outer peripheral side;
a plurality of diaphragms stacked between the rotor and the casing in an axial direction and configured to form a flow channel of a fluid fed under pressure using the impellers; and
restraining members configured to restrain the diaphragms from the outer peripheral side.

2. The centrifugal rotary machine according to claim 1, wherein the restraining members are annular rings fitted to outer peripheral surfaces of the diaphragms, and outer peripheral surfaces of the rings are formed to come into contact with an inner peripheral surface of the casing.

3. The centrifugal rotary machine according to claim 2, wherein the restraining members are made of a resin.

4. The centrifugal rotary machine according to claim 2 or 3, wherein concave grooves formed at regular intervals in a peripheral direction are formed in outer peripheral surfaces of the restraining members.

5. The centrifugal rotary machine according to claim 1, wherein the restraining members are key grooves formed to continue to the diaphragms which are adjacent to each other and key members fitted into the key grooves.

6. The centrifugal rotary machine according to any one of claims 1 to 5, wherein the impellers include:

a first impeller group disposed at a first side in an axial direction and causing the fluid to flow toward a central position in an axial direction of the rotary shaft;
a second impeller group disposed at a second side opposite to the first side in the axial direction and causing the fluid to flow toward the central position in the axial direction of the rotary shaft; and
bearings provided at both ends of the rotary shaft and configured to rotatably support the rotary shaft,
wherein the restraining members are provided at positions of the diaphragms near the central position.

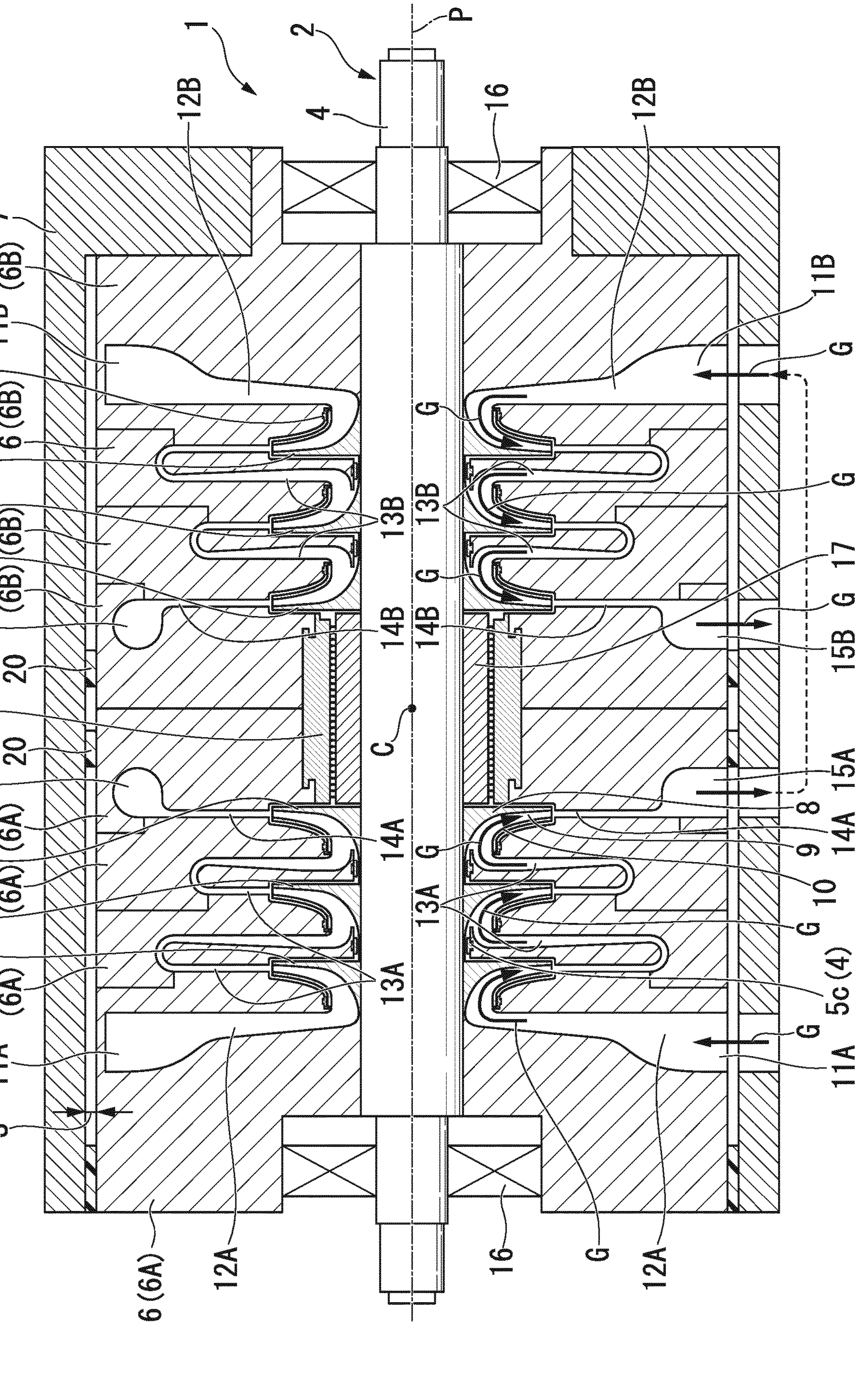

1
2
P
4
16
12B
7
6 (6B)
11B
5b (5)
G
3B
3
13B
17
14B
15B
20
5a (5)
C
15A
6 (6A)
3A
14A
8
9
10
13A
5c (4)
11A
12A
S

FIG. 1

FIG. 2

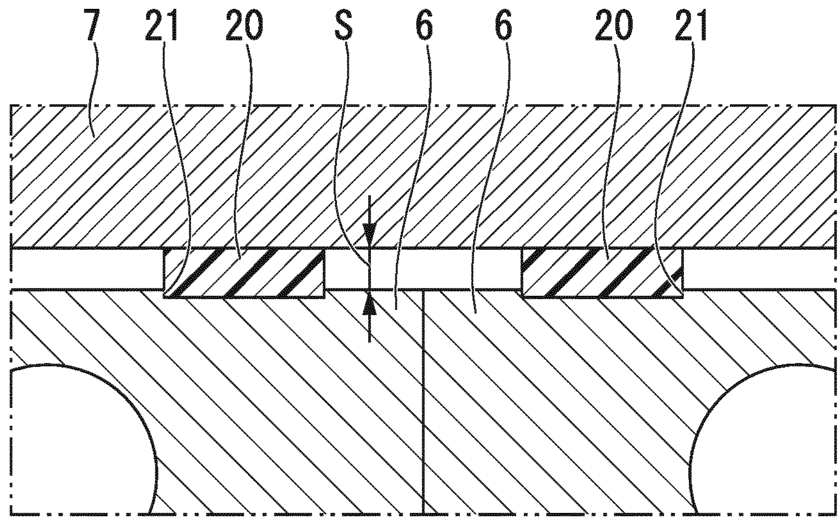


FIG. 3

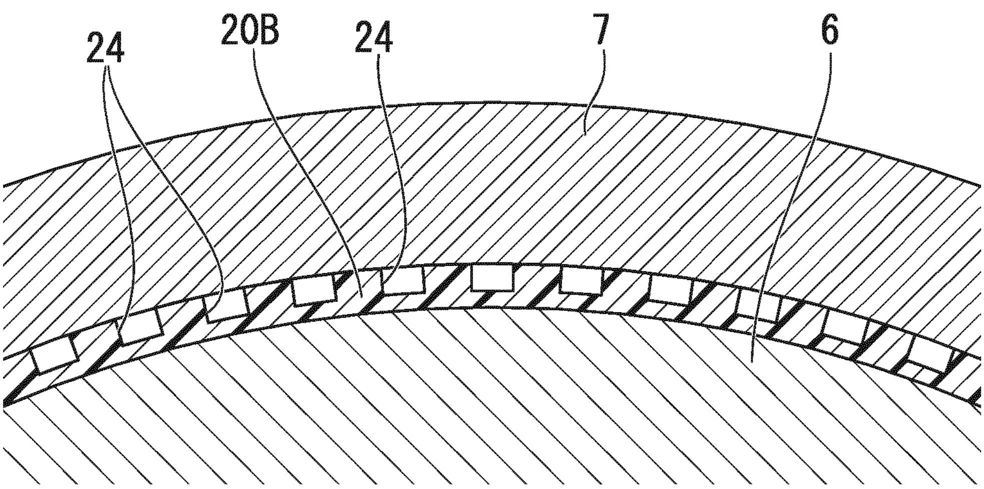


FIG. 4

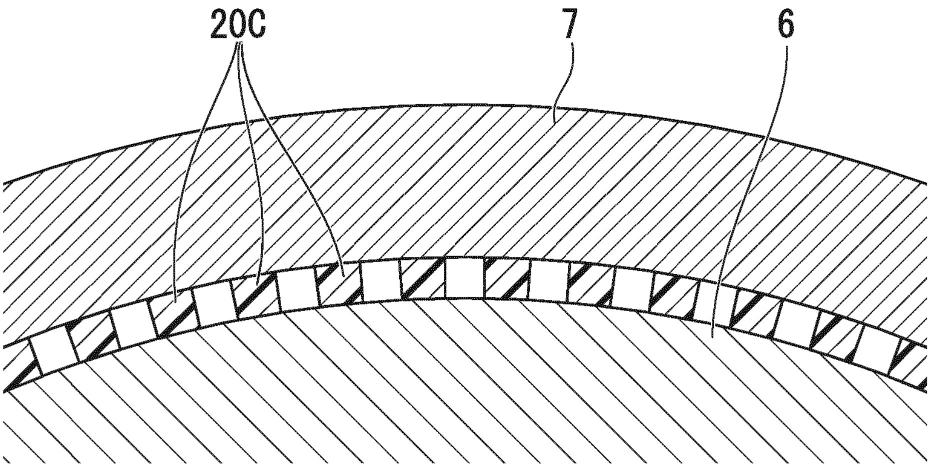
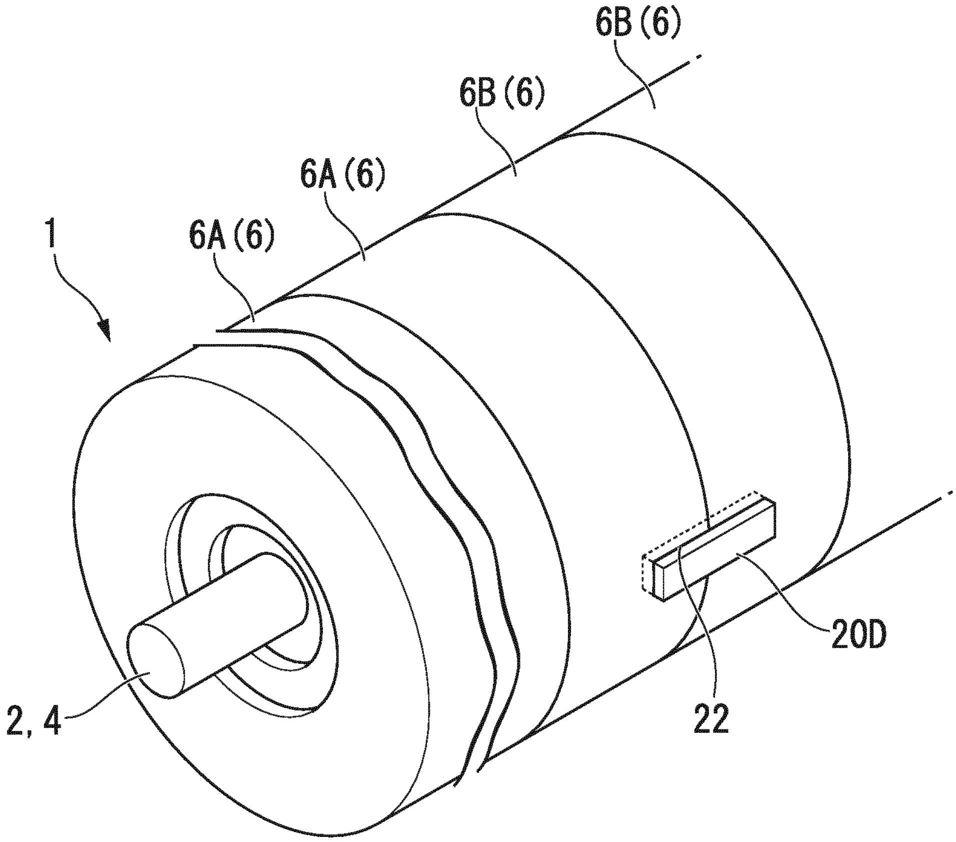


FIG. 5



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2015/051049

A. CLASSIFICATION OF SUBJECT MATTER
F04D29/62(2006.01)i, *F04D17/12*(2006.01)i, *F04D29/66*(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)
F04D29/62, F04D17/12, F04D29/66

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	1996-2015
Kokai Jitsuyo Shinan Koho	1971-2015	Toroku Jitsuyo Shinan Koho	1994-2015

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 A	US 3044684 A (John FULLEMANN), 17 July 1962 (17.07.1962), column 2, line 55 to column 3, line 72; fig. 1, 2 & GB 959711 A	1-3 6 4,5
Y	JP 2014-109263 A (Mitsubishi Heavy Industries, Ltd.), 12 June 2014 (12.06.2014), paragraphs [0033] to [0035]; fig. 1 & WO 2014/087708 A	6
Y	JP 59-54800 A (Hitachi, Ltd.), 29 March 1984 (29.03.1984), page 2, lower right column, line 19 to page 3, lower left column, line 3; fig. 1 (Family: none)	6

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

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Date of the actual completion of the international search
31 March 2015 (31.03.15)

Date of mailing of the international search report
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International application No.
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C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2014-129752 A (Mitsubishi Heavy Industries, Ltd.), 10 July 2014 (10.07.2014), entire text; all drawings (Family: none)	1-6
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REFERENCES CITED IN THE DESCRIPTION

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- JP 2011032908 A **[0008]**