



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

(43) Date of publication:
10.06.2015 Bulletin 2015/24

(51) Int Cl.:
F04C 29/00 (2006.01) F04C 23/00 (2006.01)

(21) Application number: **13824733.3**

(86) International application number:
PCT/JP2013/065292

(22) Date of filing: **31.05.2013**

(87) International publication number:
WO 2014/020983 (06.02.2014 Gazette 2014/06)

(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

- **ESAKI, Ikuo**
Tokyo 108-8215 (JP)
- **SASAKAWA, Chikako**
Tokyo 108-8215 (JP)
- **SATO, Hajime**
Tokyo 108-8215 (JP)
- **TATEISHI, Taichi**
Tokyo 108-8215 (JP)
- **NOGUCHI, Akihiro**
Nagoya-shi
Aichi 453-0862 (JP)

(30) Priority: **31.07.2012 JP 2012169931**

(71) Applicant: **Mitsubishi Heavy Industries, Ltd.**
Tokyo 108-8215 (JP)

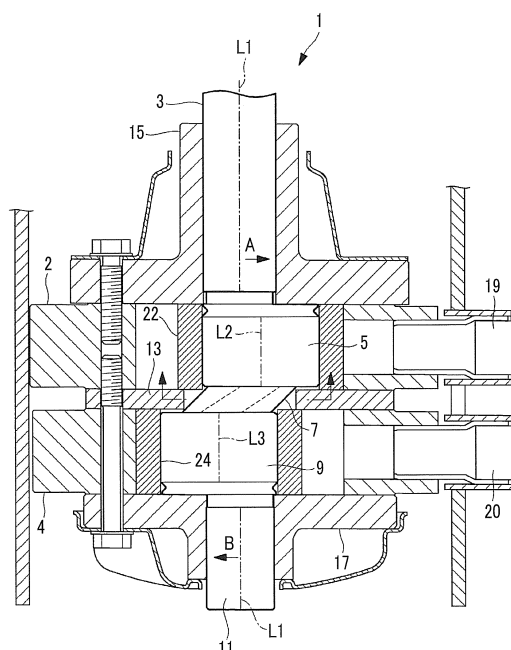
(74) Representative: **Intès, Didier Gérard André et al**
Cabinet Beau de Loménie
158, rue de l'Université
75340 Paris Cedex 07 (FR)

(72) Inventors:
• **OGAWA, Makoto**
Tokyo 108-8215 (JP)
• **MIURA, Shigeki**
Tokyo 108-8215 (JP)

(54) **ROTARY FLUID MACHINE AND METHOD FOR ASSEMBLING SAME**

(57) Provided is a rotary fluid machine in which the irregular contact of a crankshaft with a bearing can be reduced by reducing the deflection of an intermediate shaft. A crankshaft (1) is provided with a first crankshaft section (3), a first crank pin (5), a second crankshaft section (11), a second crank pin (9), and an intermediate shaft (7), wherein the intermediate shaft (7) has a shape in which the intermediate shaft (7) has a first side which is located on the first direction (A) side in a longitudinal cross-section which includes the axes of any two of the first crankshaft section (3), the first crank pin (5), and the second crank pin (9), the first side (X) is provided so as to continuously connect a first side-side first connection point which is connected to the first crank pin (5) and a first side-side second connection point which is connected to the second crank pin (9), and the first side-side first connection point is provided at a position displaced further in the first direction (A) than the first side-side second connection point.

FIG. 1



Description

Technical Field

[0001] The present invention relates to a rotary fluid machine and a method for assembling the rotary fluid machine and more specifically, to an intermediate shaft of a crankshaft which is used in a twin rotary fluid machine.

Background Art

[0002] In a rotary fluid machine, a crankshaft being bent due to gas load at the time of compression, thereby entering a state of coming into irregular contact with a bearing section is generally known. In particular, in a twin (two-cylinder) rotary fluid machine, the distance between bearing support points is large, and thus a crankshaft is easily bent, thereby causing irregular contact. There is a problem in that bearing friction loss increases due to the irregular contact and reliability decreases due to abnormal wear or seizure. Further, there is also a problem in that a rolling piston is tilted, and thus friction loss with a cylinder inner circumferential surface or a separator plate increases and noise and vibration increases.

[0003] Therefore, in order to increase the rigidity of a crankshaft, PTL 1 discloses a technique of increasing an intermediate shaft cross-sectional area by increasing the thickness of the intermediate shaft which connects a first crank pin and a second crank pin. Further, PTL 2 discloses a technique of providing an intermediate shaft with a first connection portion and a second connection portion projecting from the intermediate shaft, thereby supporting load which is applied to the intermediate shaft.

Citation List

Patent Literature

[0004]

[PTL 1] Japanese Patent No. 3723408

[PTL 2] Japanese Patent No. 4065654

Summary of Invention

Technical Problem

[0005] However, the intermediate shaft is still bent even by the techniques disclosed in PTL 1 and PTL 2, and thus there is a problem in that a state where the crankshaft comes into irregular contact with a bearing section occurs.

[0006] Further, the technique of providing a first connection portion and a second connection portion projecting from an intermediate shaft is disclosed in PTL 2. However, the respective connection portions are provided separately from the intermediate shaft, and therefore,

there is a problem in that it is not possible to integrally mold the intermediate shaft by casting.

[0007] The present invention has been made in view of such circumstances and has an object to provide a rotary fluid machine in which a crankshaft being bent, thereby entering a state of coming into irregular contact with a bearing section is reduced, and a method for assembling the rotary fluid machine.

10 Solution to Problem

[0008] According to a first aspect of the present invention, there is provided a rotary fluid machine including: a crankshaft which is provided with a first crankshaft section, a first crank pin connected eccentrically in a first direction with respect to the first crankshaft section, a second crankshaft section having the same axis as the first crankshaft section, a second crank pin connected eccentrically in a second direction opposite to the first direction with respect to the second crankshaft section, and an intermediate shaft which connects the first crank pin and the second crank pin; and a separator plate which partitions a first cylinder corresponding to the first crank pin and a second cylinder corresponding to the second crank pin and has a hole portion in which the intermediate shaft is inserted and located, wherein the intermediate shaft has a first side which is located on the first direction side in a longitudinal cross-section which includes axes of any two of the first crankshaft section, the first crank pin, and the second crank pin, the first side is provided so as to continuously connect a first side-side first connection point which is connected to the first crank pin and a first side-side second connection point which is connected to the second crank pin, and the first side-side first connection point is provided at a position displaced further in the first direction than the first side-side second connection point.

[0009] According to the first aspect, in the longitudinal cross-section which includes the axes of any two of the first crankshaft section, the first crank pin, and the second crank pin, the first side-side first connection point is provided at a position displaced further in the first direction than the first side-side second connection point, and thus the first side is inclined in the first direction with respect to the axis of the crankshaft. In this way, compared to a shape in the related art having a side extending parallel to the axis of a crankshaft, it is possible to increase the cross-sectional area of the intermediate shaft. Here, since a cross-section modulus is proportional to an area, the cross-section modulus of the intermediate shaft becomes large, compared to the related art. Further, since deflection is inversely proportional to a cross-section modulus, it is possible to reduce the deflection of the intermediate shaft by adopting the above-described configuration.

[0010] In the rotary fluid machine described above, a configuration is also acceptable in which the intermediate shaft has a second side which is located on the second

direction side in the longitudinal cross-section, the second side is provided so as to continuously connect a second side-side first connection point which is connected to the first crank pin and a second side-side second connection point which is connected to the second crank pin, and the second side-side second connection point is provided at a position displaced further in the second direction than the second side-side first connection point.

[0011] According to this configuration, in the longitudinal cross-section which includes the axes of any two of the first crankshaft section, the first crank pin, and the second crank pin, the second side-side second connection point is provided at a position displaced further in the second direction than the second side-side first connection point, and thus the second side is inclined in the first direction with respect to the axis of the crankshaft. In this manner, not only the first side, but also the second side is inclined with respect to the axis of the crankshaft, and therefore, compared to a shape in the related art having a side extending parallel to the axis of a crankshaft, it is possible to increase the cross-sectional area of the intermediate shaft.

[0012] In the rotary fluid machine described above, a configuration is also acceptable in which in the longitudinal cross-section, the second side of the intermediate shaft, which is located on the second direction side, extends parallel to an axis of the second crankshaft section with the second connection point which is at a position displaced further in the second direction than the first connection point as a starting point.

[0013] According to this configuration, the shape of the intermediate shaft is extended by a distance by which the second connection point is displaced further in the second direction than the first connection point, compared to the shape in the related art, and therefore, it is possible to increase the cross-sectional area of the intermediate shaft.

[0014] In the rotary fluid machine according to any one of the above, a configuration is also acceptable in which in the longitudinal cross-section, the maximum distance between both the sides of the intermediate shaft in a direction orthogonal to an axis of the crankshaft is equal to a diameter of the hole portion of the separator plate.

[0015] According to this configuration, due to a shape in which the maximum distance between both sides of the intermediate shaft in a direction orthogonal to the axis of the crankshaft is equal to the diameter of the hole portion of the separator plate, it is possible to make the intermediate shaft as large as possible to the extent that the intermediate shaft can pass through the separator plate.

[0016] In the rotary fluid machine according to any one of the above, a configuration is also acceptable in which the intermediate shaft has a surface from molding by casting.

[0017] According to this configuration, since the intermediate shaft has no sliding portion as in a crank pin, it is not necessary to perform surface finishing by cutting

or the like. For this reason, even in a case where a crankshaft section, a crank pin, and an intermediate shaft are integrally molded by casting, it is possible to omit the surface finishing of the intermediate shaft, and thus it is possible to attain a reduction in cost.

[0018] According to a second aspect of the present invention, there is provided a method for assembling a rotary fluid machine, including: a shaft section insertion step of inserting the first crankshaft section or the second crankshaft section into the hole portion of the separator plate as far as a plane where the first crank pin or the second crank pin and the intermediate shaft are in contact with each other, by relatively moving the crankshaft and the separator plate; an intermediate shaft insertion step of relatively inclining the crankshaft and the separator plate and relatively inserting the intermediate shaft into the hole portion along the first side while making the separator plate follow the first side; and an intermediate shaft positioning step of releasing relative inclination between the crankshaft and the separator plate and positioning the intermediate shaft in the hole portion of the separator plate.

[0019] According to the second aspect, in the intermediate shaft insertion step, the crankshaft and the separator plate are relatively inclined and the intermediate shaft is then inserted along the first side, and therefore, even if the first side is inclined, it is possible to insert the intermediate shaft. In addition, even in a shape which is as large as possible to the extent that the intermediate shaft can pass through the separator plate, it is possible to insert the intermediate shaft. Further, in the intermediate shaft positioning step, inclination is released, and therefore, it is possible to position the intermediate shaft at a desired position. In this manner, the method includes the shaft section insertion step, the intermediate shaft insertion step, and the intermediate shaft positioning step, and therefore, even in a shape in which it is not possible to perform insertion in an insertion method which is performed with the separator plate and the crankshaft section kept relatively vertical, as in a method of the related art, that is, a shape in which the intermediate shaft sticks out from the side surface in the first direction of the second crank pin, the intermediate shaft can pass through the separator plate.

Advantageous Effects of the Invention

[0020] According to the present invention, the first connection point is provided at a position displaced further in the first direction than the second connection point, and thus the first side is inclined with respect to the axis of the crankshaft, and therefore, compared to a shape in the related art having a side parallel to a crankshaft, it is possible to increase the cross-sectional area of the intermediate shaft. The deflection of the intermediate shaft is reduced in this manner, whereby the irregular contact of the crankshaft with a bearing can be reduced. The irregular contact of the crankshaft with a bearing is re-

duced, whereby it is possible to suppress an increase in bearing friction loss and suppress a decrease in reliability due to abnormal wear or seizure. Further, it is possible to suppress a tilt of a rolling piston, an increase in friction loss with a cylinder inner circumferential surface or the separator plate, and an increase in noise and vibration.

Brief Description of Drawings

[0021]

Fig. 1 is a longitudinal cross-sectional view of the periphery of an intermediate shaft of a rotary compressor according to an embodiment of the present invention.

Fig. 2 shows the intermediate shaft shown in Fig. 1, wherein (a) is a longitudinal cross-sectional view of an intermediate shaft of the related art, (b) is a longitudinal cross-sectional view of an intermediate shaft according to a first embodiment, (c) is a longitudinal cross-sectional view of an intermediate shaft according to a second embodiment, and (d) is a longitudinal cross-sectional view of an intermediate shaft according to a third embodiment. In addition, it should be noted that a first direction A and a second direction B are reverse to those in Fig. 1.

Fig. 3 is cross-sectional views in which the intermediate shafts shown in Fig. 2 are projected on a plane perpendicular to a rotary shaft, wherein (a) shows the intermediate shaft of the related art, (b) shows the intermediate shaft according to the second embodiment, and (c) shows the intermediate shaft according to the third embodiment. In addition, it should be noted that the first direction A and the second direction B are reverse to those in Fig. 1.

Fig. 4 is side views showing a method of inserting a separator plate in an embodiment of the present invention.

Fig. 5 is a side view showing a main section of a crankshaft which includes the intermediate shaft in the third embodiment of the present invention.

Description of Embodiments

[0022] Hereinafter, embodiments related to the present invention will be described with reference to the drawings.

[First Embodiment]

[0023] Hereinafter, a first embodiment of the present invention will be described using Figs. 1 to 5.

[0024] A rotary compressor according to this embodiment is provided with a hermetically-sealed housing, an electric motor section, and a compression mechanism section. The motor section and the compression mechanism section are coupled to each other by a crankshaft. The motor section housed in the hermetically-sealed

housing has a motor rotor and a motor stator, and an oil separation plate for suppressing a decrease in the lubrication performance of a sliding portion of the compressor is provided at an upper portion of the motor section.

[0025] In Fig. 1, the longitudinal cross-section of the periphery of an intermediate shaft 7 of the rotary compressor according to this embodiment is shown.

[0026] The compression mechanism section described above is provided with a crankshaft 1, a separator plate 13, and a cylinder section.

[0027] The cylinder section is divided into an upper cylinder 2 and a lower cylinder 4 and has a blade accommodation groove.

[0028] The crankshaft 1 is provided with an upper crankshaft section 3 which is located on the upper side in Fig. 1 and has an axis L1, and a lower crankshaft section 11 which is located on the lower side in Fig. 1 and has the axis L1 shared by the upper crankshaft section 3. The upper crankshaft section 3 is supported on a main bearing 15, and the lower crankshaft section 11 is supported on a sub-bearing 17.

[0029] An upper crank pin 5 and a lower crank pin 9 are connected between the upper crankshaft section 3 and the lower crankshaft section 11. The upper crank pin 5 is located such that an axis L2 thereof is eccentric with respect to the axis L1 of the upper crankshaft section 3. Here, a direction in which the axis L2 of the upper crank pin 5 is eccentric with respect to an axis of the crankshaft 1, that is, the axis L1 of the upper crankshaft section 3 and the lower crankshaft section 11 is set to be a first direction A, and the opposite direction to the first direction A is set to be a second direction B. The lower crank pin 9 is located with an axis L3 thereof being eccentric in the second direction B with respect to the axis L1 of the lower crankshaft section 11.

[0030] Further, an upper piston 22 is fitted onto the upper crank pin 5, and a lower piston 24 is fitted onto the lower crank pin 9.

[0031] The intermediate shaft 7 is provided between the upper crank pin 5 and the lower crank pin 9, and the upper crank pin 5 and the lower crank pin 9 which are eccentric to each other are connected by the intermediate shaft 7.

[0032] Further, the surfaces of the upper crankshaft section 3 and the lower crankshaft section 11 or the surfaces of the upper crank pin 5 and the lower crank pin 9 are machined, whereas the intermediate shaft 7 has a surface from molding by casting.

[0033] The separator plate 13 is disposed so as to partition the upper cylinder 2 corresponding to the upper crank pin 5 and the lower cylinder 4 corresponding to the lower crank pin 9. A hole portion is formed in the separator plate 13, and the intermediate shaft 7 is inserted into the hole portion.

[0034] An upper suction pipe 19 and a lower suction pipe 20 are connected to the respective sides of the upper cylinder 2 and the lower cylinder 4. A refrigerant is sucked from each of the upper suction pipe 19 and the lower

suction pipe 20 into each of the upper cylinder 2 and the lower cylinder 4.

[0035] The rotary compressor described above sucks refrigerant gas into the lower cylinder 4 through the lower suction pipe 20, and a compression chamber formed in the lower cylinder 4 is made smaller with the rotation of the crankshaft 1, whereby the refrigerant gas is compressed. Then, the refrigerant compressed in the lower cylinder 4 is discharged into a lower muffler and then discharged into an upper muffler through a communication path connecting the lower cylinder, the separator plate, and the upper cylinder. A refrigerant sucked into the upper cylinder through the upper suction pipe 19 is compressed in the upper cylinder and then discharged into the upper muffler. As the refrigerant, R410A refrigerant is suitably used. However, R32 refrigerant and other mixed refrigerants may be used.

[0036] In Fig. 2(b), a main section of the crankshaft 1 which includes the intermediate shaft 7 according to this embodiment is shown. As shown in the drawings, in a longitudinal cross-section which includes the axes of any two of the upper crankshaft section 3, the upper crank pin 5, and the lower crank pin 9, the intermediate shaft has a first side X which is located on the first direction A side, and the first side X is provided so as to continuously connect an intermediate shaft upper left point (a first side X-side first connection point) a which is connected to the upper crank pin 5, and an intermediate shaft lower left point (a first side X-side second connection point) b which is connected to the lower crank pin 9. In addition, the intermediate shaft upper left point a is provided at a position displaced further to the first direction A side than the intermediate shaft lower left point b.

[0037] Further, a second side Y is provided so as to continuously connect an intermediate shaft upper right point (a second side Y-side first connection point) c which is connected to the upper crank pin 5, and an intermediate shaft lower right point (a second side Y-side second connection point) d which is connected to the lower crank pin 9. In addition, the intermediate shaft lower right point d is provided at a position displaced further to the second direction B side than the intermediate shaft upper right point c. That is, both sides may have a diagonal shape.

[0038] Next, a method for assembling the crankshaft 1 described above, specifically, a method of inserting the separator plate 13 onto the crankshaft 1 will be described using Fig. 4. Assembling is performed in order from Fig. 4(a) to Fig. 4(e). First, as shown in Fig. 4(a), the lower crankshaft section 11 is inserted into the hole portion of the separator plate 13 as far as a plane where the lower crank pin 9 and the intermediate shaft 7 are in contact with each other, by relatively moving the crankshaft 1 and the separator plate 13 (a shaft section insertion step). Next, as shown in Fig. 4(b), the crankshaft 1 and the separator plate 13 are inclined relatively. By performing the inclination with an upper left end point e of the lower crank pin 9 as a fulcrum at the time of the inclination, it is possible to prevent the position of the separator plate

13 from being shifted. Next, as shown in Fig. 4(c), the intermediate shaft 7 is relatively inserted into the hole portion along the first side X while making the separator plate 13 follow the first side X (an intermediate shaft insertion step). When relatively inserting the intermediate shaft 7 into the hole portion while making the separator plate 13 follow the first side X, it is favorable if the insertion is performed with a gap to the extent that the separator plate 13 and the intermediate shaft 7 are not in contact with each other provided. Next, as shown in Fig. 4(d), the inclination between the crankshaft 1 and the separator plate 13 relatively inclined by Fig. 4(b) is released. When releasing the inclination, it is favorable if movement is performed such that an end point of the separator plate coincides with the intermediate shaft upper left point a.

[0039] Then, as shown in Fig. 4(e), the intermediate shaft 7 is positioned in the hole portion of the separator plate 13 (an intermediate shaft positioning step). When positioning the intermediate shaft 7 in the hole portion of the separator plate 13, it is favorable if movement is performed such that the separator plate becomes perpendicular to the axis L1 of the crankshaft 1.

[0040] In addition, the separator plate 13 may be inserted from the upper crankshaft section 3, rather than from the lower crankshaft section 11, as described above.

[0041] Due to the configuration described above, according to this embodiment, the following operations and effects are exhibited.

[0042] The intermediate shaft upper left point a (and/or the intermediate shaft upper right point c) is provided at a position displaced further to the first direction A side than the intermediate shaft lower left point b (and/or the intermediate shaft lower right point d), and thus the first side X is inclined with respect to the axis of the crankshaft 1, and therefore, compared to a shape in the related art in Figs. 2(a) and 3(a) having a side parallel to the crankshaft 1, it is possible to increase the cross-sectional area of the intermediate shaft 7. The deflection of the intermediate shaft 7 is reduced in this manner, whereby the irregular contact of the crankshaft 1 with the main bearing 15 and the sub-bearing 17 can be reduced. Since the irregular contact of the crankshaft 1 with the bearing is reduced, it is possible to suppress an increase in bearing friction loss and suppress a decrease in reliability due to abnormal wear or seizure. Further, it is possible to suppress a tilt of a rolling piston, an increase in friction loss with a cylinder inner circumferential surface or the separator plate 13, and an increase in noise and vibration.

[0043] Further, due to the assembling method which includes the intermediate shaft insertion step of relatively inclining the crankshaft 1 and the separator plate 13 and relatively inserting the intermediate shaft 7 into the hole portion along the first side X while making the separator plate 13 follow the first side X, even if the first side X is inclined, it is possible to insert the separator plate 13 and position the intermediate shaft 7 at a desired position. In addition, the same also applies to a shape which is as

large as possible to the extent that the intermediate shaft 7 can pass through the separator plate 13. In this manner, even in a shape in which it is not possible to perform insertion in an insertion method of the related art which is performed with the separator plate 13 and the crankshaft 1 kept relatively vertical, that is, a shape in which the intermediate shaft 7 sticks out from the side surface of the lower crank pin in the first direction A, the intermediate shaft 7 can pass through the separator plate 13.

[Second Embodiment]

[0044] Next, a second embodiment of the present invention will be described using Figs. 2(c) and 3(b).

[0045] This embodiment is different in the shape of the intermediate shaft 7 from the first embodiment described above. Since other aspects are the same as those in the first embodiment, description thereof is omitted.

[0046] In this embodiment, the second side Y of the intermediate shaft 7, which is located on the second direction B side, extends parallel to the axis of the lower crankshaft section 11 with the intermediate shaft lower right point d which is at a position displaced further than the intermediate shaft upper right point c as a starting point.

[0047] In this manner, the shape of the intermediate shaft 7 is extended by a distance by which the intermediate shaft lower right point d is displaced further to the second direction B side than the intermediate shaft upper right point c, compared to the shape in the related art, and therefore, it is possible to increase the cross-sectional area of the intermediate shaft 7.

[Third Embodiment]

[0048] Next, a third embodiment of the present invention will be described using Figs. 2(d), 3(c), and 5.

[0049] This embodiment is different in the shape of the intermediate shaft 7 from the first embodiment and the second embodiment described above. Since other aspects are the same as those in the first embodiment, description thereof is omitted.

[0050] A shape is made in which the maximum distance between both sides of the shape of the intermediate shaft 7 is equal to the diameter of the hole portion of the separator plate 13. Here, due to the maximum distance between both sides, a shape shown by a broken line in Fig. 2(d) is also acceptable. Further, Fig. 5 is a diagram in which the separator plate is inserted in this embodiment, and the intermediate shaft is increased by a triangular cross-section portion 8.

[0051] In this manner, due to the presence of the triangular cross-section portion 8, a gap between the intermediate shaft shape and the separator plate is effectively filled, and a shape in which the maximum distance between both sides of the shape of the intermediate shaft 7 is equal to the diameter of the hole portion of the separator plate 13 is made, and thus it is possible to make

the intermediate shaft 7 as large as possible to the extent that the intermediate shaft 7 can pass through the separator plate 13.

[0052] In addition, in each embodiment described above, description has been made as an example in which the surfaces of the upper crankshaft section 3 and the lower crankshaft section 11 or the surfaces of the upper crank pin 5 and the lower crank pin 9 are machined, whereas the intermediate shaft 7 has a surface from molding by casting. However, the present invention is not limited thereto, and, for example, the intermediate shaft 7 may be machined. Further, working is not limited to machining.

[0053] Further, in each embodiment described above, description has been made as a rotary compressor. However, the present invention is not limited thereto, and, for example, an expander is also acceptable.

[Other Embodiments]

[0054] Next, other embodiments of the present invention will be described.

[0055] In each embodiment described above, an example in which the present invention is applied to a two-cylinder rotary compressor and a single-cylinder rotary compressor has been described. However, it is also possible to likewise apply the present invention to the following compressors, and these compressors shall also be included in the present invention.

(1) Multi-cylinder Rotary Compressor

[0056] In each embodiment described above, a two-cylinder rotary compressor has been described. However, the present invention may also be applied to a multi-cylinder rotary compressor having three or more cylinders.

(2) Multistage Rotary Compressor

[0057] In each embodiment described above, a two-cylinder rotary compressor has been described. However, the present invention may also be applied to a multistage rotary compressor as a configuration in which a cylinder on one side is set as a low-stage side, a cylinder on the other side is set as a high-stage side, and intermediate-pressure gas compressed by a compression mechanism on the low-stage side is sucked by a compression mechanism on the high-stage side and further compressed into high-pressure gas.

(3) Multistage Compressor combined with other types of compression mechanism

[0058] It is also possible to apply the present invention to a multistage compressor of a type in which a second compression mechanism of a different type from a rotary compression mechanism which is driven by an electric

motor is provided at an upper portion of the electric motor in the housing of each embodiment described above, the rotary compression mechanism is set as a low-stage side compression mechanism, the second compression mechanism is set as a high-stage side compression mechanism, intermediate-pressure gas compressed by the low-stage side rotary compression mechanism is discharged into the housing, and the gas is sucked by the high-stage side compression mechanism that is the second compression mechanism and compressed in two stages.

[0059] As a typical example of the multistage compressor, a compressor in which the second compression mechanism is a scroll compression mechanism has already been put to practical use.

[0060] Even in a case of being applied to these compressors, it is possible to obtain the same effects as those in each embodiment described above. Reference Signs List

[0061]

- 1: crankshaft
- 2: upper cylinder
- 3: upper crankshaft section (first crankshaft section)
- 4: lower cylinder
- 5: upper crank pin (first crank pin)
- 7: intermediate shaft
- 8: triangular cross-section portion
- 9: lower crank pin (second crank pin)
- 11: lower crankshaft section (second crankshaft section)
- 13: separator plate
- 15: main bearing
- 17: sub-bearing
- 19: upper suction pipe
- 20: lower suction pipe
- 22: upper piston
- 24: lower piston
- L1, L2, L3: axis
- A: first direction
- B: second direction
- X: first side
- Y: second side
- a: first side X-side first connection point
- b: first side X-side second connection point
- c: second side Y-side first connection point
- d: second side Y-side second connection point
- e: lower crank pin upper left end point

Claims

1. A rotary fluid machine comprising:

a crankshaft which is provided with a first crankshaft section, a first crank pin connected eccentrically in a first direction with respect to the first crankshaft section, a second crankshaft section

having the same axis as the first crankshaft section, a second crank pin connected eccentrically in a second direction opposite to the first direction with respect to the second crankshaft section, and an intermediate shaft which connects the first crank pin and the second crank pin; and a separator plate which partitions a first cylinder corresponding to the first crank pin and a second cylinder corresponding to the second crank pin and has a hole portion in which the intermediate shaft is inserted and located, wherein the intermediate shaft has a first side which is located on the first direction side in a longitudinal cross-section which includes axes of any two of the first crankshaft section, the first crank pin, and the second crank pin, the first side is provided so as to continuously connect a first side-side first connection point which is connected to the first crank pin and a first side-side second connection point which is connected to the second crank pin, and the first side-side first connection point is provided at a position displaced further in the first direction than the first side-side second connection point.

2. The rotary fluid machine according to Claim 1, wherein the intermediate shaft has a second side which is located on the second direction side in the longitudinal cross-section, the second side is provided so as to continuously connect a second side-side first connection point which is connected to the first crank pin and a second side-side second connection point which is connected to the second crank pin, and the second side-side second connection point is provided at a position displaced further in the second direction than the second side-side first connection point.

3. The rotary fluid machine according to Claim 1, wherein in the longitudinal cross-section, the second side of the intermediate shaft, which is located on the second direction side, extends parallel to an axis of the second crankshaft section with the second connection point which is at a position displaced further in the second direction than the first connection point as a starting point.

4. The rotary fluid machine according to any one of Claims 1 to 3, wherein in the longitudinal cross-section, the maximum distance between both the sides of the intermediate shaft in a direction orthogonal to an axis of the crankshaft is equal to a diameter of the hole portion of the separator plate.

5. The rotary fluid machine according to any one of Claims 1 to 4, wherein the intermediate shaft has a

surface from molding by casting.

6. A method for assembling the rotary fluid machine according to any one of Claims 1 to 5, comprising:

5
a shaft section insertion step of inserting the first crankshaft section or the second crankshaft section into the hole portion of the separator plate as far as a plane where the first crank pin or the second crank pin and the intermediate shaft are in contact with each other, by relatively moving the crankshaft and the separator plate; 10
an intermediate shaft insertion step of relatively inclining the crankshaft and the separator plate and relatively inserting the intermediate shaft into the hole portion along the first side while making the separator plate follow the first side; and 15
an intermediate shaft positioning step of releasing relative inclination between the crankshaft and the separator plate and positioning the intermediate shaft in the hole portion of the separator plate. 20

25

30

35

40

45

50

55

FIG. 1

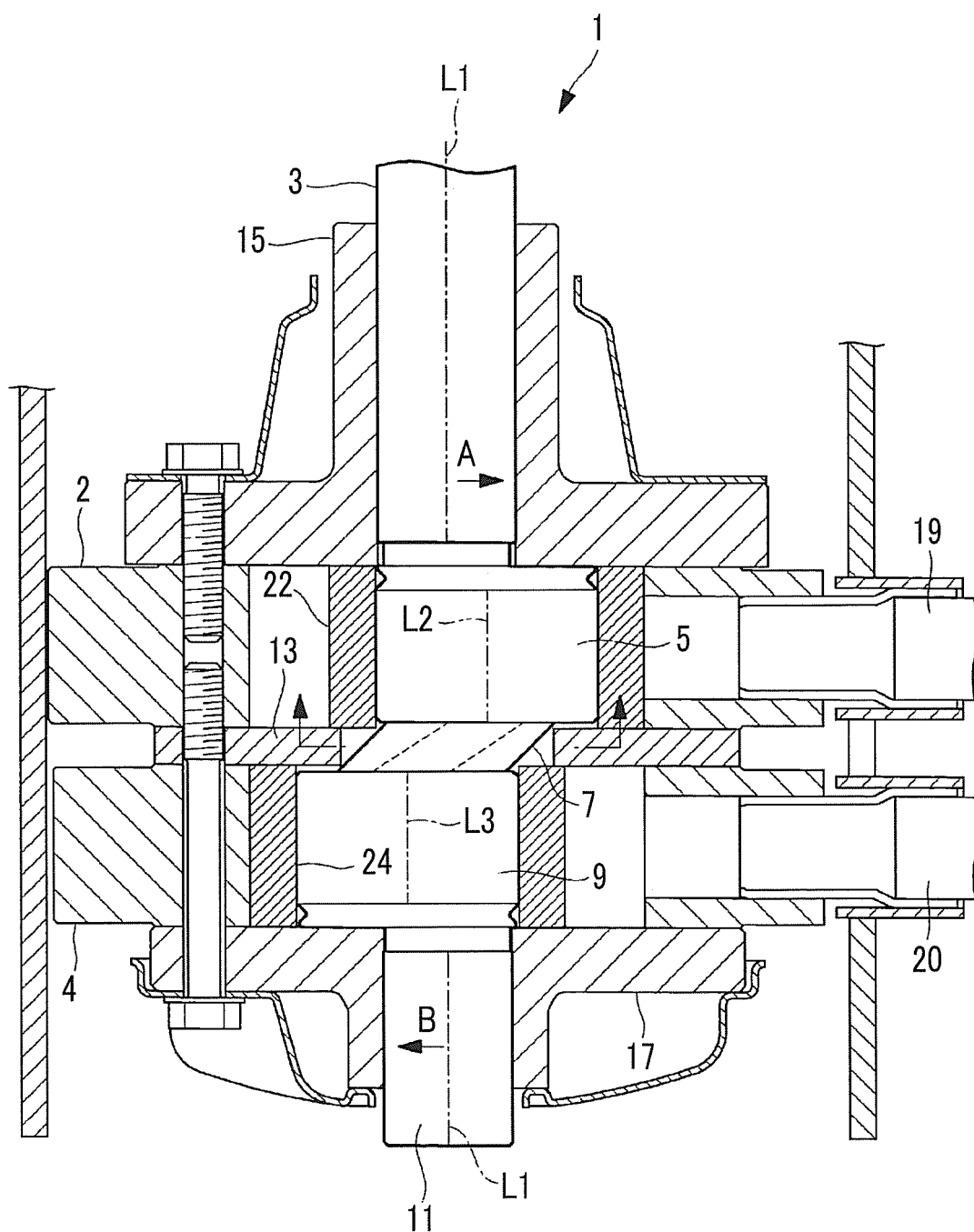


FIG. 2

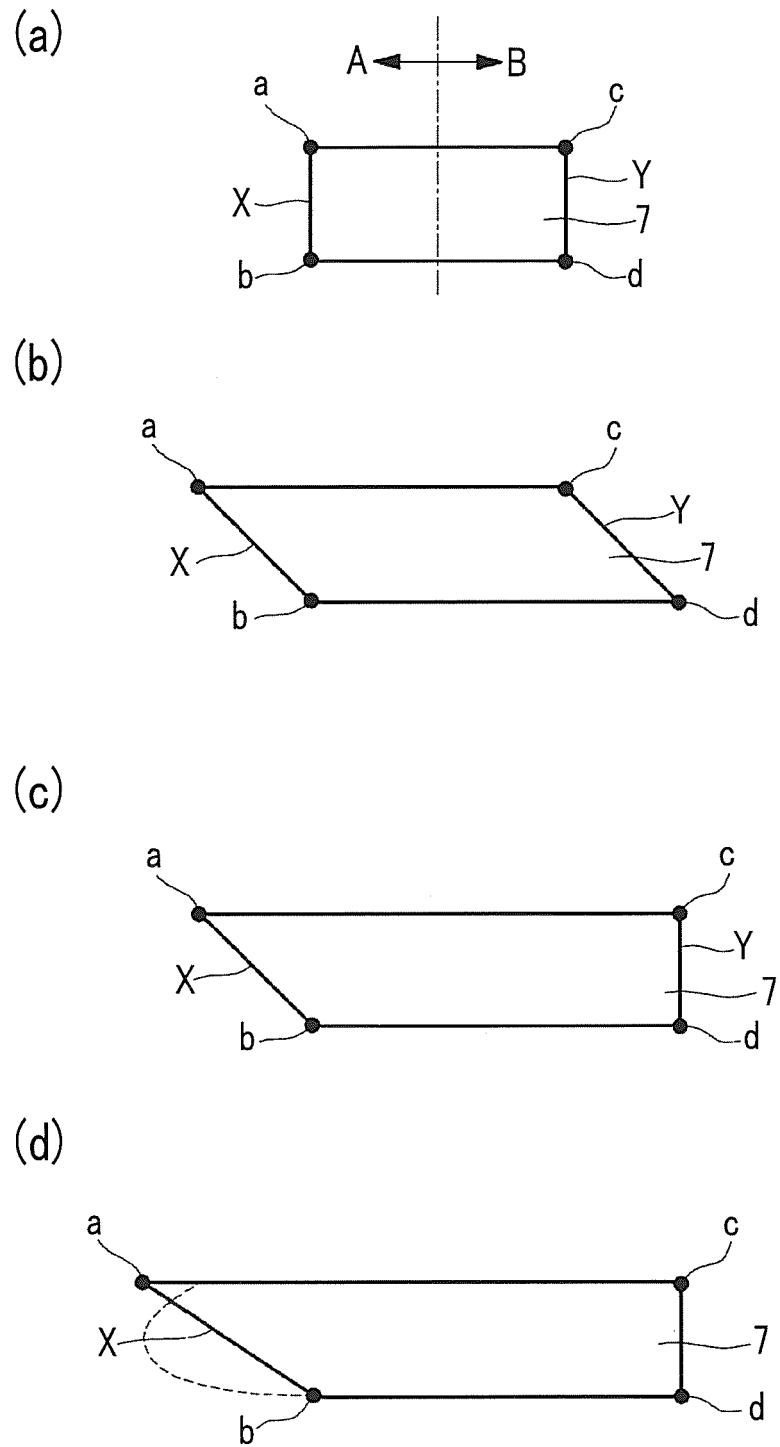
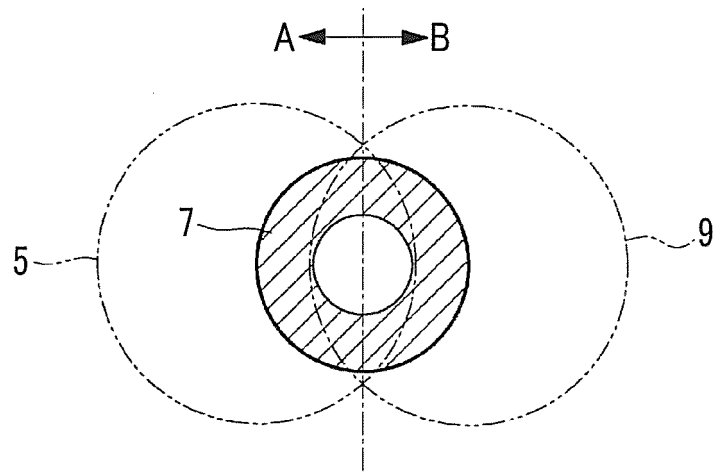
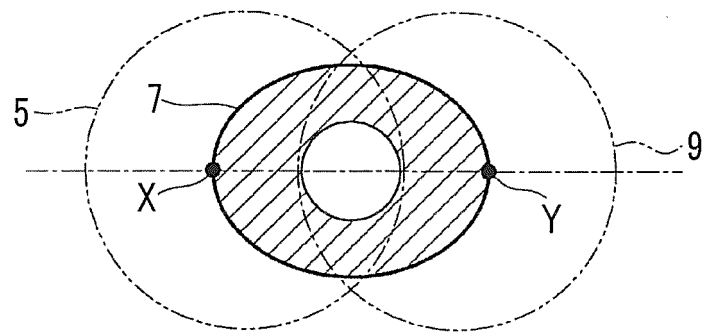


FIG. 3

(a)



(b)



(c)

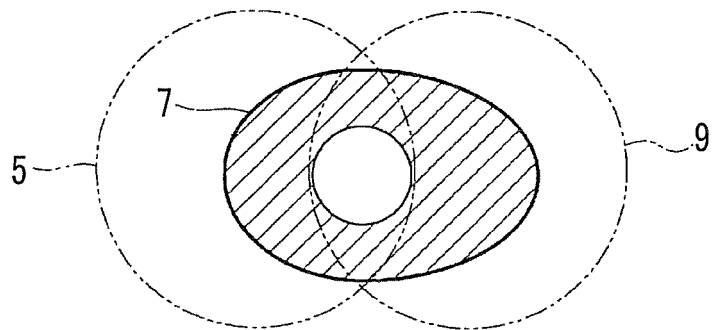


FIG. 4

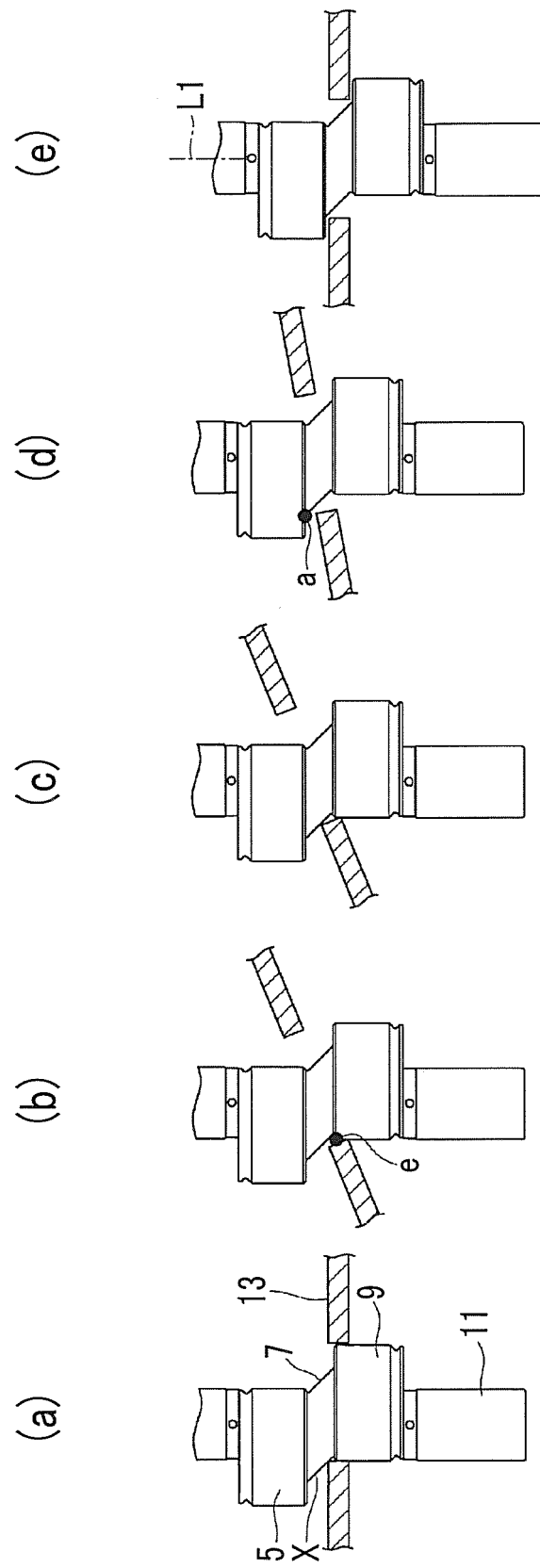
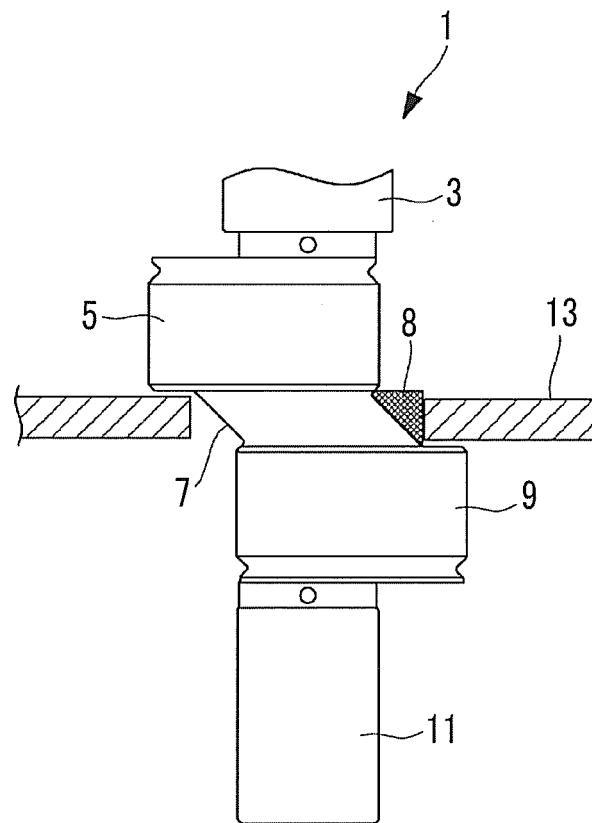


FIG. 5



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2013/065292

A. CLASSIFICATION OF SUBJECT MATTER

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)

F04C29/00, F04C23/00

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 1996-2013

Kokai Jitsuyo Shinan Koho 1971-2013 Toroku Jitsuyo Shinan Koho 1994-2013

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	WO 2009/028633 A1 (Toshiba Carrier Corp.), 05 March 2009 (05.03.2009), paragraphs [0020] to [0133]; fig. 2A, 7A, 12A & JP 5117503 B2 & US 2010/0147013 A1 & CN 101688535 A	1-4 5, 6
Y	JP 2002-138979 A (Hitachi, Ltd.), 17 May 2002 (17.05.2002), paragraph [0023]; fig. 2 & KR 10-2002-0034883 A & CN 1356476 A	5, 6
Y	JP 2010-101169 A (Mitsubishi Electric Corp.), 06 May 2010 (06.05.2010), paragraph [0052]; fig. 14 (Family: none)	6

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

* Special categories of cited documents:

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

"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
07 August, 2013 (07.08.13)Date of mailing of the international search report
20 August, 2013 (20.08.13)Name and mailing address of the ISA/
Japanese Patent Office

Authorized officer

Facsimile No.

Telephone No.

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2013/065292

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 2004-100608 A (Hitachi Home & Life Solution, Inc.), 02 April 2004 (02.04.2004), paragraph [0022]; fig. 5 to 7 & CN 1482364 A	6

Form PCT/ISA/210 (continuation of second sheet) (July 2009)

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 3723408 B [0004]
- JP 4065654 B [0004]