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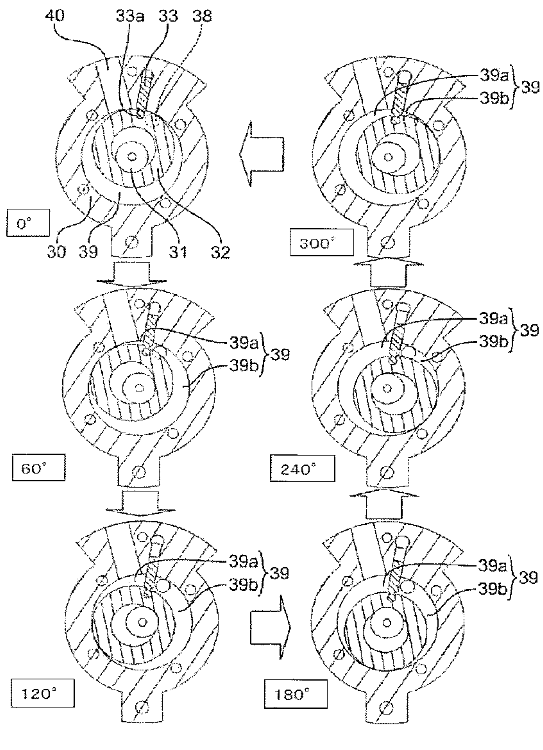
(54) ROTARY COMPRESSOR

(57) A rotary compressor includes a cylinder 30, an eccentric portion 31a of a shaft 31 disposed in the cylinder 30, and a piston 32 which is fitted into the eccentric portion 31a. A columnar groove 32a is formed in the piston 32, and angle of an arc of the groove 32a is greater than 180°. The rotary compressor further includes a piston 32 inserted into a slot formed in the cylinder 30, a slot 30b formed in the cylinder 30, and the groove 32a formed in the piston 32, and a columnar portion 33a having a columnar portion 33a on its one end. A compression chamber 39 is formed between the cylinder 30 and the piston 32, the columnar portion 33a is swingably fitted into the groove 32a, and the vane 33 reciprocates in the slot 30b as the shaft 31 rotates. The compression chamber 39 is divided into a high pressure-side space 39b and a low pressure-side space 39a by the vane 33. The groove 32a formed in the piston 32 is formed into a columnar shape, the groove 32a has the arc and an angle of the arc is greater than 180°. A fictitious extension La of the arc is located inside of the outer periphery fictitious line Lb of the piston 32. Gas and oil are less prone to leak from the high pressure-side space 39b to the low pressure-side space 39a of the compression chamber 39.

[Fig. 3]



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Description

Technical Field

[0001] The present invention relates to a rotary compressor having a vane including a columnar portion, in which a compression chamber is divided into a high pressure-side space and a low pressure-side space by the vane by inverting the columnar portion into a slot formed in a cylinder.

Background Technique

[0002] In a conventional refrigerating appliance and air conditioner, a compressor is used for sucking gas refrigerant evaporated by an evaporator, for compressing the gas refrigerant to a pressure required for condensing the sucked gas refrigerant, and for sending out the high temperature and high pressure gas refrigerant. A rolling piston type rosary compressor (simply rotary compressor, hereinafter) is known as one of such compressors.

[0003] Fig. 10 is a partial vertical sectional view showing one example: of the conventional rotary compressor. Fig. 11 is a transverse sectional view of the rotary compressor shown in Fig. 10 taken along a plane A-A.

[0004] As shown in Figs. 10 and 11, the rotary compressor includes a container 201, and an electric motor 202, a compressing mechanism 203 and a shaft 231 are accommodated in the container 201, and the electric motor 202 and the compressing mechanism 203 are connected to each other through the shaft 231. The compressing mechanism 203 includes a cylinder 230, an upper bearing 234 and a lower bearing 235 which respectively close an upper end surface and a lower end surface of the cylinder 230. The cylinder 230, the upper bearing 234 and the lower bearing 235 form a space called a compression chamber 239.

[0005] A piston 232 is provided in the compression chamber 239. The piston 232. is fitted into an eccentric portion 231a of the shaft 231 supported by the upper bearing 234 and the lower bearing 235. A vane 233 is provided in the compression chamber 239. The vane 233 follows eccentric rotation of an outer periphery of the piston 232 and reciprocates, and the vane 233 divides the compression chamber 239 into a low pressure-side space and a high pressure-side space.

[0006] An oil hole 241 is formed in the shaft 231 along a center axis of the shaft 231, and an oil supply hole 242 and an oil supply hole 243 which are in communication with the oil hole 241 are formed in a lower end of the upper bearing 234 and an upper end of the lower bearing 235. In the shaft 231, an oil supply hole 244 which is in communication with the oil hole 241 is provided in the shaft 231 at a location adjacent to the eccentric portion 231a. An oil groove 245 passing through an opening of the oil supply hole 244 is formed in an outer periphery of the shaft 231.

[0007] A suction port 240 through which gas is sucked is formed in the cylinder 230 in a low pressure-side space of the cylinder 239. A discharge port 238 through which gas is discharged from a high pressure-side, space of the compression chamber 239 which is formed from the low pressure-side space is formed in the upped bearing 234. The discharge port 238 penetrates the upper bearing 234, and the discharge port 238 is a circular hole as viewed from above. A discharge valve 236 is provided in the upper bearing 234 above the discharge port 238. When the discharge valve 236 receives a pressure greater than a predetermined value from the discharge port 238, the discharge valve 236 opens the discharge port 238. A cup muffler 237 is disposed on the upper bearing 234 such as to cover the discharge valve 236.

[0008] In the rotary compressor having the above-described configuration, if sliding portions between the piston 232 and the cylinder 230 pass through the suction port 240 by the eccentric rotation, the low pressure-side space of the compression chamber 239 is gradually enlarged. While the low pressure-side space of the compression chamber 239 is enlarged, gas is sucked from the suction port 240 into the low pressure-side space. In the high pressure-side space of the compression chamber 239, a sliding portion of the piston 232 approaches the discharge port 238 while gradually contracting, and gas in the high pressure-side space of the compression chamber 239 is compressed to a predetermined value or higher, the discharge valve 236 opens and the gas flows from the discharge port 238 to the cup muffler 237. Gas in the cup muffler 237 is discharged into the container 201.

[0009] According to the above-described configuration, oil is less prone to be held at the sliding portions between the piston 232 and a tip end of the vane 233, and the sliding performance is severe. That is, since the oil film is not easily formed, metal contact occur and the sliding portions are prone to be worn. If R407C or R410A which is nonazeotropic refrigerant mixture started to be used in recent years is used in the conventional rotary compressor, since lubricity of the refrigerant itself is poor, the sliding portion is further prone

[0010] Hence, several means for solving the wearing problem are proposed. Fig. 12 is a transverse sectional view showing an essential portion of a swinging piston type rotary compressor which is one solving means of the wearing problem. In Fig. 12, the swinging piston type rotary compressor includes a cylinder 130 in which a slot 130b is formed, a piston 132 disposed in the cylinder 130, and a vane 133 which is swingably connected to the piston 132 and which reciprocates in the slot 130b as the piston 132 moves. The piston 132 is fitted into an eccentric portion of a crankshaft 131. By swingably connecting the vane 133 to the piston 132, oil is prone to be held at the swinging portions between, the piston 132 and a tip end of the vane 133, an oil film is formed by the held oil and thus, the reliability of the tip end of the vane 133 can largely be enhanced (see patent document 1 for example).

Prior Art Document

[0011]

[Patent Document 1] Japanese Patent Application Laid-Open No.2000-120572

[0012] According to the swinging piston type rotary compressor shown in Fig. 12, however, since it is absolutely necessary to provide a gap between the swinging portions between the piston 132 and the vane 133, gas and oil are prone to leak from a high pressure-side space to a low pressure-side space of the compression chamber. As a result, the conventional swinging piston type rotary compressor has a problem that a compression loss is increased and the efficiency of the compressor is deteriorated.

Disclosure of the Invention

[0013] Hence, it is an object of the present invention to provide a rotary compressor in which gas and oil are less prone to leak from the high pressure-side space to the low pressure-side space of the compression chamber.

[0014] To achieve the above object, the present invention provides a rotary compressor comprising: a cylinder; an eccentric portion of a shaft disposed in the cylinder; a piston fitted to the eccentric portion; a slot formed in the cylinder; a groove formed in the piston; and a vane having a columnar portion on its one of ends; in which a compression chamber is formed between the cylinder and the piston, the columnar portion is swingably fitted into the groove, the vane reciprocates in the slot as the shaft rotates, and the compression chamber is divided into a high pressure-side space and a low pressure-side space by the vane, wherein the groove is formed into a columnar shape having an arc whose angle is greater than 180°, and a fictitious extension of the arc is located inside of an outer periphery fictitious line of the piston.

[0015] According to the above-described configuration, since the arc portion of the groove formed in the piston can be increased, a sealing width between the high pressure-side space and the low pressure-side space is increased. According to this, when the vane reciprocates in the slot, leakage of gas and oil from the high pressure-side space to the low pressure-side space can be minimized and therefore, it is possible to provide a rotary compressor having high efficiency.

Brief Description of the Drawings

[0016]

Fig, 1 is a partial vertical sectional view of a swinging piston type rotary compressor according to an embodiment of the present invention;

Fig. 2 is an enlarged sectional view of a compressing mechanism of the rotary compressor;

Fig. 3 is a diagram showing a state transition of the compressing mechanism while a shaft of the rotary compressor: makes one rotation;

Fig. 4 is an exploded perspective view of a piston and a vane in the rotary compressor;

Fig. 5 is an enlarged view of an essential portion of the piston in the rotary compressor;

Fig. 6 is a diagram of a comparative example corresponding to Fig. 5;

Fig. 7 is an enlarged diagram of an essential portion of an embodiment of a vane of the rotary compressor;

Fig. 8 is an enlarged diagram of an essential portion of another embodiment of a vane of the rotary compressor;

Fig. 9 is a perspective view of an essential portion of another embodiment of a vane of the rotary compressor;

Fig. 10 is a vertical sectional view of a conventional rolling piston type rotary compressor;

Fig. 11 is a transverse sectional view showing a compressing mechanism of the rolling piston type rotary compressor shown in Fig. 10; and

Fig. 12 is a transverse sectional view showing a compressing mechanism of a conventional swinging piston type rotary compressor.

Mode for Carrying Out the Invention

[0017] The present invention is **characterized in that** the groove is formed into a columnar shape having an arc whose angle is greater than 180°, and a fictitious extension of the arc is located inside of an outer periphery fictitious line of the piston.

[0018] According to this configuration, since the arc portion of the groove can be increased, the sealing width between the high pressure-side space and the low pressure-side space is increased. According to this, when the vane reciprocates in the slot, leakage of gas and oil from the high pressure-side space to the low pressure-side space of the compression chamber can be reduced and as a result, the efficiency of the rotary compressor is enhanced. When the groove of the piston is formed, a hole is first formed in the piston and then, portions other than arc can be formed. According to this, the machining precision such as the roundness of the arc portion of the groove and the squareness is enhanced, and the machining cost can be reduced, and the efficiency of the rotary compressor is enhanced.

[0019] Preferably, in the present invention, a body of the vane includes one of side surfaces facing the low pressure-side space, the other side surface facing the high pressure-side space, an upper end surface which is in contact with an upper end of the one side surface and an upper end of the other side surface, and a lower end surface which is in contact with a lower end of the one side surface and a lower end of the other side surface, a low pressure-side constriction is provided between the one side surface and the columnar portion, a high pressure-side constriction is provided between the other side surface and the columnar portion, in a state where the piston is in contact with the slot, a top clearance volume is formed by the high pressure-side constriction, the piston and the cylinder, a clearance volume is formed by the low pressure-side constriction, the piston and the cylinder, and the clearance volume is smaller than the top clearance volume.

[0020] In the present invention, as one means for making the top clearance volume smaller than the clearance volume, a fictitious surface which passes through a center of the columnar portion and which is in parallel to the fictitious center surface is deviated toward the other side surface with respect to the fictitious center surface of the pair of the side surfaces.

[0021] In the present invention, as another means for making the top clearance volume smaller than the clearance volume, the high pressure-side constriction is smaller than the low pressure-side constriction. In the rotary compressor, it is necessary to provide a low pressure-side constriction, a high pressure-side constriction and a releasing space. The top clearance volume formed by the high pressure-side constriction, the piston and the cylinder again expands at the time of the section operation, and a loss is generated. However, since the top clearance volume is made smaller than the clearance volume, a moving amount of the high pressure gas toward the low pressure-side space is reduced, and the efficiency of the compressor is enhanced.

[0022] Further, the present invention is **characterized in that** a mark is provided on an upper end surface or the lower end surface. The mark functions as a remarque for determining upper and lower directions when the compressor is assembled, and a loss caused by erroneous assembling operation can be reduced. The mark may be provided in a lower end surface instead of the upper end surface of the vane. It is preferable that the mark is a dip.

[0023] In the rotary compressor of the present invention, it is possible to use a CO_2 refrigerant as the working fluid. The CO_2 refrigerant has a great pressure difference, a sliding loss and a leakage loss are high, but if the columnar portion and the groove are designed as described above, it becomes preferable to use CO_2 as the working fluid. According to this, the efficiency and the reliability of the compressor can be enhanced.

[0024] In the rotary compressor of the present invention, as the working fluid, it is possible to use a refrigerant having hydrofluoroolefin as a base ingredient having a carbon-carboy double bond in which hydrofluorocarbon having no double bond is mixed. Since this refrigerant does not include chlorine, the refrigerant is extremely severe in terms of reliability of the sliding portions. However, if the groove is formed as described above and this refrigerant is used, it is possible to enhance the efficiency and the reliability of the compressor more effectively. Further, since this refrigerant has a low warming potential and is free from ozone destruction, it is possible to contribute to configuration of an earth-friendly air-conditioning cycle,

[0025] Embodiments of the present invention will be described with reference to the drawings.

[0026] Fig. 1 is a partial vertical sectional view of a swinging piston type rotary compressor according to one embodiment of the present invention. Fig. 2 is an enlarged sectional view of a compressing mechanism of the rotary compressor shown in Fig. 1.

[0027] As shown in Figs. 1 and 2, the rotary compressor has a container 1. An electric motor 2, a compressing mechanism 3 and a shaft 31 are accommodated in the container 1. The electric motor 2 and the compressing mechanism 3 are connected to each other through the shaft 31. The compressing mechanism 3 includes a cylinder 30. The compressing mechanism 3 further includes an upper bearing 34 and a lower bearing 35 which respectively close an upper end surface and a lower end surface of the cylinder 30. The upper bearing 34 and the lower bearing 35 support the shaft 31.

[0028] The shaft 31 forms an eccentric portion 31a, and the eccentric portion 31a is disposed in the cylinder 30. A piston 32 is fitted into the eccentric portion 31a. A compression chamber 39 is formed by a space surrounded by the upper bearing 34 and the lower bearing 35 between the cylinder 30 and the piston 32. A vane 33 is provided in the compression chamber 39. The vane 33 divides the compression chamber 39 into a low pressure-side space 39a and a high pressure-side space 39b. A slot 30b is provided in the cylinder 30. A body portion of the vane 33 is inserted into the slot 30b such that the body portion can reciprocate therein. A columnar portion 33a as shown in Figs . 3 to 5 is formed on one of ends of the vane 33. The columnar portion 33a of the vane 33 is swingably fitted into a groove 32a formed in an outer periphery of the piston 32. The groove 32a is formed in parallel to a rotation axis of the piston 32.

[0029] An oil hole 41 is formed in the shaft 31 along a center axis of the shaft 31, and an oil supply hole 42 and an oil supply hole 43 which are in communication with the oil hole 41 are provided in a lower end of the upper bearing 34 and an upper end of the lower bearing 35. An oil supply hole 44 which is in communication with the oil hole 41 is provided in the shaft 31 at a location adjacent to the eccentric portion 31a. An oil groove 45 passing through the oil supply hole 44 is formed in an outer periphery of the shaft 31.

[0030] A suction port 40 through which gas as working fluid is sucked is formed in the low pressure-side space 39a of the compression chamber 39 of the cylinder 30. A discharge port 38 through which gas is discharged from the high pressure-side space 39b of the compression chamber 39 changed from the low pressure-side space 39a is formed in the upper bearing 34. The discharge port 38 penetrates the upper bearing 34, and is formed as a circular hole as viewed from above. A discharge valve 36 is provided above the discharge port 38 of the upper bearing 34, and the discharge valve 36 opens when it receives a pressure greater than a predetermined value from the discharge port 38. A cup muffler 37 is disposed in the upper bearing 34 such as to cover the discharge valve 36.

[0031] Fig. 3 is a diagram showing a state transition of the compressing mechanism 3 while the shaft 31 shown in Fig. 1 makes one rotation. In Fig. 3, a position where the columnar portion 33a of the vane 33 most approaches an inner wall of the cylinder 30 is defined as 0°. In Fig. 3, if sliding portions between the piston 32 and the cylinder 30 pass through the suction port 40 and separate from the suction port 40, the low pressure-side space 39a of the compression chamber 39 is gradually enlarged to suck gas from the suction port 40. The high pressure-side space 39b of the compression chamber 39 is gradually contracted to compress gas in the high pressure-side space 39b. When the gas in the high pressure-side space 39b of the compression chamber 39 is compressed to a predetermined pressure or higher, the discharge valve 36 (see Fig. 1) opens, and the gas flows out from the discharge port 38. The gas which flowed out is discharged into the container 1 from the cup muffler 37 shown in Fig. 1, more specifically, into a high pressure discharge space 52 which is outside of the compressing mechanism 3.

[0032] A space 46 (see Fig. 2) is formed between the eccentric portion 31a, the upper bearing 34 and the piston 32, and a space 47 (see Fig. 2) is formed between the eccentric portion 31a, the lower bearing 35 and the piston 32. Oil leaks from the oil hole 41 into the spaces 46 and 47 through the oil supply holes 42 and 43. Pressures in the spaces 46 and 47 are higher than that in the compression chamber 39 at the time of normal operation.

[0033] Fig. 4 is an exploded perspective view of the piston 32 and the vane 33 shown in Figs. 1 and 2. In Fig. 4, a columnar portion 33a is provided on one of ends of the vane 33. A body of the vane 33 includes one side surface 33b facing the low pressure-side space 39a, the other side surface 33c facing the high pressure-side space 39b, an upper end surface 33d connected to an upper end of the one side surface 33b and an upper end of the other side surface 33c, and a lower end surface 33e connected to a lower end of the one side surface 33b and a lower end of the other side surface 33c. A low pressure-side constriction 33f is provided between the one side surface 33b and the columnar portion 33a, and a high pressure-side constriction 33g is provided between the other side surface 33c and the columnar portion 33a. The columnar groove 32a is formed in the piston 32. The groove 32a has substantially the same diameter as that of the columnar portion 33a, and an angle of an arc of the groove 32a is greater than 180°. The columnar portion 33a is swingably fitted into the groove 32a, and they are connected to each other.

[0034] As shown in Fig 5, a fictitious extension La of the arc of the groove 32a is located inside of an outer periphery fictitious line Lb of the piston 32. By providing the groove 32a such that the fictitious extension La is located inside of the outer periphery fictitious line Lb, the arc of the groove 32a can be made large, and an inner peripheral area of the groove 32a with which the columnar portion 33a is in contact can be increased. Therefore, a sealing width between the high pressure-side space 39b and the low pressure-side space 39a of the compression chamber 39 is increased, leakage of gas and oil is reduced and thus, the efficiency of the compressor can be enhanced. When the groove 32a of the piston 32 is formed, a columnar hole is first formed in the piston 32 and then, portions other than arc are removed by cutting and the groove 32a can be formed. According to this, the machining precision such as the roundness of the arc portion of the groove 32a and the squareness with respect to the piston 32 is enhanced, and the machining cost can be reduced, and the efficiency is enhanced.

[0035] On the contrary, if the fictitious extension La is located outside from the outer periphery fictitious line Lb as in a comparative example shown in Fig. 6, the arc portion of the groove 32a is reduced and the sealing width is also reduced.

[0036] It is preferable that the columnar portion 33a is provided on the vane 33 such that a fictitious surface Pb which passes through a center of the columnar portion 33a and which is in parallel to a fictitious center surface Pa of the pair of side surfaces 33b and 33c is deviated toward the other side surface 33c than the fictitious center surface Pa with respect to the fictitious center surface Pa as shown in Fig. 7. In the swinging piston type rotary compressor, to prevent the piston 32 and the vane 33 from coming into contact with each other during operation, it is necessary to provide the low pressure-side constriction 33f and the high pressure-side constriction 33g to form a releasing space. Therefore, in a state where the piston 32 is in contact with the slot 30b, a top clearance volume Vg is formed by the high pressure-side constriction 33g, the piston 32 and the cylinder 30, and a clearance volume Vf is formed by the low pressure-side constriction 33f, the piston 32 and the cylinder 30. In the top clearance volume Vg, since gas is expanded when it is sucked, a loss is generated. Therefore, if the high pressure-side constriction 33g is made smaller than the low pressure-side constriction 33f as shown in Fig. 7, the top clearance volume Vg becomes smaller than the clearance volume Vf, the loss when the gas is sucked is reduced, and the efficiency of the compressor is enhanced.

[0037] If the columnar portion 33a is provided such that the top clearance volume Vg becomes smaller than the clearance volume Vf as shown in Fig. 7, the loss when the gas is sucked is reduced and the efficiency of the compressor is enhanced as compared with a case where the columnar portion 33a is provide on the vane 33 such that the fictitious center surface Pa matches with the fictitious surface Pb as shown in Fig. 8.

[0038] It is preferable that a small dip is provided in the upper end surface 33d of the vane 33 as a mark 33h as shown in Fig. 9 for example. According to this, the mark functions as a remarque for determining upper and lower directions when the compressor is assembled, and a loss caused by erroneous assembling operation can be reduced. The mark 33h may be provided in a lower end surface 33e instead of the upper end surface 33d of the vane 33.

[0039] This compressor is suitable when CO_2 refrigerant is used as the working fluid. The CO_2 refrigerant has a large pressure difference, a leakage loss and a sliding loss are high, but if the piston 32 and the vane 33 of this embodiment are employed, the efficiency and the reliability of the compressor can be enhanced more effectively.

[0040] In this compressor, as the working fluid, it is possible to use a refrigerant having hydrofluoroolefin as a base ingredient having a carbon-carbon double bond in which hydrofluorocarbon having no double bond is mixed. Since this refrigerant does not include chlorine, the refrigerant is extremely severe in terms of reliability of the sliding portions but the reliability and efficiency can be enhanced more effectively by employing the piston 32 and the vane 33 of the embodiment. Further, since this refrigerant has a low warming potential and is free from ozone destruction, it is possible to constitute an earth-friendly air-conditioning cycle.

[0041] According to the rotary compressor of the present invention, gas and oil are less prone to leak from the high pressure-side space to the low pressure-side space of the compression chamber, and the rotary compressor is suitable for a hot water supply apparatus, air conditioner, a refrigerator-freezer, a dehumidifier and the like.

Claims

1. A rotary compressor comprising:

   a cylinder;
   an eccentric portion of a shaft disposed in the cylinder;
   a piston fitted to the eccentric portion;
   a slot provided in the cylinder;
   a groove formed in the piston; and
   a vane having a columnar portion on its one of ends; in which
   a compression chamber is formed between the cylinder and the piston,
   the columnar portion is swingably fitted into the groove,
   the vane reciprocates in the slot as the shaft rotates, and
   the compression chamber is divided into a high pressure-side space and a low pressure-side space by the vane, wherein
   the groove is formed into a columnar shape having an arc whose angle is greater than 180°, and a fictitious extension of the arc is located inside of an outer periphery fictitious line of the piston.

2. The rotary compressor according to claim 1, wherein a body of the vane includes
   one of side surfaces facing the low pressure-side space,
   the other side surface facing the high pressure-side space,
   an upper end surface which is connected to an upper end of the one side surface and an upper end of the other side surface, and
   a lower end surface which is connected to a lower end of the one side surface and a lower end of the other side surface,
   a low pressure-side constriction is provided between the one side surface and the columnar portion,
   a high pressure-side constriction is provided between the other side surface and the columnar portion,
   in a state where the piston is in contact with the slot, a top clearance volume is formed by the high pressure-side constriction, the piston and the cylinder,
   a clearance volume is formed by the low pressure-side constriction, the piston and the cylinder, and
   the top clearance volume is smaller than the clearance volume.

3. The rotary compressor according to claim 2, wherein a fictitious surface which passes through a center of the columnar portion and which is in parallel to a fictitious center surface is deviated toward the other side surface with respect to the fictitious center surface of the pair of the side surfaces.

4. The rotary compressor according to claim 2 or 3, wherein the high pressure-side constriction is smaller than the low pressure-side constriction.

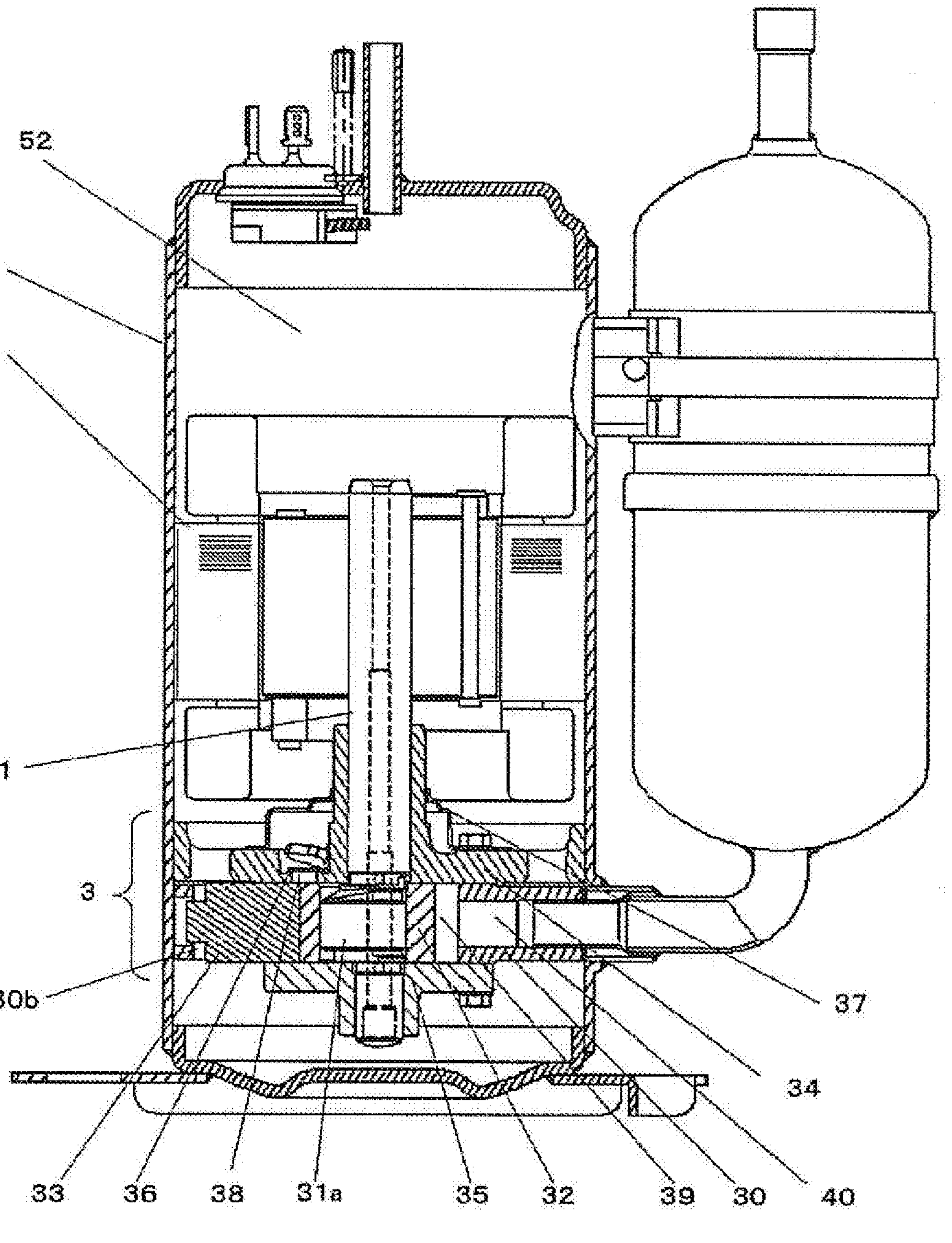
5. The rotary compressor according to claim 2, wherein a mark is provided on the upper end surface or the lower end surface.

6. The rotary compressor according to claim 5, wherein the mark is a dip.

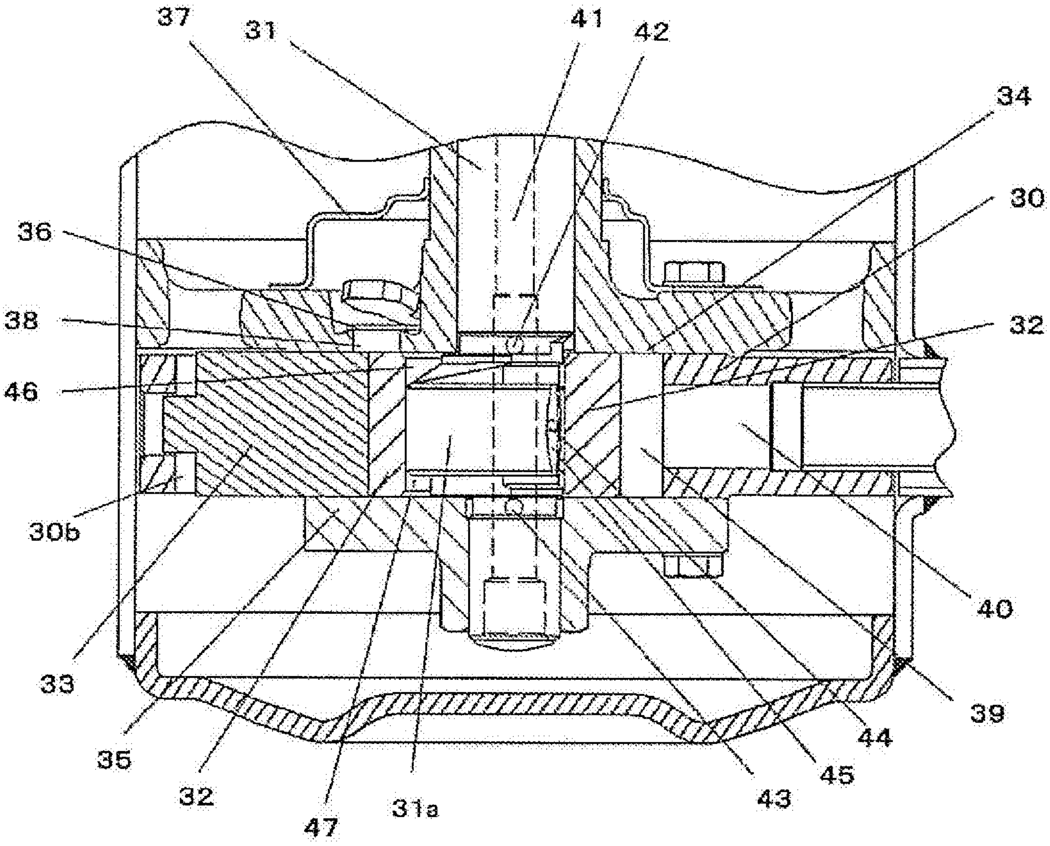
7. The rotary compressor according to any one of claims 1 to 6, a CO_2 refrigerant is used as the working fluid.

8. The rotary compressor according to any one of claims 1 to 6, wherein a refrigerant having hydrofluoroolefin as a base ingredient having a carbon-carbon double bond in which hydrofluorocarbon having no double bond is mixed is used as the working fluid.

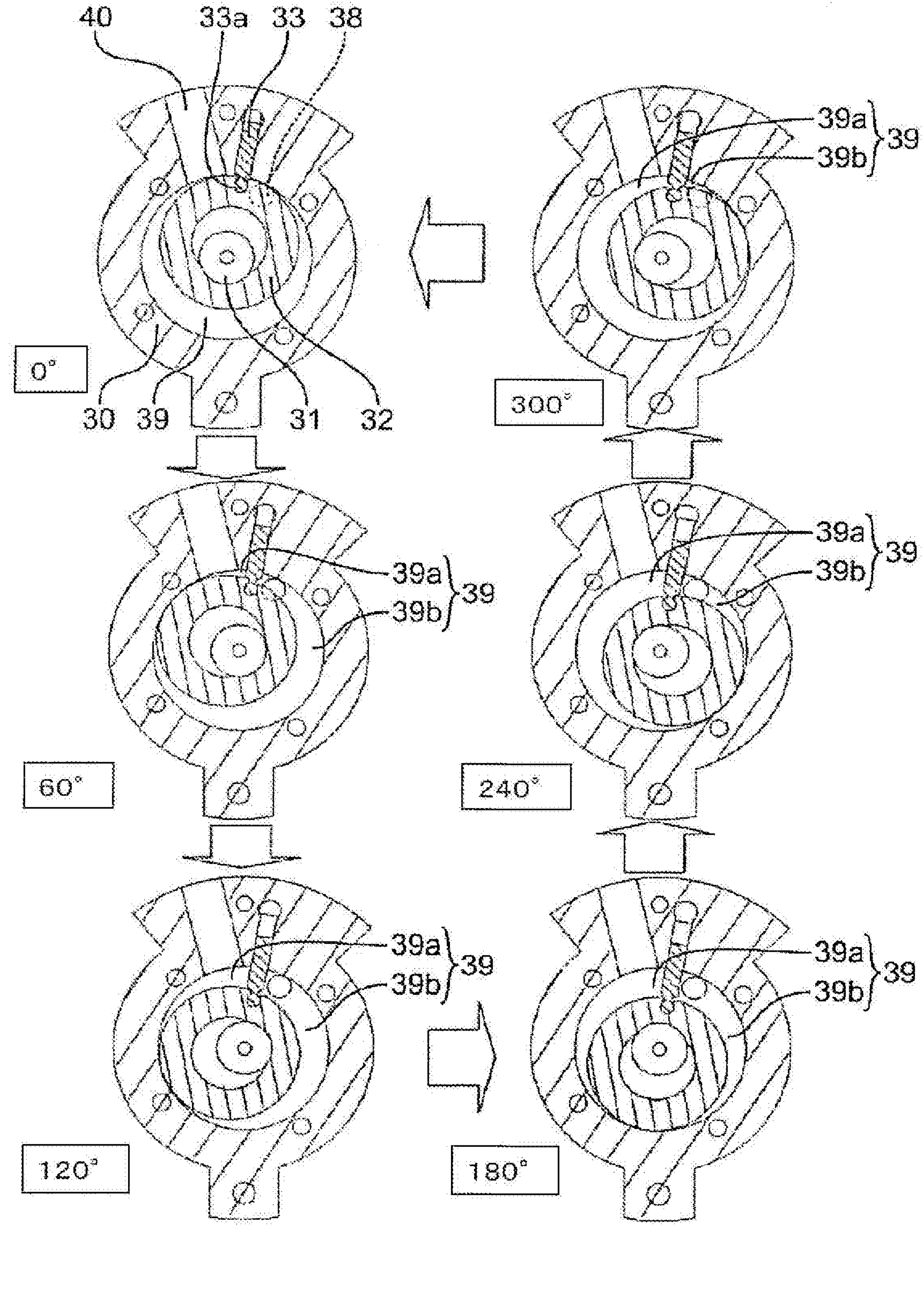
[Fig. 1]



[Fig. 2]



[Fig. 3]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33a
33
38
0°
30
39
31
32
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39a
39b
39
60°
39a
39b
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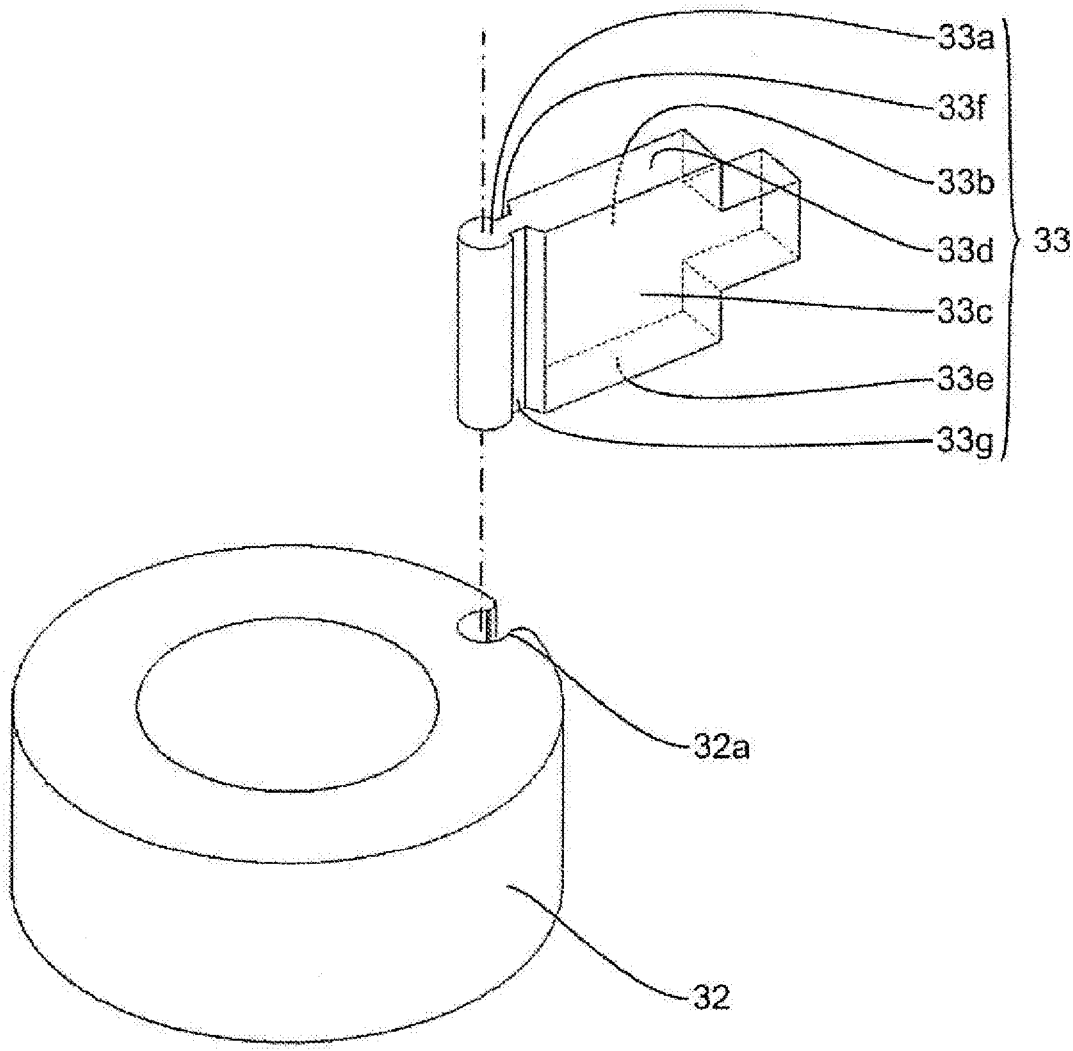
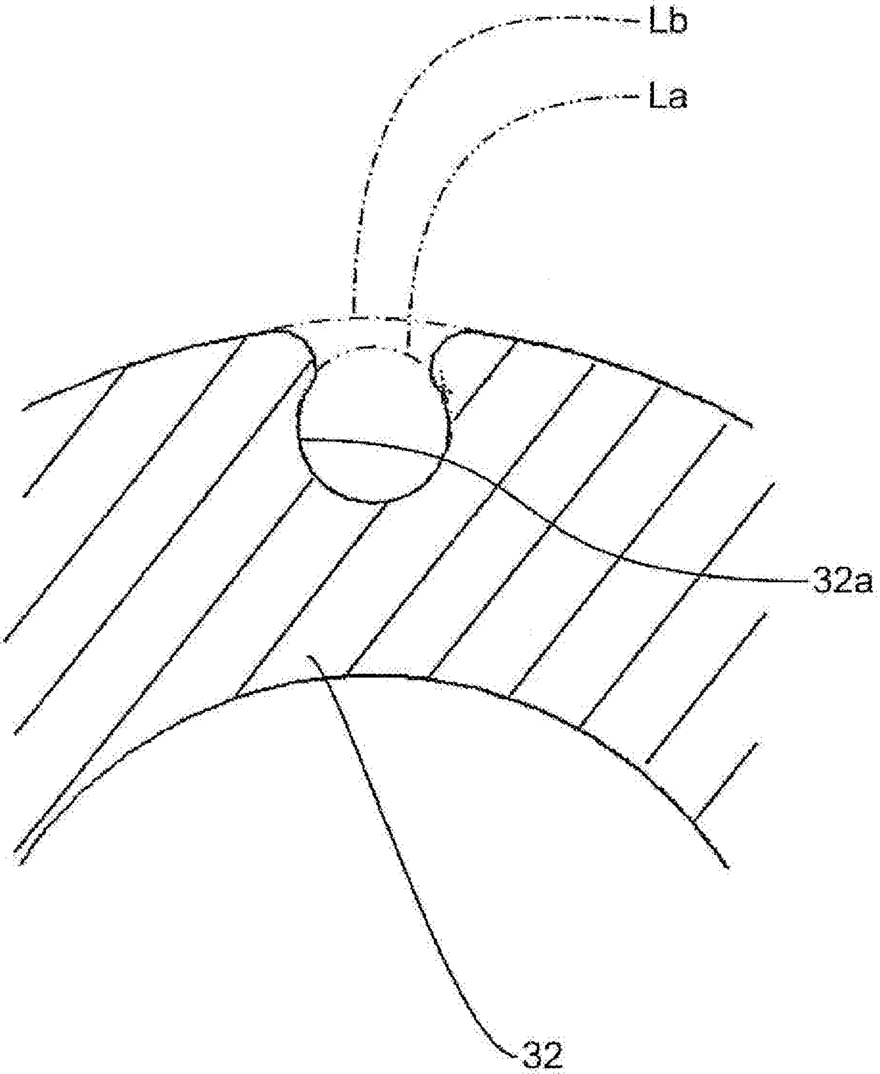
240°
39a
39b
39
120°
39a
39b
39
180°
39a
39b
39

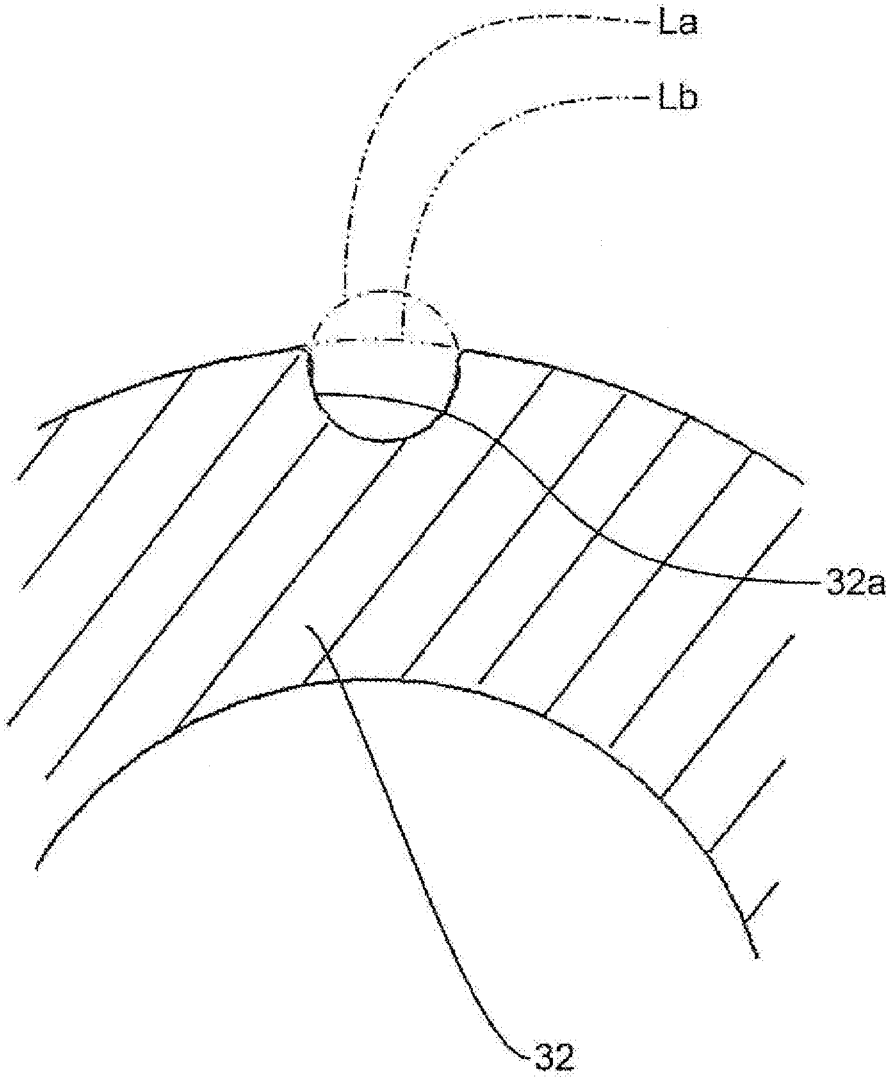
[Fig. 4]



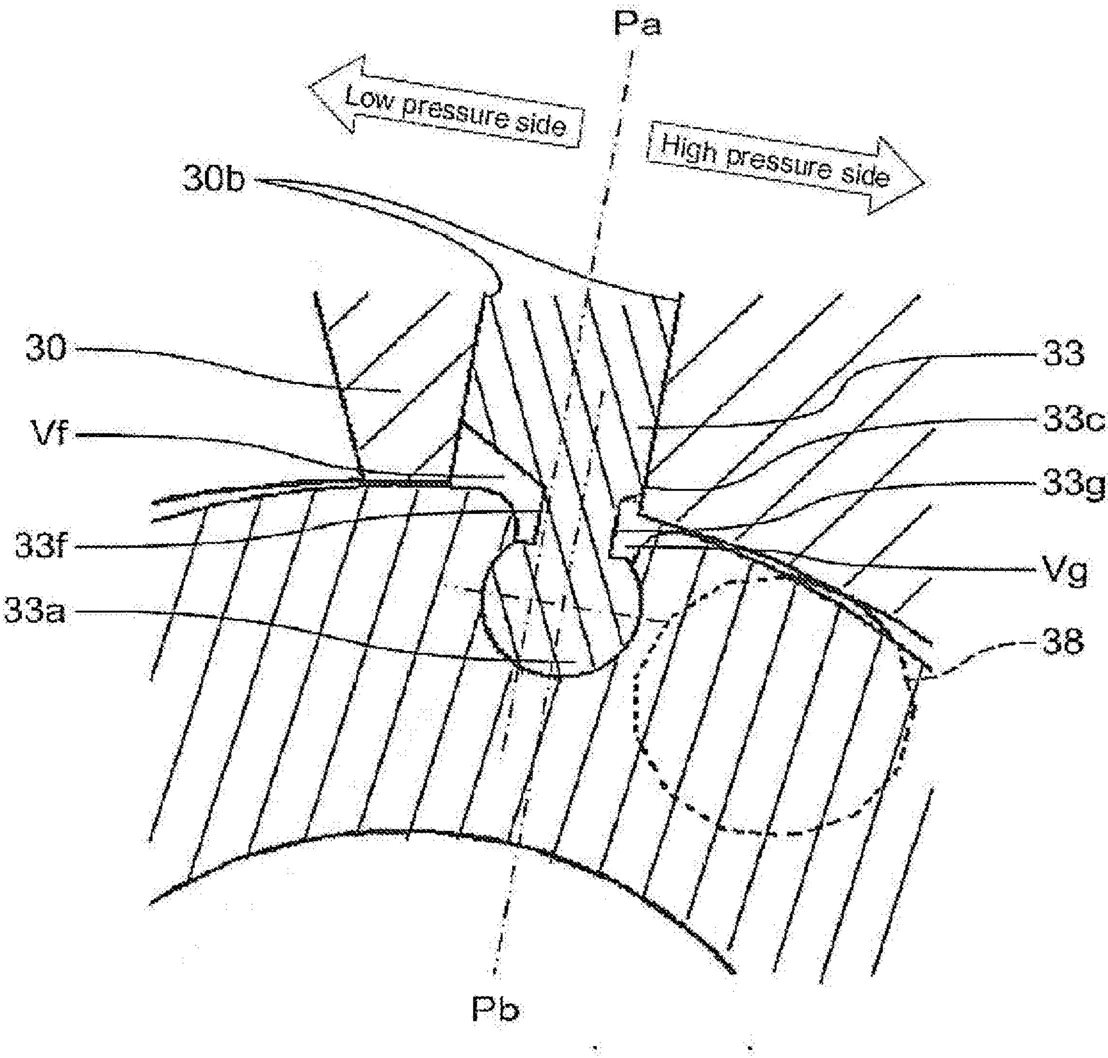
[Fig. 5]



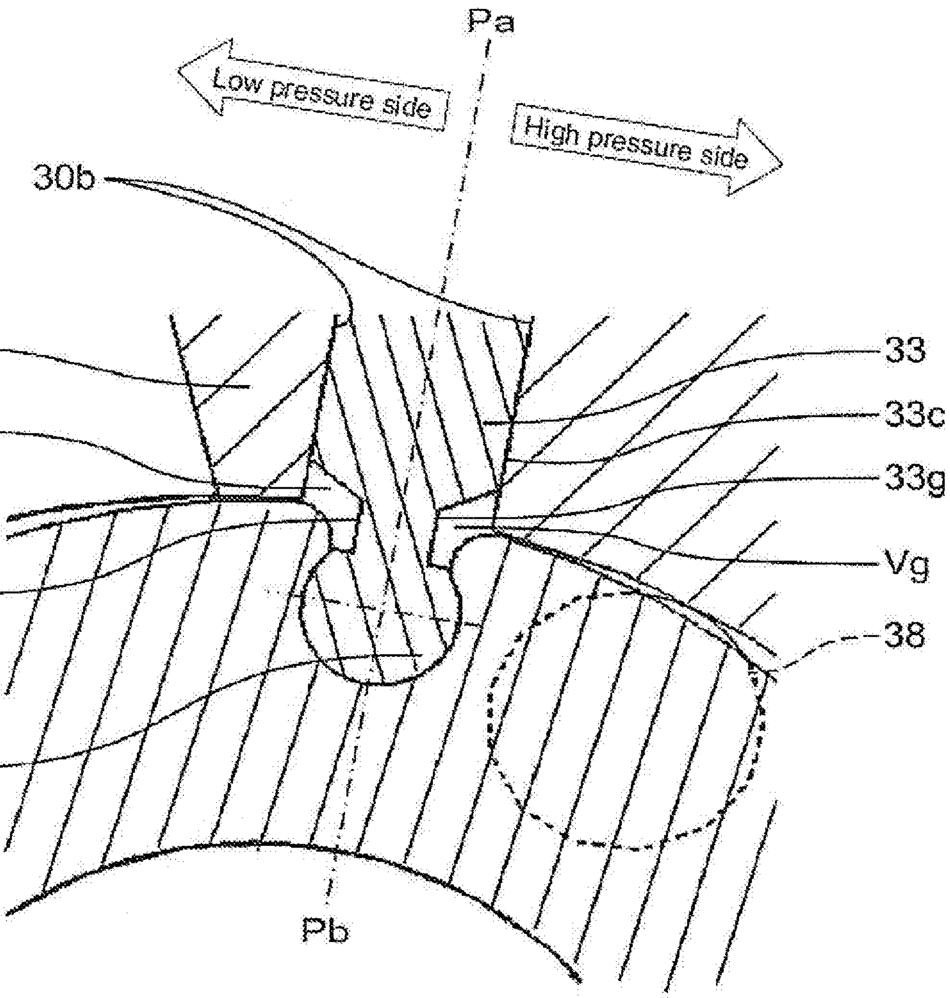
[Fig. 6]



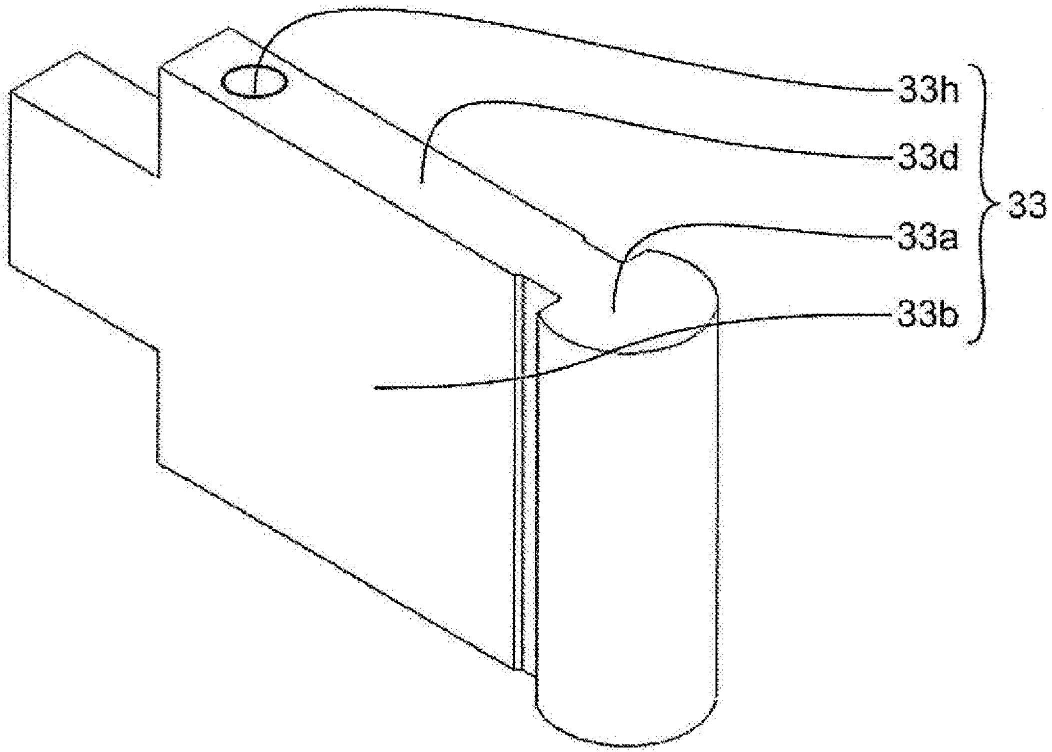
[Fig. 7]


Pa
Low pressure side
High pressure side
30b
30
Vf
33f
33a
33
33c
33g
Vg
38
Pb

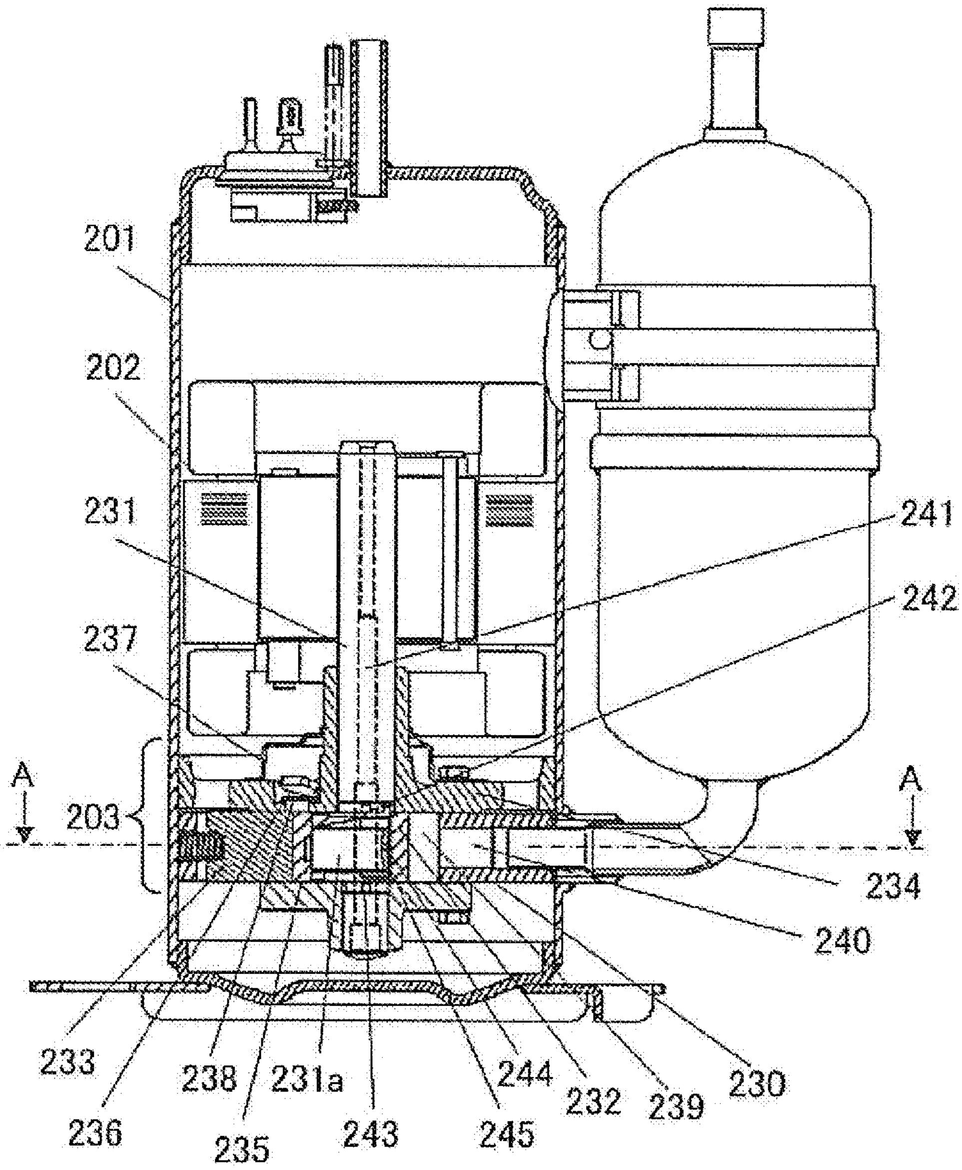
[Fig. 8]


Pa
Low pressure side
High pressure side
30b
30
Vf
33f
33a
33
33c
33g
Vg
38
Pb

[Fig. 9]



[Fig. 10]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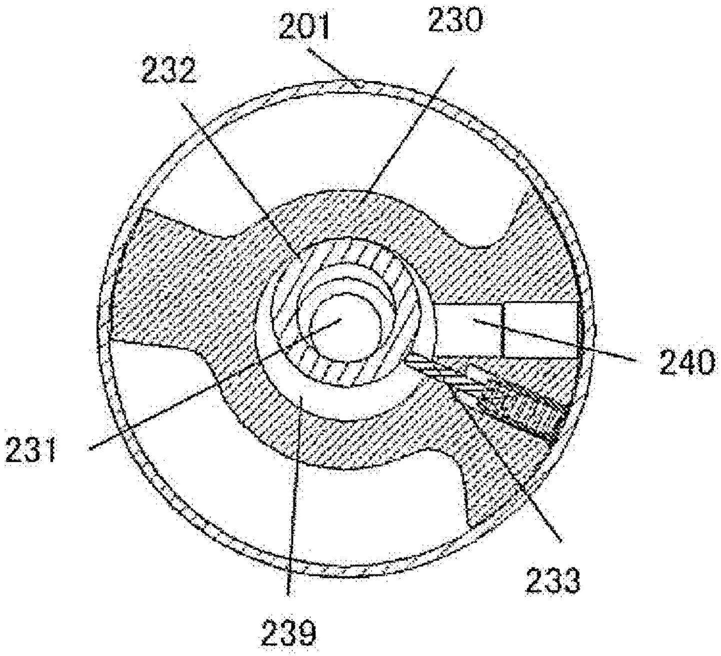
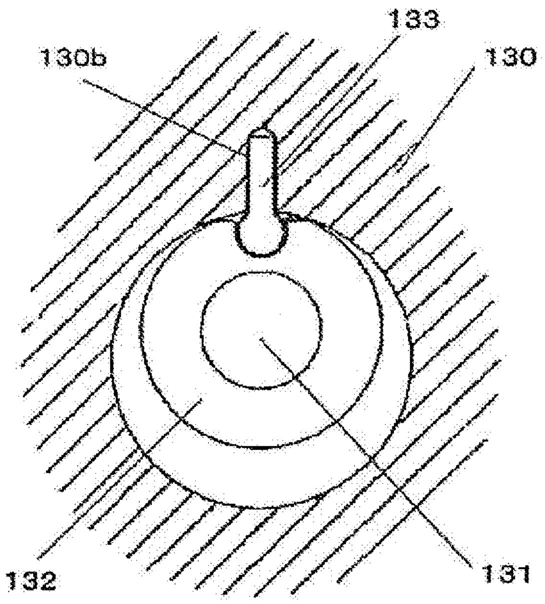
[Fig. 11]



[Fig. 12]



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Patent documents cited in the description

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