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(72) Inventors:
• **MAEDA, Katsuya**
Tokyo 100-8310 (JP)
• **KAMIKAWA, Masaaki**
Tokyo 100-8310 (JP)
• **ITO, Takeshi**
Tokyo 100-8310 (JP)

(71) Applicant: **Mitsubishi Electric Corporation**
Chiyoda-ku
Tokyo 100-8310 (JP)

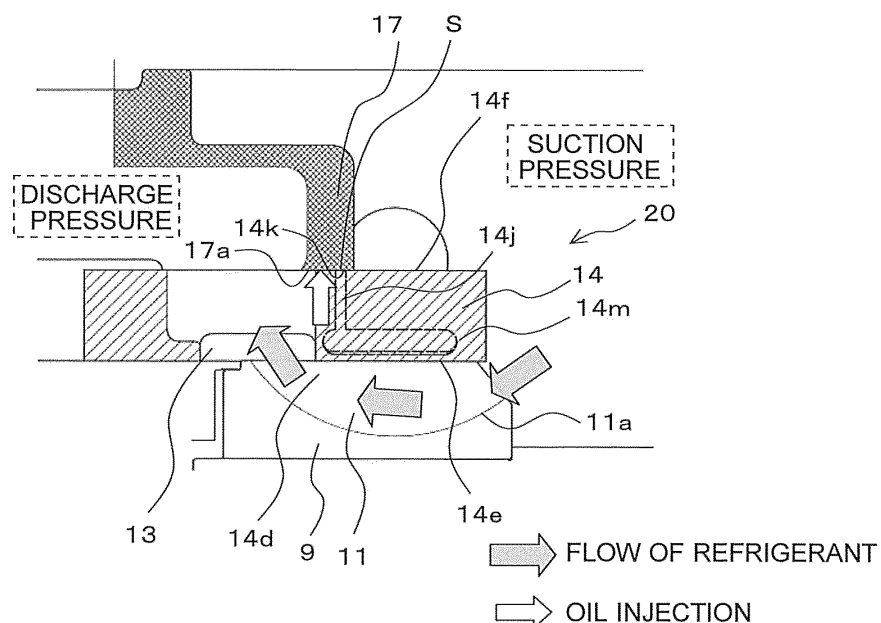
(74) Representative: **Pfenning, Meinig & Partner mbB**
Patent- und Rechtsanwälte
Theresienhöhe 11a
80339 München (DE)

(54) **SCREW COMPRESSOR**

(57) A screw compressor 1 includes a casing body 8, a screw rotor 9 disposed to rotate inside the casing body 8, a slide valve 14 movably provided between the casing body 8 and the screw rotor 9, a high-low pressure partition wall 17 provided to face a back surface side 14f of the slide valve 14 and configured to divide an interior

of the casing body 8 into a discharge pressure space and a suction pressure space, and an injection mechanism 20 configured to supply oil to a gap between the high-low pressure partition wall 17 and the back surface side of the slide valve 14 to seal the gap.

FIG. 5



Description

Technical Field

[0001] The present invention relates to a screw compressor, and particularly to a screw compressor including a slide valve.

Background Art

[0002] Conventional screw compressors each include a casing body and a screw rotor rotatably housed in a cylinder chamber formed inside the casing body. Also, among the conventional screw compressors, a screw compressor further includes a slide valve that controls the operation capacity by allowing a part of refrigerant introduced into a compression chamber to be bypassed to a low-pressure space during a compression process (see Patent Literature 1, for example). The slide valve is disposed on an outer circumference of the screw rotor, and is movable in the axial direction of the screw rotor.

[0003] As described above, the slide valve is provided on the outer circumference of the screw rotor to be movable in the axial direction of the screw rotor, and a gap opens up between a casing body side (hereinafter referred to as the back surface side) of the slide valve and a slide valve side of the casing body.

[0004] Further, a screw rotor-side surface (hereinafter referred to as the inner circumferential surface) of the slide valve is normally disposed to be located outside in the radial direction of an inner circumferential surface of the cylinder chamber to prevent mutual contact between the slide valve and the screw rotor. Consequently, the gap between the inner circumferential surface of the slide valve and the outer circumferential surface of the screw rotor is greater than the gap between an inner circumferential surface of the cylinder and the outer circumferential surface of the screw rotor.

[0005] In the screw compressor, the back surface side and the inner circumferential surface side of the slide valve each have a structurally necessary gap, as described above. Through these gaps, more than a small amount of refrigerant inevitably leaks from a discharge pressure (high pressure) side to a suction pressure (low pressure) side, degrading performance.

[0006] A technique of eliminating or reducing the refrigerant leakage from the inner circumferential surface of the slide valve includes a covering member provided to the inner circumferential surface of the slide valve to fill the gap between the inner circumferential surface of the slide valve and the outer circumferential surface of the screw rotor (see Patent Literature 2, for example).

Citation List

Patent Literature

[0007]

Patent Literature 1: Japanese Unexamined Patent Application Publication No. 2004-316586

Patent Literature 2: Japanese Patent No. 4103709

5 Summary of Invention

Technical Problem

[0008] With the covering member provided to the inner circumferential surface of the slide valve, the technique of Patent Literature 2 described above eliminates or reduces the gap between the inner circumferential surface of the slide valve and the outer circumferential surface of the screw rotor, thereby eliminating or reducing the refrigerant leakage from the inner circumferential surface side of the slide valve, as described above. The technique of Patent Literature 2, however, does not eliminate or reduce the refrigerant leakage from the gap on the back surface side of the slide valve.

[0009] The casing body is formed with a partition wall that separates the discharge pressure (high pressure) side and the suction pressure (low pressure) side from each other (hereinafter referred to as the high-low pressure partition wall), and an inner circumferential side of the high-low pressure partition wall faces the back surface side of the slide valve. Further, a gap is opened up between the back surface of the slide valve and an inner circumferential surface of the high-low pressure partition wall to prevent mutual contact with each other. From this gap, the refrigerant leaks owing to the pressure difference between the discharge pressure (high pressure) and the suction pressure (low pressure) at a boundary of the high-low pressure partition wall. The pressure difference tends to be increased particularly in high-pressure refrigerant, such as R410A, substantially degrading performance due to the refrigerant leakage from the back surface side of the slide valve.

[0010] The present invention has been made to solve the above-described problems, and aims to provide a highly efficient screw compressor that eliminates or reduces the refrigerant leakage from the gap between the back surface of the slide valve and the inner circumferential surface of the high-low pressure partition wall. Solution to Problem

[0011] A screw compressor according to an embodiment of the present invention includes a casing body, a screw rotor disposed to rotate inside the casing body, a slide valve movably provided between the casing body and the screw rotor, a partition wall provided to face a back surface side of the slide valve and configured to divide an interior of the casing body into a discharge pressure space and a suction pressure space, and an injection mechanism configured to supply oil to a gap between an inner circumferential surface of the partition wall and the back surface side of the slide valve to seal the gap.

Advantageous Effects of Invention

[0012] An embodiment of the present invention eliminates or reduces the refrigerant leakage from the gap between the back surface of the slide valve and the inner circumferential surface of the high-low pressure partition wall, and improves the performance of the screw compressor.

Brief Description of Drawings

[0013]

[Fig. 1] Fig. 1 is a schematic configuration diagram of a refrigeration apparatus including a screw compressor according to Embodiment 1 of the present invention.

[Fig. 2] Fig. 2 is a schematic configuration diagram of the screw compressor according to Embodiment 1 of the present invention.

[Fig. 3] Fig. 3 is an illustrative diagram of an operation of a conventional screw compressor illustrated for comparison with an operation of Embodiment 1.

[Fig. 4] Fig. 4 is a diagram illustrating a refrigerant leakage passage of a conventional slide valve, viewed from a back surface side of the slide valve, illustrated for comparison with a slide valve of Embodiment 1.

[Fig. 5] Fig. 5 is an illustrative diagram of the operation of the screw compressor according to Embodiment 1 of the present invention.

[Fig. 6] Fig. 6 is a perspective view illustrating an oil passage of the slide valve of the screw compressor according to Embodiment 1 of the present invention, with the slide valve viewed from a back surface side of the slide valve.

[Fig. 7] Fig. 7 is a perspective view of the slide valve of the screw compressor according to Embodiment 1 of the present invention, with the slide valve viewed from an inner surface side of the slide valve.

[Fig. 8] Fig. 8 is a plan view of the slide valve of the screw compressor according to Embodiment 1 of the present invention, with the slide valve viewed from the back surface side of the slide valve.

[Fig. 9] Fig. 9 is a view of the slide valve in Fig. 6, with the slide valve vertically reversed and viewed in the direction of arrow X (in a direction in which a sump 14m is visible).

[Fig. 10] Fig. 10 is a sectional view taken along line A-A in Fig. 9.

[Fig. 11] Fig. 11 is a sectional view taken along line B-B in Fig. 9.

[Fig. 12] Fig. 12 is a schematic diagram illustrating main parts of a screw compressor according to Embodiment 2 of the present invention.

[Fig. 13] Fig. 13 is a perspective view of a slide valve of the screw compressor according to Embodiment 2 of the present invention, with the slide valve viewed

from a backside of the slide valve.

[Fig. 14] Fig. 14 is a perspective view of a slide valve of a screw compressor according to Embodiment 3 of the present invention.

[Fig. 15] Fig. 15 is an illustrative diagram of the positional relationship between a high-low pressure partition wall and screw grooves corresponding to a stop position of the slide valve of the screw compressor according to Embodiment 3 of the present invention.

[Fig. 16] Fig. 16 is a perspective view of a slide valve of a screw compressor according to Embodiment 4 of the present invention.

[Fig. 17] Fig. 17 is a diagram illustrating a structure of a slide valve of a screw compressor according to Embodiment 5 of the present invention. Description of Embodiments

Embodiment 1

[0014] Fig. 1 is a schematic configuration diagram of a refrigeration apparatus including a screw compressor according to Embodiment 1 of the present invention. As illustrated in Fig. 1, the refrigeration apparatus includes devices such as a screw compressor 1, a condenser 5, an expansion valve 6, and an evaporator 7. Further, the screw compressor 1 includes a compression unit 2, a motor 3 connected in series with the compression unit 2 to drive the compression unit 2, and an oil separator 4. In the screw compressor 1, refrigerating machine oil (hereinafter referred to as the oil) is mixed in refrigerant discharged from the compression unit 2, and thus the oil separator 4 separates the refrigerant and the oil from each other. The separated oil is returned to the compression unit 2 by the pressure difference. Although Fig. 1 illustrates the specifications of the screw compressor 1 including the oil separator 4 inside the screw compressor 1, the oil separator 4 may be configured to be disposed separately outside the screw compressor 1.

[0015] Fig. 2 is a schematic configuration diagram of the screw compressor according to Embodiment 1 of the present invention.

[0016] As illustrated in the schematic configuration in Fig. 2, the screw compressor includes a tubular casing body 8, a screw rotor 9 housed inside the casing body 8, and the motor 3 that drives the screw rotor 9 to rotate. The motor 3 is formed of a stator 3a inscribed in and fixed to the casing body 8 and a motor rotor 3b disposed inside the stator 3a. The screw rotor 9 and the motor rotor 3b are both disposed on the same axis and fixed to a screw shaft 10.

[0017] Further, the screw rotor 9 has an outer circumferential surface formed with a plurality of helical grooves (screw grooves) 11a, and is coupled to and driven to rotate by the motor rotor 3b fixed to the screw shaft 10. Further, the space inside the screw grooves 11a is surrounded by an inner tubular surface of the casing body 8 and a pair of gate rotors (not illustrated) that are in

meshing engagement with the screw grooves 11a, thereby forming a compression chamber 11. Further, the interior of the casing body 8 is divided into a discharge pressure side and a suction pressure side by a high-low pressure partition wall 17. The high-low pressure partition wall 17 is provided to the casing body 8 to face a casing body 8 side of a later-described slide valve 14. Further, the discharge pressure side of the casing body 8 is formed with a pair of discharge ports 13, which open to a discharge chamber 12.

[0018] Further, the casing body 8 includes the slide valve 14. The slide valve 14 is connected to a rod 15 of a driving device 16, and is movable in the axial direction of the screw rotor 9. The slide valve 14, which forms a part of the discharge ports 13, is a mechanism that changes a discharge start (compression completion) position of high-pressure gas compressed in the compression chamber 11, thereby changing a discharge opening time and changing an internal volume ratio.

[0019] Herein, the internal volume ratio refers to the ratio between the volume of the compression chamber 11 at suction completion (compression start) time and the volume of the compression chamber 11 immediately before discharge. Although two or more slide valves 14 may be provided, the illustration of the slide valves 14 other than one is omitted. In the following, the casing body 8 side and a screw rotor 9 side of the slide valve 14 will be referred to as the "back surface side" and the "inner circumferential side," respectively.

[0020] A description will be given below of a conventional screw compressor for comparison with the screw compressor of Embodiment 1.

[0021] Fig. 3 is an illustrative diagram of an operation of the conventional screw compressor illustrated for comparison with an operation of Embodiment 1. Further, Fig. 4 is a diagram illustrating a refrigerant leakage passage of a conventional slide valve illustrated for comparison with the slide valve of Embodiment 1, with the slide valve viewed from a back surface side.

[0022] As described above, the conventional configuration allows a slide valve 140 provided inside a casing body 80 to move in the axial direction of a screw rotor 90. Thus, a gap opens up between a back surface 140a of the slide valve 140 and an inner circumferential surface 170a of a high-low pressure partition wall 170, which is a part of the casing body 80. Herein, the high-low pressure partition wall 170 is located at a position separating a discharge pressure (high pressure) side and a suction pressure (low pressure) side from each other. Consequently, refrigerant leaks from the gap, as indicated by an arrow in Fig. 3, degrading performance.

[0023] Embodiment 1, on the other hand, has the following configuration.

[0024] Fig. 5 is an illustrative diagram of an operation of the screw compressor according to Embodiment 1 of the present invention. Further, Fig. 6 is a perspective view illustrating an oil passage of the slide valve of the screw compressor according to Embodiment 1 of the

present invention, with the slide valve viewed from a back surface side of the slide valve.

[0025] As illustrated in Figs. 5 and 6, the slide valve 14 of Embodiment 1 includes an injection mechanism 20 that injects the oil to a gap between sealing surfaces S, which define the gap between a back surface side 14f of the slide valve 14 and an inner circumferential surface 17a of the high-low pressure partition wall 17.

[0026] The injection mechanism 20 will be described in detail below.

[0027] Fig. 7 is a perspective view of the slide valve of the screw compressor according to Embodiment 1 of the present invention, with the slide valve viewed from an inner surface side of the slide valve. Fig. 8 is a plan view of the slide valve of the screw compressor according to Embodiment 1 of the present invention, with the slide valve viewed from the back surface side of the slide valve. Fig. 9 is a view of the slide valve in Fig. 6, with the slide valve vertically reversed and viewed in the direction of arrow X (in a direction in which a sump 14m is visible). Fig. 10 is a sectional view taken along line A-A in Fig. 9. Fig. 11 is a sectional view taken along line B-B in Fig. 9. In Figs. 10 and 11, arrows indicate oil passages.

[0028] Herein, a description will be given first of a basic structure of the slide valve 14 and then of the injection mechanism 20. As illustrated in these drawings, the slide valve 14 includes a valve body 14a, a guide portion 14b, and a connecting portion 14c that connects the valve body 14a and the guide portion 14b. A gap communicating with the discharge ports 13 is opened up between the valve body 14a and the guide portion 14b to form a part of the discharge ports 13. Further, in the valve body 14a, a discharge port end portion 14d of an inner circumferential side 14e on a side of the discharge ports 13 forms a part of the discharge ports 13, and determines the time of discharging the compressed refrigerant. That is, the discharge port end portion 14d is moved in the axial direction of the screw rotor 9 at the same as the slide valve 14 is moved in the axial direction of the screw rotor 9, thereby changing the internal volume ratio. Further, the guide portion 14b has a connecting hole 15a, to which the rod 15 is connected, as illustrated in Fig. 2.

[0029] As illustrated in Fig. 11, the slide valve 14 of Embodiment 1 is formed with an oil feed hole 14g passing through the slide valve 14 to inject the high-pressure oil to the screw rotor 9. In the oil feed hole 14g, a screw rotor portion oil supply port 14i serving as an oil inflow-side opening is located on the back surface side 14f of the slide valve 14, and a screw rotor portion oil feed port 14h serving as an oil outflow-side opening is located on the inner circumferential side 14e of the slide valve 14. The hole shape and the number of the oil feed hole 14g are not limited.

[0030] Further, as illustrated in Figs. 5, 8, 9, and 10, the slide valve 14 of Embodiment 1 is formed with an oil feed hole 14j to inject the oil to the gap (between the sealing surfaces S) between the high-low pressure partition wall 17 and the back surface side 14f of the slide

valve 14. In the oil feed hole 14j, a slide valve back surface portion oil supply port 141 serving as an oil inflow-side opening of the oil feed hole 14j is located on the back surface side 14f of the slide valve 14. Further, as illustrated in Fig. 5, a slide valve back surface portion oil feed port 14k serving as an oil outflow-side opening of the oil feed hole 14j is located in a portion, facing the high-low pressure partition wall 17, of the back surface side 14f of the slide valve 14, that is, within the range of the sealing surfaces S. The hole shape and the number of the oil feed hole 14j are not limited. The oil feed hole 14j corresponds to a first oil feed hole of the present invention.

[0031] Further, the slide valve 14 is formed with the sump 14m recessed on the back surface side 14f. As illustrated in Fig. 9, the screw rotor portion oil supply ports 14i and the slide valve back surface portion oil supply port 141 are located in the sump 14m.

[0032] Flows of the oil will be described below.

[0033] In the screw compressor 1 according to Embodiment 1, the high-pressure oil is injected to a gap between the inner circumferential side 14e of the slide valve 14 and a portion facing the inner circumferential side 14e and a gap between the back surface side 14f of the slide valve 14 and a portion facing the back surface side 14f to eliminate or reduce the refrigerant leakage from the screw rotor 9 and prevent burning.

[0034] Herein, the injection on the inner circumferential side 14e of the slide valve 14 will first be described. As illustrated in Fig. 1, the high-pressure oil in the oil separator 4 is first supplied by the pressure difference to the sump 14m provided in the slide valve 14 via a flow passage (not illustrated) inside the casing body 8. Subsequently, the oil supplied to the sump 14m is caused by the pressure difference to flow into the oil feed hole 14g from the screw rotor portion oil supply port 14i provided inside the sump 14m, and passes through the oil feed hole 14g. Then, the high-pressure oil is injected to the screw rotor 9 from the screw rotor portion oil feed port 14h.

[0035] The injection on the back surface side 14f of the slide valve 14 will next be described. Embodiment 1 is characterized in that the high-pressure oil is injected to a gap between the sealing surfaces S from the back surface side 14f. Firstly, the above-described oil in the sump 14m distributed by the oil separator 4 is used. The high-pressure oil in the sump 14m is caused by the pressure difference to flow into the oil feed hole 14j from the slide valve back surface portion oil supply port 141 provided inside the sump 14m, and passes through the oil feed hole 14g. Subsequently, the oil is injected to the gap between the sealing surfaces S from the slide valve back surface portion oil feed port 14k. The oil feed hole 14g formed in the slide valve 14 corresponds to a part of the injection mechanism 20 of the present invention.

[0036] In Embodiment 1, the screw rotor portion oil supply ports 14i and the slide valve back surface portion oil supply port 141 are set to be located inside the same sump 14m, but are not necessarily required to have this

configuration, and may be configured to be located in separate sumps 14m. Further, Embodiment 1 basically aims to reduce the refrigerant leakage on the back surface side of the slide valve 14, and the oil feed hole 14j is also applicable to the slide valve 14 not having the oil feed hole 14g. Further, the thickness of the high-low pressure partition wall 17 may be increased to cause an opening of the oil feed hole 14j to face the high-low pressure partition wall 17 even when the slide valve 14 is moved.

[0037] As described above, Embodiment 1 includes the injection mechanism 20 that injects the oil to the gap between the sealing surfaces S to seal the sealing surfaces S, thereby eliminating or reducing the refrigerant leakage from the discharge pressure (high pressure) side to the suction pressure (low pressure) side. Consequently, the efficiency of the screw compressor 1 can be improved to contribute to energy saving.

[0038] The injection mechanism 20 is configured to have the oil feed hole 14j passing through the slide valve 14 to supply the oil flowing from the slide valve back surface portion oil supply port 141 of the oil feed hole 14j to the gap between the sealing surfaces S from the slide valve back surface portion oil feed port 14k, that is, simply configured to have a hole formed through the slide valve 14. Consequently, the injection mechanism 20 can be configured at low cost.

Embodiment 2

[0039] Embodiment 2 is different from Embodiment 1 only in the area having the oil feed hole for feeding the oil to the gap between the sealing surfaces S.

[0040] Fig. 12 is a schematic diagram illustrating main parts of a screw compressor according to Embodiment 2 of the present invention. Fig. 13 is a perspective view of a slide valve of the screw compressor according to Embodiment 2 of the present invention, with the slide valve viewed from a backside of the slide valve. In Embodiment 2, differences from Embodiment 1 will be described, and configurations not described in Embodiment 2 are similar to those of Embodiment 1.

[0041] In Embodiment 2, the oil feed hole 14j formed in the slide valve 14 in Embodiment 1 is eliminated, and an oil feed hole 17b is formed in the high-low pressure partition wall 17, which forms a part of the casing body 8. Further, a configuration is designed in which the inner circumferential surface 17a of the high-low pressure partition wall 17 has a slide valve back surface portion oil feed port 17c serving as an oil outflow-side opening of the oil feed hole 17b, to inject the high-pressure oil flowing into the oil feed hole 17b to the gap between the sealing surfaces S from the slide valve back surface portion oil feed port 17c.

[0042] The position of an oil inflow-side opening of the oil feed hole 17b is not particularly limited as long as the oil inflow-side opening of the oil feed hole 17b is formed at a position at which the oil inflow-side opening is capable of receiving the oil in the screw compressor 1. Further,

the hole shape and the number of the oil feed hole 17b are not limited. The oil feed hole 17b corresponds to a second oil feed hole of the present invention.

[0043] As described above, according to Embodiment 2, the high-pressure oil is injected to the gap between the sealing surfaces S from the slide valve back surface portion oil feed port 17c provided in the inner circumferential surface 17a of the high-low pressure partition wall 17. Consequently, the refrigerant leakage from the discharge pressure (high pressure) side to the suction pressure (low pressure) side in the sealing surfaces S can be eliminated or reduced, and the efficiency of the screw compressor 1 can be improved.

Embodiment 3

[0044] Embodiment 3 is different from Embodiment 1 only in that an oil groove is provided in the back surface side 14f of the slide valve 14.

[0045] Fig. 14 is a perspective view of a slide valve of a screw compressor according to Embodiment 3 of the present invention. In Embodiment 3, differences from Embodiment 1 will be described, and configurations not described in Embodiment 1 are similar to those of Embodiment 1.

[0046] In Embodiment 3, the back surface side 14f of the valve body 14a of the slide valve 14 is formed with an oil groove 18 extending in the circumferential direction of the back surface side 14f to efficiently spread the oil injected to the gap between the sealing surfaces S in Embodiment 1 over the sealing surfaces S. The position of processing the oil groove 18 is set to correspond within the range of the sealing surfaces S. The oil groove 18 corresponds to a first oil groove of the present invention. The sectional shape and the number of the above-described oil groove 18 are not limited.

[0047] Fig. 15 is an illustrative diagram of the positional relationship between the high-low pressure partition wall and the screw grooves corresponding to a stop position of the slide valve of the screw compressor according to Embodiment 3 of the present invention. As illustrated in Fig. 15, the oil groove 18 may extend across more than one of the screw grooves 11a, depending on a sliding position of the slide valve 14. The pressures in the screw grooves 11a are different from each other. When the oil groove 18 thus extends across more than one of the screw grooves 11a, the oil groove 18 may allow communication between a high pressure-side screw groove 11a and a low pressure-side screw groove 11a and cause refrigerant leakage from the high-pressure side to the low-pressure side. To prevent the oil groove 18 from thus forming a refrigerant leakage passage, the oil groove 18 is not limited to the configuration in which the oil groove 18 is provided over the entirety in the circumferential direction of the back surface side 14f of the slide valve 14, and an area not processed to form a groove may be left in the back surface side 14f.

[0048] With the oil groove 18 thus provided, the oil in-

jected to the gap between the sealing surfaces S from the slide valve back surface portion oil feed port 14k efficiently spreads over the sealing surfaces S.

[0049] The area having the oil groove 18 is not limited to the back surface side 14f of the slide valve 14, and may be the inner circumferential surface 17a of the high-low pressure partition wall 17 forming a part of the sealing surfaces S, or may be both the back surface side 14f and the inner circumferential surface 17a. When an oil groove is to be provided in the inner circumferential surface 17a of the high-low pressure partition wall 17, the oil groove is formed to extend in the circumferential direction of the inner circumferential surface 17a similarly to the oil groove 18. The oil groove thus provided in the inner circumferential surface 17a of the high-low pressure partition wall 17 corresponds to a third oil groove of the present invention.

[0050] As described above, according to Embodiment 3, effects similar to those of Embodiment 1 are obtained, and the following effects are obtained. That is, the oil injected to the gap between the sealing surfaces S from the back surface side 14f of the slide valve 14 is more likely to spread over the entire circumference of the back surface of the slide valve through the oil groove 18. With the oil groove 18, Embodiment 3 is more capable of eliminating or reducing the refrigerant leakage from the discharge pressure (high pressure) side to the suction pressure (low pressure) side in the sealing surfaces S than in a case in which the configuration of Embodiment 1 (the configuration having the slide valve back surface portion oil feed port 14k) is implemented alone. Consequently, the efficiency of the screw compressor 1 can be further improved.

Embodiment 4

[0051] Embodiment 4 corresponds to a configuration combining the configuration of Embodiment 2 and the configuration of Embodiment 3. That is, the oil groove 18 is provided to the slide valve 14 of the screw compressor 1 of Embodiment 2, which is characterized in that the oil is injected to the gap between the sealing surfaces S from the side of the high-low pressure partition wall 17. Features such as the shape of the oil groove 18 and the position at which the oil groove 18 is formed are similar to those of Embodiment 3.

[0052] Fig. 16 is a perspective view of a slide valve of a screw compressor according to Embodiment 4 of the present invention. In Embodiment 4, differences from Embodiment 2 will be described, and configurations not described in Embodiment 2 are similar to those of Embodiment 2.

[0053] The oil injected to the gap between the sealing surfaces S from the side of the high-low pressure partition wall 17, as indicated by a solid-white arrow in Fig. 16, flows along the oil groove 18, as indicated by solid arrows, and efficiently spreads over the sealing surfaces S.

[0054] As described above, according to Embodiment

4, effects similar to those of Embodiment 2 are obtained, and the following effects are obtained. That is, the oil injected to the gap between the sealing surfaces S from the side of the high-low pressure partition wall 17 is more likely to spread over the entire circumference of the back surface of the slide valve through the oil groove 18. With the action of the oil groove 18, Embodiment 4 is more capable of eliminating or reducing the refrigerant leakage from the discharge pressure (high pressure) side to the suction pressure (low pressure) side in the sealing surfaces S than in a case in which the configuration of Embodiment 2 (the configuration in which the oil is injected to the gap between the sealing surfaces S from the side of the high-low pressure partition wall 17) is implemented alone. Consequently, the efficiency of the screw compressor 1 can be further improved.

Embodiment 5

[0055] Embodiment 5 is characterized in allowing communication between the sump 14m and the oil groove 18.

[0056] Fig. 17 is a diagram illustrating a structure of a slide valve of a screw compressor according to Embodiment 5 of the present invention.

[0057] The slide valve 14 of Embodiment 1 illustrated in Fig. 9 described above is configured to cause the oil in the sump 14m to pass through the valve body 14a with the oil feed hole 14j to inject the oil to the gap between the sealing surfaces S from the slide valve back surface portion oil feed port 14k.

[0058] Embodiment 5, on the other hand, is configured to cause the oil to flow along the back surface side (the outer circumferential surface) of the slide valve 14 to inject the oil to the gap between the sealing surfaces S. Specifically, the oil feed hole 14j of Embodiment 1 is eliminated, and an oil groove 18a is provided to communicate with the sump 14m to inject the high-pressure oil in the sump 14m to the gap between the sealing surfaces S through the oil groove 18a. The oil groove 18a of Embodiment 5 is different from the oil groove 18 of Embodiment 3 only in that the oil groove 18 communicates with the sump 14m, and is similar to the oil groove 18 of Embodiment 3 in the other features. The oil groove 18a corresponds to a second oil groove of the present invention.

[0059] As described above, according to Embodiment 5, the high-pressure oil in the sump 14m can be caused to spread over the sealing surfaces S without the oil feed hole 14j as in Embodiments 1 to 4, which passes through the slide valve 14. Consequently, the refrigerant leakage can be eliminated or reduced and efficiency of the screw compressor 1 can be improved with a simpler configuration.

[0060] Embodiments 1 to 5 may be combined as appropriate. For example, Embodiment 1 and Embodiment 2 may be combined to inject the oil to the gap between the sealing surfaces S from both the back surface side 14f of the slide valve 14 and the inner circumferential surface 17a of the high-low pressure partition wall 17.

[0061] Further, Embodiments 1 to 5 are applicable to any screw compressor including a mechanism that has a gap between the back surface side 14f of the slide valve 14 and the inner circumferential surface 17a of the high-low pressure partition wall 17. For example, although the above description has been given of a single-stage screw compressor including one compression unit 2, the compressor may be a multi-stage compressor including two or more compression units 2. Further, the present invention is useful not only in a screw compressor of constant speed specifications but also in an inverter-driven screw compressor.

[0062] In Embodiments 1 to 5, the description has been given of the slide valve 14 capable of changing the internal volume ratio. However, the slide valve to which the present invention is applicable is not limited to the slide valve capable of changing the internal volume ratio. For example, the slide valve to which the present invention is applicable may be a volume-control slide valve allowing a part of the refrigerant gas to be bypassed to the suction side (low pressure), or may be an immovable slide valve fixed to the casing body 8.

Reference Signs List

[0063]

1 screw compressor 2 compression unit 3 motor 3a stator 3b motor rotor 4 oil separator 5 condenser 6 expansion valve 7 evaporator 8 casing body 9 screw rotor 10 screw shaft 11 compression chamber 11a screw groove 12 discharge chamber 13 discharge port 14 slide valve 14a valve body 14b guide portion 14c connecting portion 14d discharge port end portion 14e inner circumferential side 14f back surface side 14g oil feed hole 14h screw rotor portion oil feed port 14i screw rotor portion oil supply port 14j oil feed hole 14k slide valve back surface portion oil feed port 14l slide valve back surface portion oil supply port 14m sump 15 rod 15a connecting hole 16 driving device 17 high-low pressure partition wall 17a inner circumferential surface 17b oil feed hole 17c slide valve back surface portion oil feed port 18 oil groove 18a oil groove 20 injection mechanism 80 casing body 90 screw rotor 140 slide valve 140a back surface 170 high-low pressure partition wall 170a inner circumferential surface S sealing surface

Claims

1. A screw compressor comprising:

- a casing body;
- a screw rotor disposed to rotate inside the casing body;
- a slide valve movably provided between the casing body and the screw rotor;

a partition wall provided to face a back surface side of the slide valve and configured to divide an interior of the casing body into a discharge pressure space and a suction pressure space; and
 an injection mechanism configured to supply oil to a gap between an inner circumferential surface of the partition wall and the back surface side of the slide valve to seal the gap.

ential direction of the inner circumferential surface.

- 5
10
2. The screw compressor of claim 1, wherein the injection mechanism is configured to have at least one first oil feed hole formed to pass through the slide valve, one end of the at least one first oil feed hole facing the partition wall and configured to supply the oil to the gap from the opening. 15
3. The screw compressor of claim 2, wherein the injection mechanism further has a first oil groove provided in the back surface side of the slide valve to face the partition wall and configured to distribute the oil supplied to the gap. 20
4. The screw compressor of claim 3, wherein the first oil groove is provided in the back surface side of the slide valve and extends in a circumferential direction of the back surface side. 25
5. The screw compressor of any one of claims 2 to 4, wherein the slide valve has a sump recessed on the back surface side, and an other end of the at least one first oil feed hole opens to the sump. 30
6. The screw compressor of claim 1, wherein the injection mechanism is configured to have a sump recessed in the back surface side of the slide valve and a second oil groove provided in the back surface side of the slide valve to face the partition wall, the sump and the second oil groove communicating with each other to supply the oil in the sump to the gap from the second oil groove. 35
40
7. The screw compressor of any one of claims 1 to 6, wherein the injection mechanism is configured to have at least one second oil feed hole formed in the partition wall, one end of the at least one second oil feed hole opening to the inner circumferential surface of the partition wall to supply the oil to the gap. 45
8. The screw compressor of any one of claims 1 to 7, wherein the injection mechanism further has a third oil groove provided in the inner circumferential surface of the partition wall and configured to distribute the oil supplied to the gap. 50
55
9. The screw compressor of claim 8, wherein the third oil groove is provided in the inner circumferential surface of the partition wall and extends in a circumfer-

FIG. 1

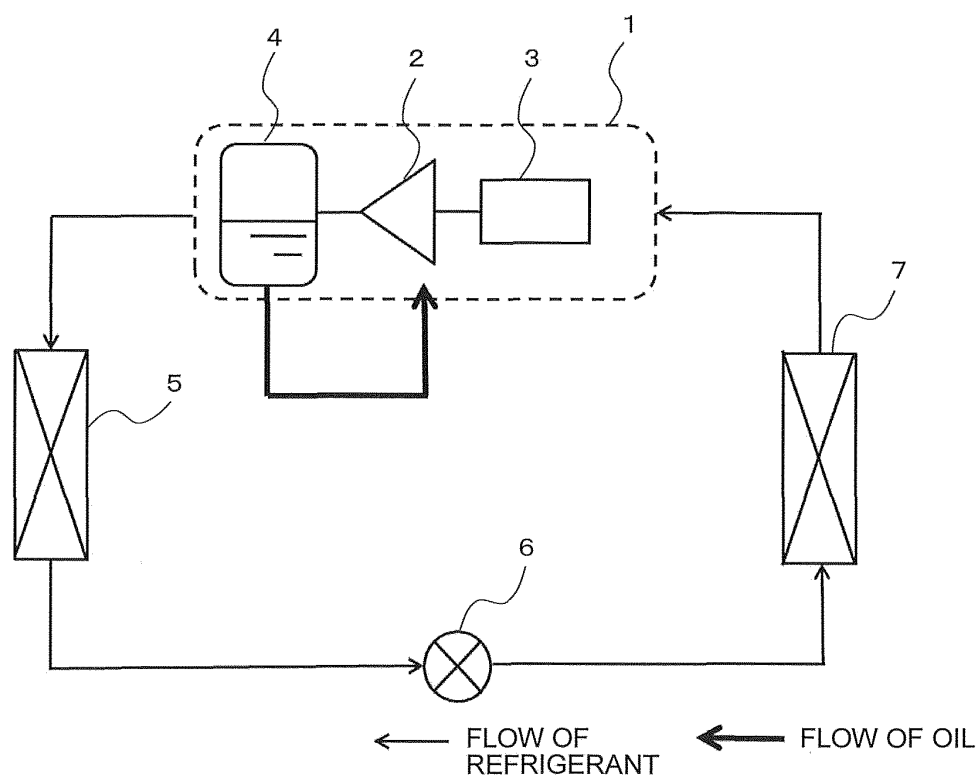


FIG. 2

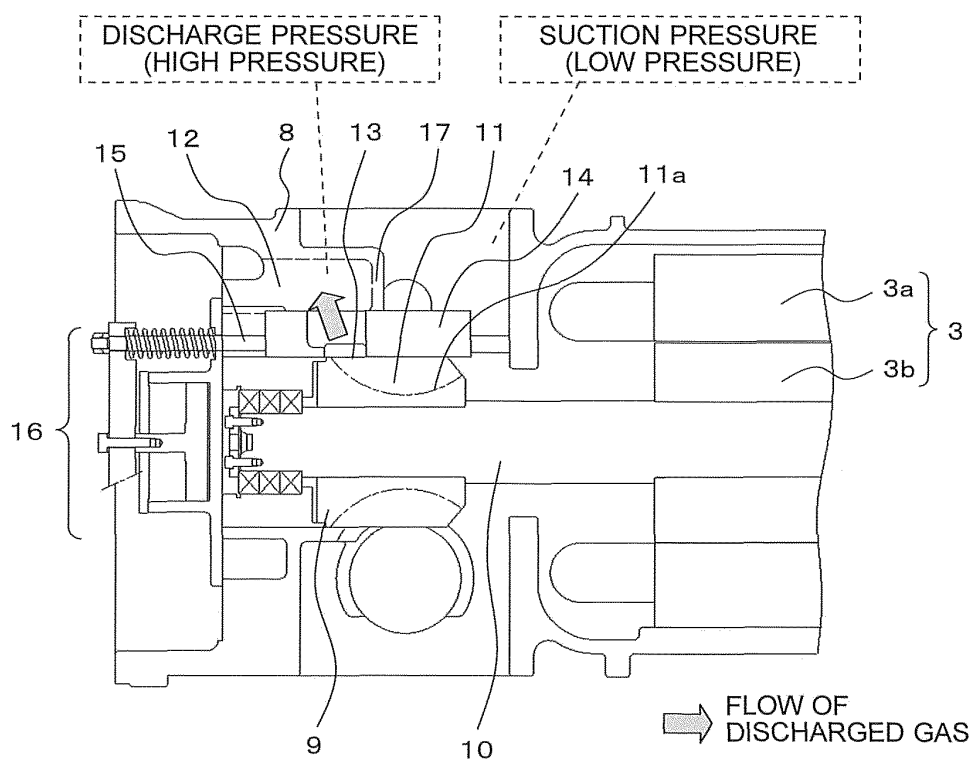


FIG. 3

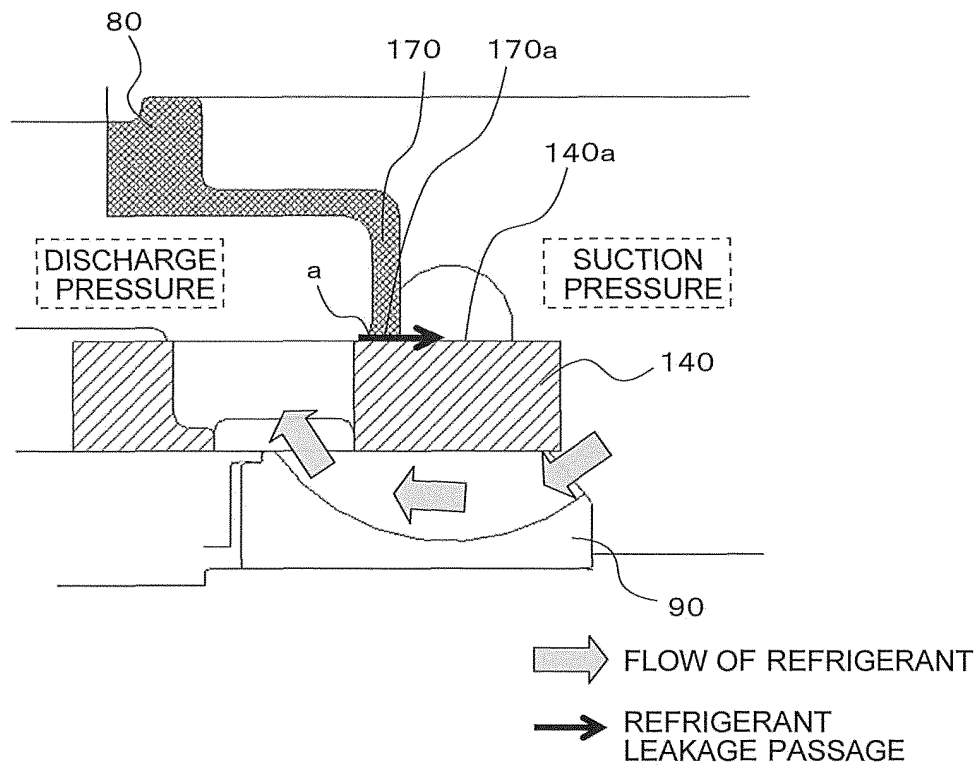


FIG. 4

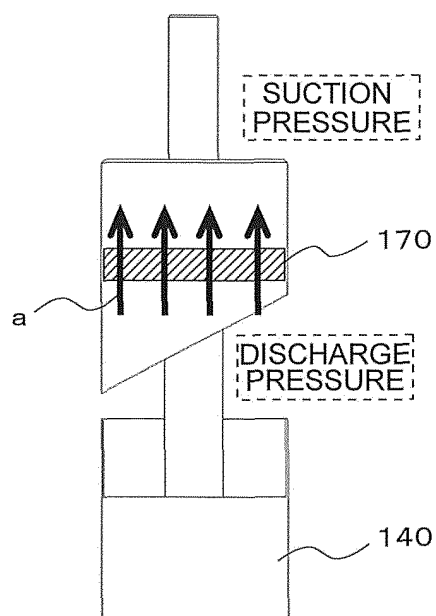


FIG. 5

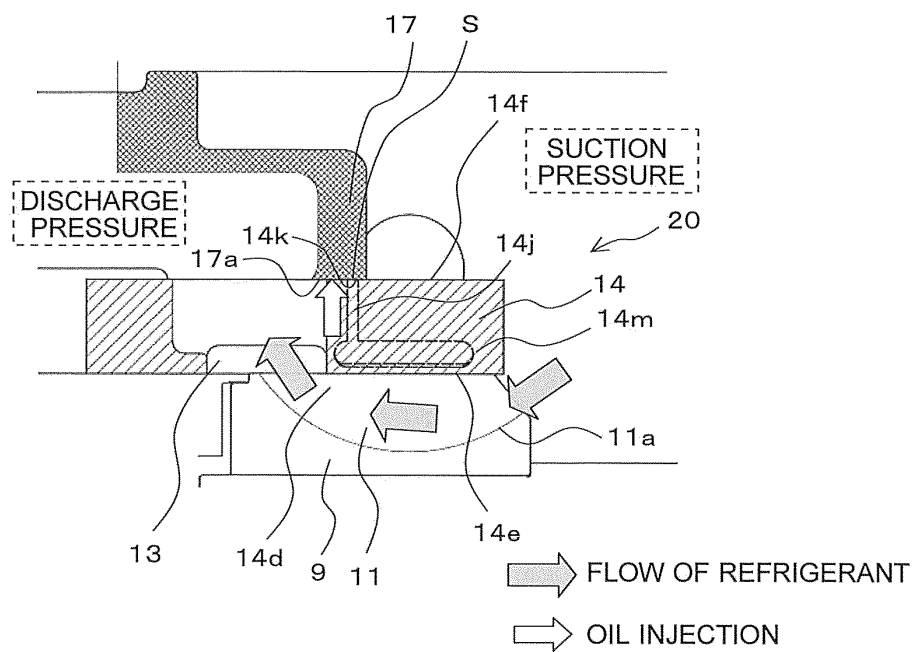


FIG. 6

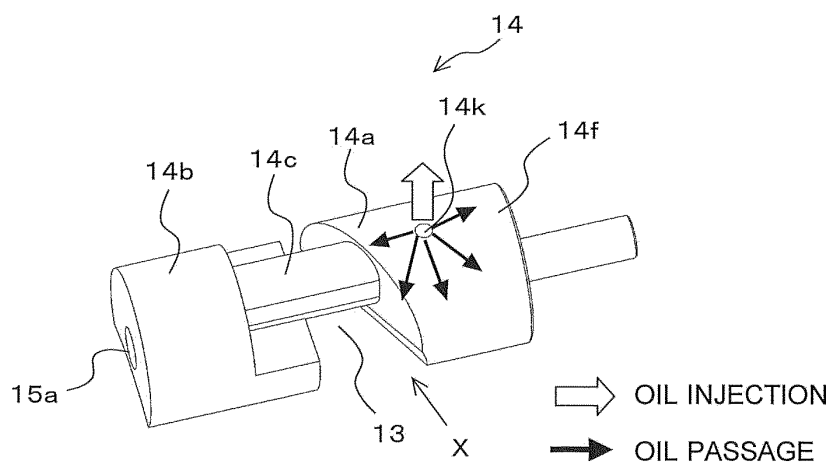


FIG. 7

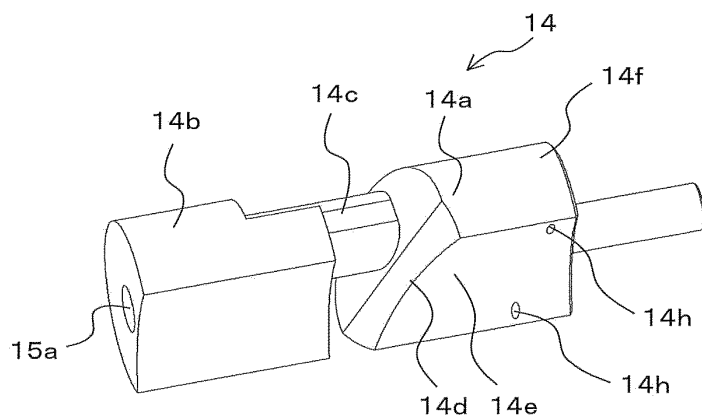


FIG. 8

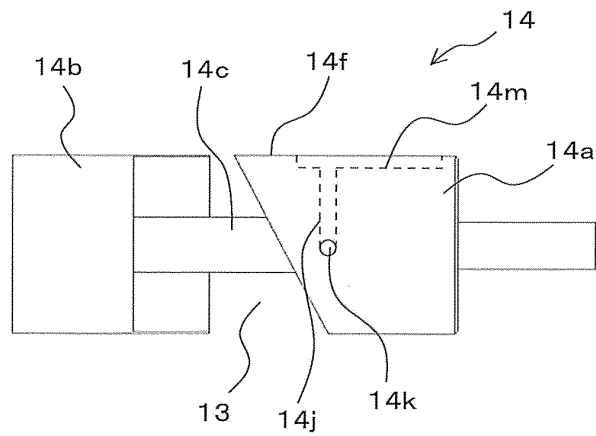


FIG. 9

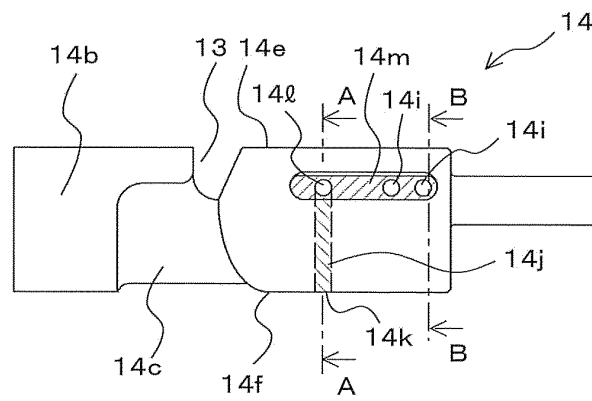


FIG. 10

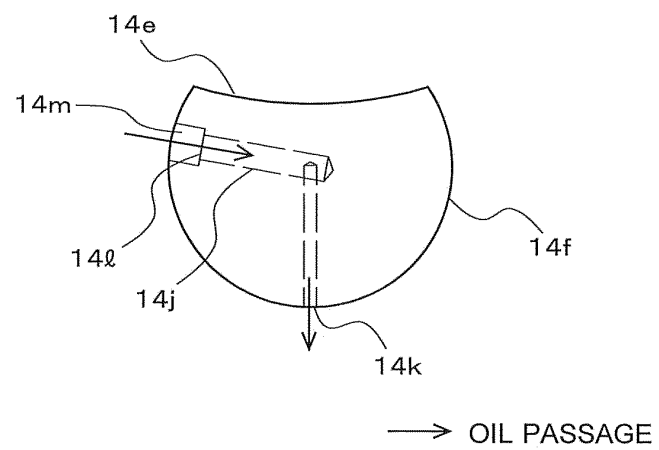


FIG. 11

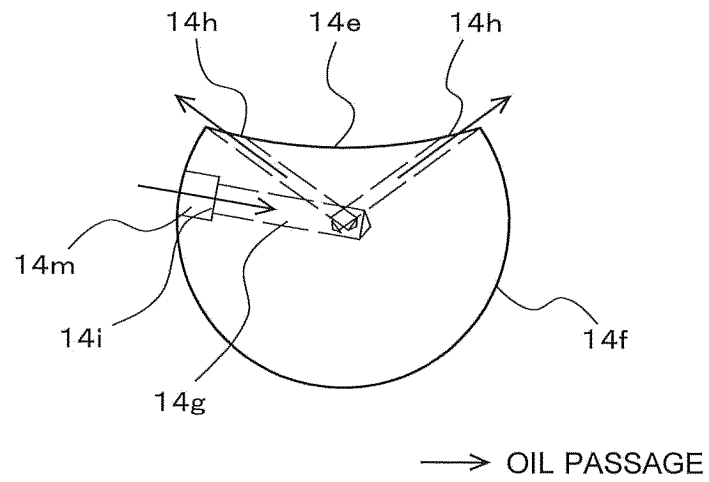


FIG. 12

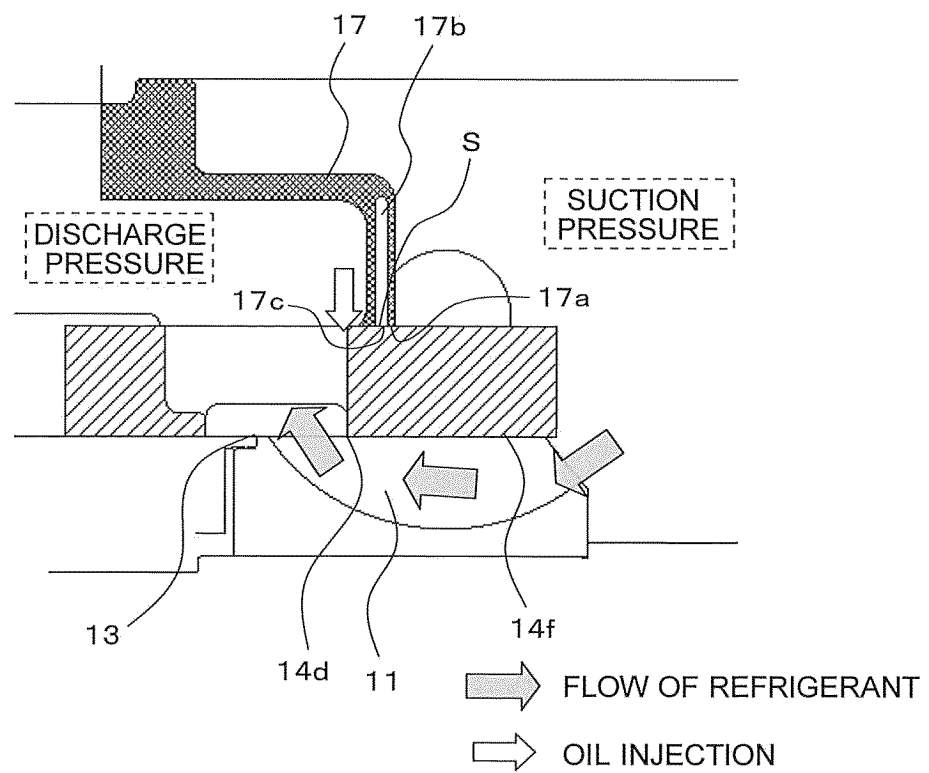


FIG. 13

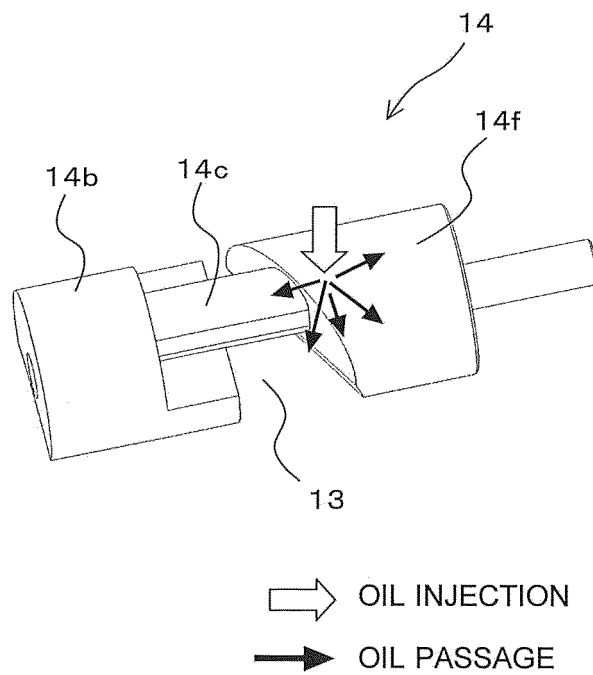


FIG. 14

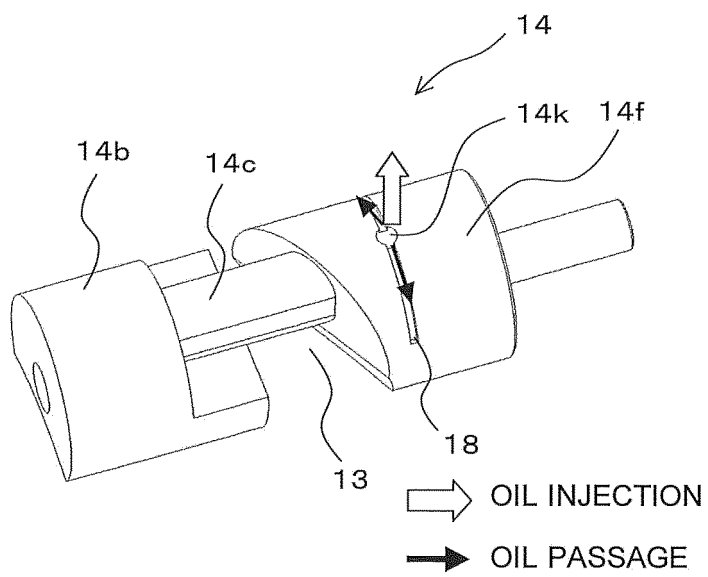


FIG. 15

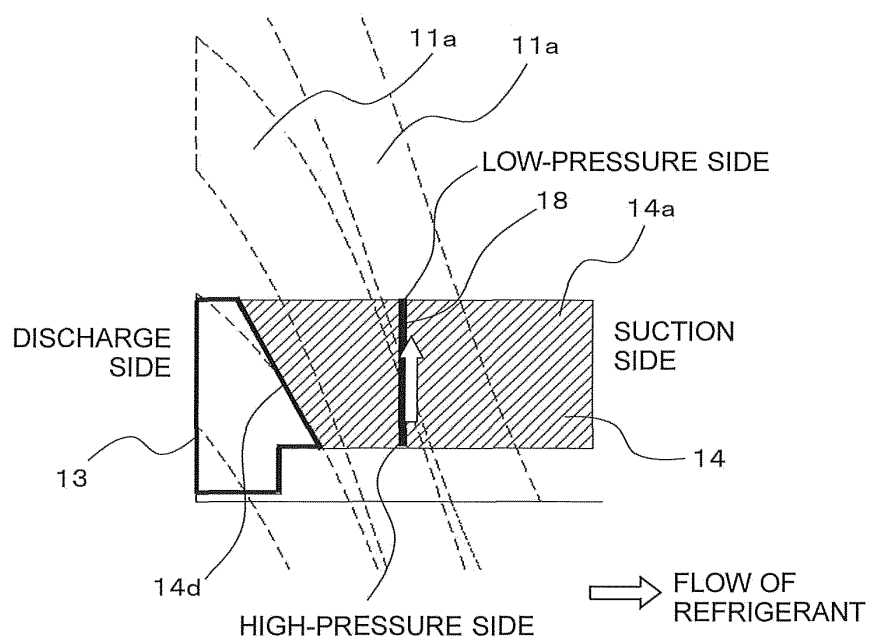


FIG. 16

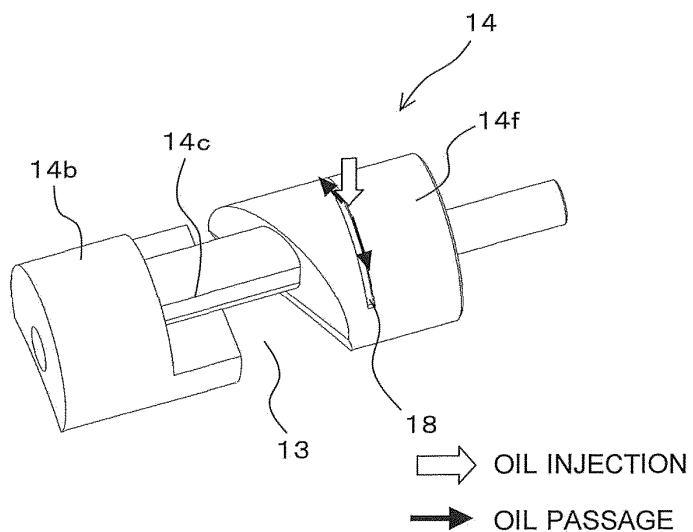
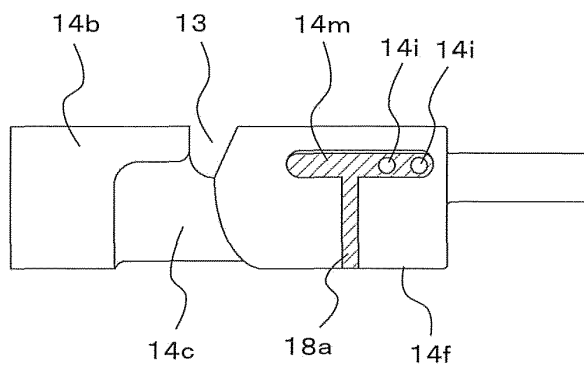


FIG. 17



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2015/052275

A. CLASSIFICATION OF SUBJECT MATTER

F04C18/16(2006.01) i

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

F04C18/16

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 A	JP 51-47051 Y2 (Hitachi, Ltd.), 13 November 1976 (13.11.1976), column 2, lines 8 to 12; fig. 1 to 2 (Family: none)	1 2-9
X A	GB 1237333 A (GUTEHOFFNUNGSHUTTE STERKRADE AG), 30 June 1971 (30.06.1971), page 2, left column, lines 20 to 40; fig. 1 to 4 & DE 1804884 A1 & FR 2021476 A1	1 2-9
A	JP 2013-127203 A (Mitsubishi Electric Corp.), 27 June 2013 (27.06.2013), entire text; all drawings (Family: none)	1-9



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Date of the actual completion of the international search

14 April 2015 (14.04.15)

Date of mailing of the international search report

21 April 2015 (21.04.15)

Name and mailing address of the ISA/

Japan Patent Office

3-4-3, Kasumigaseki, Chiyoda-ku,

Tokyo 100-8915, Japan

Authorized officer

Telephone No.

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

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2015/052275

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 5-106572 A (Daikin Industries, Ltd.), 27 April 1993 (27.04.1993), entire text; all drawings (Family: none)	1-9

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- JP 2004316586 A [0007]
- JP 4103709 B [0007]