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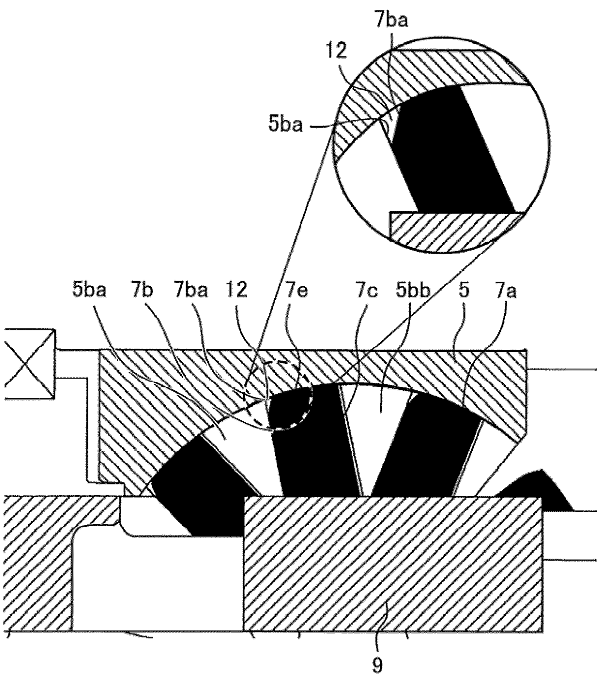
(54) SCREW COMPRESSOR

(57) At least part of a region in which a distal end portion of each tooth portion of a gate rotor and a discharge-side wall portion that is a discharge-side wall forming a screw groove, with which the distal end portion of the tooth portion is meshed with, face each other during reverse rotation of a screw rotor has a non-contact structure.

FIG. 6



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Description

Technical Field

[0001] The present invention relates to a screw compressor and, more particularly, to measures to prevent damage to a gate rotor.

Background Art

[0002] Hitherto, there is known a single screw compressor that is used as a compressor for refrigeration and air-conditioning or other purposes. For example, a single screw compressor of Patent Literature 1 includes a screw rotor and disc-shaped two gate rotors. The screw rotor has a plurality of screw grooves at its outer peripheral portion. A plurality of tooth portions is disposed radially in each of the gate rotors. The screw rotor is rotatably located inside a cylindrical wall. The cylindrical wall is provided inside a casing of the compressor. In addition, each of the gate rotors is formed such that the tooth portions extend through the cylindrical wall and mesh with the screw grooves. The two gate rotors have axes perpendicular to an axis of the screw rotor, and are symmetrically arranged across the screw rotor. Two compression chambers are defined inside the cylindrical wall by an inner periphery of the cylindrical wall, the screw grooves, and the tooth portions of the gate rotors.

[0003] In this single screw compressor, as the screw rotor rotates, the tooth portions of the gate rotors slide along the screw grooves, and the volumes of the compression chambers increase and then reduce. This operation is repeated. While the volumes of the compression chambers are increasing, refrigerant is sucked into the compression chambers. As the volumes of the compression chambers start reducing, the sucked refrigerant is compressed. As the screw grooves that define the compression chambers communicate with discharge ports, compressed high-pressure refrigerant is discharged from the compression chambers via the discharge ports.

[0004] In the single screw compressor in operation, the screw rotor rotates while, of a pair of circumferentially opposing lateral faces of any one of the tooth portions of each gate rotor, the suction-side lateral face located on a suction side in a state where the tooth portion is in mesh with the screw groove and a wall portion that defines the screw groove are in contact with each other. On the other hand, while the single screw compressor is at rest, the screw rotor rotates in the reverse direction because of a difference in pressure, i.e., high and low, of refrigerant. As the screw rotor rotates in the reverse direction, the screw rotor rotates while the discharge-side lateral face of the pair of lateral faces of any one of the tooth portions and the wall portion that defines the screw groove are in contact with each other. Damage or abrasion may occur in the gate rotors because of this reverse rotation.

[0005] In the single screw compressor of Patent Literature 1, a difference in pressure, i.e., high and low, is reduced by refrigerant gas introduced into the screw grooves via economizer ports while the single screw compressor is at rest. Thus, duration of reverse rotation can be reduced. As a result, damage on or abrasion of each gate rotor can be suppressed.

Citation List

Patent Literature

[0006] Patent Literature 1: Japanese Unexamined Patent Application Publication No. 2013-136957

Summary of Invention

Technical Problem

[0007] However, the structure of Patent Literature 1 is based on the fact that economizer ports for introducing refrigerant gas into compression chambers are provided, so the structure of Patent Literature 1 cannot be applied to a compressor with no economizer port.

[0008] The present invention has been attained taking the problem mentioned above into consideration, and an object thereof is to suppress damage on or abrasion of a gate rotor during reverse rotation of a screw rotor.

Solution to Problem

[0009] A screw compressor according to an embodiment of the present invention comprises: a screw rotor including a plurality of screw grooves on an outer periphery, one end of the screw rotor being a suction side of a fluid, an other end of the screw rotor being a discharge side of the fluid; and a gate rotor including a plurality of tooth portions to be meshed with the screw groove at an outer peripheral portion, the gate rotor rotating with rotation of the screw rotor to compress the fluid, wherein during reverse rotation of the screw rotor, at least part of a region in which a distal end portion of each of the tooth portions and a discharge-side wall portion as a discharge-side wall forming the screw groove, with which the distal end portion of the tooth portion meshes, face each other has a non-contact structure.

Advantageous Effects of Invention

[0010] With the screw compressor according to the embodiment of the present invention, at least part of the region in which the distal end portion of each of the tooth portions of the gate rotor and the discharge-side wall portion forming the screw groove, with which the distal end portion of the tooth portion meshes, face each other during reverse rotation has a non-contact structure, so damage on or abrasion of the gate rotor can be suppressed.

Brief Description of Drawings

[0011]

Fig. 1 is a schematic sectional view of a screw compressor according to Embodiment 1 of the present invention.

Fig. 2 is a perspective view showing a portion at which screw grooves of a screw rotor and tooth portions of gate rotors mesh with each other in the screw compressor according to Embodiment 1 of the present invention.

Fig. 3 illustrates an operation of the screw compressor according to Embodiment 1 of the present invention.

Fig. 4 illustrates a location of the tooth portion of the gate rotor relative to the screw groove during forward rotation of the screw rotor.

Fig. 5 illustrates a location of the tooth portion of the gate rotor relative to the screw groove during reverse rotation of the screw rotor.

Fig. 6 is a schematic enlarged view showing part of the screw compressor according to Embodiment 1 of the present invention.

Fig. 7 is a schematic sectional view of an essential portion of a screw compressor according to Embodiment 2 of the present invention.

Fig. 8 is an expansion plan of a groove bottom of each of screw grooves of the screw compressor according to Embodiment 2 of the present invention.

Fig. 9 is a schematic sectional view of an essential portion of a screw compressor according to Embodiment 3 of the present invention.

Fig. 10 is an expansion plan of a groove bottom of each of screw grooves of the screw compressor according to Embodiment 3 of the present invention.

Description of Embodiments

[0012] Hereinafter, embodiments of the present invention will be described with reference to the drawings.

[0013] In the drawings, like reference signs denote the same or corresponding components, and this applies to the entire text of the specification. Furthermore, modes of elements described in the entire text of the specification are only illustrative, and the elements are not limited to these modes.

Embodiment 1

[0014] A screw compressor according to Embodiment 1 will be described with reference to Fig. 1 to Fig. 6. The screw compressor is connected to a refrigeration circuit that operates a vapor compression refrigeration cycle by circulating refrigerant.

[0015] Fig. 1 is a schematic sectional view of the screw compressor according to Embodiment 1 of the present invention. In Fig. 1, the right side is a suction side, and the left side is a discharge side. Fig. 2 is a perspective view showing a portion at which screw grooves of a screw rotor and tooth portions of gate rotors mesh with each other in the screw compressor according to Embodiment 1 of the present invention. In Fig. 2, the upper right side indicates the suction side, and the lower left side indicates the discharge side. In addition, in Fig. 2, the solid arrow represents a rotation direction of a screw shaft, and the outline arrows represent how suction gas is sucked.

[0016] The screw compressor 1 according to Embodiment 1 is a single screw compressor. Embodiment 1 will be described by way of an example of a single screw compressor of a type in which two gate rotors 7 are meshed with one screw rotor 5.

[0017] As shown in Fig. 1, the screw compressor 1 includes a cylindrical casing 2, a motor 3, a screw shaft 4, the screw rotor 5, and other components. The motor 3 is accommodated in the casing 2. The screw shaft 4 is fixed to the motor 3, and is driven to rotate by the motor 3. The screw rotor 5 is fixed to the screw shaft 4. An end portion of the screw shaft 4, not fixed to the motor 3, is rotatably supported via a bearing 6.

[0018] The motor 3 is formed of a stator 3a and a motor rotor 3b. The stator 3a is fixed in the casing 2 so as to be internally in contact the casing 2. The motor rotor 3b is disposed radially inside the stator 3a. The motor rotor 3b, as well as the screw rotor 5, is fixed to the screw shaft 4, and is disposed along the same axis as the screw rotor 5.

[0019] The screw rotor 5 has a cylindrical shape. A plurality of screw grooves 5a is formed at an outer peripheral portion of the screw rotor 5. The screw grooves 5a run spirally from one end of the screw rotor 5 toward the other end thereof. One end side (right side in Fig. 1) of the screw rotor 5 is the suction side from which refrigerant gas is sucked, and the other end side (left side in Fig. 1) is the discharge side from which refrigerant gas is discharged. The inside of the casing 2 is separated by a separation wall (not shown) into a suction pressure space and a discharge pressure space. The suction pressure space is filled with low-pressure refrigerant gas. The discharge pressure space is filled with high-pressure refrigerant gas. One end side of the screw rotor 5 communicates with the suction pressure space, and the other end side communicates with the discharge pressure space.

[0020] In addition, the two gate rotors 7 are disposed on the sides of the screw rotor 5 so as to be symmetric across the screw shaft 4.

[0021] Each of the gate rotors 7 has a disc shape. A plurality of tooth portions 7a is provided radially at an outer periphery of each gate rotor 7 along a circumferential direction. Each gate rotor 7 is supported by a gate rotor support 8. Each gate rotor 7 is disposed such that the tooth portions 7a are in mesh with the screw grooves 5a of the screw rotor 5. Compression chambers 10 are spaces each surrounded by the screw groove 5a, the tooth portions 7a of the gate rotor 7, an inner periphery of the casing 2, and a slide valve 9. The compression chambers 10 are filled with refrigerant gas sucked from the suction pressure space. Oil for lubricating the bearing 6 and sealing the compression chambers 10 is also introduced into the compression chambers 10.

[0022] In addition, the slide valves 9 are disposed between the inner periphery of the casing 2 and the screw rotor 5. Each of the slide valves 9 is provided so as to be slidable in the direction of the screw shaft 4 of the screw rotor 5 along the outer periphery of the screw rotor 5. Each slide valve 9 has an opening port 9a.

[0023] Discharge ports 2a (see Fig. 3, given later) are formed in the casing 2. The discharge ports 2a communicate with a discharge chamber 11 formed inside the casing 2. High-pressure refrigerant gas and oil filled in the compression chambers 10 pass through the opening ports 9a of the slide valves 9 and then discharged to the discharge chamber 11 via the discharge ports 2a.

[0024] Next, the operation of the screw compressor 1 according to Embodiment 1 will be described.

[0025] Fig. 3 illustrates the operation of the screw compressor according to Embodiment 1 of the present invention.

[0026] As the motor 3 is started in the screw compressor 1, the screw rotor 5 rotates with the rotation of the screw shaft 4. Here, the screw rotates in the forward direction. The gate rotors 7 also rotate with the rotation of the screw rotor 5, and a suction stroke, a compression stroke, and a discharge stroke are repeated in each compression chamber 10. A compression operation will be described focusing on the compression chamber 10 dotted in Fig. 3.

[0027] Fig. 3(a) shows a state of the compression chamber 10 in the suction stroke. The screw groove 5a in which the compression chamber 10 is formed is meshed with the tooth portion 7a of the gate rotor 7. As the screw rotor 5 is driven by the motor 3 to rotate in the direction indicated by the solid arrow, this tooth portion 7a relatively moves toward the terminal end of the screw groove 5a. As a result, the gate rotor 7 rotates in the narrow outline arrow direction. The compression chamber 10 in the suction stroke is expanded to have the largest volume, communicates with a suction-side space of the casing 2, and is filled with low-pressure refrigerant gas.

[0028] As the screw rotor 5 further rotates, simultaneously with this rotation, the tooth portion 7a of the gate rotor 7 sequentially moves rotationally toward the discharge port 2a. Thus, as shown in Fig. 3(b), the volume of the compression chamber 10 reduces, and refrigerant gas in the compression chamber 10 is compressed.

[0029] As the screw rotor 5 continuously rotates, the compression chamber 10 communicates with the discharge port 2a, as shown in Fig. 3(c). Thus, high-pressure refrigerant gas compressed in the compression chamber is discharged via the opening port 9a of the slide valve 9 (not shown in Fig. 3) to the discharge chamber 11 through the discharge port 2a. Refrigerant discharged to the discharge chamber 11 is discharged to the outside of the screw compressor 1.

[0030] During such operation of the screw compressor 1, the pressure in the compression chamber 10 gradually increases in order of (a), (b), and (c), and is high in (c). As the operation of the screw compressor 1 is stopped, the screw rotor 5 rotates in the reverse direction as described above because of a pressure difference between the low-pressure side and high-pressure side of the screw rotor 5. As the screw rotor 5 rotates in the reverse direction, the pressure in the compression chamber 10 is reduced to be lower than the suction-side pressure, and, when the gate rotor 7 has the existing configuration to which no improvement of the present invention is applied, the gate rotor 7 is damaged. This phenomenon will be described later with reference to Fig. 4 and Fig. 5.

[0031] Fig. 4 illustrates a location of the tooth portion of the gate rotor relative to the screw groove during forward rotation of the screw rotor. Fig. 5 illustrates a location of the tooth portion of the gate rotor relative to the screw groove during reverse rotation of the screw rotor. Fig. 4 and Fig. 5 both show an expansion plan of one screw groove together with the tooth portion of the gate rotor, meshed with the screw groove. The arrow in Fig. 4 indicates a moving direction during forward rotation of the screw rotor 5. The arrow in Fig. 5 indicates a moving direction of the screw rotor 5 during reverse rotation. In addition, in Fig. 4 and Fig. 5, the right side is the suction side, and the left side is the discharge side.

[0032] During operation of the screw compressor 1, that is, while the screw rotor 5 is rotating in the forward direction, the tooth portion 7a of the gate rotor 7 contacts a suction-side wall portion 5bb that is a wall portion on the suction side, of two wall portions 5b forming the screw groove 5a with which the tooth portion 7a meshes as shown in Fig. 2 and Fig. 4. More specifically, a suction-side lateral face 7c of the tooth portion 7a contacts the suction-side wall portion 5bb. The suction-side lateral face 7c is, of a pair of circumferentially opposing lateral faces of the tooth portion 7a, the lateral face on the suction side in a state where the tooth portion 7a is in mesh with the screw groove 5a. Hereinafter, of the pair of circumferentially opposing lateral faces of the tooth portion 7a, the lateral face on the discharge side is referred to as the discharge-side lateral face 7b. In addition, of the two wall portions 5b, the discharge-side wall portion is referred to as discharge-side wall portion 5ba.

[0033] On the other hand, as the screw rotor 5 rotates in the reverse direction and, as a result, the pressure in the compression chamber 10 is reduced to be lower than the pressure in a suction chamber, a pressing force acts on the gate rotor 7 in a direction opposing to that during operation, and the discharge-side lateral face 7b of the tooth portion 7a contacts the discharge-side wall portion 5ba as shown in Fig. 5. The portion represented by dotted line in Fig. 5 shows the shape of the tooth portion of existing technologies in which the width of the tooth portion 7a is set to the same width from the proximal portion to the distal end portion. The solid line represents the tooth portion 7a of Embodiment 1.

[0034] When the tooth portion 7a of the gate rotor 7 is in mesh with the screw rotor 5 during reverse rotation, the discharge-side lateral face 7b of the tooth portion 7a contacts the discharge-side wall portion 5ba. A distal end portion 70 of the discharge-side lateral face 7b of the tooth portion 7a constantly contacts the discharge-side wall portion 5ba during reverse rotation.

[0035] A discussion will be made focusing on the tooth portion 7a that is in mesh with the screw groove 5a communicating with the discharge port 2a at the time of switching from forward rotation to reverse rotation. In the state shown in Fig. 2, the tooth portion 7a communicating with the discharge port 2a is not in contact with the discharge-side wall portion 5ba from the center portion to the proximal portion within the discharge-side lateral face 7b of the tooth portion 7a, and only the distal end portion 70 contacts the discharge-side wall portion 5ba. Until the tooth portion 7a separates from the screw groove 5a as a result of reverse rotation in this state, the distal end portion 70 of the discharge-side lateral face 7b of the tooth portion 7a constantly contacts the discharge-side wall portion 5ba.

[0036] In this way, the distal end portion 70 of the discharge-side lateral face 7b of the tooth portion 7a contacts the discharge-side wall portion 5ba for a longer period of time during reverse rotation than the center portion and proximal portion of the discharge-side lateral face 7b, so damage or abrasion easily occurs at the distal end portion 70.

[0037] In addition, as shown in Fig. 4 and Fig. 5, in the tooth portion 7a of the gate rotor 7, the angle formed by the surface 7d of the tooth portion 7a and the suction-side lateral face 7c is an obtuse angle; whereas the angle formed by the surface 7d and the discharge-side lateral face 7b is an acute angle, that is, the discharge-side thickness of the tooth portion 7a is smaller. In the tooth portion 7a of the gate rotor 7, the angle formed by the surface 7d and the discharge-side side-surface 7b is an acute angle only at the discharge-side distal end portion, not entire portion of the discharge side of the tooth portion 7a. In the remaining portion, the angle formed by the surface 7d and the discharge-side lateral face 7b is an obtuse angle. The fact that the thickness of the discharge-side distal end portion of the tooth portion 7a is smaller also causes the tooth portion 7a to be easily damaged. The reason why the tooth portion 7a is formed such that the above-described angle is changed to an acute angle or an obtuse angle depending on a location is that the angle of tangent relative to the discharge-side wall portion 5b of the screw groove 5a approaches a right angle toward the discharge side.

[0038] In Embodiment 1, to avoid damage on the gate rotor 7 before it happens, the following structure is employed.

[0039] Fig. 6 is a schematic enlarged view showing part of the screw compressor according to Embodiment 1 of the present invention.

[0040] In Embodiment 1, as shown in Fig. 6, a space 12 is provided between the distal end portion of each tooth portion 7a and the discharge-side wall portion 5ba. That is, the position of the distal end portion 7ba of the discharge-side lateral face 7b of the tooth portion 7a is located on the suction side as compared with the other portion of the tooth portion 7a, and the facewidth of the distal end portion of each tooth portion 7a is smaller than the facewidth of the other portion of the tooth portion 7a. More specifically, each tooth portion 7a has a shape in which a corner portion formed by the discharge-side lateral face 7b and distal end face 7e of the existing tooth portion 7a as represented by dashed line in Fig. 5 is cut out. In this way, in a state where the tooth portion 7a is in mesh with the screw groove 5a, the distal end portion 7ba of the discharge-side lateral face 7b of the tooth portion 7a does not contact the discharge-side wall portion 5ba, that is, a non-contact structure is provided.

[0041] In each of the tooth portions 7a of each gate rotor 7, the space 12 is uniform, and a space dimension is preferably set to, for example, 20 μm to 70 μm. This space 12 is constantly formed while the tooth portion 7a is in mesh with the screw groove 5a.

[0042] Due to the above configuration, during reverse rotation, the tooth portion 7a moves toward the discharge-side wall portion 5ba of the screw rotor 5 and contacts the discharge-side wall portion 5ba as shown in Fig. 5; however, a portion that contacts the discharge-side wall portion 5ba is the center to proximal portion of the tooth portion 7a, and the distal end portion does not contact the discharge-side wall portion 5ba. Thus, damage on the distal end portion of each tooth portion 7a is suppressed.

- Advantageous Effects of Embodiment 1 -

[0043] According to Embodiment 1, the space 12 is provided between the discharge-side wall portion 5ba and the distal end portion of each of the tooth portions 7a of each gate rotor 7, so damage on and abrasion of the distal end portion of each tooth portion 7a of each gate rotor 7 during reverse rotation are suppressed. With the space 12 provided in this way, during reverse rotation, a portion that contacts the discharge-side wall portion 5ba in the tooth portion 7a is the center portion to proximal portion of each tooth portion 7a. In the center to proximal portion of each tooth portion 7a, the angle formed by the suction-side lateral face 7c of the tooth portion 7a and the surface 7d is not an acute angle unlike the distal end portion but an obtuse angle, so the center to proximal portion has high strength. Thus, also in this regard, damage on the gate rotors 7 is reduced, and deterioration of performance by aging is reduced.

[0044] In addition, to suppress damage on the gate rotors 7 in this way, no complicated control mechanism or component needs to be provided, and merely the space 12 just needs to be provided, so suppression of damage on the gate rotors 7 is easily achieved without increasing the number of components. In addition, in providing the space 12, the shape of the distal end portion of each tooth portion 7a is obtained by just changing the distal end shape of each tooth portion of the existing configuration in which the facewidth is the same from the proximal portion to the distal end portion, so the space 12 is easily applicable to the existing products as well.

Embodiment 2

[0045] In Embodiment 1, as a configuration to form a space between the distal end portion of each tooth portion 7a and the discharge-side wall portion 5ba, the distal end-side facewidth of each tooth portion 7a is smaller than the proximal end-side facewidth of the tooth portion 7a because the position of the distal end portion 7ba of the discharge-side lateral face 7b of each tooth portion 7a shifts toward the suction side. In contrast, in Embodiment 2, another mode different from that of Embodiment 1 will be described as a configuration to form a space between the distal end portion of each tooth portion 7a and the discharge-side wall portion 5ba. Hereinafter, differences from Embodiment 1 will be mainly described, and components not described in Embodiment 2 are similar to those of Embodiment 1.

[0046] Fig. 7 is a schematic sectional view of an essential portion of a screw compressor according to Embodiment 2 of the present invention. Fig. 8 is an expansion plan of a groove bottom of each screw groove of the screw compressor according to Embodiment 2 of the present invention.

[0047] In Embodiment 2, during reverse rotation, a region 5c facing the distal end portion of each tooth portion 7a in the discharge-side wall portion 5ba is located on the discharge side as compared to the other region, and a space 13 is formed between the distal end portion of each tooth portion 7a and the discharge-side wall portion 5ba. In Fig. 8, the alternate long and two short dashed line represents the location of the discharge-side wall portion 5ba in the other region that does not form the space 13 in the discharge-side wall portion 5ba.

[0048] The region 5c is a region that lies in the groove direction (arrow direction in Fig. 8) of the screw groove 5a with a depth comparable to the thickness of the tooth portion 7a from the groove bottom within the discharge-side wall portion 5ba. The length of the space 13 in the groove direction is at least a length by which the tooth portion 7a moves along the screw groove 5a by the time the tooth portion 7a separates from the screw groove 5a from a state where the tooth portion 7a meshes with the screw groove 5a during reverse rotation. This space 13 is always formed while the tooth portion 7a is in mesh with the screw groove 5a.

- Advantageous Effects of Embodiment 2 -

[0049] According to Embodiment 2, advantageous effects similar to those of Embodiment 1 are obtained.

Embodiment 3

[0050] In Embodiment 2, each space 13 is formed so as to extend in the groove direction of the screw groove 5a. In Embodiment 3, the length of each space 13 in the groove direction is made smaller than that of Embodiment 2, and the location of the space 13 is restricted. Hereinafter, differences from Embodiment 2 will be mainly described, and components not described in Embodiment 3 are similar to those of Embodiment 2.

[0051] Fig. 9 is a schematic sectional view of an essential portion of a screw compressor according to Embodiment 3 of the present invention. Fig. 10 is an expansion plan of a groove bottom of each screw groove of the screw compressor according to Embodiment 3 of the present invention.

[0052] In Embodiment 3, part of a region facing the distal end portion of the tooth portion 7a in the discharge-side wall portion 5ba during reverse rotation, that is, part of a region that extends in the groove direction (arrow direction in Fig. 10), is located on the discharge side as compared to the other region and, as a result, the groove width widens toward the discharge side and increases. The part is specifically an end region that is a distal end side in the rotation direction of the screw rotor 5 during reverse rotation within a region that extends in the groove direction (arrow direction in Fig. 10), that is, a region that communicates with the discharge port 2a (see Fig. 2).

[0053] With the space 13 provided in this region, no contact occurs between the screw rotor 5 and each gate rotor 7 in the region that communicates with the discharge port 2a during reverse rotation, that is, no contact occurs between the discharge-side wall portion 5ba of the screw rotor 5 and the discharge-side lateral face 7b of the gate rotor 7. Thus, a duration during which the distal end portion of each gate rotor 7 contacts the discharge-side wall portion 5ba of the screw rotor 5 shortens, so the effect of reducing damage to each gate rotor 7 is sufficiently obtained.

[0054] In addition, by restricting the region in which the space 13 is provided to the region that communicates with the discharge port 2a within the screw groove 5a, the length of the space 13 in the groove direction is reduced to be shorter than that of Embodiment 2. In this way, when the length of the space 13 in the groove direction reduces, leakage of refrigerant through the space 13 during forward rotation, that is, during normal operation, is reduced. Therefore, Embodiment 3 improves performance during normal operation as compared to Embodiment 1 and Embodiment 2.

- Advantageous Effects of Embodiment 3 -

[0055] According to Embodiment 3, advantageous effects similar to those of Embodiment 2 are obtained, and additionally, since the location of the space 13 is restricted to the portion where damage on the tooth portion 7a can be suppressed more effectively than that of Embodiment 2, that is, the region that communicates with the discharge port 2a, the following advantageous effect is obtained. That is, leakage of refrigerant through the space 13 during normal operation is suppressed as compared to those of Embodiment 1 and Embodiment 2. Therefore, Embodiment 3 improves performance during normal operation as compared to Embodiment 1 and Embodiment 2.

Reference Signs List

[0056] 1 screw compressor 2 casing 2a discharge port 3 motor 3a stator 3b motor rotor 4 screw shaft 5 screw rotor 5a screw groove 5b wall portion 5ba discharge-side wall portion 5bb suction-side wall portion 5c region 6 bearing 7 gate rotor 7a tooth portion 7b discharge-side lateral face 7ba distal end portion 7c suction-side lateral face 7d surface 7e distal end face 8 gate rotor support 9 slide valve 9a opening port 10 compression chamber 11 discharge chamber 12 space 13 space 70 distal end portion

Claims

1. A screw compressor comprising: a screw rotor including a plurality of screw grooves on an outer periphery, one end of the screw rotor being a suction side of a fluid, an other end of the screw rotor being a discharge side of the fluid; and a gate rotor including a plurality of tooth portions to be meshed with the screw groove at an outer peripheral portion, the gate rotor rotating with rotation of the screw rotor to compress the fluid, wherein
during reverse rotation of the screw rotor, at least part of a region in which a distal end portion of each of the tooth portions and a discharge-side wall portion as a discharge-side wall forming the screw groove, with which the distal end portion of the tooth portion meshes, face each other has a non-contact structure.

2. The screw compressor of claim 1, wherein the non-contact structure is formed as a space between the distal end portion of each of the tooth portions and the discharge-side wall portion.

3. The screw compressor of claim 1 or 2, wherein, of a pair of circumferentially opposing lateral faces of the tooth portion, a distal end portion of the discharge-side lateral face on the discharge side in a state where the tooth portion is meshed with the screw groove is located on the suction side as compared with a portion other than the distal end portion, and a facewidth of the distal end portion of the tooth portion is smaller than that of an other portion of the tooth portion.

4. The screw compressor of claim 1 or 2, wherein a region facing the distal end portion of the tooth portion in the discharge-side wall portion during reverse rotation is located on the discharge side as compared with an other region, a groove width of the screw groove widens toward the discharge side, and the space is formed between the distal end portion of the tooth portion and the discharge-side wall portion.

5. The screw compressor of claim 1 or 2, further comprising a casing in which a discharge port is formed, the compressed fluid being discharged through the discharge port, wherein
within a region facing the distal end portion of the tooth portion in the discharge-side wall portion during reverse rotation, a region being a distal end side in a rotation direction of the screw rotor during reverse rotation and communicating with the discharge port is located on the discharge side as compared with an other region, a groove width of the screw groove widens toward the discharge side, and the space is formed between the distal end portion of the tooth portion and the discharge-side wall portion.

FIG. 1

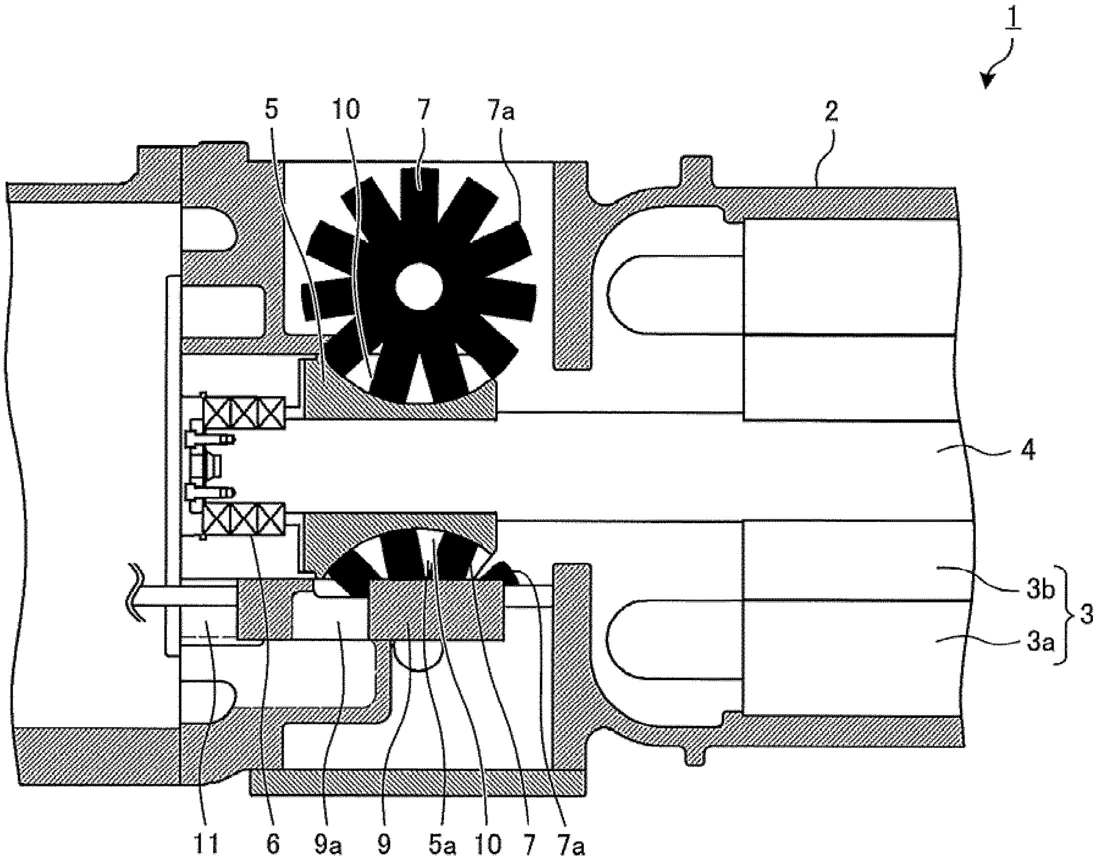


FIG. 2

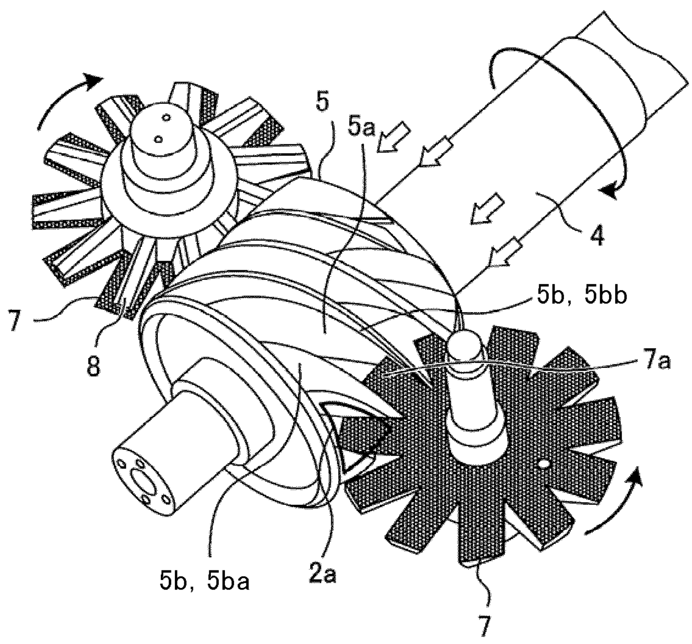
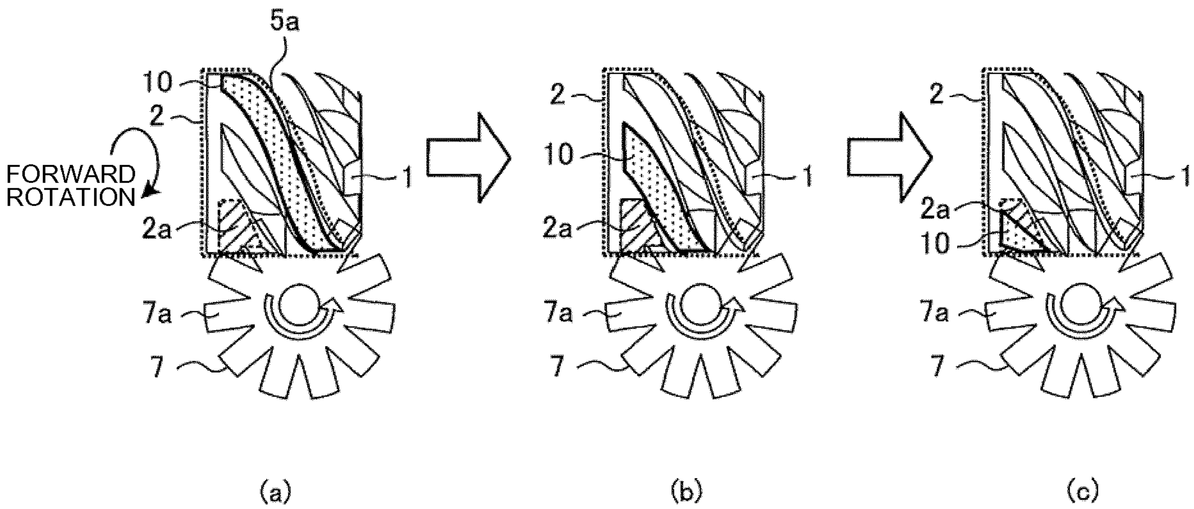


FIG. 3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FORWARD
ROTATION
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7a
7
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7a
7
2
2a
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7a
7
(a)
(b)
(c)

FIG. 4

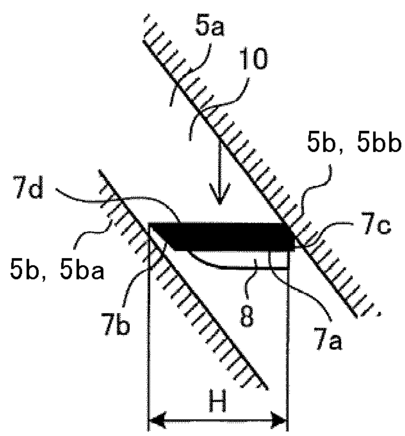

5a
10
5b, 5bb
7d
7c
5b, 5ba
7b
8
7a
H

FIG. 5

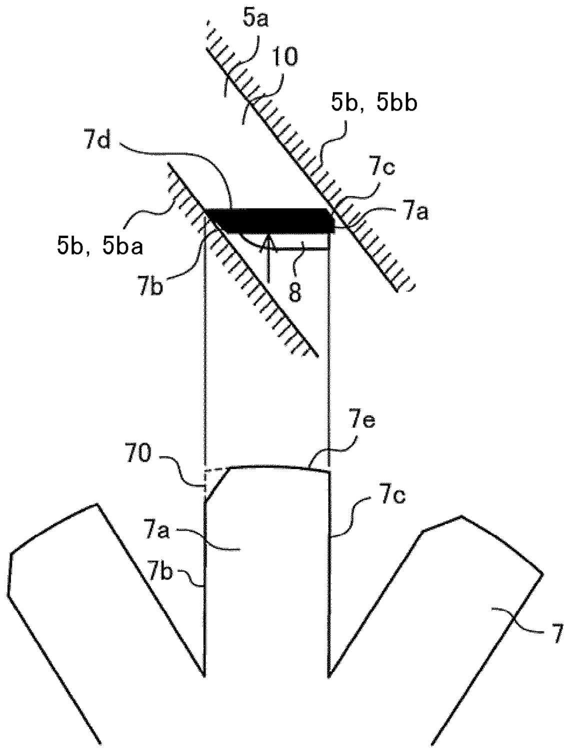

5a
10
5b, 5bb
7d
7c
7a
5b, 5ba
7b
8
7e
70
7c
7a
7b
7

FIG. 6

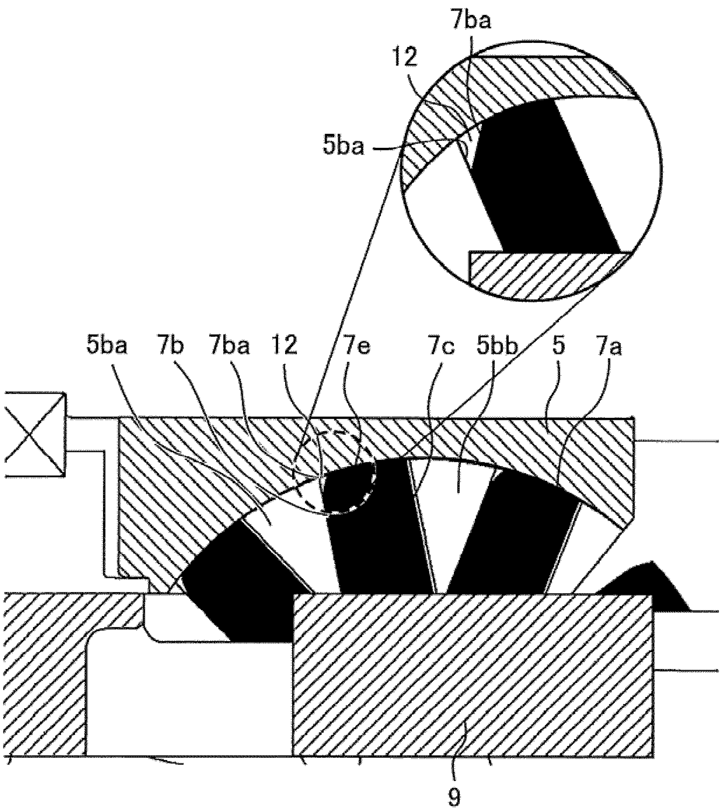

7ba
12
5ba
5ba
7b
7ba
12
7e
7c
5bb
5
7a
9

FIG. 7

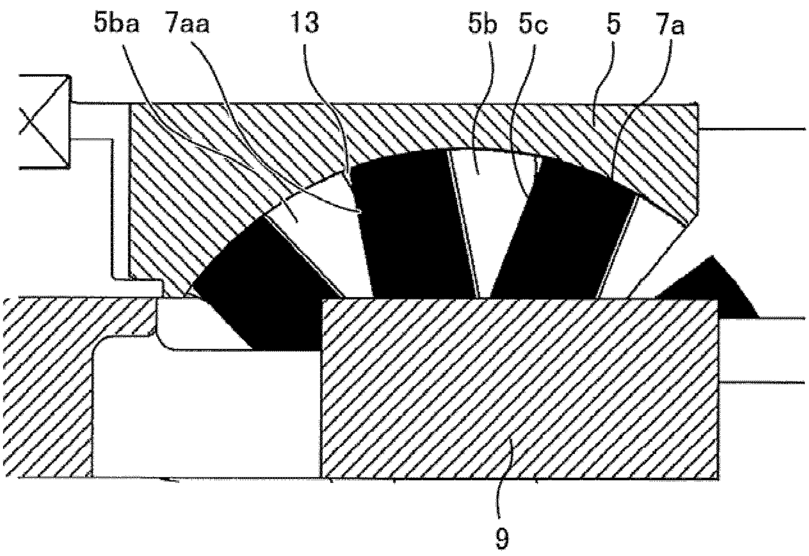


FIG. 8

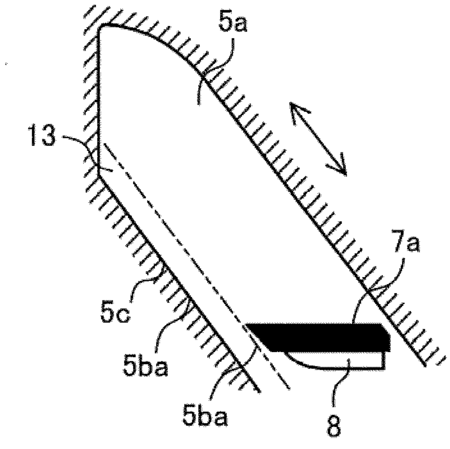


FIG. 9

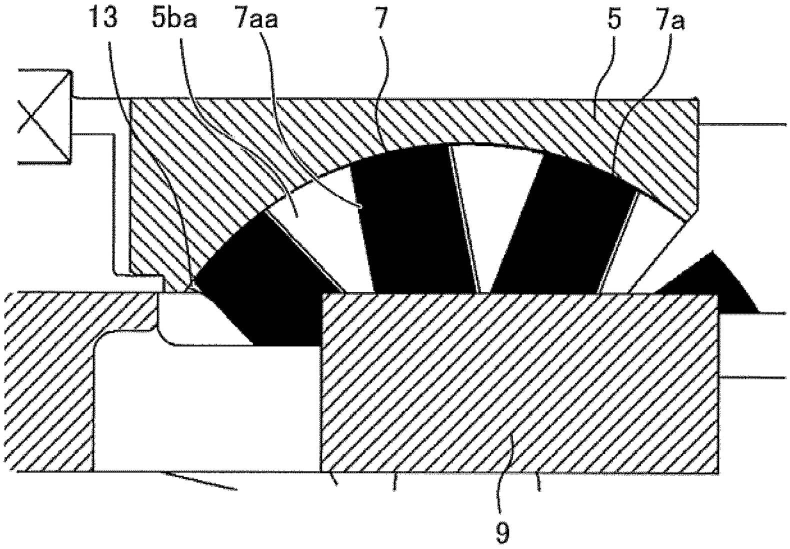
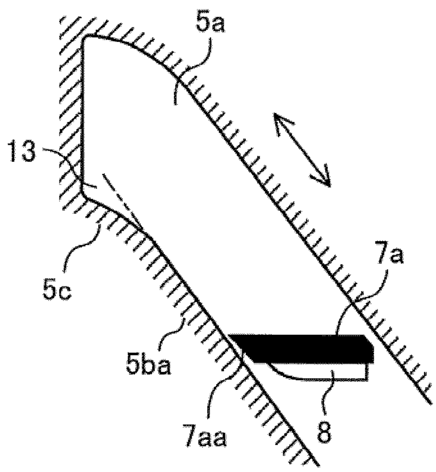


FIG. 10



INTERNATIONAL SEARCH REPORT

International application No. PCT/JP2016/087623

A. CLASSIFICATION OF SUBJECT MATTER
F04C18/52(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)
F04C18/52

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	1996-2017
Kokai Jitsuyo Shinan Koho	1971-2017	Toroku Jitsuyo Shinan Koho	1994-2017

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.
Y A	JP 2014-126028 A (Daikin Industries, Ltd.), 07 July 2014 (07.07.2014), paragraphs [0002] to [0005] (Family: none)	1-4 5
Y A	JP 2015-224676 A (Taiho Kogyo Co., Ltd.), 14 December 2015 (14.12.2015), paragraphs [0066] to [0067]; fig. 7 (Family: none)	1-4 5
Y A	JP 2015-140557 A (Omron Corp.), 03 August 2015 (03.08.2015), paragraph [0038]; fig. 6 (Family: none)	1-4 5

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

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
27 February 2017 (27.02.17)	07 March 2017 (07.03.17)

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

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2016/087623

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y A	JP 2016-37150 A (FTS Co., Ltd.), 22 March 2016 (22.03.2016), paragraph [0038]; fig. 8 (Family: none)	1-4 5
A	US 5129800 A (BOBLITT,Wayne W.), 14 July 1992 (14.07.1992), (Family: none)	1-5

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REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2013136957 A **[0006]**