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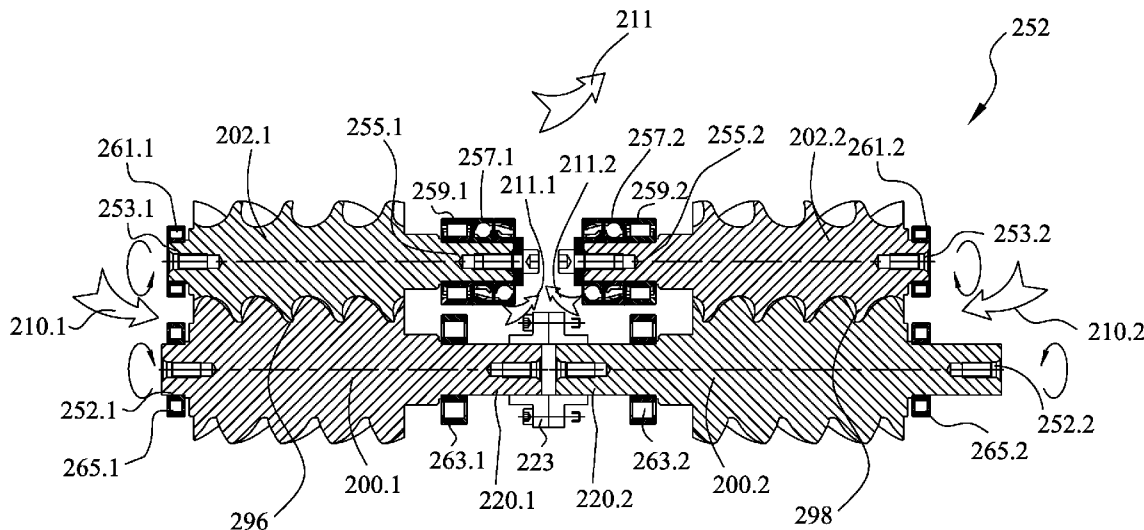


Figure 2B

(57) Abstract: A screw compressor (252) comprises first and second male rotors (200.1, 200.2) which have convex-helical teeth (292), first and second female rotors (202.1, 202.2) which have concave-helical teeth (294), each of the first and second male rotors (200.1, 200.2) being rigidly connected together, each of the first and second female rotors (202.1, 202.2) being arranged separately from and opposite to each other; wherein the convex-helical teeth (292) are engaged with the corresponding concave-helical teeth (294). The first and second male rotors (200.1, 200.2) are symmetrically so that the axial force exerted on the first male rotor counteracts with the axial force exerted on the second male rotor.



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A Screw Compressor with Male and Female Rotors

TECHNICAL FIELD

The present application generally relates to the field of refrigerating and air-conditioning, and more particularly to a screw compressor with male and female rotors which is used in refrigerating and air-conditioning.

BACKGROUND

Screw compressors have a wide application in the field of refrigerating and air-conditioning due to their wide applicability and high reliability. It is known that a load on a screw compressor is most suitable only when the screw compressor is designed for a working condition. However, in actual operation, loads on the rotors of the screw compressors vary greatly due to different application demands and working conditions.

Figure 1 shows a conventional screw compressor 100 that has a female rotor 110 and a male rotor 120. In the process in which the screw compressor is compressing gas medium, the gaseous refrigerant is compressed from low pressure into high pressure, such that the refrigerant pressure increases gradually from a low entry pressure to a high discharge pressure when the gaseous refrigerant moves from the inlet 121 to the outlet 122 of the screw compressor 100. As a result, a force along the axial direction from the outlet 122 to the inlet 121 is exerted on the male rotor 120. Usually, cylindrical roller bearings 123 are provided at the respective ones of two ends 120 of the helical male rotor 120 to bear the force along the radial direction, while thrust bearings 124 are provided at end of the male rotor 120 to bear the force along the axial direction.

Because the working conditions of refrigerating screw compressors vary greatly, the axial force exerted on the helical rotors designed for such a screw compressor also vary greatly. When the discharge pressure and the entry pressure of the screw compressor differ greatly, the axial force exerted on the rotors will be tremendous accordingly. Especially for the male rotor 120, the axial force possibly exceeds the design load for the thrust bearing of the screw compressor, which may reduce the life of the thrust bearing; or in worse cases, the axial force may even damage the thrust bearing, causing failure because the helical rotors stuck within the body of the screw compressor. However, when the difference between the discharge pressure and the entry pressure is very small, the axial force exerted on the helical

rotors will also be very small, even being possibly smaller than the minimum load needed by the thrust bearings of the screw compressor, causing slippage of the balls in the thrust bearings. To prevent over-load on the thrust bearing of the male rotor 120 under a working condition with high pressure-difference, some screw compressors are designed to provide a balancing piston at the male rotor 120 side so as to balance a portion of the axial force. However, such an approach cannot fully solve the variation issue of the axial force, especially cannot solve the slippage issue of the thrust bearings when the load on the compressor is too small.

Therefore, there is a need for an improved screw compressor that can solve some or all of the above mentioned shortcomings in the traditional compressors.

SUMMARY

The present application provides a screw compressor that comprises: a first male rotor and a second male rotor, each of the first male rotor and the second male rotor having convex-helical teeth, the first male rotor and the second male rotor being rigidly connected together; a first female rotor and a second female rotor, each of the first female rotor and the second female rotor having concave-helical teeth, the first female rotor being arranged separately from and opposite to each other; wherein the convex-helical teeth of the first male rotor are engaged with the concave-helical teeth of the first female rotor, and the convex-helical teeth of the second male rotor are engaged with the concave-helical teeth of the second female rotor .

The screw compressor above, wherein a first compressing channel is formed between the first male rotor and the first female rotor, the first compressing channel has a first inlet and a first outlet, a first stream of medium flows through the first compressing channel in a first flow direction from the first inlet to the first outlet; a second compressing channel is formed between the second male rotor and the second female rotor, the second compressing channel has a second inlet and a second outlet, a second stream of medium flows through the second compressing channel in a second flow direction from the second inlet to the second outlet; the first flow direction is opposite to the second flow direction.

The screw compressor above, wherein: the first stream of medium generates a first axial force that is exerted on the first male rotor when the first stream of medium is being compressed in the first compressing channel; the second stream of medium generates a

second axial force that is exerted on the second male rotor when the second stream of medium is being compressed in the second compressing channel; the first axial force and the second axial force are opposite to each other.

The screw compressor above, wherein the first male rotor and the second male rotor being rigidly connected together by rigid shaft coupling or rigid union joint, by welding or by being made as one piece.

The screw compressor above, wherein the first stream of medium and the second stream of medium flow towards to or flow away from each other.

The screw compressor above, wherein the medium is refrigerant.

The screw compressor above, wherein the first stream of medium and the second stream of medium are introduced from an evaporator and sent to a condenser after being compressed by the screw compressor.

The screw compressor above, wherein when the first male rotor and the second male rotor rotate in a first rotation direction, the first female rotor and the second female rotor are driven by the first male rotor and the second male rotor to rotate in a second rotating direction, the first rotation direction is opposite to the second rotation direction.

The screw compressor above, wherein the first male rotor, the second male rotor, the first female rotor and the second female rotor are enclosed in a housing in a sealed condition.

The screw compressor above, wherein the two ends of the first male rotor and the second male rotor are amounted on two roller bearings, respectively; the two ends of the first female rotor and the second female rotor are amounted on two roller bearings, respectively.

The screw compressor above, wherein one of the two ends of the first female rotor and the second female rotor is amounted on thrust bearings .

The screw compressor above, further comprises:

a motor that is amounted on the shaft between the first male rotor and the second male rotor.

The present application also provides a refrigeration air-conditioning unit that comprises:

a screw compressor that is made according to any one of the above defined screw compressor.

BRIEF DESCRIPTION OF THE DRAWINGS

The drawings below are for understanding the present application. The embodiments and depictions thereof as illustrated in the drawings are for explaining the principle of the present application. In the drawings,

Figure 1 shows a conventional screw compressor 100;

Figure 2A shows an illustrative block diagram of a refrigeration air-conditioning unit 240 according to the first embodiment in the present application;

Figure 2B shows the compressor 252 of Figure 2A in greater detail according to the first embodiment in the present application;

Figures 2C (1)-(3) show the helical teeth on the male rotor 200.2 and female rotor 202.2 in greater details according to one embodiment in the present application;

Figure 2D shows the compressor 252 of Figure 2A in greater detail according to the second embodiment of the present application;

Figure 3A shows an illustrative block diagram of a refrigeration air-conditioning unit 240 according to the second embodiment in the present application;

Figure 3B shows the compressor 252 of Figure 2A in greater detail according to the third embodiment of the present application;

Figure 3C shows the compressor 252 of Figure 3B in greater detail according to the fourth embodiment of the compressor 252 in the present application.

DETAILED DESCRIPTION OF EMBODIMENTS

Hereinafter, details are provided for understanding of the present application. However, those skilled in the art would appreciate that the present application may be implemented with variations of these details. It needs to be noted that the terms “upper,” “lower,” “front,” “rear,” “left,” “right,” and similar directional expressions used herein are only for illustration purposes, not intended for limiting. In the accompany drawings, similar or same components use the same reference numbers to simplify descriptions of the present application.

The sequential numerals such as “first” and “second” referenced in the present disclosure are only for identifying, without any limiting (such as a specific sequence). Moreover, the

term “a first component” itself does not imply existence of “a second component,” and the term “a second component” does not imply existence of “a first component.”

Figure 2A shows an illustrative block diagram of a refrigeration air-conditioning unit 240 according to the first embodiment in the present application, in which the screw compressor 252 is used according to the present application. As shown in Figure 2A, the refrigeration air-conditioning unit 240 includes four components, namely, evaporator 250, compressor 252, condenser 254 and throttling apparatus 256. The four components are fluently connected by pipe lines and medium (such as refrigerant) is circulated through the four components via these pipe lines. In the first embodiment of the refrigeration air-conditioning unit 240, the evaporator 250 is connected to a pipe 269, which is divided into two pipes of 269.1, 269.2 that are in turn connected to compressor 252. In operation, the evaporator 250 contains refrigerant in gaseous-liquid mixture format and changes the refrigerant mixture into gaseous format. The gaseous refrigerant is then introduced in to the compressor 252 via the pipe 269, where the pipe is divided into 269.1, 269.2 that are connected to the compressor 252. In the compressor 252, the gaseous refrigerant is compressed into high-pressure refrigerant gas, which is further introduced into the condenser 254. The condenser 254 changes the high-pressure refrigerant gas into liquid format, and the liquid refrigerant is then introduced into the throttling apparatus 256 via pipe 281. The throttling apparatus 256 converts the liquid refrigerant to gaseous-liquid mixture format again, and the gaseous-liquid mixture is led back to the evaporator 250 via pipe 282. The above process is repeated among the four components during the operation of the refrigeration air-conditioning unit 240.

Figure 2B shows the compressor 252 of Figure 2A in greater detail according to the first embodiment in the present application. As shown in Figure 2B, the screw compressor 252 comprises two male rotors 200.1, 200.2 and two female rotors 202.1, 202.2. The two female rotors 202.1, 202.2 and the two male rotors 200.1, 200.2 are oppositely disposed and symmetrically arranged, respectively.

In Figure 2B, roller bearings 265.1, 263.1 are installed at the entry end 252.1 and the discharge end 220.1 of the male rotor 200.1, respectively; roller bearings 265.2, 263.2 are installed at the entry end 252.2 and the discharge end 220.2 of the male rotor 200.2, respectively; roller bearings 261.1, 259.1 are installed at the entry end 253.1 and the discharge end 255.1 of the female rotor 202.1, respectively; roller bearings 261.2, 259.2 are installed at the entry end 253.2 and the discharge end 255.2 of the female rotor 202.2, respectively; thrust

bearings 257.1, 257.2 are installed, in parallel with roller bearings 259.1, 259.2, at the discharge ends 255.1, 255.2 of the female rotors 202.1, 202.2, respectively. The two male rotors 200.1, 200.2 and two female rotors 202.1, 202.2 are rotationally supported by these bearings.

More specifically, an inlet 210.1 and an outlet 211.1 are disposed at the two ends of the male rotor 200.1 and the female rotor 202.1; an inlet 210.2 and an outlet 211.2 are disposed at the two ends of the male rotor 200.2 and the female rotor 202.2. The entry end 252.1 of the male rotor 200.1 and entry end 253.1 of the female rotor 202.1 are located at the inlet 210.1; the entry end 252.2 of the male rotor 200.2 and entry end 253.2 of the female rotor 202.2 are located at the inlet 210.2; the discharge end 220.1 of the male rotor 200.1 and discharge end 255.1 of the female rotor 202.1 are located near the outlet 211.1; the discharge end 220.2 of the male rotor 200.2 and discharge end 255.2 of the female rotor 202.2 are located near the outlet 211.2. The two male rotors 200.1, 200.2 are co-axially rigidly coupled on the discharge ends 220.1, 220.2 of the male rotors 200.1, 200.2. As one embodiment, the discharge ends 220.1, 220.2 of the two male rotors 200.1, 200.2 are rigidly coupled together by using rigid shaft coupling or rigid union joint 223, such that the outlets 211.1, 211.2 are combined as a combined outlet 211 at the discharge ends 220.1, 220.2 of the two male rotors 200.1, 200.2 and the discharge ends 255.1, 255.2 of the two female rotors 202.1, 202.2. In this arrangement, the forces exerted on the two male rotors 200.1, 200.2 along an axial direction counteract with each other during the operation of the screw compressor 252.

In other words, an axial force exerted on male rotor 200.1 is directed from its discharge end 220.1 towards its entry end 252.1 and an axial force exerted on the male rotor 200.2 is directed from its discharge end 220.2 towards its entry end 252.2. The directions of these two forces are opposite and counteract to each other because the two male rotors 220.1, 220.2 are fixedly and rigidly coupled with each other. The counteraction of the two axial forces can save the thrust bearings on the two male rotors 200.1, 200.2, thereby reducing the manufacturing cost of the screw compressor. Moreover, by saving the thrust bearings, the screw compressor can run stably and smoothly even in a high pressure-difference working condition without the problem of overload to the thrust bearings, thereby improving the reliability of the screw compressor in the present application. Further, in a low pressure-difference working condition, slippage caused by under-load (meaning the load is lower than the required load) on the thrust bearings can be avoided, which also improves the

reliability of the screw compressor in the present application. Also, with counteraction of the two axial forces, a balancing piston at the male rotors can be saved, thus further reducing the cost and improving the durability of the compressor in the present application.

Figures 2C (1)-(3) show the helical teeth on the male rotor 200.2 and female rotor 202.2 in greater details according to one embodiment in the present application. As shown in Figures 2C (1)-(3), the male rotor 200.2 contains four convex-helical teeth 292 and the female rotor 202.2 contains six concave-helical teeth 294. The four convex-helical teeth 292 on the male rotor 200.2 engage with the six concave-helical teeth 294 on the female rotor 202.2 while the male rotor 200.2 rotates in counter clockwise direction, which drives the female rotor 202.2 to rotate in clockwise direction. When in a sealed condition by a housing (see Figure 2D), with the engagement between the four convex-helical teeth 292 and six concave-helical teeth 294, four chambers (which can be deemed as a second compress channel 298) are formed between the four convex-helical teeth 292 and the six concave-helical teeth 294 when the male rotor 200.2 and the female rotor 202.2 are rotating. The four convex-helical teeth 292 on the male rotor 200.2 and the six concave-helical teeth 294 on the female rotor 202.2 are designed such that, during the rotation of the male rotor 200.2 and the female rotor 202.2, the refrigerant is sucked into the inlet 210.2 of the chambers, is being compressed within the compress chambers while moving from the inlet 210.2 to the outlet 211.2 of the compress chambers and is pushed out of the outlet 211.2 where the refrigerant is compressed as high pressure refrigerant. Figure 2C(1) shows that the refrigerant is sucked into the inlet 210.2; Figure 2C(2) shows that the refrigerant is being compressed in one of the four compress channels or chambers while moving from the inlet 210.2 to the outlet 211.2; Figure 2C(3) shows that refrigerant is pushed out of the outlet 211.2 where the refrigerant is compressed as high pressure refrigerant. In Figures 2C (1)-(3), the blackened portions in the drawings indicate that the refrigerant is being compressed while moving from the inlet 210.2 to the outlet 211.2.

A person skilled in the art would understand that the male rotor 200.1 and female rotor 202.1 are designed by using the same principle as described in connection with Figures 2C(1)-(3). Specifically, the four convex-helical teeth 292 on the male rotor 200.1 engage with the six concave-helical teeth 294 on the female rotor 202.2 while the male rotor 200.1 rotates in counter clockwise direction, which drives the female rotor 202.1 to rotate in clockwise direction. The four convex-helical teeth 292 on the male rotor 200.1 and the six

concave-helical teeth 294 on the female rotor 202.1 are designed such that, during rotation of the male rotor 200.1 and the female rotor 202.1, the refrigerant is sucked into the inlet 210.1 of the four compress channels or chambers (which can be deemed as a first compress channel 296), is being compressed within the compress channels or chambers while moving from the inlet 210.1 to the outlet 211.1 and is pushed out of the outlet 211.1 where the refrigerant is compressed as high pressure refrigerant.

Figure 2D shows the compressor 252 of Figure 2A in greater detail according to the second embodiment of the present application. As shown in Figure 2D, the two male rotors 200.1, 200.2 and two female rotors 202.1, 202.2 are installed in a housing 268, which encloses the two male rotors 200.1, 200.2 and two female rotors 202.1, 202.1 into a sealed environment. As shown in Figure 2D, the housing 268 is connected to a pipe inlet 269.1, which is in turn connected to the pipe 269 shown in Figure 2A, at the lateral side of the entry ends 252.1, 253.1 of the male rotor 200.1 and the female rotor 202.1; the housing 268 is also connected to the pipe 269.2, which is also in turn connected to the pipe 269 shown in Figure 2A, at the lateral side of the entry ends 252.2, 253.2 of the male rotor 200.2 and the female rotor 202.2; the housing 268 is further connected pipe 270, which is connected to the condenser 254 shown in Figure 2A, at the location above of the discharge ends 255.1, 255.2 of the female rotors 202.1, 202.2. To maintain the housing 268 in a sealed condition, a seal 272 is installed around the shaft 274, which is located at the entry end 252.2 of the male rotor 200.2 and is extended outside of the housing 268.

To describe the operation of the compressor 252, reference is still made to Figure 2D. In operation, a motor (not shown) drives the shaft 274 so that the male rotors 200.1, 200.2 rotate in counter clockwise direction, which in turn drives the female rotors 202.1, 202.2 to rotate in clockwise direction through the engagements between the convex-helical teeth on the male rotors 200.1, 200.2 and the concave-helical teeth on the female rotors 202.1, 202.2. With the rotation of the male rotors 200.1, 200.2 and the female rotors 202.1, 202.2, the refrigerant from the evaporator 250 as shown in Figure 2A is sucked into the inlets 210.1, 210.2 through the pipes 269.1, 269.2, respectively. The two streams of refrigerant move from the inlets 210.1, 210.2 to the outlets 211.1, 211.2. towards each other while they are being compressed. These two compressed streams are combined as one compressed stream at the combined outlet 211, which is led to the pipe 270 as shown in Figure 2B.

Figure 3A shows an illustrative block diagram of a refrigeration air-conditioning unit 240

according to the third embodiment in the present application, in which the screw compressor 252 is used according to the present application. As shown in Figure 3A, the refrigeration air-conditioning unit 240 has the same structure as that in Figure 2A except some pipe connections to the compressor 252. Specifically, in Figure 3A, the evaporator 250 is connected to the compressor 252 via the pipe 269 and the compressor 252 is connected to the condenser 254 via pipes 270.1, 270.2, which are combined into one pipe 270. The refrigerant flows through the evaporator 250, compressor 252, condenser 254 and the throttling apparatus 256 in the same fashion as described in connection with Figure 2A.

Figure 3B shows the compressor 252 of Figure 2A in greater detail according to the third embodiment of the present application. As shown in Figure 3B, the third embodiment also comprises the male rotors 200.1, 200.2 and female rotors 202.1, 202.2 as those the in the first embodiment of compressor 252 shown in Figure 2B. However, in the third embodiment, the male rotors 200.1, 200.2 and female rotors 202.1, 202.2 are reversely installed comparing with the male rotors 200.1, 200.2 and female rotors 202.1, 202.2 shown in Figure 2B.

Specifically, in Figure 3B, the entry ends 252.1, 252.2 of the male rotors 200.1, 200.2 are rigidly connected together by using rigid shaft coupling or rigid union joint 223 and the entry ends 253.1, 253.2 of the female rotors 202.1, 202.2 are installed above the entry ends 252.1, 252.2 of the male rotors 200.1, 200.2. The entry ends 253.1, 253.2 of the female rotors 202.1, 202.2 are oppositely facing each other such that the inlets 210.1, 210.2 are arranged among the four entry ends 252.1, 252.2, 253.1, 253.2 of the four rotors 200.1, 200.2, 202.1, 202.2, respectively. As shown in Figure 3B, the discharge ends 220.1, 255.1 of the male rotor 200.1 and female rotor 202.1 are arranged at one end of the compressor 252 while the discharge ends 220.2, 255.2 of the male rotor 200.2 and female rotor 202.2 are arranged at the other end of the compressor 252 such that the outlets 211.1 and 211.2 are arranged at the two ends of the compressor 252. By contrast, in Figure 2B, the discharge ends 220.1, 220.2 of the male rotors 200.1, 200.2 are rigidly connected together by using rigid shaft coupling or rigid union joint 223. The discharge ends 255.1, 255.2 are installed above the discharge ends 220.1, 220.2 of the male rotors 200.1, 200.2 and are oppositely facing each other such that the outlets 211.1, 211.2 are arranged among the four discharge ends 220.1, 220.2, 255.1, 255.2 of the four rotors 200.1, 200.2, 202.1, 202.2, respectively. As shown in Figure 2B, the entry ends 252.1, 253.1 of the male rotor 200.1 and female rotor 202.1 are arranged at one end of the compressor 252 while the entry ends 252.2, 253.2 of the male rotor 200.2 and female

rotor 202.2 are arranged at the other end of the compressor 252 such that the inlets 210.1 and 210.2 are arranged at the two ends of the compressor 252.

In Figure 3B, the four convex-helical teeth on the male rotor 200.1, 200.2 and the six concave-helical teeth on the female rotor 202.1, 202.2 are arranged such that, during rotation of the male rotor 200.1, 200.2 and the female rotor 202.1, 202.2, two streams of refrigerant are respectively sucked into the inlets 210.1, 210.2 and are being compressed within the compress chambers (which can be deemed as a first compress channel 296) between the male rotor 200.1 and female rotor 202.1 and within the compress chambers (which can be deemed as a second compress channel 298) between the male rotor 200.2 and female rotor 202.2. One of the two streams flows from the inlet 210.1 to the outlet 211.1 and is pushed out of the outlet 211.1 as high pressure refrigerant. The other one of the two streams flows from the inlet 210.2 to the outlet 211.2 and is pushed out of the outlet 211.2 as high pressure refrigerant. In the embodiment of Figure 3B, the two streams of the compressed refrigerant flow away from each other, therefore the forces exerted on the two male rotors 200.1, 200.2 along an axial direction counteract with each other during the operation of the screw compressor 252 because the entry ends 252.1, 252.2 of the two male rotors 200.1, 200.2 are rigidly coupled together, which can generate at least the same advantageous technical results as described in connection with Figure 2B.

In the embodiment as shown in Figure 3B, a motor 312 is installed on the shaft 314 between the male rotors 200.1, 200.2 near the rigid shaft coupling or rigid union joint 223, which drives the shaft 314 to rotate the male rotors 200.1, 200.2. The motor 312 comprises a stator 333 and a rotor 335, which is mounted on the shaft 314 between the male rotors 200.1, 200.2 near the rigid shaft coupling or rigid union joint 223. Because the male rotors 200.1, 200.2 are mounted between the two male rotors 200.1, 200.2, it can apply rotation torque onto the two male rotors 200.1, 200.2 in a more balanced and smooth fashion.

In Figure 3B, the motor 312 is not mounted on traditional cantilever mechanism, but is mounted on the shaft 314 which is located in the middle location of the male rotors 200.1, 200.2. Such an arrangement according to the embodiment in Figure 3B does not produce, or produce less, bending torque on the shaft 314. The deflection on the rotating shaft on the traditional cantilever mechanism can cause the stator and rotor off the rotating center of the rotating shaft on the traditional cantilever mechanism, which can cause vibration and electromagnetic noise or in worse situation can cause friction between the stator and rotor of

the motor. The embodiment shown in Figure 3B can overcome the shortcomings in the traditional cantilever mechanism.

Figure 3C shows the compressor 252 of Figure 3B in greater detail according to the fourth embodiment of the compressor 252 in the present application. As shown in Figure 3C, the two male rotors 200.1, 200.2, two female rotors 202.1, 202.1 and motor 312 are installed in a housing 284, which encloses these five components into a sealed environment. As shown in Figure 3C, the housing 284 is connected to a pipe inlet 269, which is in turn connected to the compressor 252 shown in Figure 3A in the top middle location of the housing 284; the housing 284 is also connected to the pipes 270.1, 270.2 at the two lateral sides of the housing 284, which are combined and in turn connected to the pipe 270 shown in Figure 3A. The pipe 270 is connected to the condenser 254 shown Figure 3A.

To describe the operation of the compressor 252 according the fourth embodiment of the compressor 252, reference is still made to Figure 3C. In operation, the motor 312 drives the shaft 314 so that the male rotors 200.1, 200.2 rotate in counter clockwise direction, which in turn drives the female rotors 202.1, 202.2 to rotate in clockwise direction through the engagements between the convex-helical teeth on the male rotors 200.1, 200.2 and the concave-helical teeth on the female rotors 202.1, 202.2. With the rotation of the male rotors 200.1, 200.2 and the female rotors 202.1, 202.2, a stream of refrigerant from the evaporator 250 as shown in Figure 3A is sucked into the housing 284 via pipe 269. The stream of refrigerant is divided into two streams of refrigerant within the housing 284. One of the two streams enters into the inlet 210.1 and comes out from the outlet 211.1 as high pressure refrigerant; while the other one the two streams enters into the inlet 210.2 and comes out from the outlet 211.2 as high pressure refrigerant.

In the embodiments of the present application, the two male rotors 200.1, 200.2 can be rigidly connected together by using a rigid shaft coupling or rigid union joint, by welding them into one unit or by making them in one piece.

By arranging the two axial forces exerted on the two rotors in two opposite directions in, the embodiments of the screw compressors in the present application, the present application has at least some advantageous technical results comparing the traditional screw compressors as follows: (1) saving the thrust bearings and balance piston can saved, thus improving the durability and reliability of the screw compressors, (2) reducing the axial force exerted on the

roller bearings, thus improving the life of the roller bearings which further improves the durability and reliability of the screw compressors, (3) solving the over-load and under-load issued in the traditional screw compressor, (4) counter-acting the two axial forces so that the screw compressors can run more smoothly and quietly with reduced vibrations.

Unless otherwise indicated, the technical and scientific terms used herein have identical meanings as generally understood by those skilled in the art. The terms used herein are only for purposes of describing specific embodiments, not for limiting the present disclosure. Terms like “dispose” appearing herein may indicate directly attaching one component to another, or indicate attachment of one component to another component via a middleware. A feature described in one embodiment herein may be separately, or jointly with other features, applied to another embodiment, unless otherwise indicated or this feature is not applicable in said another embodiment.

The present invention has been described through the embodiments above. However, it should be understood that the embodiments are only for exemplary and illustrative purposes, not intended to limit the present application within the scope of the described embodiments. Besides, those skilled in the art may understand that the present application is not limited to the embodiments above, and more alternation and modifications may be made according to the teaching of the present application, and all of these alterations and modifications fall within the protection scope claimed by the present application.

Claims

1. A screw compressor (252), comprising:

a first male rotor (200.1) and a second male rotor (200.2), each of the first male rotor (200.1) and the second male rotor (200.2) having convex-helical teeth (292), the first male rotor (200.1) and the second male rotor (200.2) being rigidly connected together;

a first female rotor (202.1) and a second female rotor (202.2), each of the first female rotor (202.1) and the second female rotor (202.2) having concave-helical teeth (294), the first female rotor (202.1) and the second female rotor (202.2) being arranged separately from and opposite to each other;

wherein the convex-helical teeth (292) of the first male rotor (200.1) are engaged with the concave-helical teeth (294) of the first female rotor (202.1), and the convex-helical teeth (292) of the second male rotor (200.2) are engaged with the concave-helical teeth (294) of the second female rotor (202.2).

2. The screw compressor (252) according to claim 1, wherein:

a first compressing channel (296) is formed between the first male rotor (200.1) and the first female rotor (202.1), the first compressing channel (296) has a first inlet (210.1) and a first outlet (211.1), a first stream of medium flows through the first compressing channel (296) in a first flow direction from the first inlet (210.1) to the first outlet (211.1);

a second compressing channel (298) is formed between the second male rotor (200.2) and the second female rotor (202.2), the second compressing channel (298) has a second inlet (210.2) and a second outlet (211.2), a second stream of medium flows through the second compressing channel (298) in a second flow direction from the second inlet (210.2) to the second outlet (211.2);

the first flow direction is opposite to the second flow direction.

3. The screw compressor (252) according to claim 1, wherein:

the first stream of medium generates a first axial force that is exerted on the first male rotor (200.1) when the first stream of medium is being compressed in the first compressing channel (296);

the second stream of medium generates a second axial force that is exerted on the second male rotor (200.2) when the second stream of medium is being compressed in the second compressing channel (298);

the first axial force and the second axial force are opposite to each other.

4. The screw compressor (252) according to claim 1, wherein the first male rotor (200.1) and the second male rotor (200.2) being rigidly connected together by rigid shaft coupling or rigid union joint (223), by welding or by being made as one piece.

5. The screw compressor (252) according to claim 1, wherein the first stream of medium and the second stream of medium flow towards to or flow away from each other.

6. The screw compressor (252) according to claim 5, wherein the medium is refrigerant.

7. The screw compressor (252) according to claim 1, wherein the first stream of medium and the second stream of medium are introduced from an evaporator (250) and sent to a condenser (254) after being compressed by the screw compressor (252).

8. The screw compressor (252) according to claim 1, wherein when the first male rotor (200.1) and the second male rotor (200.2) rotate in a first rotation direction, the first female rotor (202.1) and the second female rotor (202.2) are driven by the first male rotor (200.1) and the second male rotor (200.2) to rotate in a second rotating direction, the first rotation direction is opposite to the second rotation direction.

9. The screw compressor (252) according to claim 1, wherein the first male rotor (200.1), the second male rotor (200.2), the first female rotor (202.1) and the second female rotor (202.2) are enclosed in a housing (268,284) in a sealed condition.

10. The screw compressor (252) according to claim 1, wherein:
the two ends of the first male rotor (200.1) and the second male rotor (200.2) are amounted on two roller bearings (265.1, 263.1, 265.2, 263.2), respectively;
the two ends of the first female rotor (202.1) and the second female rotor (202.2) are amounted on two roller bearings (261.1, 259.1, 261.2, 259.2), respectively.

11. The screw compressor (252) according to claim 10, wherein:

one of the two ends of the first female rotor (202.1) and the second female rotor (202.2) is amounted on thrust bearings (257.1,257.2).

12. The screw compressor (252) according to claim 10, further comprising:
a motor (312) that is amounted on the shaft (314) between the first male rotor (200.1) and the second male rotor (200.2).

13. A refrigeration air-conditioning unit (240), comprising:
a screw compressor (252) that is made according to any one of the claims 1-12.

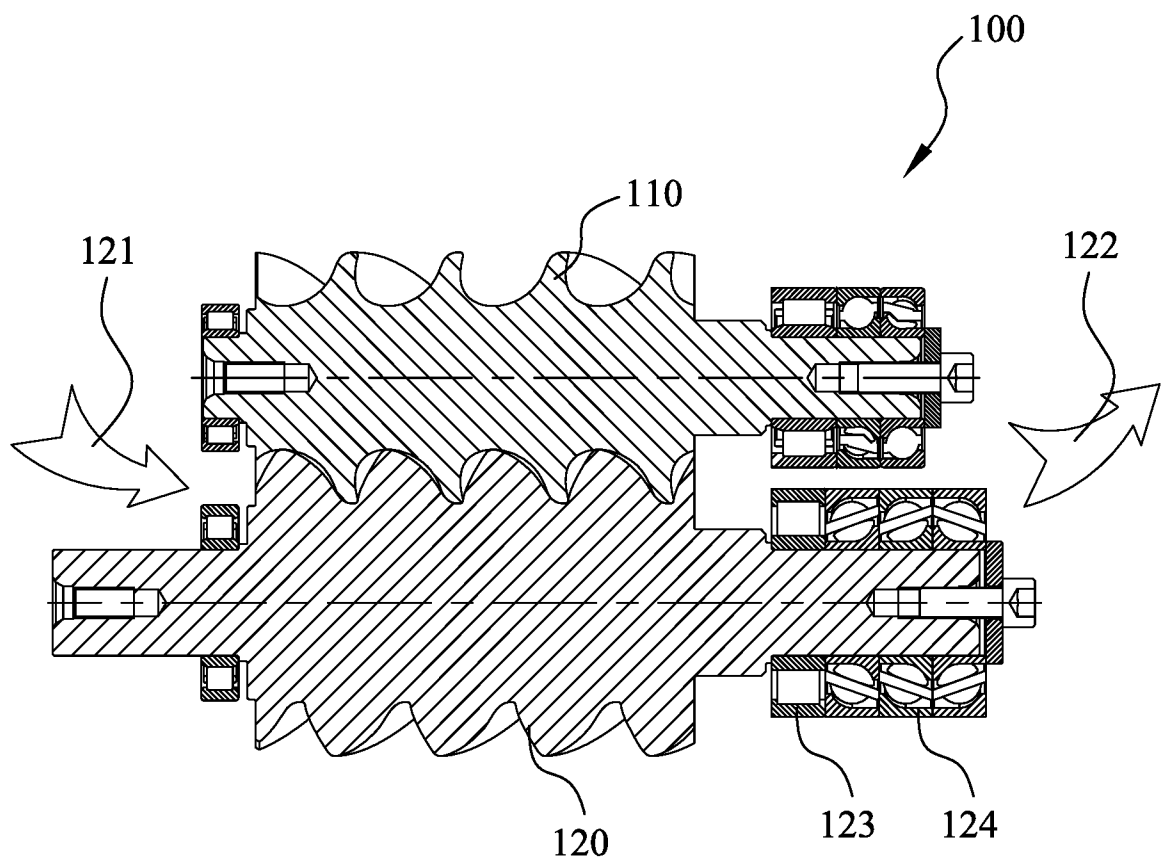


Figure 1

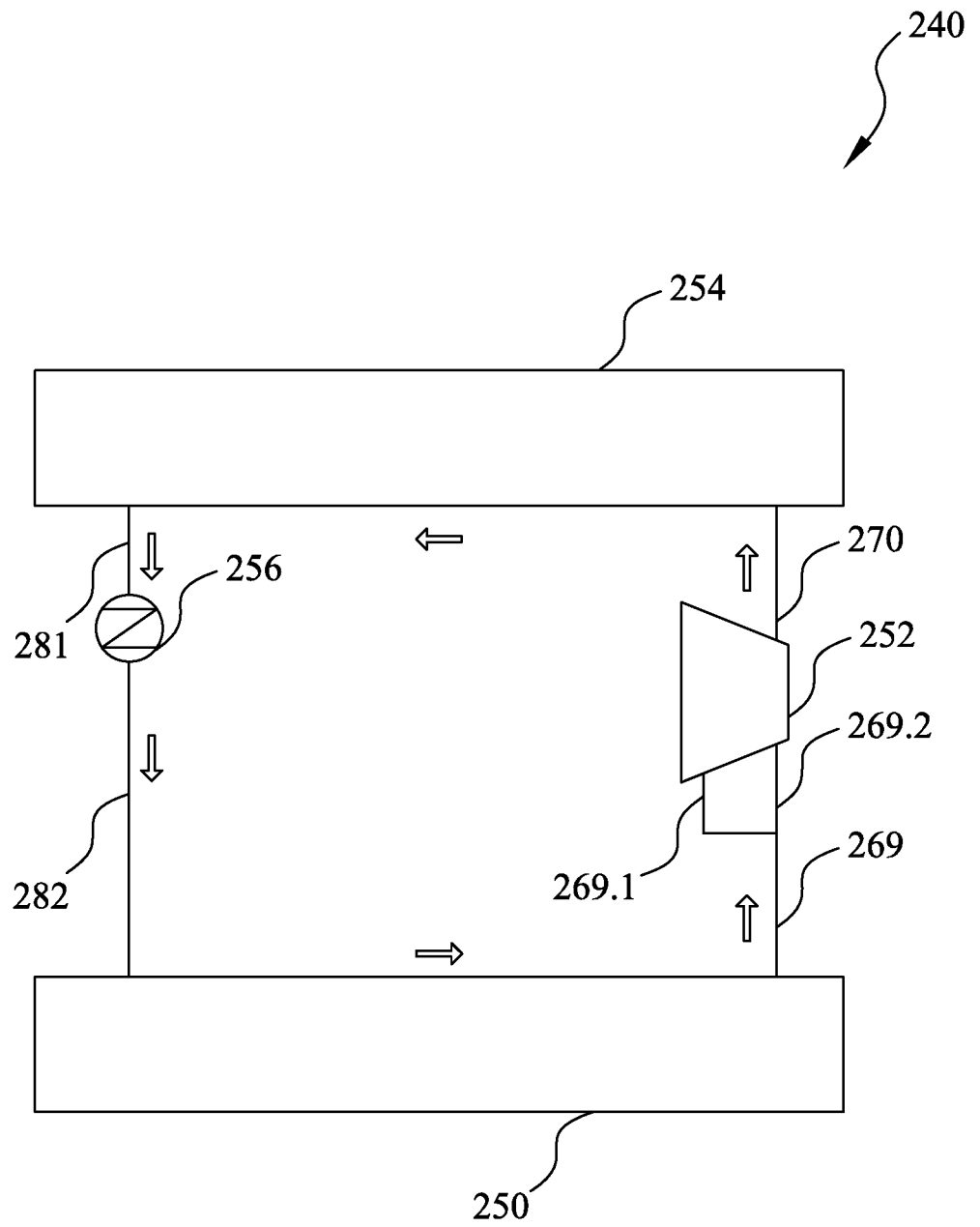


Figure 2A

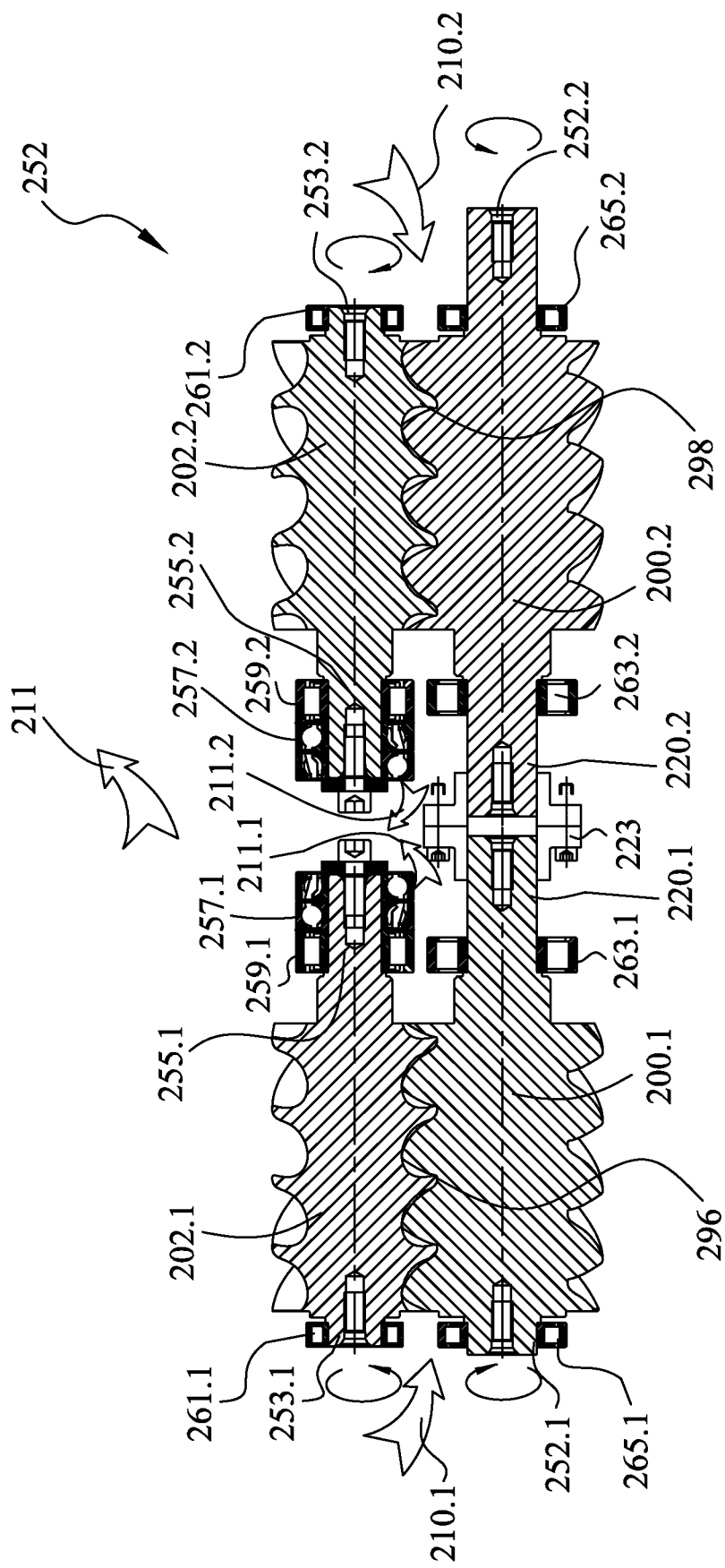


Figure 2B

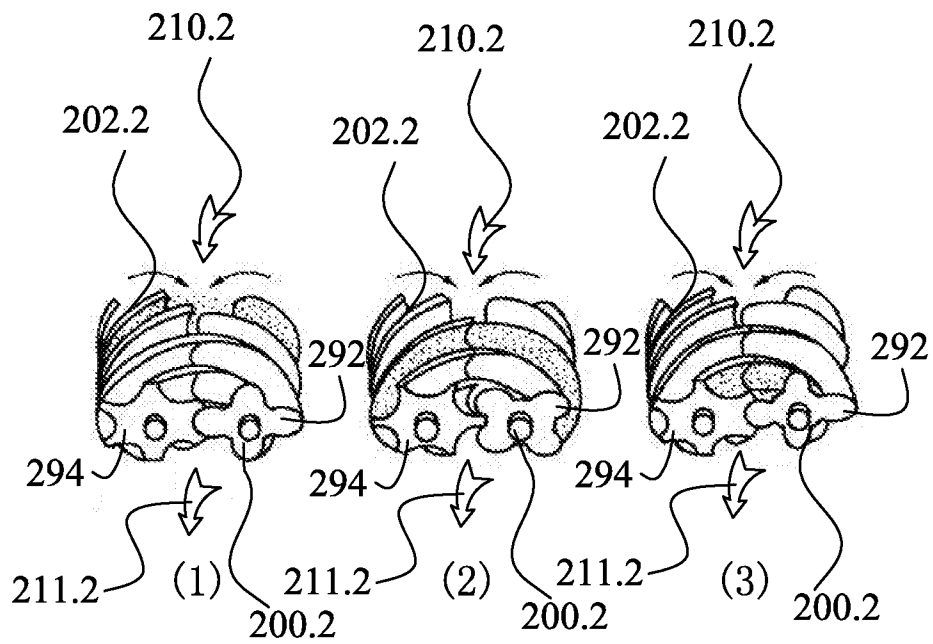


Figure 2C

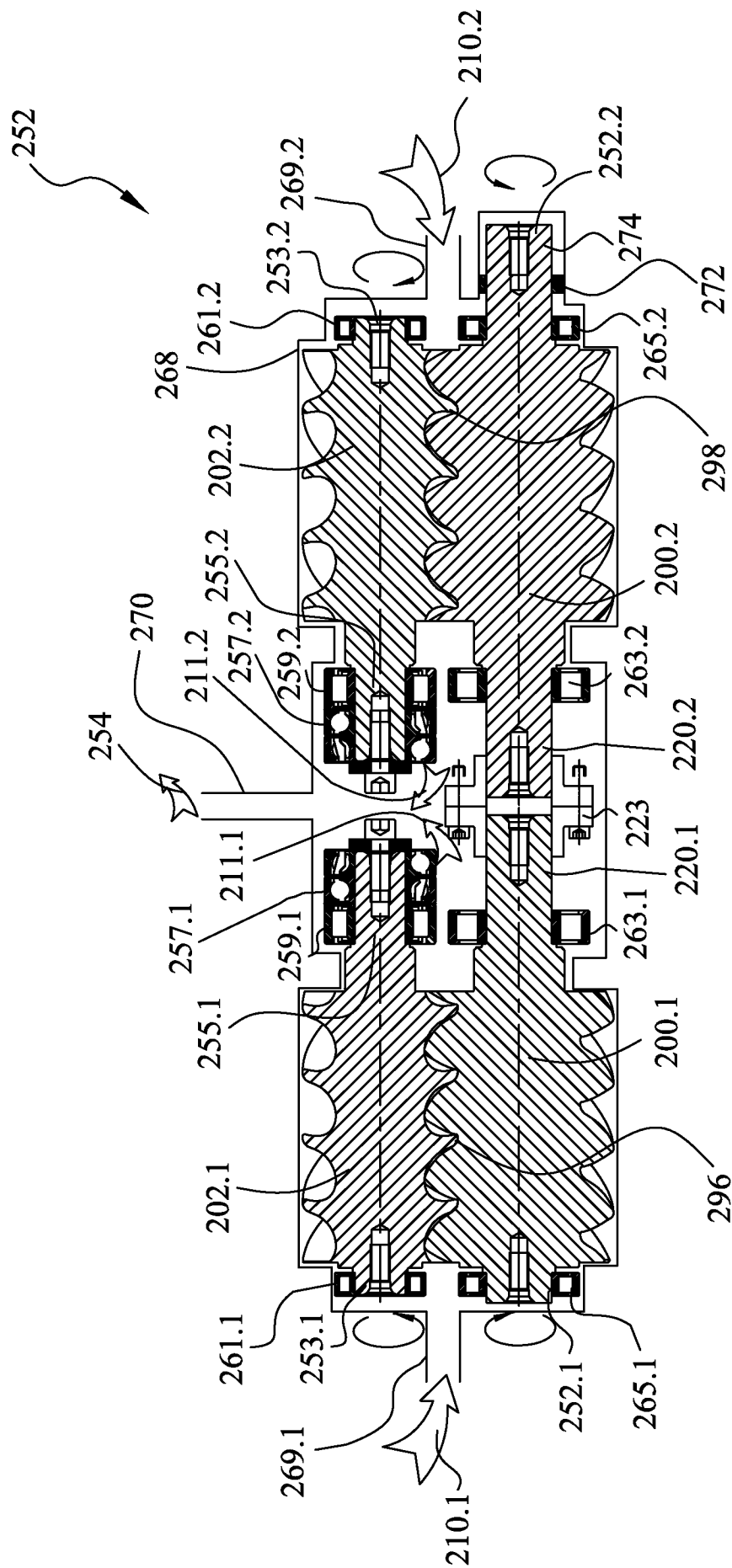


Figure 2D

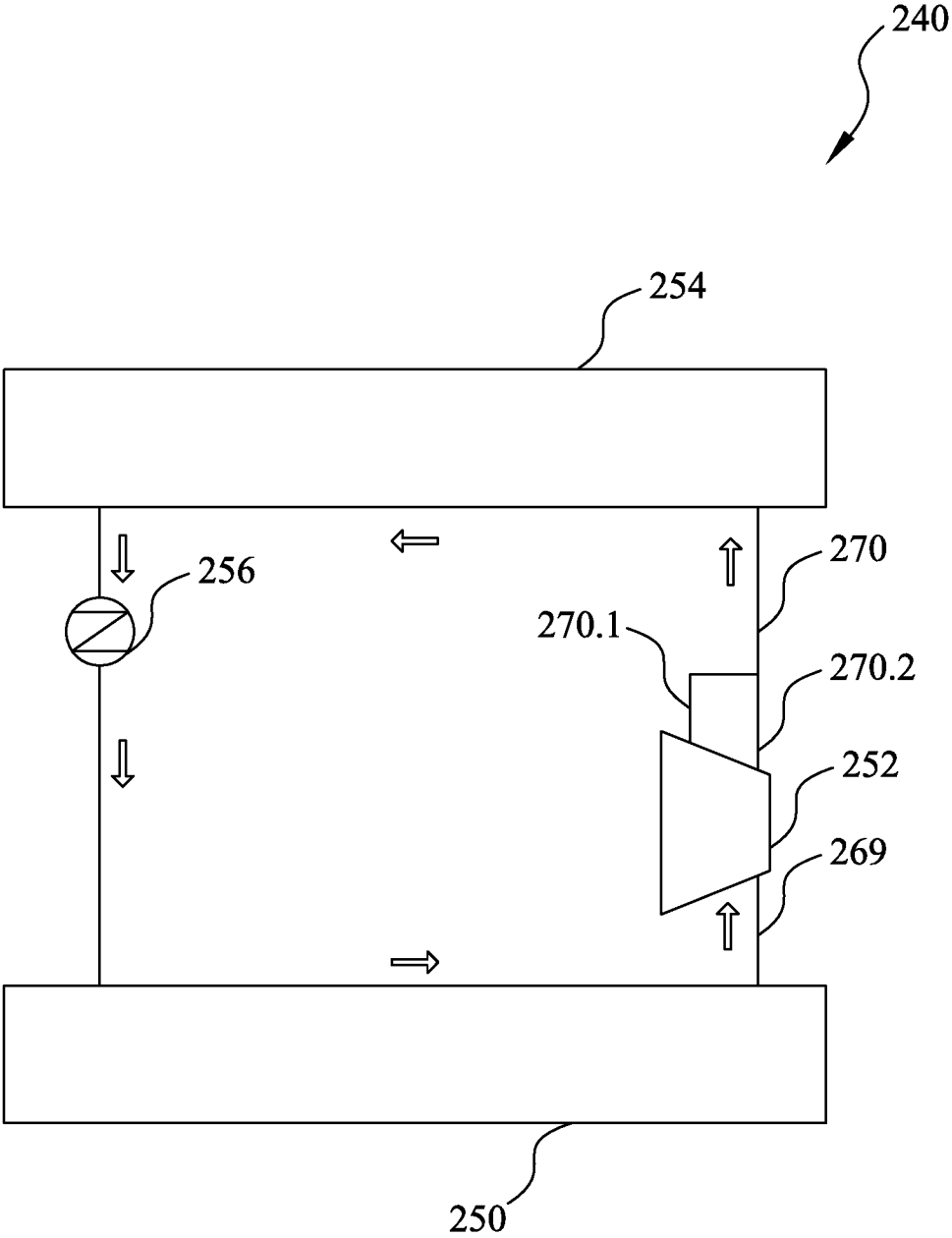


Figure 3A

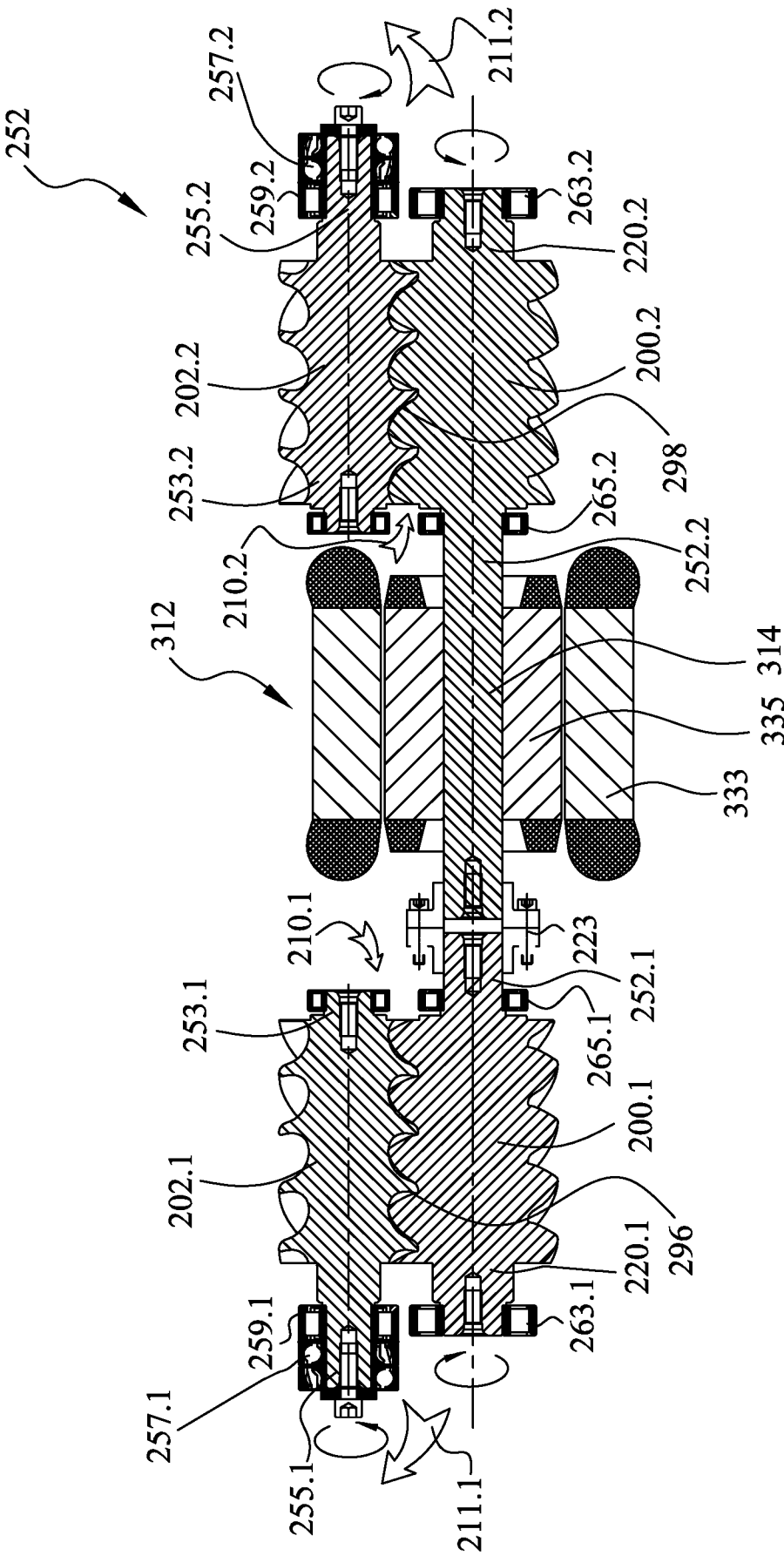


Figure 3B

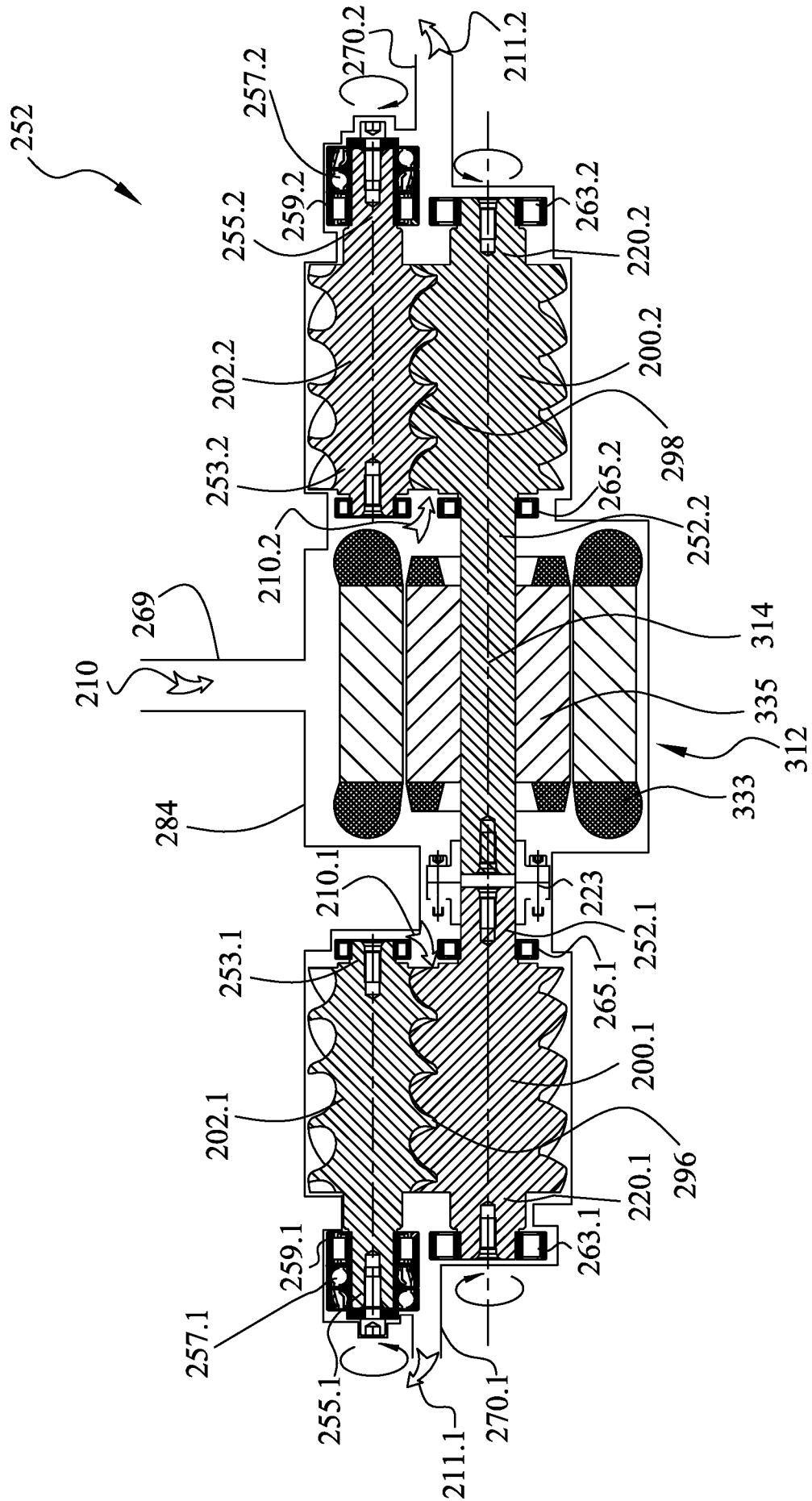


Figure 3C

INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2017/095491

A. CLASSIFICATION OF SUBJECT MATTER

F04C 18/16(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/-; F04C23/-

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

CNPAT, CNKI, WPI, EPODOC: screw, compressor, pump, double, thrust, counteract, balance, opposite, reverse, symmetrical
+, anti+**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
PX	CN 205937114 U (JOHNSON CONTROLS AIR-CONDITIONING AND REFRIGERATION EQUIPMENT WUXI CO., LTD. ET AL.) 08 February 2017 (2017-02-08) claims 1-5, description, paragraphs [0001], [0027]-[0032], figures 2 and 3	1-13
PX	CN 205618356 U (UNIV. EAST CHINA JIAOTONG) 05 October 2016 (2016-10-05) description, paragraphs [0034]-[0037], figures 1-12	1-13
X	CN 102996450 A (SHANGHAI HANBELL PRECISE MACHINERY CO., LTD.) 27 March 2013 (2013-03-27) description, paragraphs [0012]-[0014], figures 1-3	1-13
X	CN 202250858 U (SHANGHAI HANBELL PRECISE MACHINERY CO., LTD.) 30 May 2012 (2012-05-30) description, paragraphs [0012]-[0014], figures 1-3	1-13
X	CN 1793654 A (UNIV. XIAN JIAOTONG) 28 June 2006 (2006-06-28) description, page 1, line 6-9, page 3, line 25 to page 5, line 23, figures 1-4	1-13
X	CN 105805002 A (UNIV. EAST CHINA JIAOTONG) 27 July 2016 (2016-07-27) description, paragraphs [0034]-[0037], figures 1-12	1-13
X	DE 19820622 A1 (FRIEDEN, PETER) 11 November 1999 (1999-11-11) description, column 2, line 22 to column 6, line 32, figures 1 and 2	1-13

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

* Special categories of cited documents:

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

“E” earlier application or patent but published on or after the international filing date

“L” document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

“O” document referring to an oral disclosure, use, exhibition or other means

“P” document published prior to the international filing date but later than the priority date claimed

“T” later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

“X” document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

“Y” document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

“&” document member of the same patent family

Date of the actual completion of the international search

18 September 2017

Date of mailing of the international search report

11 October 2017

Name and mailing address of the ISA/CN

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INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2017/095491

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	JP S60249689 A (TOSHIBA K.K.) 10 December 1985 (1985-12-10) description, the embodiment and figure 1	1-13

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.

PCT/CN2017/095491

Patent document cited in search report			Publication date (day/month/year)	Patent family member(s)	Publication date (day/month/year)
CN	205937114	U	08 February 2017	None	
CN	205618356	U	05 October 2016	None	
CN	102996450	A	27 March 2013	None	
CN	202250858	U	30 May 2012	None	
CN	1793654	A	28 June 2006	None	
CN	105805002	A	27 July 2016	None	
DE	19820622	A1	11 November 1999	None	
JP	S60249689	A	10 December 1985	None	