(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 3 287 638 A1

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

(43) Date of publication:
28.02.2018 Bulletin 2018/09

(21) Application number: **16782497.8**

(22) Date of filing: **09.03.2016**

(51) Int Cl.:
F04C 18/02 *(2006.01)* ***F04C 29/00*** *(2006.01)*

(86) International application number:
PCT/CN2016/075986

(87) International publication number:
WO 2016/169349 (27.10.2016 Gazette 2016/43)

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
MA MD

(30) Priority: **23.04.2015 CN 201520251170 U**
23.04.2015 CN 201510196948

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(54) SCROLL COMPRESSOR AND DRIVING SHAFT AND UNLOADING BUSH FOR SCROLL COMPRESSOR

(57) A scroll compressor comprises a compressing mechanism (10) for compressing working fluid and a driving shaft (30) for driving the compressing mechanism (10). The driving shaft (30) comprises an eccentric crank pin (32). An unloading bush (42) is arranged between the compressing mechanism (10) and the eccentric crank pin (32), so that the eccentric crank pin (32) drives the compressing mechanism (10) via the unloading bush (42) to realize radial flexibility of the compressing mechanism (10). The eccentric crank pin (32) comprises an eccentric crank pin matching part which is in contact with the unloading bush (42) and relatively displaces. The unloading bush (42) comprises an unloading bush matching part which is in contact with the eccentric crank pin (32) and relatively displaces. A wear resisting layer (50) is arranged on at least one part of at least one of the eccentric crank pin matching part and the unloading bush matching part. An unloading bush provided with a wear resisting layer for a scroll compressor and a driving shaft with an eccentric crank pin provided with the wear resisting layer. Because of the arrangement of the wear resisting layer, the service life of the scroll compressor is prolonged.

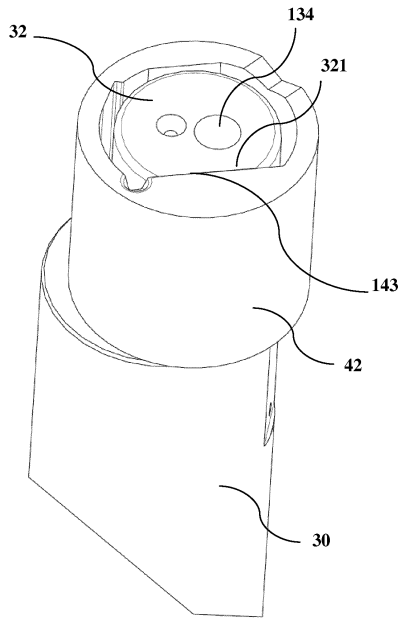


Fig. 2

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Description

[0001] This application claims the benefit of priorities to Chinese Patent Application Nos. 201510196948.3 and 201520251170.7, filed with the Chinese State Intellectual Property Office on April 23, 2015, the entire disclosures of which are incorporated herein by reference.

FIELD OF THE INVENTION

[0002] The present application relates to a scroll compressor and a driving shaft and an unloading bush for the scroll compressor.

BACKGROUND OF THE INVENTION

[0003] The contents of this section only provide background information related to this disclosure, which may not constitute the prior art.

[0004] A scroll compressor generally has a compression mechanism that compresses a working fluid (e.g., a refrigerant) and includes a fixed scroll member and an orbiting scroll member. The compression mechanism is driven by an eccentric crank pin of a driving shaft. An unloading bush is provided between the eccentric crank pin and the compression mechanism. The unloading bush is arranged so as to be driven by the eccentric crank pin and capable of displacing with respect to the eccentric crank pin, whereby a radial compliance between a vane of the fixed scroll member and a vane of the orbiting scroll member can be achieved.

[0005] However, the relative movement between the unloading bush and the eccentric crank pin causes their contact surfaces to be rapidly worn, thereby adversely affecting performance of the radial compliance of the compressor and shortening the service life of the unloading bush and the eccentric crank pin.

[0006] Accordingly, there is a need for a wear-resistant unloading bush and a wear-resistant eccentric crank pin for a scroll compressor.

SUMMARY OF THE INVENTION

[0007] An object of the present application is to provide a scroll compressor having a wear-resistant unloading bush and/or a wear-resistant eccentric crank pin.

[0008] Another object of the present application is to provide a scroll compressor having a long service life.

[0009] Another object of the present application is to provide a wear-resistant unloading bush.

[0010] Another object of the present application is to provide a driving shaft having a wear-resistant eccentric crank pin.

[0011] According to an aspect of the present application, a scroll compressor is provided, which includes a compression mechanism configured to compress a working fluid and a driving shaft configured to be capable of driving the compression mechanism. The driving shaft includes an eccentric crank pin, and an unloading bush is provided between the compression mechanism and the eccentric crank pin to allow the eccentric crank pin to drive the compression mechanism via the unloading bush so as to achieve a radial compliance of the compression mechanism. The eccentric crank pin includes an eccentric crank pin mating portion to be in contact with the unloading bush and displaced with respect to the unloading bush, and the unloading bush includes an unloading bush mating portion to be in contact with the eccentric crank pin and displaced with respect to the eccentric crank pin. At least a part of at least one of the eccentric crank pin mating portion and the unloading bush mating portion is provided with a wear-resistant layer.

[0012] In the scroll compressor described above, since the wear-resistant layer is provided on the mating portion of the eccentric crank pin or the mating portion of the unloading bush, the wear resistance of the eccentric crank pin or the unloading bush is improved, and the service life of the eccentric crank pin or the unloading bush is extended. As a result, the service life of the scroll compressor having the eccentric crank pin and the unloading bush is extended.

[0013] Preferably, the eccentric crank pin includes a driving surface extending in parallel with a rotation axis of the driving shaft, and the eccentric crank pin mating portion includes at least a part of the driving surface.

[0014] Preferably, the wear-resistant layer is provided on at least a portion of the driving surface bulged about at its center.

[0015] Preferably, the unloading bush may include a hole capable of receiving the eccentric crank pin, the hole has a driven surface cooperated with the driving surface of the eccentric crank pin, and the unloading bush mating portion includes at least a part of the driven surface.

[0016] Preferably, the wear-resistant layer is provided on at least a substantially central portion of the driven surface.

[0017] Preferably, the wear-resistant layer is a hardened layer having a surface hardness in a range of 1500HV to 3000HV.

[0018] Preferably, the thickness of the wear-resistant layer is in a range of 0.1 μm to 4.5 μm.

[0019] Preferably, the wear-resistant layer is formed by one of physical vapor deposition, chemical vapor deposition, plasma vapor deposition, electroplating, electroless plating, carburizing, nitriding, carbonitriding, shot peening and surface hardening heat treatment.

[0020] Preferably, the wear-resistant layer is formed of one of a metal layer, diamond-like carbon, carbide, nitride, silicide, boride and oxide. Optionally, the wear-resistant layer is formed of chromium nitride.

[0021] According to another aspect of the present application, the present application further relates to a driving shaft for a scroll compressor. The driving shaft includes an eccentric crank pin arranged at one end thereof and configured to dive a compression mechanism of the

scroll compressor, and the eccentric crank pin includes a driving surface extending in parallel with a rotation axis of the driving shaft. A wear-resistant layer is provided on at least a substantially central bulged portion of the driving surface, and the wear-resistant layer is a hardened layer including a metal layer, diamond-like carbon, carbide, nitride, silicide, boride or oxide and formed by physical vapor deposition, chemical vapor deposition, plasma vapor deposition, electroplating, electroless plating, carburizing, nitriding, carbonitriding, shot peening or surface hardening heat treatment.

[0022] According to another aspect of the present application, the present application further relates to an unloading bush for a scroll compressor. The unloading bush includes a substantially D-shaped hole, and the hole has a driven surface cooperated with a driving surface of an eccentric crank pin of the scroll compressor. A wear-resistant layer is provided on at least a substantially central portion of the driven surface, and the wear-resistant layer is a hardened layer including a metal layer, diamond-like carbon, carbide, nitride, silicide, boride or oxide and formed by physical vapor deposition, chemical vapor deposition, plasma vapor deposition, electroplating, electroless plating, carburizing, nitriding, carbonitriding, shot peening or surface hardening heat treatment.

BRIEF DESCRIPTION OF THE DRAWINGS

[0023] The features and advantages of one or more embodiments of the present application will become more readily understood from the following description with reference to the accompanying drawings in which:

Fig. 1 is a longitudinal sectional view of a scroll compressor;

Fig. 2 is a schematic illustration showing the assembly of an eccentric crank pin of a driving shaft and an unloading bush of the scroll compressor in Fig. 1;

Fig. 3 shows a schematic perspective view of the eccentric crank pin of the driving shaft of Fig. 2;

Fig. 4 shows a schematic perspective view of the unloading bush of Fig. 2;

Fig. 5 schematically shows a method for forming a wear-resistant layer according to a first embodiment of the present application; and

Fig. 6 is a schematic view of the wear-resistant layer.

DETAILED DESCRIPTION

[0024] The following description of the preferred embodiments is merely exemplary and is by no means intended to limit the present application, its application or usage. The same reference numerals are used to designate like parts throughout the drawings, and the construction of the same parts will not be described repeatedly.

[0025] First, the overall construction and operation principle of a scroll compressor will be described with reference to Fig. 1. A high side compressor is shown in Fig. 1. However, it is to be appreciated that the high side compressor in Fig. 1 is for illustrative purposes only and is not intended to limit the present application. The present application may be adapted to any type of compressors including low side compressors, vertical compressors, horizontal compressors and the like.

[0026] As shown in Fig. 1, the scroll compressor 100 (hereinafter referred to as a compressor sometimes) generally includes a housing 110, a top cover 112 provided at one end of the housing 110 and a bottom cover 114 provided at the other end of the housing 110. A motor 20 consisting of a stator 122 and a rotor 124 is arranged in the housing 110. A driving shaft 30 is arranged in the rotor 124 to drive a compression mechanism 10 consisting of a fixed scroll member 150 and an orbiting scroll member 160. The orbiting scroll member 160 includes an end plate 164, a hub 162 formed on one side of the end plate and a spiral vane 166 formed on the other side of the end plate. The fixed scroll member 150 includes an end plate 154, a spiral vane 156 formed on one side of the end plate and a discharge port 152 formed at a substantially central position of the end plate. A series of compression chambers with volumes gradually decreased from radially outer side to radially inner side are formed between the spiral vane 156 of the fixed scroll member 150 and the spiral vane 166 of the orbiting scroll member 160. A radially outermost compression chamber is at a suction pressure and a radially innermost compression chamber is at a discharge pressure. An intermediate compression chamber is at a pressure between the suction pressure and the discharge pressure, and is also referred to as an intermediate pressure chamber.

[0027] The orbiting scroll member 160 is supported at one side by an upper portion (which constitutes a thrust surface) of a main bearing housing 140, and a part of the driving shaft 30 is supported by a main bearing arranged in the main bearing housing 140. An eccentric crank pin 32 is provided at one end of the driving shaft 30, and an unloading bush 42 is provided between the eccentric crank pin 32 and the hub 162 of the orbiting scroll member 160. Driven by the motor 20, the orbiting scroll member 160 orbits with respect to the fixed scroll member 150 (i.e., a central axis of the orbiting scroll member 160 rotates about a central axis of the fixed scroll member 150, however, the orbiting scroll member 160 itself does not rotate about its own central axis) to compress fluid. The above orbiting movement is achieved by an Oldham coupling provided between the fixed scroll member 150 and the orbiting scroll member 160.

[0028] In the example of the scroll compressor shown in Fig. 1, a lubricant is stored at the bottom of the compressor housing. Correspondingly, a channel is formed

in the driving shaft 30 and extends substantially in an axial direction of the driving shaft 30, including a center hole 136 formed at a lower end of the driving shaft 30 and an eccentric hole 134 extending upwardly from the center hole 136 to an end face of the eccentric crank pin 32. An end of the center hole 136 is immersed in the lubricant at the bottom of the compressor housing or is otherwise supplied with a lubricant. During operation of the compressor, one end of the center hole 136 is supplied with a lubricant by a lubricant supply device, and the lubricant entering the center hole 136 is pumped or thrown into the eccentric hole 134 by a centrifugal force during the rotation of the driving shaft 30 and flows upwardly along the eccentric hole 134 to the end face of the eccentric crank pin 32. The lubricant discharged from the end face of the eccentric crank pin 32 flows downward through a gap between the unloading bush 42 and the eccentric crank pin 32 and a gap between the unloading bush 42 and the hub 162 into a recess of the main bearing housing 140. A portion of the lubricant that is accumulated in the recess flows through the main bearing and then flows downwards and a portion of the lubricant is agitated by the hub 162 to move upwardly to the underside of the end plate 164 of the orbiting scroll member 160 and be distributed over the thrust surfaces of the orbiting scroll member 160 and the main bearing housing 140 as the orbiting scroll member 160 orbits. During the operation of the compressor, the lubricant supplied to the various moving parts in the compressor is thrown out and splashes to form droplets or mist.

[0029] In the scroll compressor shown in Fig. 1, effective sealing must be formed between the fixed scroll member 150 and the orbiting scroll member 160 in order to achieve fluid compression. On the one hand, an axial sealing is required between the top end of the spiral vane 156 of the fixed scroll member 150 and the end plate 164 of the orbiting scroll member 160 and between the top end of the spiral vane 166 of the orbiting scroll member 160 and the end plate 154 of the fixed scroll member 150. The axial compliance of the scroll compressor is well known to the person skilled in the art and will not be described in detail herein.

[0030] On the other hand, a radial sealing is required between a side surface of the spiral vane 156 of the fixed scroll member 150 and a side surface of the spiral vane 166 of the orbiting scroll member 160 as well. This radial sealing between the two side surfaces is generally achieved by means of the relative displacement between the eccentric crank pin 32 and the unloading bush 42. During operation, the orbiting scroll member 160, driven by the motor 20, orbits with respect to the fixed scroll member 150 so that the orbiting scroll member 160 generates a centrifugal force. Besides, the eccentric crank pin 32 of the driving shaft 30 also generates, during rotation, a driving component of force that facilitates the realization of the radial sealing between the fixed scroll member 150 and the orbiting scroll member 160. The spiral vane 166 of the orbiting scroll member 160 abuts against the spiral vane 156 of the fixed scroll member 150 under the above-described centrifugal force and driving component of force, thereby achieving the radial sealing therebetween. When an incompressible material (such as a solid impurity, lubricating oil, and liquid refrigerant) enters a compression chamber and is caught between the spiral vane 156 and the spiral vane 166, the spiral vane 156 and the spiral vane 166 can be temporarily separated from each other in the radial direction to allow the foreign matter passes therebetween, that is, a relative displacement occurs between the eccentric crank pin 32 and the unloading bush 42, thereby preventing damage to the spiral vane 156 or the spiral vane 166. This radially separable capability provides a radial compliance for the scroll compressor and improves the reliability of the compressor.

[0031] However, the relative displacement between the eccentric crank pin 32 and the unloading bush 42 causes them to be worn too fast and excessively. In order to address this issue, in the present application, a quick-wearing portion of the eccentric crank pin 32 and/or a quick-wearing portion of the unloading bush 42 is coated with a wear-resistant layer to improve its hardness and wear resistance.

[0032] The eccentric crank pin and the unloading bush are described in detail hereinafter with reference to Figs. 2 to 4.

[0033] As shown in Fig. 3, there is shown a schematic perspective view of the eccentric crank pin of the driving shaft. The driving shaft 30 includes an eccentric crank pin 32 at one end thereof. An eccentric hole 134 running substantially in a first direction (a longitudinal direction) in parallel with a rotation axis of the driving shaft 30 is formed in the driving shaft 30 to supply the lubricant to an end of the eccentric crank pin 32. The eccentric crank pin 32 of the driving shaft 30 is fitted in the hub 162 of the orbiting scroll member 160 via the unloading bush 42, as shown in Fig. 1. The eccentric crank pin 32 includes a driving surface 321 extending in parallel with the rotation axis of the driving shaft 30. Accordingly, the unloading bush 42 has a substantially D-shaped hole through which the eccentric crank pin 32 passes and includes a driven surface 143 capable of being cooperated with the driving surface 321 of the eccentric crank pin 32. After the unloading bush 42 and the eccentric crank pin 32 are assembled to the compressor 100, the dimension of the substantially D-shaped hole in the unloading bush 42 is greater than the dimension of the eccentric crank pin 32 to ensure the radial compliance between the orbiting scroll member 160 and the fixed scroll member 150.

[0034] As shown in Fig. 2, there is shown a schematic illustration of the assembly of an unloading bush and an eccentric crank pin. When the unloading bush 42 is mounted onto the eccentric crank pin 32, the eccentric crank pin 32 is received in the D-shaped hole of the unloading bush 42 while the driving surface 321 of the eccentric crank pin 32 is fitted with the driven surface 143 of the unloading bush 42. With this structure, when the

eccentric crank pin 32 rotates, the eccentric crank pin 32 can drive the unloading bush 42 to rotate since the driving surface 321 of the eccentric crank pin 32 is fitted with the driven surface 143 of the unloading bush 42. In addition, the width of the driving surface 321 of the eccentric crank pin 32 (i.e., the dimension perpendicular to the axial direction of the driving shaft) is less than the width of the driven surface 143 of the unloading bush 42 (i.e., the dimension perpendicular to the axial direction of the driving shaft). In this way, the driving surface 321 of the eccentric crank pin 32 can be moved with respect to the driven surface 143 of the unloading bush 42.

[0035] In the case of an ideal operating condition of the compressor with an ideal design and ideal manufacturing dimensions (i.e., no manufacturing and installation errors), when the compressor operates, the spiral vanes of the fixed scroll member and the orbiting scroll member may abut tightly against each other. In this case, the distance between the center of the unloading bush and the center of the driving shaft is maximized and substantially constant.

[0036] However, the inventors have found that the distance between the centers of the fixed scroll member and the orbiting scroll member is not uniform due to manufacturing and installation errors, and therefore, after the compressor has run for a period of time, the unloading bush and the acentric crank pin may have a displacement (which corresponds to manufacturing and installation errors) with respect to each other, in particular, the flatness of the unloading bush. In addition, the inventors have also found that, in actual working conditions, in case of ingress of an impurity or a liquid refrigerant, the unloading bush may move with respect to the eccentric crank pin such that the center of the orbiting scroll member can move toward the center of the driving shaft, and the spiral vane of the fixed scroll member and the spiral-like vane of the orbiting scroll member are thus separated temporarily to prevent damage thereto.

[0037] During the actual operation of the compressor, the driven surface 143 of the unloading bush 42 and the driving surface 321 of the eccentric crank pin 32 are both subjected to normal loads and there is a relative movement between the driving surface 321 and the driven surfaces 143. Therefore, the driven surface 143 of the unloading bush 42 and the driving surface 321 of the eccentric crank pin 32 are seriously worn and, as a result, the service life thereof is shortened and the working efficiency of the compressor is adversely affected.

[0038] To this end, according to the present application, a wear-resistant layer (also referred to as a "hardened coating" or a "hardened film") may be provided on the driven surface 143 of the unloading bush 42 and/or the driving surface 321 of the eccentric crank pin 32 to improve the wear resistance thereof.

[0039] An example of a wear-resistant layer according to the present application and its production process is described hereinafter with reference to Figs. 5 and 6.

[0040] As shown in Fig. 5, a substrate S to be coated (for example, the driven surface 143 of the unloading bush 42 and/or the driving surface 321 of the eccentric crank pin 32 herein) is placed into a chamber and also grounded or connected to a negative power source. Meanwhile, a target material T (e.g., a target material of chromium) is also placed into the chamber and connected to a positive power source. The chamber is evacuated and filled with nitrogen gas. The target material and the nitrogen gas are ionized with the electric arc generated at low voltage and high current and accelerated by an electric field, striking on the workpiece to form a chromium nitride thin layer adhered onto the surface of the substrate.

[0041] The above production process is merely an example of physical vapor deposition and is not intended to limit the present application. The wear-resistant layer 50 according to the present application may be formed by other processes known in the art, for example, chemical vapor deposition, plasma vapor deposition, electroplating, electroless plating, carburizing, nitriding, carbonitriding, shot peening or surface hardening heat treatment or the like. Depending on various processes, the wear-resistant layer 50 may be formed of a metal layer, diamond-like carbon, carbide, nitride, silicide, boride or oxide or the like. For example, the wear-resistant layer 50 may be formed of chromium nitride.

[0042] In the present application, the eccentric crank pin 32 and/or the unloading bush 42 may be made of a powder metallurgical material having a surface hardness in the range of about 600HV to 800HV. When the eccentric crank pin 32 and/or the unloading bush 42 (e.g., on the driving surface 321 of the eccentric crank pin 32 and/or the driven surface 143 of the unloading bush 42) is coated with a chromium nitride wear-resistant layer 50 of about 2 to 4 microns thick according to the process shown in Figs. 5 and 6, the surface hardness of the chromium nitride wear-resistant layer 50 may be in the range of 1500HV to 3000HV, optionally in the range of 1700HV to 2700HV. Thereby, the surface hardness of the driving surface of the eccentric crank pin 32 and/or the driven surface of the unloading bush 42 can be remarkably improved, and the wear resistance thereof can be greatly enhanced. In addition, the thickness of the wear-resistant layer 50 may be in the range of 0.1μm to 4.5 μm.

[0043] The inventors conducted a reliability test on the eccentric crank pin 32 and the unloading bush 42 coated with the chromium nitride wear-resistant layer 50 described above. Specifically, the eccentric crank pin 32 and the unloading bush 42 are mounted to the compressor, and the compressor is operated for 500 hours under high speed and heavy load working conditions. It is found that almost no wear presented on the driving surface of the eccentric crank pin 32 and the driven surface of the unloading bush 42.

[0044] The above tests show that, after the driving surface of the eccentric crank pin 32 and/or the driven surface of the unloading bush 42 is coated with the wear-resistant layer 50, the wear-resistant layer 50 can prevent

direct contact of the powder metallurgical materials of the eccentric crank pin 32 and the unloading bush 42, and thus can prevent the powder metallurgical materials from falling off. Therefore, the wear-resistant layer 50 greatly improves the wear resistance of the eccentric crank pin 32 and/or the unloading bush 42.

[0045] Furthermore, in some cases, the driving surface 321 of the eccentric crank pin 32 may have a substantially central and slightly bulged portion in order to allow the eccentric crank pin 32 to be cooperated well with the unloading bush 42 based on the movement mode thereof. The wear-resistant layer 50 may be provided only on the substantially central and slightly bulged portion of the driving surface 321 or on a substantially central portion of the driven surface 143. Alternatively, the wear-resistant layer 50 may be provided on the entire driving surface 321 and/or the entire driven surface 143. Also, in addition to the driving surface 321 and/or the driven surface 143, the wear-resistant layer may be applied to other portions of the eccentric crank pin 32 and/or the unloading bush 42 subjected to wear.

[0046] It is to be appreciated that the outer contour and/or the position of the wear-resistant layer 50 may be set according to actual requirements.

[0047] Various embodiments and variations of the present application have been described in detail hereinabove, however it should be appreciated by the person skilled in the art that the present application is not limited to the specific embodiments and variations described above but may include various other possible combinations and integrations.

[0048] While the various embodiments of the present application have been described in detail herein, it is to be appreciated that the present application is not limited to the specific embodiments described and illustrated herein in detail, and other variations and modifications can be made by the person skilled in the art without departing from the spirit and scope of the present application. All the variations and modifications are within the scope of the present application. Moreover, all of the components described herein may be replaced by other technically equivalent components.

Claims

1. A scroll compressor (100), comprising:

a compression mechanism (10) configured to compress a working fluid; and
a driving shaft (30) configured to drive the compression mechanism (10); wherein
the driving shaft (30) comprises an eccentric crank pin (32), an unloading bush (42) is provided between the compression mechanism (10) and the eccentric crank pin (32) to allow the eccentric crank pin (32) to drive the compression mechanism (10) via the unloading bush (42) so as to achieve a radial compliance of the compression mechanism (10),
the eccentric crank pin (32) comprises an eccentric crank pin mating portion to be in contact with the unloading bush (42) and displaced with respect to the unloading bush (42), and the unloading bush (42) comprises an unloading bush mating portion to be in contact with the eccentric crank pin (32) and displaced with respect to the eccentric crank pin (32), and
a wear-resistant layer (50) is provided on at least a part of at least one of the eccentric crank pin mating portion and the unloading bush mating portion.

2. The scroll compressor (100) according to claim 1, wherein the eccentric crank pin (32) comprises a driving surface (321) extending in parallel with a rotation axis of the driving shaft (30), and the eccentric crank pin mating portion comprises at least a part of the driving surface (321).

3. The scroll compressor (100) according to claim 2, wherein the driving surface (321) has a bulged portion approximately at its center, and the wear-resistant layer (50) is provided on at least the bulged portion.

4. The scroll compressor (100) according to claim 2, wherein the unloading bush (42) comprises a hole for receiving the eccentric crank pin (32), the hole has a driven surface (143) cooperated with the driving surface (321) of the eccentric crank pin (32), and the unloading bush mating portion comprises at least a part of the driven surface (143).

5. The scroll compressor (100) according to claim 4, wherein the wear-resistant layer (50) is provided on at least a substantially central portion of the driven surface (143).

6. The scroll compressor (100) according to any one of claims 1 to 5, wherein the wear-resistant layer (50) is a hardened layer having a surface hardness in a range of 1500HV to 3000HV.

7. The scroll compressor (100) according to any one of claims 1 to 5, wherein the thickness of the wear-resistant layer (50) is in a range of 0.1μm to 4.5 μm.

8. The scroll compressor (100) according to any one of claims 1 to 5, wherein the wear-resistant layer (50) is formed by one of physical vapor deposition, chemical vapor deposition, plasma vapor deposition, electroplating, electroless plating, carburizing, nitriding, carbonitriding, shot peening and surface hardening heat treatment.

9. The scroll compressor (100) according to any one of claims 1 to 5, wherein the wear-resistant layer (50) is formed of one of a metal layer, diamond-like carbon, carbide, nitride, silicide, boride and oxide.

10. The scroll compressor (100) according to claim 9, wherein the wear-resistant layer (50) is formed of chromium nitride.

11. A driving shaft (30) for a scroll compressor (100), wherein the driving shaft (30) comprises an eccentric crank pin (32) arranged at one end thereof and configured to dive a compression mechanism (10) of the scroll compressor (100), and the eccentric crank pin (32) comprises a driving surface (321) extending in parallel with a rotation axis of the driving shaft (30), and
the driving surface (321) has a bulged portion approximately at its center, and a wear-resistant layer (50) is provided on at least the bulged portion of the driving surface (321), and the wear-resistant layer (50) is a hardened layer comprising a metal layer, diamond-like carbon, carbide, nitride, silicide, boride or oxide and formed by physical vapor deposition, chemical vapor deposition, plasma vapor deposition, electroplating, electroless plating, carburizing, nitriding, carbonitriding, shot peening or surface hardening heat treatment.

12. An unloading bush (42) for a scroll compressor (100), wherein the unloading bush (42) comprises a substantially D-shaped hole, and the hole has a driven surface (143) cooperated with a driving surface (321) of an eccentric crank pin (32) of the scroll compressor (100), and
a wear-resistant layer (50) is provided on at least a substantially central portion of the driven surface (143), and the wear-resistant layer (50) is a hardened layer comprising a metal layer, diamond-like carbon, carbide, nitride, silicide, boride or oxide and formed by physical vapor deposition, chemical vapor deposition, plasma vapor deposition, electroplating, electroless plating, carburizing, nitriding, carbonitriding, shot peening or surface hardening heat treatment.

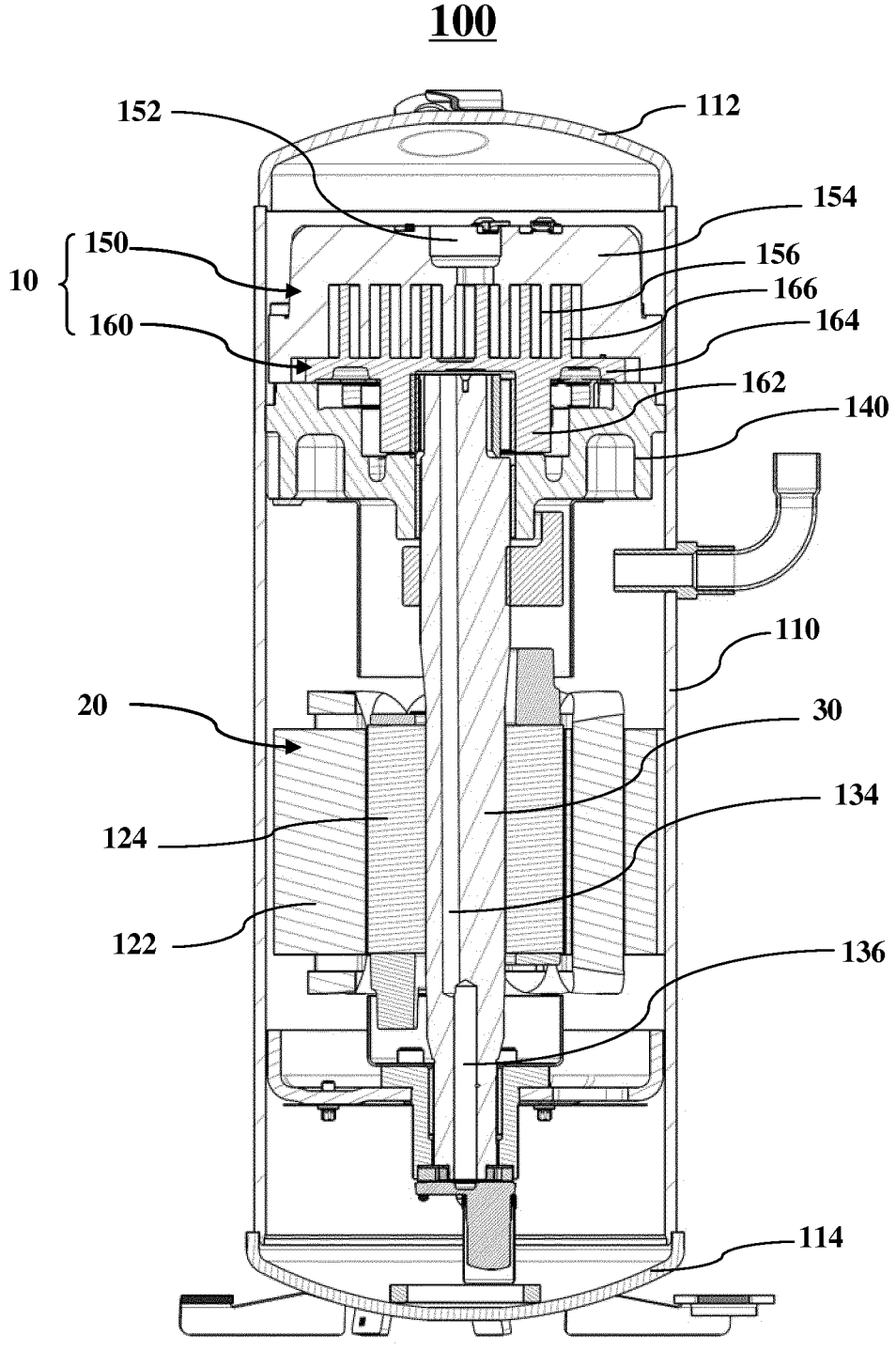

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Fig. 1

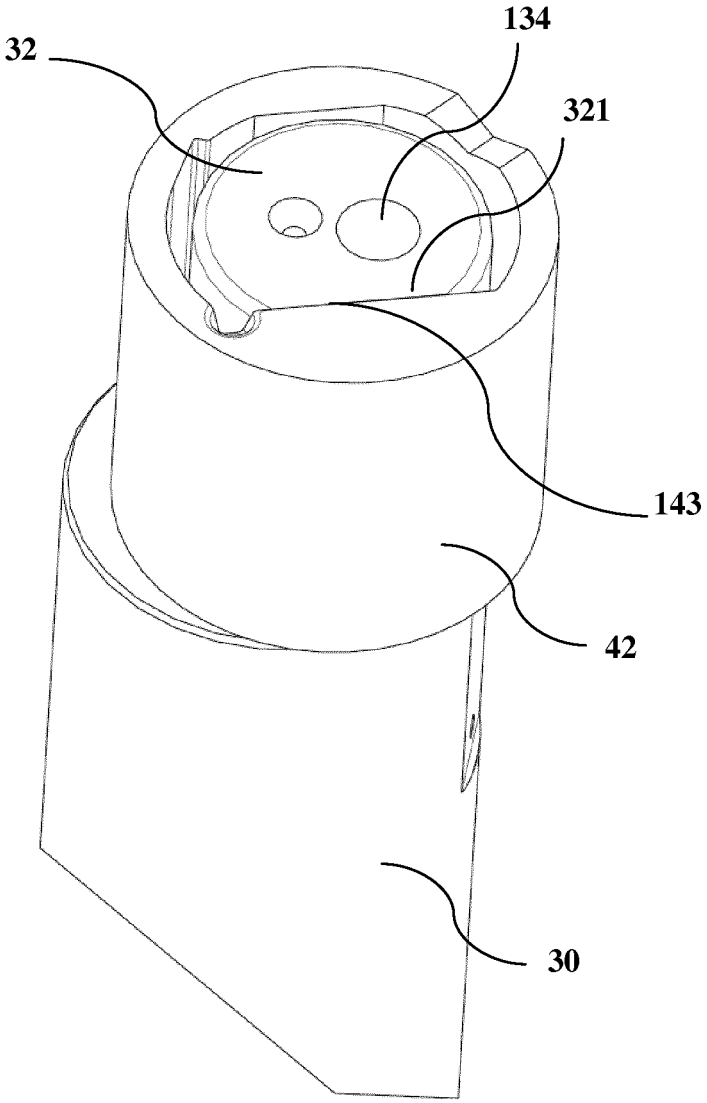


Fig. 2

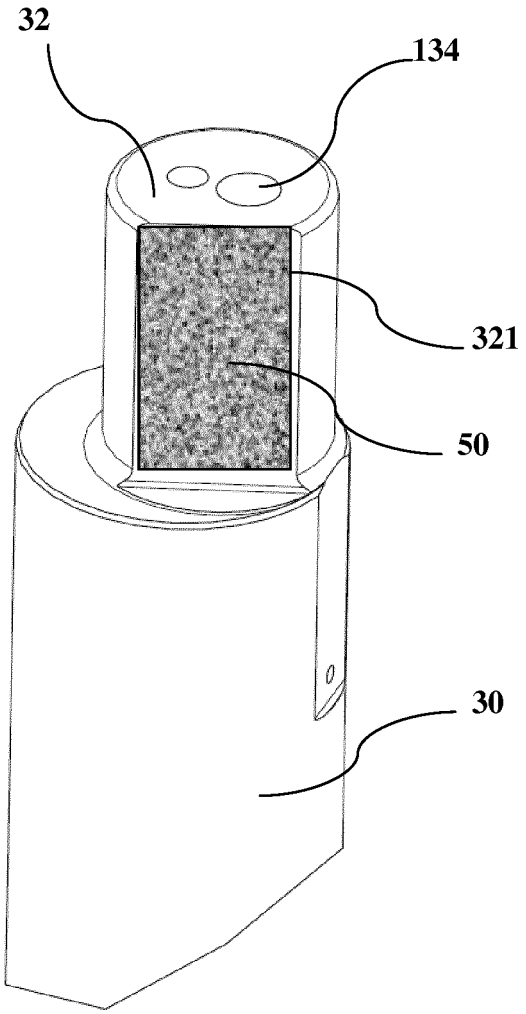


Fig. 3

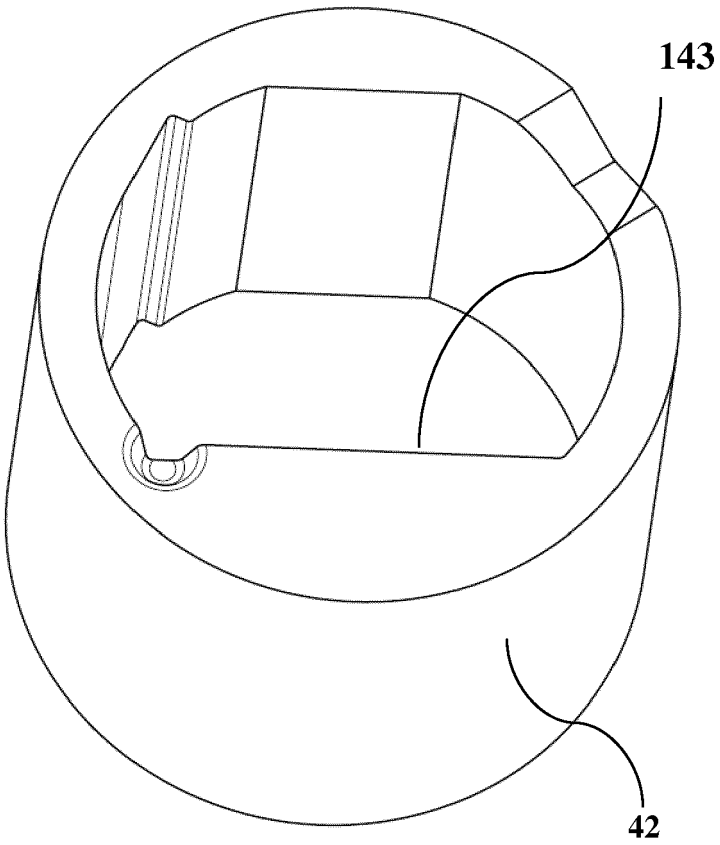


Fig. 4

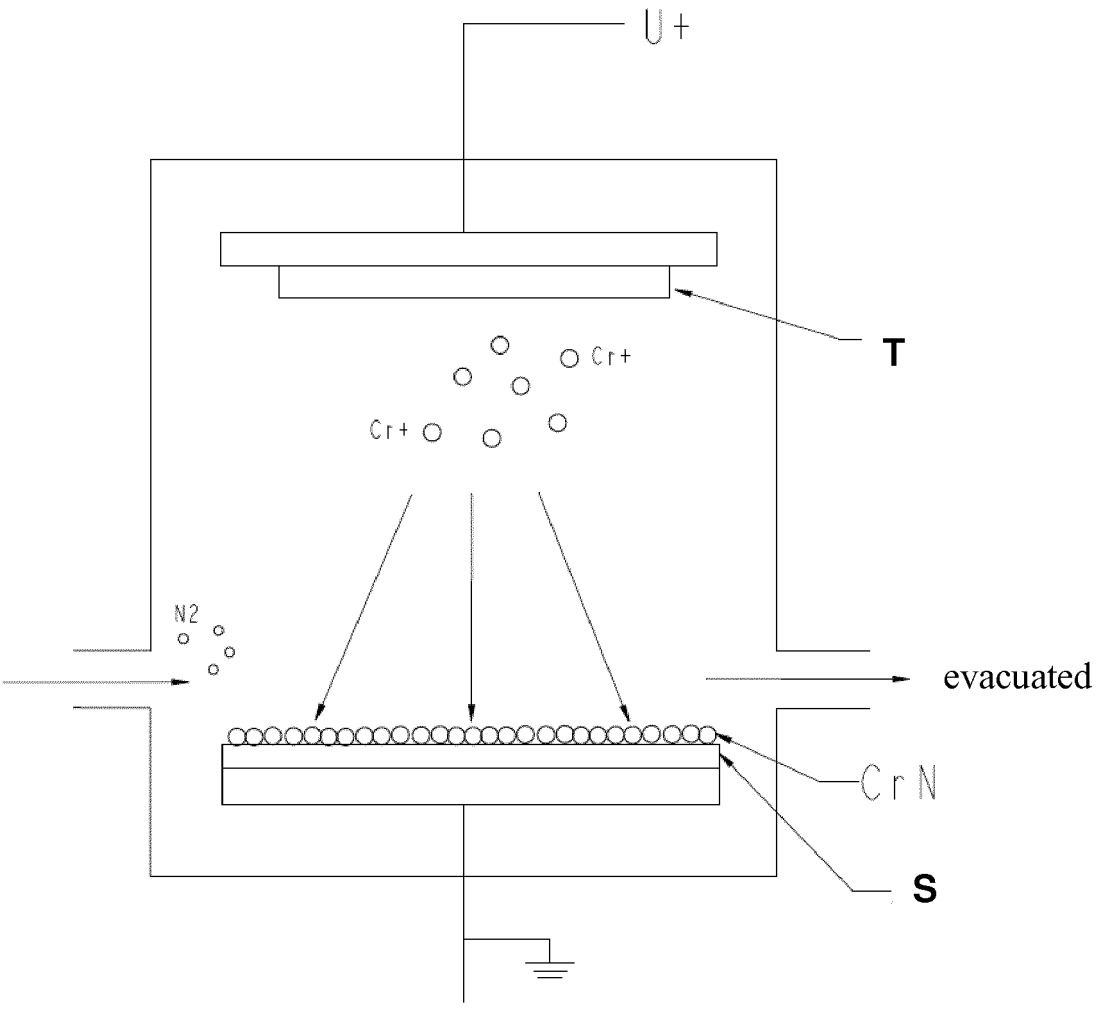


Fig. 5

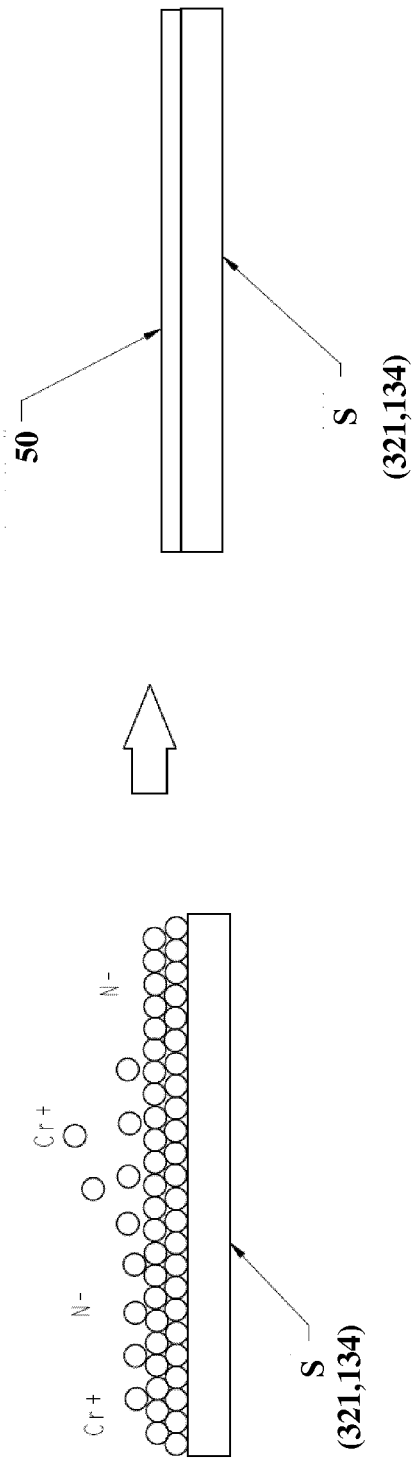


Fig. 6

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2016/075986

A. CLASSIFICATION OF SUBJECT MATTER

F04C 18/02 (2006.01) i; F04C 29/00 (2006.01) i
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

F04C

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, SIPOABS, DWPI, CNKI: scroll, compressor, bush, lubricat+, wear+, coat, layer

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
PX	CN 204591668 U (EMERSON CLIMATE TECH SUZHOU CO., LTD.) 26 August 2015 (26.08.2015) see claims 1-12	1-12
A	CN 204200574 U (ZHUHAI GREE REFRIGERATION TECHNOLOGY CT ENERGY SAVING & ENVIRONMENTAL PROT CO., LTD.) 11 March 2015 (11.03.2015) see description, paragraphs [0045]-[0050] and figures 1-5	1-12
A	CN 101133126 A (DAIKIN IND LTD) 27 February 2008 (27.02.2008) see the whole document	1-12
A	CN 202707485 U (SHANGHAI SANDEN BEHR AUTOMOTIVE A/C CO., LTD.) 30 January2013 (30.01.2013) see the whole document	1-12
A	KR 20110131752 A (LG ELECTRONICS INC.) 07 December 2011 (07.12.2011) see the whole document	1-12
A	JP 2010203252 A (TOYOTA IND CORP.) 16 September 2010 (16.09.2010) see the whole document	1-12

☒ 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	Date of mailing of the international search report
17 May 2016	03 June 2016
Name and mailing address of the ISA State Intellectual Property Office of the P. R. China No. 6, Xitucheng Road, Jimenqiao Haidian District, Beijing 100088, China Facsimile No. (86-10) 62019451	Authorized officer YANG, Guiquan Telephone No. (86-10) 62085242

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

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2016/075986

Patent Documents referred in the Report	Publication Date	Patent Family	Publication Date
CN 204591668 U	26 August 2015	None	
CN 204200574 U	11 March 2015	None	
CN 101133126 A	27 February 2008	KR 20070112851 A	27 November 2007
		AU 2006223991 A1	21 September 2006
		EP 1860156 A1	28 November 2007
		EP 1860156 A4	03 October 2012
		JP 2006257231 A	28 September 2006
		WO 2006098303 A1	21 September 2006
		JP 3941815 B2	04 July 2007
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		AU 2006223991 B2	15 July 2010
		KR 100934843 B1	31 December 2009
		CN 101133126 B	19 May 2010
CN 202707485 U	30 January 2013	None	
KR 20110131752 A	07 December 2011	KR 10159758 B1	25 February 2016
JP 2010203252 A	16 September 2010	JP 5326660 B2	30 October 2013
		US 2010221135 A1	02 September 2010
		EP 2224135 A2	01 September 2010
		US 8353692 B2	15 January 2013

Form PCT/ISA /210 (patent family annex) (July 2009)

REFERENCES CITED IN THE DESCRIPTION

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