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(54) **CRANKSHAFT AND ROTARY COMPRESSOR**

(57) The present invention provides a crankshaft and a rotary compressor. An eccentric section of the crankshaft defines a recess in its outer circumferential surface. The recess defines an opening at the outer circumferential surface of the eccentric section and a bottom surface within the eccentric section. An orthogonal projection of the opening on a cross-section of the eccentric section includes an arc set including at least one arc. A total length of the arc set is less than a perimeter of the eccentric section. An orthogonal projection of the bottom surface on the cross-section of the eccentric section includes a curve set including at least one curve having a first endpoint and a second endpoint. A first line segment connects the first endpoint and a center of a circle defined by the eccentric section, and a second line segment connects the second endpoint and the center of the circle defined by the eccentric section. The first and second line segments define an angle of α therebetween, which satisfies $0° < \alpha \leq 180°$. A minimum distance between the curve and the center of the circle defined by the eccentric section is equal to r, which satisfies $1/2 \leq r/R < 1$. This invention allows for better lubrication between the eccentric section and the piston, which reduces friction power losses and improves the compressor performance.

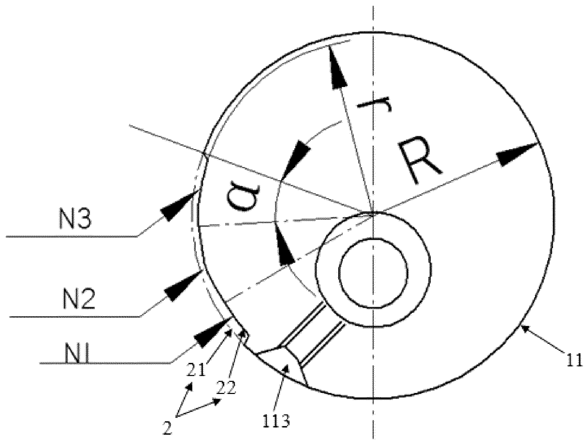

Fig. 1

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Description

TECHNICAL FIELD

[0001] The present invention relates to the field of compressor technology, and particularly to a crankshaft and a rotary compressor.

BACKGROUND

[0002] Rotary compressors comprise a crankshaft, a piston and a cylinder. The crankshaft has an eccentric section, and the piston is disposed in the cylinder over the eccentric section, with a very small clearance being left between the piston and the eccentric section. The eccentric section can be rotated to rotate the piston. However, during the rotation, the eccentric section tends to encounter significant friction with the piston, which leads to considerable friction power losses and degrades the compressor performance.

SUMMARY

[0003] Provided herein are a crankshaft and a rotary compressor, which overcome the above-described problem of significant friction between an eccentric section and a piston.

[0004] To this end, the present invention provides a crankshaft including an eccentric section defining a recess in its circumference, the recess defining an opening at an outer circumferential surface of the eccentric section and a bottom surface within the eccentric section,

> wherein an orthogonal projection of the opening on a cross-section of the eccentric section includes an arc set including at least one arc and having a total length less than a perimeter of the eccentric section, the cross-section of the eccentric section perpendicular to an axis of the eccentric section, and
>
> wherein an orthogonal projection of the bottom surface on the cross-section of the eccentric section includes a curve set including at least one curve having a first endpoint and a second endpoint, the first endpoint connected to a center of a circle defined by the eccentric section by a first line segment, the second endpoint connected to the center of the circle defined by the eccentric section by a second line segment, the first and second line segments defining an angle of α therebetween, which satisfies $0° < \alpha \leq 180°$, the curve spaced from the center of the circle defined by the eccentric section at a minimum distance of r, which satisfies $1/2 \leq r/R < 1$, where R represents a radius of the eccentric section.

[0005] Optionally, each of the at least one curve may be an arc.

[0006] Optionally, the curve set may include at least two curves, which are arcs joined end-to-end.

[0007] Optionally, the recess may extend through upper and lower end faces of the eccentric section.

[0008] Optionally, the recess may be perpendicular to upper and lower end faces of the eccentric section.

[0009] Optionally, the recess may helically extend in the circumference of the eccentric section.

[0010] Optionally, the recess may helically extend in a direction opposite to a direction in which the eccentric section rotates.

[0011] Optionally, the orthogonal projection of the bottom surface on the cross-section of the eccentric section may further include a line-segment set including at least one line segment having a third endpoint and a fourth endpoint, the third endpoint connected to the center of the circle defined by the eccentric section by a third line segment, the fourth endpoint connected to the center of the circle defined by the eccentric section by a fourth line segment, the third and fourth line segments defining an angle therebetween, which is equal to α, the line segment spaced from the center of the circle defined by the eccentric section by a minimum distance, which is equal to r.

[0012] The present invention also provides a rotary compressor including the crankshaft as defined in any of the preceding paragraphs.

[0013] Optionally, the rotary compressor may further include a housing, a piston, an upper cylinder cap, a cylinder and a lower cylinder cap, wherein the eccentric section of the crankshaft and the piston are mounted within the cylinder; the piston is disposed over the eccentric section, with a clearance being left between the piston and the eccentric section; the eccentric section is used to drive the piston to rotate; the upper cylinder cap is fixed to an upper end face of the cylinder; the lower cylinder cap is fixed to a lower end face of the cylinder;

> an oil intake is provided on an axis of the crankshaft, and an oil outlet is provided on the eccentric section into communication with the oil intake; and
>
> a bottom portion of the housing defines an oil tank, and the oil intake is used to draw lubricant oil from the oil tank.

[0014] In the crankshaft and the rotary compressor of the present invention, during rotation of the piston driven by the eccentric section, the presence of the recess in the eccentric section leads to a smaller contact area, and hence reduced friction, between the eccentric section and the piston. In addition, lubricant oil may be introduced into the recess to enhance lubrication between the eccentric section and the piston and reduce friction power losses, improving the compressor performance. Configuring the angle α between the first and second line segments within $0° < \alpha \leq 180°$ can prevent a loss of power from the eccentric section to drive rotation of the piston due to an excessively large α value. Configuring the minimum distance r between the curve and the center of the circle defined by the eccentric section within

$1/2 \leq r/R < 1$ can take into account strength of the crankshaft and lubrication of the recess and avoid the recess from having an excessively large or small depth. An excessively large depth of the recess may lead to reduced strength of the crankshaft. An inadequate depth of the recess may not allow it to contain sufficient lubricant oil necessary for providing desirable lubrication.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015]

Fig. 1 is a schematic cross-sectional view of a crankshaft according to an embodiment of the present invention, taken through an eccentric section thereof.
Fig. 2 is a schematic diagram showing a crankshaft according to an embodiment of the present invention, which has an eccentric section defining one recess therein.
Fig. 3 is a schematic right view of Fig. 2.
Fig. 4 is a schematic diagram showing a crankshaft according to an embodiment of the present invention, which has an eccentric section defining two recesses therein.
Fig. 5 is a schematic right view of Fig. 4.
Fig. 6 is a schematic diagram showing a crankshaft according to an embodiment of the present invention, which has an eccentric section defining one recess therein.
Fig. 7 is a schematic right view of Fig. 6.
Fig. 8 is a schematic partial view of a rotary compressor according to an embodiment of the present invention.

List of Reference Numerals

[0016]

1, crankshaft; 2, recess; 3, upper cylinder cap; 4, cylinder; 5, lower cylinder cap;
11, eccentric section;
111, outer circumferential surface; 112, lower end face; 113, oil outlet;
21, opening; 22, bottom surface.

DETAILED DESCRIPTION

[0017] Objectives, advantages and features of the present invention will become more apparent upon reading the following detailed description of crankshafts and rotary compressors described herein with reference to the accompanying drawings. Note that the figures are provided in a very simplified form not necessarily drawn to exact scale for the only purpose of helping to explain the disclosed embodiments in a more convenient and clearer way.

[0018] As used herein, the terms "first", "second" and the like are employed for ease of description and reference only, and are not to be construed as denoting or implying relative importance or as implicitly indicating the numerical number of the referenced items. Accordingly, defining an item with "first", "second" or the like is an explicit or implicit indication of the presence of one or more such items.

[0019] As shown in Figs. 1 to 7, embodiments of the present invention provide a crankshaft 1 includes an eccentric section 11, the eccentric section 11 defines a recess 2 in its circumference. The recess 2 has an opening 21 and a bottom surface 22. The opening 21 is defined at an outer circumferential surface 111 of the eccentric section 11, and the bottom surface 22 is located within the eccentric section 11. An orthogonal projection of the opening 21 on a cross-section of the eccentric section 11 includes an arc set, the arc set includes at least one arc. A total length of the arc set is less than a perimeter of the eccentric section 11. The cross-section of the eccentric section 11 is defined perpendicular to an axis of the eccentric section 11. An orthogonal projection of bottom surface 22 on the cross-section of the eccentric section 11 includes a curve set, the curve set includes at least one curve having first endpoint and a second endpoint. A first line segment connects the first endpoint and a center of a circle defined by the eccentric section 11. A second line segment connects the second endpoint and the center of the circle defined by the eccentric section 11. The first and second line segments define an angle of α therebetween, which satisfies $0° < \alpha \leq 180°$. A minimum distance between the curve and the center of the circle defined by the eccentric section 11 is equal to r, which satisfies $1/2 \leq r/R < 1$, where R represents a radius of the eccentric section 11. The outer circumferential surface 111 refers to a side wall surface of the eccentric section 11 and the outer circumferential surface 111 is perpendicular to both an upper end face and a lower end face 112 of the eccentric section 11.

[0020] In the crankshaft 1 according to these embodiments of the present invention, a recess 2 is provided in the eccentric section 11 of the crankshaft 1, during rotation of a piston driven by the eccentric section 11, the presence of the recess 2 leads to a smaller contact area between the eccentric section 11 and the piston, and hence reduced friction between the eccentric section 11 and the piston. In addition, lubricant oil may be introduced into the recess 2 to enhance lubrication between the eccentric section 11 and the piston and reduce friction power losses, improving the compressor performance. Configuring the angle α between the first and second line segments within $0° < \alpha \leq 180°$ can prevent a loss of power from the eccentric section 11 to drive rotation of the piston due to an excessively large α value. Configuring the minimum distance r between the curve and the center of the circle defined by the eccentric section 11 within $1/2 \leq r/R < 1$ can take into account strength of the crankshaft 1 and lubrication of the recess 2 and avoid the recess 2 from having an excessively large or small depth.

An excessively large depth of the recess 2 may lead to reduced strength of the crankshaft 1. An inadequate depth of the recess 2 may not allow the recess 2 to contain sufficient lubricant oil necessary for providing desirable lubrication.

[0021] Optionally, as shown in Fig. 1, the curve set may be an arc set. In this case, each of the aforesaid curve(s) is an arc. If the orthogonal projection of the bottom surface 22 of the recess 2 on the cross-section of the eccentric section 11 is an arc, then the recess 2 will have a constant depth throughout its entire extent. This facilitates the machining of the recess 2 in the eccentric section 11. If the orthogonal projection of the bottom surface 22 of the recess 2 on the cross-section of the eccentric section 11 is a curve, then the recess 2 will have a constant depth throughout its entire extent, or not. In the latter case, the machining of the recess 2 may require changing a cutting depth of the cutter used and therefore be more difficult. Alternatively, the recess 2 may be directly formed by casting.

[0022] Optionally, as shown in Figs. 1 and 5, the curve set may include at least two curves, which are arcs joined end-to-end. This facilitates the machining of the recess 2. As shown in Fig. 1, the arc set includes three arcs N1, N2 and N3. In alternative embodiments, two or more of the arcs may be spaced apart. That is, two or more recesses 2 may be spaced circumferentially around the eccentric section 11.

[0023] Optionally, as shown in Figs. 1 and 2, the recess 2 may extend through the upper end face and the lower end face 112 of the eccentric section 11. This allows the opening 21 of the recess 2 to have a larger area, which makes the recess 2 easier to machine.

[0024] Optionally, as shown in Figs. 2 and 4, the recess 2 may be perpendicular to the upper end face and the lower end face 112 of the eccentric section 11. This makes the recess 2 easier to machine.

[0025] Optionally, as shown in Figs. 1 and 6, the recess 2 may extend helically in the circumference of the eccentric section 11. Referring to Figs. 6 and 7, if the crankshaft 1 is designed to rotate counterclockwise, then the recess 2 may extend helically clockwise from the side of a longer section of the crankshaft 1 to the side of a shorter section thereof. This enables more lubricant oil to be stored in the recess 2 during rotation of the eccentric section 11.

[0026] Optionally, referring to Fig. 1, the orthogonal projection of the bottom surface 22 on the cross-section of the eccentric section 11 may further include a line-segment set, the line-segment set includes at least one line segment having a third endpoint and a fourth endpoint. A third line segment connects the third endpoint and the center of the circle defined by the eccentric section 11, and a fourth line segment connects the fourth endpoint and the center of the circle defined by the eccentric section 11. The third and fourth line segments define an angle therebetween, which is equal to α. A minimum distance between the line segment and the center of the circle defined by the eccentric section 11 is r. Alternatively, the orthogonal projection of the bottom surface 22 of the recess 2 on the cross-section of the eccentric section 11 may be a combination of curved and straight lines. In this way, crankshafts 1 in various forms can be provided, and hence compressors in various forms with different performance specifications as well.

[0027] As shown in Fig. 8, based on the same inventive concept as the crankshaft 1 as discussed above, embodiments of the present invention also provide a rotary compressor including the crankshaft 1 as defined in any of the preceding paragraphs.

[0028] In the crankshaft 1 of the rotary compressor according to these embodiments of the present invention, a recess 2 is provided in the eccentric section 11 of the crankshaft 1, during rotation of a piston driven by the eccentric section 11, the presence of the recess 2 leads to a smaller contact area between the eccentric section 11 and the piston, and hence reduced friction between the eccentric section 11 and the piston. In addition, lubricant oil may be introduced into the recess 2 to enhance lubrication between the eccentric section 11 and the piston and reduce friction power losses, improving the compressor performance. Configuring the angle α between the first and second line segments within $0° < \alpha \leq 180°$ can prevent a loss of power from the eccentric section 11 to drive rotation of the piston due to an excessively large α value. Configuring the minimum distance r between the curve and the center of the circle defined by the eccentric section 11 within $1/2 \leq r/R < 1$ can take into account strength of the crankshaft 1 and lubrication of the recess 2 and avoid the recess 2 from having an excessively large or small depth. An excessively large depth of the recess 2 may lead to reduced strength of the crankshaft 1. An inadequate depth of the recess 2 may not allow it to contain sufficient lubricant oil necessary for providing desirable lubrication.

[0029] Optionally, as shown in Figs. 1 and 8, the rotary compressor may further include a housing, the piston, an upper cylinder cap 3, a cylinder 4 and a lower cylinder cap 5. The eccentric section 11 of the crankshaft 1 and the piston are mounted within the cylinder 4, and piston is disposed over the eccentric section 11, with a clearance being left between the piston and the eccentric section 11. The eccentric section 11 is used to drive the piston to rotate. The upper cylinder cap 3 is fixed to an upper end face of the cylinder 4, and the lower cylinder cap 5 is fixed to a lower end face 112 of the cylinder 4. An oil intake is provided on an axis of the crankshaft 1, and an oil outlet 113 is provided on the eccentric section 11, the oil outlet 113 is in communication with the oil intake. A bottom portion of the housing defines an oil tank, and the oil intake is used to draw lubricant oil from the oil tank. The lubricant oil flows through the oil intake and the oil outlet into the clearance between the eccentric section 11 and the piston and then into the recess 2, leading to enhanced lubrication between the eccentric section 11 and the piston, which reduces friction power losses and improves the compressor performance.

[0030] Therefore, in the crankshaft 1 and the rotary compressor of the present invention, a recess 2 is provided in the eccentric section 11 of the crankshaft 1, during rotation of the piston driven by the eccentric section 11, the presence of the recess 2 leads to a smaller contact area between the eccentric section 11 and the piston, and hence reduced friction between the eccentric section 11 and the piston. In addition, lubricant oil may be introduced into the recess 2 to enhance lubrication between the eccentric section 11 and the piston and reduce friction power losses, improving the compressor performance. Configuring the angle α between the first and second line segments within $0° < \alpha \leq 180°$ can prevent a loss of power from the eccentric section 11 to drive rotation of the piston due to an excessively large α value. Configuring the minimum distance r between the curve and the center of the circle defined by the eccentric section 11 within $1/2 \leq r/R < 1$ can take into account strength of the crankshaft 1 and lubrication of the recess 2 and avoid the recess 2 from having an excessively large or small depth. An excessively large depth of the recess 2 may lead to reduced strength of the crankshaft 1. An inadequate depth of the recess 2 may not allow the recess 2 to contain sufficient lubricant oil necessary for providing desirable lubrication.

[0031] Described above are merely a few preferred embodiments of the present invention, which are not intended to limit the scope of the present invention in any way. Any and all changes and modifications made by those of ordinary skill in the art in light of the above teachings are intended to fall within the scope of the invention.

Claims

1. A crankshaft comprising an eccentric section, a circumference of the eccentric section providing with a recess, the recess defining an opening and a bottom surface, the opening formed at an outer circumferential surface of the eccentric section and the bottom surface formed within the eccentric section,

    wherein an orthogonal projection of the opening on a cross-section of the eccentric section comprises an arc set, the arc set comprising at least one arc, the arc set having a total length less than a perimeter of the eccentric section, and the cross-section of the eccentric section perpendicular to an axis of the eccentric section, and
    wherein an orthogonal projection of the bottom surface on the cross-section of the eccentric section comprises a curve set, the curve set comprising at least one curve, each curve having a first endpoint and a second endpoint, the first endpoint connected to a center of a circle defined by the eccentric section by a first line segment, the second endpoint connected to the center of the circle defined by the eccentric section by a second line segment, the first line segment and the second line segment defining an angle of α therebetween, which satisfies $0° < \alpha \leq 180°$, the curve spaced from the center of the circle defined by the eccentric section at a minimum distance of r, which satisfies $1/2 \leq r/R < 1$, where R represents a radius of the eccentric section.

2. The crankshaft of claim 1, wherein each of the at least one curve is an arc.

3. The crankshaft of claim 1, wherein the curve set comprises at least two curves, which are arcs joined end-to-end.

4. The crankshaft of claim 1, wherein the recess extends through both an upper end face and a lower end face of the eccentric section.

5. The crankshaft of claim 1, wherein the recess is perpendicular to both an upper end face and a lower end face of the eccentric section.

6. The crankshaft of claim 1, wherein the recess helically extends in the circumference of the eccentric section.

7. The crankshaft of claim 6, wherein the recess helically extends in a direction opposite to a direction in which the eccentric section rotates.

8. The crankshaft of claim 1, wherein the orthogonal projection of the bottom surface on the cross-section of the eccentric section further comprises a line-segment set, the line-segment set comprising at least one line segment having a third endpoint and a fourth endpoint, the third endpoint connected to the center of the circle defined by the eccentric section by a third line segment, the fourth endpoint connected to the center of the circle defined by the eccentric section by a fourth line segment, the third line segment and the fourth line segment defining an angle therebetween, which is equal to α, the line segment spaced from the center of the circle defined by the eccentric section by a minimum distance, which is equal to r.

9. A rotary compressor comprising the crankshaft of any one of claims 1 to 8.

10. The rotary compressor of claim 9, further comprising a housing, a piston, an upper cylinder cap, a cylinder and a lower cylinder cap, wherein the eccentric section of the crankshaft and the piston are mounted within the cylinder; the piston is disposed over the

eccentric section, a clearance is left between the piston and the eccentric section; the eccentric section is used to drive the piston to rotate; the upper cylinder cap is fixed to an upper end face of the cylinder; the lower cylinder cap is fixed to a lower end face of the cylinder;

an oil intake is provided on an axis of the crankshaft, an oil outlet is provided on the eccentric section, and the oil outlet is in communication with the oil intake; and
a bottom portion of the housing defines an oil tank, and the oil intake is used to draw lubricant oil from the oil tank.

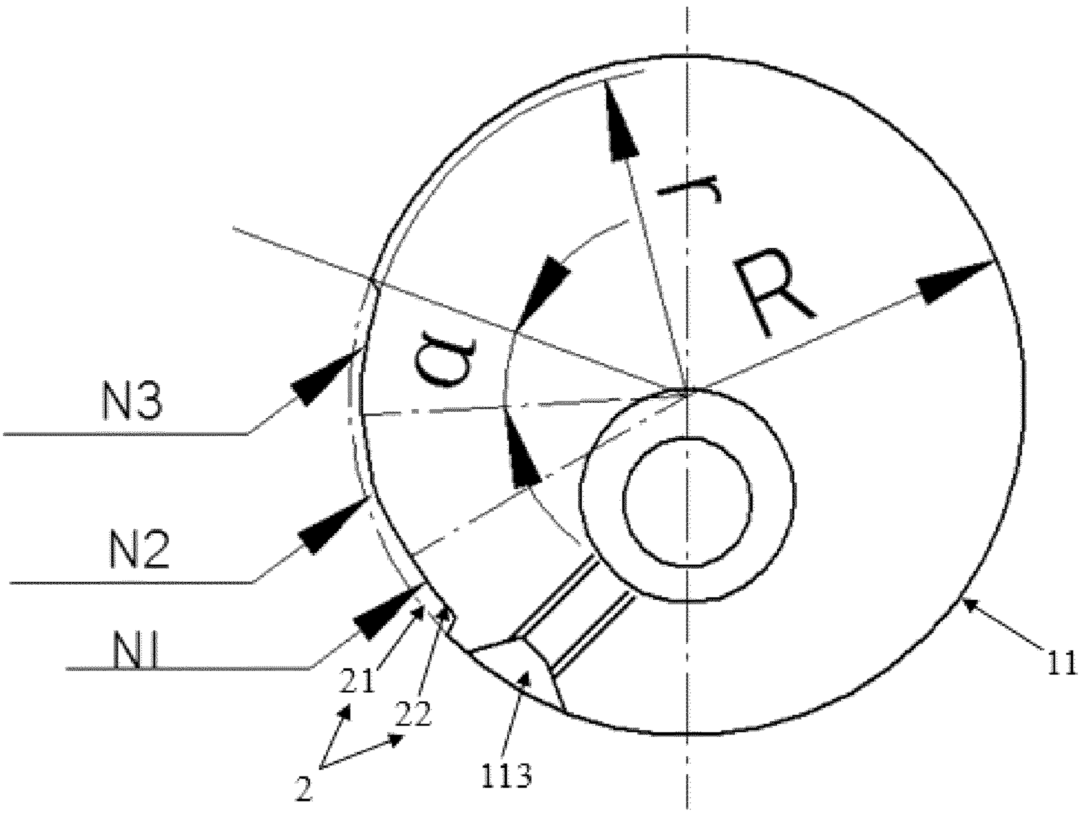

Fig. 1

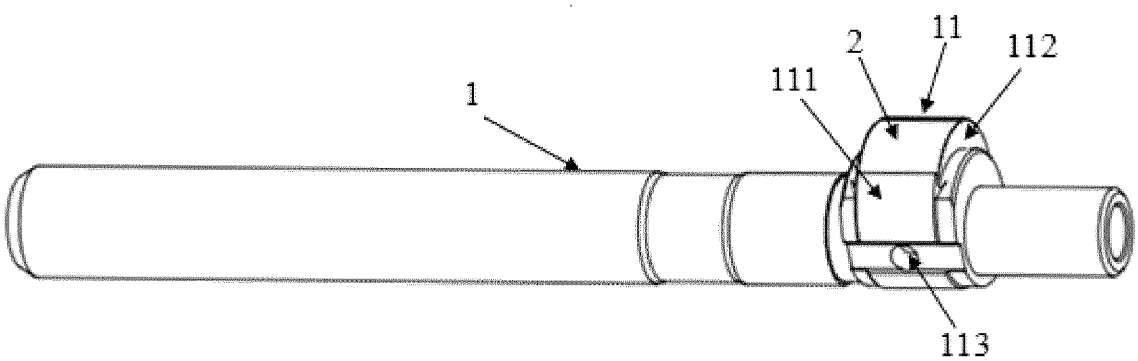

Fig. 2

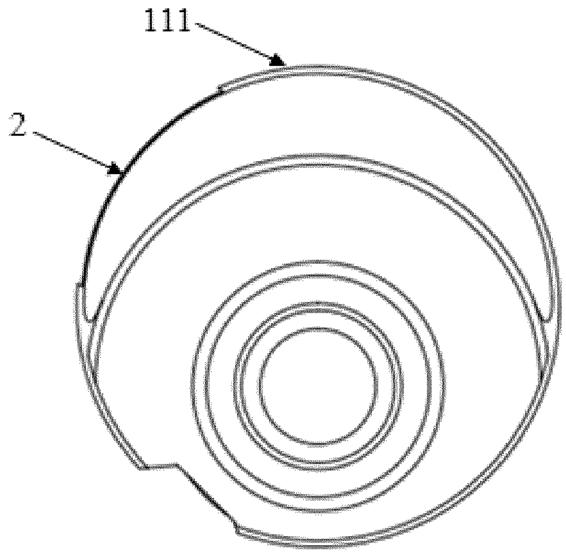

Fig. 3

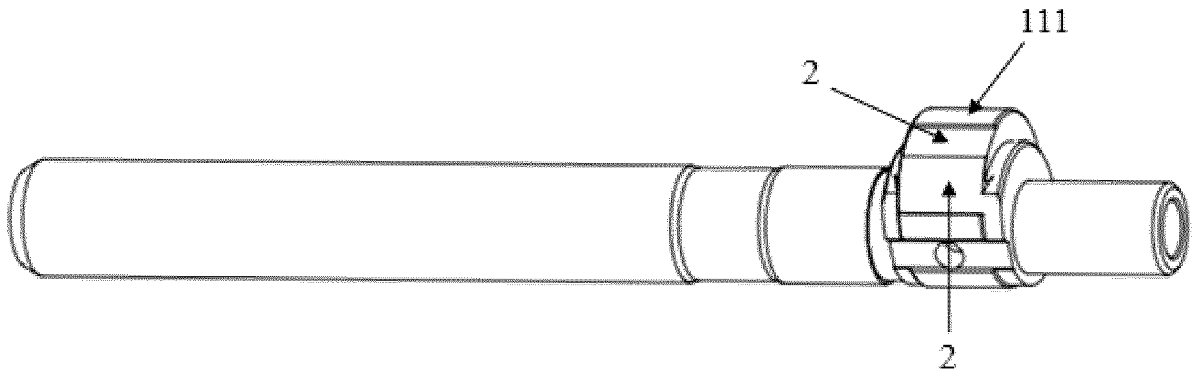

Fig. 4

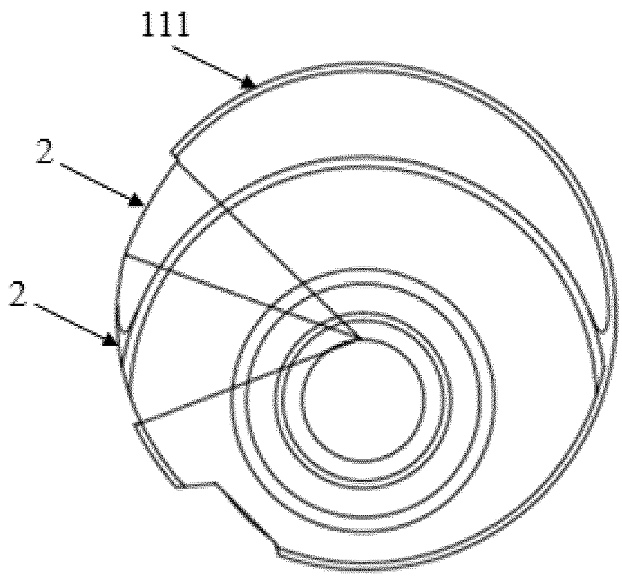

Fig. 5

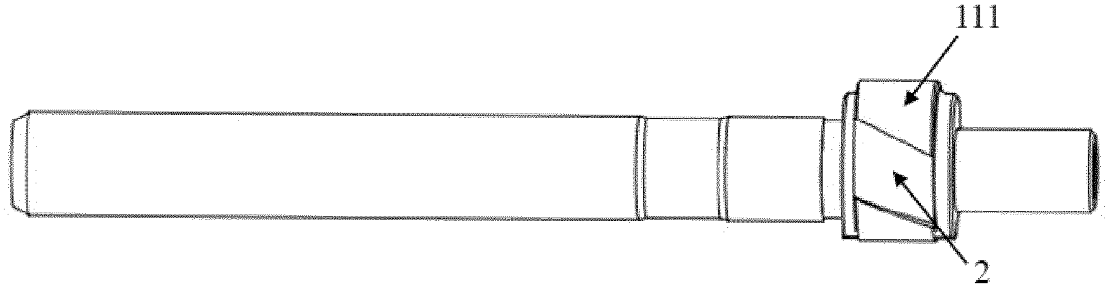

Fig. 6

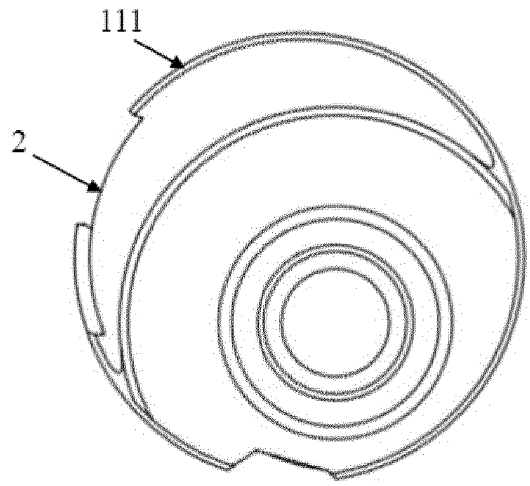

Fig. 7

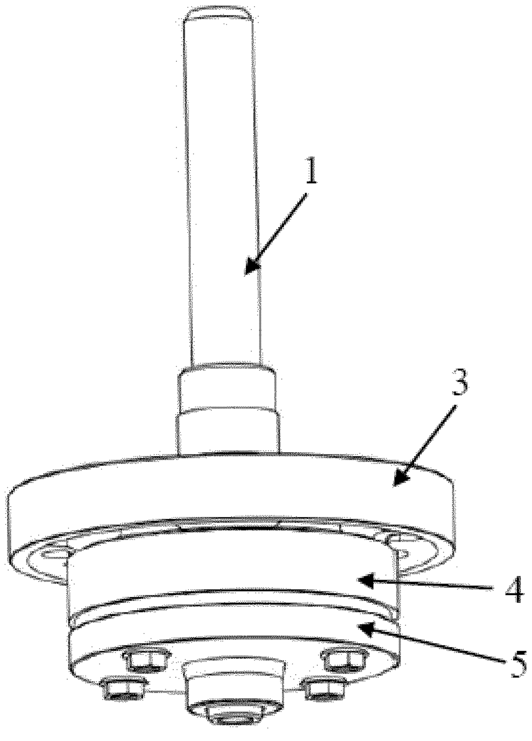

Fig. 8

INTERNATIONAL SEARCH REPORT

International application No. **PCT/CN2023/129065**

A. CLASSIFICATION OF SUBJECT MATTER

F04C18/07(2006.01)i; F04C29/00(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)

IPC: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)

CNABS, CNTXT, ENTXTC: 压缩机, 泵, 曲轴, 活塞, 偏心, 凹, 槽, 切口, 夹角, 半径, 距离, 摩擦, 磨损, 润滑; VEN, DWPI, WPABS, ENTXT, EPTXT, USTXT, WOTXT: compressor, pump, crankshaft, piston, eccentric, concave, groove, slot, cut, angle, radius, distance, friction, wear, brade, lubricate.

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	CN 115701491 A (SHANGHAI HIGHLY ELECTRICAL APPLIANCES CO., LTD.) 10 February 2023 (2023-02-10) description, paragraphs 32-47, and figures 1-9	1-10
X	CN 219139373 U (SHANGHAI HIGHLY ELECTRICAL APPLIANCES CO., LTD.) 06 June 2023 (2023-06-06) description, paragraphs 7-56, and figures 1-8	1-10
A	CN 206159025 U (SHANGHAI HITACHI ELECTRICAL APPLIANCES CO., LTD.) 10 May 2017 (2017-05-10) entire document	1-10
A	CN 103452845 A (GUANGDONG MEIZHI COMPRESSOR CO., LTD.) 18 December 2013 (2013-12-18) entire document	1-10
A	JP 2022056590 A (FUJITSU GENERAL LTD.) 11 April 2022 (2022-04-11) entire document	1-10

☐ 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

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"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
13 March 2024	**24 March 2024**

Name and mailing address of the ISA/CN	Authorized officer
China National Intellectual Property Administration (ISA/CN) **China No. 6, Xitucheng Road, Jimenqiao, Haidian District, Beijing 100088**	Telephone No.

Form PCT/ISA/210 (second sheet) (July 2022)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2023/129065

Patent document cited in search report			Publication date (day/month/year)	Patent family member(s)			Publication date (day/month/year)
CN	115701491	A	10 February 2023	CN	215805182	U	11 February 2022
CN	219139373	U	06 June 2023		None		
CN	206159025	U	10 May 2017		None		
CN	103452845	A	18 December 2013	CN	103452845	B	06 July 2016
JP	2022056590	A	11 April 2022	JP	7424260	B2	30 January 2024

Form PCT/ISA/210 (patent family annex) (July 2022)