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KR 1020180091506

(58) Field of Search:
INT CL **F04C**
Other: **WPI, EPODOC, Patent Fulltext**

(54) Title of the Invention: **Scroll pump**
Abstract Title: **A scroll pump with a clamping assembly preventing distortion of the base of the orbiting scroll.**

(57) A non-contacting scroll pump 100, with a scroll 130 which has a base 132, and a spiral wall 134 extending perpendicularly from the base. Also, a recess (132a, fig 5) within the base, a drive shaft 140, and annular bearing 160a for supporting and facilitating rotation. The annular bearing is placed in the recess with an interference fit, which causes deformation of the scroll. A clamping assembly (200, fig. 5) is arranged to apply a force to the base of the orbiting scroll to counteract the misshape caused by the interference fit, which may cause the base to be slightly convex rather than flat. The clamping assembly may include a ring (200, fig. 5), a spring (210, fig. 5) and multiple spacers (220, fig. 5). A bearing cover (230, fig. 5) may be over the recess and the spring can be located between the ring and the cover. The spacers may allow a set a load to be applied by the spring. The clamping ring may clamp onto the bearing and the base to prevent the bearing moving out of the recess. The drive shaft may extend through the scroll. The pump may be used as a vacuum pump in an array of pumps and to pump liquid.

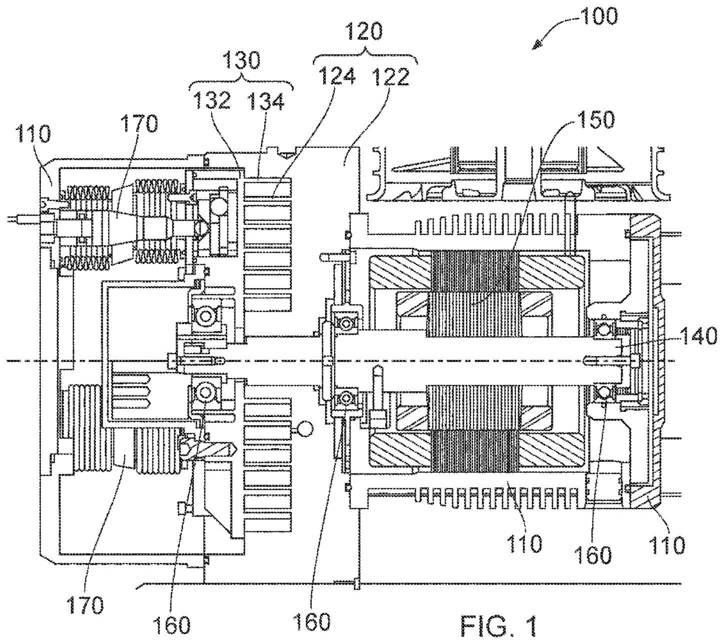

FIG. 1

At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

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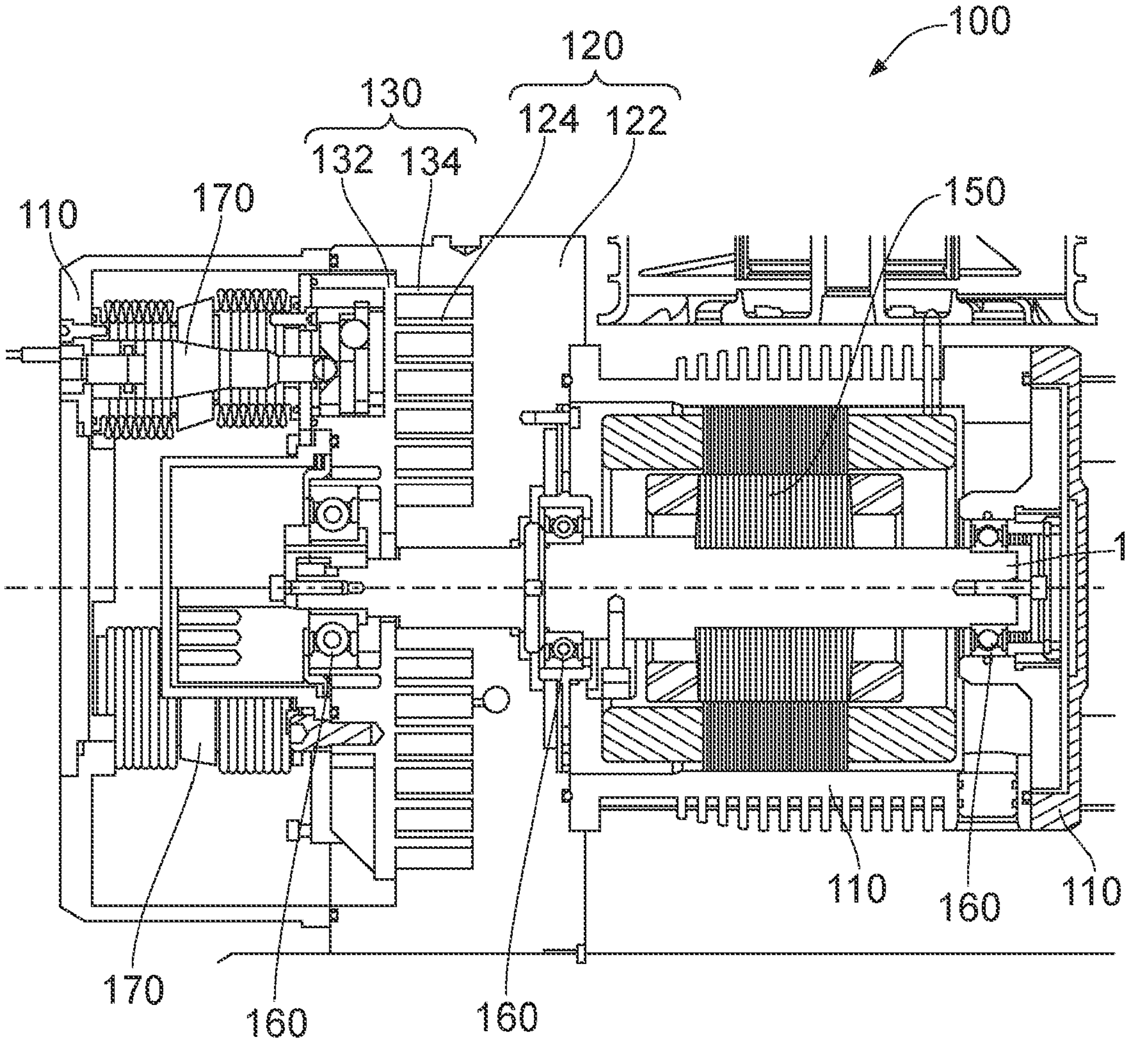
100
120
130
124
122
132
134
110
170
150
140
160
110
110
170
160
160

FIG. 1

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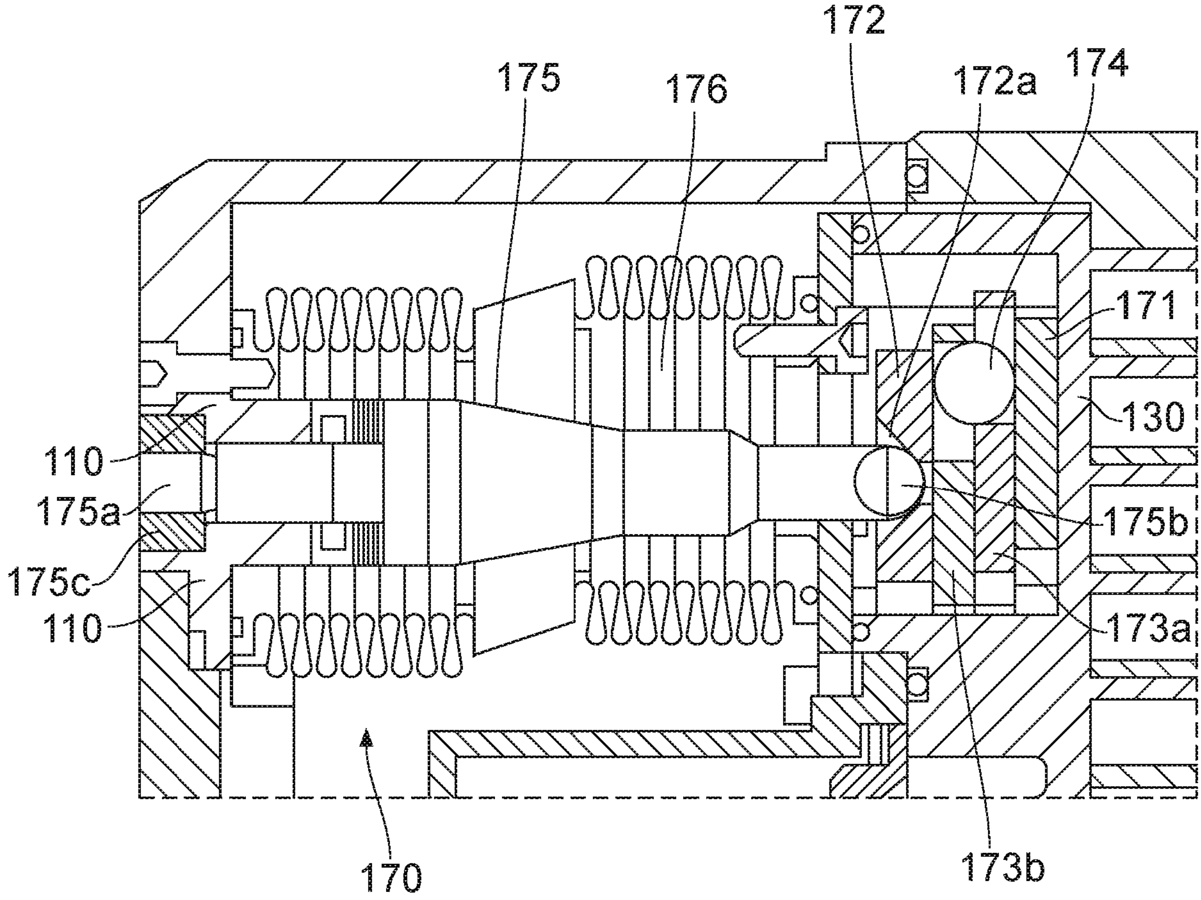
172
175
176
172a
174
171
130
110
175a
175b
175c
110
173a
170
173b

FIG. 2

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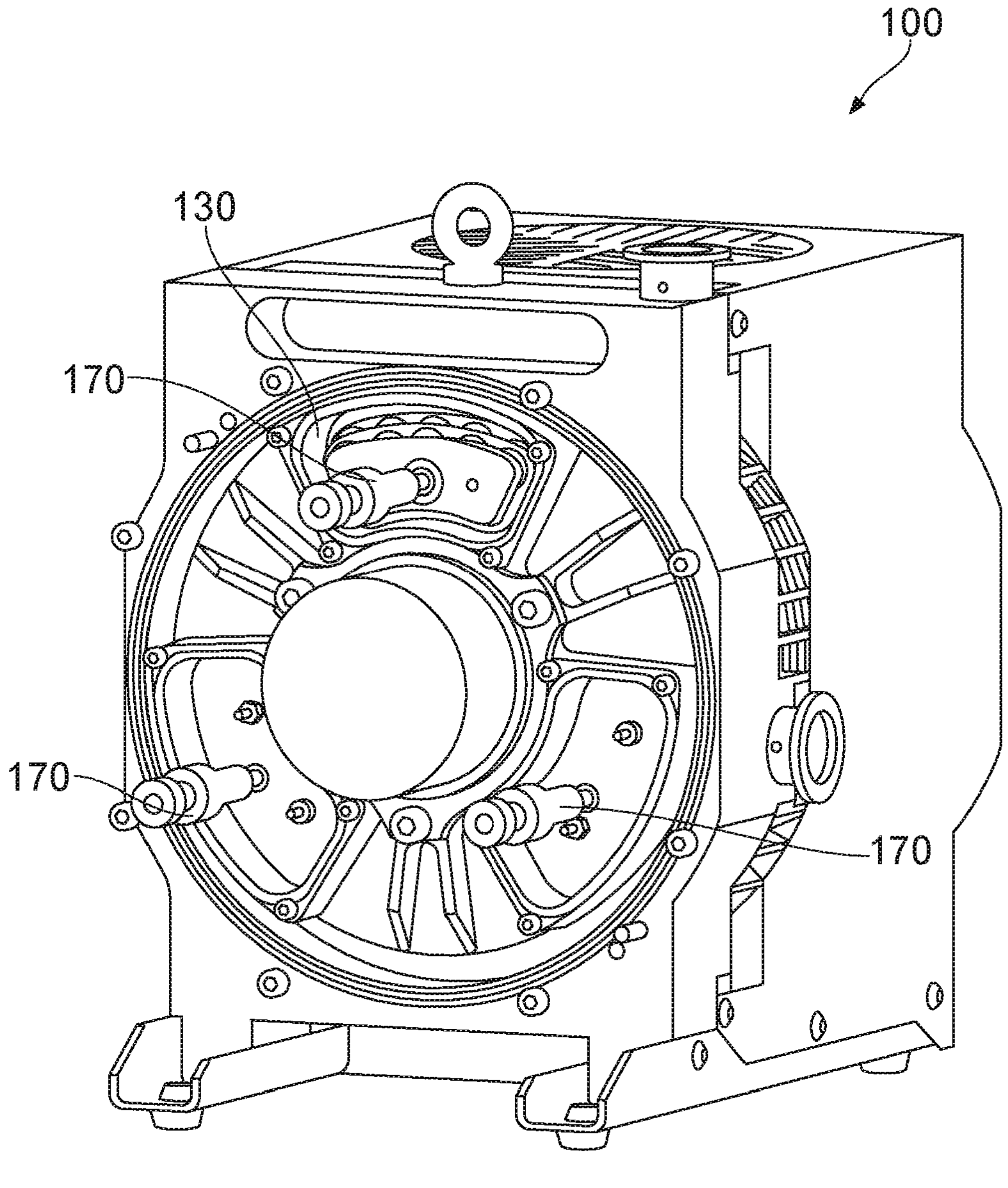

FIG. 3

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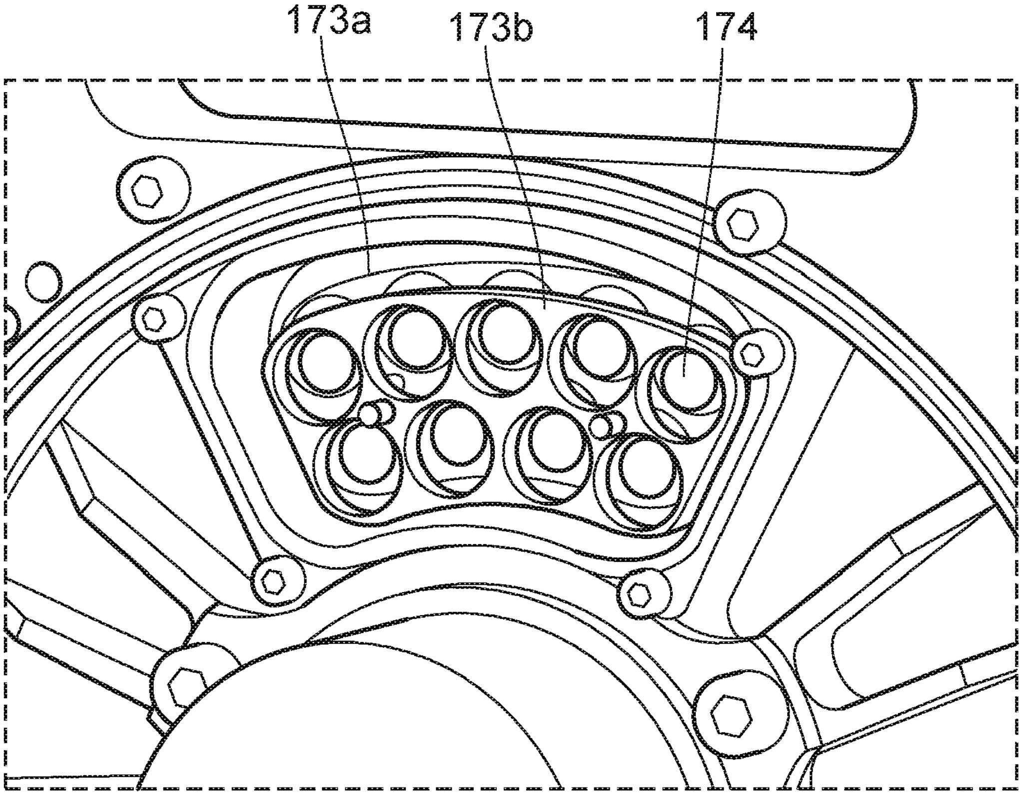

FIG. 4

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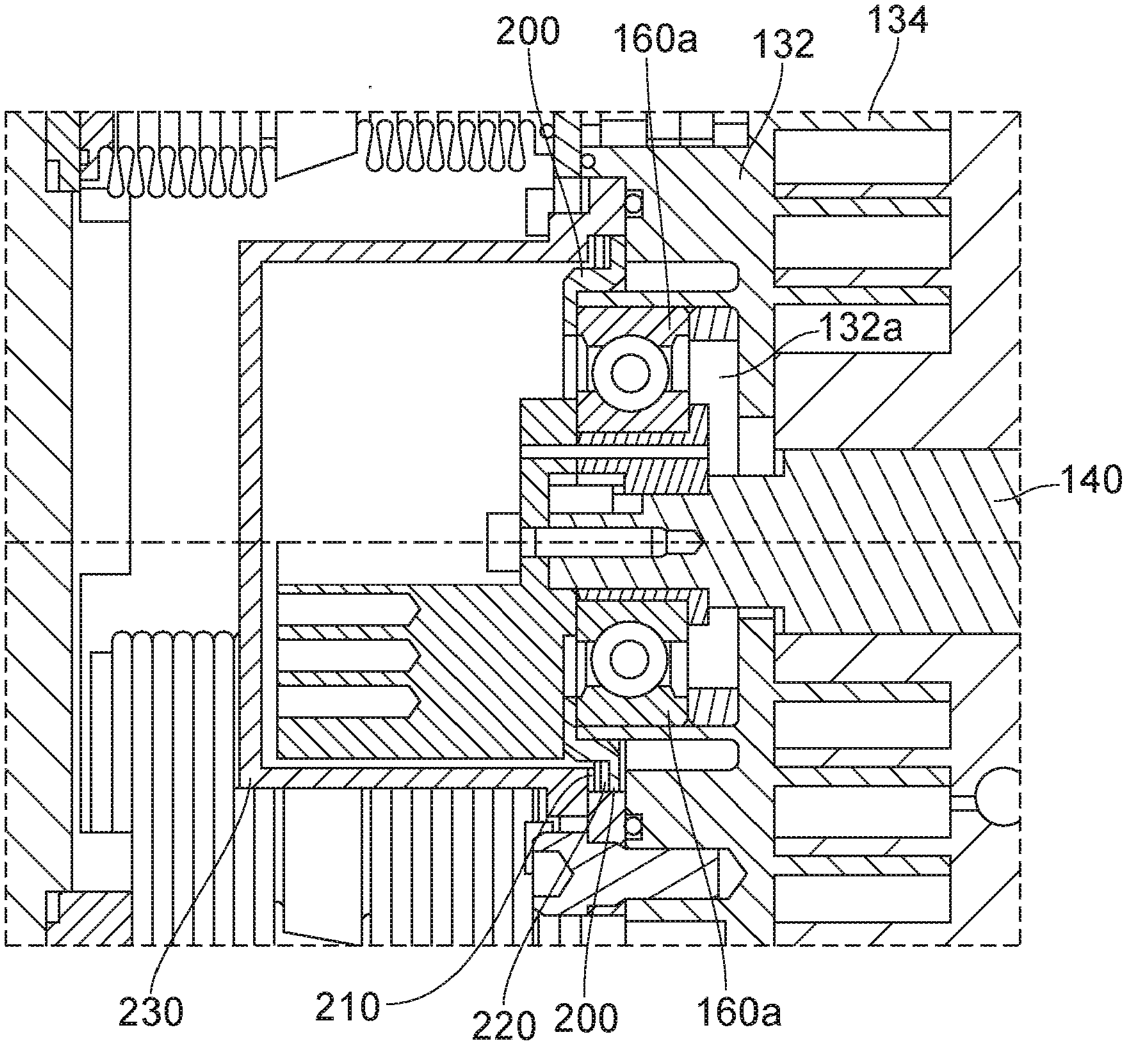

FIG. 5

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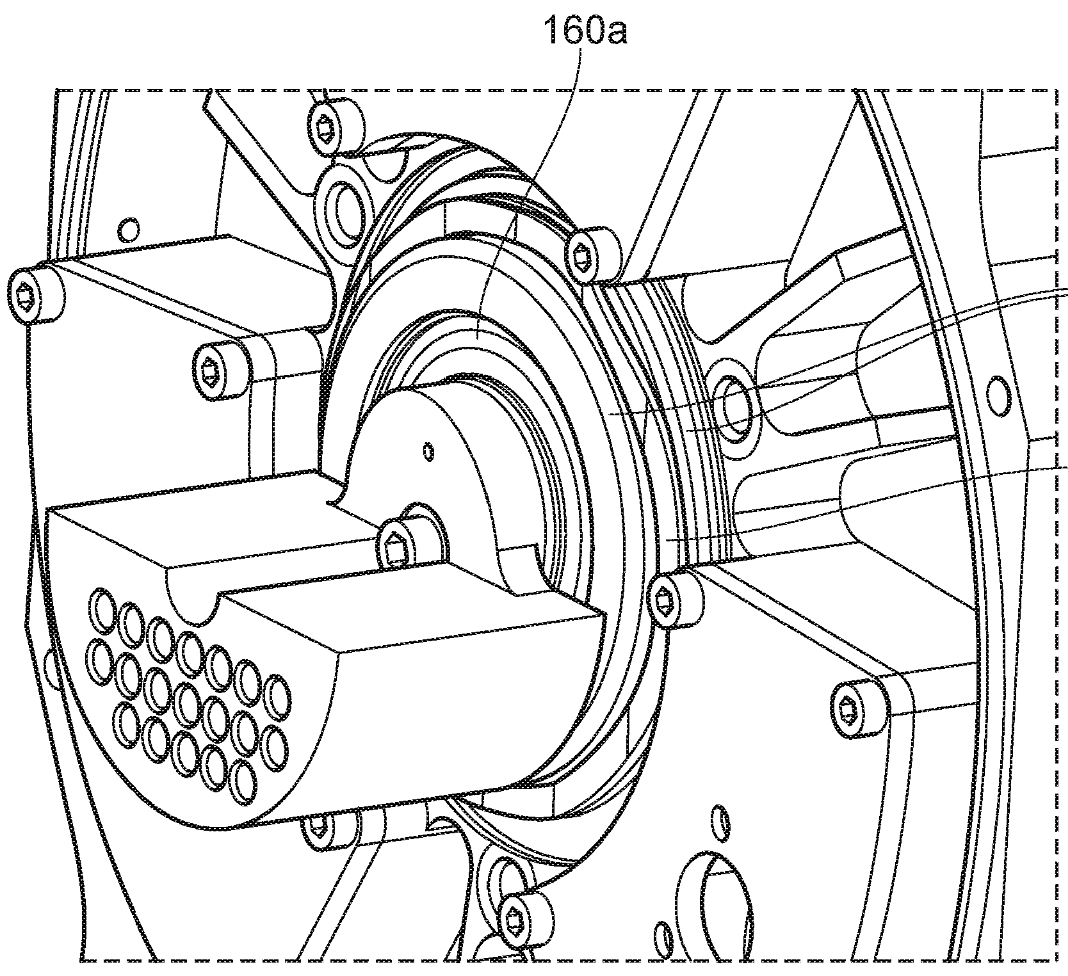

FIG. 6

SCROLL PUMP

FIELD OF THE INVENTION

The present invention relates to scroll pumps.

BACKGROUND

Scroll pumps are a known type of pump used in various different industries to pump fluid. Scroll pumps operate by using the relative motion of two intermeshed scrolls (known as a fixed scroll and an orbiting scroll) to pump fluid. Each of the fixed and orbiting scrolls includes a spiral wall extending from a base.

One type of scroll pump is a non-contacting scroll pump. In a non-contacting scroll pump, there is no contact between the tip (i.e. the end of the spiral wall) of each of the fixed and orbiting scrolls and the other scroll. Furthermore, in a non-contacting scroll pump, there is no tip seal between the tip of each of the fixed and orbiting scrolls and the other scroll. Therefore, in non-contacting scrolls pumps, there is a small gap (or clearance), e.g. of 10-20 microns, between the tip of each of the fixed and orbiting scrolls and the other scroll.

SUMMARY OF INVENTION

In an aspect of the invention, there is provided a non-contacting scroll pump, comprising a scroll comprising a base and a spiral wall extending perpendicularly from the base, the base comprising a recess. The non-contacting scroll pump further comprises a drive shaft, an annular bearing for supporting and facilitating rotation of the drive shaft, the annular bearing being located in the recess with an interference fit, wherein the interference fit causes a force which acts to deform the scroll. The non-contacting scroll pump further comprises a clamping assembly arranged to apply a force to the base of the orbiting scroll to counteract the deformation caused by the interference fit.

The clamping assembly may comprise an annular clamping ring and a spring.

The clamping assembly may further comprise one or more spacers.

The annular clamping ring may clamp around the annular bearing and a portion of the base defining the recess.

The non-contacting scroll pump may further comprise a bearing cover attached to the orbiting scroll to cover the recess. The spring may be located between the annular clamping ring and the bearing cover.

The one or more spacers may be located between the spring and the annular clamping ring to set an amount of compression of the spring, thereby controlling the spring load applied by the spring.

The annular clamping ring may clamp onto the annular bearing to prevent movement of the annular bearing out of the recess.

The drive shaft may extend through the scroll.

In another aspect of the invention, there is provided a vacuum pumping system comprising a plurality of vacuum pumps, wherein one of the vacuum pumps is the non-contacting scroll pump according to the above aspect.

In yet another aspect of the invention, there is provided the use of the non-contacting scroll pump of any of the above aspects to pump fluid.

BRIEF DESCRIPTION OF DRAWINGS

Figure 1 is a schematic illustration (not to scale) showing a cross-sectional view of a non-contacting scroll pump;

Figure 2 is a schematic illustration (not to scale) showing a close-up cross-sectional view of a thrust bearing assembly of the non-contacting scroll pump;

Figure 3 is a schematic illustration (not to scale) showing a perspective view of a plurality of thrust bearing assemblies of the non-contacting scroll pump; and

Figure 4 is a schematic illustration (not to scale) showing a close-up perspective view of part of a thrust bearing assembly of the non-contacting scroll pump; and

Figure 5 is a schematic illustration (not to scale) showing a close-up cross-sectional view of part of a main bearing assembly of the non-contacting scroll pump.

Figure 6 is a schematic illustration (not to scale) showing a perspective view of part of the main bearing assembly of the non-contacting scroll pump.

DETAILED DESCRIPTION

Figure 1 is a schematic illustration (not to scale) showing a cross-sectional view of a non-contacting scroll pump 100.

The scroll pump 100 comprises housing portions 110, a fixed scroll 120, an orbiting scroll 130, a drive shaft 140, an actuator 150, a main bearing assembly 160, and a plurality of thrust bearing assemblies 170.

In this embodiment, the housing portions 110 and the fixed scroll 120 together define an overall housing of the scroll pump 100 within which other components of the scroll pump 100 are located. However, it will be appreciated that, in other embodiments, the fixed scroll 120 may not define any of the overall housing of the scroll pump 100 and instead may be located entirely within an overall housing. In this embodiment, the orbiting scroll 130 is located within the overall housing of the scroll pump 100.

The orbiting scroll 130 is intermeshed with the fixed scroll 120 to define a space (or channel) which is used by the scroll pump 100 during operation to pump fluid (e.g. a gas). The orbiting scroll 130 is configured to orbit relative to the fixed scroll 120 to pump fluid from an inlet (not shown) of the scroll pump 100 to an outlet (not shown) of the scroll pump 100. The precise physical mechanism by which fluid is pumped by the orbiting of the orbiting scroll 130 relative to the fixed scroll 120 is well understood and will not be described herein for the sake of brevity.

The fixed scroll 120 comprises a first base 122 and a first spiral wall 124. The orbiting scroll 130 comprises a second base 132 and a second spiral wall 134. The first spiral wall 124 and second spiral wall 134 are intermeshed with each other. Furthermore, the first spiral wall 124 extends perpendicularly from the first base 122 towards the second base 132 such that an end surface (also known as the tip) of the first spiral wall 124 is proximate to (e.g. 10-20 microns away) but not in contact with an opposing surface of the second base 132. The second spiral wall 134 extends perpendicularly from the second base 132 towards the first base 122 such that an end surface (or tip) of the second spiral wall 134 is proximate to (e.g. 10-20 microns away) but not in contact with an opposing surface of the first base 122. Thus, there is a gap or clearance (e.g. of 10-20 microns) between the end surfaces of the first and second spiral walls 124, 134 the respective opposing surfaces of the first and second bases 122, 132. The distance between the end surface of the first spiral wall 124 and the opposing surface of the second base 132 is the same as the distance between the second spiral wall 134 and the opposing surface of the first base 122. The gaps are empty in the sense that there are no objects or other scroll pump parts located within the gaps. For example, there are no tip seals within the gaps. Accordingly, the end surfaces of the first and second spiral walls 124, 134 are not in contact with any objects or other scroll pump parts.

In this embodiment, the first base 122 and first spiral wall 124 are integrally formed with each other, and the second base 132 and second spiral wall 134 are integrally formed with each other. However, in other embodiments, one or both of the spiral walls 124, 134 are not integrally formed with their respective bases 122, 132.

The drive shaft 140 is coupled to the orbiting scroll 130 and configured to rotate to drive the orbiting of the orbiting scroll 130. The drive shaft 140 is located within the overall housing of the scroll pump 100 and mounted via the main bearing assembly 160 which facilitates rotation of the drive shaft 140. In this embodiment, the draft shaft 140 extends through both the fixed scroll 120 and the orbiting scroll 130, and the orbiting scroll 130 is mounted at an end of the draft shaft 140.

The actuator 150 (e.g. an electric motor) is coupled to the drive shaft 140 and configured to actuate the drive shaft 140 to cause the drive shaft 140 to rotate to drive the orbiting of the orbiting scroll 130. The actuator 150 is located within the overall housing of the scroll pump 100 and mounted around the drive shaft 140.

The main bearing assembly 160 mechanically couples the drive shaft 140 to the orbiting scroll 130 and the overall housing of the scroll pump 100 such that the drive shaft 140 is able to rotate within the scroll pump 100 to drive the orbiting scroll 130. In this embodiment, the main bearing assembly 160 comprises a bearing located between (and mechanically coupling) a first end of the drive shaft 140 and the overall housing of the scroll pump 100, a bearing located between (and mechanically coupling) the orbiting scroll 130 and a second end of the drive shaft 140 opposite to the first end, and a bearing located between (and mechanically coupling) the fixed scroll 120 and the drive shaft 140.

The plurality of thrust bearing assemblies 170 are each located between the orbiting scroll 130 and a housing portion 110 which is axially spaced apart from the orbiting scroll 130. Each thrust bearing assembly 170 is coupled to (and engaged with) the orbiting scroll 130 to constrain and/or control the axial position of the orbiting scroll 130 relative to the fixed scroll 120. In this embodiment, there are three thrust bearing assemblies 170 evenly angularly distributed around the central rotation axis of the orbiting scroll in a triangular formation to provide a stable axial force on the orbiting scroll 130 (this is illustrated further in Figure 3). The precise structure of each of the thrust bearing assemblies will be described in more detail with reference to Figure 2.

Figure 2 is a schematic illustration (not to scale) showing a close-up cross-sectional view of a thrust bearing assembly 170 of the non-contacting scroll pump 100.

The thrust bearing assembly 170 comprises a first plate 171, a second plate 172, a first ball bearing cage 173a, a second ball bearing cage 173b, a plurality of ball bearings 174, an adjustment pin 175, and a casing 176. Via these structures, the thrust bearing assembly 170 provides axial support to the orbiting scroll 130 while also facilitating the orbiting of the orbiting scroll 130 during operation, as will be described in more detail below.

The first and second plates 171, 172 each have a first side facing towards the orbiting scroll 130 and a second side opposite to the first side facing away from the orbiting scroll 130. The first and second ball bearing cages 173a, 173b also each have a first side facing towards the orbiting scroll 130 and a second side opposite to the first side facing away from the orbiting scroll 130. The first side of the first plate 171 is fixed to a back surface of the orbiting scroll 130, and the second side of the first plate 171 is fixed to the first side of the first ball bearing cage 173a. The second side of the first ball bearing cage 173a is spaced apart from the first side of the second ball bearing cage 173b by the ball bearings 174, thereby allowing relative motion of the first and second ball bearing cages 173a, 173b. The second side of the second ball bearing cage 173b is fixed to the first side of the second plate 172. The second side of the second plate 172 is engaged with an end of the adjustment pin 175.

The first and second ball bearing cages 173a, 173b each comprise a plurality of holes within which the plurality of ball bearings 174 are located. Each hole of the first ball bearing cage 173a partially overlaps with a corresponding hole of the second ball bearing cage 173b to form a plurality of hole pairs. Each hole pair houses a single ball bearing 174. The partial overlap of the holes enables the first and second bearing cages 173a, 173b to accommodate the orbiting motion of the orbiting scroll 130 during operation while constraining the movement of the ball bearings 174. This is illustrated further in Figure 4.

The plurality of ball bearings 174 are sandwiched between the first and second plates 171, 172 such that each of the first and second plates 171, 172 are in contact with the ball bearings 174. Each ball bearing 174 of the plurality of ball bearings 174 is housed within a respective hole pair of the first and second ball bearing cages 173a, 173b. The plurality of ball bearings 174 may be formed from steel or ceramic.

During operation, to facilitate the orbiting of the orbiting scroll 130, the plurality of ball bearings 174 roll against the first and second plates 171, 172 within the hole pairs of the first and second ball bearing cages 173a, 173b. During operation of the scroll pump 100, the first plate 171 and first ball bearing cage 173a, which are fixed to each other and to the orbiting scroll 130, move together with the orbiting scroll 130. Thus, during operation, the first plate 171, first ball bearing cage 173a and orbiting scroll 130 all move together relative to the second plate 172 and the second ball bearing cage 173b on the plurality of ball bearings 174.

The adjustment pin 175 extends axially between a housing portion 110 of the scroll pump 100 and the second plate 172. A first end 175a of the adjustment pin 175 is attached to the housing portion 110, and a second end 175b opposite to the first end 175a of the adjustment pin 175 is engaged with the second side of the second plate 172. The first end 175a of the adjustment pin 175 is threaded and coupled to the housing portion 110 via a corresponding threaded nut 175c. The threaded nut 175c is at the first end 175a of the adjustment pin 175 and is rotatable on the threading of the first end 175a to adjust the axial position of the adjustment pin 175, thereby facilitating control of the axial position of the orbiting scroll 130 via the rest of the thrust bearing assembly 170.

The second end 175b of the adjustment pin 175 sits in a tapered recess 172a in the second side of the second plate 172. The tapered recess 172a has a generally conical shape. More specifically, the second end 175b of the adjustment pin 175 comprises a rounded surface which is engaged with a surface of the second side of the second plate 172 which defines the tapered recess 172a. In this way, the rounded surface of the second end 175b of the adjustment pin 175 and the surface defining the tapered recess 172a together form a ball and socket joint, which enables the second plate 172 and second ball bearing cage 173b to articulate/rotate on the first end 175b of the adjusting pin 175.

The casing 176 surrounds the adjustment pin 175 and acts as a barrier to prevent escape of lubricant (e.g. oil or grease) used for the ball bearings 174, the first and second bearing cages 173a, 173b, and the first and second plates 171, 172. In this embodiment, the casing 176 has a bellows shape.

Figure 3 is a schematic illustration (not to scale) showing a perspective view of the plurality of thrust bearing assemblies 170 of the non-contacting scroll pump 100. As shown, in this embodiment, the scroll pump 100 comprises three thrust bearing assemblies 170 which evenly angularly distributed around the central rotation axis of the orbiting scroll in a triangular formation to provide a stable axial force on the orbiting scroll 130.

Figure 4 is a schematic illustration (not to scale) showing a close-up perspective view of part of a thrust bearing assembly 170 of the non-contacting scroll pump 100. Specifically, Figure 4 illustrates a close-up view of the first and second bearing cages 173a, 173b of the thrust bearing assembly 170. As shown, each hole of the first ball bearing cage 173a partially overlaps with a corresponding hole of the second ball bearing cage 173b to form a plurality of hole pairs. The ball bearings 174 are each located within a respective hole pair (only one is labelled in Figure 4).

Figure 5 is a schematic illustration (not to scale) showing a close-up cross sectional view of part of the main bearing assembly 160 of the non-contacting scroll pump 100.

The main bearing assembly 160 comprises an annular bearing 160a located around the drive shaft 140 and configured to facilitate rotation of the drive shaft 140. The annular bearing 160a is located within a recess 132a of the base 132 of the orbiting scroll 130. The annular bearing 160a is fitted in the recess with an interference fit. The process of inserting the annular bearing 160a with an interference fit into the recess 132a tends to cause the orbiting scroll 130 to be slightly deformed such that the surface of the base 132 from which the spiral wall 134 extends becomes slightly convex rather than flat. In particular for non-contacting scroll pumps, which do not have tip seals, even such slight deformation of the orbiting scroll tends to cause undesirable internal leakage and loss of pressure during operation.

In order to counteract this deformation, the scroll pump 100 further comprises a clamping assembly comprising an annular clamping ring 200, a spring 210 and one or more spacers 220. The annular clamping ring 200 is clamped around the annular bearing 160a and a portion of the base 132 defining the recess. The spring 210 is located to provide a force on the clamping ring 200 which acts to counteract the deformation described above so as to restore the flatness of the surface of the base 132 from which the spiral wall 134 extends. Specifically, the spring 210 is located between a portion of a bearing cover 230 of the scroll pump 100 and the annular clamping ring 200. The bearing cover 230 is attached to the orbiting scroll 130 such that it is located over the recess in which the annular bearing 160a is located in order to cover the recess. In this embodiment, the one or more spacers 220 are located between the spring 210 and the annular clamping ring 200 to set the space between the spring 210 and the annular clamping ring 200 so that the amount of force applied by the spring (also known as the spring load) can be adjusted depending on the spacing between the annular clamping ring 200 and the spring 210. For example, a smaller spacing corresponds to a greater force as the spring 210 is more compressed and a larger spacing corresponds to a smaller force as the spring 210 is less compressed. In this way, a user can choose an appropriate spacing depending on the amount of deformation of the orbiting scroll 130.

The above-described clamping assembly also advantageously helps to retain the annular bearing 160a in the recess 132a, since the annular clamping ring 200 clamps onto the annular bearing 160a to prevent movement of the annular bearing 160a in an axial direction away from the drive shaft 140.

Figure 6 is a schematic illustration (not to scale) showing a perspective view of part of the main bearing assembly 160 of the non-contacting scroll pump. As shown, the annular clamping ring 200 clamps around the annular bearing 160a. The spring 210 is an annular shape extending around annular bearing 160a.

The above-described non-contacting scroll pump 100 may be used as part of a vacuum pumping system including multiple pumps and/or other components.

It will be appreciated that various modifications/deviations may be made to the above described embodiments without departing from the scope of the invention.

In the above-described embodiments, the scroll pump comprises three separate thrust bearing assemblies. However, in other embodiments, the scroll pump comprises a different number of thrust bearing assemblies, e.g. only one, two or more than 3.

In the above-described embodiments, the thrust bearing assembly comprises a plurality of ball bearings. However, in other embodiments, the thrust bearing assembly comprises only one ball bearing.

In the above-described embodiments, the thrust bearing assembly comprises ball bearing cages to constrain the movement of the ball bearings. However, in other embodiments, the ball bearing cages are omitted.

In the above-described embodiments, the one or more spacers are located between the spring and the annular clamping ring. However, in other embodiments, the one or more spacers are located between the spring and bearing cover instead.

In the above-described embodiments, an elongate adjustment pin is used to couple the housing to the second plate. However, in other embodiments, a different type of coupling structure may be used, e.g. a different type of elongate member.

REFERENCE NUMERAL LIST

100: non-contacting scroll pump
110: housing
120: fixed scroll
122: base of fixed scroll
124: spiral wall of fixed scroll
130: orbiting scroll
132: base of orbiting scroll
134: spiral wall of orbiting scroll
140: drive shaft
150: actuator
160: main bearing assembly
160a: annular bearing
170: thrust bearing assembly
171: first plate
172: second plate
172a: recess
173a: first ball bearing cage
173b: second ball bearing cage
174: ball bearing
175: adjustment pin
175a: first end of adjustment pin
175b: second end of adjustment pin
175c: nut
176: casing
200: annular clamping ring
210: spring
220: spacers
230: bearing cover

CLAIMS

1. A non-contacting scroll pump, comprising:

a scroll comprising a base and a spiral wall extending perpendicularly from the base, the base comprising a recess;

a drive shaft;

an annular bearing for supporting and facilitating rotation of the drive shaft, the annular bearing being located in the recess with an interference fit, wherein the interference fit causes a force which acts to deform the scroll;

a clamping assembly arranged to apply a force to the base of the orbiting scroll to counteract the deformation caused by the interference fit.

2. The non-contacting scroll pump of claim 1, wherein the clamping assembly comprises an annular clamping ring and a spring.

3. The non-contacting scroll pump of claim 2, wherein the clamping assembly further comprises one or more spacers.

4. The non-contacting scroll pump of claim 2 or 3, wherein the annular clamping ring clamps around the annular bearing and a portion of the base defining the recess.

5. The non-contacting scroll pump of any of claims 2 to 4, further comprising a bearing cover attached to the orbiting scroll to cover the recess, wherein the spring is located between the annular clamping ring and the bearing cover.

6. The non-contacting scroll pump of any of claims 3 to 5, wherein the one or more spacers are located between the spring and the annular clamping ring to set an amount of compression of the spring, thereby controlling the spring

load applied by the spring.

7. The non-contacting scroll pump of any of claims 2 to 6, wherein the annular clamping ring clamps onto the annular bearing to prevent movement of the annular bearing out of the recess.

8. The non-contacting scroll pump of any preceding claim, wherein the drive shaft extends through the scroll.

9. A vacuum pumping system comprising a plurality of vacuum pumps, wherein one of the vacuum pumps is the non-contacting scroll pump of any preceding claim.

10. Use of the non-contacting scroll pump of any of claims 1 to 7 to pump fluid.

Intellectual Property Office

Application No:	GB2204517.3	**Examiner:**	Sarah O'Neill
Claims searched:	1-10	**Date of search:**	22 September 2022

Patents Act 1977: Search Report under Section 17

Documents considered to be relevant:

Category	Relevant to claims	Identity of document and passage or figure of particular relevance
A	1	KR 1020180091506 A (HANON SYSTEMS)

Categories:

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.

Field of Search:

Search of GB, EP, WO & US patent documents classified in the following areas of the UKC^{X} :

Worldwide search of patent documents classified in the following areas of the IPC

F04C

The following online and other databases have been used in the preparation of this search report

WPI, EPODOC, Patent Fulltext

International Classification:

Subclass	Subgroup	Valid From
F04C	0018/02	01/01/2006