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(72) Inventor: **FENG, Yongbing**
Suzhou City
Jiangsu 215168 (CN)

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(74) Representative: **Heine, Christian Klaus**
KNH Patentanwälte Kahlhöfer Neumann
Rößler Heine PartG mbB
Postfach 10 33 63
40024 Düsseldorf (DE)

(71) Applicant: **Ecovacs Robotics (Suzhou) Co., Ltd.**
Suzhou, Jiangsu 215168 (CN)

(54) **CRANKSHAFT-TYPE VACUUM AIR PUMP AND GLASS-WIPING APPARATUS THEREOF**

(57) A crankshaft-type vacuum air pump comprising a drive motor (1), an air pump main body (2), and piston air pump components (3) arranged on the air pump main body (2). A crankshaft unit is arranged within the air pump main body (2). The top of the crankshaft unit is connected to the air pump main body (2) via an upper eccentric wheel (4), while the end is connected to the drive motor (1) via a lower eccentric wheel (5). The drive motor (1) outputs power to rotate the crankshaft unit. The crankshaft unit is connected to the piston air pump components (3) and drives the piston air pump components into motion, thus completing air intake and air discharge of the piston air pump components (3). The air pump is structurally simple and compact, the crankshaft *per se* is centrosymmetric, and one or more crankshaft units are made to serve as a rotary shaft, where the overall center of gravity during rotation is always located at the center of rotation and no vibration is caused by a centrifugal force. The rotary shaft is subjected to the force of piston rods on two sides that are always symmetric relative to the center of rotation, thus the rotary shaft is subjected to a radial force that is basically zero, the problem of vibration caused by unbalanced stress during rotation is greatly reduced, and a stable working state is allowed.

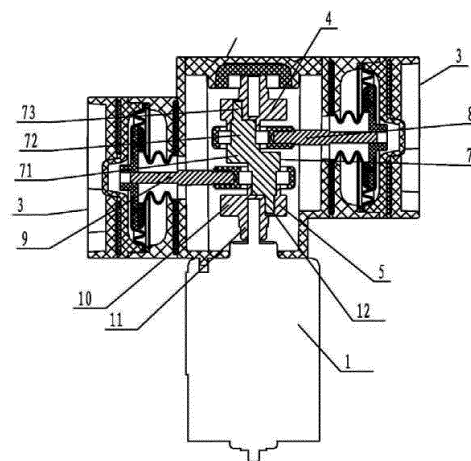


Fig5

Description

Technical Field

[0001] The present invention relates to a crankshaft-type vacuum air pump and glass-wiping apparatus thereof, and belongs to the field of machinery manufacture.

Background Arts

[0002] Figure 1 shows a schematic view of the overall structure of the conventional eccentric wheel-type vacuum air pump. As shown in Figure 1, the conventional vacuum air pump employs an eccentric wheel 200 mounted on the output shaft 110 of the motor 100 to drive a piston rods 300 of the air pump to reciprocate, in order to proceed the vacuum operation. Figure 2 shows a schematic view of the relationship between the distance from the center of gravity to the rotary shaft and the rotation angle in the conventional vacuum air pump. As shown in Figure 2, when the rotation angle is 0° , the distance is 0; with the rotation angle changes, the distance also increases, and when the rotation angle is 90° , the distance reaches its maximum value of 0.55mm; when the rotation angle changes from 90° to 180° , the distance gradually decreases again. During the process that the rotation angle changes from 180° to 360° , the above variation is repeated. As shown in Figure 2, due to the employment of the high-speed motor to drive the rotation of the eccentric wheel, the variation of the distance from the center of gravity to the rotary shaft is large. Figures 3 and 4 respectively shows the force analysis diagram of the radial force X or Y of the eccentric wheel in the conventional eccentric wheel-type vacuum air pump. As shown in Figure 3 and 4, the centrifugal force generated by the rotation of the eccentric wheel and the force applied by the piston rod render the rotary shaft being subjected to a radial force in X direction along the piston rod and a radial force in Y direction perpendicular to the piston rod, each of which changing with the rotation angle. As shown in Figure 3, as the rotation angle varies, the radial force X ranges from $-2.00\text{e-}06\text{N}$ (min. value) to $1.625\text{e-}06\text{N}$ (max. value); while as shown in Figure 4, as the rotation angle varies, the radial force Y ranges from -0.9N (min. value) to 0.9N (max. value). Since the difference between the alternating forces is large, the vacuum pump is suffered from serious vibration. As shown in Figure 1, for the purpose of reducing the vibration, the current practice is to add a counterweight block 400 on the eccentric wheel, so as to balance the center of gravity, but the effect is still far from satisfactory.

Summary of the Invention

[0003] The technical problem to be solved by the present invention is to aim at the deficiency of the prior art, providing a crank shaft type vacuum air pump, which is structurally simple and compact, crankshaft units are

made to serve as a rotary shaft, since each crankshaft therein *per se* is centrosymmetric, the overall center of gravity during rotation is always located at the center of rotation and no vibration is caused by a centrifugal force.

The rotary shaft is subjected to the force of piston rods on two sides that are always symmetric relative to the center of rotation, thus the rotary shaft is subjected to a radial force that is basically zero, the problem of vibration caused by unbalanced stress during rotation is greatly reduced, and a stable working state is allowed. Besides, the number of the crankshaft units mounted can be adjusted to achieve the most suitable amount and volume of air.

[0004] The present invention is achieved by the following technical solutions:

[0005] A crankshaft-type vacuum air pump comprising a drive motor, an air pump main body, and piston air pump components arranged on the air pump main body, a crankshaft unit is arranged within the air pump main body, the top of the crankshaft unit is connected to the air pump main body via an upper eccentric wheel, while the end is connected to the drive motor via a lower eccentric wheel, the drive motor outputs power to rotate the crankshaft unit, the crankshaft unit is connected to the piston air pump components and drives the piston air pump components into motion, thus completing air intake and air discharge of each piston air pump component.

[0006] Specifically, the crankshaft unit comprises a crankshaft, an upper piston rod and a lower piston rod are respectively sheathed on the upper side and the lower side of the crankshaft, the lower piston rod and the upper piston rod are respectively connected to the piston air pump components arranged on the different sides of the air pump main body.

[0007] The crankshaft comprises a crankshaft main body and two shaft portions, each of which respectively extends upward and downward from the left end and the right end of the crankshaft main body, the shaft portion of the crankshaft comprises a piston rods connection part on which the piston rods are sheathed via a bearing, and an eccentric wheel connection part which inserts into an eccentric hole of the eccentric wheel and is fixed therein.

[0008] The crankshaft is centrosymmetric in order to ensure that the crankshaft is always in force equilibrium and the vibration is reduced.

[0009] For the purpose of simplification, the upper eccentric wheel and the lower eccentric wheel are structurally the same, which respectively comprises a wheel disk, a wheel shaft is projected out from one side of the wheel disk, and an eccentric hole is provided on the other side; besides the upper eccentric wheel and the lower eccentric wheel are symmetrically arranged with respect to the crankshaft unit.

[0010] As needed, one or more crankshaft units are installed, wherein two adjacent crankshaft units are connected by a connection disk, which comprises a disk body and two connection seats respectively provided on the upper/lower surface of the disk body, which respectively

connects to different crankshafts in two neighbouring crankshaft units.

[0011] Usually, two or three of the crankshaft units are employed.

[0012] The present invention also provides a glass-wiping apparatus, comprising a sucking unit and a walking unit, the glass-wiping apparatus is sucked on the surface of the glass via the sucking unit, wherein the sucking unit comprises a sucker and a vacuum air pump, the vacuum air pump provides vacuum sucking force to the sucker, and wherein the vacuum air pump employs the above mentioned crankshaft type vacuum air pump.

[0013] In conclusion, the present invention provides a crankshaft type vacuum air pump, which is structurally simple and compact, as each crankshaft therein *per se* is centrosymmetric, the overall center of gravity during rotation is always located at the center of rotation and no vibration is caused by a centrifugal force. The rotary shaft is subjected to the force of piston rods on two sides that are always symmetric relative to the center of rotation, thus the rotary shaft is subjected to a radial force that is basically zero, the problem of vibration caused by unbalanced stress during rotation is greatly reduced, and stable working state is allowed. Besides, as the crankshaft unit comprises a crankshaft main body and two shaft portions, the piston rods can be easily sheathed on the piston rods connection parts, the assembly time of the vacuum air pump is greatly reduced.

[0014] The present invention is now described in details with reference to the attached drawings and the embodiments.

Description of the Drawings

[0015]

Figure 1 shows a schematic view of the overall structure of the conventional eccentric wheel-type vacuum air pump.

Figure 2 shows a schematic view of the relationship between the distance from the center of gravity to the rotary shaft and the rotation angle in the conventional vacuum air pump.

Figures 3 and 4 respectively shows the force analysis diagram of the radial force X or Y of the eccentric wheel in the conventional eccentric wheel-type vacuum air pump.

Figure 5 shows a schematic view of the overall structure of Example 1 of the present invention.

Figure 6 shows a schematic view of the relationship between the distance from the center of gravity to the rotary shaft and the rotation angle in Example 1 of the present invention.

Figures 7 and 8 respectively shows the force analysis diagram of the radial force X or Y of the crankshaft in Example 1 of the present invention.

Figure 9 shows a prospective view of the assembly of the crankshaft unit of Example 2 of the present

invention.

Figure 10 shows a sectional view of the crankshaft unit of Example 2 of the present invention.

Detailed Description

Example 1

[0016] Figure 5 shows a schematic view of the overall structure of Example 1 of the present invention. As shown in Figure 5, the present invention provides a crankshaft-type vacuum air pump comprising a drive motor 1, an air pump main body 2, and piston air pump components 3 arranged within the air pump main body 2, a crankshaft unit is arranged on the air pump main body 2 to rotate the air pump main body, the center line of the output shaft of the driver motor 1 is coincide with the center of rotation of the crankshaft unit. The top of the crankshaft unit is connected to the air pump main body 2 via an upper eccentric wheel 4, while the end is connected to the drive motor 1 via a lower eccentric wheel 5, the drive motor 1 outputs power to the crankshaft unit, the crankshaft unit is connected to the piston air pump components 3 and drives the piston air pump components into motion, thus completing air intake and air discharge of the piston air pump components 3. Specifically, the crankshaft unit comprises a crankshaft 7, an upper piston rod 8 and a lower piston rod 9 are respectively sheathed on the upper side and the lower side of the crankshaft 7, the lower piston rod 9 and the upper piston rod 8 are respectively connected to the piston air pump components 3 arranged on the different sides of the air pump main body 2. The crankshaft 7 comprises a crankshaft main body 71 and two shaft portions, which respectively extends upward and downward from the left end and the right end of the crankshaft main body 71, the shaft portion of the crankshaft 7 comprises a piston rods connection part 72 on which the piston rods are sheathed via a bearing, and an eccentric wheel connection part 73 which inserts into an eccentric hole of the eccentric wheel 4 and is fixed therein. The wheel shaft of the lower eccentric wheel 5 is fixed in connection with the rotary shaft of the motor, while the wheel shaft of the upper eccentric wheel 4 is connected to the air pump main body 2 via a bearing. The crankshaft is centrosymmetric in order to ensure that the crankshaft is always in force equilibrium and the vibration is reduced. For the purpose of simplification, the upper eccentric wheel 4 and the lower eccentric wheel 5 are structurally the same, which respectively comprises a wheel disk 10, and a wheel shaft 11 is projected out from one side of the wheel disk 10, and an eccentric hole 12 is provided on the other side; the upper eccentric wheel 4 and the lower eccentric wheel 5 are symmetrically arranged with respect to the crankshaft unit.

[0017] With reference to Figure 5, the operating process of the crankshaft type vacuum air pump according to the present invention is: as the drive motor 1 starts running, when the motor rotates, the crankshaft 7 as well

as the up/lower eccentric wheels 4 and 5 rotate synchronously, thus drive the upper piston rod 8 and the lower piston rod 9 into reciprocating motion, thus the piston air pump components 3 at the both ends operate in the air intake and air discharge synchronously, so as to continuously vacuum the suckers in connection with the piston air pump components 3.

[0018] Figure 6 shows a schematic view of the relationship between the distance from the center of gravity to the rotary shaft and the rotation angle in Example 1 of the present invention. Figures 7 and 8 respectively shows the force analysis diagram of the radial force X or Y of the crankshaft in Example 1 of the present invention. As shown in Figure 6, as the rotation angle varies, the distance from the center of gravity to the rotary shaft is maintained at 0, with no changes occurring. As shown in Figure 7, as the rotation angle varies, the radial force X ranges from $-1.75 \times 10^{-9} \text{N}$ (min. force) to $1.75 \times 10^{-9} \text{N}$ (max. force); while as shown in Figure 8, as the rotation angle varies, the radial force Y ranges from $-3.75 \times 10^{-9} \text{N}$ (min. value) to 0N (max. value). With reference to the data shown in Figures 6 to 8, first of all, the crankshaft of the invention *per se* is centrosymmetric, thus the employment of the crankshaft-type vacuum air pump renders that the overall center of gravity during rotation is always located at the center of rotation and no vibration is caused by a centrifugal force. Secondly, during rotation, the rotary shaft is subjected to the force of piston rods on two sides that are always symmetric relative to the center of rotation, thus the rotary shaft is subjected to a radial force that is basically zero, therefore the problem of vibration caused by unbalanced stress during rotation is reduced; besides, as the crankshaft unit comprises a crankshaft main body and two shaft portions, the piston rods can be easily sheathed on the piston rods connection parts, the assembly time of the vacuum air pump is greatly reduced.

Example 2

[0019] Figure 9 shows a prospective view of the assembly of the crankshaft unit of Example 2 of the present invention; and Figure 10 shows a sectional view of the crankshaft unit of Example 2 of the present invention. As shown in Figures 9 and 10, as needed, one or more crankshaft units are installed, wherein two adjacent crankshaft units are connected by a connection disk 6, which comprises a disk body 61 and two connection seats 62 respectively provided on the upper/lower surface of the disk body, the two connection seats 62 respectively connect to different crankshafts in two neighbouring crankshaft units. Usually, two or three of the crankshaft units are employed.

[0020] The difference between the present Example 2 and Example 1 lies only in that, the numbers of the crankshaft units installed in the crankshaft type vacuum air pump are different, and other technical features in the present Example are basically the same as those employed in Example 1, which are not repeated herein.

[0021] The present invention also provides a glass-wiping apparatus, comprising a sucking unit and a walking unit, and the glass-wiping apparatus is sucked on the surface of the glass via the sucking unit, wherein the sucking unit comprises a sucker and a vacuum air pump, which provides vacuum sucking force to the sucker, and wherein the vacuum air pump employs the crankshaft type vacuum air pump according to the above Example 1 or Example 2.

[0022] Besides, it is noted that, the crankshaft type vacuum air pump according to the present invention employs a configuration similar to the crankshaft of automobile engine, and can be made of two connecting rods, four connecting rods or more. However, as is distinguished from the unitary crankshaft of the automobile engine, which aims at fixing the number of cylinders at work during the movement, so as to maintain a constant output power during the movement, the crankshaft according to the present invention employ a sectional installation type, thus makes a convenient installation, moreover the crankshaft maintains a force equilibrium during operation, reducing the vibration caused by the force disequilibrium; and the overall center of gravity of the air pump coincides with the rotary shaft, thus reduces the vibration caused by the inertial force. In conclusion, since the present invention employs the crankshaft structure, canceling the clump weight of the prior art, thus is structurally simple and compact, as each crankshaft therein *per se* is centrosymmetric, the overall center of gravity during rotation is always located at the center of rotation and no vibration is caused by a centrifugal force. The rotary shaft is subjected to the force of piston rods on two sides that are always symmetric relative to the center of rotation, thus the rotary shaft is subjected to a radial force that is basically zero, the problem of vibration caused by unbalanced stress during rotation is greatly reduced, and a stable working state is allowed.

Claims

1. A crankshaft-type vacuum air pump comprising a drive motor (1), an air pump main body (2), and piston air pump components (3) arranged on the air pump main body, **characterized in that**, a crankshaft unit is arranged within the air pump main body (2), the top of the crankshaft unit is connected to the air pump main body via an upper eccentric wheel (4), while the end is connected to the drive motor via a lower eccentric wheel (5), the drive motor (1) outputs power to rotate the crankshaft unit, the crankshaft unit is connected to the piston air pump components (3) and drives the piston air pump components into motion, thus completing air intake and air discharge of each piston air pump component.
2. The crankshaft-type vacuum air pump of claim 1, **characterized in that**, the crankshaft unit comprises

a crankshaft (7), an upper piston rod (8) and a lower piston rod (9) are respectively sheathed on the upper side and the lower side of the crankshaft (7), the lower piston rod (9) and the upper piston rod (8) are respectively connected to the piston air pump components (3) arranged on the different sides of the air pump main body (2).

3. The crankshaft-type vacuum air pump of claim 2, **characterized in that**, the crankshaft (7) comprises a crankshaft main body (71) and two shaft portions, each of which respectively extends upward and downward from the left end and the right end of the crankshaft main body, the shaft portion of the crankshaft comprises a piston rods connection part (72) on which the piston rods are sheathed via a bearing, and an eccentric wheel connection part (73) which inserts into an eccentric hole of the eccentric wheel and is fixed therein.
4. The crankshaft-type vacuum air pump of claim 3, **characterized in that**, the crankshaft is centrosymmetric.
5. The crankshaft-type vacuum air pump of claim 3, **characterized in that**, the upper eccentric wheel (4) and the lower eccentric wheel (5) are structurally the same, which respectively comprises a wheel disk (10), a wheel shaft (11) is projected out from one side of the wheel disk, and an eccentric hole (12) is provided on the other side; the upper eccentric wheel (4) and the lower eccentric wheel (5) are symmetrically arranged with respect to the crankshaft unit.
6. The crankshaft-type vacuum air pump of claim 4 or 5, **characterized in that**, one or more crankshaft units are installed, wherein two adjacent crankshaft units are connected by a connection disk (6), which comprises a disk body (61) and two connection seats (62) respectively provided on the upper/lower surface of the disk body, which respectively connects to different crankshafts (7) in two neighbouring crankshaft units.
7. The crankshaft-type vacuum air pump of claim 6, **characterized in that**, two or three of the crankshaft units are employed.
8. A glass-wiping apparatus, comprising a sucking unit and a walking unit, the glass-wiping apparatus being sucked on the surface of the glass via the sucking unit, wherein the sucking unit comprises a sucker and a vacuum air pump which provides vacuum sucking force to the sucker, **characterized in that**, the vacuum air pump employs the crankshaft type vacuum air pump of any one of claims 1 to 7.

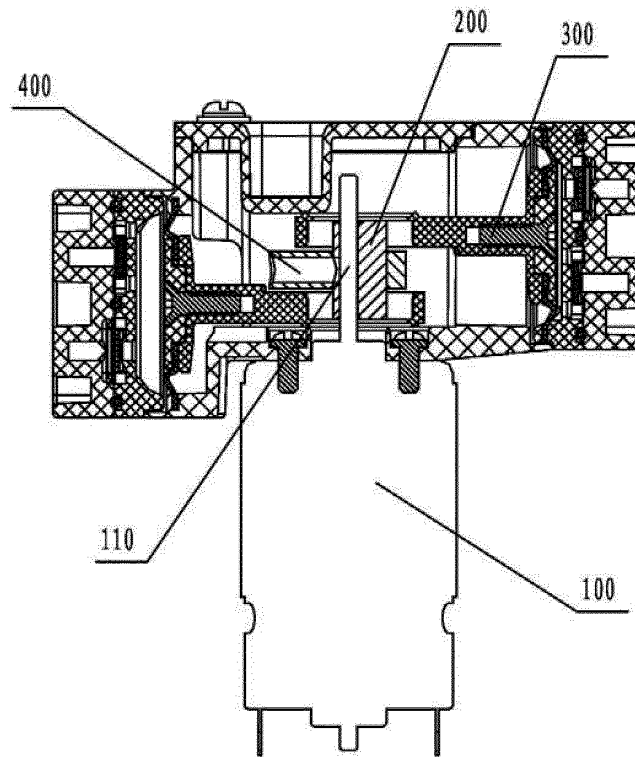


Fig1

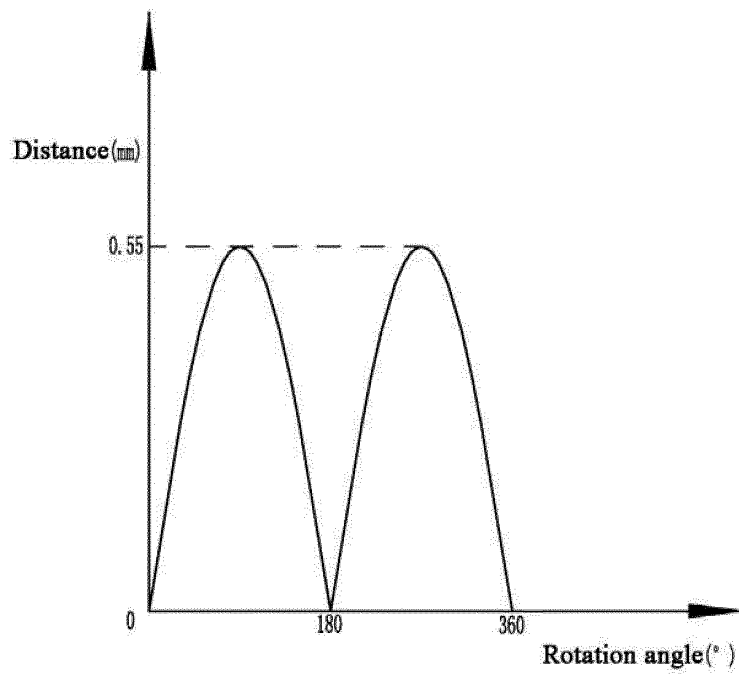


Fig2

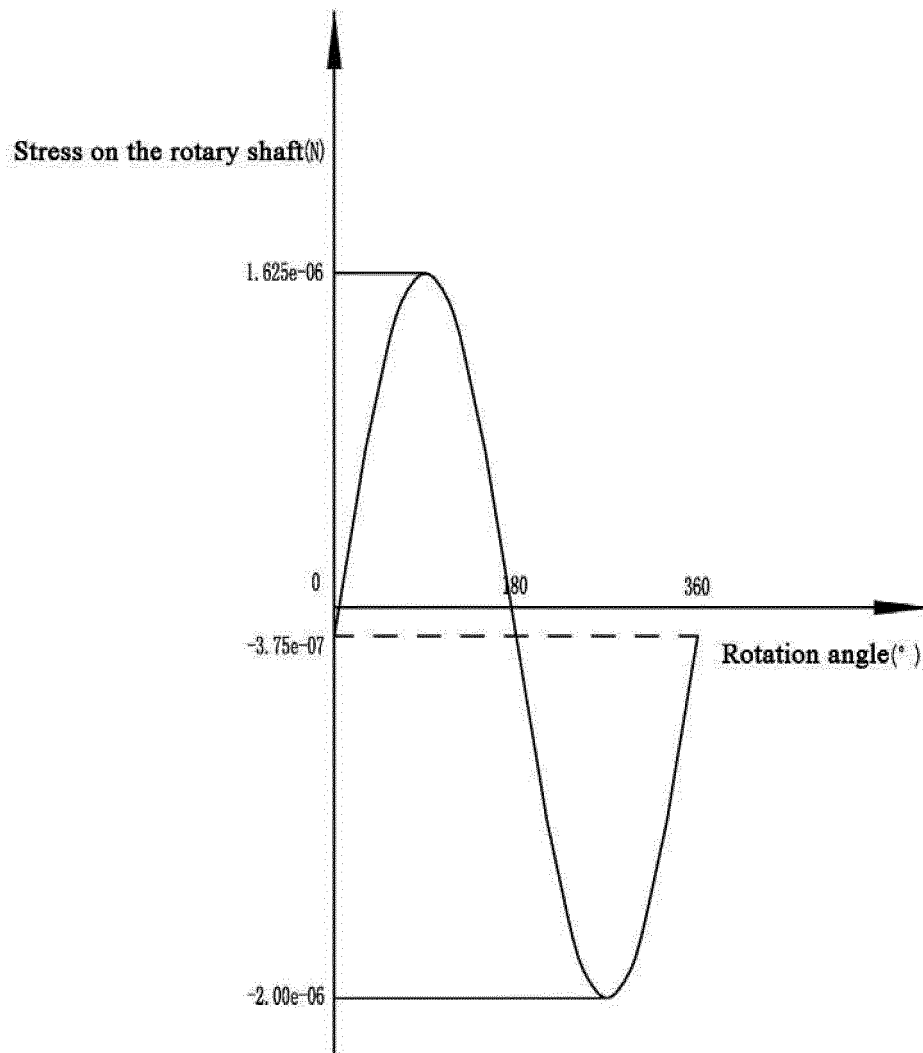


Fig3

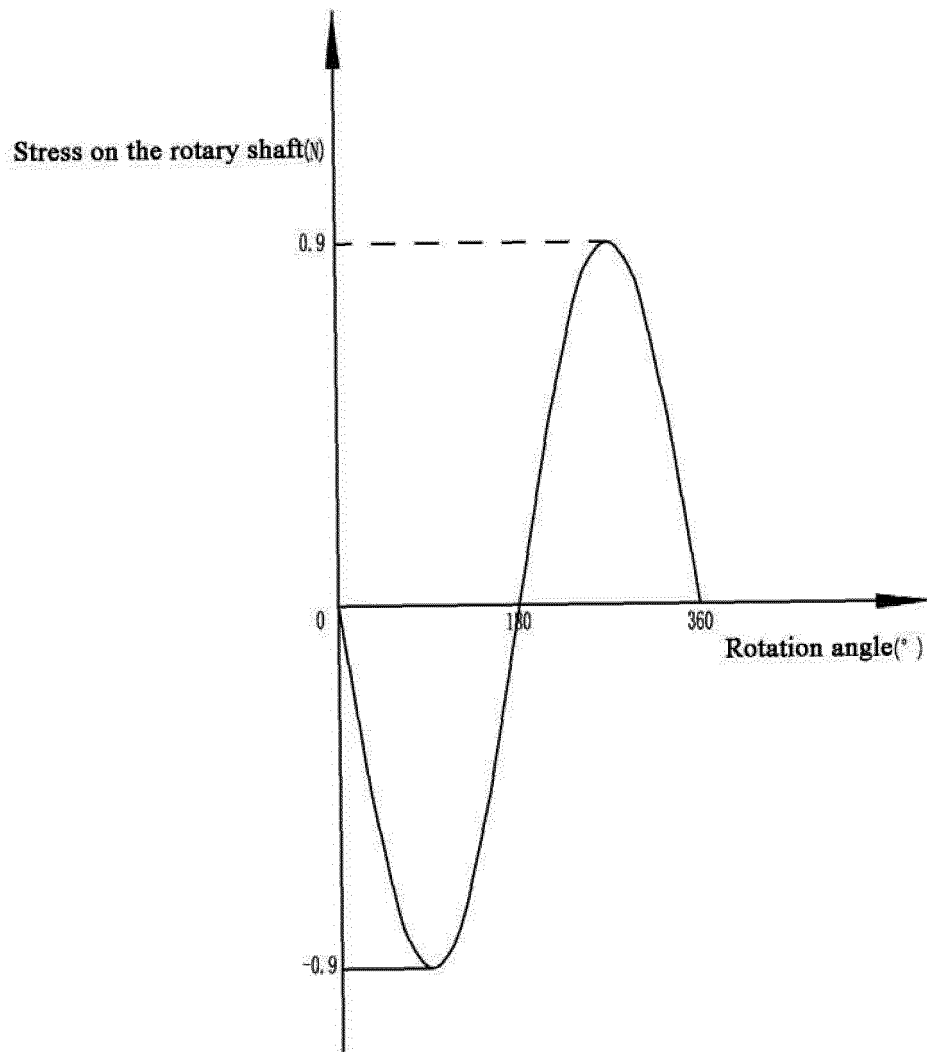


Fig4

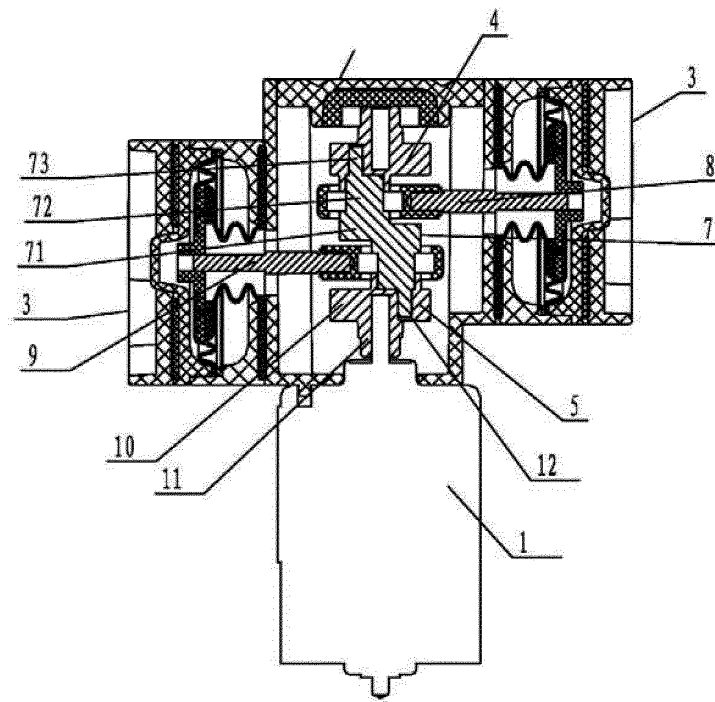


Fig5

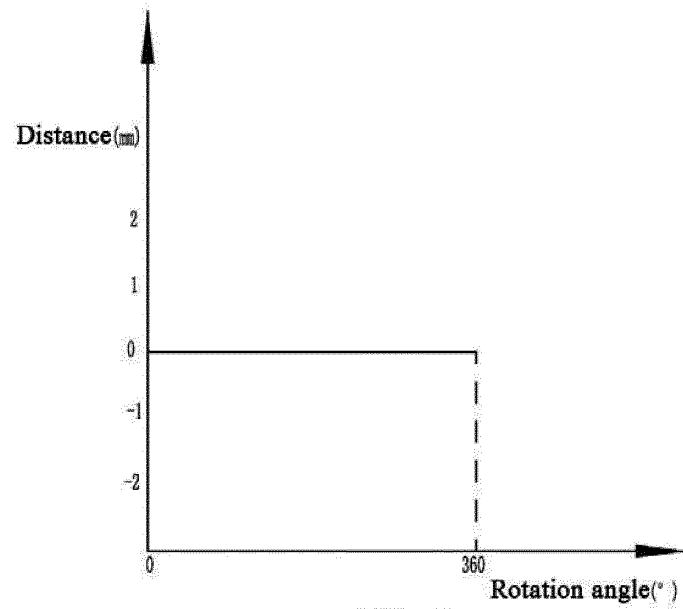


Fig6

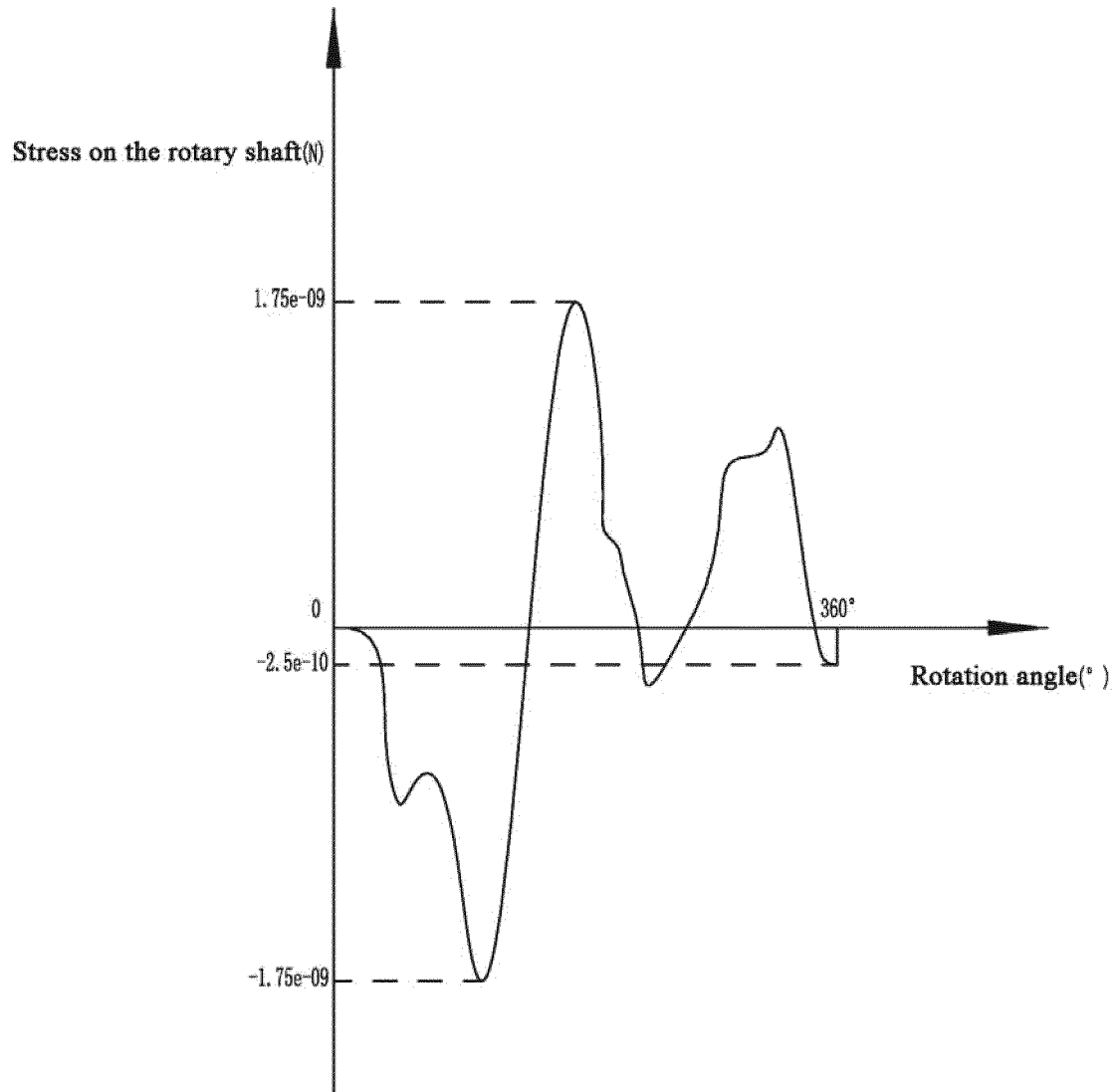


Fig7

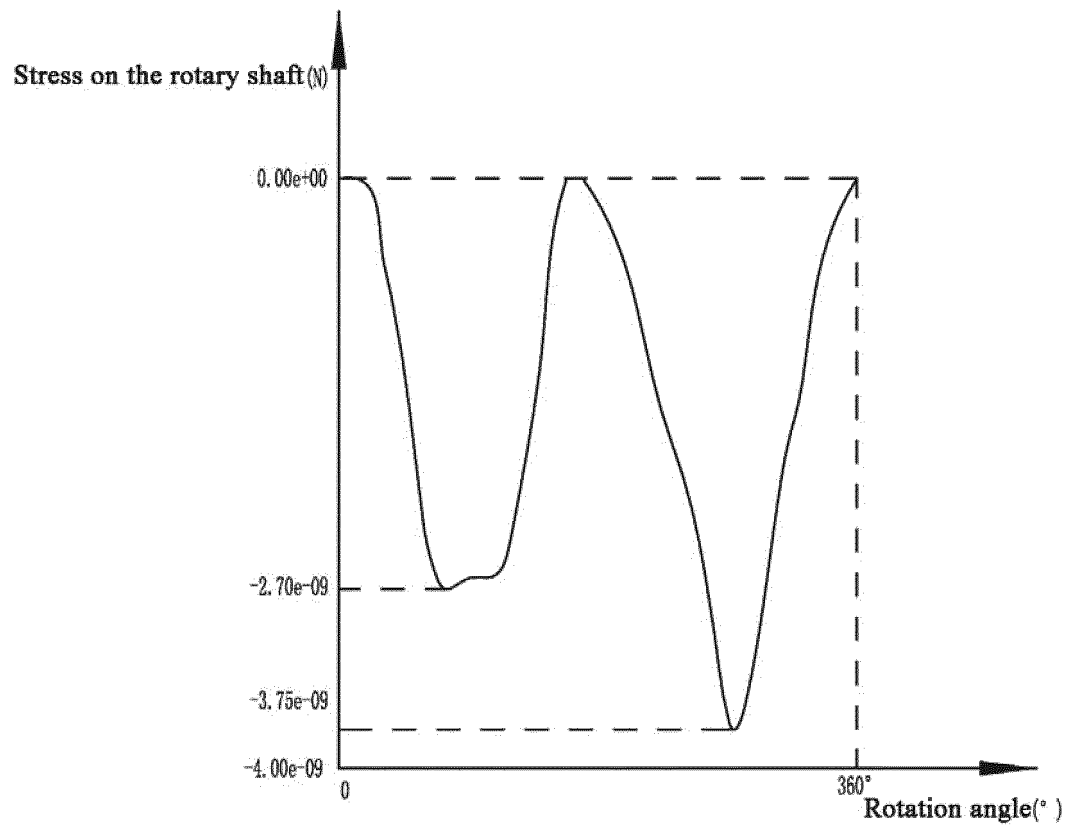


Fig8

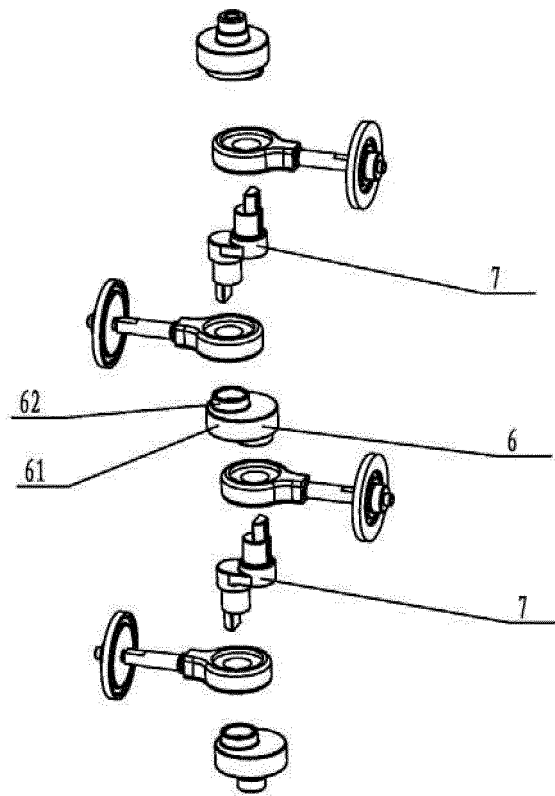


Fig9

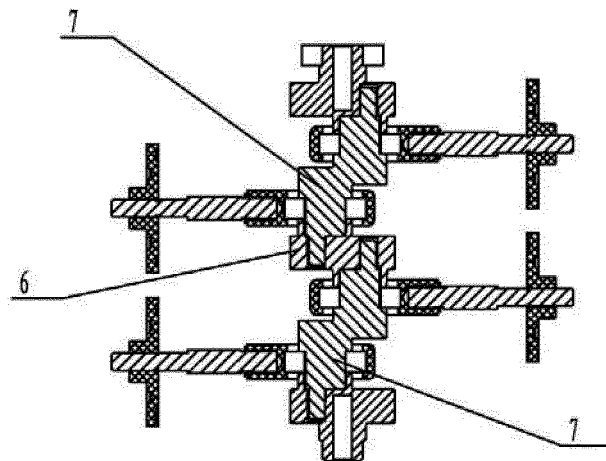


Fig10

INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2014/072976

A. CLASSIFICATION OF SUBJECT MATTER

F04B 37/02 (2006.01) i; F16H 21/16 (2006.01) i; A47L 1/02 (2006.01) n

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)

F04B, F16H, A47L 1/-

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, WPI, EPODOC, CNTXT, CNKI: crankshaft, eccent+, piston, balanc+, weight, hole, vac+, clean+, window+, glass+, balance weight, symmetry, vacuum pump, clean glass

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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

* Special categories of cited documents:	"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
"A" document defining the general state of the art which is not considered to be of particular relevance	
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Date of the actual completion of the international search 14 May 2014 (14.05.2014)	Date of mailing of the international search report 05 June 2014 (05.06.2014)
Name and mailing address of the ISA/CN: 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 ZHANG, Yongfeng Telephone No.: (86-10) 01062413093

INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2014/072976

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

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/CN2014/072976

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