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(54) **VACUUM PUMP**

VAKUUMPUMPE

POMPE À VIDE

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(56) References cited:
EP-A2- 0 733 804 **EP-A2- 2 431 613**
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Description

[0001] The present invention relates to a vacuum pump.

Description of the Related Art

[0002] A vacuum pump is a pump which creates negative pressure inside a container by evacuating gas from the container. There are various types of vacuum pumps. For example, a vacuum pump is known which evacuates gas by rotating a pair of pump rotors, provided on a pair of opposite shafts, synchronously in opposite directions.

[0003] In this vacuum pump, a motor rotor having a permanent magnet provided on the outer periphery, or a motor rotor having a permanent magnet embedded on the inside thereof, is provided on each of the pair of shafts, and a magnetic coupling is formed through a stator core by different magnetic pole faces of the motor rotors. This vacuum pump uses a magnetic coupling between the motor rotors to rotate the pair of pump rotors synchronously in opposite directions. Since this vacuum pump forms a magnetic coupling through the stator core, a magnetic circuit is formed not only between the two shafts but also inside the single shafts, which results in a weak magnetic coupling force.

[0004] Therefore, a gear which suppresses the loss of synchronization between the pair of pump rotors is mounted on each of the pair of shafts. Since the pump rotors are synchronized by means of the gears in order to compensate for the weak magnetic coupling force, the load applied to the gears is relatively large. Accordingly, the gears are increased in size to retain a relatively high strength. Moreover, to suppress wear due to contact etc. of the gears, it is conceivable to provide a space, filled with lubricating oil etc., separately from a motor chamber and a pump chamber and provide the gears inside that space. However, this aspect makes the structure of the vacuum pump complicated and causes an increase in size of the vacuum pump.

[0005] On the other hand, a vacuum pump having an enhanced magnetic coupling force is also known. In this vacuum pump, a motor rotor having a permanent magnet provided on the outer periphery is mounted on each of a pair of shafts, and a magnetic coupling is directly formed by different magnetic pole faces of the motor rotors without a stator core interposed therebetween. According to this vacuum pump, it is possible to rotate the two shafts synchronously in opposite directions without using a gear.

[0006] WO 2004/031585 A1 was used as a basis for the preamble of claim 1 and discloses a screw pump which includes a pair of screw rotors having teeth which are held in mesh with each other for drawing and discharging a fluid by rotating the screw rotors synchronously in opposite directions. The teeth of the screw rotors have the same shape as each other and are coiled helically in opposite directions. The teeth of the screw rotors

have an axial tooth profile which allows a pair of facing teeth surfaces of the screw rotors to be brought into contact with each other only at a pitch line when the pair of facing teeth surfaces are brought into contact with each other.

[0007] With regard to the available prior art, attention is also drawn to JP H08-319967 A and JP 2001-37175 A.

[0008] However, if the above vacuum pump, which directly forms a magnetic coupling, suctions a small solid, synchronization between the pump rotors may be lost as the solid is caught between the pump rotors, and the pump rotors may come into contact with each other. In this case, the vacuum pump may stop. Even if the solid is removed by the rotary force of the pump rotors, any contact between the pump rotors may result in damage to the pump rotors. In this case, the vacuum pump can no longer maintain its performance, and the vacuum pump may stop.

[0009] It is therefore an object of the present invention to realize a vacuum pump having a simple structure which can suppress contact between pump rotors even when synchronization is lost between the pump rotors.

[0010] According to the present invention, a vacuum pump is provided as set forth in claim 1. When synchronization between the pair of pump rotors is lost, the pair of gears come into contact with each other so as to resolve the loss of synchronization between the pair of pump rotors. As a result, according to the vacuum pump of one embodiment, contact between the pump rotors can be suppressed. In addition, in the vacuum pump of this embodiment, the pair of motor rotors directly form a magnetic coupling and the magnetic coupling force is sufficiently large. Therefore, in a normal state where the vacuum pump has not suctioned a small solid etc., the pair of pump rotors are synchronously rotated by the magnetic coupling force of the pair of motor rotors alone, and the pair of gears do not come into contact with each other. Accordingly, the strength required of the pair of gears is relatively small, so that the size of the pair of gears can be reduced. Moreover, since the pair of gears come into contact with each other infrequently and do not easily wear, it is not necessary to dispose the pair of gears in a space filled with lubricating oil, for example. Therefore, the vacuum pump can be simplified in structure and reduced in

[0011] Moreover, when synchronization between the pair of pump rotors is lost, the pair of gears come into contact with each other before the pair of pump rotors come into contact with each other. As the pair of gears come into contact with each other and corotate, the pair of pump rotors are synchronized. As a result, the pair of pump rotors can synchronously rotate while keeping out of contact with each other.

[0012] The vacuum pump of one embodiment may further include armatures disposed outside the outer periphery of the pair of motor rotors, and the armatures may be disposed in an elliptical shape with a predetermined clearance kept to the outer periphery of the pair of motor

rotors. Accordingly, the pair of motor rotors can directly form a magnetic coupling and produce a sufficiently large magnetic coupling force.

[0013] In the vacuum pump of one embodiment, the pair of gears may be disposed in a space not filled with a lubricant. The pair of gears may be disposed inside a pump chamber where the pair of pump rotors are disposed. Or, the pair of gears may be disposed inside a motor chamber where the pair of motor rotors are disposed.

[0014] That is, since the pair of gears come into contact with each other infrequently and do not easily wear, it is not necessary to dispose the pair of gears in a space filled with lubricating oil etc. Therefore, the vacuum pump can be simplified in structure and reduced in size.

[0015] In the vacuum pump of one embodiment, at least one of the pair of gears may be formed of a self-lubricating material. At least one of the pair of gears may be formed of a resin. The surface of at least one of the pair of gears may be coated with a lubricant.

FIG. 1 is a schematic cross-sectional view of a vacuum pump of one embodiment;

FIG. 2 is a cross-sectional view showing the structure of a drive motor of one embodiment;

FIG. 3 is a view showing the connection of windings of the drive motor;

FIG. 4A is a view showing the flow of an electric current through the windings connected as shown in FIG. 3;

FIG. 4B is a view showing the flow of an electric current through armature windings of the drive motor of FIG. 2 and the rotation of pump rotors;

FIG. 5A is a view showing the flow of an electric current through the windings connected as shown in FIG. 3;

FIG. 5B is a view showing the flow of an electric current through the armature windings of the drive motor of FIG. 2 and the rotation of the pump rotors;

FIG. 6A is a view showing the flow of an electric current through the windings connected as shown in FIG. 3;

FIG. 6B is a view showing the flow of an electric current through the armature windings of the drive motor of FIG. 2 and the rotation of the pump rotors;

FIG. 7A is a view showing the flow of an electric current through the windings connected as shown in FIG. 3;

FIG. 7B is a view showing the flow of an electric current through the armature windings of the drive motor of FIG. 2 and the rotation of the pump rotors;

FIG. 8A is a view showing the flow of an electric current through the windings connected as shown in FIG. 3;

FIG. 8B is a view showing the flow of an electric current through the armature windings of the drive motor of FIG. 2 and the rotation of the pump rotors;

FIG. 9A is a view showing the flow of an electric

current through the windings connected as shown in FIG. 3;

FIG. 9B is a view showing the flow of an electric current through the armature windings of the drive motor of FIG. 2 and the rotation of the pump rotors; and

FIG. 10 is a view schematically showing a clearance between the teeth of gears.

[0016] In the following, a vacuum pump device according to one embodiment of the present invention will be described on the basis of the drawings.

[0017] FIG. 1 is a schematic cross-sectional view of the vacuum pump of one embodiment. In this embodiment, a screw vacuum pump will be described as an example of a vacuum pump. However, the present invention is applicable not only to a screw vacuum pump but also to a synchronous opposite rotation-type vacuum pump such as a Roots pump. A vacuum pump 1000 of this embodiment is used, for example, to evacuate gas from a space where an object to be analyzed with a scanning electron microscope is installed. However, the vacuum pump 1000 can also be used for various other applications including evacuation of gas in semiconductor manufacturing equipment.

[0018] As shown in FIG. 1, the vacuum pump 1000 includes a drive motor unit 200, and a pair of pump rotor units 300, 400 which are driven to rotate by the drive motor unit 200.

[0019] The pump rotor unit 300 includes a pump main shaft 310 and a screw-type pump rotor 312 mounted on the pump main shaft 310.

[0020] The pump rotor unit 400 includes a pump main shaft 410 disposed facing the pump main shaft 310 and a screw-type pump rotor 412 mounted on the pump main shaft 410. The pump rotor 312 and the pump rotor 412 face each other. As shown in FIG. 1, the screw of the pump rotor 312 and the screw of the pump rotor 412 are separated from each other with predetermined clearances S1, S2 kept therebetween.

[0021] The pump rotor 312 and the pump rotor 412 are disposed inside a pump chamber 500 which is formed by an upper casing (not shown) and a lower casing 330.

[0022] First ends of the pump main shafts 310, 410 are supported by bearings 340, 440. On the other hand, the pump main shafts 310, 410 are supported by bearings 342, 442 at a border part between the drive motor unit 200 and the pump rotor units 300, 400. Second ends of the pump main shafts 310, 410 protrude toward the drive motor unit 200 from the positions where the pump main shafts 310, 410 are supported by the bearings 342, 442.

[0023] Next, the configuration of the drive motor unit 200 will be described. The drive motor unit 200 includes motor rotors 110, 210, a stator yoke 120, and gears 380, 480.

[0024] The motor rotors 110, 210 are mounted on the second ends of the pump main shafts 310, 410, respectively. The motor rotor 110 and the motor rotor 210 face

each other. The stator yoke 120 surrounds the motor rotors 110, 210.

[0025] The gears 380, 480 are mounted on the pump main shafts 310, 410, respectively. The gear 380 and the gear 480 face each other.

[0026] The motor rotors 110, 210, the stator yoke 120, and the gears 380, 480 are disposed inside a motor chamber 600 which is formed by a motor frame 130.

[0027] Next, the drive motor unit 200 will be described in detail. FIG. 2 is a cross-sectional view showing the structure of the drive motor of one embodiment. FIG. 3 is a view showing the connection of the windings of the drive motor.

[0028] The motor rotors 110, 210 have permanent magnets 112, 212 provided around their surfaces. Specifically, in this embodiment, the permanent magnets 112, 212 each have three pairs of poles, and six poles, S, N, S, N, S, and N, are provided around each of the motor rotors 110, 210. In this embodiment, the vacuum pump including a surface permanent magnet (SPM) motor which has the permanent magnets 112, 212 provided around the surfaces of the motor rotors 110, 210 has been illustrated, but the present invention is not limited to this example. For example, the present invention is also applicable to a vacuum pump including an interior permanent magnet (IPM) motor which has a permanent magnet embedded inside the motor rotor.

[0029] The stator yoke 120 surrounds the motor rotors 110, 210 in an elliptical shape. The stator yoke 120 is provided with a plurality of armatures 122. The armatures 122 each include an armature iron core 124 and a winding 126 wound around the armature iron core 124. The armatures 122 are positioned by being fitted into the common stator yoke 120. The armatures 122 are disposed at a distance of a predetermined clearance $\delta 1$ from the outer peripheral surfaces of the motor rotors 110, 210. The armatures 122 are disposed in an elliptical shape with a predetermined clearance kept to the outer periphery of the pair of motor rotors 110, 210.

[0030] Each winding 126 is divided into six slots, U, V, W, U', V', and W'. Here, it is shown that the windings U', V', and W' are opposite in phase to the windings U, V, and W, respectively. As shown in FIG. 3, the windings U1, U2, V1, V2, and W1, W2 are connected in series, and they are windings with an equal number of turns. The windings U1, U1', V1, V1', W1, and W1' and the windings U2, U2', V2, V2', W2, and W2' are disposed symmetrically with respect to a line of symmetry B. The windings U1, U2, V1, V2, W1, and W2 and the windings U1', U2', V1', V2', W1', and W2' are disposed symmetrically with respect to a line of symmetry C. Here, as shown in FIG. 3, the winding 126 has the windings U1, U2 connected in series and the windings U1', U2', which are opposite in phase to the windings U1, U2, connected in series, and the windings U1, U2 and the windings U1', U2' are connected in parallel to constitute the U-phase. The same applies to the V-phase and the W-phase, and as a whole the U-, V-, and W-phases are connected with

one another in a Y-shape.

[0031] The motor rotors 110, 210 are disposed with a predetermined center distance t kept therebetween. The motor rotors 110, 210 have the permanent magnets 112, 212, which are magnetized in six poles, alternately as N and S at regular intervals, respectively provided on the outer periphery. In the motor rotors 110, 210, each two poles facing each other across the line of symmetry C of the six-pole permanent magnets 112, 212 are used as a magnetic coupling. The motor rotors 110, 210 form a magnetic coupling by having their different magnetic pole faces facing each other, and synchronously rotate only in the opposite directions from each other.

[0032] The outer peripheries of the motor rotors 110, 210 face each other with a predetermined clearance distance $\delta 0$ kept therebetween. In the vacuum pump 1000 of this embodiment, the motor rotors 110, 210 directly face each other across a space, without a stator core, such as an iron core, interposed therebetween. That is, the vacuum pump 1000 of this embodiment is a vacuum pump in which the motor rotors 110, 210 directly form a magnetic coupling. Here, too large a clearance between the motor rotors 110, 210 causes a decrease in magnetic coupling force. In this embodiment, when the distance between the armature iron core 124 and the outer periphery of the motor rotors 110, 210 is $\delta 1$ and the clearance distance between the motor rotors 110, 210 is $\delta 0$, the expression $\delta 0 \approx 1$ to $3\delta 1$ holds. Thus, the attraction force between the permanent magnets 112, 212 and the attraction force between the motor rotors 110, 210 and the armature 122 are almost canceled, so that the magnetic coupling force becomes sufficiently large.

[0033] The drive motor unit 200 includes 12 armatures 122. The armatures 122 are disposed in groups of six poles so as to be symmetrical with respect to the line of symmetry C. At positions symmetrical with respect to the line of symmetry C, the windings 126 are wound around the armature iron cores 124 in the same phase and in the opposite directions. In the drive motor unit 200, an opposite-phase relation is established as the windings 126 at symmetrical positions are energized in the opposite directions. Thus, the drive motor unit 200 is driven as one motor. Since the drive motor unit 200 is driven as one three-phase motor, there may also be one drive power source device.

[0034] FIG. 4A to FIG. 9A are views showing the flow of an electric current through the wirings connected as shown in FIG. 3. FIG. 4B to FIG. 9B are views showing the flow of an electric current through the armature windings of the drive motor of FIG. 2 and the rotation of the pump rotors. According to the magnetic pole position of the motor rotors 110, 210, the drive motor unit 200 repeatedly switches energization in six ways as indicated by the arrows in FIG. 4A to FIG. 9A. Thus, the drive motor unit 200 continues rotation by rotating the motor rotors 110, 210 synchronously in opposite directions, the directions of the arrows in FIG. 4B to FIG. 9B.

[0035] The number of the magnetic poles of the motor

rotors 110, 210, the number of the armatures 122, and the combination thereof are not limited to those shown in this embodiment but are arbitrary. For example, the number of the magnetic poles of each of the motor rotors 110, 210 may be four, and the number of the armatures 122 may be six.

[0036] Next, the gears 380, 480 will be described. FIG. 10 is a view schematically showing the clearance between the teeth of the gears. FIG. 10 shows only a part of the gears 380, 480. As shown in FIG. 10, the clearances between teeth 380a of the gear 380 and teeth 480a of the gear 480 are set to G1, G2. Here, when compared with the clearances S1, S2 between the pump rotor 312 and the pump rotor 412, the clearances G1, G2 between the teeth 380a of the gear 380 and the teeth 480a of the gear 480 are backlash dimensions which satisfy the relation $G1, G2 < S1, S2$. In other words, the pump rotors 312, 412 and the gears 380, 480 are formed so as to satisfy the relation $G1, G2 < S1, S2$.

[0037] In the vacuum pump 1000 of this embodiment, the motor rotors 110, 210 directly form a magnet coupling between the opposite different magnetic poles, without an iron core interposed therebetween, and rotate synchronously in opposite directions. This allows the pump rotors 312, 412 to rotate synchronously in opposite directions in a noncontact state during operation of the vacuum pump 1000. In addition, the gears 380, 480 can rotate without coming into contact with each other. Therefore, the vacuum pump 1000 can eliminate contact resistance of the gears 380, 480 and loss of grease or lubricating oil. Thus, this embodiment can provide the vacuum pump 1000 which suffers little gear loss and is highly efficient as well as capable of highspeed rotation. Even when the vacuum pump 1000 for some reason suctions a foreign matter, or even when a product adheres to the inside of the vacuum pump 1000, the gears 380, 480 mesh with each other before the pump rotors 312, 412 come into contact with each other. Therefore, the vacuum pump 1000 of this embodiment can rotate the pump rotors 312, 412 synchronously in opposite directions without causing the pump rotors 312, 412 to come into contact with each other.

[0038] To describe this point in detail, it is assumed that the vacuum pump 1000 has suctioned a small solid. In this case, as the solid matter is caught between the pump rotors 312, 412, synchronization between the pump rotors 312, 412 may be lost.

[0039] However, the vacuum pump of this embodiment includes the gears 380, 480. When synchronization between the pump rotors 312, 412 is lost, the gears 380, 480 come into contact with each other so as to resolve the loss of synchronization between the pump rotors 312, 412. As a result, the vacuum pump 1000 can suppress contact between the pump rotors.

[0040] More specifically, in the vacuum pump 1000, the clearances S1, S2 between the pump rotor 312 and the pump rotor 412 are larger than the clearances G1, G2 between the teeth 380a of the gear 380 and the teeth

480a of the gear 480. Accordingly, when synchronization between the pump rotors 312, 412 is lost, the gear 380 and the gear 480 come into contact with each other before the pump rotor 312 and the pump rotor 412 come into contact with each other. As the gear 380 and the gear 480 come into contact with each other and corotate, the pump rotors 312, 412 are synchronized. As a result, the pump rotor 312 and the pump rotor 412 can synchronously rotate while keeping out of contact with each other.

[0041] In addition, in the vacuum pump of this embodiment, the motor rotors 110, 210 directly form a magnetic coupling and the magnetic coupling force is sufficiently large as described above. Therefore, in a normal state where the vacuum pump 1000 has not suctioned a small solid etc., the pump rotors 312, 412 are synchronously rotated by the magnetic coupling force of the motor rotors 110, 210 alone. As a result, in the normal state, the gears 380, 480 keep the clearances G1, G2 and do not come into contact with each other. That is, the gears 380, 480 are emergency components in case of loss of synchronization between the pump rotors 312, 412 due to an abnormal state where the vacuum pump 1000 has suctioned a small solid etc.

[0042] Since the gears 380, 480 keep the clearances G1, G2 and do not come into contact with each other in the normal state, the strength required of the gears 380, 480 is relatively small. Therefore, according to the vacuum pump 1000 of this embodiment, the size of the gears 380, 480 can be reduced. Since the gears 380, 480 come into contact with each other infrequently and do not easily wear, it is not necessary to dispose the gears 380, 480 in a space filled with lubricating oil, for example.

[0043] In this embodiment, the gears 380, 480 are disposed inside the motor chamber 600 which is a space not filled with a lubricant. However, this is not the only option, and the gears 380, 480 may be disposed inside the pump chamber 500 which is a space not filled with a lubricant. When the gears 380, 480 are disposed in a space not filled with a lubricant, the gears 380, 480 can be used without using lubricating oil or grease. At least one of the gears 380, 480 may be formed of a self-lubricating material such as Teflon (R) or a resin. In this case, at least a part of the gears 380, 480 may be formed of a self-lubricating material. For example, at least a part of the teeth 380a, 480a may be formed of a self-lubricating material, or the entire surface of at least one of the gears 380, 480 or the surface of the contact part between the gears 380, 480 may be formed of a self-lubricating material. The surface of at least one of the gears 380, 480 may be coated with a lubricant. According to the vacuum pump 1000 of this embodiment, the vacuum pump 1000 can be simplified in structure and reduced in size, since it is not necessary to provide a space, filled with a lubricant, separately from the pump chamber 500 and the motor chamber 600.

Claims

1. A vacuum pump (1000) comprising:
 - a pair of shafts (310, 410) disposed facing each other;
 - a pair of pump rotors (312, 412) provided on the pair of shafts (310, 410); and
 - a pair of motor rotors (110, 210) provided on the pair of shafts (310, 410) and directly forming a magnetic coupling by having different magnetic poles of magnets (112, 212) facing each other; **characterized in that**
 - a pair of gears (380, 490) provided on the pair of shafts (310, 410), wherein
 - a clearance between teeth of the pair of gears (380, 480) is set such that the pair of gears (380, 480) do not come into contact with each other, and
 - the clearance between the teeth of the pair of gears (380, 480) is set to be smaller than a clearance between the pair of pump rotors (312, 412).
2. The vacuum pump according to claim 1, further comprising armatures (122) disposed outside the outer periphery of the pair of motor rotors (110, 210), wherein the armatures (122) are disposed in an elliptical shape with a predetermined clearance kept to the outer periphery of the pair of motor rotors (110, 210).
3. The vacuum pump according to claim 1 or 2, wherein the pair of gears (380, 480) are disposed in a space not filled with a lubricant.
4. The vacuum pump according to claim 3, wherein the pair of gears (380, 480) are disposed inside a pump chamber (500) where the pair of pump rotors (312, 412) are disposed.
5. The vacuum pump according to claim 3, wherein the pair of gears (380, 480) are disposed inside a motor chamber (600) where the pair of motor rotors (110, 210) are disposed.
6. The vacuum pump according to any one of claims 1 to 5, wherein at least one of the pair of gears (380, 480) is formed of a self-lubricating material.
7. The vacuum pump according to any one of claims 1 to 5, wherein at least one of the pair of gears (380, 480) is formed of a resin.
8. The vacuum pump according to any one of claims 1 to 5, wherein the surface of at least one of the pair of gears (380, 480) is coated with a lubricant.

Patentansprüche

1. Vakuumpumpe (1000), die Folgendes aufweist:
 - ein Paar von Wellen (310, 410), die zueinander weisend angeordnet sind;
 - ein Paar von Pumpenrotoren (312, 412), die auf dem Paar von Wellen (310, 410) vorgesehen sind; und
 - ein Paar von Motorrotoren (110, 210), die auf dem Paar von Wellen (310, 410) vorgesehen sind und direkt eine magnetische Kopplung bilden, indem sie unterschiedliche Magnetpole der Magnete (112, 212) aufweist, die zueinander weisen;
 - dadurch gekennzeichnet, dass**
 - ein Paar von Zahnrädern (380, 490) auf dem Paar von Wellen (310, 410) vorgesehen ist, wobei
 - ein Zwischenraum zwischen den Zähnen des Paares von Zahnrädern (380, 480) so eingestellt ist, dass das Paar von Zahnrädern (380, 480) nicht in Kontakt miteinander kommt, und der Zwischenraum zwischen den Zähnen des Paares von Zahnrädern (380, 480) so eingestellt ist, dass er kleiner als ein Zwischenraum zwischen dem Paar von Pumpenrotoren (312, 412) ist.
2. Vakuumpumpe gemäß Anspruch 1, die ferner Anker (122) aufweist, die außerhalb des Außenumfangs des Paares von Motorrotoren (110, 210) angeordnet sind, wobei die Anker (122) in einer elliptischen Form angeordnet sind, wobei ein vorbestimmter Abstand zu dem Außenumfang des Paares von Motorrotoren (110, 210) gehalten wird.
3. Vakuumpumpe gemäß Anspruch 1 oder 2, wobei das Paar von Zahnrädern (380, 480) in einem Raum angeordnet ist, der nicht mit einem Schmiermittel gefüllt ist.
4. Vakuumpumpe gemäß Anspruch 3, wobei das Paar von Zahnrädern (380, 480) innerhalb einer Pumpenkammer (500) angeordnet ist, in der das Paar von Pumpenrotoren (312, 412) angeordnet ist.
5. Vakuumpumpe gemäß Anspruch 3, wobei das Paar von Zahnrädern (380, 480) innerhalb einer Motor-kammer (600) angeordnet ist, in der das Paar von Motorrotoren (110, 210) angeordnet ist.
6. Vakuumpumpe gemäß einem der Ansprüche 1 bis 5, wobei zumindest eines der Paare von Zahnrädern (380, 480) aus einem selbstschmierenden Material gebildet ist.
7. Vakuumpumpe gemäß einem der Ansprüche 1 bis

5, wobei zumindest eines der Paare von Zahnrädern (380, 480) aus einem Harz gebildet ist.

8. Vakuumpumpe gemäß einem der Ansprüche 1 bis 5, wobei die Oberfläche von zumindest einem des Paares von Zahnrädern (380, 480) mit einem Schmiermittel bedeckt ist.

Revendications

1. Pompe à vide (1000) comprenant :

deux arbres (310, 410) disposés face-à-face ;
deux rotors de pompe (312, 412) prévus sur les
deux arbres (310, 410) ; et
deux rotors de moteur (110, 210) prévus sur les
deux arbres (310, 410) et formant directement
un couplage magnétique par le fait qu'ils com-
portent différents pôles magnétiques d'aimants
(112, 212) face-à-face ;

caractérisé par

deux engrenages (380, 490) prévus sur les deux
arbres (310, 410),

dans lesquels

un jeu entre les dents des deux engrenages
(380, 480) est réglé de telle sorte que les deux
engrenages (380, 480) ne viennent pas en con-
tact entre eux, et

le jeu entre les dents des deux engrenages (380,
480) est réglé plus petit qu'un jeu entre les deux
rotors de pompe (312, 412).

2. Pompe à vide selon la revendication 1, comprenant
en outre des armatures (122) disposées à l'extérieur
de la périphérie extérieure des deux rotors de moteur
(110, 210), les armatures (122) étant disposées en
forme elliptique avec un jeu prédéterminé maintenu
par rapport à la périphérie extérieure des deux rotors
de moteur (110, 210).

3. Pompe à vide selon la revendication 1 ou 2, dans
laquelle les deux engrenages (380, 480) sont dispo-
sés dans un espace non rempli de lubrifiant.

4. Pompe à vide selon la revendication 3, dans laquelle
les deux engrenages (380, 480) sont disposés à l'in-
térieur d'une chambre de pompe (500) où les deux
rotors de pompe (312, 412) sont disposés.

5. Pompe à vide selon la revendication 3, dans laquelle
les deux engrenages (380, 480) sont disposés à l'in-
térieur d'une chambre de moteur (600) où les deux
rotors de moteur (110, 210) sont disposés.

6. Pompe à vide selon l'une quelconque des revendi-
cations 1 à 5, dans laquelle au moins l'un des deux
engrenages (380, 480) est formé en un matériau

autolubrifiant.

7. Pompe à vide selon l'une quelconque des revendi-
cations 1 à 5, dans laquelle au moins l'un des deux
engrenages (380, 480) est en résine.

8. Pompe à vide selon l'une quelconque des revendi-
cations 1 à 5, dans laquelle la surface d'au moins
l'un des deux engrenages (380, 480) est revêtue
d'un lubrifiant.

FIG. 1

1000

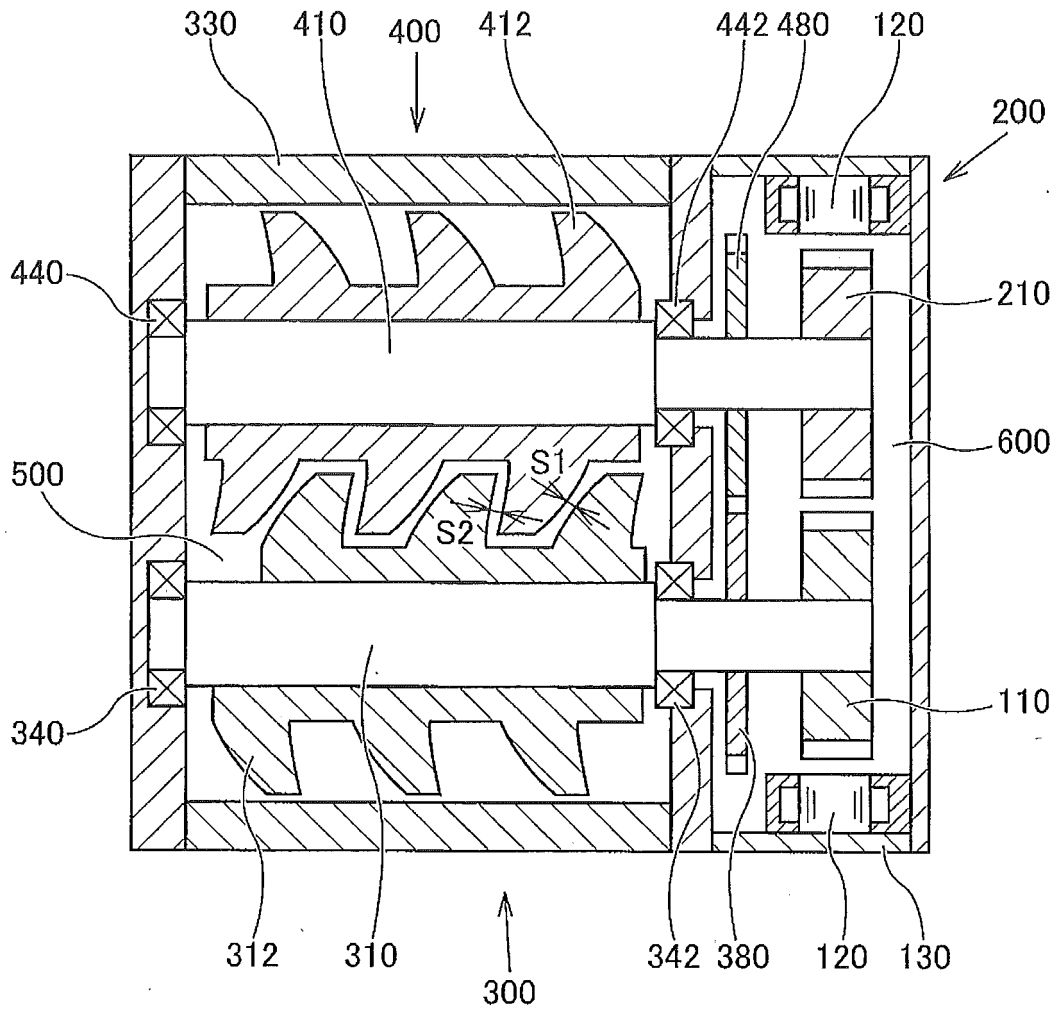


FIG. 4A

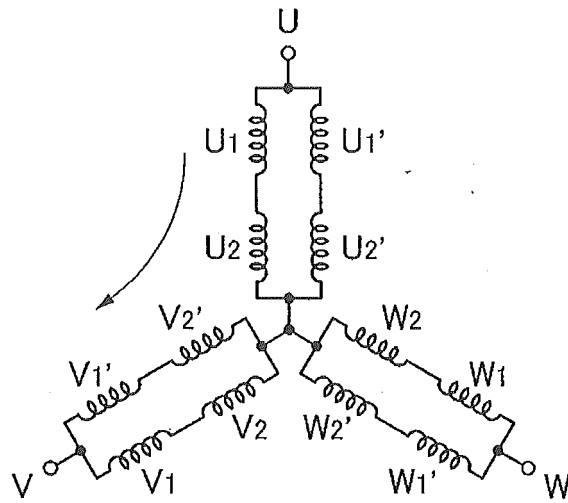


FIG. 4B

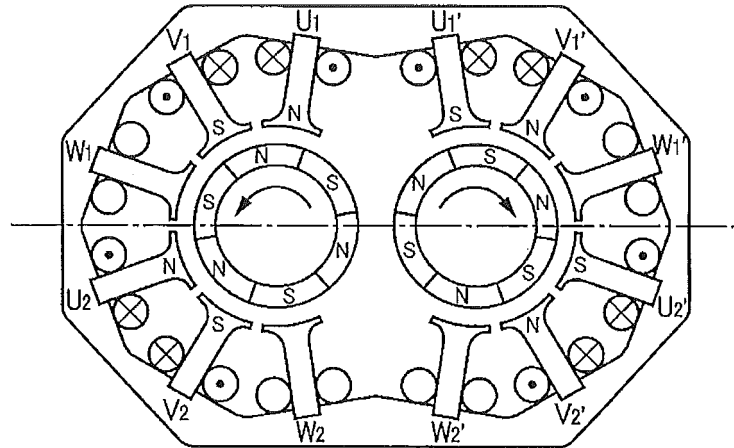


FIG. 5A

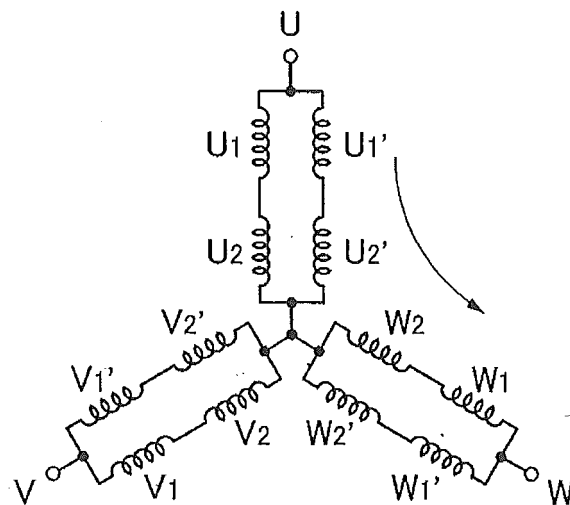


FIG. 7A

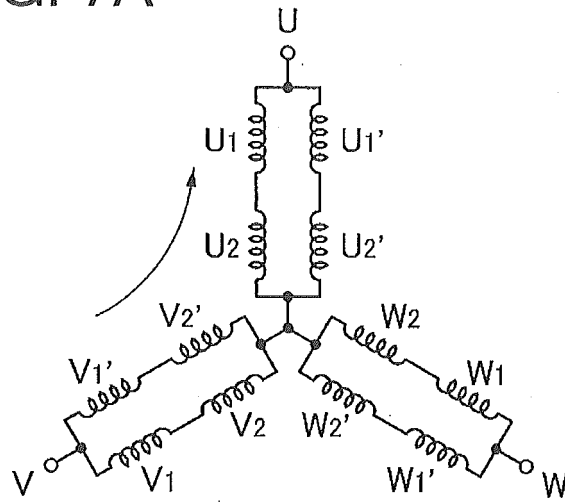


FIG. 7B

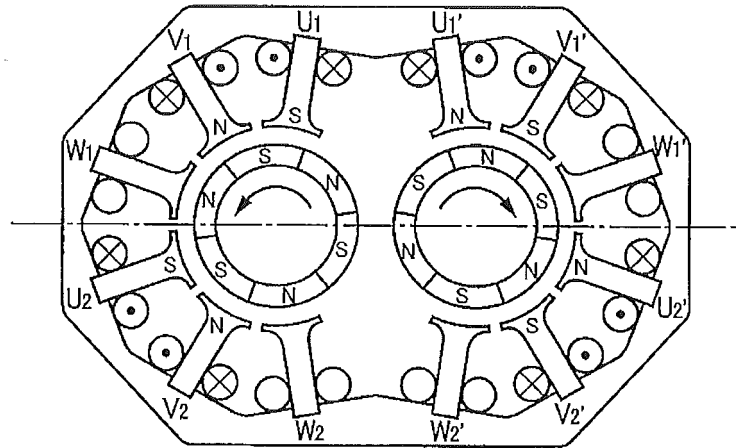


FIG. 8A

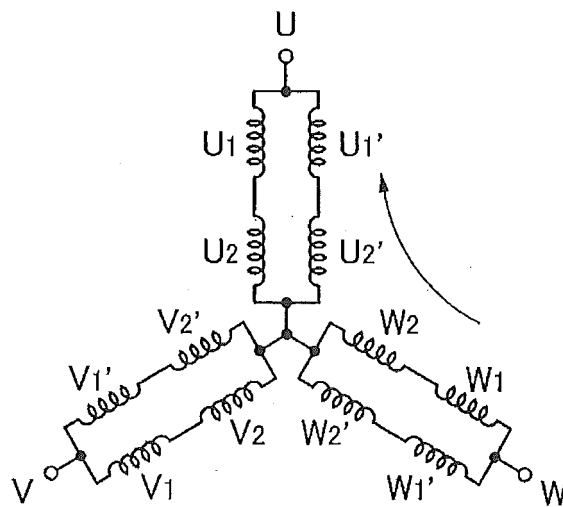


FIG. 8B

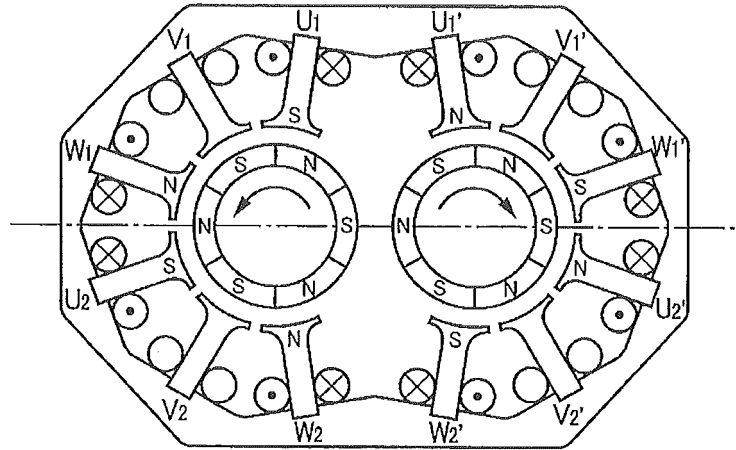


FIG. 9A

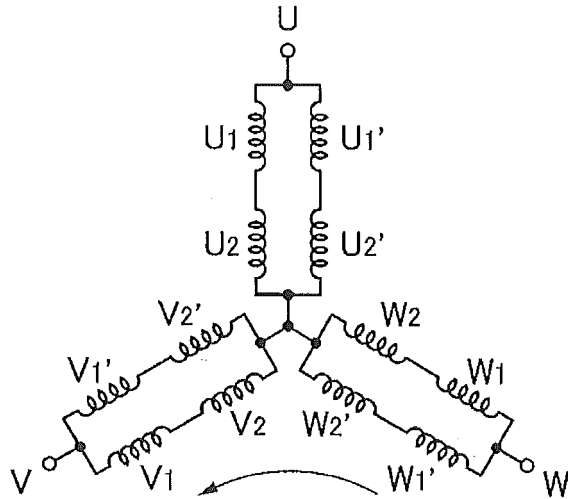


FIG. 9B

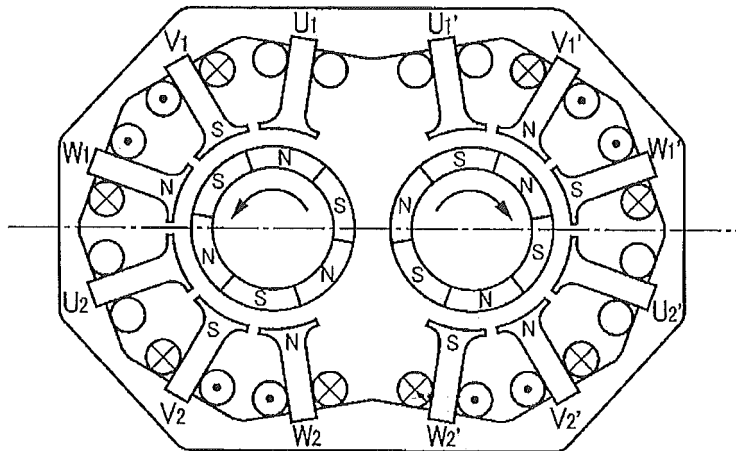
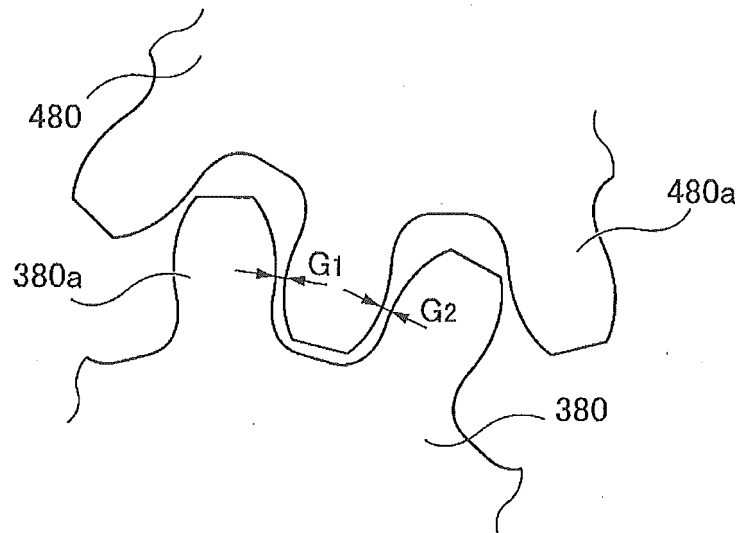


FIG. 10



REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- WO 2004031585 A1 [0006]
- JP H08319967 A [0007]
- JP 2001037175 A [0007]