

DESCRIPTION

BRUSHLESS DC MOTOR AND BLOWER DEVICE

5 TECHNICAL FIELD

[0001]

The present invention relates to a blower device having a brushless DC motor for driving a fan, such as a ceiling fan.

10 BACKGROUND ART

[0002]

In recent years, high output power and high efficiency has been demanded on a blower device used for a ceiling fan, for example. In a blower device on which a brushless DC motor is mounted, a magnet in the motor has to
15 have high magnetic force. Further, to eliminate noise and vibration, the motor has to be smoothly rotated.

[0003]

As such a brushless DC motor, the structure disclosed in Patent Literature 1 is conventionally known. Hereinafter, the brushless DC motor
20 will be described with reference to FIG. 13 and FIG. 14.

[0004]

FIG. 13 is a vertical cross-sectional view of a conventional brushless DC motor. FIG. 14 is an external view, seen from below, of rotor holder 120 where 12 rotor magnets 130 are disposed on the inner-circumference plane
25 of cylinder 122 in the radial direction (i.e., in the direction perpendicular to central axis L; hereinafter, the same).

[0005]

As shown in FIG. 13, motor 101 has, as the main components, stator 102 fixed to a device housing of a motor driving device (not shown) and rotor 103 that rotates on predetermined central axis L.

[0006]

5 Stator 102 has bracket 111, stator core 112, coil 113, and slide bearing 114.

[0007]

10 Stator core 112 has core back 116 of an annular shape and a plurality of teeth 117. Core back 116 is fitted on the outer-circumference plane in the radial direction (hereinafter, simply referred to the outer-circumference plane) of holder 212 of bracket 111. Teeth 117 protrude from core back 116 toward the side of the outer circumference in the radial direction.

[0008]

15 Coil 113 is formed of a conductive wire wound around each periphery of teeth 117 of stator core 112.

[0009]

Slide bearing 114 is fixed to the inner-circumference plane of holder 115 of bracket 111 by, for example, adhesive so as to be arranged one above the other at intervals in the axial direction.

20 [0010]

Rotor 103 has shaft 121, rotor holder 120, and rotor magnets 130.

[0011]

25 Shaft 121 is a member formed substantially into a columnar shape and disposed along central axis L. It is inserted into holder 115 of bracket 111 of stator 102 via slide bearing 114.

[0012]

On the inner-circumference plane of cylinder 122 of rotor holder 120, a

plurality of rotor magnets 130 is arranged at equal spaces in the circumferential direction having central axis L as the center and is fixed by adhesive, for example.

[0013]

5 Rotor magnets 130, as shown in FIG. 14, are formed of rotor magnets 131 whose outer side is magnetized to the north pole and rotor magnets 132 whose outer side is magnetized to the south pole. Magnets 131 and magnets 132 are alternately arranged in the circumferential direction. Further, as shown in FIG. 13, rotor magnets 130 are fixed on cylinder 122 of
10 rotor holder 120 such that the inner-circumference plane of rotor magnets 130 faces the tip section of stator core 112 via a narrow gap in the radial direction. Besides, adhesion layer 124 is formed on the inner-circumference plane of cylinder 122 of rotor holder 120.

15 Citation List

[0014]

Patent Literature

PTL 1: Japanese Unexamined Patent Application Publication No.
2010-98783

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SUMMARY OF THE INVENTION

[0015]

In such a blower device with a conventional brushless DC motor mounted, a plurality of rotor magnets 131, 132 is bonded to rotor holder 120,
25 i.e., the rotor yoke. Fixing magnets by adhesive causes wide variation in adhesion strength. Further, the adhesion strength tends to degrade with time. If bonded rotor magnets 131, 132 drop off and make contact with stator core

112, it can cause abnormal noise; further, friction caused by the contact between them can be an excessive load on the motor. The conventional structure has the problem above.

[0016]

5 The present invention solves the pending problem above. The present invention provides a brushless DC motor capable of keeping normal operation even if a bonded magnet comes off. It also provides a blower device having the brushless DC motor above.

[0017]

10 The structure of the present invention has a stator core around which a coil is wound, a shaft fixed to the central position of the stator core, a bearing whose inner ring is fixed to the shaft, and a rotor yoke fixed to an outer ring of the bearing. The rotor yoke has a plurality of magnets on its inner-circumference plane in a circumferential direction so as to face the stator
15 core. Further, the structure has a first holding ring and a second holding ring in the circumferential direction of the magnets. The first holding ring has a protrusion that holds a first end of the shaft in the axial direction. The second holding ring has a protrusion that holds a second end facing the first end of the shaft in the axial direction.

20 [0018]

 If a magnet comes off a fixed position (regardless of with use or with no use of adhesive), the aforementioned structure prevents the magnets from making contact with the stator core, so that the motor keeps normal rotating operation.

25

BRIEF DESCRIPTION OF DRAWINGS

[0019]

FIG. 1 is an assembly diagram showing the structure of the brushless DC motor in accordance with a first exemplary embodiment of the present invention.

FIG. 2 is an assembly diagram showing the structure of the rotor of the
5 brushless DC motor in accordance with the first exemplary embodiment of the present invention.

FIG. 3A is an external view of a magnet of the brushless DC motor in accordance with the first exemplary embodiment of the present invention.

FIG. 3B is a view seen from the direction of arrow A shown in FIG. 3A.

10 FIG. 3C is an external view of the structure with the magnets fixed of the brushless DC motor in accordance with the first exemplary embodiment of the present invention.

FIG. 4 is an external view of the holding ring of the brushless DC motor in accordance with the first exemplary embodiment of the present invention.

15 FIG. 5 is an external view showing the structure of the rotor of the brushless DC motor in accordance with the first exemplary embodiment of the present invention.

FIG. 6 is a cross-sectional view in the shaft direction, showing the structure of the brushless DC motor in accordance with the first exemplary
20 embodiment of the present invention.

FIG. 7A is an external view of a conventional brushless DC motor as a comparative example of the brushless DC motor in accordance with the first exemplary embodiment of the present invention.

FIG. 7B shows distribution of magnetic force of the brushless DC motor
25 shown in FIG. 7A.

FIG. 8A is an external view of the brushless DC motor in accordance with the first exemplary embodiment of the present invention.

FIG. 8B shows distribution of magnetic force of the brushless DC motor shown in FIG. 8A.

FIG. 9 is an external view of the holding ring of the brushless DC motor in accordance with a second exemplary embodiment of the present invention.

5 FIG. 10A is a perspective view showing the positional relationship between the rotor cover and the holding ring when the rotor cover and the rotor yoke are fixed with each other in the brushless DC motor in accordance with the second exemplary embodiment of the present invention.

10 FIG. 10B shows an opposite-protrusion seen from the direction of the center of the rotor cover of the brushless DC motor in accordance with the second exemplary embodiment of the present invention.

FIG. 11 is a perspective view showing a structure of a ceiling fan on which a blower device as a modification example of the present invention is mounted.

15 FIG. 12 is an external view showing a structure of a ceiling fan on which a blower device as a modification example of the present invention is mounted.

FIG. 13 is a vertical cross-sectional view of a conventional brushless DC motor.

20 FIG. 14 is an external view showing an arrangement of the magnets of a conventional brushless DC motor.

DESCRIPTION OF EMBODIMENTS

[0020]

25 Hereinafter, an exemplary embodiment of the present invention will be described with reference to the accompanying drawings. The exemplary embodiments below are described as a mere example of the present invention, and therefore, it is to be understood that they are not to be construed as

limitation on the technical scope of the present invention. Throughout the drawings, like parts have similar reference marks and description thereof, when it overlaps with the firstly provided one, will be omitted. Further, in each drawing, in-detail description on a part having no direct relation to the present invention will be omitted.

[0021]

FIRST EXEMPLARY EMBODIMENT

First, the structure of the brushless DC motor of the first exemplary embodiment of the present invention will be schematically described with reference to FIG. 1. FIG. 1 is an assembly diagram showing the structure of brushless DC motor 9.

[0022]

As shown in FIG. 1, brushless DC motor 9 of the embodiment has stator core 1, rotor yoke 5, and rotor cover 8.

[0023]

Stator core 1 is formed into a hollow cylinder and the outer circumference is surrounded by a plurality of teeth 1a. Driving coil 2 is wound, via resin-mold bobbin, on each of teeth 1a. Passing current through driving coil 2 generates a magnetic field. Shaft 3 is fixed at the central part of stator core 1.

[0024]

On the upper section of shaft 3 in the axial direction (i.e., on the upper side of FIG. 1), the inner ring of bearing 4a is fixed so as to be rotatable on shaft 3. On the lower section, which is opposite to bearing 4a via stator core 1, of shaft 3 in the axial direction (i.e., on the lower side of FIG. 1), the inner ring of bearing 4b is fixed so as to be rotatable on shaft 3.

[0025]

On the outer circumference of stator core 1, position detecting element 7 is fixed. It detects magnetic flux of magnets 6 disposed on the inner-circumference plane of rotor yoke 5.

[0026]

5 Rotor yoke 5 has a shape of a closed-top cylinder. The central part of the top face has a shaft opening (not shown) through which shaft 3 runs. Rotor yoke 5 is so formed that the diameter of the cylinder is decreased between the opened bottom and the closed top, by which bump section 71 is formed in the way. On the inner-circumference plane of rotor yoke 5, a plurality of
10 magnets 6 is fixed with a predetermined spacing therebetween in the circumferential direction of the side surface of the cylinder. The details will be described later.

[0027]

Rotor cover 8 has a substantially round shape larger than the bottom
15 opening of rotor yoke 5. The central part of the substantially round shape of rotor cover 8 has shaft opening 8a through which shaft 3 runs.

[0028]

In the assembling process of such structured stator core 1, rotor yoke 5, and rotor cover 8, the outer ring of bearing 4a is fixed to the
20 inner-circumference plane of rotor yoke 5, and the outer ring of bearing 4b is fixed to rotor cover 8. Under the state, the upper section of shaft 3 runs through the shaft opening of rotor yoke 5, while the lower section of shaft 3 runs through shaft opening 8a of rotor cover 8. Magnets 6, which are disposed on the inner-circumference plane of rotor yoke 5, face the curved surface of the
25 outer circumference of teeth 1a that form stator core 1. That is, stator core 1 is fixed so as to be covered with rotor yoke 5 and rotor cover 8. Brushless DC motor 9 is thus formed.

[0029]

In brushless DC motor 9, rotor yoke 5 and rotor cover 8 rotate together on shaft 3 in response to application of controlled current to driving coil 2. The control way of current has no direct relation to the present invention, and
5 therefore, the details will be omitted.

[0030]

Next, how to arrange magnets 6 onto rotor yoke 5 is described in detail, with reference to FIG. 2 through FIG. 6. FIG. 2 is an assembly diagram showing a structure of the rotor of the brushless DC motor of the embodiment.
10 FIG. 3A and FIG. 3B are external views of the magnets of the brushless DC motor of the embodiment. FIG. 3C is an external view of the structure with the magnets fixed of the brushless DC motor of the embodiment. FIG. 4 is an external view of the holding ring of the brushless DC motor of the embodiment. FIG. 5 is an external view showing a structure of the rotor of the brushless DC
15 motor of the embodiment. FIG. 6 is a cross-sectional view in the shaft direction, showing the structure of the brushless DC motor of the embodiment.

[0031]

As shown in FIG. 2, a plurality of magnets 6 (ten magnets in the embodiment) is disposed at regular intervals on the inner-circumference plane
20 of rotor yoke 5 in the circumferential direction.

[0032]

As shown in FIG. 3A, each of magnets 6 has a shape of a plate having rectangular flat plane 51 (seen from the side). Magnets 6 are disposed such that short side 52 of flat plane 51 of adjacent two magnets faces to each other.
25 Long side 53 of flat plane 51 makes contact with first holding ring 10a and second holding ring 10b, which will be described later in detail.

[0033]

FIG. 3B is a view seen from the direction of arrow A shown in FIG. 3A. Each of magnets 6 has two major surfaces: flat inner-circumference surface 54 and curved outer-circumference surface 55. Flat inner-circumference surface 54 and curved outer-circumference surface 55 has a distance as thickness MW
5 between them. Outer-circumference surface 55 has a bulge in the outward direction from magnets 6, that is, in a direction away from inner-circumference surface 54. Outer-circumference surface 55 has curvature R, which agrees with curvature R of the inner-circumference plane of rotor yoke 5 on which magnets 6 are bonded (see FIG. 3C). That is, each of magnets 6 has a cross
10 section of a round-arch shape (a D-shape), and both ends of long side 53, i.e., each end in the circumferential direction has thin-walled section 18 whose thickness is smaller than that of the central part.

[0034]

First holding ring 10a and second holding ring 10b are used for setting
15 aforementioned magnets 6 on rotor yoke 5. According to the embodiment, first holding ring 10a and second holding ring 10b are of a same shape.

[0035]

As shown in FIG. 4, first holding ring 10a (second holding ring 10b) has bottom 15 of a hollow-disc shape. Bottom 15 has thickness W from outer
20 circumference 61 of the ring toward the direction of ring axis 60 (i.e., the direction toward inner circumference 62). Bottom 15 has a plurality of protrusions 14a (protrusions 14b) at regular intervals. Each protrusion has a height nearly the same with thickness W in size and protrudes in a direction parallel to ring axis 60.

25 [0036]

The number of protrusions 14a (protrusions 14b) is the same with that of magnets 6. The structure of the embodiment has ten protrusions 14a

(protrusions 14b). Each of protrusions 14a (protrusions 14b) has a triangular cross-section vertical to ring axis 60. Protrusions 14a (protrusions 14b) are disposed such that side 63 of the triangle meets with inner circumference 62. Besides, height H of the triangle measures half or less than thickness W of bottom 15. That is, protrusions 14a (protrusions 14b) are disposed closer to inner circumference 62 than the central position of bottom 15 in the radial direction.

[0037]

Rotor yoke 5 is assembled through the procedures below.

10 [0038]

First, as shown in FIG. 2, first holding ring 10a is fitted into rotor yoke 5 from the open bottom toward the top face. At that time, protrusions 14a of first holding ring 10a are directed toward the opening of rotor yoke 5, i.e., toward the direction of magnets 6. The rear side of bottom 15 of first holding ring 10a, which has no protrusions 14a thereon, is positioned to bump section 71 formed in the inner circumference of rotor yoke 5. First holding ring 10a is fixed into bump section 71 by, for example, using adhesive or fitting the outer circumference of first holding ring 10a in the inner circumference of rotor yoke 5.

20 [0039]

Next, each of magnets 6 is positioned so as to fit between adjacent two protrusions 14a of first holding ring 10a. Magnets 6 are bonded to rotor yoke 5 so as to fit outer-circumference surface 55 of magnets 6 with the inner circumference of rotor yoke 5 since the facing surfaces have the same curvature. In the same manner, positioning and bonding procedure is performed on ten magnets 6. Through the process above, ten magnets 6 are fixed to the inner-circumference plane of rotor yoke 5.

[0040]

FIG. 3C shows the state in which one of protrusions 14a urges two magnets 6 to the inner-circumference plane of rotor yoke 5. That is, of side 63, side 65, and side 66 that form the triangle of protrusions 14a, side 65 and side 66 abut against first end 57 of short side 52 of magnets 6 in FIG. 3A, i.e., abut against one end section in a direction perpendicular to the circumferential direction. The abutment allows protrusions 14a to suppress magnets 6 from moving in the circumferential direction on rotating rotor yoke 5.

[0041]

Further, protrusions 14a urge magnets 6 toward the inner-circumference plane of rotor yoke 5, by which movement of magnets 6 toward the center of the ring, i.e., movement toward shaft 3, in other words, movement toward the center of rotation is suppressed.

[0042]

Besides, first holding ring 10a has, as described earlier, bottom 15 with thickness W. In such structured holding ring 10a, bottom 15 makes contact with magnets 6 in rotor yoke 5, by which magnets 6 are suppressed so as not to move toward the axial direction of shaft 3.

[0043]

After setting all of magnets 6 in rotor yoke 5, second holding ring 10b is disposed. According to the embodiment, second holding ring 10b has the same shape with first holding ring 10a. Second holding ring 10b is disposed with protrusions 14b directed toward magnets 6 and faced protrusions 14a of first holding ring 10a. Each of protrusions 14b of second holding ring 10b, as is the same with the case of first holding ring 10a, is disposed between two magnets 6. Through the setting above, of side 63, side 65, and side 66 that form the triangle of protrusions 14b, side 65 and side 66 abut against second end 58 of

short side 52 of magnets 6 in FIG. 3A, i.e., abut against the other end section in a direction perpendicular to the circumferential direction.

[0044]

Through the process above, as shown by rotor yoke 5 of FIG. 5, on one side in the axial direction of shaft 3, i.e., on the side away from the opening of rotor yoke 5, first holding ring 10a is disposed, whereas on the other side in the axial direction of shaft 3, i.e., on the side of the opening of rotor yoke 5, second holding ring 10b is disposed. Each of first holding ring 10a and second holding ring 10b keeps magnets 6 from moving in the direction toward shaft 3, in the axial direction of shaft 3, and in the circumferential direction.

[0045]

With the structure above, even if adhesive, which was used for bonding magnets 6 to rotor yoke 5, comes off, first holding ring 10a and second holding ring 10b keep magnets 6 from moving. This eliminates the problem that magnets 6 make contact with stator core 1, by which brushless DC motor 9 retains normal rotating operation. It will be understood that increase in manufacturing accuracy of first holding ring 10a, second holding ring 10b, and magnets 6 may eliminate adhesive for bonding magnets 6 to rotor yoke 5.

[0046]

Besides, restraint from the three directions by bottom 15 and protrusions 14a, 14b suppresses not only vibration of magnets 6 but also vibration of brushless DC motor 9 itself.

[0047]

Of three sides 63, 65, and 66 of each triangle of protrusions 14a and 14b, side 65 and side 66 have a structure that urges different two magnets 6 to the inner-circumference plane of rotor yoke 5. That is, in the structure above, two magnets 6 are kept by one of protrusions 14a and one of protrusions 14b. The

structure decreases the number of protrusions 14a, 14b and increases the area in which magnets 6 are disposed. As a result, increase in area occupied by magnets 6 in the circumferential direction enhances motor output.

[0048]

5 Further, protrusions 14a of first holding ring 10a and protrusions 14b of second holding ring 10b, which are disposed so as to be faced to each other, have clearance 72 therebetween. Having clearance 72 allows magnets 6 to create desirable magnetic field with no obstacle, contributing to smooth rotation of brushless DC motor 9.

10 [0049]

Besides, as shown in FIG. 4, protrusions 14a and protrusions 14b of a triangular shape are disposed on first holding ring 10a and second holding ring 10b, respectively, so as to be positioned close to the inner circumference of bottom 15 of each holding ring. Such positioning, for example, leaves a wide
15 space for the magnets on the side of the outer circumference of bottom 15, increasing the volume of magnets 6, as shown in FIG. 3C. The structure increases magnetic force and therefore enhances motor output.

[0050]

Further, side 63 of the triangle of each of protrusions 14a (14b) is fitted
20 to the inner circumference of bottom 15 of first holding ring 10a (second holding ring 10b). The structure shortens the distance between stator core 1 and first holding ring 10a (second holding ring 10b), by which magnetic force of magnets 6 is easily carried to stator core 1. As a result, it enhances motor output.

[0051]

25 Further, according to the structure above, flat inner-circumference surface 54 of magnets 6 is positioned on the side of stator core 1, and protrusions 14a, 14b having a triangular cross-section urge the end section

(thin-walled section 18) of inner-circumference surface 54 toward the side of the inner circumference. That is, the urging force of protrusions 14a (14b) toward the inner circumference works at part 68, as shown in FIG. 3C, which has the longest distance between magnets 6 and stator core 1. Protrusions 14a (14b) do not work as an obstacle in the arrangement of magnets 6 and stator core 1.

[0052]

Stator core 1 described above is covered with rotor yoke 5 and rotor cover 8. FIG. 6 shows the cross-section view of such structured brushless DC motor 9.

[0053]

As shown in FIG. 6, length M is the length of magnets 6 in the axial direction of shaft 3, and length S is the length of the facing surface to magnets 6 in the axial direction of shaft 3. The part of length M is longer than the part of length S so as to go beyond the both ends of the facing surface in the axial direction of shaft 3. The facing surface is the outer circumference of teeth 1a forming stator core 1, which means the curved surface itself, i.e., a bobbin and the like are not included (see FIG. 1).

[0054]

Protrusions 14a of first holding ring 10a are disposed so as not to face the aforementioned facing surface and retain only the upper end of magnets 6 in the circumferential direction. Similarly, protrusions 14b of second holding ring 10b are disposed so as not to face the aforementioned facing surface and retain only the lower end of magnets 6 in the circumferential direction.

[0055]

Compared to a structure where first holding ring 10a and second holding ring 10b retain the whole length of magnets 6 in the axial direction, protrusions 14a, 14b of the embodiment do not disturb the workings of the motor; on the

contrary, they retain an appropriate distance between first holding ring 10a (second holding ring 10b) and stator core 1 (strictly speaking, teeth 1a of stator core 1), preventing collision between first holding ring 10a (second holding ring 10b) and stator core 1. Further, protrusions 14a, 14b do not disturb magnets 6
5 to be disposed close to stator core 1, contributing to increased motor output.

[0056]

When rotor yoke 5 and rotor cover 8 are fixed to each other, second holding ring 10b is urged in the direction of first holding ring 10a by rotor cover 8, by which movement of magnets 6 in the axial direction is firmly suppressed.

10 [0057]

Besides, since each of magnets 6 has thin-walled section 18, as shown in FIG. 3C, the distance between magnets 6 and stator core 1 is short in the proximity of the central part of each magnet in the circumferential direction, and therefore, stator core 1 receives a large magnetic force from the central
15 part. In contrast, the distance between magnets 6 and stator core 1 is long in the proximity of the end part of each magnet in the circumferential direction, and therefore, stator core 1 receives a small magnetic force from the end part. That is, in the proximity of the end part at which the polarity of magnets 6 changes, magnetic force is smaller than that in the proximity of the central part.
20 Therefore, the structure allows polarity to have a smooth change, reducing motor noise.

[0058]

The technique to reduce motor noise by aforementioned thin-walled section 18 will be described in detail with reference to FIG. 7A, FIG. 7B, FIG.
25 8A, and FIG. 8B. FIG. 7A and FIG. 7B show distribution of magnetic force of a conventional brushless DC motor. FIG. 8A and FIG. 8B show distribution of magnetic force of brushless DC motor 9 of the embodiment.

[0059]

FIG. 7A shows a conventional brushless DC motor formed on the assumption the following structure: the outer-circumference surface of magnet 82 is the curved surface having a curvature the same as that of the inner-circumference plane of rotor yoke 80; and the inner-circumference surface of magnet 82 is the curved surface having a curvature the same as that of stator core 81. In the structure above, as shown in FIG. 7B, the distance between magnet 82 and stator core 81 measures constant at all of the rotor's rotating positions; accordingly, the absolute value of magnetic flux fed into stator core 81 measures nearly constant. This brings an abrupt change in magnetic flux fed into stator core 81 at the boundary of the north pole and the south pole, as shown in FIG. 7B. This causes vibration of the motor.

[0060]

In contrast, according to the structure of the embodiment, as shown in FIG. 8A, the outer-circumference surface of magnets 6 forms outer-circumference surface 55 having a curvature the same as that of the inner-circumference plane of rotor yoke 5 (see FIG. 3B), and the inner-circumference surface of magnets 6 forms flat inner-circumference surface 54 (see FIG. 3B). With the structure above, as shown in FIG. 8B, the distance between magnets 6 and stator core 1 becomes long at the boundary of the north pole and the south pole, whereas it becomes short at the central part of the pole. Due to the difference in distance, as shown in FIG. 8B, the magnetic flux fed into stator core 1 decreases at the boundary of the north pole and the south pole, and increases at the central part of the pole. The amount of the magnetic flux fed into the stator has a gradual change, which decreases vibration of the motor.

[0061]

SECOND EXEMPLARY EMBODIMENT

Next, the brushless DC motor according to the second exemplary embodiment is described with reference to FIG.9, FIG. 10A and FIG. 10B. The structure of the embodiment differs from that described in the first exemplary embodiment in the shape of the holding ring.

[0062]

First holding ring 20a of the embodiment (corresponding to first holding ring 10a) and second holding ring 20b (corresponding to second holding ring 10b), as shown in FIG.9, like the structure in the first exemplary embodiment, have protrusions 14a and protrusions 14b, respectively, and bottom 15. Bottom 15 and protrusions 14a, 14b have the shape the same as those described in the first exemplary embodiment. First holding ring 20a and second holding ring 20b are of a same shape.

[0063]

First holding ring 20a and second holding ring 20b differ from those of the first exemplary embodiment in having anti-drop section 23, slit 24, and opposite-protrusion 22, which will be described blow.

[0064]

Anti-drop section 23 is a protrusion that protrudes further outwardly beyond the outer circumference of bottom 15. A plurality of anti-drop sections 23 (three, in the embodiment) is disposed at equal spaces so as to protrude outwardly beyond the outer circumference of first holding ring 20a and second holding ring 20b. In terms of ensuring stability, three or more anti-drop sections 23 should preferably be disposed at equal spaces. When first holding ring 20a and second holding ring 20b are fitted into rotor yoke 5, anti-drop sections 23 are firmly pressed against the inner-circumference plane of rotor yoke 5 to hold first holding ring 20a and second holding ring 20b within rotor

yoke 5. For example, suppose that brushless DC motor 9 is assembled in bottom-to-top order, i.e., in the order of rotor cover 8, stator core 1, rotor yoke 5. In the process above, rotor yoke 5 is retained with its opening directed downward, as shown in FIG. 1. At that time, anti-drop section 23 keeps first
5 holding ring 20a and second holding ring 20b from dropping out of rotor yoke 5. That is, anti-drop section 23 offers easy assembling of brushless DC motor 9.

[0065]

Wall section 21 of first holding ring 20a and second holding ring 20b is a cylindrical wall that rises from bottom 15 as the starting point and extends
10 parallel to ring axis 60 and in the direction opposite to protrusions 14a and 14b. Wall section 21 is formed along the inner edge of bottom 15. The height of wall section 21 substantially equals to thickness W of bottom 15. Wall section 21 is also formed on first holding ring 10a and second holding ring 10b in the first exemplary embodiment, but it is indispensable; opposite-protrusion 22
15 may be disposed directly on bottom 15 without forming wall section 21. Wall section 21 has a plurality of slits 24 at positions making contact with bottom 15.

[0066]

Slits 24 of wall section 21 are rectangular spaces and disposed along the circumference of each holding ring at regular intervals. Forming slits 24
20 contributes to reduction in weight and raw materials of the holding ring. Besides, the weight-reduced structure of the holding ring enhances anti-drop effect of first holding ring 20a and second holding ring 20b themselves retained by aforementioned anti-drop section 23.

[0067]

25 Opposite-protrusion 22 is disposed on the side opposite to bottom 15 and in parallel to ring axis 60; in other words, it extends in the direction opposite to protrusions 14a, 14b of wall section 21. Opposite-protrusion 22, which has a

shape of a rectangular flat plate, is disposed on holding ring 20 such that the long side of the rectangular makes contact with the inner circumference of wall section 21. That is, opposite protrusion 22 protrudes from the round edge of wall section 21 by the length of a short side of the rectangular. A plurality of
5 opposite-protrusions 22 (five, in the embodiment) is disposed on the round holding ring at equal spaces. In terms of ensuring stability, three or more opposite protrusions 22 should preferably be disposed at equal spaces.

[0068]

FIG. 10A is a perspective view showing the positional relationship
10 between rotor cover 8 and second holding ring 20b when rotor cover 8 and rotor yoke 5 are fixed with each other. FIG. 10B is a cross-section view that partly shows opposite-protrusion 22 seen from the direction of the center of rotor cover 8.

[0069]

15 Rotor cover 8 has projections 26 on plane 25 on the side of rotor yoke 5. They protrude on the side of rotor yoke 5.

[0070]

Projections 26 are formed of push sections 27 of a straight shape and round sections 28 of a round shape. Push sections 27, which are disposed
20 radially from the central part through which shaft 3 of rotor cover 8 runs, protrude on the side of rotor yoke 5. Round sections 28 are disposed at equal spaces from the central part toward the outer circumference and protrude toward the outer circumference.

[0071]

25 The protruding part of push section 27, which is to be pushed into opposite-protrusion 22, has a width smaller than a long side of the rectangular of opposite-protrusion 22. When rotor cover 8 and rotor yoke 5 are fixed to

each other, as shown in FIG. 10B, push section 27 made of, for example, an aluminum-based material is pushed against opposite-protrusion 22 with a wide width. In the case where the holding ring is a resin-molded product, push section 27 breaks into opposite-protrusion 22. That is, pushing push section 27 into opposite-protrusion 22 allows bottom 15 of second holding ring 20b to have firm connection with magnets 6.

[0072]

With the structure above, magnets 6 is pressed against second holding ring 20b, and the position of magnets 6 can be stability.

10 [0073]

According to the structure of the embodiment, push section 27 is disposed on the side of rotor cover 8, it is not limited to; even when opposite-protrusion 22 is fixed with rotor cover 8 without forming push section 27 thereon, it is also effective in positioning magnets 6 with stability.

15 [0074]

According to the structure of the embodiment, as for first holding ring 20a disposed in rotor yoke 5, opposite-protrusion 22 is directly pushed into the top plane of rotor yoke 5 and bottom 15 of first holding ring 20a is fixed with magnets 6. Needless to say, as another effective structure, push section 27 may be disposed on the inner side of the top plane of rotor yoke 5. In that case, magnets 6 are fixed with pressure from the upper and the lower directions.

[0075]

MODIFICATION EXAMPLE

Although the triangular shape of protrusions 14a, 14b is described as an isosceles triangle having an acute vertex, it is not limited to; the triangle does not necessarily have an acute vertex, it may be an equilateral triangle, or it is not necessarily to be an isosceles triangle. Further, it may be formed as a

trapezoid by adding a side between side 65 and side 66 of the triangle of protrusions 14a, 14b.

[0076]

5 In the description of the embodiments above, magnets 6 are bonded to rotor yoke 5 one by one, but it is not limited to; all of ten magnets 6 may be temporarily retained by a predetermined jig and then, the retained ten magnets may be disposed together on first holding ring 10a in rotor yoke 5.

[0077]

10 Further, any one of first holding ring 10a and second holding ring 10b may not have protrusions 14a (protrusions 14b) i.e., have bottom 15 only. In that case, too, movement of magnets 6 in the three directions can be suppressed by eliminating a wobble of first holding ring 10a and second holding ring 10b when they are positioned.

[0078]

15 Besides, in the structure above, second holding ring 10b is urged by rotor cover 8 toward first holding ring 10a, but second holding ring 10b may be fixed in rotor yoke 5 by adhesive, for example. In that case, the structure allows margins of error in designing of rotor yoke 5 and rotor cover 8 to be tolerated to some extent.

20 [0079]

According to brushless DC motor 9 described above, as shown in FIG. 11 and FIG. 12, blade 11 is connected to rotor cover 8, and shaft 3 is covered with a decorative cover to complete blower device 12. When being disposed the ceiling, blower device 12 can work as ceiling fan 13.

25 [0080]

As described above, the brushless DC motor of the present invention has a stator core on which a coil is wound, a shaft fixed at the central position of the

stator core, a bearing whose inner ring is fixed to the shaft, and a rotor yoke fixed to an outer ring of the bearing. The rotor yoke has a plurality of magnets disposed on an inner-circumference plane in a circumferential direction so as to face the stator core. Further, the structure has a first holding ring and a
5 second holding ring in the circumferential direction of the magnets. The first holding ring has a protrusion for holding a first end of the shaft in the axial direction, while the second holding ring has a protrusion for holding a second end of the shaft in the axial direction.

[0081]

10 With the structure above, even if the bonded magnets come off, the holding rings keep magnets from making contact with the stator core, by which the motor keeps normal rotating operations.

[0082]

Each of the first holding ring and the second holding ring has a bottom
15 having a thickness from the outer circumference of the ring toward the axial direction of the ring (i.e., the bottom has a hollow-disc shape) and a protrusion protruding from the bottom in the axial direction of the ring. The bottom may be structured so as to suppress the magnets from moving in the axial direction of the shaft, and the protrusion may be structured so as to suppress the
20 magnets from moving in the circumferential direction.

[0083]

With the structure above, even if the bonded magnets come off, the bottom of the ring suppresses the magnets from moving in the axial direction of the ring (i.e., in the axial direction of the shaft); at the same time the protrusion
25 suppresses the magnets from moving in the circumferential direction of the ring, by which vibration of the magnets is suppressed. As a result, the motor keeps normal rotating operations.

[0084]

The protrusion has a cross section of a triangle, and is disposed on the bottom such that one side of the triangle meets with the inner circumference of the bottom so as to be disposed close to the inner circumference of the bottom.

5 Further, remaining two sides of the triangle may have a structure for urging different two magnets against the inner-circumference plane of the rotor yoke so as to suppress the magnets from moving not only in the direction of the center of the ring but also in the circumferential direction of the magnets.

[0085]

10 One side of the triangle of the protrusion is fitted to the inner circumference of the bottom of the holding ring. The structure shortens the distance between the holding ring and the stator core, by which magnetic force of the magnets is easily carried to the stator core. As a result, it enhances the motor output. Besides, the triangle of the protrusion is disposed on the bottom
15 so as to be positioned close to the inner circumference of the bottom of the holding ring. Such positioning leaves a wide space for the magnets on the side of the outer circumference of the bottom of the ring, increasing the volume of the magnets. Increase in magnetic force enhances the motor output.

[0086]

20 Each magnet may have the following structure. That is, the outer-circumference side of the magnet has a surface having a curvature the same as that of the inner-circumference plane of the rotor yoke, and the inner-circumference side of the magnet has a flat surface. The magnet has thin-walled sections at its both ends in the circumferential direction of the
25 magnets. The thin-walled sections are urged by the protrusion toward the inner-circumference plane of the rotor yoke.

[0087]

With the structure above, in the proximity of the central part of the magnet in the circumferential direction, the distance between the magnet and the stator core becomes short, by which the magnetic force fed into the stator increases; whereas, in the proximity of the ends of the magnet in the circumferential direction, the distance between the magnet and the stator becomes long, by which the magnetic force fed into the stator decreases. That is, the magnetic force of the magnet is smaller in the proximity of the ends—where the polarity of the magnet switches—than in the central part of the magnet. This contributes to a smooth change in polarity, reducing motor noise.

[0088]

The magnets are structured so as to have each length in the axial direction of the shaft is longer than the length in the axial direction of the shaft of a part of the surface of the stator core that faces the magnet. Besides, in the structure above, each protrusion of the first holding ring and the second holding ring may be disposed so as not to face the part of the surface of the stator core that faces the magnets.

[0089]

The aforementioned structure, compared to a structure where the first holding ring and the second holding ring hold the whole length of each magnet in the axial direction, keeps an appropriate distance between each holding ring and the stator core, preventing collision between the first holding ring (the second holding ring) and the stator core. Furthermore, the structure allows the magnets to be close to the stator core without making the protrusion an obstacle between them.

[0090]

The first holding ring has an opposite-protrusion that protrudes in the

axial direction of the ring and in the direction opposite to the protrusion. In the structure above, the opposite-protrusion may work for firmly pressing the bottom of the first holding ring with the magnets when the rotor yoke is fixed to the rotor cover.

5 [0091]

The structure allows magnets 6 to be positioned with stability.

[0092]

The second holding ring has an opposite-protrusion that protrudes in the axial direction of the ring and in the direction opposite to the protrusion.

10 Fixing the rotor yoke and the rotor cover may allow the bottom of the second holding ring to be firmly pressed with the magnets.

[0093]

The structure, too, allows magnets 6 to be positioned with stability.

[0094]

15 The rotor cover may have a push section that makes contact with the opposite-protrusion. In that case, the structure allows the bottom to have a firm contact with the magnets via the opposite-protrusion.

[0095]

20 Compared to a structure with no push section, the aforementioned structure allows magnets 6 to be positioned with enhanced stability.

[0096]

At least any one of the first holding ring and the second holding ring may have an anti-drop section that protrudes from the outer circumference of the bottom toward the outer direction. In the structure, the anti-drop section
25 firmly presses its outer-circumference end onto the inner-circumference plane of the rotor yoke so that the holding ring is held by the rotor yoke.

[0097]

Even when the opening of the rotor yoke is directed downward in the assembling process, the structure above prevents the first holding ring and the second holding ring from dropping out of the rotor yoke.

[0098]

5 Further, the brushless DC motors described above may be employed for a blower device.

[0099]

The structure offers the following effect. Even if the bonded magnets come off, the motor keeps normal rotating operations; accordingly, the blower
10 device having the motor keeps working with no interruption. The magnets are not necessarily bonded; they can be fixed by the first holding ring and the second holding ring only.

INDUSTRIAL APPLICABILITY

15 [0100]

According to the blower device on which the brushless DC motor of the present invention is mounted, even if bonded magnets come off, it keeps normal rotating operation with no interruption. Therefore, the structure is useful for a blower device having a brushless DC motor for driving a fan, such as a ceiling
20 fan.

REFERENCE MARKS IN THE DRAWINGS

[0101]

1, 81, 112	stator core
25 1a, 117	teeth
2	driving coil
3, 121	shaft

	4a, 4b	bearing
	5, 80	rotor yoke
	6, 82	magnets
	7	position detecting element
5	8	rotor cover
	8a	shaft opening
	9	brushless DC motor
	10a, 20a	first holding ring
	10b, 20b	second holding ring
10	11	blade
	12	blower device
	13	ceiling fan
	14a, 14b	protrusions
	15	bottom
15	18	thin-walled section
	21	wall section
	22	opposite-protrusion
	23	anti-drop section
	24	slit
20	25	plane
	26	projection
	27	push section
	28	round section
	51	flat plane
25	52	short side
	53	long side
	54	inner-circumference surface

	55	outer-circumference surface
	57	first end
	58	second end
	60	ring axis
5	61	outer circumference
	62	inner circumference
	63	side
	65, 66	side
	71	bump section
10	72	clearance
	130, 131, 132	rotor magnets

15

CLAIMS

1. An outer-rotor-type brushless DC motor comprising:
 - a stator core around which a coil is wound;
 - 5 a shaft fixed to a central position of the stator core;
 - a bearing whose inner ring is fixed to the shaft;
 - a rotor yoke fixed to an outer ring of the bearing and comprising:
 - a plurality of magnets disposed on an inner-circumference
 - plane facing the stator core of the rotor yoke in a circumferential direction; and
 - 10 a first holding ring disposed in a circumferential direction of the magnets and comprising:
 - a protrusion for holding a first end of the shaft in an axial
 - direction; and
 - a second holding ring disposed in the circumferential direction of
 - 15 the magnets and comprising:
 - a protrusion for holding a second end facing the first end of the shaft in the axial direction.
2. The brushless DC motor according to claim 1, wherein
 - 20 each of the first holding ring and the second holding ring has a ring section, a bottom of a hollow-disc shape integrally formed with the ring section toward an outer circumferential direction of the ring section, and the protrusion protruding from the bottom toward an axial direction of the ring section,
 - 25 the bottom suppresses the magnets from moving in an axial direction of the shaft, and
 - the protrusion suppresses the magnets from moving in the

circumferential direction of the magnets.

3. The brushless DC motor according to claim 2, wherein

the protrusion has a cross section of a triangle, one side of the
5 triangle is fitted with an inner circumference of the bottom so as to be disposed
close to the inner circumference of the bottom, remaining two sides other than
the one side have an urging structure by which different two magnets of the
magnets are urged against the inner-circumference plane of the rotor yoke, and
the urging structure suppresses the magnets from moving in a
10 direction of a center of the ring and in the circumferential direction of the
magnets.

4. The brushless DC motor according to claim 1, wherein

each of the magnets has a structure in which an
15 outer-circumference surface forms a curved face having a same curvature with
the inner-circumference plane of the rotor yoke and an inner-circumference
surface forms a flat face, by which a thin-walled section is formed at both ends
in the circumferential direction of the magnets, and

the protrusion urges the thin-walled section against the
20 inner-circumference plane of the rotor yoke.

5. The brushless DC motor according to claim 1, wherein

the magnets have a length in an axial direction of the shaft longer
than a length of a facing plane of the stator core that faces the magnets in the
25 axial direction of the shaft, and

the protrusion that forms the first holding ring and the protrusion
that forms the second holding ring are disposed so as not to face the facing

plane.

6. The brushless DC motor according to claim 2, wherein the first holding ring has an opposite-protrusion that protrudes in an axial direction of
5 the ring section and in a direction opposite from the protrusion, and the opposite-protrusion presses the bottom of the first holding ring against the magnets when the rotor yoke and a rotor cover are fixed to each other.

7. The brushless DC motor according to claim 2, wherein the second
10 holding ring has a second opposite-protrusion that protrudes in an axial direction of the ring section and in a direction opposite from the protrusion, and the second opposite-protrusion presses the bottom of the second holding ring against the magnets when the rotor yoke and a rotor cover are fixed to each other.

15

8. The brushless DC motor according to claim 7, wherein
the rotor cover has a push section that makes contact with the second opposite-protrusion, and
the push section presses, via the second opposite-protrusion, the
20 bottom of the second holding ring against the magnets.

9. The brushless DC motor according to claim 2, wherein
at least any one of the first holding ring and the second holding ring has an anti-drop section that further outwardly protrudes from an outer
25 circumference of the bottom, and
the anti-drop section firmly presses an outer-circumference end of the anti-drop section against the inner-circumference plane of the rotor yoke so

that the first holding ring or the second holding ring is held by the rotor yoke.

10. A blower device comprising the brushless DC motor according to any one of claim 1 through claim 9.

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