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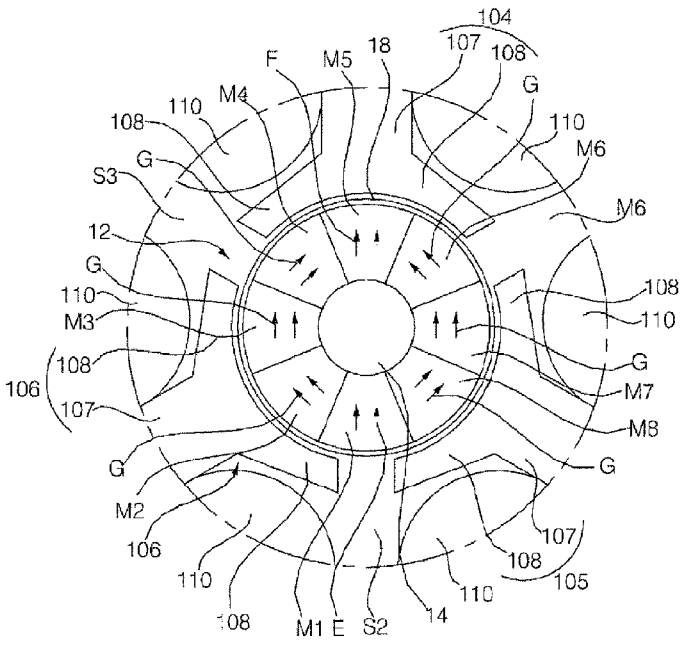
(54) Title: BLDC MOTOR AND CLEANER HAVING THE SAME



(57) Abstract: A brushless direct current (BLDC) motor is disclosed. The BLDC motor includes a shaft made of a nonmagnetic material, a plurality of magnets surrounding the outer circumference of the shaft, a stator surrounding the outer circumferences of the magnets, wherein each of the magnets has an arc-shaped outer circumferential surface, an arc-shaped inner circumferential surface facing the shaft, and opposite side surfaces facing other adjacent magnets, and the magnets include a first magnet magnetized in a direction directed from the outer circumferential surface to the inner circumferential surface, a second magnet magnetized in a direction directed from the inner circumferential surface to the outer circumferential surface, and a third magnet magnetized in a direction directed from one side surface to the other side surface. The efficiency of the motor is improved while eddy current loss is minimized.

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Description

Title of Invention: BLDC MOTOR AND CLEANER HAVING THE SAME

Technical Field

[1] The present invention relates to a brushless direct current (BLDC) motor and a cleaner having the same, and more particularly to a BLDC motor including a plurality of magnets mounted at a shaft and a cleaner having the same.

Background Art

[2] A brushless direct current (BLDC) motor, which is a kind of DC motor, is configured such that a rotor includes a magnet, whereby no brush is needed.

[3] The BLDC motor may include a motor housing, a stator disposed in the motor housing, and a magnet located inside the stator.

[4] The BLDC motor generates low noise, and is suitable for high-speed rotation. In a case in which the BLDC motor is applied to a cleaner, an impeller for suctioning air and moving the suctioned air into a duct collection unit may rotate at a high speed.

[5] It is required for the BLDC motor to rotate at a high speed with high efficiency.

Disclosure of Invention

Technical Problem

[6] Therefore, the present invention has been made in view of the above problems, and it is an object of the present invention to provide a brushless direct current (BLDC) motor having low eddy current loss and high efficiency and a cleaner having the same.

Solution to Problem

[7] In accordance with an aspect of the present invention, the above and other objects can be accomplished by the provision of a brushless direct current (BLDC) motor including a shaft made of a nonmagnetic material, a plurality of magnets surrounding the outer circumference of the shaft, a stator surrounding the outer circumferences of the magnets, wherein each of the magnets has an arc-shaped outer circumferential surface, an arc-shaped inner circumferential surface facing the shaft, and opposite side surfaces facing other adjacent magnets, and the magnets include a first magnet magnetized in a direction directed from the outer circumferential surface to the inner circumferential surface, a second magnet magnetized in a direction directed from the inner circumferential surface to the outer circumferential surface, and a third magnet magnetized in a direction directed from one side surface to the other side surface.

[8] The first magnet and the second magnet may be opposite to each other while the shaft is located between the first magnet and the second magnet.

[9] The third magnet may be located between the first magnet and the second magnet in

a circumferential direction.

[10] The third magnet may include a plurality of third magnets sequentially arranged along the outer circumference of the shaft.

[11] The third magnet may include a plurality of left-side third magnets and a plurality of right-side third magnets. The left-side third magnets may be located on the left side of the second magnet, the shaft, and the first magnet, and the right-side third magnets may be located on the right side of the second magnet, the shaft, and the first magnet.

[12] The left-side third magnets and the right-side third magnets may be magnetized toward the second magnet.

[13] Each of the magnets may be configured such that an angle between a first extension line connecting from the center of rotation of the shaft to the one side surface and a second extension line connecting from the center of rotation of the shaft to the other side surface is one selected from among 36 degrees, 45 degrees, and 60 degrees.

[14] The BLDC motor may further include a sleeve surrounding the magnets, the sleeve being made of carbon fiber.

[15] The shaft may be made of stainless steel (STS).

[16] In accordance with another aspect of the present invention, there is provided a cleaner including a BLDC motor having a shaft, an impeller mounted at the shaft, and an impeller cover surrounding the impeller, the impeller cover being configured to guide air driven by the impeller into the BLDC motor, wherein the BLDC motor includes a plurality of magnets surrounding the outer circumference of the shaft, a stator surrounding the outer circumferences of the magnets, each of the magnets has an arc-shaped outer circumferential surface, an arc-shaped inner circumferential surface facing the shaft, and opposite side surfaces facing other adjacent magnets, and the magnets include a first magnet magnetized in a direction directed from the outer circumferential surface to the inner circumferential surface, a second magnet magnetized in a direction directed from the inner circumferential surface to the outer circumferential surface, and a third magnet magnetized in a direction directed from one side surface to the other side surface.

[17] The first magnet and the second magnet may be opposite to each other while the shaft is located between the first magnet and the second magnet.

[18] The third magnet may be located between the first magnet and the second magnet in a circumferential direction.

[19] The third magnet may include a plurality of third magnets sequentially arranged along the outer circumference of the shaft.

[20] The third magnet may include a plurality of left-side third magnets and a plurality of right-side third magnets. The left-side third magnets may be located on the left side of the second magnet, the shaft, and the first magnet, and the right-side third magnets

may be located on the right side of the second magnet, the shaft, and the first magnet.

[21] The left-side third magnets and the right-side third magnets may be magnetized toward the second magnet.

[22] Each of the magnets may be configured such that an angle between a first extension line connecting from the center of rotation of the shaft to the one side surface and a second extension line connecting from the center of rotation of the shaft to the other side surface is one selected from among 36 degrees, 45 degrees, and 60 degrees.

[23] The BLDC motor may further include a sleeve surrounding the magnets, the sleeve being made of carbon fiber.

Advantageous Effects of Invention

[24] The present invention has the effect of smoothing the flow of flux, thereby maximizing the performance of magnets, and of minimizing eddy current loss using an assembly of a plurality of magnets having different directions of magnetization.

[25] In addition, the present invention has the effect of optimizing a pattern of magnetization, thereby improving field energy.

Brief Description of Drawings

[26] The above and other objects, features and other advantages of the present invention will be more clearly understood from the following detailed description taken in conjunction with the accompanying drawings, in which:

[27] FIG. 1 is a view showing a fan motor assembly of an embodiment of a cleaner having a brushless direct current (BLDC) motor according to the present invention;

[28] FIG. 2 is a cross-sectional view showing a stator and a rotor of an embodiment of the BLDC motor shown in FIG. 1;

[29] FIG. 3 is an enlarged sectional view showing part A of FIG. 2;

[30] FIG. 4 is a view showing a magnet magnetization direction in the embodiment of the BLDC motor according to the present invention;

[31] FIG. 5 is a view showing a magnet magnetization angle in the embodiment of the BLDC motor according to the present invention;

[32] FIG. 6 is a view showing eddy current loss in the embodiment of the BLDC motor according to the present invention and eddy current loss in a comparative example; and

[33] FIG. 7 is a view showing eddy current loss in the rotor based on the number of magnets in the embodiment of the BLDC motor according to the present invention.

Best Mode for Carrying out the Invention

[34] Hereinafter, embodiments of the present invention will be described in detail with reference to the accompanying drawings.

[35] FIG. 1 is a view showing a fan motor assembly of an embodiment of a cleaner having a brushless direct current (BLDC) motor according to the present invention.

[36] The cleaner having the BLDC motor may include a fan motor assembly 2 for suctioning air. The fan motor assembly 2 may include a fan 4 and a BLDC motor 6 for rotating the fan 4. The cleaner having the BLDC motor may further include a collection unit for collecting foreign matter in air flowing as the result of the operation of the fan motor assembly 2. The collection unit may include a dust collection net or a cyclone duct collection box, which is installed in front of the fan motor assembly 2 in a direction in which the air flows.

[37] The fan 4 includes an impeller 42 and an impeller cover 44 configured to surround the impeller 42. The impeller cover 44 is provided with an air suction port 43.

[38] The impeller 42 is constituted by a plurality of blades. The blades are curved in a circumferential direction. During the rotation of the impeller 42, air may be suctioned through the air suction port 43, and may then be discharged in a radial direction of the impeller 42. The impeller 42 may be mounted at a shaft 14, which will be described hereinafter in detail. When the shaft 14 is rotated as the result of driving of the BLDC motor 6, the impeller 42 may be rotated together with the shaft 14.

[39] The impeller cover 44 may be coupled to a motor housing 8 of the BLDC motor 6.

[40] The fan 4 may further include a diffuser 46 for forcibly feeding air discharged through the outlet of the impeller 42 and a guide vane 48 for guiding the air forcibly fed by the diffuser 46 into the motor.

[41] The diffuser 46 may be located around the outside of the impeller 42. The air having passed through the impeller 42 is forcibly fed by the diffuser 46. At this time, speed energy may be converted into pressure energy.

[42] The guide vane 48 may be located between the diffuser 46 and the BLDC motor 6 in the direction in which the air flows. The fan 4 may further include a disk body 49. The guide vane 48 may be formed at the outer circumference of the disk body 49. The disk body 49 may have a coupling part 50, which is coupled to at least one selected from between the impeller cover 44 and the motor housing 8.

[43] The BLDC motor 6 may be a 3-phase, 2-pole, 3-slot BLDC motor.

[44] The BLDC motor 6 may include a motor housing 8, a stator 10, and a rotor 12. The BLDC motor 6 may further include a bearing 16 mounted in the motor housing 8 for supporting the shaft 14.

[45] The motor housing 8 may define the external appearance of the BLDC motor 6. In the motor housing 8 may be defined a space 82 for receiving the stator 10 and the rotor 12. The motor housing 8 may be formed in the shape of a cup when viewed in section. One surface of the motor housing 8 that faces the impeller cover 44 may be open.

[46] The motor housing 8 may be provided with an impeller cover coupling part 84, which is coupled to the impeller cover 44. One selected from between the impeller cover coupling part 84 and the impeller cover 44 may be inserted into the other

selected from between the impeller cover coupling part 84 and the impeller cover 44. The impeller cover coupling part 84 and the impeller cover 44 may be coupled to each other by means of a fastening member, such as a screw, or a hanger member, such as a hook.

[47] Heat may be dissipated from the BLDC motor 6 due to air that is blown by the fan 4. The motor housing 8 may be provided with an opening 86, through which the air blown by the fan 4 is introduced into the motor housing 8.

[48] The motor housing 8 may include an air discharge port 88, through which the air having cooled the interior of the BLDC motor 6 is discharged from the BLDC motor 6. The air discharge port 88 may be formed in at least one selected from between the circumference of the motor housing 8 and the side of the motor housing 8 opposite to the opening 86.

[49] FIG. 2 is a cross-sectional view showing a stator and a rotor of an embodiment of the BLDC motor shown in FIG. 1, FIG. 3 is an enlarged sectional view showing part A of FIG. 2, FIG. 4 is a view showing a magnet magnetization direction in the embodiment of the BLDC motor according to the present invention, and FIG. 5 is a view showing a magnet magnetization angle in the embodiment of the BLDC motor according to the present invention.

[50] The BLDC motor 6 may include a shaft 14, which is made of a nonmagnetic material, and a plurality of magnets M1, M2, M3, M4, M5, M6, M7, and M8, which surround the outer circumference of the shaft 14.

[51] Since the shaft 14 is made of a nonmagnetic material, little flux flows in the shaft 14. The shaft 14 may be made of stainless steel (STS).

[52] The magnets M1, M2, M3, M4, M5, M6, M7, and M8 may constitute the rotor 12.

[53] The BLDC motor 6 may further include a sleeve 18. The sleeve 18 may surround the magnets M1, M2, M3, M4, M5, M6, M7, and M8. The sleeve 18 may constitute the rotor 12 together with the magnets M1, M2, M3, M4, M5, M6, M7, and M8. The sleeve 18 may be made of carbon fiber. The sleeve 18 may protect the magnets M1, M2, M3, M4, M5, M6, M7, and M8. The sleeve 18 may define the external appearance of the rotor 12.

[54] The stator 10 includes a stator core 102 and a coil 110 wound on the stator core 102.

[55] The stator 10 may surround the magnets M1, M2, M3, M4, M5, M6, M7, and M8. The stator core 102 may include a back yoke 103 having teeth 104, 105, and 106 protruding therefrom.

[56] The stator core 102 may surround the magnets M1, M2, M3, M4, M5, M6, M7, and M8. The back yoke 103 may have therein spaces S4 for receiving the magnets M1, M2, M3, M4, M5, M6, M7, and M8 and the shaft 14.

[57] The teeth 104, 105, and 106 may protrude from the back yoke 103. Specifically, the

teeth 104, 105, and 106 may protrude from the inner circumference of the back yoke 103. The teeth 104, 105, and 106 may be arranged along the back yoke 103 at equal intervals. The stator core 102 may have spaces S1, S2, and S3, which are defined between the respective teeth 104, 105, and 106. The coil 110 may be located in the spaces S1, S2, and S3. The BLDC motor 6 may include the three teeth 104, 105, and 106, which protrude from the back yoke 103 toward a magnet 122. In this case, the BLDC motor 6 may be a 3-slot BLDC motor. Each of the teeth 104, 105, and 106 may include a neck 107 protruding from the back yoke 103 and a shoe 108 protruding from the neck 107 in a direction in which the magnet is partially surrounded.

[58] The spaces S1, S2, and S3, in which the coil 110 can be received, of the stator core 102 may be defined between the respective necks 107. The spaces S4, in which the magnets M1, M2, M3, M4, M5, M6, M7, and M8 can be received, of the stator core 102 may be defined between the respective shoes 108.

[59] The coil 110 may be a 3-phase coil.

[60] The magnets M1, M2, M3, M4, M5, M6, M7, and M8 may be arranged so as to surround the outer circumference of the shaft 14 in a ring shape.

[61] 6 to 10 magnets M1, M2, M3, M4, M5, M6, M7, and M8 may be disposed around the shaft 14. The rotor 12 may include the magnets M1, M2, M3, M4, M5, M6, M7, and M8, which surround the shaft 14 in a divided state. The rotor 12 may be configured to have a divided structure.

[62] A part of each of the magnets M1, M2, M3, M4, M5, M6, M7, and M8 that faces the shaft 14 is provided with a semicircular recess. The magnets M1, M2, M3, M4, M5, M6, M7, and M8 may surround the outer circumference of the shaft 14.

[63] Each of the magnets M1, M2, M3, M4, M5, M6, M7, and M8 may have an arc-shaped outer circumferential surface 21 and an arc-shaped inner circumferential surface 22. Opposite side surfaces 23 and 24 of each of the magnets M1, M2, M3, M4, M5, M6, M7, and M8, which connect the outer circumferential surface 21 with inner circumferential surface 22, may be formed in a straight line. The magnets M1, M2, M3, M4, M5, M6, M7, and M8 may be bonded to the outer circumferential surface of the shaft 14.

[64] Each of the magnets M1, M2, M3, M4, M5, M6, M7, and M8 may have an arc-shaped outer circumferential surface 21, an arc-shaped inner circumferential surface 22 facing the shaft 14, and opposite side surfaces 23 and 24 facing other adjacent magnets. Each of the magnets M1, M2, M3, M4, M5, M6, M7, and M8 may include an outer circumferential surface 21, one side surface 23, an inner circumferential surface 22, and the other side surface 24.

[65] The magnets M1, M2, M3, M4, M5, M6, M7, and M8 may have the same shape. The magnets M1, M2, M3, M4, M5, M6, M7, and M8 may have the same size.

[66] The magnets M1, M2, M3, M4, M5, M6, M7, and M8 include a first magnet M1 magnetized in a direction E directed from the outer circumferential surface 21 to the inner circumferential surface 22, a second magnet M5 magnetized in a direction F directed from the inner circumferential surface 22 to the outer circumferential surface 21, and third magnets M2, M3, M4, M6, M7, and M8 magnetized in a direction G directed from one side surface 23 to the other side surface 24.

[67] As shown in FIG. 3, the first magnet M1 and the second magnet M5 may be opposite to each other in a state in which the shaft 14 is located between the first magnet M1 and the second magnet M5. The first magnet M1 and the second magnet M5 may be arranged at the outer circumference of the shaft 14 so as to have a phase difference of 180 degrees. When the shaft 14 is rotated 180 degrees, the positions of the first magnet M1 and the second magnet M5 may be inversed.

[68] The third magnets M2, M3, M4, M6, M7, and M8 may be located between the first magnet M1 and the second magnet M5 in a circumferential direction. The third magnets M2, M3, M4, M6, M7, and M8 may surround the remaining parts of the shaft 14 that are not surrounded by the first magnet M1 and the second magnet M5. The third magnets M2, M3, M4, M6, M7, and M8 may be sequentially arranged along the outer circumference of the shaft 14. The third magnets M2, M3, M4, M6, M7, and M8 may surround the remaining parts of the shaft 14 that are not surrounded by the first magnet M1 and the second magnet M5.

[69] The magnets constituting the rotor 12 may be generally magnetized in a direction of the first magnet M1 -> the third magnets M2, M3, M4, M6, M7, and M8 -> the second magnet M5.

[70] Referring to FIG. 3, the third magnets M2, M3, M4, M6, M7, and M8 may include a plurality of left-side third magnets M2, M3, and M4 and a plurality of right-side third magnets M6, M7, and M8.

[71] Referring to FIG. 3, the left-side third magnets M2, M3, and M4 may be located on the left side of the second magnet M5, the shaft 14, and the first magnet M1, and the right-side third magnets M6, M7, and M8 may be located on the right side of the second magnet M5, the shaft 14, and the first magnet M1.

[72] The left-side third magnets M2, M3, and M4 and the right-side third magnets M6, M7, and M8 may be symmetric with respect to the second magnet M5, the shaft 14, and the first magnet M1. The left-side third magnets M2, M3, and M4 and the right-side third magnets M6, M7, and M8 may be magnetized in the direction toward the second magnet M5.

[73] When the shaft 14 is rotated 180 degrees, the positions of the left-side third magnets M2, M3, and M4 and the right-side third magnets M6, M7, and M8 may be inversed.

[74] The rotor 12 may be divided into two poles, such as an N pole and an S pole. A 180

degree part of the rotor 12 may have an N pole, and another 180 degree part of the rotor 12 may have an S pole. The BLDC motor 6 may be a 2-pole BLDC motor. Here, the N pole and the S pole are divided from each other at one of the left-side third magnets M2, M3, and M4 and one of the right-side third magnets M6, M7, and M8.

[75] In a case in which the rotor 12 includes 8 magnets, the BLDC motor 6 may have a 2-pole, 8-division pattern of magnetization.

[76] The first magnet M1 shown in FIG. 4(B) may be magnetized between a pair of magnetizing yokes 200 and 202 for magnetizing the magnet, and may be magnetized in a direction directed from the outer circumferential surface 21 to the inner circumferential surface 22. The first magnet M1 may be magnetized in a direction E perpendicular to a tangent line of the center of the outer circumferential surface 21 and to a tangent line of the center of the inner circumferential surface 22.

[77] The second magnet M5 shown in FIG. 4(C) may be magnetized between a pair of magnetizing yokes 200 and 202 for magnetizing the magnet, and may be magnetized in a direction directed from the inner circumferential surface 22 to the outer circumferential surface 21. The second magnet M5 may be magnetized in a direction F perpendicular to a tangent line of the center of the inner circumferential surface 22 and to a tangent line of the center of the outer circumferential surface 21.

[78] The third magnets M2, M3, M4, M6, M7, and M8 shown in FIG. 4(D) may be magnetized between a pair of magnetizing yokes 200 and 202 for magnetizing the magnets, and may be magnetized in a direction directed from one side surface 23 to the other side surface 24.

[79] Each of the magnets M1, M2, M3, M4, M5, M6, M7, and M8 is configured such that an angle θ1 between a first extension line X1 connecting from the center 0 of rotation of the shaft to one side surface 23 and a second extension line X2 connecting from the center 0 of rotation of the shaft to the other side surface 24 may be one selected from among 36 degrees, 45 degrees, and 60 degrees.

[80] Here, the first extension line X1 and the second extension line X2 may be division lines for dividing the magnets. The angle θ1 between the first extension line X1 and the second extension line X2 may be a division angle θ1 by which the magnets are divided from each other.

[81] The division angle θ1 may be defined by Equation 1 below.

[82] [Equation 1]

[83] $\theta 1 = 360 / N$

[84] Where N indicates the number of magnets surrounding the shaft 14. N may be one selected from among 6, 8, and 10.

[85] In a case in which the number of magnets is 10, the division angle θ1 is 36 degrees. In a case in which the number of magnets is 8, the division angle θ1 is 45 degrees. In a

case in which the number of magnets is 6, the division angle θ1 is 60 degrees.

[86] Each of the magnets M1, M2, M3, M4, M5, M6, M7, and M8 may have a magnetizing angle X.

[87] The magnetizing angle X may be set based on the middle line Y between the first extension line X1 and the second extension line X2. Here, the middle line Y may be located between the first extension line X1 and the second extension line X2.

[88] The magnetizing angle X of the first magnet M1 and the magnetizing angle X of the second magnet M5 may be identical to or parallel to the middle line Y

[89] In a case in which the magnetizing angle X shown in FIG. 5 is 0 degrees, this magnet may be the first magnet M1, magnetized in the direction directed from the outer circumferential surface 21 to the inner circumferential surface 22.

[90] In a case in which the magnetizing angle X shown in FIG. 5 is 180 degrees, this magnet may be the second magnet M5, magnetized in the direction directed from the inner circumferential surface 22 to the outer circumferential surface 21.

[91] The magnetizing angle X of the third magnets M2, M3, M4, M6, M7, and M8 may be defined by Equation 2 below.

[92] [Equation 1]

[93] $\theta 2 = 180° - (\theta 1/2 + X)$

[94] Where θ2 indicates an angle between a line Z in a direction of magnetization and the first extension line X1, and X indicates the magnetizing angle of the third magnets M2, M3, M4, M6, M7, and M8.

[95] A direction G in which each of the third magnets M2, M3, M4, M6, M7, and M8 is magnetized may be symmetric to the middle line Y.

[96] FIG. 6 is a view showing eddy current loss in the embodiment of the BLDC motor according to the present invention and eddy current loss in a comparative example, and FIG. 7 is a view showing eddy current loss in the rotor based on the number of magnets in the embodiment of the BLDC motor according to the present invention.

[97] In a case in which the rotor 12 includes 6 divided magnets, these magnets may include one first magnet M1, one second magnet M5, and four third magnets. In a case in which the rotor 12 includes 8 divided magnets, these magnets may include one first magnet M1, one second magnet M5, and six third magnets. In a case in which the rotor 12 includes 10 divided magnets, these magnets may include one first magnet M1, one second magnet M5, and eight third magnets.

[98] In a case in which the rotor 12 of the BLDC motor 6 does not have a divided magnet type structure, eddy current loss in the rotor may be high. In a case in which the rotor 12 of the BLDC motor 6 is configured to have a divided magnet type structure having different magnetizing directions according to the present invention, eddy current loss in the rotor may be low.

[99] FIG. 6(H) is a view showing saturation of eddy current loss in the comparative example, and FIG. 6(I) is a view showing saturation of eddy current loss in the BLDC motor according to the present invention.

[100] Specifically, FIG. 6(H) is a view showing saturation of eddy current loss in a case in which a undivided magnet M is provided as a comparative example, and FIG. 6(I) is a view showing saturation of eddy current loss in a case in which 8 divided magnets are provided.

[101] It can be seen that the sum of the saturations of eddy current loss I1, I2, I3, I4, I5, and I6 shown in FIG. 6(I) is less than the sum of the saturations of eddy current loss H1, H2, H3, H4, H5, and H6 shown in FIG. 6(H). In addition, it can be seen that in a case in which the first magnet M1, the second magnet M5, and the third magnets M2, M3, M4, M6, M7, and M8, which have different magnetizing directions, surround the shaft 14, eddy current loss in the rotor is reduced.

[102] Meanwhile, in a case in which the number of divided magnets is 4 or less, the effect of magnet loss reduction in the BLDC motor 6 is not significant. According to the present invention, therefore, 6 or more magnets are provided. However, in a case in which the number of divided magnets is 12 or more, the number of parts may be increased, and the assembly process may be complicated, whereby productivity may be reduced.

[103] In the BLDC motor 6 according to the present invention, the number of divided magnets may be one selected from among 6, 8, and 10.

[104] Referring to FIG. 7, on the assumption that eddy current loss in the rotor is 100 % in a case in which the number of magnets is 6, eddy current loss in the rotor may be about 60 % in a case in which the number of magnets is 8, and eddy current loss in the rotor may be about 35 % in a case in which the number of magnets is 10. In the BLDC motor 6, therefore, the number of divided magnets may be one selected from among 6, 8, and 10.

Mode for the Invention

[105] Various embodiments have been described in the best mode for carrying out the invention.

Industrial Applicability

[106] The present invention is applied to the fields related to a brushless direct current (BLDC) motor and a cleaner having the same.

[107] Although the preferred embodiments of the present invention have been disclosed for illustrative purposes, those skilled in the art will appreciate that various modifications, additions and substitutions are possible, without departing from the scope and spirit of the invention as disclosed in the accompanying claims.

Claims

[Claim 1] A brushless direct current (BLDC) motor comprising:
a shaft made of a nonmagnetic material;
a plurality of magnets surrounding an outer circumference of the shaft;
a stator surrounding outer circumferences of the magnets, wherein
each of the magnets has:
an arc-shaped outer circumferential surface;
an arc-shaped inner circumferential surface facing the shaft; and
opposite side surfaces facing other adjacent magnets, and
the magnets comprise:
a first magnet magnetized in a direction directed from the outer circumferential surface to the inner circumferential surface;
a second magnet magnetized in a direction directed from the inner circumferential surface to the outer circumferential surface; and
a third magnet magnetized in a direction directed from one side surface to the other side surface.

[Claim 2] The BLDC motor according to claim 1, wherein the first magnet and the second magnet are opposite to each other while the shaft is located between the first magnet and the second magnet.

[Claim 3] The BLDC motor according to claim 1, wherein the third magnet is located between the first magnet and the second magnet in a circumferential direction.

[Claim 4] The BLDC motor according to claim 3, wherein the third magnet comprises a plurality of third magnets sequentially arranged along the outer circumference of the shaft.

[Claim 5] The BLDC motor according to claim 2, wherein
the third magnet comprises a plurality of left-side third magnets located on a left side of the second magnet, the shaft, and the first magnet and a plurality of right-side third magnets located on a right side of the second magnet, the shaft, and the first magnet, and
the left-side third magnets and the right-side third magnets are magnetized in the direction toward the second magnet.

[Claim 6] The BLDC motor according to claim 1, wherein each of the magnets is configured such that an angle between a first extension line connecting from a center of rotation of the shaft to the one side surface and a second extension line connecting from the center of rotation of the shaft to the other side surface is one selected from among 36 degrees, 45

degrees, and 60 degrees.

[Claim 7] The BLDC motor according to claim 1, further comprising a sleeve surrounding the magnets, the sleeve being made of carbon fiber.

[Claim 8] The BLDC motor according to claim 1, wherein the shaft is made of stainless steel (STS).

[Claim 9] A cleaner comprising:
a BLDC motor having a shaft;
an impeller mounted at the shaft; and
an impeller cover surrounding the impeller, the impeller cover being configured to guide air driven by the impeller into the BLDC motor, wherein
the BLDC motor comprises:
a plurality of magnets surrounding an outer circumference of the shaft; and
a stator surrounding outer circumferences of the magnets,
each of the magnets has:
an arc-shaped outer circumferential surface;
an arc-shaped inner circumferential surface facing the shaft; and
opposite side surfaces facing other adjacent magnets, and
the magnets comprise:
a first magnet magnetized in a direction directed from the outer circumferential surface to the inner circumferential surface;
a second magnet magnetized in a direction directed from the inner circumferential surface to the outer circumferential surface; and
a third magnet magnetized in a direction directed from one side surface to the other side surface.

[Claim 10] The cleaner according to claim 9, wherein the first magnet and the second magnet are opposite to each other while the shaft is located between the first magnet and the second magnet.

[Claim 11] The cleaner according to claim 9, wherein the third magnet is located between the first magnet and the second magnet in a circumferential direction.

[Claim 12] The cleaner according to claim 11, wherein the third magnet comprises a plurality of third magnets sequentially arranged along the outer circumference of the shaft.

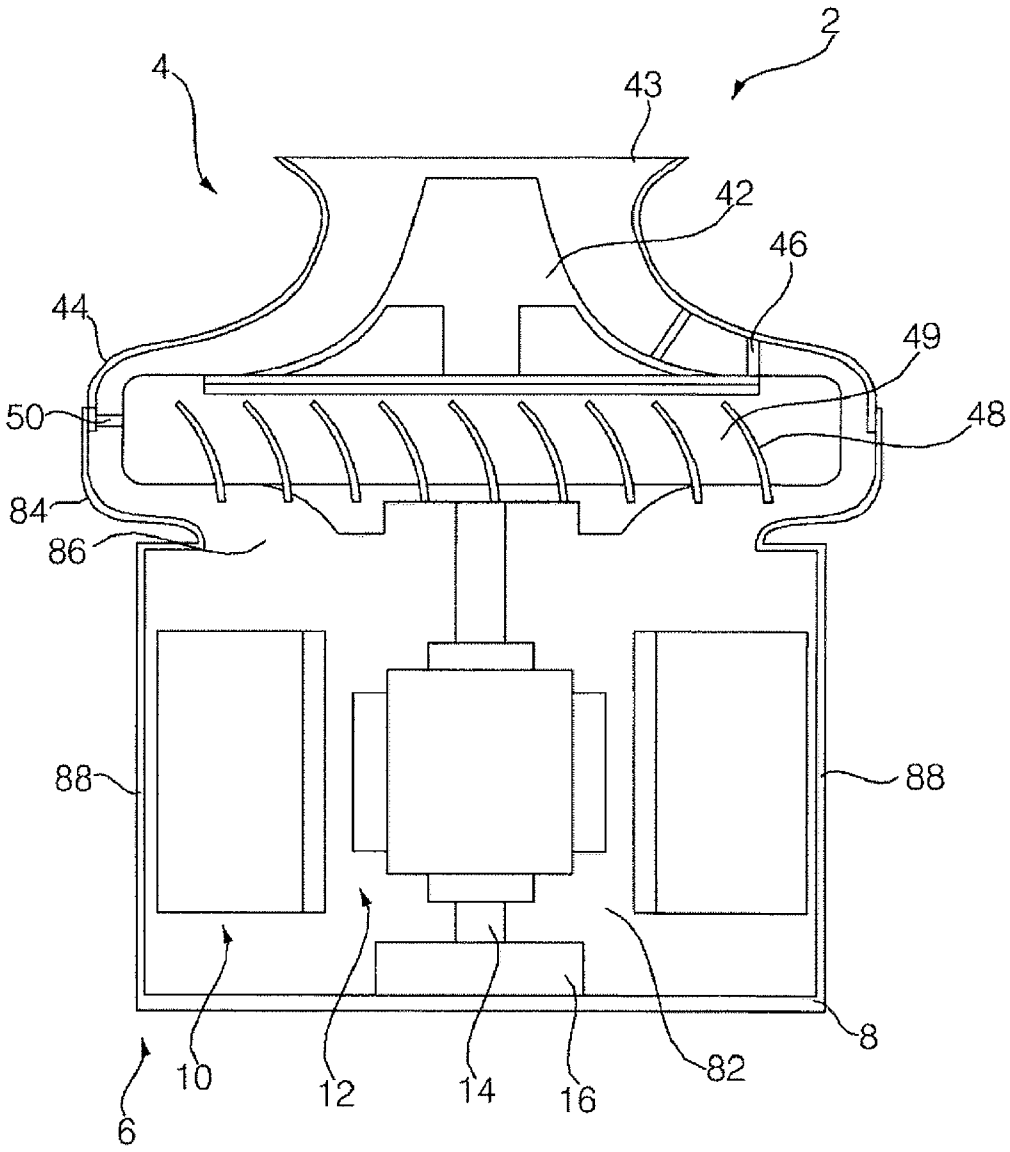
[Claim 13] The cleaner according to claim 10, wherein
the third magnet comprises a plurality of left-side third magnets located on a left side of the second magnet, the shaft, and the first magnet and a

plurality of right-side third magnets located on a right side of the second magnet, the shaft, and the first magnet, and
the left-side third magnets and the right-side third magnets are magnetized in the direction toward the second magnet.

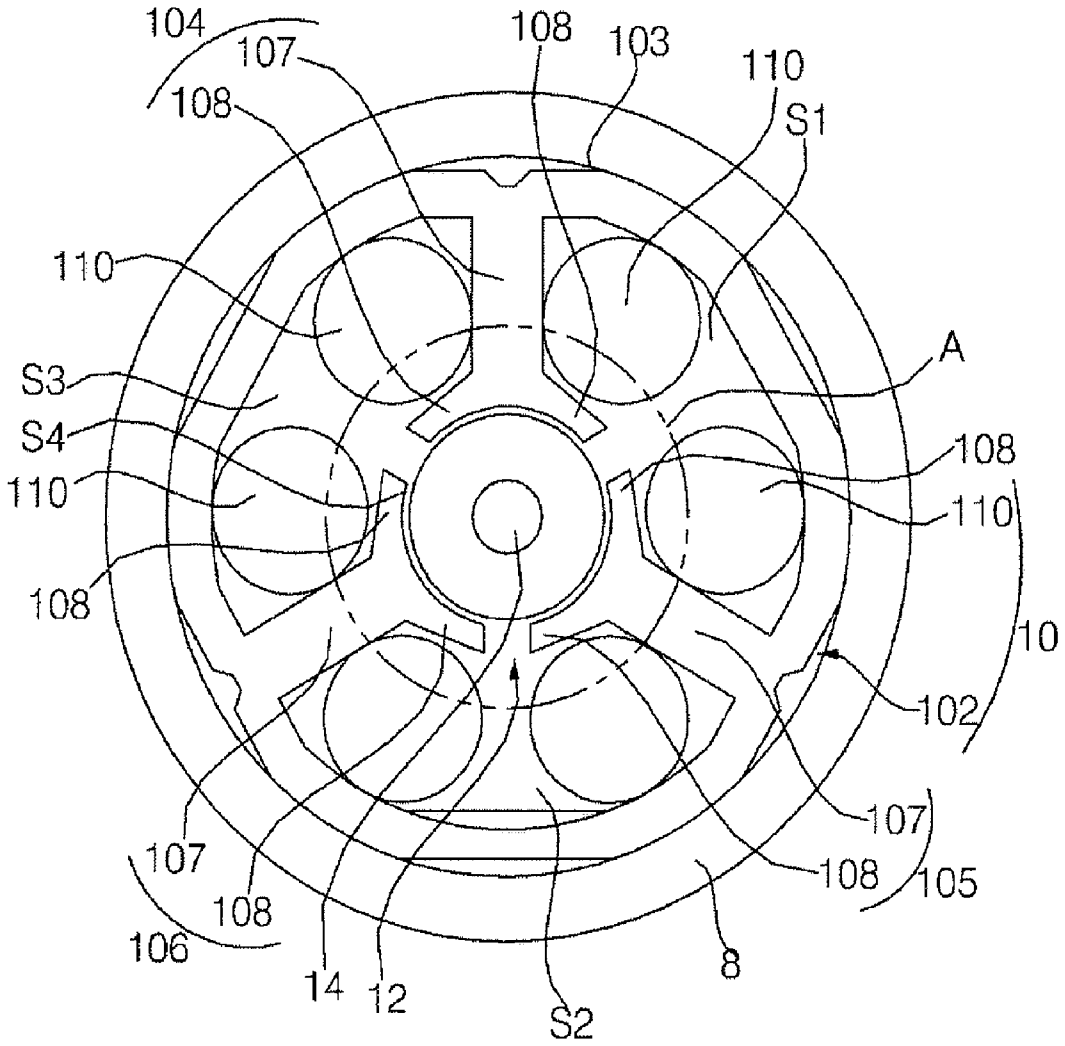
[Claim 14] The cleaner according to claim 9, wherein each of the magnets is configured such that an angle between a first extension line connecting from a center of rotation of the shaft to the one side surface and a second extension line connecting from the center of rotation of the shaft to the other side surface is one selected from among 36 degrees, 45 degrees, and 60 degrees.

[Claim 15] The cleaner according to claim 9, wherein the BLDC motor further comprises a sleeve surrounding the magnets, the sleeve being made of carbon fiber.

[Fig. 1]



[Fig. 2]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A
S3
S4
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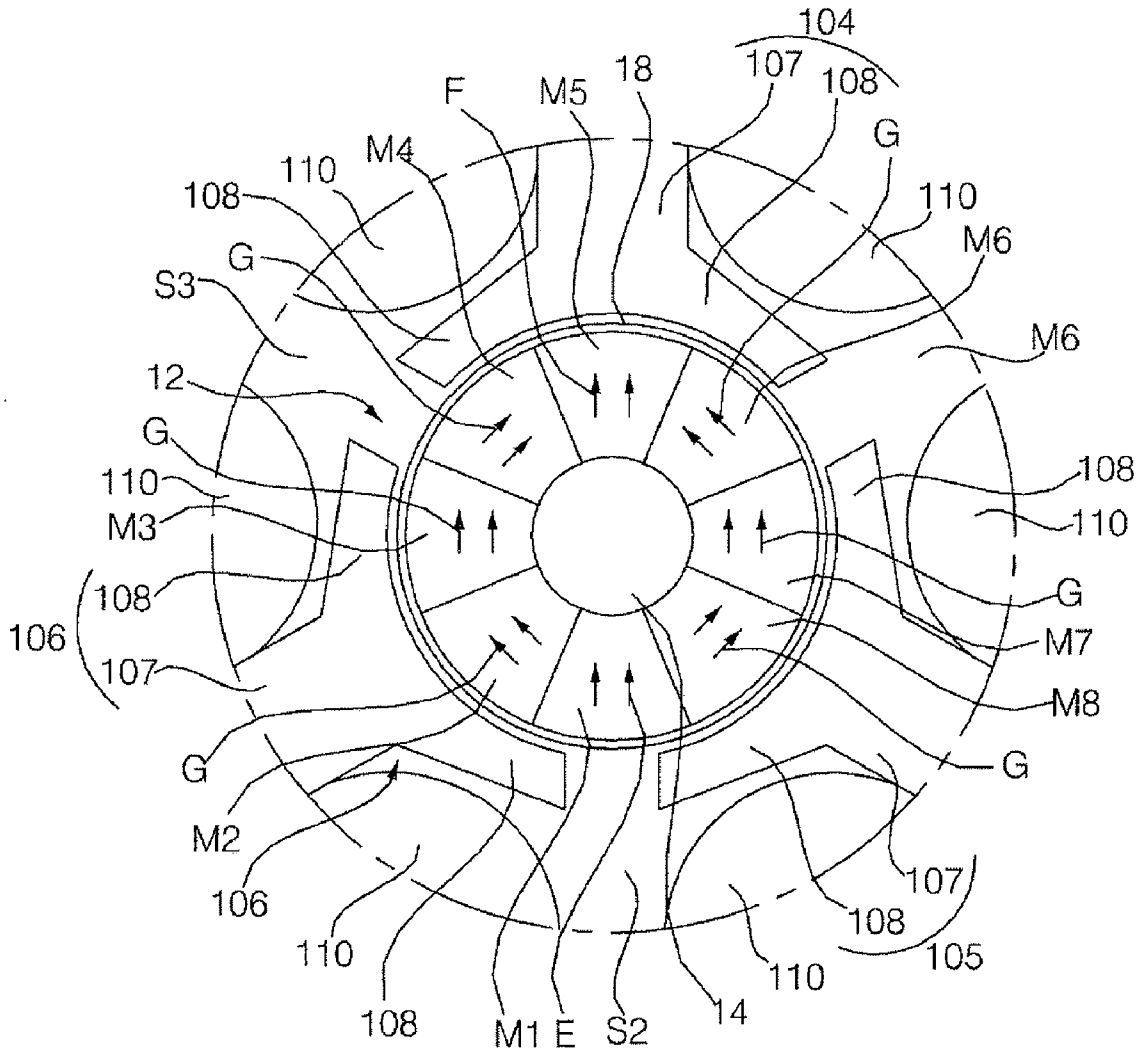
105
106
14
12
S2
8

[Fig. 3]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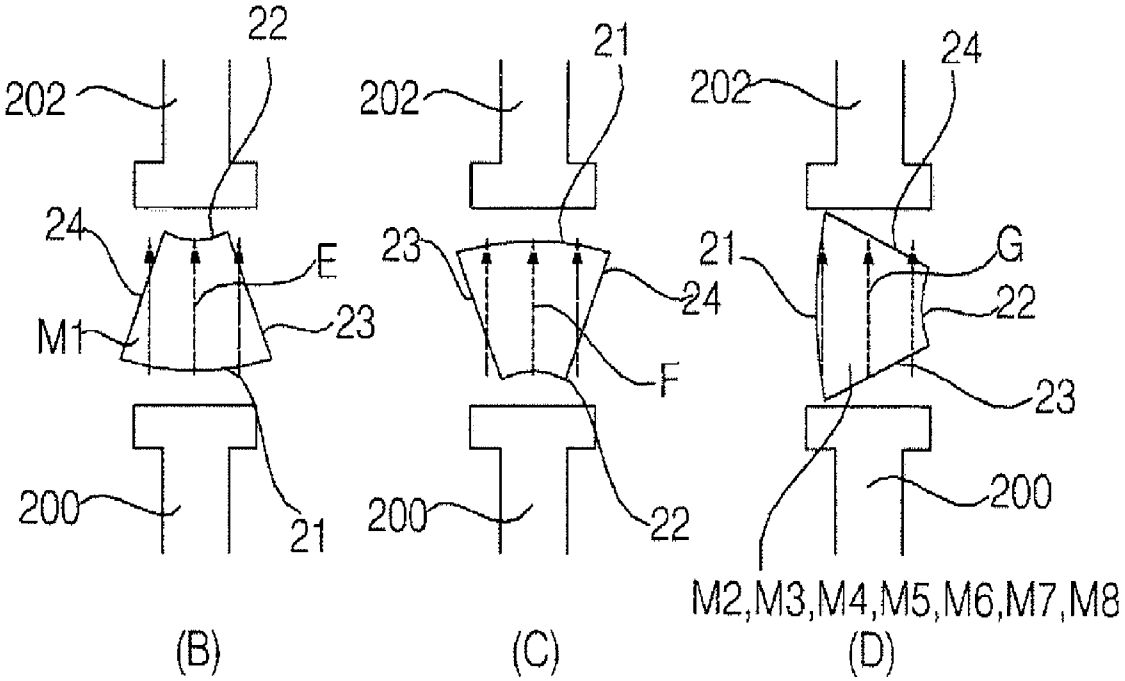
108
106
107
G
M2
106
110
108
M1
E
S2
14
110
107
108
105
G
M8
M7
G
108
110

[Fig. 4]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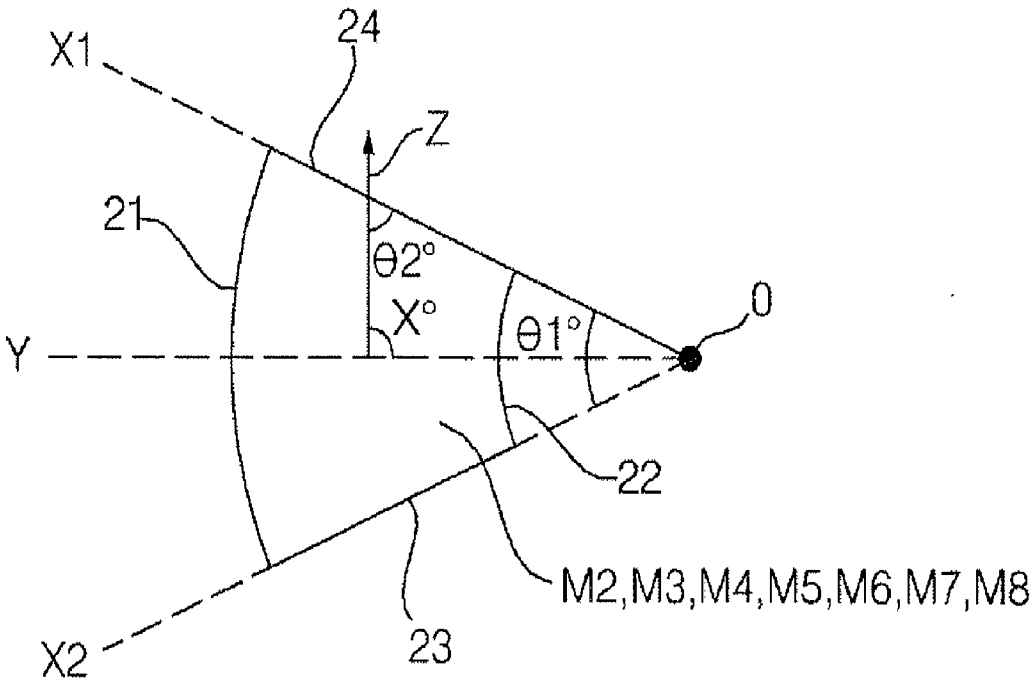
202
24
E
M1
23
200
21
(B)
21
202
23
24
F
200
22
(C)
24
202
21
G
22
23
200
M2,M3,M4,M5,M6,M7,M8
(D)

[Fig. 5]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24
Z
21
θ2°
X°
θ1°
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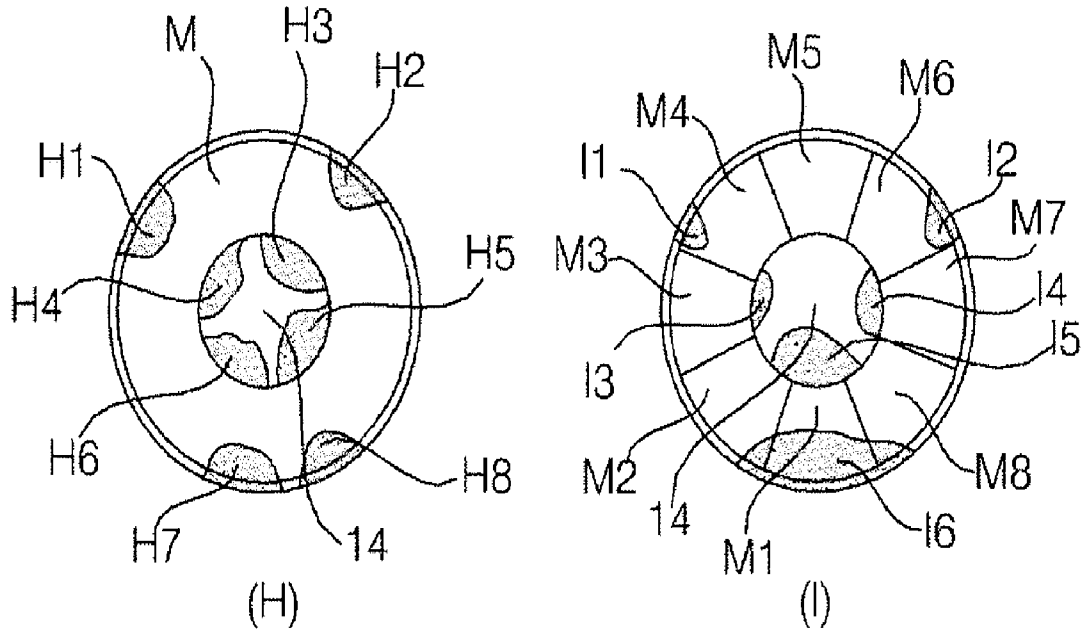
23
X2

[Fig. 6]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H1
H5
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H6
H8
H7
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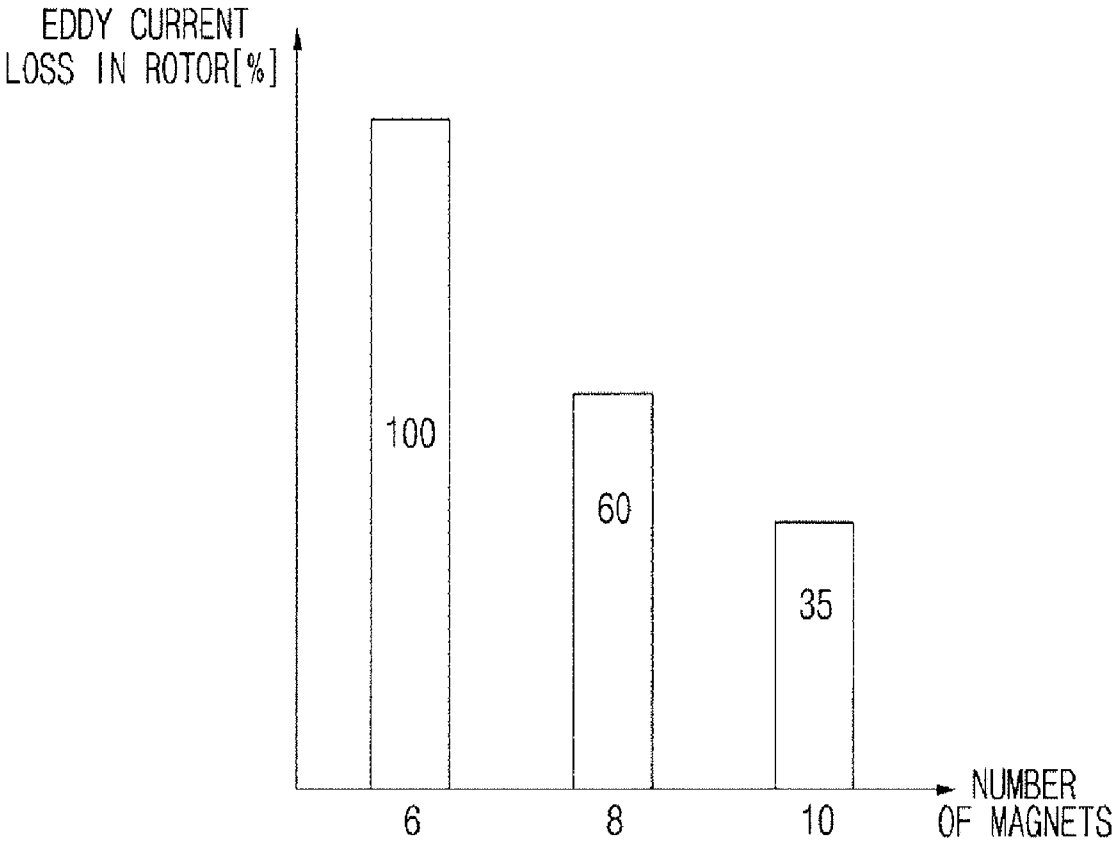
I4
I5
I3
M2
M8
14
M1
I6
(I)

[Fig. 7]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35
6
8
10
NUMBER
OF MAGNETS

INTERNATIONAL SEARCH REPORT

International application No.
PCT/KR2016/000956

A. CLASSIFICATION OF SUBJECT MATTER

H02K 1/27(2006.01)i, A47L 9/28(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H02K 1/27; H01L 43/12; H01F 7/02; H02K 15/03; H02K 21/14; H02K 1/04; A47L 9/28

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Korean utility models and applications for utility models
Japanese utility models and applications for utility models

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
eKOMPASS(KIPO internal) & Keywords: motor, rotor, stator, magnet, field, current loss, shaft, arc-shaped, circumferential, direction

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	JP 2002-354721 A (HITACHI LTD.) 06 December 2002 See abstract, paragraphs 13-33 and figures 1-4, 7.	1-6,8
Y		7,9-15
Y	JP 09-149572 A (TOSHIBA CORP.) 06 June 1997 See paragraphs 39-67, claims 1-5 and figures 1-5.	7,15
Y	KR 10-2014-0145059 A (SAMSUNG ELECTRONICS CO., LTD.) 22 December 2014 See abstract, paragraphs 38-63 and figures 1-2.	9-15
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A	KR 10-2012-0048511 A (SHIN-ETSU CHEMICAL CO., LTD.) 15 May 2012 See abstract, paragraphs 35-50 and figures 1-4.	1-15

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

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"P" document published prior to the international filing date but later than the priority date claimed
"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
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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents,such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
07 June 2016 (07.06.2016)	**07 June 2016 (07.06.2016)**

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Form PCT/ISA/210 (second sheet) (January 2015)

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/KR2016/000956

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