

DESCRIPTION

BRUSHLESS DC MOTOR

5 TECHNICAL FIELD

[0001] The present disclosure relates to a brushless DC motor provided on a ceiling fan.

BACKGROUND ART

[0002] A brushless DC motor including a stator has been known. For example, PTL 1
10 describes a stator of an electric motor. The stator includes a stator core covered with a
covering member made of an insulating resin, a coil wound around the stator core from
above the covering member, and a jumper wire housing provided on one end face of the
covering member in an axial direction and extending in a circumferential direction in
which a jumper wire of the coil is housed. A jumper wire introduction notch for
15 introducing the coil jumper wire from the coil to the jumper wire housing is provided in the
covering member. The stator is manufactured by integrally molding resin on the stator
core.

Citation List

Patent Literature

20 [0003] PTL 1: Unexamined Japanese Patent Publication No. 2003-204645

SUMMARY OF THE INVENTION

[0004] In a ceiling fan on which the brushless DC motor is mounted, it is desirable to
provide a height of a blade from a floor surface at a high position from the viewpoint of
25 dispersing an air flow in a wide range. Thus, when a ceiling height is determined, it is
advantageous that a housing of the ceiling fan is vertically short. In order to shorten a
vertical length of the housing, it is necessary to reduce a thickness of the brushless DC
motor incorporated in the housing.

[0005] In order to reduce the thickness of the motor, it is conceivable to reduce a
30 thickness of the resin provided in the stator core. However, in the stator described in PTL
1, since a core is integrally molded with the resin, when the resin covering the stator core is
thinned, there is a problem that the resin is easily cracked due to a difference in thermal
expansion between a steel plate of the core and the resin, and it is disadvantageous for

thinning the motor.

[0006] Alternatively, it is conceivable to reduce the height of the resin provided in the stator core in order to reduce the thickness of the motor. However, in the stator described in PTL 1, since three or more jumper wires are housed in parallel to the jumper wire

5 storage, a jumper wire storage side wall needs to have a predetermined height or more, and it is disadvantageous in reducing the thickness of the motor.

[0007] The present disclosure has been made to solve the above problems, and an object of the present disclosure is to provide a brushless DC motor capable of reducing a thickness of a ceiling fan.

10 [0008] In order to solve the above problem, a brushless DC motor according to an aspect of the present disclosure is a brushless DC motor provided on a ceiling fan. The brushless DC motor includes a stator core that has a plurality of teeth extending in a radial direction, and a plurality of slots provided between the plurality of teeth, a plurality of insulating sheets that are provided in the plurality of slots, and have sheet protrusions protruding from
15 end faces of the teeth, and insulating members that each have an annular base and an advancing portion extending in a radial direction along the end faces of the teeth from the base and advancing between adjacent two sheet protrusions.

[0009] In order to solve the above problem, a brushless DC motor according to another aspect of the present disclosure is a brushless DC motor provided on a ceiling fan. The
20 brushless DC motor includes a stator that has a stator core constructed by connecting a plurality of teeth extending in a radial direction in an annular shape, and coil bodies wound around the stator core, a shaft that is fixed to a central portion of the stator core, and a rotor that has a magnet surrounding the stator core. The stator includes an insulating member that secures insulation between jumper wires connecting the coil bodies to an end
25 in an axial direction, the insulating member includes a disk plane positioned closer to the stator core than an end of the coil body in an axial direction on an inner peripheral side of the coil body, and the jumper wires are wired along the disk plane.

[0010] The expressions of the present disclosure among methods, devices, systems, recording media, and computer programs are also effective as aspects of the present
30 disclosure.

[0011] According to the present disclosure, it is possible to provide the brushless DC motor capable of reducing the thickness of the ceiling fan.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] Fig. 1 is a perspective view illustrating a ceiling fan on which a motor according to an exemplary embodiment is provided.

5 Fig. 2 is a cross-sectional view illustrating a peripheral structure of the motor of Fig. 1.

Fig. 3 is an exploded perspective view of the motor of Fig. 1.

Fig. 4 is a side view illustrating a stator of the motor of Fig. 1.

Fig. 5 is a bottom view illustrating a circuit board of the motor of Fig. 1.

10 Fig. 6 is a block diagram illustrating a configuration of a circuit board of the motor of Fig. 1.

Fig. 7 is a perspective view illustrating a stator assembly of the motor of Fig. 1.

Fig. 8 is a perspective view illustrating a first example of an insulating member of the motor of Fig. 1.

15 Fig. 9 is a perspective view illustrating a second example of the insulating member of the motor of Fig. 1.

Fig. 10A is a perspective view illustrating the stator assembly of the motor of Fig. 1.

Fig. 10B is a connection diagram of the stator assembly of the motor of Fig. 1.

Fig. 11 is a plan view illustrating the stator assembly of the motor of Fig. 1.

20 Fig. 12 is an enlarged view illustrating a disk plane of the stator assembly of the motor in Fig. 1.

DESCRIPTION OF EMBODIMENTS

[0013] Hereinafter, exemplary embodiments of the present disclosure will be described with reference to the accompanying drawings. Same reference marks are assigned to same or equivalent components and members illustrated in exemplary embodiments and modifications. Explanation for the same or equivalent components and members will not be repeated as appropriate. Dimensions of members in the drawings are appropriately enlarged or reduced to facilitate understanding. From each of the drawings, some of members not important for describing the exemplary embodiments are omitted.

[0014] Terms including ordinal numbers such as first and second are used to describe various components, but the terms are used only for the purpose of distinguishing one component from other components, and the components are not limited by the terms.

[0015] (First exemplary embodiment)

Motor 10 according to the exemplary embodiment of the present disclosure is a brushless DC motor provided on ceiling fan 1. First, an entire configuration of ceiling fan 1 will be described. Fig. 1 is a perspective view illustrating ceiling fan 1. Ceiling fan 1 is attached to ceiling 4 and functions as an electric fan having a plurality of blades 2 that rotate to generate an air flow. Ceiling fan 1 includes motor 10 that rotates the plurality of blades 2, and housing 5 that extends downward from ceiling 4 and surrounds motor 10. Illumination unit 3 having a light emitting element such as an LED is provided at a lower end of ceiling fan 1.

[0016] Housing 5 has substantially conical first portion 5a of which a diameter gradually decreases downward from a ceiling side, and substantially conical second portion 5b of which a diameter gradually increases downward from a lower portion of first portion 5a. Connection portion 5c between first portion 5a and second portion 5b is narrower than first portion 5a and second portion 5b. A lower portion of second portion 5b has a cylindrical shape with a constant diameter. Second portion 5b functions as an outer shell that houses motor 10.

[0017] Next, the description is continued with reference to Figs. 2 to 4. Fig. 2 is a cross-sectional view illustrating a peripheral structure of motor 10 of ceiling fan 1. Fig. 3 is an exploded perspective view of motor 10. Fig. 4 is a side view illustrating stator 20. Motor 10 mainly includes stator 20, shaft 30, rotor 40, first bearing 32, second bearing 34, circuit board 48, blade holder 70, and rotation detector 400. Hereinafter, a direction along central axis La of shaft 30 is referred to as an "axial direction", and a circumferential direction and a radial direction of a circle with central axis La as a center are referred to as a "circumferential direction" and a "radial direction", respectively. Hereinafter, for the sake of convenience, one side in the axial direction (upper side in the drawing) is referred to as "upper" and "upward", and the other side (lower side in the drawing) will be referred to as "lower" and "downward". Such directional notation does not restrict a use posture of motor 10, and motor 10 can be used in any posture.

[0018] First, operations of motor 10 and ceiling fan 1 will be described. In ceiling fan 1, stator 20, shaft 30, circuit board 48, and rotation detector 400 constitute a stationary body, and rotor 40, blade holder 70, and the plurality of blades 2 constitute a rotating body. Circuit board 48 supplies a drive current to stator 20 based on a detection signal of rotation detector 400. Stator 20 generates a rotating magnetic field in accordance with the drive

current. Rotor 40 rotates about central axis La in accordance with the rotating magnetic field. Blade holder 70 rotates the plurality of blades 2 by rotating integrally with rotor 40. The plurality of blades 2 rotate to generate a downward air flow. Hereinafter, each portion will be described in detail.

5 **[0019]** First bearing 32, rotor 40 and stator 20, circuit board 48, and second bearing 34 are arranged in this order from an upper side to a lower side, and surround shaft 30. Rotor 40 is disposed opposite to stator 20 in the radial direction. Rotor 40 and stator 20 have diameters larger than first bearing 32, and circuit board 48 has a diameter larger than rotor 40 and stator 20. Shaft 30 is a pipe-shaped member having a hollow portion for causing a
10 wire for wiring to pass through in a central portion. Lateral hole 30h vertically penetrating and causing a wire to pass through a side surface of shaft 30 is provided in the hollow portion of shaft 30.

[0020] Stator 20 includes stator core 22 around which coil 24 is wound. Coil 24 constitutes a three-phase armature coil. Shaft 30 is fixed to a central portion of stator core
15 22. Rotor 40 includes magnet 42 surrounding stator core 22 and is fixed to an outer ring of first bearing 32.

[0021] Stator core 22 includes a plurality of (for example, 12) teeth 22t and a plurality of slots 22s provided between the plurality of teeth 22t. Each slot 22s is opened to opening 22k of stator core 22. Insulating sheet 23 made of a resin film is inserted into each slot 22s.
20 Insulating sheet 23 includes slot insulator 23b that covers an inner side surface (surface on slot 22s side) of tooth 22t and slot key 23c provided on an outer peripheral side of slot 22s. Insulating sheet 23 in this example protrudes in the axial direction from an end face of teeth 22t. Insulating members 200 are provided on an upper surface and a lower surface of stator core 22, respectively. Insulating member 200 functions as a core cover that covers a
25 part of each tooth 22t. Insulating member 200 is a resin member formed by molding.

[0022] Coil 24 includes a plurality of (for example, 12) coil bodies 22a wound around teeth 24t, respectively. The plurality of coil bodies 24a are connected in series for phases. A terminal of coil body 24a of each phase is connected to a motor drive circuit to be described later.

30 **[0023]** Rotor 40 includes rotor yoke 44. Rotor yoke 44 includes hollow disk-shaped top plate 44a, cylindrical magnet support 44b extending downward from an outer peripheral portion of top plate 44a, and donut-shaped extension portion 44c extending outward in the radial direction from a lower portion of magnet support 44b. A central portion of top plate

44a is fixed to the outer ring of first bearing 32. Magnet 42 is fixed to an inner peripheral surface of magnet support 44b. An outer peripheral portion of extension portion 44c is fixed to blade holder 70 by male screw S1.

[0024] Magnet 42 has a plurality of (for example, 10) magnetic poles that supply a field magnetic flux to stator core 22. Magnet 42 is divided into a plurality of segments. As illustrated in Fig. 4, an upper end and a lower end of magnet 42 extend up and down by a predetermined dimension (for example, 5 mm) of stator core 22.

[0025] As illustrated in Fig. 3, rotor 40 includes magnet holder 300 that holds magnet 42 at a predetermined position. Magnet holder 300 is disposed above and below magnet 42, and restricts a position of magnet 42 in the axial direction. Magnet holder 300 includes first holder 310 disposed below magnet 42 and second holder 320 disposed above magnet 42. An outer peripheral portion of first holder 310 is locked to rotor yoke 44 to restrict downward movement of magnet 42. Second holder 320 restricts upward movement of magnet 42. First holder 310 and second holder 320 are substantially ring-shaped resin members that are elastically deformable.

[0026] As illustrated in Fig. 2, first bearing 32 and second bearing 34 are rolling bearings having rolling elements 33 such as balls. Inner rings of first bearing 32 and second bearing 34 are fixed to shaft 30 via E washers 32c and 34c. First bearing 32 and second bearing 34 are arranged to be vertically separated from each other with stator core 22 and circuit board 48 interposed therebetween. First bearing 32 is disposed above stator core 22. Second bearing 34 is disposed below circuit board 48 on a side of stator core 22 opposite to first bearing 32.

[0027] The description is continued with reference to Figs. 5 and 6. Fig. 5 is a bottom view illustrating circuit board 48. Fig. 6 is a block diagram illustrating a configuration of circuit board 48. Circuit board 48 includes wiring board 50, primary-side power supply circuit 51, secondary-side power supply circuit 52, and motor drive circuit 53. Primary-side power supply circuit 51, secondary-side power supply circuit 52, and motor drive circuit 53 are provided on wiring board 50. Wiring board 50 is a printed circuit board.

[0028] Primary-side power supply circuit 51 rectifies an input AC voltage (for example, 220 V to 240 V) and supplies first DC voltage V1 (for example, 310 V to 340 V). Secondary-side power supply circuit 52 supplies second DC voltage V2 of 15 V and third DC voltage V3 of 5 V by DC-DC converters 52a and 52b based on the first DC voltage.

[0029] Motor drive circuit 53 includes microprocessor 53a, controller 53b, and switching

unit 53c, and supplies a drive current to coil 24. First DC voltage V1 is mainly supplied to switching unit 53c. Second DC voltage V2 is mainly supplied to controller 53b.

[0030] Third DC voltage V3 is mainly supplied to microprocessor 53a. Controller 53b generates an FG signal based on position signals Hs acquired from Hall elements HE1,

5 HE2, and HE3 of rotation detector 400, and outputs the FG signal to microprocessor 53a.

[0031] Microprocessor 53a generates rotation control signal Cs for controlling the rotation of motor 10 based on the FG signal output from controller 53b, and outputs rotation control signal Cs to controller 53b. Controller 53b generates phase switching signal Qs for energization phase switching based on position signals Hs acquired from the
10 Hall elements of rotation detector 400. Controller 53b generates PWM signal Ps based on rotation control signal Cs and phase switching signal Qs output from microprocessor 53a, and outputs PWM signal Ps to switching unit 53c.

[0032] Switching unit 53c includes a switching element (not illustrated) constituting a three-phase bridge. Switching unit 53c controls energization and non-energization of the
15 switching element based on PWM signal Ps output from controller 53b, and causes a drive current to flow to coil 24. Controller 53b and switching unit 53c constitute a three-phase inverter. Switching unit 53c of the present exemplary embodiment is realized by a one-chip motor drive IC.

[0033] As illustrated in Fig. 5, circuit board 48 of the present exemplary embodiment
20 further includes sub-wiring board 49, illumination drive circuit 55 that drives illumination unit 3, and communication circuit 56 that communicates with a remote controller (not illustrated) that remotely operates ceiling fan 1. Illumination drive circuit 55 is provided on sub-wiring board 49, and communication circuit 56 is provided on wiring board 50. Sub-wiring board 49 is a printed circuit board.

[0034] As illustrated in Fig. 4, circuit board 48 has a ring shape surrounding shaft 30, and is provided between stator core 22 and second bearing 34 in the axial direction. Circuit board 48 is supported by stator core 22 by fixing wiring board 50 to stator core 22 via board holder 100. Sub-wiring board 49 is fixed to a lower surface of wiring board 50 via board holder 60. As illustrated in Fig. 5, wiring board 50 is a ring-shaped circular member
30 having center hole 50h, and sub-wiring board 49 is a partial member in a ring shape.

[0035] As illustrated in Fig. 5, wiring connection component 58 such as a connector for connecting a wiring is mounted on lower surface 50j of wiring board 50 opposite to stator core 22. Wiring connection component 58 in this example is a male connector. As a result,

at the time of assembling motor 10, since a female connector in which a lead wire is connected to wiring connection component 58 can be easily attached and detached in a state where circuit board 48 is fixed to stator core 22 via board holder 100, assembly workability and maintenance are improved. Since wiring board 50 can be brought close to stator core 22, it is advantageous for thickness reduction.

[0036] As illustrated in Fig. 4, electronic component 51p constituting primary-side power supply circuit 51 is mounted on lower surface 50j of wiring board 50 opposite to stator core 22. As a result, since heat generated in electronic component 51p is blocked by wiring board 50, heat conduction to stator 20 and rotor 40 is reduced, a temperature rise of coil 24 is suppressed, and deterioration in quality can be prevented.

[0037] As illustrated in Fig. 3, heat dissipating portion 46 that dissipates heat of motor drive circuit 53 is provided between board holder 100 and wiring board 50. Heat dissipating portion 46 promotes heat dissipation of the motor drive IC (switching unit 53c) of motor drive circuit 53 to suppress the temperature rise.

[0038] As illustrated in Fig. 4, rotation detector 400 includes Hall elements HE1, HE2, and HE3 that detect a magnetic flux of magnet 42, and HE holder 410. Hall elements HE1, HE2, and HE3 are arranged at positions shifted by 120 degrees at an electrical angle in the circumferential direction. Hall element HE2 is disposed at a position of predetermined opening 22k (hereinafter, referred to as opening 22k(H)) in the circumferential direction. Input and output terminals of Hall elements HE1, HE2, and HE3 are connected to circuit board 48. Output signals of Hall elements HE1, HE2, and HE3 are input to controller 53b. HE holder 410 is a member that supports Hall elements HE1, HE2, and HE3, is held by board holder 100, and is sandwiched and fixed between wiring board 50 and stator core 22. HE holder 410 has protrusion 420 protruding upward to engage opening 22k(H).

[0039] As illustrated in Fig. 2, blade holder 70 rotates integrally with rotor 40, and transmits the rotation of rotor 40 to the plurality of (for example, 5) blades 2. Blade holder 70 is a hollow circular member, and includes holder cylindrical portion 70a, trumpet-shaped portion 70b extending downward in a trumpet shape from a lower portion of holder cylindrical portion 70a, hollow disk-shaped holder disk 70c extending inward in the radial direction from the lower portion of holder cylindrical portion 70a, and holder flange 70d extending outward in the radial direction from a lower portion of trumpet-shaped portion 70b.

[0040] As illustrated in Fig. 2, an upper portion of holder cylindrical portion 70a is fixed

to extension portion 44c of rotor yoke 44. Holder cylindrical portion 70a surrounds circuit board 48 via a gap. An outer ring of second bearing 34 is fixed to a central portion of holder disk 70c. The plurality of blades 2 are fixed to holder flange 70d. The plurality of blades 2 are arranged at predetermined intervals in the circumferential direction and extend outward in the radial direction from holder flange 70d. The lower portion of trumpet-shaped portion 70b surrounds an upper portion of illumination unit 3 through a gap. The upper portion of illumination unit 3 is fixed to a lower portion of shaft 30.

[0041] Insulating member 200 will be described with reference to Figs. 7, 8, and 9. Fig. 7 is a perspective view illustrating stator assembly 28. Stator assembly 28 includes stator core 22, insulating sheet 23, coil 24, insulating member 200, and connection pin 28p. As described above, insulating member 200 is a resin member formed by molding. As illustrated in Fig. 7, insulating sheet 23 includes slot insulator 23b and slot key 22c that closes an opening of slot 23s. Slot insulator 23b is inserted into slot 22s before coil 24 is wound. Slot key 23c is inserted into slot 22s after coil 24 is wound.

[0042] As described above, coil 24 includes 12 coil bodies 24a, jumper wire 24j connecting coil bodies 24a for the phases, and terminals 24e for the phases. When jumper wire 24j directly comes into contact with an end face of stator core 22, an insulation failure may occur there. Thus, in this example, insulating member 200 interposed between jumper wire 24j and stator core 22 is provided. Insulating member 200 has base 202 for supporting jumper wire 24j of coil 24. Base 202 has disk-shaped disk plane 202a that covers a central portion of the end face of stator core 22. Jumper wire 24j is wired along an end face (hereinafter, referred to as "upper surface") of disk plane 202a opposite to stator core 22.

[0043] Base 202 has hollow portion 202h provided at a center of disk plane 202a and circumferential wall 202b. Circumferential wall 202b protrudes in the axial direction from the upper surface of disk plane 202a at an edge of hollow portion 202h. A shaft penetrates an inner peripheral side of circumferential wall 202b. Circumferential wall 202b prevents jumper wire 24j from coming into contact with the shaft. Base 202 has pin support 202p for supporting connection pin 28p. Pin support 202p is a cylindrical protrusion protruding from the upper surface of disk plane 202a, and has a hole formed to press-fit connection pin 28p at the center.

[0044] Connection pin 28p is a wire-shaped conductive member extending in the axial direction. Connection pin 28p protrudes downward (toward circuit board 48) in the axial direction from stator core 22. Terminal 24e is connected to a base side of connection pin

28p by soldering or the like. A distal end side of connection pin 28p is connected to motor drive circuit 53 via wiring board 50. With this configuration, coil 24 is electrically connected to motor drive circuit 53. Three connection pins 28p for UVW phases and one connection pin for a middle point are fixed to insulating member 200. In this manner, base 202 supports connection pins 28p and functions as a terminal block for processing terminals 24e.

[0045] Fig. 8 is a perspective view illustrating a first example of insulating member 200. Insulating sheet 23 is provided in the plurality of slots 22s. Insulating sheet 23 has sheet protrusion 23e protruding from the end face of tooth 22t. Insulating member 200 includes annular base 202 and advancing portion 204 that extends in the radial direction from base 202 along the end face of tooth 22t and enters between two adjacent sheet protrusions 23e. In this case, when coil 24 is wound around tooth 22t, advancing portion 204 enters inside coil 24. The movement of advancing portion 204 is restricted by being sandwiched between tooth 22t and coil 24. As a result, insulating member 200 is held on stator core 22. A shape of base 202 is the same as the shape described in Fig. 7, and redundant description will be omitted.

[0046] In order to stably hold insulating member 200, a pair of advancing portions 204 may be provided at positions separated from each other by 180° in the circumferential direction. The pair of advancing portions 204 extend in directions opposite to each other in the radial direction. Insulating member 200 may have only the pair of advancing portions 204 arranged with the center interposed therebetween. In this case, the number of advancing portions 204 is minimized, and thus, a mold can be simplified. As a result, the amount of resin used can be reduced.

[0047] In the example of Fig. 8, four advancing portions 204 are provided at intervals of 90° in the circumferential direction. In this case, insulating member 200 can be held more stably.

[0048] Fig. 9 is a perspective view illustrating a second example of insulating member 200. The present exemplary embodiment employs the second example. A shape of base 202 is the same as the shape described in Fig. 7, and redundant description will be omitted. When an extension length of advancing portion 204 is short, it may not be possible to secure an insulation distance between coil 24 and stator core 22. Thus, in the second example, as illustrated in Fig. 9, advancing portion 204 extends to outer peripheral end 22e of stator core 22. In this case, as illustrated in Fig. 7, since advancing portion 204 is

interposed between coil 24 and stator core 22, the insulation distance therebetween can be secured.

[0049] A width of advancing portion 204 in the circumferential direction may be smaller than a width of the portion of tooth 22t around which coil 24 is wound in the

5 circumferential direction. In a state where coil 24 is wound, sheet protrusion 23e is bent, and insulation of a corner of tooth 22t can be secured. In this case, bent sheet protrusion 23e may be brought into contact with advancing portion 204.

[0050] In some cases, coil 24 protrudes to an outer peripheral side of stator core 22, and the insulation distance from stator core 22 may be insufficient. In order to prevent coil 24
10 from protruding, it is conceivable to perform varnish impregnation, but it is disadvantageous in terms of manufacturing cost. Thus, in the example of Fig. 9, insulating member 200 has overhanging portion 206 that protrudes from an outer peripheral end of advancing portion 204 to a side opposite to stator core 22. In this case, since an outer peripheral side of coil 24 is regulated by overhanging portion 206, it is possible to prevent
15 coil 24 from protruding to an outer periphery without impregnating the varnish. As a result, the insulation distance between stator core 22 and coil 24 can be secured.

[0051] When a width of overhanging portion 206 in the circumferential direction is larger than a width of advancing portion 204 in the circumferential direction, the protrusion of coil 24 can be restricted in a wider range. When the width of overhanging portion 206 in
20 the circumferential direction is smaller than the width of advancing portion 204 in the circumferential direction, the amount of resin used for insulating member 200 can be reduced. In the example of Fig. 9, the width of overhanging portion 206 in the circumferential direction is the same as the width of advancing portion 204 in the circumferential direction. When a protrusion height of overhanging portion 206 is too low,
25 an effect of regulating the projection of coil 24 becomes insufficient. When the protrusion height of overhanging portion 206 is too high, the overhanging portion becomes an obstacle when coil 24 is wound. Thus, the protrusion height of overhanging portion 206 is set to be substantially equal to a height of coil 24 from stator core 22.

[0052] From the viewpoint of securing insulation, it is desirable to provide insulating
30 members on both surfaces of stator core 22. From the viewpoint of workability, it is desirable to collectively arrange the terminal blocks for processing terminals 24e on the upper surface side. From these viewpoints, it is also conceivable to provide insulating member 200 having the terminal block (base 202) on the upper surface side of stator core

22 and provide the insulating member having no terminal block on the other lower surface side. However, in this case, a mold for molding is required for each insulating member, and it is disadvantageous in terms of manufacturing cost.

[0053] Thus, in the example of Fig. 9, insulating members 200 having the same shape are provided on both sides of stator core 22 in the axial direction. That is, insulating member 200 having the terminal block (base 202) is also provided on a lower surface side on which terminal 24e is not processed. In this case, since insulating members 200 having the same shape are used on both surfaces of stator core 22, the mold can be shared, and the mold cost can be reduced as compared with a case where separate molds are used. Both surfaces of stator core 22 are insulated with insulating members 200, and thus, desired insulating performance can be realized without impregnating coil 24 with varnish.

[0054] According to the present exemplary embodiment, since stator core 22 is not integrally molded with resin, the resin is hardly cracked due to a thermal expansion difference between a steel plate of stator core 22 and the resin. Thus, since a thickness of insulating member 200 can be reduced, a thickness of the brushless DC motor can be easily reduced. As a result, a vertical length of the ceiling fan can be shortened, the blades can be provided at high positions, and the air flow can be dispersed in a wide range. Since the downward air flow can be expanded in a wide range, comfort can be improved by reducing unevenness of an air volume near a floor. Interference with a person can be avoided. Since connection portion 5c of housing 5 can be thinned by thinning motor 10, a flow of air guided to blades 2 becomes smooth at this portion, and thus, it is advantageous for reduction of power consumption.

[0055] An outline of one aspect of the present disclosure is as follows. Brushless DC motor (10) according to an aspect of the present disclosure is a brushless DC motor provided on ceiling fan (1). The brushless DC motor includes stator core (22) that has a plurality of teeth (22t) extending in a radial direction, and a plurality of slots (22s) provided between the plurality of teeth (22t), a plurality of insulating sheets (23) that are provided in the plurality of slots (22s), and have sheet protrusions (23e) protruding from end faces of teeth (22t), and insulating members (200) that each have annular base (202) and advancing portion (204) extending in a radial direction along the end faces of teeth (22t) from base (202) and advancing between adjacent two sheet protrusions (23e).

[0056] A pair of advancing portions (204) may be arranged at positions separated from each other by 180° in a circumferential direction.

[0057] Advancing portion (204) may extend to outer peripheral end (22e) of stator core (22).

[0058] Insulating member (200) may have overhanging portion (206) protruding to a side opposite to stator core (22) from an outer peripheral end of advancing portion (204).

5 [0059] Insulating members (200) may be provided on both sides of stator core (22) in an axial direction, respectively.

[0060] (Second exemplary embodiment)

Insulating member 200 according to a second exemplary embodiment will be described with reference to Figs. 10A, 10B, 11, and 12. Fig. 10A is a perspective view
10 illustrating stator assembly 28. Fig. 10B is a connection diagram of stator assembly 28. Stator assembly 28 includes stator core 22, insulating sheet 23, coil 24, insulating member 200, and connection pin 28p. As described above, insulating member 200 is a resin member formed by molding. As illustrated in Fig. 10A, insulating sheet 23 includes slot insulator 23b and slot key 23c that closes an opening of slot 22s. Slot insulator 23b is
15 inserted into slot 22s before coil 24 is wound. Slot key 23c is inserted into slot 22s after coil 24 is wound.

[0061] As described above, coil 24 includes three-phase coil 24, that is, 12 coil bodies 24a of U-phase winding 240, V-phase winding 241, and W-phase winding 242, jumper wire 24j connecting coil bodies 24a of the phases, and terminals 24e of the phases. U-
20 phase winding 240 is continuously wound around U-phase winding 240a, U-phase winding 240b, U-phase winding 240c, and U-phase winding 240d in this order. The same applies to V-phase winding 241 and W-phase winding 242. When jumper wire 24j directly comes into contact with an end face of stator core 22, an insulation failure may occur there. Thus, in this example, insulating member 200 is interposed between jumper wire 24j and stator
25 core 22. Insulating member 200 has base 202 for supporting jumper wire 24j of coil 24. Base 202 has disk-shaped disk plane 202a that covers a central portion of the end face of stator core 22. Jumper wire 24j is wired along an end face (hereinafter, referred to as "upper surface") of disk plane 202a opposite to stator core 22. In a state in which coil 24 is wound, disk plane 202a is positioned on an inner peripheral side of an end of coil body 24a
30 in the axial direction, that is, on stator core 22 side (lower side in Fig. 10A) of the end of coil body 24a (upper side in Fig. 10A) in the axial direction. Disk plane 202a is a plane perpendicular to shaft 30.

[0062] As a result, jumper wire 24j crosses over a position lower than the end of coil

body 24a in the axial direction, and an end of stator assembly 28 in the axial direction substantially coincides with the end of coil body 24a in the axial direction. That is, since jumper wire 24j does not protrude outward from the end of coil body 24a in the axial direction, a height of insulating member 200, in other words, stator assembly 28 can be reduced, and motor 10 can be thinned.

[0063] Fig. 11 is a plan view illustrating stator assembly 28. From a viewpoint in the axial direction of shaft 30, one jumper wire 24j intersects different jumper wire 24j only at point 25 on disk plane 202a.

[0064] In the example of Fig. 11, jumper wire 24j for U-phase winding 240c positioned substantially opposite from U-phase winding 240b and jumper wire 24j for V-phase winding 241c positioned opposite from V-phase winding 241b intersect only at point 25. Here, the term "substantially opposite" refers to a relationship between a predetermined winding and a winding (tooth 22t) adjacent to a winding (tooth 22t) opposite to the winding, and is a concept included in the opposite. That is, the winding (tooth 22t) opposite to the predetermined winding refers to a winding exactly opposite to the predetermined winding and windings adjacent to both sides of the winding. Similarly, jumper wire 24j for U-phase winding 240c positioned substantially opposite from U-phase winding 240b and jumper wire 24j for W-phase winding 242c positioned opposite from W-phase winding 242b intersect only at point 25.

[0065] Jumper wire 24j for V-phase winding 241c positioned opposite from V-phase winding 241b and jumper wire 24j for W-phase winding 242c positioned opposite from W-phase winding 242b intersect only at point 25. Jumper wire 24j from U-phase winding 240b to U-phase winding 240c and terminal 24e from V-phase winding 241d to connection pin 28p also intersect only at point 25.

[0066] With the above configuration, since jumper wires 24j are not wired in parallel and intersect only at point 25, a possibility that the jumper wires come into contact with each other is reduced, and a layer short due to damage of an insulating film of coil 24 can be suppressed. Insulating member 200 does not require a complicated groove for storing the jumper wires wired in parallel, and has a small and simple structure of separation portion 26. As a result, the mold can be simplified.

[0067] Fig. 12 is an enlarged view illustrating disk plane 202a of stator assembly 28. Disk plane 202a includes separation portion 26 that separates jumper wires 24j from each other in the axial direction at a position where jumper wires 24j intersect at point 25. Separation

portion 26 is provided at a portion where jumper wires 24j intersect at an upper portion (upward in Fig. 12) of wall 27 that guides jumper wires 24j.

[0068] As a result, jumper wires 24j intersecting in the axial direction at point 25 can be vertically separated, the contact between jumper wires 24j can be eliminated, and the layer

5 short due to the damage of the insulating film of coil 24 can be suppressed.

[0069] Separation portion 26 is positioned at a position lower than the end of coil body 24a in the axial direction, and thus, jumper wires 24j can also be lower than the end of coil body 24a in the axial direction. As a result, the height of stator assembly 28 can be reduced and motor 10 can be thinned.

10 **[0070]** As illustrated in Fig. 12, circumferential wall 202b protrudes in the axial direction from the upper surface of disk plane 202a at the edge of hollow portion 202h. Shaft 30 penetrates the inner peripheral side of circumferential wall 202b. Circumferential wall 202b can prevent the insulation failure by preventing jumper wires 24j from coming into contact with shaft 30.

15 **[0071]** Circumferential wall 202b is set to be lower than the end of coil body 24a in the axial direction, and thus, the height of stator assembly 28 can be reduced. As a result, motor 10 can be thinned.

[0072] In circumferential wall 202b, jumper wire holder 29 may be provided on coil body 24a side, that is, on the outer peripheral side. As a result, it is possible to prevent jumper

20 wires 24j from falling off circumferential wall 202b and approaching shaft 30 side.
[0073] In Fig. 12, the outer peripheral wall is biased toward shaft 30 by arranging jumper wires 24j along an outer peripheral wall of circumferential wall 202b and connecting coil body 24a between opposite or substantially opposite teeth 22t. As a result, since positions of jumper wires 24j are easily determined and point 25 where jumper wires 24j intersect

25 each other is also easily determined, the winding by a winding machine is facilitated without complicated operation in the winding machine.

[0074] Since jumper wires 24j are biased toward shaft 30 along the outer peripheral wall of circumferential wall 202b, jumper wires 24j can be prevented from loosening.

[0075] According to the present exemplary embodiment, since jumper wires 24j are

30 positioned closer to stator core 22 than the end of coil body 24a in the axial direction, the height of insulating member 200 can be reduced. As a result, the brushless DC motor can be easily thinned. As a result, a vertical length of the ceiling fan can be shortened, the blades can be provided at high positions, and the air flow can be dispersed in a wide range.

Since the downward air flow can be expanded in a wide range, comfort can be improved by reducing unevenness of an air volume near a floor. Interference with a person can be avoided. Since connection portion 5c of housing 5 can be thinned by thinning motor 10, a flow of air guided to blades 2 becomes smooth at this portion, and thus, it is advantageous for reduction of power consumption.

[0076] The present disclosure has been described so far based on the exemplary embodiments. It is to be understood by those skilled in the art that this exemplary embodiment is an example, various modifications can be made to combinations of those components or processing processes, and such modifications are also within the scope of the present disclosure.

REFERENCE MARKS IN THE DRAWINGS

[0077]	1	ceiling fan
	4	ceiling
15	5	housing
	10	motor
	20	stator
	22	stator core
	23	insulating sheet
20	23e	sheet protrusion
	24	coil
	30	shaft
25	32	first bearing
	34	second bearing
	40	rotor
	42	magnet
	48	circuit board
30	50	wiring board
	51	primary-side power supply circuit
	52	secondary-side power supply circuit
	53	motor drive circuit
	58	wiring connection component
	60	board holder

	100	board holder
	200	insulating member
	204	advancing portion
	206	overhanging portion
5	400	rotation detector

CLAIMS

1. A brushless DC motor provided on a ceiling fan, comprising:

5 a stator core that includes a plurality of teeth extending in a radial direction, and a plurality of slots each provided between a corresponding pair of adjacent teeth among the plurality of teeth;

a plurality of insulating sheets each being provided in a corresponding one of the plurality of slots, and having a sheet protrusion protruding from end faces of teeth adjacent to the slot; and

10 an insulating member that has an annular base and advancing portions extending in a radial direction along the end faces of the plurality of teeth from the annular base, the advancing portions each advancing between a corresponding pair of adjacent sheet protrusions each being the sheet protrusion.

15 2. The brushless DC motor according to Claim 1, wherein a pair of the advancing portions are at positions separated from each other by 180° in a circumferential direction.

20 3. The brushless DC motor according to Claim 1 or 2, wherein each of the advancing portions extends to an outer peripheral end of the stator core.

4. The brushless DC motor according to Claim 3, wherein each of the insulating members has an overhanging portion protruding to a side opposite to the stator core from an outer peripheral end of the advancing portion.

25 5. The brushless DC motor according to any one of Claims 1 to 4, wherein the insulating members are provided on both sides of the stator core in an axial direction, respectively.

30 6. A brushless DC motor provided on a ceiling fan, comprising:
a stator that has a stator core constructed by connecting a plurality of teeth extending in a radial direction in an annular shape, and coil bodies wound around the stator core;

a shaft that is fixed to a central portion of the stator core; and
a rotor that has a magnet surrounding the stator core,
wherein the stator includes an insulating member that secures insulation between
jumper wires connecting the coil bodies to an end in an axial direction,

5 the insulating member includes a disk plane positioned closer to the stator core
than an end of each of the coil bodies in an axial direction on an inner peripheral side of
the each of the coil bodies, and
the jumper wires are wired along the disk plane.

10 7. The brushless DC motor according to Claim 6, wherein each of the jumper
wires intersects a different jumper wire only at a point on the disk plane from a viewpoint
in an axial direction of the shaft.

15 8. The brushless DC motor according to Claim 7, wherein the disk plane
includes a separation portion that separates the jumper wires from each other in the axial
direction at a position where the jumper wires intersect at the point.

20 9. The brushless DC motor according to Claim 6, further comprising a
circumferential wall that protrudes from an upper surface of the disk plane in an axial
direction on an inner peripheral side of the disk plane, and prevents the jumper wires from
coming into contact with the shaft.

25 10. The brushless DC motor according to Claim 9, wherein an outer peripheral
wall of the circumferential wall is biased to the shaft by arranging the jumper wires along
the outer peripheral wall and connecting the coil bodies between the opposite teeth.

11. The brushless DC motor according to Claim 6, wherein the disk plane is a
plane perpendicular to the shaft.