

DESCRIPTION

BRUSHLESS DC MOTOR

5 TECHNICAL FIELD

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

BACKGROUND ART

10 [0002] A ceiling fan on which a brushless DC motor is mounted has been known. For example, PTL 1 describes a ceiling fan in which blades for blowing air is provided at a distal end of a cylindrical housing extending downward from a ceiling. The ceiling fan includes a brushless DC motor for rotating the blades. The brushless DC motor includes a motor body including a stator and a rotor, and a drive circuit that drives the motor body. The drive circuit is disposed above the motor body in the housing.

15 Citation List

Patent Literature

[0003] PTL 1: Unexamined Japanese Patent Publication No. 2016-063678

SUMMARY OF THE INVENTION

20 [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 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 the housing up and down, it is necessary to reduce a thickness of the brushless DC motor in
25 which the motor body and the drive circuit are combined.

[0005] 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.

30 [0006] In order to solve the above problem, a brushless DC motor according to an aspect of the present invention is a brushless DC motor provided on a ceiling fan. The brushless DC motor includes a stator that has a stator core around which a coil is wound, a shaft that is fixed to a central portion of the stator core, a bearing, a rotor that has a magnet surrounding the stator core, and a circuit board that has a primary-side power supply circuit

between the stator core and the bearing in an axial direction, a secondary-side power supply circuit that converts a voltage supplied from the primary-side power supply circuit, and a motor drive circuit that supplies a drive current to the coil based on a power supplied from the secondary-side power supply circuit.

5 **[0007]** The expressions of the present disclosure among methods, devices, systems, recording media, and computer programs are also effective as aspects of the present disclosure.

[0008] According to the present disclosure, it is possible to provide the brushless DC motor capable of reducing the thickness of the ceiling fan.

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BRIEF DESCRIPTION OF THE DRAWINGS

[0009] Fig. 1 is a perspective view illustrating a ceiling fan on which a motor according to an exemplary embodiment is provided.

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

15 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.

20 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 of a board holder of the motor of Fig. 1 as viewed from a stator core side.

Fig. 8 is a cross-sectional view taken along line A-A of Fig. 4 illustrating a relationship between a board holder and a stator core.

25 Fig. 9 is an enlarged view of portion B of Fig. 8 illustrating positioning protrusions of the board holder and an opening of the stator core.

Fig. 10 is a perspective view of the board holder as viewed from the circuit board side.

30 Fig. 11 is an exploded perspective view illustrating a relationship between a heat dissipating portion of the stator and the circuit board.

Fig. 12A is a plan view illustrating a state where a lead wire is held by the stator.

Fig. 12B is a cross-sectional view taken along line C-C of Fig. 12A illustrating a state where the lead wire is held by the stator.

Fig. 13 is a cross-sectional view taken along line D-D of Fig. 12A illustrating a state where the heat dissipating portion is interposed between the board holder and the circuit board.

DESCRIPTION OF EMBODIMENTS

[0010] 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.

[0011] 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.

[0012] 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.

[0013] 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.

[0014] 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

5 "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.

10 **[0015]** 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

15 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.

[0016] First bearing 32, rotor 40 and stator 20, circuit board 48, and second bearing 34

20 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 wire for wiring to pass through in a central portion. Lateral hole 30h vertically penetrating

25 and causing a wire to pass through a side surface of shaft 30 is provided in the hollow portion of shaft 30.

[0017] 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 22. Rotor 40 includes magnet 42 surrounding stator core 22 and is fixed to an outer ring of

30 first bearing 32.

[0018] 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. A side surface of 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. 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
5 surface and a lower surface of stator core 22, respectively. Insulating member 200 functions as a core cover that covers a part of each tooth 22t. Insulating member 200 is a resin member formed by molding.

[0019] 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.
10 A terminal of coil body 24a of each phase is connected to a motor drive circuit to be described later.

[0020] 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
15 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.

[0021] Magnet 42 has a plurality of (for example, 10) magnetic poles that supply a field
20 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.

[0022] 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,
25 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
30 members that are elastically deformable.

[0023] 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.

5 **[0024]** 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
10 circuit 53 are provided on wiring board 50. Wiring board 50 is a printed circuit board.

[0025] 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.

15 **[0026]** 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.

[0027] 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, HE2, and HE3 of rotation detector 400, and outputs the FG signal to microprocessor 53a.
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[0028] 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 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.
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[0029] Switching unit 53c includes a switching element (not illustrated) constituting a three-phase bridge. Switching unit 53c controls energization and non-energization of the 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.
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5 [0030] As illustrated in Fig. 5, circuit board 48 of the present exemplary embodiment 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.

10 [0031] 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. Board holder 100 is positioned between stator core 22 and circuit board 48 and has substantially the same shape as an end of stator core 22 in the axial direction in axial view. As a result, since an insulation distance between coil 24 wound around stator core 22 and circuit board 48 can be secured, insulation safety can be kept high and thickness reduction can be realized. 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 having center hole 50h, and sub-wiring board 49 is a partial member in a ring shape.

20 [0032] 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.

30 [0033] 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.

[0034] 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.

[0035] 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).

[0036] 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.

[0037] 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.

[0038] Surface 102 (upper surface) of board holder 100 facing stator core 22 will be described with reference to Figs. 4, 7, and 8. Fig. 7 is a perspective view of board holder 100 as viewed from stator core 22 side. Fig. 8 is a cross-sectional view taken along line A-A of Fig. 4 illustrating a relationship between board holder 100 and stator core 22. Board holder 100 is a substantially disk-shaped member made of resin, is provided between stator core 22 and circuit board 48, and holds circuit board 48.

- [0039] As illustrated in Fig. 7, cylindrical portion 120 having a hollow cylindrical shape and extending vertically is provided at a central portion of board holder 100. Cylindrical portion 120 circumscribes an outer peripheral surface of shaft 30. As a result, since cylindrical portion 120 extends vertically, a contact area with shaft 30 increases, and board holder 100 and wiring board 50 can be held on a surface orthogonal to shaft 30. As a result, components of primary-side power supply circuit 51 and motor drive circuit 53 can be stably held. As illustrated in Fig. 7, two slits 122 cut out at intervals of 180° in the circumferential direction and with a width of approximately 30° are provided in cylindrical portion 120.
- 10 [0040] As illustrated in Fig. 7, a plurality of positioning protrusions 110 are provided on surface 102 of board holder 100 facing stator core 22. Positioning protrusions 110 extend upward from an outer peripheral portion of board holder 100. In this example, four positioning protrusions 110 are arranged at intervals of 90° in the circumferential direction. Seat 112 on which stator core 22 abuts is provided at a base of each positioning protrusion
- 15 110. Each positioning protrusion 110 vertically engages with opening 22k provided on a side surface of stator core 22. As a result, the positioning accuracy of board holder 100 and wiring board 50 with respect to stator core 22 is improved.
- [0041] As illustrated in Fig. 4, positioning protrusions 110 are provided at least at a position near Hall elements HE1, HE2, and HE3 and a position on an opposite side in the circumferential direction of the position near the Hall elements (position separated by 180° in the circumferential direction). As a result, a positional relationship between wiring board 50 and Hall elements HE1, HE2, and HE3 is stabilized. Since the number of positioning protrusions 110 can be reduced, a mold for manufacturing board holder 100 is simplified, and the amount of resin can be reduced. The position near Hall elements HE1, HE2, and
- 20 HE3 is a position of opening 22k(A) adjacent to opening 22k(H) corresponding to Hall element HE2.
- [0042] As illustrated in Fig. 7, a plurality of (for example, 12) radial ribs 130 are provided on surface 102 of board holder 100 facing stator core 22. As a result, the strength of board holder 100 can be increased, and it is advantageous for thickness reduction.
- 30 Radial ribs 130 extend outward in the radial direction from outer periphery of cylindrical portion 120. In this example, 12 radial ribs 130 are arranged at intervals of 30° in the circumferential direction. As illustrated in Fig. 8, radial rib 130 is positioned at a center of each slot 22s in the circumferential direction to avoid coil 24 in plan view. In other words,

the position at which coil 24 is avoided is an intermediate position between adjacent coils 24 in plan view, and is a position corresponding to a space provided between adjacent coils 24. As a result, interference between radial rib 130 and coil 24 is avoided, and it is advantageous for reducing the thickness of board holder 100.

5 **[0043]** A hollow annular peripheral rib 140 having an outer peripheral diameter substantially coinciding with an outer peripheral diameter of stator core 22 is provided on an outer peripheral side of surface 102 of board holder 100 facing stator core 22. As a result, the strength of an outer peripheral side of board holder 100 can be improved. It is possible to suppress floating of positioning protrusions 110 due to deformation of board
10 holder 100. Peripheral rib 140 extends circumferentially to connect positioning protrusions 110.

[0044] Fig. 9 is an enlarged view of portion B in Fig. 8 illustrating positioning protrusion 110 and opening 22k of stator core 22. As illustrated in Fig. 9, positioning protrusion 110 has a tapered shape along wall surface 22m on an inner side of opening 22k in plan view.
15 As a result, positioning protrusion 110 is restricted from protruding outward in the radial direction from opening 22k, and is prevented from coming into contact with rotor 40. In the example of Fig. 9, wall surface 22m is an end face of tooth 22t in the circumferential direction, and is a wall surface extending inward in the radial direction from an outer peripheral side of opening 22k of tooth 22t. That is, wall surface 22m is a wall surface
20 extending inward in the radial direction from opening 22k of stator core 22.

[0045] Surface 150 of board holder 100 opposite to stator core 22 will be described with reference to Figs. 10 to 13. Fig. 10 is a perspective view of board holder 100 as viewed from circuit board 48 side. Fig. 11 is an exploded perspective view illustrating a relationship between heat dissipating portion 46 of stator 20 and circuit board 48. Fig. 12A
25 is a plan view illustrating a state where lead wire 154 is held by stator 20. Fig. 12B is a cross-sectional view taken along line C-C of Fig. 12A illustrating a state where lead wire 154 is held by stator 20. Fig. 13 is a cross-sectional view taken along line D-D of Fig. 12 A illustrating a state where heat dissipating portion 46 is interposed between board holder 100 and circuit board 48. In Figs. 10 to 13, a floor surface (downside) is illustrated as the
30 upper side (upward) of the drawing in order to describe the assembling workability.

[0046] As illustrated in Fig. 10, a plurality of support columns 151 for holding circuit board 48 are provided on surface 150 of board holder 100 opposite to stator core 22. Support columns 151 extend upward from the outer peripheral portion of board holder 100.

In this example, four support columns 151 are arranged at intervals of 90° in the circumferential direction. Support columns 151 hold heat dissipating portion 46 and circuit board 48. Support column 151 includes two arrangement surfaces 151a and 151b that share a central axis and have different lengths in the radial direction and different heights in the axial direction from the central axis. Lead wire holder 155 that holds the plurality of lead wires 154 passing through a hollow space of shaft 30 and connected onto circuit board 48 is provided.

[0047] As illustrated in Fig. 11, heat dissipating portion 46 includes thin plate-shaped heat sink 46h, insulating film 46f, and heat dissipation gel sheet 46g made of silicon having high thermal conductivity. As a result, the motor drive IC (switching unit 53c) of motor drive circuit 53 mounted on wiring board 50 of circuit board 48 is thermally connected to heat sink 46h via heat dissipation gel sheet 46g.

[0048] As illustrated in Figs. 12A and 12B, an end of lead wire holder 155 opposite to stator core 22 penetrates through notched inner peripheral space 50k of circuit board 48 and extends to arrangement surface 50j of primary-side power supply circuit 51 in circuit board 48. As a result, at the time of assembling motor 10, since lead wire 154 is not held by circuit board 48 but is held by lead wire holder 155 of board holder 100 penetrating therethrough, lead wire 154 can be easily wired to circuit board 48. Accordingly, assembly workability and maintenance are improved. Since wiring board 50 can be brought close to stator core 22, it is possible to reduce the thickness.

[0049] As illustrated in Fig. 13, heat dissipating portion 46 is disposed on one arrangement surface 151a of support column 151, and circuit board 48 is disposed on other arrangement surface 151b. Here, arrangement surface 151a is the same as surface 150, but may be disposed between surface 150 and arrangement surface 151b. Support column 151 has a substantially cylindrical shape having a hole for fastening circuit board 48 with male screw S2 from above. An outer diameter of arrangement surface 151a of support column 151 is larger than an outer diameter of arrangement surface 151b. As a result, heat dissipating portion 46 can be reliably held at a predetermined position.

[0050] Heat dissipating portion 46 is provided, and thus, heat dissipation is promoted. As a result, a temperature rise of the motor drive IC is suppressed. With this configuration, heat sink 46h can be disposed in a narrow space, and it is advantageous for thickness reduction. Since the temperature rise of the motor drive IC is suppressed, an output of motor 10 can be increased accordingly, and an air volume of ceiling fan 1 can be increased.

[0051] According to the present embodiment, motor 10 can be easily thinned. Blades 2 of ceiling fan 1 can be arranged at a high position in accordance with the reduction in the thickness of motor 10. As a result, 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.

5 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.

[0052] 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
10 provided on ceiling fan (1). The brushless DC motor includes stator (20) that has stator core (22) around which coil (24) is wound, shaft (30) that is fixed to a central portion of stator core (22), bearing (34), rotor (40) that has magnet (42) surrounding stator core (22), and circuit board (48) that has primary-side power supply circuit (51) between stator core (22) and bearing (34) in an axial direction, secondary-side power supply circuit (52) that
15 converts a voltage supplied from primary-side power supply circuit (51), and motor drive circuit (53) that supplies a drive current to coil (24) based on a power supplied from secondary-side power supply circuit (52).

[0053] Brushless DC motor (10) may further include board holder (100) that holds circuit board (48) by stator core (22), and board holder (100) may be positioned between stator
20 core (22) and circuit board (48), and may have substantially the same shape as a shape of an end of stator core (22) in an axial direction in axial view.

[0054] Board holder (100) may have cylindrical portion (120) that circumscribes an outer peripheral surface of shaft (30).

[0055] The brushless DC motor may further include heat dissipating portion (46) that
25 dissipates heat of motor drive circuit (53) between board holder (100) and circuit board (48).

[0056] The brushless DC motor may further include support column (151) that holds circuit board (48) on surface (150) of board holder (100) opposite to stator core (22), and support column (151) may hold heat dissipating portion (46) and circuit board (48).

30 **[0057]** Support column (151) may include two arrangement surfaces (151a) and (151b) that share a central axis and may have different lengths in a radial direction and different heights in an axial direction from the central axis, heat dissipating portion (46) may be disposed on one arrangement surface (151a), and circuit board (48) may be disposed on

other arrangement surface (151b).

[0058] The brushless DC motor may further include wiring connection component (58) for connecting a wiring to surface (50j) of circuit board (48) opposite to stator core (22).

[0059] The brushless DC motor may further include electronic component (51p)

5 constituting primary-side power supply circuit (51) on surface (50j) of circuit board (48) opposite to stator core (22).

[0060] The brushless DC motor may further include lead wire holder (155) that holds a plurality of lead wires (154) passing through a hollow space of shaft (30) and connected onto circuit board (48) on surface (150) of board holder (100) opposite to stator core (22),
10 and an end of lead wire holder (155) opposite to stator core (22) may penetrate through inner peripheral side space (50k) of circuit board (48), and may extend up to arrangement surface (50j) of primary-side power supply circuit (51) in circuit board (48).

[0061] Board holder (100) may have positioning protrusions (110) engaging with opening (22k) of stator core (22).

15 **[0062]** Positioning protrusions (110) may be provided at a position near Hall elements (HE1, HE2, and HE3) that detect a magnetic flux of magnet (42) and a position opposite to the position near the Hall element in a circumferential direction.

[0063] Positioning protrusion (110) may have a shape along wall surface (22m) of opening (22k).

20 **[0064]** Radial rib (130) may be provided at a position where coil (24) on surface (102) of board holder (100) opposite to stator core (22) is avoided.

[0065] Peripheral rib (140) may be provided on an outer peripheral side of surface (102) of board holder (100) opposite to stator core (22).

[0066] The present disclosure has been described so far based on the exemplary
25 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.

30 REFERENCE MARKS IN THE DRAWINGS

[0067] 1 ceiling fan
4 ceiling
5 housing

	10	motor
	20	stator
	22	stator core
	24	coil
5	30	shaft
	32	first bearing
	34	second bearing
	40	rotor
	42	magnet
10	46	heat dissipating portion
	46g	heat dissipation gel sheet
	46f	insulating film
	46h	heat sink
	48	circuit board
15	50	wiring board
	51	primary-side power supply circuit
	52	secondary-side power supply circuit
	53	motor drive circuit
	58	wiring connection component
20	60	board holder
	100	board holder
	110	positioning protrusion
	130	radial rib
	140	peripheral rib
25	151	support column
	151a	arrangement surface
	151b	arrangement surface
	154	lead wire
	155	lead wire holder
30	400	rotation detector

CLAIMS

1. A brushless DC motor provided on a ceiling fan, comprising:
 - a stator including a stator core around which a coil is wound;
 - 5 a shaft fixed to a central portion of the stator core;
 - a bearing;
 - a rotor including a magnet surrounding the stator core; and
 - a circuit board including, between the stator core and the bearing in an axial direction:
 - 10 a primary-side power supply circuit;
 - a secondary-side power supply circuit that converts a voltage supplied from the primary-side power supply circuit; and
 - a motor drive circuit that supplies a drive current to the coil based on a power supplied from the secondary-side power supply circuit.
 - 15
2. The brushless DC motor according to Claim 1, further comprising a board holder that holds the circuit board by the stator core,
 - wherein the board holder is positioned between the stator core and the circuit board, and has substantially a same shape as a shape of an end of the stator core in an axial
 - 20 direction in axial view.
3. The brushless DC motor according to Claim 2, wherein the board holder includes a cylindrical portion that circumscribes an outer peripheral surface of the shaft.
- 25 4. The brushless DC motor according to Claim 2 or 3, further comprising a heat dissipating portion that dissipates heat of the motor drive circuit between the board holder and the circuit board.
5. The brushless DC motor according to Claim 4, further comprising a support
- 30 column that holds the circuit board on a surface of the board holder opposite to the stator core,
- wherein the support column holds the heat dissipating portion and the circuit board.

6. The brushless DC motor according to Claim 5, wherein
the support column includes two arrangement surfaces that share a central axis
and have different lengths in a radial direction and different heights in an axial direction
5 from the central axis,
the heat dissipating portion is disposed on one of the two arrangement surfaces,
and
the circuit board is disposed on another arrangement surface.
- 10 7. The brushless DC motor according to any one of Claims 2 to 6, further
comprising a wiring connection component for connecting a wiring to a surface of the
circuit board opposite to the stator core.
- 15 8. The brushless DC motor according to any one of Claims 2 to 7, further
comprising an electronic component constituting the primary-side power supply circuit on
the surface of the circuit board opposite to the stator core.
- 20 9. The brushless DC motor according to Claim 8, further comprising a lead wire
holder that holds a plurality of lead wires passing through a hollow space of the shaft and
connected onto the circuit board on a surface of the board holder opposite to the stator
core, wherein an end of the lead wire holder opposite to the stator core penetrates through
an inner peripheral side space of the circuit board, and extends up to an arrangement
surface of the primary-side power supply circuit in the circuit board.
- 25 10. The brushless DC motor according to any one of Claims 2 to 9, wherein the
board holder includes positioning protrusions engaging with an opening of the stator core.
- 30 11. The brushless DC motor according to Claim 10, wherein the positioning
protrusions are provided at a position near a Hall element that detects a magnetic flux of
the magnet and a position opposite to the position near the Hall element in a
circumferential direction.
12. The brushless DC motor according to Claim 10 or 11, wherein each of the

positioning protrusions has a shape along a wall surface of the opening.

13. The brushless DC motor according to any one of Claims 2 to 12, wherein a radial rib is provided at a position where the coil on a surface of the board holder opposite
5 to the stator core is avoided.

14. The brushless DC motor according to any one of Claims 2 to 13, wherein a peripheral rib is provided on an outer peripheral side of the surface of the board holder opposite to the stator core.
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