

AIR BLOWER AND BLOWING CONTROL SYSTEM USING THE SAME

Technical Field

[0001] The present disclosure generally relates to air blowers and blowing control systems using the same. More particularly, the present disclosure relates to an air blower communicable with a wireless communications device and a blowing control system using the air blower.

Background Art

[0002] A unit for controlling environmental conditions recited in Patent Literature 1 includes a fan for circulating the air and an illumination light fixture. This unit can control the operations of the fan and the light fixture wirelessly with a remote controller.

[0003] In the unit for controlling the environmental conditions recited in Patent Literature 1, since a wireless signal receiver is housed in the housing, the wireless signals could not be transmitted correctly from the remoter controller.

Citation List

Patent Literature

[0004] Patent Literature 1: JP-T-2017-520881 A

Summary of Invention

[0005] It is therefore an object of the present disclosure to provide an air blower and a blowing control system using the air blower, which can increase the chances of the wireless signals being transmitted correctly.

[0006] An air blower according to one aspect of the present disclosure includes a shaft, a motor, a rotation blade connecting member made of metal, a plurality of rotation blades, and a wireless communications unit. The shaft is attachable to a structure above a space. The motor is attached to the shaft. The rotation blade connecting member is made of metal and is configured to be rotated by the motor. The plurality of rotation blades are attached to the rotation blade connecting member, and are disposed apart from each other in a rotational direction of the rotation blade connecting member. The wireless communications unit is disposed such that at least a part of the wireless communications unit is disposed inside or under the rotation blade connecting member. The wireless communications unit is configured to receive a wireless signal as an

electromagnetic wave for controlling the motor. The rotation blade connecting member is formed with at least one opening.

[0007] A blowing control system according to another aspect of the present disclosure includes the air blower, and a wireless communications device configured to communicate with the wireless communications unit to control the air blower.

Brief Description of Drawings

[0008] FIG. 1 is a front view schematically illustrating a home in which a blowing control system according to an exemplary embodiment is installed;

FIG. 2 is a perspective view schematically illustrating an air blower according to the exemplary embodiment;

5 FIG. 3 is a cross-sectional view schematically illustrating the air blower;

FIG. 4 is an exploded perspective view schematically illustrating a light fixture according to the exemplary embodiment;

FIG. 5 is a perspective view schematically illustrating the air blower in a situation where a cover of the air blower has been removed;

10 FIG. 6 is a block diagram illustrating a configuration of the blowing control system according to the exemplary embodiment;

FIG. 7 is a view schematically illustrating a display and an operation unit of a wireless communications device according to the exemplary embodiment;

15 FIG. 8 is a cross-sectional view schematically illustrating an air blower according to a first variation;

FIG. 9 is a front view schematically illustrating a home in which a blowing control system according to a second variation is installed; and

FIG. 10 is a block diagram illustrating a configuration of the blowing control system according to the second variation.

Description of Embodiments

[0009] An air blower 1 and a blowing control system 2 according to an embodiment of the present disclosure will now be described in detail with reference to figures. Note that embodiments and their variations to be described below are only examples of the present disclosure and should not be construed as limiting. Rather, those embodiments and variations may be readily modified in various manners, depending on a design choice or any other factor, without departing from a true

spirit and scope of the present disclosure.

[0010] (1) Overview

An overview of the air blower 1 and the blowing control system 2 according to this embodiment will now be described with reference to FIG. 1–FIG. 3 and FIG. 6.

[0011] According to this embodiment, the air blower 1 corresponds to a fan, which is located on a structure above a space, e.g., ceilings 4 of rooms (a living room 31, a kitchen 32, a bedroom 33) of a home 3, as shown in FIG. 1 and FIG. 2. The fan rotates its rotation blades 5 to circulate the air in a room for air conditioning. The home 3 may have two stories where the living room 31 and the kitchen 32 may be located on the first floor and the bedroom 33 may be located on the second floor.

[0012] As shown in FIG. 2 and FIG. 3, the air blower 1 includes a shaft 6 that is attachable to the structure above the space, a motor 7 attached to the shaft 6, a metallic rotation blade connecting member 8 that is rotated by the motor 7, and a plurality of rotation blades 5. The plurality of the rotation blades 5 are attached to the rotation blade connecting member 8 such that they are arranged apart from each other in a rotational direction of the rotation blade connecting member 8. This configuration achieves a function of air conditioning by a fan. As used herein, "space" refers to a space in which the air blower 1 is disposed, e.g., a space inside facilities such as the home 3 (a room, for example). "Structure above the upper space" may include a building part such as a ceiling and a wall, and a structure material such as a beam and a column above the upper space inside facilities such as the home 3.

[0013] The air blower 1 includes a wireless communications unit 9 that receives wireless signals as electromagnetic waves for controlling the motor 7. At least a part of the wireless communications unit 9 is disposed inside or under the rotation blade connecting member 8. This configuration allows, as shown in FIG. 1, a user 10 of the air blower 1 to control the air blower 1 wirelessly. In this embodiment, wireless signals for wirelessly operating the air blower 1 are transmitted from a wireless communications device 11.

[0014] The wireless communications device 11 may communicate with the wireless communications unit 9 to control the air blower 1. As shown in FIG. 6, the wireless communications device 11 constitutes, along with the air blower 1, the blowing control system 2. In other words, the blowing control system 2 according to this embodiment includes the air blower 1 and the wireless communications device 11.

[0015] The rotation blade connecting member 8 is formed with at least one opening 12. This configuration reduces the chances of the metallic rotation blade connecting member 8 shielding the wireless signals, so the wireless communications unit 9 can receive the wireless signals

correctly. "Correctly receiving the wireless signals" refers to a state of receiving the data of the wireless signals without errors.

[0016] (2) Details

Next, the air blower 1 and the blowing control system 2 according to this embodiment will be described in further detail with reference to FIG. 1–FIG. 7. Note that in the following description of the embodiments, "being perpendicular" and "being vertical" refers to a state where
 5 two members are substantially perpendicular to each other. In other words, it refers to not only a state where two members intersect with each other exactly at right angles but also a state where two members intersect with each other within a certain tolerance range, e.g., several degrees from 90 degrees as a reference (less than five degrees, for examples). In the following description, "being parallel" refers to a state where two members are substantially in parallel with each other.
 10 In other words, it refers to not only a state where two members are exactly in parallel with each other but also a state where the angle between two members are within a certain tolerance range, e.g., several degrees (less than five degrees, for example).

[0017] In the following description, a direction along the central axis Ax1 of the shaft 6 attached to the ceiling 4 vertically may be referred to as "vertically or in a vertical direction." A direction in which the ceiling 4 is viewed from the air blower 1 side may be referred to as "upward," and a direction in which the air blower 1 viewed from the ceiling 4 side may be referred to as "downward."

[0018] (2.1) Overall configuration of air blower

Next, the overall configuration of the air blower 1 of the blowing control system 2
 15 according to this embodiment will be described in detail.

[0019] As shown in FIG. 3, the shaft 6 includes a portion 61 to be attached to a ceiling and a motor attachment portion 62. The portion 61, which is to be attached to a ceiling, of the shaft 6 is fixed to a pipe 13, which is fixed to the ceiling 4 with bolts or any other fastening member, and the shaft 6 is attached to the ceiling 4 via the pipe 13. The pipe 13 is hollow, and power cables for supplying the air blower 1 with power are disposed through the pipe 13. To the motor attachment portion 62 of the shaft 6, the motor 7, which generates motive power for rotating the rotation blades 5, is attached.

[0020] The motor 7 includes a stator 71 attached to the shaft 6. In more detail, the stator 71 has a disc-like shape, for example. The stator 71 of the motor 7 is attached to the motor attachment portion 62 of the shaft 6. The central axis of the stator 71 agrees with the central axis Ax1 of the shaft 6.

[0021] The motor 7 includes a rotor 72 that is located radially outward of the stator 71 rotatably.

To the rotor 72, the rotation blade connecting member 8 is attached. In this embodiment, the rotor 72 is cylindrical, and the rotor 72 is disposed radially outward of the stator 71 such that the central axis of the rotor 72 agrees with the central axis Ax1 of the shaft 6. A ceiling plate 721 is integrally formed with an upper end of the cylindrical rotor 72 and laid between the shaft 6 and the rotor 72. At a lower end of the rotor 72, a flange portion 722 is provided that expands radially outward of the rotor 72. To the flange portion 722, the rotation blade connecting member 8 is fixed via bolts or any other fastening member.

[0022] In this embodiment, the rotation blade connecting member 8, to which the plurality of the rotation blades 5 are attached, is a metallic tubular component. In more detail, the rotation blade connecting member 8 is a cylindrical component including a tubular portion 84 and a flare portion 81 that expands radially outward of the tubular portion 84 as the distance from the lower end of the tubular portion 84 increases downward. In addition, to the rotation blade connecting member 8, a fixation plate 82 is provided that projects from an inner surface of the tubular portion 84 toward the shaft 6.

[0023] As described above, in this embodiment, to the flange portion 722 of the rotor 72, the upper end of the rotation blade connecting member 8 is fixed. The central axis of the rotor 72, the central axis of the rotation blade connecting member 8, and the central axis Ax1 of the shaft 6 agree with each other.

[0024] The air blower 1 further includes a first bearing 14 and a second bearing 15. Note that "bearing" refers to a so-called ball bearing (see Figures). The first bearing 14 and the second bearing 15 are attached to the shaft 6, with the stator 71 of the motor 7 being located between the first bearing 14 and the second bearing 15. The first bearing 14 supports the rotor 72 rotatably, and the second bearing 15 supports the rotation blade connecting member 8 rotatably. In more detail, the first bearing 14 is fixed to the ceiling plate 721 disposed on the upper end of the rotor 72, and supports the ceiling plate 721 rotatably around the central axis Ax1 of the shaft 6 as a rotational axis. The second bearing 15 is fixed to the fixation plate 82 disposed on the inner surface of the rotation blade connecting member 8, and supports the fixation plate 82 rotatably around the central axis Ax1 of the shaft 6 as a rotational axis.

[0025] The motor 7 includes a plurality of magnets 74 disposed on the inner surface of the rotor 72 (a radially inner surface of the cylinder) that corresponds to the outer surface of the stator 71. The motor 7 further includes a coil 73 wound around the stator 71, so an electromagnetic force caused by a current flowing through the coil 73 and a magnetic field of the magnets 74 can rotate the rotor 72 of the motor 7.

[0026] As described above, the rotor 72 of the motor 7 is disposed radially outward of the outer

circumferential surface of the stator 71 rotatably. Specifically, the plurality of magnets 74 on the inner surface of the rotor 72 and the stator 71 are arranged in a non-contact manner. The stator 71 is fixed to the motor attachment portion 62 of the shaft 6. According to the motor 7 of this embodiment the rotor 72 rotates which is supported by the first bearing 14 rotatably, and accordingly the rotation blade connecting member 8 rotates which is attached to the rotor 72 and is supported by the second bearing 15 rotatably. That is to say, the rotor 72 of the motor 7 and the rotation blade connecting member 8 are connected and are respectively supported by the first bearing 14 and the second bearing 15 to rotate around the central axis Ax1 of the shaft 6.

[0027] At the lower end portion of the rotation blade connecting member 8, a plurality of blade fixation portions 83 are provided that project in the radial direction of the rotation blade connecting member 8. In this embodiment, the rotation blade connecting member 8 and the plurality of blade fixation portions 83 are integrally made of the same material. Alternatively, the rotation blade connecting member 8 and the plurality of blade fixation portions 83 may be different bodies and they may be connected with each other with screws or any other fastening member.

[0028] To the plurality of blade fixation portions 83, the rotation blades 5 are respectively attached. The plurality of the rotation blades 5, which are respectively attached to the plurality of blade fixation portions 83, are made of a synthetic resin for example, and are attached to the blade fixation portions 83 with screws or any other fastening member. This allows, as described above, the motor 7 to rotate the rotation blade connecting member 8, thereby causing the plurality of blade fixation portions 83 and the plurality of the rotation blades 5 rotate in conjunction of each other, thereby blowing the air near the ceiling 4 downward.

[0029] The air blower 1 further includes the wireless communications unit 9 that receives wireless signals. At least a part of the wireless communications unit 9 is disposed inside or under the rotation blade connecting member 8. As used herein, "inside the rotation blade connecting member 8" refers to a hollow portion of the tubular rotation blade connecting member 8. "Under the rotation blade connecting member 8" refers to a region that is within the rotation blade connecting member 8 in a plane view where the rotation blade connecting member 8 is viewed upward, i.e., from below, and is under the rotation blade connecting member 8 in a front view where the rotation blade connecting member 8 is viewed from the front of the rotation blade connecting member 8.

[0030] The wireless communications unit 9 is, for example, a plate-like module composed of a circuit substrate on which electronic components are installed. In this embodiment, the wireless communications unit 9 is positioned such that the thickness direction of the circuit substrate is aligned with the vertical direction. In that case, the wireless communications unit 9 is disposed

inside the rotation blade connecting member 8.

[0031] The user 10 of the air blower 1 can transmit, for example, wireless signals from the wireless communications device 11 such as a smart phone 16 to the wireless communications unit 9 to control, for example, the rotation speed of the motor 7 of the air blower 1 wirelessly (see FIG. 6). Note that the wireless communications device 11 is not limited to the smart phone 16, and may also be a mobile terminal such as a tablet terminal and a wearable terminal such as a smart watch. The wireless communications device 11 may be a dedicated remote controller for the air blower 1.

[0032] In this embodiment, the air blower 1 further includes, as shown in FIG. 3, a cover 17. The cover 17 is attached to the shaft 6, and covers at least a part of the motor 7 and at least a part of the rotation blade connecting member 8. In more detail, the cover 17 is attached, without making physical contact with the motor 7 or the rotation blade connecting member 8, to the shaft 6 via a cover attachment plate 18 attached to the first bearing 14. Therefore, the cover 17 is not rotated by the motor 7.

[0033] The cover 17 is, for example, a cylindrical component having a diameter expanding as it extends downward. The cover 17 is, for example, made of a synthetic resin. In this embodiment, the cover 17 is composed of two parts divided along a plane passing through the central axis Ax1 of the shaft 6. One of the parts is attached to the cover attachment plate 18 with screws or any other fastening member, and then the other part is engaged with the part of the cover 17 that has been attached to the cover attachment plate 18, thus attaching the cover 17 to the shaft 6.

[0034] As show in FIG. 2 and FIG. 3, the air blower 1 further includes a light fixture 19 that illuminates a room.

[0035] The shaft 6 includes a light-fixture attachment portion 63 at its lower end, and the light fixture 19 is attached to the light-fixture attachment portion 63 of the shaft 6. This configuration allows the light fixture 19 to be disposed under the rotation blade connecting member 8 and not to be rotated by the motor 7. In this embodiment, the light fixture 19 is disposed to be surrounded by the plurality of the rotation blades 5 in a plane view where the light fixture 19 is viewed upward, i.e., from below.

[0036] As shown in FIG. 3 and FIG. 4, the light fixture 19 includes a substrate 191 on which lighting modules 1911 are installed, and a metallic heat radiation member 192 for dissipating heat of the substrate 191. In this embodiment, the lighting modules 1911 are installed on a single side of the substrate 191. The light fixture 19 further includes an upper cover 193 and a lower cover 194.

[0037] The lighting modules 1911 may be light emitting diode (LED) modules, for example. The heat radiation member 192 may be made, for example, by aluminum die-casting, and is attached to an upper surface of the substrate 191. The heat radiation member 192 is, for example, a flat plate-like member. In order to enhance heat dissipation performance by expanding the surface area, the upper surface of the heat radiation member 192 is formed, for example, with a plurality of fins.

[0038] In this embodiment, the substrate 191 and the heat radiation member 192 are disposed such that at least a part of the substrate 191 and at least a part of the heat radiation member 192 are overlapped with each other as viewed along the vertical direction (along the central axis Ax1 direction of the shaft 6). Specifically, the upper cover 193 is attached to the light-fixture attachment portion 63 of the shaft 6 and is disposed under the rotation blade connecting member 8. The heat radiation member 192 is disposed under the upper cover 193. The substrate 191 is disposed under the heat radiation member 192 in a manner that allows the light emitting surface on which the lighting modules 1911 are installed to face downward such that at least a part of the substrate 191 overlaps the heat radiation member 192 vertically. The heat radiation member 192 and the substrate 191 are attached to the upper cover 193 with screws or any other fastening member. Under the substrate 191, the lower cover 194 is disposed. The lower cover 194 is attached to the upper cover 193 with screws or any other fastening member. This configuration allows the heat radiation member 192 and the substrate 191 to be covered by the lower cover 194. The lower cover 194 may be made of a synthetic resin having a light-transmitting property. This allows light emitted from the lighting modules 1911 installed on the substrate 191 to illuminate a room. Brightness of the light fixture 19 can be controlled according to the wireless signals transmitted from the wireless communications device 11 to the wireless communications unit 9.

[0039] The air blower 1 further includes a control unit 20 that is connected to the motor 7, the wireless communications unit 9, and the light fixture 19. The air blower 1 further includes a storage unit 23 that is connected to the control unit 20.

[0040] As shown in FIG. 3, in this embodiment, the control unit 20 and the storage unit 23 are installed on a control substrate 24. The control substrate 24 is attached to the shaft 6. In other words, the control unit 20 is attached to the shaft 6. This configuration does not allow the motor 7 to rotate the control substrate 24, on which the control unit 20 is installed. The operation of the control unit 20 will be described in detail later.

[0041] (2.2) Configuration of air blower for wireless control

Next, a configuration of the air blower 1 for wireless control will be described in detail.

[0042] In this embodiment, the smart phone 16 transmits wireless signals to the wireless

communications unit 9 to change, for example, the rotation speed of the motor 7 and the brightness of the light fixture 19. The change in the rotation speed of the motor 7 may include ON/OFF control of the rotation of the motor 7, and the change in the brightness of the light fixture 19 may include ON/OFF control of the light fixture 19.

[0043] In this embodiment, in order to correctly provide the wireless signals, which have been transmitted from the wireless communications device 11, to the wireless communications unit 9, a structure is provided for reducing the chances of the wireless signals as electromagnetic waves being shielded. Next, the structure for reducing the chances of wireless signal being shielded will be described in detail.

[0044] First, the rotation blade connecting member 8 is formed with at least one opening 12 (hereinafter, referred to as "first opening"). As used herein, the at least one opening 12 (first opening) includes a portion where an opening size of the at least one opening 12 (first opening) is $1/2$ of wavelength λ of electromagnetic waves that are used by the wireless communications unit 9 for communication. As used herein, "opening size" refers to a distance between two points opposing each other on the circumferential edge of the first opening 12. The at least one opening 12 (first opening) may include an opening extending in one direction.

[0045] As shown in FIG. 5, in this embodiment, the rotation blade connecting member 8 is formed with the plurality of first openings 12. Each of the plurality of first openings 12 is an opening extending in one direction. In more detail, as shown in FIG. 3 and FIG. 5, each of the first openings 12 has a slot-like shape with a longitudinal direction corresponding to one direction along the outer surface of the rotation blade connecting member 8. The length of the slot-like first opening 12 in the longitudinal direction is equal to opening size $L1$, which is $1/2$ of the wavelength λ .

[0046] As shown in Table 1, according to Condition 1 ($L1 = \lambda/2$) where the opening size $L1$ of the first opening 12 is equal to $1/2$ of the wavelength λ , it turned out that radiation efficiency η (later described) was better than Condition 2 ($L1 = \lambda/4$) or Condition 3 ($L1 = 0$). Note that condition 3 is a condition where the opening size $L1$ of the first opening 12 is zero, i.e., the first opening 12 is not formed in the rotation blade connecting member 8.

[0047] Radiation efficiency η was obtained by causing a transmitting antenna located inside the rotation blade connecting member 8 to transmit wireless signals (electromagnetic waves) of wavelength λ and a receiving antenna located outside the rotation blade connecting member 8 to receive the wireless signals of wavelength λ . Radiation efficiency η was calculated according to the following Equation 1 where "P1" denotes the power supplied to the transmitting antenna to transmit the wireless signals of wavelength λ and "P2" denotes the power of the wireless signals

of wavelength λ received by the receiving antenna.

[0048] η [dB] = $10\log_{10}(P_2/P_1)$... (Equation 1)

[0049] [Table 1]

	Condition 1 ($L1 = \lambda/2$)	Condition 2 ($L1 = \lambda/4$)	Condition 3 ($L1 = 0$)
radiation efficiency η [dB]	-2.4	-3.0	-3.4

[0050] In this embodiment, each of the first openings 12 is formed such that its longitudinal direction is in parallel with the vertical direction in a front view where the first opening 12 and the air blower 1 are viewed from the front of the air blower 1.

[0051] Note that each of the first openings 12 does not have to have a slot-like shape, but may have a circular shape or any other shape.

[0052] As described above, at least a part of the wireless communications unit 9 is disposed inside or under the metallic rotation blade connecting member 8. Therefore, if the rotation blade connecting member 8 is not formed with the first opening 12, the wireless signals to the wireless communications unit 9 could be shielded by the metallic rotation blade connecting member 8.

[0053] In contrast, if the rotation blade connecting member 8 is formed with the at least one first opening 12, the wireless signals can pass through the at least one first opening 12 and reach the wireless communications unit 9, thereby reducing the chances of the wireless signals being shielded.

[0054] In addition, the rotation blade connecting member 8, which is formed with the at least one opening 12 (first opening), includes the tubular portion 84 and the flare portion 81 expanding outward from the tubular portion 84. In detail, as shown in FIG. 3 and FIG. 5, the rotation blade connecting member 8 includes the tubular portion 84 having a substantially constant diameter along the vertical direction and the flare portion 81 having a cylindrical portion with a diameter expanding as it extends downward. In that case, the outer portion of the flare portion 81 faces the ceiling 4.

[0055] Furthermore, at least a part of the at least one opening 12 (first opening) is provided in the flare portion 81. In detail, the at least one first opening 12 is disposed spreading over the tubular portion 84 and the flare portion 81 of the rotation blade connecting member 8. This structure allows a portion provided in the flare portion 81 of the first opening 12 (i.e., slot-like lower portion) to face the ceiling 4. This arrangement allows the wireless signals transmitted downward, i.e., from above the air blower 1 (e.g., wireless signals transmitted from a room above

the room on which the air blower 1 is attached) to be received correctly by the wireless communications unit 9, thereby reducing the chances of the communication errors being generated.

[0056] As shown in FIG. 5, in this embodiment, the rotation blade connecting member 8 is formed with the plurality of first openings 12, each of which is a slot-like opening extending in one direction along the outer surface of the rotation blade connecting member 8. The plurality of the first openings 12 are classified into a plurality of groups G1 each of which includes four first openings 12.

[0057] The plurality of groups G1 and the plurality of the rotation blades 5, which are attached to the rotation blade connecting member 8, are arranged alternately in the rotational direction of the rotation blade connecting member 8 in a plain view where the rotation blade connecting member 8 is viewed vertically. In other words, the plurality of the rotation blades 5 and the at least one opening 12 (first opening) are arranged in different positions along the rotational direction of the rotation blade connecting member 8 in a plane view where the rotation blade connecting member 8 is viewed along the vertical direction (along the central axis Ax1 direction of the shaft 6). That is to say, since the first opening 12 is not overlapped with the blade fixation portions 83 of the metallic rotation blade connecting member 8 in a plane view where the air blower 1 is viewed upward, i.e., from below, the wireless signals transmitted to the communications unit 9 from the lower side of the air blower 1 is unlikely to be shielded by the blade fixation portion 83 for fixing the rotation blades 5. This allows the wireless signals transmitted upward, i.e., from below the air blower 1 to be correctly received by the wireless communications unit 9. This also does not allow the first opening 12 to be formed on the upper portion of the blade fixation portion 83, to which the weight of the rotation blades 5 is being applied, thereby preventing strength reduction of the rotation blade connecting member 8.

[0058] As shown in FIG. 4, the substrate 191 of the light fixture 19 is formed with a second opening 21, and the heat radiation member 192 of the light fixture 19 is formed with a third opening 22. In a plain view where the substrate 191 and the heat radiation member 192 are viewed along the vertical direction (along the central axis Ax1 direction of the shaft 6), at least a part of the second opening 21 and at least a part of the third opening 22 are overlapped with each other, defining an overlapped region AR1. The wireless communications unit 9 is located within the region AR1 in a plane view where the substrate 191 and the heat radiation member 192 are viewed along the vertical direction (along the central axis Ax1 direction of the shaft 6).

[0059] In this embodiment, as shown in FIG. 4, the second opening 21 and the third opening 22 are formed such that a size of the third opening 22 is larger than a size of the second opening 21. Furthermore, the substrate 191 and the heat radiation member 192 are arranged such that the

second opening 21 is positioned within the third opening 22 in a plane view where the substrate 191 and the heat radiation member 192 are viewed vertically. That is to say, the region AR1 and the second opening 21 agree with each other, and the wireless communications unit 9 is disposed in a position corresponding to the second opening 21 in a plane view where the substrate 191 and the heat radiation member 192 are viewed vertically.

[0060] Along the vertical direction, the wireless communications unit 9 is disposed above the third opening 22. This arrangement allows the wireless communications unit 9 to be disposed without directly contacting the substrate 191 or the heat radiation member 192, so heat due to lighting of the lighting modules 1911 installed on the substrate 191 can be prevented from being provided to the wireless communications unit 9. In addition, in a plane view where the substrate 191 and the heat radiation member 192 are viewed upward, i.e., from below, the wireless communications unit 9 is exposed in the second opening 21, so the wireless communications unit 9 can correctly receive the wireless signals transmitted to the wireless communications unit 9 upward, i.e., from below the light fixture 19. Furthermore, since the third opening 22 of the metallic heat radiation member 192 is larger than the second opening 21 of the substrate 191, the shielding of the wireless signals by the heat radiation member 192 is reduced, so the wireless communications unit 9 can correctly receive the wireless signals.

[0061] (2.3) Wireless control operation of blowing control system

Next, the wireless control operation of the blowing control system 2 according to this embodiment will be described in detail.

[0062] As shown in FIG. 6, the blowing control system 2 includes the air blower 1 and the wireless communications device 11 that communicates with the wireless communications unit 9 to control the air blower 1. In this embodiment, the wireless communications device 11 may be, for example, the smart phone 16. The smart phone 16 includes a display 161, an operation unit 162, a storage unit 163, a wireless communications unit 164, and a control unit 165. To the control unit 165, the display 161, the operation unit 162, the storage unit 163, and the wireless communications unit 164 are connected.

[0063] In this embodiment, as shown in FIG. 7, when the user 10 of the air blower 1 activates an operation application for the air blower 1 in the smart phone 16, the operation unit 162 will be displayed on the display 161 as a touchscreen. The operation unit 162 may be physical buttons or any other input device, other than the display 161.

[0064] The user 10 can operate the operation unit 162 to change the rotation speed of the motor 7 and the brightness of the light fixture 19 of the air blower 1. The operation unit 162 displayed on the display 161 is configured so as to change the rotation speed of the motor 7 and the brightness

of the light fixture 19 of each of the air blowers 1 disposed on the ceilings 4 in the rooms (the living room 31, the kitchen 32, and the bed room 33) of the home 3.

[0065] On each of the operation units 162, a button icon 168 that is to be operated to control ON/OFF of the rotation of the motor 7 and a button icon 169 that is to be operated to control ON/OFF of the light fixture 19 are displayed. On each of the operation units 162, two slider bars 166 that respectively correspond to the rotation speed of the motor 7 and brightness of the light fixture 19 are displayed on the right sides of the button icon 168 and the button icon 169, and the user 10 can move sliders 167 on the slider bars 166 to the right or to the left to change settings of the rotation speed of the motor 7 and the brightness of the light fixture 19 to a desired value.

[0066] When the user 10 presses the button icon 168 or the button icon 169 to select ON/OFF of the rotation of the motor 7 or ON/OFF of the light fixture 19, as shown in FIG. 6, the control unit 165 of the smart phone 16 transmits, from the wireless communications unit 164 to the wireless communications unit 9 of the air blower 1, wireless signals Sig1 having a signal pattern for use to control ON/OFF of the rotation of the motor 7 or ON/OFF of the light fixture 19. When the user 10 moves the slider 167 to change the settings of the rotation speed of the motor 7 or the brightness of the light fixture 19 to a desired value, the control unit 165 of the smart phone 16 will read out a signal pattern corresponding to the changed settings from the storage unit 163, and transmit, from the wireless communications unit 164 to the wireless communications unit 9 of the air blower 1, wireless signals Sig1 having the signal pattern read out from the storage unit 163.

[0067] The wireless communications unit 9 of the air blower 1 receives the wireless signals Sig1 transmitted from the wireless communications unit 164 of the smart phone 16.

[0068] When the wireless communications unit 9 receives the wireless signals Sig1, the control unit 20 of the air blower 1 will perform ON/OFF of the rotation of the motor 7 or ON/OFF of the light fixture 19 according to the signal pattern in the received wireless signals Sig1. Alternatively, when the wireless communications unit 9 receives the wireless signals Sig1, the control unit 20 of the air blower 1 may read out, from the storage unit 23 of the air blower 1, the settings of the rotation speed of the motor 7 or the brightness of the light fixture 19 according to the signal pattern of the wireless signals Sig1.

[0069] When the settings of the rotation speed of the motor 7 or the brightness of the light fixture 19 are to be changed, the control unit 20 changes the rotation speed of the motor 7 or the brightness of the light fixture 19 according to the settings read out from the storage unit 23.

[0070] The storage unit 163 of the smart phone 16 and the storage unit 23 of the air blower 1 may be implemented as a storage device selected from electrically rewritable nonvolatile memories such as an electrically erasable programmable read-only memory (EEPROM) and a

flash memory. Each of the control unit 165 of the smart phone 16 and the control unit 20 of the air blower 1 described above includes a computer system. In that case, the computer system may include, as hardware components, a processor and a memory. The functions of the control unit 165 of the smart phone 16 and the control unit 20 of the air blower 1 may be performed by making the processor execute a program stored in the memory of the computer system. The program may be stored in advance in the memory of the computer system. Alternatively, the program may also be downloaded through a telecommunications line or be distributed after having been recorded in some non-transitory storage medium such as a memory card. The processor of the computer system may be made up of a single or a plurality of electronic circuits including a semiconductor integrated circuit (IC) or a large-scale integrated circuit (LSI). As used herein, the “integrated circuit” such as an IC or an LSI is called by a different name depending on the degree of integration thereof. Examples of the integrated circuits include a system LSI, a very largescale integrated circuit (VLSI), and an ultra largescale integrated circuit (ULSI). Optionally, a field-programmable gate array (FPGA) to be programmed after an LSI has been fabricated or a reconfigurable logic device allowing the connections or circuit sections inside of an LSI to be reconfigured may also be adopted as the processor. Those electronic circuits may be either integrated together on a single chip or distributed on multiple chips, whichever is appropriate. Those multiple chips may be integrated together in a single device or distributed in multiple devices without limitation.

[0071] (3) Variations

Next, an air blower 1 and a blowing control system 2 according to variations of the embodiment will be described. In the following description of the variations, any constituent member thereof corresponding to a counterpart of the air blower 1 and the blowing control system 2 according to the embodiment described above will be designated by the same reference numeral as that counterpart's, and redundant description thereof will be omitted. Note that any of various configurations of the variations to be described below may be adopted as appropriate in combination with any of the configurations described for the embodiment.

[0072] (3.1) First variation

Next, an air blower 1 according to the first variation will be described.

[0073] In the air blower 1 according to the embodiment, the wireless communications unit 9 is a plate-like module having the circuit substrate on which electronic components are installed, and is positioned such that the plate-thickness direction of the circuit substrate is in parallel with the vertical direction.

[0074] In the first variation, as shown in FIG. 8, a wireless communications unit 9 is positioned

such that the plate-thickness direction of the circuit substrate of the wireless communications unit 9 is perpendicular to the vertical direction, which is a major difference from the embodiment. In this case, an upper part of the circuit substrate is disposed inside a rotation blade connecting member 8, and the rest part, i.e., a lower part of the circuit substrate is positioned under the rotation blade connecting member 8.

[0075] (3.2) Second variation

Next, a blowing control system 2 according to the second variation will be described.

[0076] The blowing control system 2 according to the embodiment includes the air blower 1 and the wireless communications device 11. The wireless communications device 11 communicates with the wireless communications unit 9 to control the air blower 1.

[0077] In this second variation, the blowing control system 2 further includes, as shown in FIG. 9, a relay device 25 that wirelessly relays communication between a wireless communications unit 9 and a wireless communications device 11, which is a major difference from the embodiment and first variation. The relay device 25 includes, as shown in FIG. 10, a wireless communications unit 252 and a control unit 253. To the control unit 253, the wireless communications unit 252 is connected.

[0078] A user 10 of the air blower 1 can transmit the wireless signals from, for example, the wireless communications device 11 such as a smart phone 16, to the wireless communications unit 9 of the air blower 1 via the relay device 25 located away from the air blower 1. This makes it possible to change, for example, the rotation speed of a motor 7 and the brightness of a light fixture 19. As shown in FIG. 9, the relay device 25 may be disposed, for example, in a corridor 34 of the second floor of a home 3.

[0079] Similar to the embodiment, the user 10 can use the smart phone 16 to select ON/OFF of the rotation of the motor 7 or ON/OFF of the light fixture 19, or to change settings of the rotation speed of the motor 7 or settings of brightness of the light fixture 19 to a desired value.

[0080] As shown in FIG. 10, the control unit 165 of the smart phone 16 transmits, from the wireless communications unit 164 to the wireless communications unit 252 of the relay device 25, the wireless signals Sig1 having a signal pattern for use to control ON/OFF of the rotation of the motor 7 or ON/OFF of the light fixture 19.

[0081] Alternatively, the control unit 165 of the smart phone 16 may read out, from a storage unit 163, the signal pattern corresponding to settings changed by the user 10, and transmit, from the wireless communications unit 164 to the wireless communications unit 252 of the relay device 25, the wireless signals Sig1 having the signal pattern read out from the storage unit 163.

[0082] When the wireless communications unit 252 receives the wireless signals Sig1, the

control unit 253 of the relay device 25 retransmits, from the wireless communications unit 252 to the wireless communications unit 9 of the air blower 1, wireless signals Sig2 corresponding to the wireless signals Sig1.

[0083] The wireless communications unit 9 of the air blower 1 receives the wireless signals Sig2 transmitted from the wireless communications unit 252 of the relay device 25.

[0084] When the wireless communications unit 9 receives the wireless signals Sig2, the control unit 20 of the air blower 1 controls ON/OFF of the rotation of the motor 7 or ON/OFF of the light fixture 19 according to the signal pattern of the received wireless signals Sig2. Alternatively, the control unit 20 of the air blower 1 may read out, from the storage unit 23 of the air blower 1, the settings of rotation speed of the motor 7 or the brightness of the light fixture 19 according to the signal pattern of the wireless signals Sig2.

[0085] When the rotation speed of the motor 7 or the brightness of the light fixture 19 is to be changed, the control unit 20 changes the rotation speed of the motor 7 or the brightness of the light fixture 19 according to the settings read out from the storage unit 23.

[0086] In this manner, since the wireless signals transmitted from the smart phone 16 are relayed by the relay device 25, the air blower 1 disposed farther away can correctly receive the wireless signals.

[0087] The control unit 253 of the relay device 25 includes a computer system. In that case, the computer system may include, as hardware components, a processor and a memory. The functions of the control unit 253 of the relay device 25 may be performed by making the processor execute a program stored in the memory of the computer system. The program may be stored in advance in the memory of the computer system. Alternatively, the program may also be downloaded through a telecommunications line or be distributed after having been recorded in some non-transitory storage medium such as a memory card. The processor of the computer system may be made up of a single or a plurality of electronic circuits including a semiconductor integrated circuit (IC) or a large-scale integrated circuit (LSI). As used herein, the “integrated circuit” such as an IC or an LSI is called by a different name depending on the degree of integration thereof. Examples of the integrated circuits include a system LSI, a very largescale integrated circuit (VLSI), and an ultra largescale integrated circuit (ULSI). Optionally, a field-programmable gate array (FPGA) to be programmed after an LSI has been fabricated or a reconfigurable logic device allowing the connections or circuit sections inside of an LSI to be reconfigured may also be adopted as the processor. Those electronic circuits may be either integrated together on a single chip or distributed on multiple chips, whichever is appropriate. Those multiple chips may be integrated together in a single device or distributed in multiple

devices without limitation.

[0088] (3.3) Other variations

Next, other variations of the embodiment described above will be enumerated one after another. Optionally, any of the variations to be described below may be adopted in combination as appropriate.

[0089] The rotation blade connecting member 8 having a flare portion may have a polygonal tubular shape.

[0090] The longitudinal direction of the first opening 12 extending in one direction may be formed so as to intersect with the vertical direction in a front view where the first opening 12 and the air blower 1 are viewed from the front of the air blower 1.

[0091] The wireless communications device 11 of the blowing control system 2 may have a voice recognition function. In that case, the wireless communications device 11 can recognize contents of instruction generated by voice of the user 10 by the voice recognition function, and transmit wireless signals according to the contents of instruction to the air blower 1 to control the air blower 1 by means of voice of the user 10.

[0092] In the embodiment, the air blower 1 is attached to the ceiling. Alternatively, the air blower 1 may be attached to a beam or any other structure above the space.

[0093] The air blower 1 is not limited to ones used for home facilities. The air blower 1 may be used for commercial facilities (offices, restaurants, hotels, for example), or vehicles such as a passenger boat.

5 [0094] (4) Encapsulation

As can be seen from the foregoing description, an air blower (1) according to a first aspect includes a shaft (6), a motor (7), a rotation blade connecting member (8), a plurality of rotation blades (5), and a wireless communications unit (9). The shaft (6) is attachable to a structure above a space. The motor (7) is attached to the shaft (6). The rotation blade connecting member (8) is made of metal and is configured to be rotated by the motor (7). The plurality of rotation blades (5) are attached to the rotation blade connecting member (8), and are disposed apart from each other in a rotational direction of the rotation blade connecting member (8). The wireless communications unit (9) is disposed such that at least a part of the wireless communications unit (9) is disposed inside or under the rotation blade connecting member (8). The wireless communications unit (9) is configured to receive a wireless signal as an electromagnetic wave for controlling the motor (7). The rotation blade connecting member (8) is formed with at least one opening (12).

[0095] This aspect allows at least one opening (12), through which the wireless signal passes, to

reduce the chances of the wireless signal being shielded by the rotation blade connecting member (8), so the wireless communications unit (9) can correctly receive the wireless signal.

[0096] In an air blower (1) according to a second aspect, which may be implemented in conjunction with the first aspect, the at least one opening (12) has a portion where an opening size of the at least one opening (12) is equal to $1/2$ of a wavelength of the electromagnetic wave used for the wireless communications unit (9) to communicate.

[0097] This aspect allows the wireless signal to pass through one opening (12) efficiently.

[0098] In an air blower (1) according to a third aspect, which may be implemented in conjunction with the first or second aspect, the at least one opening (12) includes an opening extending in one direction.

[0099] This aspect allows the wireless signal to pass through least one opening (12) efficiently.

[0100] In an air blower (1) according to a fourth aspect, which may be implemented in conjunction with any one of the first to third aspects, the rotation blade connecting member (8) includes a tubular portion (84), and a flare portion (81) extending outward from the tubular portion (84). At least a part of the at least one opening (12) is provided in the flare portion (81).

[0101] This aspect allows the wireless communications unit (9) to correctly receive the wireless signal transmitted downward, i.e., from above the air blower (1).

[0102] In an air blower (1) according to a fifth aspect, which may be implemented in conjunction with any one of the first to fourth aspects, the plurality of rotation blades (5) and the at least one opening (12) are arranged at different positions in a rotational direction of the rotation blade connecting member (8) in a plane view where the rotation blade connecting member (8) is viewed along a central-axis (Ax1) direction of the shaft (6).

[0103] This aspect allows the wireless signals, which have been transmitted from the lower direction of the air blower (1), to readily pass through the opening (12), so the wireless communications unit (9) can receive the wireless signal correctly.

[0104] An air blower (1) according to a sixth aspect, which may be implemented in conjunction with any one of the first to fifth aspects, further includes a light fixture (19) attached to the shaft (6). The light fixture (19) includes a substrate (191) on which a lighting module (1911) is installed and a heat radiation member (192) made of metal for dissipating heat of the substrate (191). The substrate (191) and the heat radiation member (192) are arranged such that at least a part of the substrate (191) and at least a part of the heat radiation member (192) are overlapped with each other as viewed along a central-axis (Ax1) direction of the shaft (6). The opening (12) is a first opening (12). The substrate (191) is formed with a second opening (21). The heat radiation member (192) is formed with a third opening (22). At least a part of the second opening

(21) and at least a part of the third opening (22) are overlapped with each other defining an overlapped region (AR1) in a plane view where the substrate (191) and the heat radiation member (192) are viewed along the central-axis (Ax1) direction of the shaft (6). The wireless communications unit (9) is located in the region (AR1) in a plain view where the substrate (191) and the heat radiation member (192) are viewed along the central-axis (Ax1) direction of the shaft (6).

[0105] This aspect allows the wireless communications unit (9) to correctly receive the wireless signal transmitted upward, i.e., from below the light fixture (19).

[0106] In an air blower (1) according to a seventh aspect, which may be implemented in conjunction with the sixth aspect, a size of the third opening (22) is larger than a size of the second opening (21).

[0107] This aspect allows the wireless communications unit (9) to correctly receive the wireless signal transmitted upward, i.e., from below the light fixture (19).

[0108] An air blower (1) according to an eighth aspect, which may be implemented in conjunction with the sixth or seventh aspect, further includes a control unit (20) connected to the motor (7), the wireless communications unit (9), and the light fixture (19). The control unit (20) is attached to the shaft (6).

[0109] This aspect allows the wireless signal to control the operation of the motor (7) and the light fixture (19).

[0110] In an air blower (1) according to a ninth aspect, which may be implemented in conjunction with any one of the first to eighth aspects, the motor (7) includes a stator (71) attached to the shaft (6) and a rotor (72) rotatably disposed radially outward of the stator (71). The rotation blade connecting member (8) is attached to the rotor (72).

[0111] This aspect allows the rotation blade connecting member (8) to rotate in conjunction with the motor (7).

[0112] An air blower (1) according to a tenth aspect, which may be implemented in conjunction with the ninth aspect, further includes a first bearing (14) and a second bearing (15). The first bearing (14) and the second bearing (15) are attached to the shaft (6), with the stator (71) being located between the first bearing (14) and the second bearing (15). The first bearing (14) supports the rotor (72) rotatably. The second bearing (15) supports the rotation blade connecting member (8) rotatably.

[0113] This aspect allows the rotor (72) and the rotation blade connecting member (8) to rotate around the central axis (Ax1) of the shaft (6) as a rotational axis.

[0114] An air blower (1) according to an eleventh aspect, which may be implemented in

conjunction with any one of the first to tenth aspects, further includes a cover (17) that covers at least a part of the motor (7) and at least a part of the rotation blade connecting member (8). The cover (17) is attached to the shaft (6).

[0115] This aspect allows the cover (17) to protect the motor (7) and the rotation blade connecting member (8).

[0116] A blowing control system (2) according to a twelfth aspect includes the air blower (1) according to any one of the first to eleventh aspects, and a wireless communications device (11). The wireless communications device (11) is configured to communicate with the wireless communications unit (9) to control the air blower (1).

[0117] This aspect allows the wireless communications device (11) to control the air blower (1).

[0118] A blowing control system (2) according to a thirteenth aspect, which may be implemented in conjunction with the twelfth aspect, further includes a relay device (25) configured to relay communication between the wireless communications unit (9) and the wireless communications device (11) wirelessly.

[0119] This aspect allows the relay device (25) to relay signals wirelessly, so the air blower (1) disposed farther away from the communications device (11) can be controlled.

[0120] Note that the configurations according to the second to eleventh aspects are not essential constituent elements of the air blower (1) but may be omitted as appropriate. Note that the configurations according to the thirteen aspect are not essential constituent elements of the blowing control system (2) but may be omitted as appropriate.

Reference Signs List

[0121]	1	Air Blower
	2	Blowing Control System
	5	Rotation blade
	6	Shaft
5	7	Motor
	71	Stator
	72	Rotor
	8	Rotation Blade Connecting Member
	81	Flare Portion
10	84	Tubular Portion
	9	Wireless Communications Unit

	11	Wireless Communications Device
	12	Opening (First Opening)
	14	First Bearing
	15	Second Bearing
5	17	Cover
	19	Light Fixture
	191	Substrate
	1911	Lighting Module
	192	Heat Radiation Member
10	20	Control Unit
	21	Second Opening
	22	Third Opening
	25	Relay Device
	Ax1	Central Axis
15	Ar1	Region

CLAIMS

1. An air blower comprising:
 - a shaft attachable to a structure above a space;
 - a motor attached to the shaft;
 - a rotation blade connecting member made of metal and configured to be rotated by the motor;
 - a plurality of rotation blades attached to the rotation blade connecting member, disposed apart from each other in a rotational direction of the rotation blade connecting member; and
 - a wireless communications unit disposed such that at least a part of the wireless communications unit is disposed inside or under the rotation blade connecting member, the wireless communications unit being configured to receive a wireless signal as an electromagnetic wave for controlling the motor,
 - the rotation blade connecting member being formed with at least one opening.
2. The air blower of claim 1, wherein
 - the at least one opening has a portion where an opening size of the at least one opening is equal to $1/2$ of a wavelength of the electromagnetic wave used for the wireless communications unit to communicate.
3. The air blower of claim 1 or 2, wherein
 - the at least one opening includes an opening extending in one direction.
4. The air blower of any one of claims 1 to 3, wherein
 - the rotation blade connecting member includes a tubular portion, and a flare portion extending outward from the tubular portion, at least a part of the at least one opening being provided in the flare portion.
5. The air blower of any one of claims 1 to 4, wherein
 - the plurality of rotation blades and the at least one opening are arranged at different positions in a rotational direction of the rotation blade connecting member in a plane view where the rotation blade connecting member is viewed along a central-axis direction of the shaft.

6. The air blower of any one of claims 1 to 5, further comprising a light fixture attached to the shaft, wherein
the light fixture includes:
a substrate on which a lighting module is installed; and
a heat radiation member made of metal for dissipating heat of the substrate, the substrate and the heat radiation member being arranged such that at least a part of the substrate and at least a part of the heat radiation member are overlapped with each other as viewed along a central-axis direction of the shaft,
the opening is a first opening,
the substrate is formed with a second opening,
the heat radiation member is formed with a third opening,
at least a part of the second opening and at least a part of the third opening are overlapped with each other defining an overlapped region in a plane view where the substrate and the heat radiation member are viewed along the central-axis direction of the shaft, and
the wireless communications unit is located in the region in a plain view where the substrate and the heat radiation member are viewed along the central-axis direction of the shaft.
7. The air blower of claim 6, wherein
a size of the third opening is larger than a size of the second opening.
8. The air blower of claim 6 or 7, further comprising a control unit connected to the motor, the wireless communications unit, and the light fixture, wherein
the control unit is attached to the shaft.
9. The air blower of any one of claims 1 to 8, wherein
the motor includes:
a stator attached to the shaft; and
a rotor rotatably disposed radially outward of the stator, and
the rotation blade connecting member is attached to the rotor.
10. The air blower of claim 9, further comprising a first bearing and a second bearing, wherein
the first bearing and the second bearing are attached to the shaft, with the stator being located between the first bearing and the second bearing,
the first bearing supports the rotor rotatably, and

the second bearing supports the rotation blade connecting member rotatably.

11. The air blower of any one of claims 1 to 10, further comprising a cover that covers at least a part of the motor and at least a part of the rotation blade connecting member, wherein the cover is attached to the shaft.
12. A blowing control system comprising:
the air blower of any one of claims 1 to 11; and
a wireless communications device configured to communicate with the wireless communications unit to control the air blower.
13. The blowing control system of claim 12, further comprising a relay device configured to relay communication between the wireless communications unit and the wireless communications device wirelessly.