



(11)

EP 4 826 254 A1

(12)

EUROPEAN PATENT APPLICATION
published in accordance with Art. 153(4) EPC

(43) Date of publication:
21.10.2026 Bulletin 2026/43

(51) International Patent Classification (IPC):
F04D 29/32 ^(2006.01) **F04D 25/08** ^(2006.01)

(21) Application number: **24909703.1**

(86) International application number:
PCT/CN2024/107101

(22) Date of filing: **23.07.2024**

(87) International publication number:
WO 2025/138749 (03.07.2025 Gazette 2025/27)

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC ME MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA
Designated Validation States:
GE KH MA MD TN

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(30) Priority: **29.12.2023 CN 202311869658**

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(54) **FAN BLADE, FAN, AND AIR-BLOWING DEVICE**

(57) Disclosed in the present application are a fan blade, a fan, and an air-blowing device. The fan blade comprises a hub and a blade assembly, wherein the blade assembly comprises N blades, N being an integer greater than or equal to 2; the blades are connected to the hub, each blade comprising a first blade section and a second blade section, and a hollow region being disposed between the first blade section and the second blade section; a pressure surface of the first blade section is connected to a suction surface of the second blade section, and a suction surface of the first blade section is connected to a pressure surface of the second blade section, and on a projection plane perpendicular to the axis of the hub; and projection points formed by the orthographic projections of curved surfaces of the blades do not overlap.

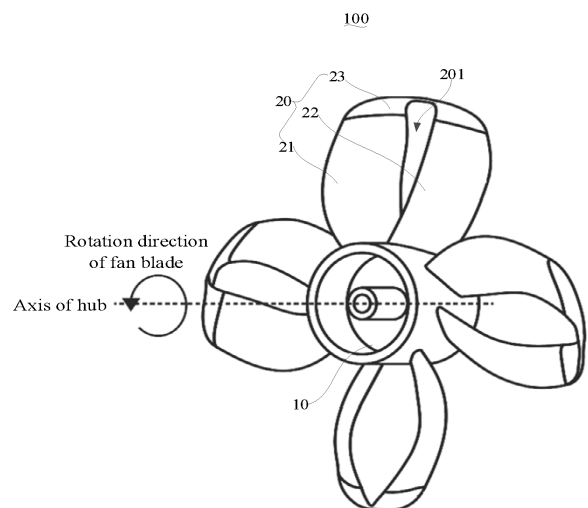


FIG. 1

Description**CROSS-REFERENCES TO RELATED APPLICATIONS**

- 5 [0001] The present application claims priority to Chinese patent application No. 202311869658.1, filed on December 29, 2023, which is hereby incorporated by reference in its entirety.

FIELD

- 10 [0002] The present application relates to the field of air-blowing devices, and particularly to a fan blade, a fan and an air-blowing device.

BACKGROUND

- 15 [0003] An air-blowing device is widely used in people's daily life. An air-blowing device with axial flow fan blades (such as a floor fan) are favored by many users due to their strong airflow and wide airflow coverage range. Blades of traditional fan blades typically adopt a simple straight plate or curved plate structure. When the air-blowing device is operated at a higher speed, its noise is often quite loud, which may cause some inconvenience to users. To achieve noise reduction of the fan, each blade needs to be designed with a more complex shape, which leads to difficulty in mold opening during an injection molding process of the fan blade to increase the manufacturing complexity of the fan blade.

SUMMARY

- 25 [0004] The present application is intended to provide a fan blade capable of effectively reducing noise during operation while simultaneously lowering the difficulty in mold opening during injection molding of the fan blade to facilitate manufacture and production of the fan blade.

[0005] According to the present application, there is disposed a fan blade including:

- 30 a hub; and
a blade assembly including N blades, where N is an integer greater than or equal to 2;
where the N blades are connected to the hub, each of the N blades includes a first segment and a second segment, a hollow region is disposed between the first segment and the second segment, a pressure surface of the first segment is connected to a suction surface of the second segment, and a suction surface of the first segment is connected to a pressure surface of the second segment, and on a projection plane perpendicular to an axis of the hub, projection points formed by orthographic projections of curved surfaces of the N blades do not overlap.

- 40 [0006] In an embodiment, projection planes formed by orthographic projections of the N blades of the blade assembly do not overlap on the projection plane perpendicular to the axis of the hub.

[0007] In an embodiment, each of the N blades further includes a bridging segment connecting an end of the first segment away from the hub and an end of the second segment away from the hub; and the first segment, the bridging segment and the second segment jointly enclose the hollow region.

- 45 [0008] In an embodiment, the bridging segment includes a plane opposite to the hub, and the plane is parallel to the axis of the hub.

[0009] In an embodiment, a height of each blade in a radial direction of the fan blade is H1 and a width of the bridging segment in an axial direction of the fan blade is not greater than $5\% \times H1$.

[0010] In an embodiment, the bridging segment is disposed at an end of each blade away from the hub.

- 50 [0011] In an embodiment, at a position of the bridging segment, a leading edge line of the first segment is connected to a leading edge line of the second segment, and a trailing edge line of the first segment is connected to a trailing edge line of the second segment.

- [0012] In an embodiment, an inner end of the first segment and an inner end of the second segment are each connected to the hub, the inner end of the first segment and the inner end of the second segment are spaced apart from each other in a circumferential direction of the fan blade, and the first segment, the bridging segment, the second segment, and the hub jointly form the hollow region.

- 55 [0013] In an embodiment, the first segment, the second segment, and the bridging segment are integrally injection-molded; and/or
each blade and the hub are integrally injection-molded.

[0014] In an embodiment, on a projection plane parallel to an axis of the hub, an orthogonal projection of an end of each blade away from the hub has a hollow ring.

[0015] In an embodiment, on the projection plane perpendicular to the axis of the hub, an orthogonal projection of the hollow region forms a first projection, an orthogonal projection of the axis of the hub forms an axis point P, a reference circle is constructed around the axis point P on an axial projection plane of the fan blade, a first distance L1 is formed by intersecting the reference circle with the first projection and is greater than 1 mm.

[0016] In an embodiment, the first distance L1 is greater than 5 mm.

[0017] In an embodiment, on the projection plane perpendicular to the axis of the hub, an orthogonal projection of each blade forms a second projection, an orthogonal projection of the axis of the hub forms an axis point P, a reference circle is constructed around the axis point P on an axial projection plane of the fan blade, a second distance L2 is formed by intersecting the reference circle with an outer edge of the second projection, and the second distance L2 gradually decreases in the radial direction of the fan blade toward a side away from the hub at the end of each blade away from the hub.

[0018] In an embodiment, a reference cylindrical surface is constructed around the axis of the hub, and a cross-section formed by intersecting each blade with the reference cylindrical surface is defined as a blade profile; a thickness of a blade profile leading edge of the first segment is greater than a thickness of a blade profile trailing edge of the first segment; and/or a thickness of a blade profile leading edge of the second segment is greater than a thickness of a blade profile trailing edge of the second segment.

[0019] According to the present application, there is further disposed a fan, including the fan blade described above, and a drive member drivably connected to the fan blade and configured to drive the fan blade to rotate.

[0020] According to the present application, there is further disposed an air-blowing device, including the fan blade described above or the fan described above.

[0021] In the solution of the present application, a hollow region is disposed between the first segment and the second segment of each blade to play a certain guiding effect on airflow over the blade. When the fan blade rotates, an airflow at the trailing edge of the blade is guided through the hollow region along a suction surface of the blade to a pressure surface of the blade, which may disperse airflow vortices at the trailing edge of the fan blade, preventing them from detaching directly from the trailing edge and generating significant noise of shedding vortex. Moreover, on a projection plane perpendicular to the axis of the hub, projection points formed by orthographic projections of curved surfaces of the N blades do not overlap to significantly reduce the difficulty in mold opening for a ring-shaped blade and be more conducive to production and manufacturing by injection molding. Through the solution of the present application, noise generated during operation of the blade is effectively reduced and the difficulty in mold opening for injection molding is simultaneously lowered to facilitate manufacture and production of the fan blade.

BRIEF DESCRIPTION OF THE DRAWINGS

[0022] In order to illustrate the technical solutions in the embodiments of the present application or the related art more clearly, the drawings used in the description of the embodiments or the related art are briefly introduced below. The drawings described below are only some embodiments of the present application. For those skilled in the art, other drawings can be obtained based on the structures shown in these drawings without creative efforts.

FIG. 1 is a schematic structural diagram of a fan blade according to a first embodiment of the present application;

FIG. 2 is a front view of the fan blade shown in FIG. 1;

FIG. 3 is a projection view of the fan blade shown in FIG. 1 on a plane perpendicular to an axis of a hub;

FIG. 4 is a schematic diagram of a group of blade profiles formed by intersecting a blade of a fan blade with a reference cylindrical surface;

FIG. 5 is a schematic diagram of multiple groups of blade profiles formed by intersecting a blade of a fan blade with multiple different reference cylindrical surfaces;

FIG. 6 is a schematic structural diagram of a same group of blade profiles shown in FIG. 5 after being unfolded into a planar state;

FIG. 7 is a schematic structural diagram of a bridging segment of the blade shown in FIG. 5;

FIG. 8 is a schematic structural diagram of the bridging segment shown in FIG. 7 from another viewing angle;

FIG. 9 is a schematic structural diagram of a bridging segment of a blade in a comparative example; and

FIG. 10 is a schematic diagram of an orthographic projection of a fan blade on a projection plane parallel to the axis of the hub according to another embodiment of the present application.

Reference signs:

[0023]

Table 1

Signs	Names	Signs	Names
100	fan blade	22	second segment
10	hub	221a	second leading edge point
20	blade	222b	second trailing edge point
201	hollow region	221	second leading edge line
21	first segment	222	second trailing edge line
211a	first leading edge point	223	second pressure side
212b	first trailing edge point	224	second suction side
211	first leading edge line	23	bridging segment
212	first trailing edge line	231	hollow ring
213	first pressure side	232	plane
214	first suction side	300	reference cylindrical surface
201a	first projection	20a	second projection
23'	bridging segment	400	reference circle
211'	first leading edge line	221'	second leading edge line
212'	first trailing edge line	222'	second trailing edge line
213'	first pressure side	223'	second pressure side
214'	first suction side	224'	second suction side

[0024] The realization of an objective, functional characteristics and advantages of the present application are further explained with reference to the accompanying drawings.

DETAILED DESCRIPTION

[0025] The solutions in the embodiments of the present application are clearly and completely described below with reference to the accompanying drawings in embodiments of the present application. The described embodiments are only a part of the embodiments of the present application, and not all of the embodiments. Based on the embodiments of the present application, all other embodiments obtained by those skilled in the art without creative efforts are within the scope of protection of the present application.

[0026] It should be noted that if the embodiments of the present application involve directional indicators such as up, down, left, right, front, back, etc., then the directional indicators are only used to explain a relative positional relationship and movement of components in a specific posture as shown in the accompanying drawings. If the specific posture changes, the directional indicators also change accordingly.

[0027] Furthermore, if the embodiments of the present application involve descriptions such as "first," "second," etc., these descriptions are for descriptive purposes only and should not be construed as indicating or implying their relative importance or implicitly specifying a number of technical features indicated. Thus, a feature defined with "first" or "second" may explicitly or implicitly include at least one of those features. Additionally, the meaning of "and/or" throughout the text is to include three parallel solutions; for example, "A and/or B" includes solution A, solution B, or a solution that simultaneously satisfies A and B. Furthermore, the solutions of the various embodiments can be combined with each other, but this must be based on the capability of those skilled in the art to implement them. When a combination of solutions is contradictory or impossible to implement, it should be considered that such a combination of solutions does not exist and is not within the scope of protection claimed by the present application.

[0028] The present application provides a fan blade 100.

[0029] Referring to FIG. 1 to FIG. 5, in an embodiment of the present application, the fan blade 100 includes:

a hub 10;

a blade assembly including N blades 20, where N is an integer greater than or equal to 2; the N blades 20 are connected to the hub 10, the N blades 20 include a first segment 21 and a second segment 22, a hollow region 201 is disposed between the first segment 21 and the second segment 22, a pressure surface of the first segment

21 is connected to a suction surface of the second segment 22, and a suction surface of the first segment 21 is connected to a pressure surface of the second segment 22, and on a projection plane perpendicular to an axis of the hub 10, projection points formed by orthographic projections of curved surfaces of the N blades 20 do not overlap.

[0030] The fan blade 100 includes a hub 10 and N blades 20 disposed on an outer circumference of the hub 10. The number of blades 20 can be set according to actual needs, generally at least two, for example, two, three, five, or more. In an embodiment, $2 \leq N \leq 9$, which ensures the work done by the fan blade 100 while reducing noise generated during operation. In an embodiment, $4 \leq N \leq 7$. An inner end (root) of the blade 20 is connected to the hub 10. A connection method can be varied; for example, the blade 20 and hub 10 can be integrally formed, or they can be assembled together using screws, clips, or other assembly structures. There is no specific limitation herein. In some embodiments, the blade 20 further includes a bridging segment 23 connecting the first segment 21 to the second segment 22. There are multiple molding manners for single blade 20. For example, the first segment 21, the second segment 22, and the bridging segment 23 may be integrally formed, or they may be individually molded and subsequently joined together and there is no specific limitation herein. In an embodiment, the first segment 21, the second segment 22, and the bridging segment 23 are integrally injection-molded, resulting in higher overall structural strength and better stability for the blade 20, while also simplifying the manufacturing process of the blade 20. In an embodiment, the blade 20 and the hub 10 are integrally injection-molded to make the connection between the blade 20 and the hub 10 more stable and reliable, while also simplifying the manufacturing process of the fan blade 100.

[0031] In an embodiment, at least portions of the first segment 21 and the second segment 22 are spaced apart in a circumferential and/or axial directions of the hub 10. It can be understood that the arrangement that at least portions of the first segment 21 and the second segment 22 are spaced apart in a circumferential and/or axial directions of the hub 10 refers to that at least portions of the first segment 21 and the second segment 22 are spaced apart solely along the axial direction of the hub 10, i.e., the first segment 21 and the second segment 22 are disposed opposite one another on the axial direction of the hub 10, and the corresponding hollow region 201 has a certain thickness; or the arrangement refers to that at least portions of the first segment 21 and the second segment 22 are spaced apart solely along the circumferential direction of the hub 10, i.e., the first segment 21 and the second segment 22 are disposed opposite one another on the circumferential direction of the hub 10, and the corresponding hollow region 201 possesses a certain width; or the arrangement refers to that at least portions of the first segment 21 and the second segment 22 are spaced apart simultaneously along both the axial and circumferential directions of the hub 10, i.e., the first segment 21 and the second segment 22 are disposed staggeringly on the hub 10.

[0032] It should be noted that an inner end of the blade 20 refers to an end closer to the hub 10, and an outer end of the blade 20 refers to the end away from the hub 10. That is, the inner end of the blade 20 corresponds to its root, and the outer end of the blade 20 corresponds to its tip. A leading edge of the blade 20 refers to a portion of the blade 20 that first comes into contact with the airflow during the rotation of the fan blade 100, while a trailing edge of the blade 20 refers to a portion where the airflow ultimately flows out of the blade 20. That is, in an inflow direction of the fan blade 100, the airflow enters via the leading edge of the blade 20 and flows out via the trailing edge of the blade 20. A pressure surface of the blade 20 refers to a side of the blade 20 that moves relative to the airflow, i.e., the side of the blade 20 that faces the direction of the airflow while a suction surface of the blade 20 refers to another side of the blade 20 that moves relative to the airflow, i.e., the side of the blade 20 that faces away from the direction of the airflow.

[0033] It can be understood that the noise of conventional axial fan blades originates partly from shedding vortices formed at the trailing edge of the blade during rotation of the fan blade. That is, when the fan blade rotates, airflow forms vortices at the trailing edge, and these vortices detach directly from the trailing edge, generating significant noise. In the present solution, the first segment 21, the bridging segment 23 and the second segment 22 of the blade 20 jointly enclose the hollow region 201. The hollow region 201 exerts a certain guiding effect on the airflow over the blade 20. When the fan blade 100 rotates, the airflow at the trailing edge of the blade 20 is guided through the hollow region 201 along the suction surface of the blade 20 to the pressure surface of the blade 20, which may disperse the airflow vortices at the trailing edge of the fan blade 100, preventing them from detaching directly from the trailing edge and generating significant noise of shedding vortex. Furthermore, by connecting the outer end of the first segment 21 to the outer end of the second segment 22 via the bridging segment 23, leakage vortices at the outer end of the blade 20 are further reduced to not only further lower the overall noise level of the fan blade 100 but also enhance work capacity of the fan blade 100.

[0034] It should be noted that on a projection plane perpendicular to an axis of the hub 10, projection points formed by orthographic projections of curved surfaces of the blades 20 do not overlap. It should be understood that without affecting the mold opening process, the projection points formed by curved surfaces of the N blades 20 do not overlap substantially. In practical applications, due to inherent manufacturing tolerances associated with the production of fan blades 100, instances may arise where portions of the projected points of the curved surfaces of the blades 20

overlap. For example, if an area occupied by all such overlapping points constitutes no more than 5% of the total projected area of the curved surfaces of the blades 20, the configuration may still be deemed to be substantially non-overlapping.

[0035] In solution of the present application, the hollow region 201 is disposed between the first segment 21 and the second segment 22 of the blade 20, which exerts a certain guiding effect on the airflow over the blade 20. When the fan blade 100 rotates, the airflow at the trailing edge of the blade 20 is guided through the hollow region 201 along the suction surface of the blade 20 to the pressure surface of the blade 20, which may disperse the airflow vortices at the trailing edge of the fan blade 100, preventing them from detaching directly from the trailing edge and generating significant noise of shedding vortex. Furthermore, by connecting the outer end of the first segment 21 to the outer end of the second segment 22 via the bridging segment 23, leakage vortices at the outer end of the blade 20 can be further reduced to not only further lower the overall noise level of the fan blade 100 but also enhance work capacity of the fan blade 100. Moreover, on a projection plane perpendicular to an axis of the hub 10, projection points formed by orthographic projections of curved surfaces of the blades 20 do not overlap, which significantly lowers the difficulty in mold opening of a ring-shaped blade 20 and facilitates its mass production and manufacture via injection molding. Through the solution of the present application, the noise generated during the operation of the fan blade 100 can be effectively reduced and difficulty in mold opening during an injection molding process of the fan blade 100 is simultaneously lowered to facilitate manufacture and production of the fan blade 100.

[0036] In an embodiment, projection planes formed by orthographic projections of the N blades 20 of the blade assembly do not overlap on the projection plane perpendicular to the axis of the hub 10.

[0037] In an embodiment, each of the N blades 20 further includes a bridging segment 23 connecting the first segment 21 and an end of the second segment 22 away from the hub 10; and the first segment 21, the bridging segment 23 and the second segment 22 jointly enclose the hollow region 201.

[0038] The first segment 21, the bridging segment 23 and the second segment 22 jointly enclosing the hollow region 201 refers to that the first segment 21, the bridging segment 23, and the second segment 22 jointly enclose to form a ring-shaped structure, where the hollow region 201 constitutes a center of the ring-shaped structure. The ring-shaped structure can be either a closed ring or an unclosed ring. For example, the first segment 21, the bridging segment 23, and the second segment 22 may be connected sequentially end-to-end to jointly enclose a closed ring-shaped structure. For another example, the first segment 21, the bridging segment 23, and the second segment 22 may be connected sequentially and a gap exists between the inner end of the first segment 21 and the inner end of the second segment 22, with both inner ends being connected to the hub 10. In this case, the first segment 21, the bridging segment 23, and the second segment 22 jointly enclose a non-closed ring-shaped structure. However, the first segment 21, the bridging segment 23, the second segment 22, and the hub 10 jointly enclose a closed ring-shaped structure.

[0039] To further reduce the difficulty in mold opening, in an embodiment, the bridging segment 23 includes a plane 232 opposite to the hub 10, where the plane 232 is parallel to the axis of the hub 10. It should be noted that the plane 232 of the bridging segment 23 is parallel to the axis of the hub 10. It should be understood that the plane 232 of the bridging segment 23 is substantially parallel to the axis of the hub 10 without affecting mold opening. That is to say, a certain included angle is permissible between the plane 232 of the bridging segment 23 and the axis of the hub 10 (for example, the included angle may range from 1° to 5° , or assume other values, provided that it does not affect mold opening). In an embodiment, the plane 232 of the bridging segment 23 may also be strictly parallel to the axis of the hub 10.

[0040] As shown in FIG. 3 and FIG. 5, in an embodiment, a height of each blade 20 in a radial direction of the fan blade 100 is $H1$ and a width of the bridging segment 23 in an axial direction of the fan blade 100 is $L0$, where $L0$ is not greater than $5\% \times H1$. That is, $L0 \leq 5\% \times H1$. This ensures that the width of the bridging segment 23 is maintained within an appropriate range to effectively reduce the noise generated during the operation of the fan blade 100. Specifically, an outer contour of the fan blade 100 has a first diameter $D1$, and the hub 10 has a second diameter $D2$; wherein $H1 = (D1 - D2)$.

[0041] Furthermore, the bridging segment 23 is disposed at an end of the blade 20 that is away from the hub 10. That is, the bridging segment 23 is disposed as far away from the hub 10 as possible. This arrangement serves to minimize interference with the main flow of the airflow sucked by the blade 20.

[0042] Since the solution of the present application incorporates an optimized structural design for the fan blade 100, the difficulty in mold opening during the injection molding process can be lowered to facilitate injection molding manufacturing. the first segment 123, the second segment 124, and the bridging segment 127 are integrally injection-molded, resulting in higher overall structural strength and better stability for the blade 121, while also simplifying the manufacturing process of the blade 121. In another embodiment, the blade 20 and the hub 10 are integrally injection-molded to ensure a more stable and reliable connection between the blade 20 and the hub 10, while also simplifying the manufacturing process of the fan blade 100. It is worth noting that although the structure of the fan blade 100 described in this solution is particularly well-suited for integral injection molding, other manufacturing methods (such

as 3D printing) may also be employed in practical applications and all such methods fall within the scope of protection of the present application.

[0043] The blade 20 is provided with a first leading edge line 211 and a first trailing edge line 212 disposed at opposite sides of the first segment 21, as well as a second leading edge line 221 and a second trailing edge line 222 disposed at opposite sides of the second segment 22.

[0044] As shown in FIG. 4, a reference cylindrical surface 300 is constructed around the axis of the hub 10, a cross-section formed by intersecting each blade 20 with the reference cylindrical surface 300 is defined as a blade profile, and the blade profiles of the first segment 21 and the second segment 22 obtained by intersecting each blade with reference cylindrical surfaces 300 of the same radius belong to a same group. FIG. 5 illustrates a total of four groups of blade profiles, each obtained by intersection with a reference cylindrical surface 300 of a different radius; these groups include blade profiles 21a and 22a, 21b and 22b, 21c and 22c, and 21d and 22d. The blade profile 21a and 22a belonging to the same group are located at the blade root of the blade 20, while the other three groups of blade profiles are distributed sequentially at intervals in a direction proximal to the blade tip.

[0045] Referring to FIG. 5 and FIG. 6, one of these groups of blade profiles (e.g., blade profiles 21c and 22c) is unfolded in the circumferential direction into a planar state. In a rotation direction of the fan blade 100, a blade profile of the first segment 21 (e.g., blade profile 21c) is located upstream of a blade profile of the second segment 22 (e.g., blade profile 22c). The blade profile of the first segment 21 (e.g., blade profile 21c) is provided with a first leading edge point 211a and a first trailing edge point 212b and the first leading edge point 211a is located upstream of the first trailing edge point 212b in the rotation direction of the fan blade 100. First leading edge points 211a of multiple blade profiles of the first segment 21 (e.g., 21a, 21b, 21c, 21d, etc.) are connected sequentially to form a first leading edge line 211. Similarly, first trailing edge points 212b of multiple blade profiles of the first segment 21 (e.g., 21a, 21b, 21c, 21d, etc.) are connected sequentially to form a first trailing edge line 212. Both the first leading edge line 211 and the first trailing edge line 212 extend toward the bridging segment 23. A blade profile of the second segment 22 (e.g., blade profile 22c) is provided with a second leading edge point 221a and a second trailing edge point 222b and the second leading edge point 221a is located upstream of the second trailing edge point 222b in the rotation direction of the fan blade 100. Second leading edge points 221a of the multiple blade profiles of the second segment 22 (e.g., 22a, 22b, 22c, 22d, etc.) are sequentially connected to form a second leading edge line 221. Similarly, second trailing edge points 222b of these multiple blade profiles are sequentially connected to form a second trailing edge line 222. Both the second leading edge line 221 and the second trailing edge line 222 extend toward the bridging segment 23.

[0046] As shown in FIG. 6, the blade profile of the first segment 21 (e.g., blade profile 21c) is separated at the first leading edge point 211a and the first trailing edge point 212b to obtain two side profile lines. A side of the blade profile of the first segment 21 proximal to the rotation direction of the fan blade 100 is defined as a first pressure side 213, while an opposite side is defined as a first suction side 214. Similarly, the blade profile of the second segment 22 (e.g., blade profile 22c) is separated at the second leading edge point 221a and the second trailing edge point 222b to obtain two side profile lines. A side of the second segment 22 blade profile proximal to the rotation direction of the fan blade 100 is defined as a second pressure side 223, while an opposite side is defined as a second suction side 224. Consequently, profile lines at the first pressure sides 213 of the multiple blade profiles of the first segment 21 are stacked together to form a pressure surface of the first segment 21, while profile lines at the first suction sides 214 of these multiple blade profiles are stacked together to form the suction surface of the first segment 21. Similarly, profile lines at the second pressure sides 223 of the multiple blade profiles of the second segment 22 are stacked together to form the pressure surface of the second segment 22, while profile lines at the second suction sides 224 of these multiple blade profiles are stacked together to form the suction surface of the second segment 22. It can be understood that the pressure surface of blade 20 is a side of blade 20 facing airflow impact, while the suction surface of blade 20 refers to a side of blade 20 opposite to the airflow impact.

[0047] As shown in FIG. 7, in an embodiment, at the location of the bridging segment 23, a leading edge line of the first segment 21 (i.e., the first leading edge line 211) is connected to a leading edge line of the second segment 22 (i.e., the second leading edge line 221), and a trailing edge line of the first segment 21 (i.e., the first trailing edge line 212) is connected to a trailing edge line of the second segment 22 (i.e., the second trailing edge line 222).

[0048] In this embodiment, through optimized design of the configuration of the bridging segment 23, the overall configuration of the blade 20 is smoother to facilitate improved airflow guidance. For example, in the rotation direction of the fan blade 100, the first segment 21 is located upstream of the second segment 22, the outer end of the first segment 21 is connected to the outer end of the second segment 22 via the bridging segment 23, the pressure surface of the first segment 21 is connected to the suction surface of the second segment 22 via an outer lateral surface of the bridging segment 23, and the suction surface of the first segment 21 is connected to the pressure surface of the second segment 22 via an inner lateral surface of the bridging segment 23. When the fan blade 100 rotates, airflow vortices at the outer end of the pressure surface of the first segment 21 are guided along the outer lateral surface of the bridging segment 23 toward the suction surface of the second segment 22 to effectively reduce vortex shedding noise at the outer end of the first segment 21 and noise generated during operation of the fan blade 100. Similarly,

airflow vortices at the outer end of the pressure surface of the second segment 22 are guided along the inner lateral surface of the bridging segment 23 toward the suction side of the first segment 21 to effectively reduce vortex shedding noise at the outer end of the first segment 21 and noise generated during operation of the fan blade 100.

[0049] FIG. 9 is a schematic structural diagram of a bridging segment 23' in a comparative example. A connection structure of the bridging segment in this comparative example differs from a connection structure of the bridging segment in the present embodiment. In the comparative example, at the bridging segment 23', a leading edge line of the first segment (i.e., the first leading edge line 211') is connected to a trailing edge line of the second segment (i.e., a second trailing edge line 222'), a trailing edge line of the first segment (i.e., a first trailing edge line 212') is connected to a leading edge line of the second segment (i.e., a second leading edge line 221'), a suction side of the first segment (i.e., a first suction side 214') is connected to a suction side of the second segment (i.e., a second suction side 224'); and a pressure side of the first segment (i.e., a first pressure side 213') is connected to a pressure side of the second segment (i.e., a second pressure side 214').

[0050] Performance tests were performed respectively on a fan having the bridging segment structure of the present embodiment (hereinafter referred to as "the solution involved") and a fan featuring the bridging structure of the aforementioned comparative example (hereinafter referred to as "the Comparative Example"). With fan blades of identical dimensions and under identical airflow conditions, the solution involved demonstrated a noise level at least 3 dB lower than that of the Comparative Example. Thus, it is evident that the bridging segment structure of the present embodiment enables the fan to effectively reduce noise levels while maintaining a constant airflow volume.

[0051] At the bridging segment 23, the first leading edge line 211 transitions smoothly into the second leading edge line 221, the first trailing edge line 212 transitions smoothly into the second trailing edge line 222, a pressure side of the first segment 21 transitions smoothly into a suction surface of the second segment 22; and a suction surface of the first segment 21 transitions smoothly into a pressure side of the second segment 22. In this manner, a flow field of the blade 20 at the hollow region 201 in particular, the blade tip region can be optimized to facilitate the maintenance of the morphology of the hollow region 201. Simultaneously, it ensures smoother transitions at the connection points between the various segments to prevent the formation of undercuts. This, in turn, further reduces the difficulty in mold opening during the injection molding of the blade 20 to further lower the manufacturing complexity of the fan blade 100.

[0052] As shown in FIG. 8 and FIG. 10, in some embodiments, on a projection plane parallel to the axis of the hub 20, an orthogonal projection of an end of each blade 20 away from the hub 10 (e.g., the bridging segment 23) has a hollow ring 231. This configuration allows airflow passing through the hollow ring 231 to have a higher speed, which can reduce the rotation speed of the fan blade 100 while maintaining a constant airflow volume and lower both the noise level and power consumption of any fan or air-blowing device equipped with the fan blade 100.

[0053] As shown in FIG. 2, in an embodiment, on the projection plane perpendicular to the axis of the hub 10, an orthogonal projection of the hollow region 201 forms a first projection 201a, an orthogonal projection of the axis of the hub 10 forms an axis point P, a reference circle 400 is constructed around the axis point P on an axial projection plane of the fan blade 100, a first distance L1 formed by intersecting the reference circle 400 with the first projection 201a is greater than 1 mm. This arrangement further ensures that the projection points formed by the curved surface of the blade 20 on the axial projection plane of the fan blade 100 do not overlap to significantly reduce the difficulty in mold opening for a ring-shaped blade 20 and be more conducive to production and manufacturing by injection molding. In an embodiment, the first distance L1 is greater than 5 mm. For example, L1 may be 6 mm, 7 mm, 8 mm, and so forth.

[0054] As shown in FIG. 2, in an embodiment, on the projection plane perpendicular to the axis of the hub 10, an orthogonal projection of each blade 20 forms a second projection 20a, an orthogonal projection of the axis of the hub 10 forms an axis point P, a reference circle 400 is constructed around the axis point P on an axial projection plane of the fan blade 100, a second distance L2 is formed by intersecting the reference circle 400 with an outer edge of the second projection 20a, and the second distance L2 gradually decreases in the radial direction of the fan blade 100 toward a side away from the hub 10 at the end of each blade 20 away from the hub 10 (i.e., at the bridging segment 23). This configuration results in a smoother overall outer contour of the blade 20 to reduce a flow resistance of airflow along the outer profile of the blade 20 and further lower noise levels.

[0055] As shown in FIG. 6, in some embodiments, a reference cylindrical surface 300 is constructed around the axis of the hub 10 and a cross-section formed by intersecting each blade 20 with the reference cylindrical surface 300 is defined as a blade profile. A thickness of a blade profile leading edge of the first segment 21 is greater than a thickness of a blade profile trailing edge of the first segment 21; and/or a thickness of a blade profile leading edge of the second segment 22 is greater than a thickness of a blade profile trailing edge of the second segment 22. It should be noted that a thickness dimension of a blade profile refers to a width dimension of the blade profile in a direction perpendicular to its arc.

[0056] With this arrangement, blade profile leading edges of the first segment 21 and/or the second segment 22 are relatively thick, while the trailing edges are relatively thin-i.e., the blade profile is characterized by a thick leading edge and a thin trailing edge. This design helps to optimize the airflow field over the first segment 21 and the second

segment 22 to reduce the aerodynamic noise generated by the fan blade 100. Furthermore, in practical applications, some fan blades 100 are installed within a protective grille; the strong inference between the protective grille and the fan blade 100 can generate significant noise. In the present solution, relatively thick blade profile leading edges of the first segment 21 and/or the second segment 22 enhances its adaptability to the non-uniform airflow exiting the air intake grille. Conversely, relatively thin blade profile at the trailing edge of the first segment 21 and/or the second segment 22 serves to reduce the non-uniformity of the airflow speed at the outlet of the blade 20 and attenuate the interference between the blade 20 and the protective grille. As the interference between the fan blade 100 and the intake/exhaust protective grilles is reduced, the noise generated by the fan is significantly lowered, while the overall efficiency of the unit is simultaneously improved.

[0057] In an embodiment, a maximum blade profile thickness of the first segment 21 is located within the region spanning the first 30% of a chord length measured from the first leading edge line 211 and a ratio of the maximum thickness to the chord length of the blade profile ranges from 5% to 35%. A maximum blade profile thickness of the second segment 22 is located within the region spanning the first 30% of a chord length measured from the second leading edge line 221 and a ratio of the maximum thickness to the chord length of the blade profile ranges from 5% to 35%. This configuration enables the leading edges of both the first segment 21 and the second segment 22 to effectively resist intake airflow distortions and generate relatively weak low-speed wake regions to further reduce the aerodynamic noise produced by the fan blade 100. In alternative embodiments, the thickness of the leading edge blade profile of the first segment 21 may be less than or equal to the thickness of its trailing edge blade profile; and/or, the thickness of the leading edge blade profile of the second segment 22 may be less than or equal to the thickness of its trailing edge blade profile.

[0058] Furthermore, there are various specific methods for constructing the hollow region 201. As shown in FIG. 1, in an embodiment, the inner end of the first segment 21 and the inner end of the second segment 22 are respectively connected to the hub 10. These inner ends of the first and second segments are circumferentially spaced apart relative to one another along the fan blade 100. The first segment 21, the bridging segment 23, the second segment 22, and the hub 10 jointly enclose the hollow region 201. In other words, the first segment 21, the bridging segment 23, the second segment 22, and the hub 10 jointly enclose to form a ring-shaped structure. In this way, effective lengths of the first segment 21 and the second segment 22 can be increased to enhance the overall work capacity of the blade 20.

[0059] For example, in yet another embodiment, the inner end of the first segment 21 is connected to the lateral edge of the second segment 22, while the inner end of the second segment 22 is connected to the hub 10. That is, the inner end of the second segment 22 serves as a root portion of the blade 20 and is connected directly to the hub 10, while the first segment 21 is not directly connected to the hub 10. In other words, the end of the blade 20 away from the hub 10 bends and winds in a direction opposite to the rotation direction of the fan blade 100 to construct the hollow region 201. In this way, the blade root of the blade 121 can be made more compact, which helps reduce the weight of the blade 121. For another example, in an embodiment, the inner ends of the first segment 21 and the second segment 22 are connected and simultaneously connected to the hub 110. That is, the root portion of the blade 20 is simultaneously composed of the first segment 21 and the second segment 22, with the hollow region 201 directly formed on the blade 121. In this way, the structural strength of the blade root portion of the blade 121 can be improved. In addition, in some embodiments, the hollow region is provided with a filter screen to provide a filtering and purifying function.

[0060] The present application further provides a fan, including a fan blade 100 and a drive member drivably connected to the fan blade and configured to drive the fan blade 100 to rotate. The specific structure of the fan blade 100 is as described in the aforementioned embodiments. Since the fan adopts all the solutions of all the above embodiments, it possesses at least all the beneficial effects brought about by the technical solutions of the above embodiments, which are not repeated herein. The fan may take the form of an axial flow fan equipped with an axialflow fan blade 100, and the drive member may be any of a motor, a hydraulic motor, or a pneumatic motor.

[0061] The present application also provides an air-blowing device, including a fan blade 100 or a fan. The specific structure of the fan blade 100 or fan is as described in the above embodiments. Since the air-blowing device adopts all the solutions of all the above embodiments, it possesses at least all the beneficial effects brought about by the technical solutions of the above embodiments, which are not repeated herein. The air-blowing device includes, but is not limited to, floor fans, ceiling fans, desktop fans, and other fan products. It can also be other devices with fan blades 100 (e.g., an outdoor unit of an air conditioner). By using the aforementioned fan blades 100 or fan, the noise of the air-blowing device can be effectively reduced, improving the user experience.

[0062] The above are merely preferred embodiments of the present application and do not limit the patent scope of the present application. Any equivalent structural variation made under the inventive concept of the present application using the description and drawings of the present application, or direct/indirect applications in other related fields, are included within the patent protection scope of the present application.

Claims

1. A fan blade, comprising:

a hub; and

a blade assembly comprising N blades, N being an integer greater than or equal to 2, wherein:

the N blades are connected to the hub, each of the N blades comprising a first segment and a second segment, a hollow region being disposed between the first segment and the second segment, a pressure surface of the first segment being connected to a suction surface of the second segment, a suction surface of the first segment being connected to a pressure surface of the second segment; and on a projection plane perpendicular to an axis of the hub, projection points formed by orthographic projections of curved surfaces of the N blades do not overlap.

2. The fan blade of claim 1, wherein on the projection plane perpendicular to the axis of the hub, projection planes formed by orthographic projections of the N blades of the blade assembly do not overlap.

3. The fan blade of claim 1, wherein:

each of the N blades further comprises a bridging segment connecting an end of the first segment away from the hub and an end of the second segment away from the hub; and the first segment, the bridging segment and the second segment jointly enclose the hollow region.

4. The fan blade of claim 3, wherein the bridging segment comprises a plane opposite to the hub, the plane being parallel to the axis of the hub.

5. The fan blade of claim 3, wherein a height of each blade in a radial direction of the fan blade is H1, and a width of the bridging segment in an axial direction of the fan blade is not greater than $5\% \times H1$.

6. The fan blade of claim 3, wherein the bridging segment is disposed at an end of each blade away from the hub.

7. The fan blade of claim 3, wherein at a position of the bridging segment, a leading edge line of the first segment is connected to a leading edge line of the second segment, and a trailing edge line of the first segment is connected to a trailing edge line of the second segment.

8. The fan blade of claim 3, wherein an inner end of the first segment and an inner end of the second segment are each connected to the hub, the inner end of the first segment and the inner end of the second segment being spaced apart from each other in a circumferential direction of the fan blade, and the first segment, the bridging segment, the second segment, and the hub jointly forming the hollow region.

9. The fan blade of claim 3, wherein:

the first segment, the second segment, and the bridging segment are integrally injection-molded; and/or each blade and the hub are integrally injection-molded.

10. The fan blade of claim 1, wherein on a projection plane parallel to the axis of the hub, an orthogonal projection of an end of each blade away from the hub has a hollow ring.

11. The fan blade of claim 1, wherein:

on the projection plane perpendicular to the axis of the hub, an orthogonal projection of the hollow region forms a first projection, an orthogonal projection of the axis of the hub forming an axis point P, a reference circle being constructed around the axis point P on an axial projection plane of the fan blade; and a first distance L1 is formed by intersecting the reference circle with the first projection and is greater than 1 mm.

12. The fan blade of claim 11, wherein the first distance L1 is greater than 5 mm.

13. The fan blade of claim 1, wherein:

on the projection plane perpendicular to the axis of the hub, an orthogonal projection of each blade forms a second projection, an orthogonal projection of the axis of the hub forming an axis point P, a reference circle being constructed around the axis point P on an axial projection plane of the fan blade; and
a second distance L2 is formed by intersecting the reference circle with an outer edge of the second projection, and the second distance L2 gradually decreases in the radial direction of the fan blade toward a side away from the hub at the end of each blade away from the hub.

14. The fan blade of any one of claims 1 to 13, wherein:

a reference cylindrical surface is constructed around the axis of the hub, and a cross-section formed by intersecting each blade with the reference cylindrical surface is defined as a blade profile; and
a thickness of a blade profile leading edge of the first segment is greater than a thickness of a blade profile trailing edge of the first segment, and/or a thickness of a blade profile leading edge of the second segment is greater than a thickness of a blade profile trailing edge of the second segment.

15. A fan, comprising

the fan blade of any one of claims 1 to 14, and
a drive member drivably connected to the fan blade and configured to drive the fan blade to rotate.

16. An air-blowing device, comprising:

the fan blade of any one of claims 1 to 14, or
the fan of claim 15.

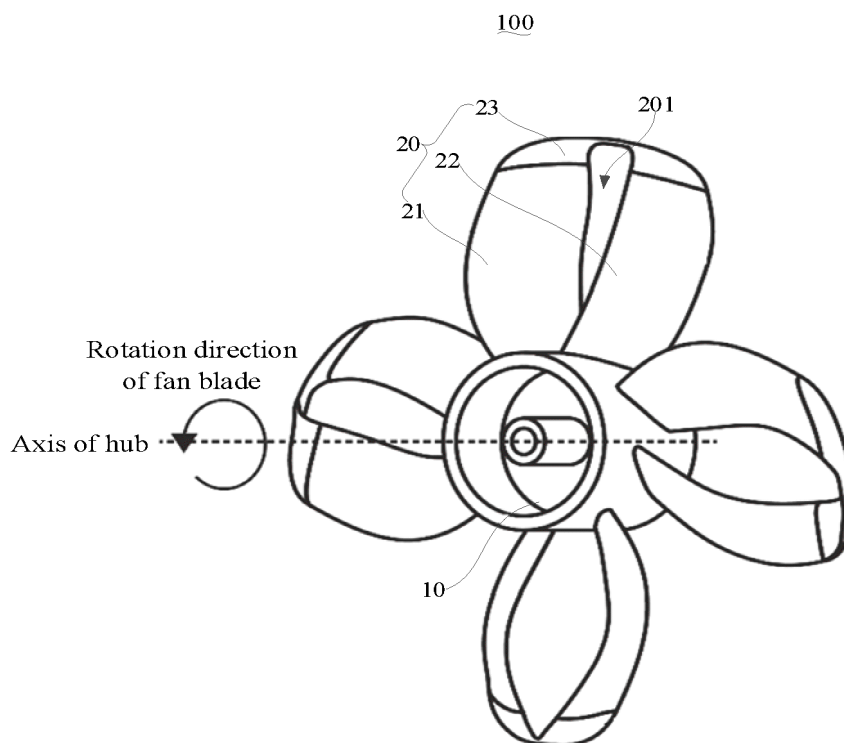


FIG. 1

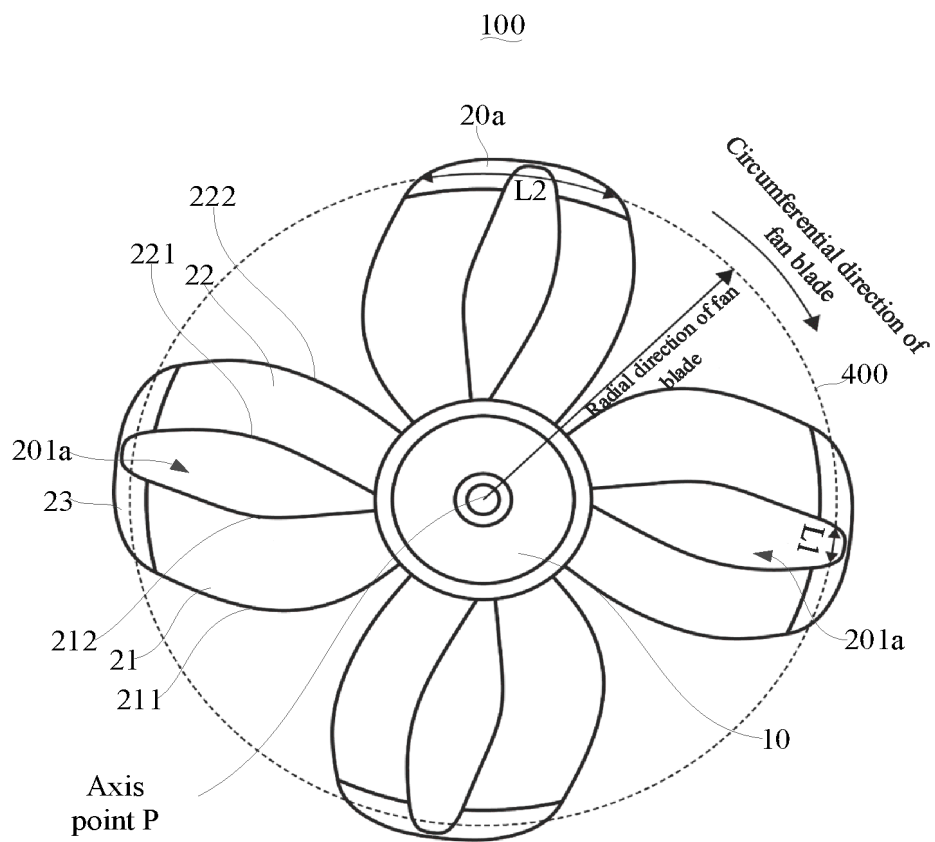


FIG. 2

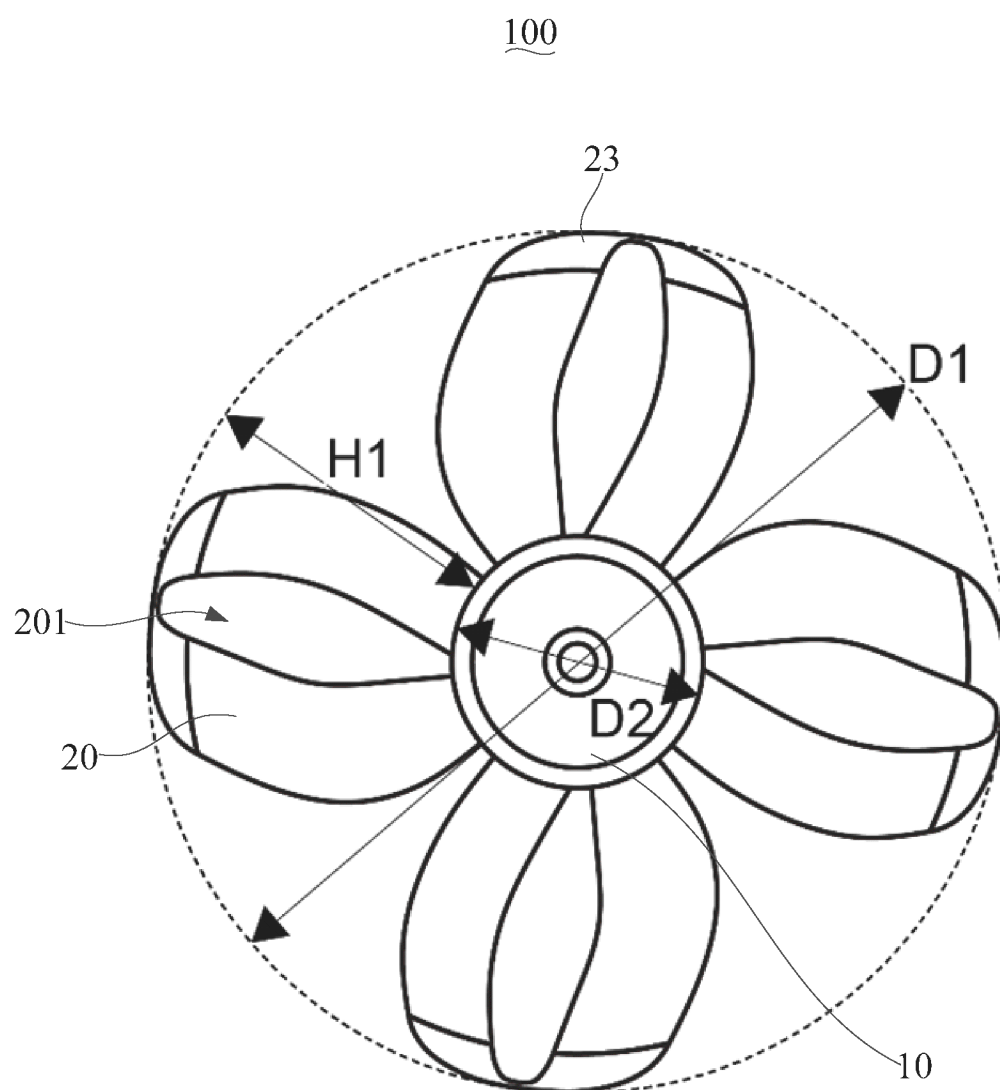


FIG. 3

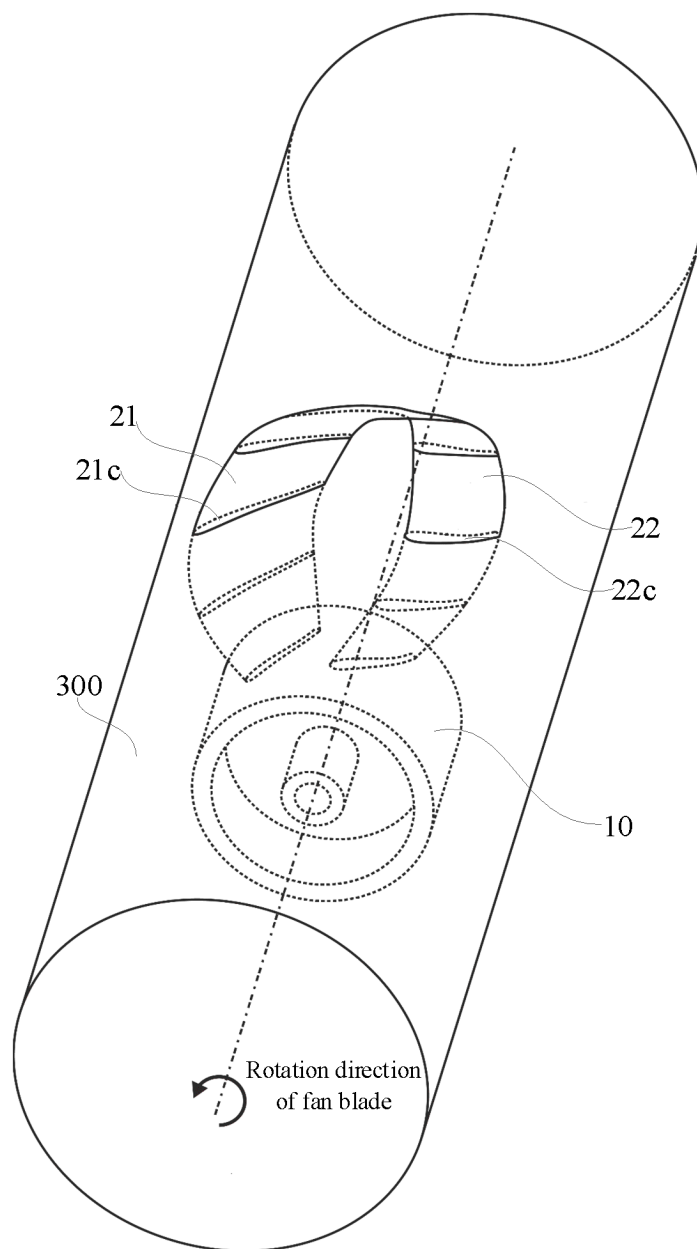


FIG. 4

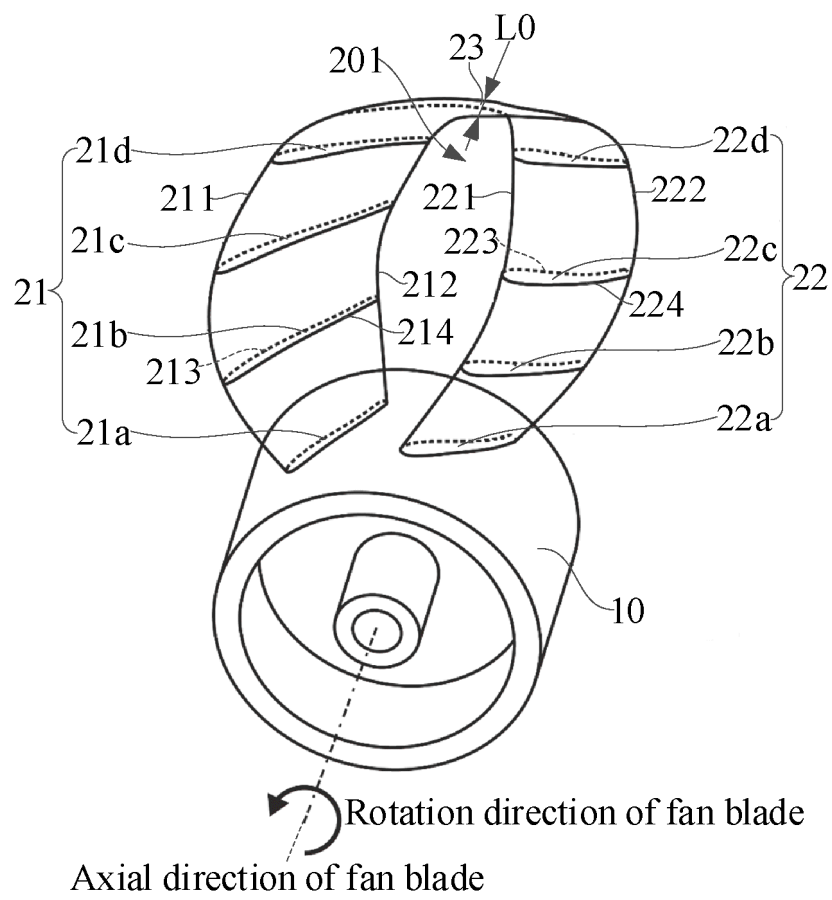


FIG. 5

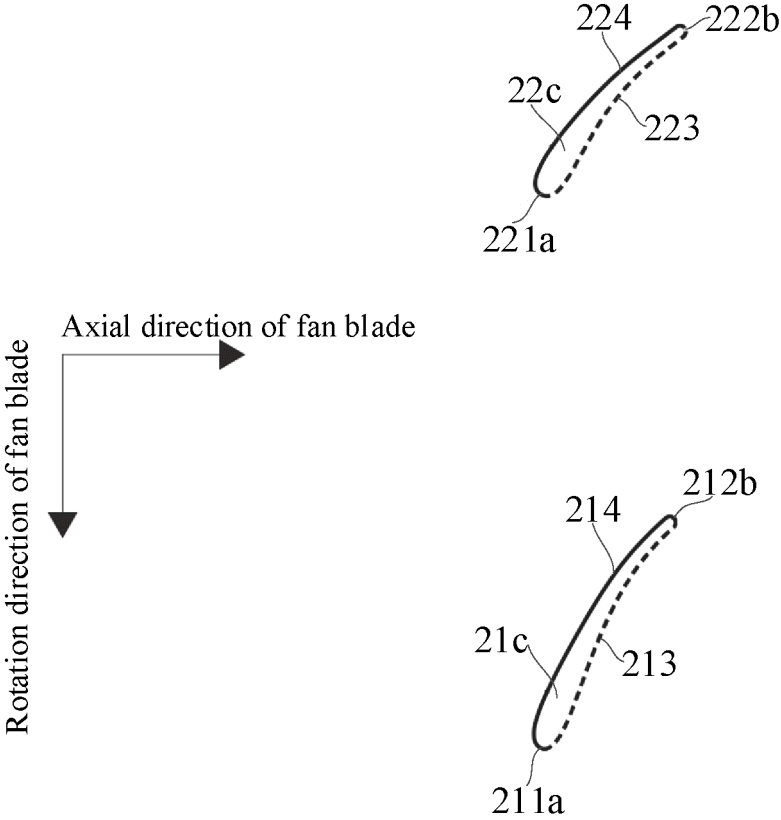


FIG. 6

23

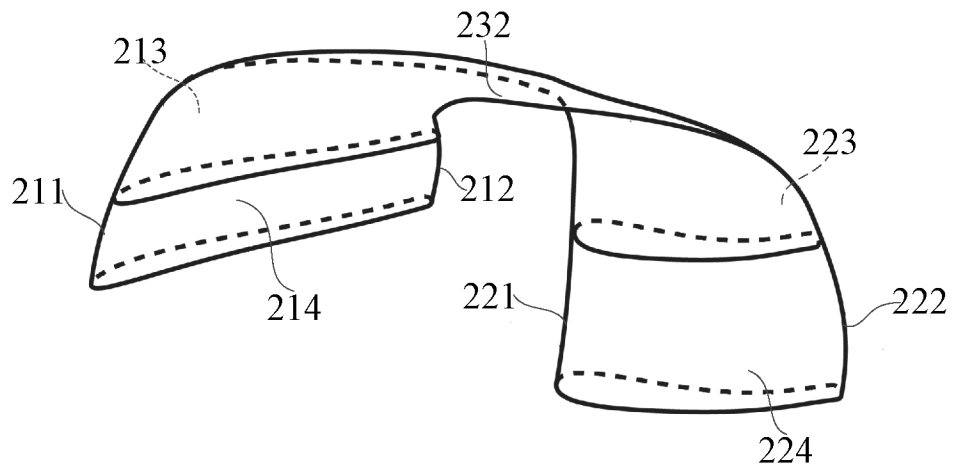


FIG. 7

23

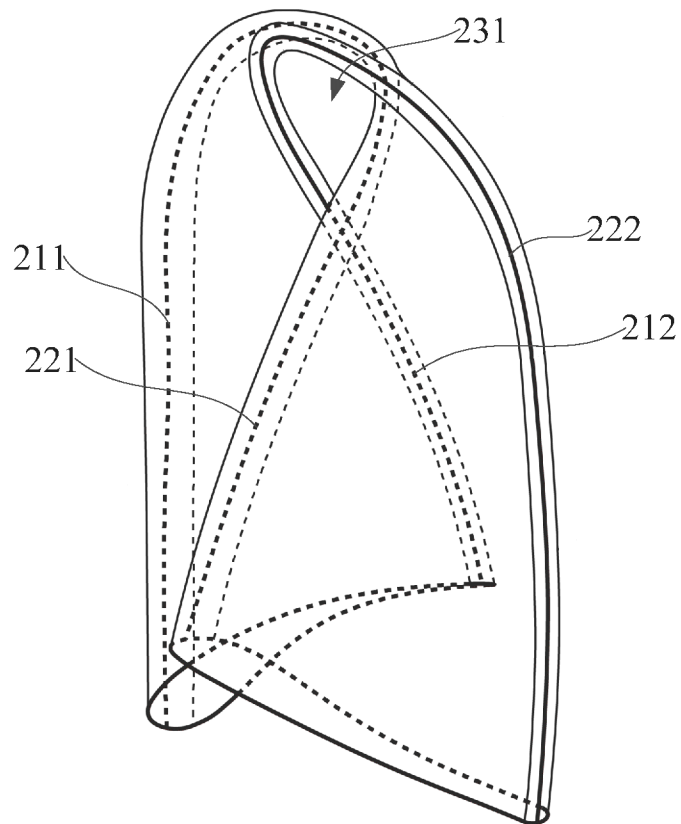


FIG. 8

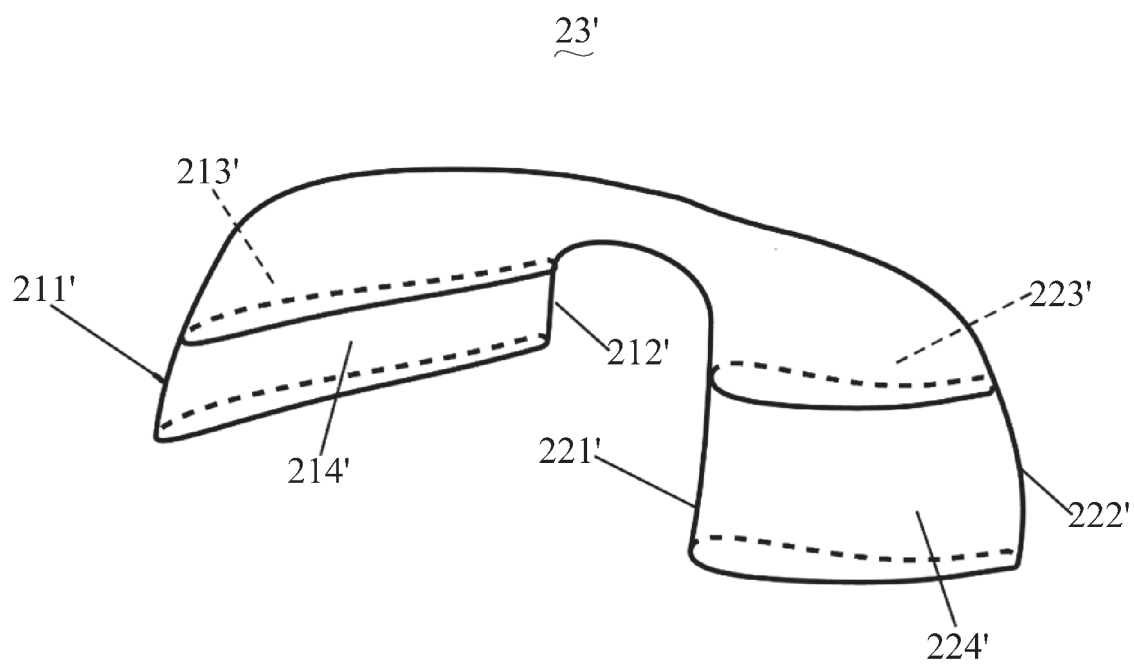


FIG. 9

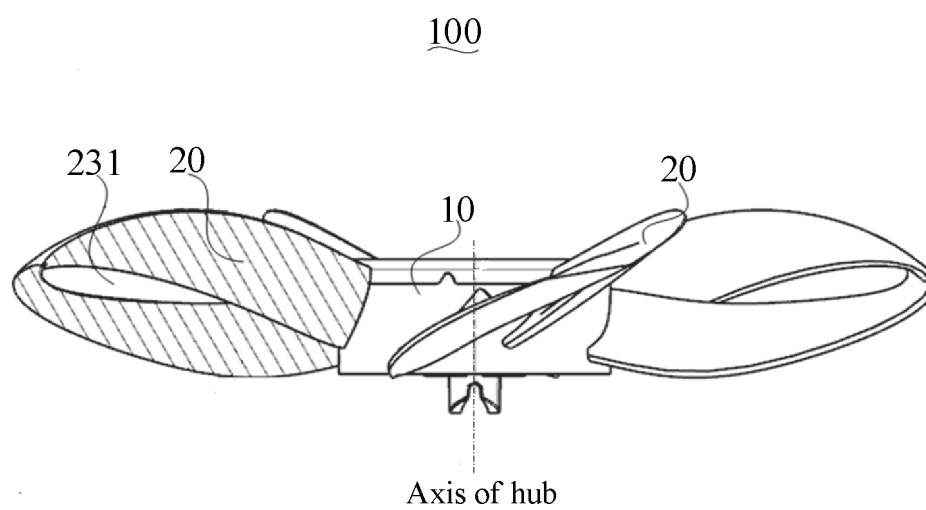


FIG. 10

INTERNATIONAL SEARCH REPORT

International application No.

PCT/CN2024/107101

A. CLASSIFICATION OF SUBJECT MATTER

F04D 29/32(2006.01)i; F04D25/08(2006.01)i

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC:F04D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

CNABS, CNTXT, CNKI, ENTXTC: 扇叶, 风叶, 扇片, 桨叶, 桨片, 叶子, 叶片, 叶轮, 翼片, 转叶, 叶盘, 莫比乌斯环, 中空, 空心, 投影, 降噪, 噪音, 减震, 减振; VEN, USTXT, EPTXT, WOTXT, ENTXT: fan, blade, vane, impeller, mobius, hollow, empty, gap, projective, noise, muffle, silence, sound, vibration, damp, shock.

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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PY	CN 308619593 S (GUANGDONG MIDEA ENVIRONMENT APPLIANCES MANUFACTURING CO., LTD.) 03 May 2024 (2024-05-03) design 2, front view, design 2, rear view, design 2, left view, design 2, right view, and brief description	14
Y	CN 114321010 A (GUANGDONG MIDEA WHITE HOME APPLIANCE TECHNOLOGY INNOVATION CENTER CO., LTD. et al.) 12 April 2022 (2022-04-12) description, paragraphs 51-80, and figures 1-15	1-16
Y	DE 202005013185 U1 (FESTO AG & CO.) 03 November 2005 (2005-11-03) description, paragraphs 44-60, and figures 1-2	1-16
Y	US 2004067138 A1 (YOSHIDA Minoru) 08 April 2004 (2004-04-08) description, paragraphs 47-103, and figures 1-28	1-16

☒ Further documents are listed in the continuation of Box C.☒ See patent family annex.

* Special categories of cited documents:	"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A" document defining the general state of the art which is not considered to be of particular relevance	"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"D" document cited by the applicant in the international application	"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"E" earlier application or patent but published on or after the international filing date	"&" document member of the same patent family
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	
"O" document referring to an oral disclosure, use, exhibition or other means	
"P" document published prior to the international filing date but later than the priority date claimed	

Date of the actual completion of the international search

18 October 2024

Date of mailing of the international search report

20 October 2024

Name and mailing address of the ISA/CN

China National Intellectual Property Administration (ISA/
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Authorized officer

Telephone No.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2024/107101

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C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2020002482 A (SHOWA SHOKAI KK) 09 January 2020 (2020-01-09) entire document	1-16
A	CN 201874885 U (FUJIAN HUADA ELECTRIC CO., LTD.) 22 June 2011 (2011-06-22) entire document	1-16

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/CN2024/107101

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REFERENCES CITED IN THE DESCRIPTION

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