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(54) AXIAL FAN BLADE, AXIAL FAN BLADE ASSEMBLY, AND AXIAL FAN DUCT ASSEMBLY

(57) An axial flow fan blade, a blade assembly for axial flow fan, and an air duct assembly for axial flow fan. Wherein, an air guide section is formed on an end of an windward edge of the axial flow fan blade (1) proximal to a blade tip, a plurality of air guide grooves (2) are disposed on the air guide section; the air guide section satisfies that the condition of $(r_2-r_1):r$ =1/3-1/2, and a depth of the air guide grooves (2) is gradually reduced along a direction running toward the rotation center. The air guide section of the axial flow fan blade can divide an airflow into small airflows so as to achieve the noise reduction effect. Moreover, the air guide groove has gradually reduced depth, thereby ensuring uniform air speed.

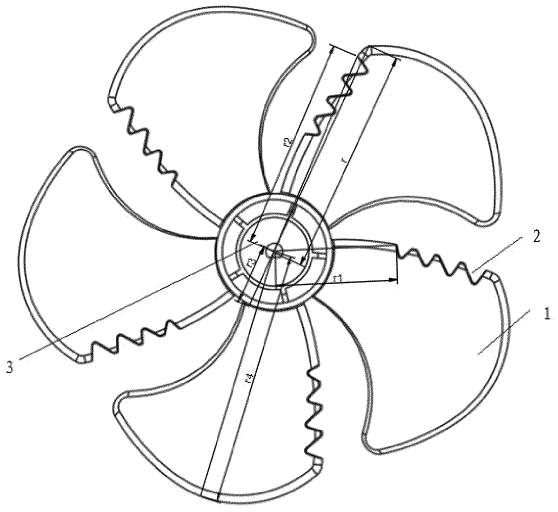

Fig. 1

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Description

CROSS-REFERENCE TO RELATED APPLICATION

[0001] The present application refers to Chinese Patent Application No. 2018200542047 filed on January 13, 2018 entitled "Axial Flow Fan Blade, Blade Assembly for Axial Flow Fan and Air Duct Assembly for Axial Flow Fan", which is incorporated herein by reference in its entirety.

FIELD OF TECHNOLOGY

[0002] The present application relates to an axial flow fan blade, a blade assembly for axial flow fan and an air duct assembly for axial flow fan.

BACKGROUND

[0003] Current products employing axial flow fans, such as heaters and cooling fans, use special-shaped fan blades to achieve large air volume and low noise, but the effects are not good, and the balance between air volume and noise cannot be achieved. Especially for heater products, air volume and air speed of the whole machine have been often compromised to meet the noise requirements of less than 50 dB(A), resulting in insufficient wind speed and air volume of the products across the whole heater industry, which leads to poor customer experience in that the hot wind is barely felt one meter away. Wherein, dB (A) refers to A-weighted sound level, which simulates frequency characteristics of human ear to low-intensity noise below 55dB.

SUMMARY

[0004] The present application is intended to solve at least one of technical problems existing in the prior art or related technologies.

[0005] It is one of the objects of the present application is to provide an axial flow fan blade, a blade assembly for axial flow fan, and an air duct assembly for axial flow fan, which solve the problem of imbalance between air speed, air volume and noise in the prior art, resulting in very poor customer experience.

[0006] In order to achieve this object, the present application provides an axial flow fan blade, a air guide section is formed on an end of an windward edge of the blade proximal to a blade tip, a plurality of air guide grooves are disposed on the air guide section; a distance between the closest point of the air guide section and a rotation center of the axial flow fan blade is r_1, a distance between the farthest point of the air guide section and the rotation center of the axial flow fan blade is r_2, a distance between the farthest point on the windward edge and the rotation center of the axial flow fan blade is r, and $(r_2-r_1):r$ =1/3-1/2, and a depth of the air guide grooves is gradually reduced along a direction running towards the rotation center.

[0007] Optionally, the air guide section has a zigzag shape.

[0008] The present application also provides a blade assembly for axial flow fan including the above-mentioned axial flow fan blades and a hub for mounting the axial flow fan blades.

[0009] Optionally, the number of the axial flow fan blades is odd.

[0010] Optionally, the number of the axial flow fan blades is three or five.

[0011] Optionally, the axial flow fan blade and a mounting surface of the hub intersects at a first curve, and an included angle between a tangent line at any point on the first curve and a vertical surface of the hub is $30\pm5°$.

[0012] Optionally, the hub has a radius of r_3, a distance between the farthest point on the fan blade and the rotation center of the axial flow fan blade is r_4, and the ratio of r_3 to r_4 is 0.2 to 0.3.

[0013] The present application also provides an air duct assembly for axial flow fan, which includes the above-mentioned blade assembly for axial flow fan, and also includes a guide duct, the axial flow fan blades of the blade assembly for axial flow fan being located within the guide duct.

[0014] Optionally, the guide duct has gradually decreased cross-sectional area along the air outflow direction.

[0015] Optionally, the duct assembly for axial flow fan also includes an air outflow shroud, on which an end of the guide duct is fixed.

[0016] The technical solutions of the present application have following advantages: the air guide section of the axial flow fan blade in the present application can divide an airflow into small airflows at the source of the airflow so as to make the air guide grooves on the windward edge achieve the best noise reduction effect. Moreover, each of the air guide grooves has the gradually decreased depth toward the rotation center, that is, farther away from the airflow source, smaller the depth of the air guide grooves, which ensures a uniform air speed and making air experienced by users more natural. As a result, the axial flow fan blade of the present application can provide users with good comprehensive

experience without compromising air speed and air volume for reducing noise.

BRIEF DESCRIPTION OF THE DRAWINGS

[0017] In order to illustrate the embodiments of the present application or the technical solutions in the prior art more clearly, the drawings required in the description of the embodiments or the prior art will be briefly described below. It will be apparent that, the drawings described below are only some embodiments of the present application, other drawings can be obtained based on these drawings without creative work by those having ordinary skill in the art.

Fig. 1 is a schematic structural diagram of a blade assembly for axial flow fan of an embodiment;

Fig. 2 is a schematic structural diagram of an air duct assembly of an axial flow fan of an embodiment;

Fig. 3 is a schematic diagram of mounting grid bars in an embodiment;

in the drawings:

1. axial flow fan blade;	2. air guide groove;
3. hub;	4. guide duct;
5. air outflow shroud;	6. air inlet shroud;
601. first air inlet surface;	602. second air inlet surface;
603. third air inlet surface.	

DETAILED DESCRIPTION

[0018] In order to make the above objects, features and advantages of the present application more clearly understood, the present application will be described in further detail below in connection with accompanying drawings and specific embodiments. It should be noted that the embodiments of the application and the features in the embodiments can be combined with each other in the case of no conflict.

[0019] With respect to the description of the present application, it should be noted that, orientation or position relationship indicated by the terms "center", "longitudinal", "lateral", "upper", "lower", "front", "rear", "left", "right", "vertical", "horizontal", "top", "bottom", "inner", "outer", etc. is based on the orientation or position relationship shown in the drawings, and is intended only to facilitate the description of the application and simplify the description, but not to indicate or imply that the referred device or element must have a particular orientation, being constructed and operated in a particular orientation, and thus cannot be understood as a limitation of the present application. In addition, the terms "first", "second", "third" are used only for descriptive purposes, and cannot be understood as indicating or implying relative importance.

[0020] In the description of the present application, it should be noted that, unless otherwise clearly specified and defined, the terms "connect with" and "connected to" should be understood in a broad sense, e.g., it can be a fixed connection, a detachable connection, or an integral connection; it can be a mechanical connection or an electrical connection; it can be directly connected or indirectly connected through an intermediary. The specific meaning of the above-mentioned terms in the present application can be understood according to specific situations by those having ordinary skill in the art.

[0021] Referring to Fig. 1, in the axial flow fan blades 1 of this embodiment, a air guide section formed on an end of an windward edge of a blade proximal to a blade tip, and a plurality of air guide grooves 2 are disposed on the air guide section; a distance between the closest point of the air guide section and a rotation center of the axial flow fan blade 1 is r_1, a distance between the farthest point of the air guide section and the rotation center of the axial flow fan blade 1 is r_2, a distance between the farthest point on the windward edge and the rotation center of the axial flow fan blade 1 is r, and the ratio of (r_2-r_1) to r is between 1/3 and 1/2. A depth of the air guide grooves 2 is gradually reduced along a direction running towards the rotation center.

[0022] The closest point and the farthest point above are both relative to the rotation center O. Moreover, the blade tip refers to a portion of the axial flow fan blade 1 far away from the rotation center O, while a blade root is a portion of the axial flow fan blade 1 close to the rotation center O.

[0023] The air guide section of the axial flow fan blades 1 in the present application can divide an airflow into small airflows at the source of the airflow so as to make the air guide grooves 2 on the windward edge achieve the best noise reduction effect. Moreover, each of the air guide grooves 2 has the gradually decreased depth toward the rotation center, that is, farther away from the airflow source, smaller the depth of the air guide grooves 2, which ensures a uniform air speed and making air experienced by users more natural. As a result, the axial flow fan blade 1 of this embodiment can

provide users with good comprehensive experience without need to sacrifice air speed and air volume for reducing noise.

[0024] In Fig. 1, there is still a certain distance between the farthest point of the air guide section and the blade tip, and the distance can be adjusted within a certain interval to facilitate the processing of the air guide section on the basis of ensuring cutting airflow. Nevertheless, the farthest point of the air guide section can also be designed against the blade tip.

[0025] Through experimental comparison, it is found that when the air guide section is formed at the end of the axial flow fan blade 1 proximal to the blade tip, and the air guide section satisfies $(r_2-r_1):r=1/3-1/2$, it has almost the same noise reduction effect as the noise reduction effect of the air guide section formed on the entire windward edge of the axial flow fan blade 1.

[0026] Moreover, the air guide section is only provided at the end of the axial flow fan blade 1 proximal to the blade tip, which can not only achieve almost the same noise reduction effect as when the air guide section is formed on the entire windward edge, but also avoid the problem that the strength of the axial flow fan blade 1 is reduced when the air guide section is formed at an end of the blade root. Once the strength of the axial flow fan blade 1 is reduced, not only will the service life of the axial flow fan blade 1 be shortened, but also the noise of the axial flow fan blade 1 will be increased due to its vibration in use.

[0027] It is noteworthy that, in the air guide section of this embodiment, the depth of the air guide groove 2 gradually decreases toward the rotation center, and thus the current axial flow fan blade 1 can be processed to obtain the above air guide section without any impact on the strength of the axial flow fan blades 1 and thus it eliminates the need for additionally separate design of the axial flow fan blades 1.

[0028] Also, when the air guide section is provided at the end of the axial flow fan blade 1 proximal to the blade tip, the air resistance to the axial flow fan blade 1 can also be reduced, thereby effectively reducing the motor load so as to increase the air speed at the same power.

[0029] In this embodiment, it is preferable to make the air guide section be in a regular zigzag shape, which is not only convenient for being processed, but also has a decorative effect when distributed at the tip of the axial flow fan blade 1. When the air guide section is in a regular zigzag shape, all air guide grooves 2 can be further disposed to have the same width. Of course, besides the zigzag shape, the air guide sections may have any other shapes, as long as they achieve the effect of dividing the airflow.

[0030] Further, this embodiment provides a blade assembly for axial flow fan including the above-mentioned axial flow fan blades 1 and a hub 3 for mounting the axial flow fan blades 1.

[0031] In this embodiment, the number of the axial flow fan blades 1 is preferably odd to reduce the noise generated by resonance. Moreover, it is preferred but not necessary that the number of the axial flow fan blades 1 is three or five, so as to ensure the performance of the blade assembly for axial flow fan.

[0032] Wherein, it is assumed that the axial flow fan blades 1 and a mounting surface of the hub 3 intersects at a first curve, when an included angle between a tangent line at any point on the first curve and a vertical surface of the hub 3 is $30\pm5°$, a greater air volume and higher motor efficiency can be obtained during the running of the axial flow fan blade assembly, and a lower noise is obtained under the same operating conditions.

[0033] Wherein, the mounting surface of the hub 3 is also a cylindrical surface on the hub 3 for mounting the axial flow fan blades 1. The vertical surface of the hub 3 is also a surface perpendicular to the central axis of the hub 3.

[0034] Further, when the points on the axial flow fan blades 1 that are equidistant from the central axis of the hub 3 are connected to form equidistant lines, then projection lines are obtained by projecting the equidistant lines onto the mounting surface of the hub 3 along the radial direction of the hub 3. When the maximum value of the included angle between the tangent line at any point on the projection lines and the vertical surface of the hub 3 is $42\pm5°$, the performance of the blade assembly for axial flow fan can be further enhanced so that high air speed, large air volume and low noise are obtained when the blade assembly for axial flow fan runs.

[0035] Wherein, it is preferred but not necessary that the axial flow fan blade 1 has a curvature distribution value of 0-0.176, by way of which the best performance of the axial flow fan blade 1 is obtained.

[0036] In addition, in this embodiment, when the hub 3 has a radius of r_3, a distance between the farthest point on the fan blade and the rotation center of the axial flow fan blade 1 is r_4., and the ratio of r_3 to r_4 is between 0.2 and 0.3, larger air volume can be obtained under the premise of ensuring the mounting strength of the hub 3 and the axial flow fan blades 1.

[0037] Based on the above, this embodiment provides dimensions of the blade assembly for axial flow fan: each of the axial flow fan blades 1 has a thickness of 2.0 mm, r_4 of 185 mm, and r_3 of 42 mm. When the blade assembly for axial flow fan is mounted on the heater, air speed of 0.5m/s are still possible at two meters away from the air outlet under the condition that the noise is less than 50dB (A).

[0038] Further, this embodiment provides an air duct assembly for axial flow fan, which includes the above-mentioned blade assembly for axial flow fan, and also includes a guide duct 4. Of course, the guide duct 4 is provided between the air inlet and the air outlet of the duct assembly for axial flow fan. The axial flow fan blades 1 of the blade assembly for axial flow fan are provided in the guide duct 4, thereby reducing air turbulence and ensuring more uniform and comfortable air obtained at the air outlet.

[0039] Referring to Fig. 2, the duct assembly for axial flow fan also includes an air outflow shroud 5, on which an end of the guide duct 4 is fixed. In the mounting processing of the air outflow shroud 5 and an air inlet shroud 6, since the air outflow shroud 5 has the above guide duct 4 provided thereon, it is possible to protect the axial flow fan blades 1 from being damaged. It is preferred but not necessary that the guide duct 4 and the air outflow shroud 5 are integrally formed, thus reducing the assembly difficulty of the entire duct assembly for axial flow fan.

[0040] In addition, the guide duct 4 has gradually decreased cross-sectional area along an air outflow direction, so that the airflow is accelerated within the guide duct 4, and higher air speed is obtained at the air outflow shroud 5 to meet user requirements.

[0041] Referring to Fig. 3, in this embodiment, a grille 7 of the air outflow shroud includes a plurality of grid bars, and all of the grid bars are distributed along the circumference. Of course, Fig. 3 does not constitute a limitation to the air outflow shroud of this application. For example, the grid bars of the air outflow shroud in this application can also be arranged in cross.

[0042] In Fig. 3, an outer section of the grid bar gradually inclines toward the rotation direction of the fan blade in a direction away from the center of the circumference, and the rotation direction of the fan blades is indicated by the arrow in Fig. 3 . Wherein, the "outer section of the grid bar" refers to a section of the grid bar away from the center of the circumference. The grid bars are provided in this way to ensure that the airflow generated at the fan blades can pass through more easily and reduce the air resistance, so as to obtain greater air speed and air volume at the air outlet air shroud.

[0043] The inclination directions of an inner section and the outer section of the grid bar in Fig. 3 are different in the direction away from the center of the circumference, the main purpose of which is to obtain a better appearance of the grille 7. Obviously, in order to reduce the air resistance, the entire grid bars can be designed such that the grid bars gradually incline toward the rotation direction of the fan blade in the direction away from the center of the circumference.

[0044] Further, when the air duct assembly for axial flow fan includes a guide duct, the guide duct is projected on the grille 7 along its own axis to obtain a first projection line 8 (referring to Fig. 3). The first projection line 8 and the grid bar intersect at a first point, and an included angle between a first tangent line of the grid bar at the first point and a second tangent line of the first projection line 8 at this point is 100°-115°. In this case, the resistance of the grille 7 to the airflow can be further reduced to obtain a greater air speed and air volume.

[0045] Moreover, it is found though experiments that when the included angle between the first tangent line and the second tangent line is 105°, the best air guiding performance of the grille 7 can be obtained.

[0046] In order to further increase the air volume and air speed, each of the grid bars of the air outflow shroud 5 has the gradually increased cross section along the air outflow direction, so that the air outlet area between adjacent grid bars of the grille 7 gradually decreases along the air outflow direction. In this case, when the airflow passes through the grille 7, an acceleration pressure is formed on the grille 7 and higher air speed is formed at the air outlet, so that the user can obtain a better experience.

[0047] In order to further reduce the air resistance, the grid bars are streamlined along the air outflow direction. Moreover, the number of the grid bars is odd to reduce the noise generated by resonance.

[0048] Moreover, in this embodiment, the ratio of the area of the air inlet surface of the air inlet shroud 6 to the area of the air outlet surface of the air outflow shroud 5 is 1.1-1.35. In this case, a greater air speed can be obtained on the air outlet surface while ensuring the appearance of the product. It is found through experiments that when the ratio of the area of the air inlet surface of the air inlet shroud 6 to the area of the air outlet surface of the air outflow shroud 5 in this embodiment is 1.25, the user can get the best experience in terms of performance and appearance.

[0049] In Figure.2, the air inlet shroud 6 includes a first air inlet surface 601, a second air inlet surface 602 and a third air inlet surface 603 which are mutually angled each other. Therefore, the area of the air inlet surface of the air inlet shroud 6 is the sum of the areas of the first air inlet surface 601, the second air inlet surface 602, and the third air inlet surface 603. Under the condition that other structures of the air duct assembly for axial flow fan remain unchanged, a plurality of mutually angled air inlet surfaces are provided such that the air inlet area of the air inlet shroud 6 can be increased, thereby increasing the ratio of the area of the air inlet surface of the air inlet shroud 6 to the area of the air outlet surface of the air outflow shroud 5 while ensuring the appearance of the product. Of course, the number of air inlet surfaces on the air inlet shroud 6 is not limited by the drawings, for example, there may be any other air inlet surfaces, or there may be one. Moreover, when the air inlet shroud 6 is formed with multiple air inlet surfaces, the angle between the multiple air inlet surfaces is not limited by the drawings.

[0050] Without loss of generality, any field requiring the application of axial flow fans can employ the above-mentioned axial flow fan blade 1, the blade assembly for axial flow fan and the air duct assembly for axial flow fan. For example, the above-mentioned axial flow fan blade 1, the blade assembly for axial flow fan and the air duct assembly for axial flow fan can be applied to heaters, coolers, ordinary fans and other products.

[0051] The above embodiments are only used to illustrate the present application, but not to limit the present application. Although the present application has been described in detail with reference to the embodiments, those having ordinary skill in the art should understand that various combinations, modifications, or equivalent substitutions to the technical

solutions of the present application do not depart from the spirit and scope of the technical solutions of the present application, and should all fall within the scope of the claims of the present application.

Claims

1. An axial flow fan blade, **characterized in that** an air guide section is formed at an end of an windward edge of the axial flow fan blade proximal to a blade tip, a plurality of air guide grooves are disposed on the air guide section; a distance between a closest point of the air guide section and a rotation center of the axial flow fan blade is r_1, a distance between a farthest point of the air guide section and the rotation center of the axial flow fan blade is r_2, a distance between the farthest point on the windward edge and the rotation center of the axial flow fan blade is r, and $(r_2-r_1):r$ = 1/3-1/2, and a depth of the air guide grooves is gradually reduced along a direction running towards the rotation center.

2. The axial flow fan blade according to claim 1, **characterized in that** the air guide section has a zigzag shape.

3. A blade assembly for an axial flow fan, **characterized by** including a plurality of axial flow fan blades of claim 1 or 2, and a hub for mounting the axial flow fan blades.

4. The blade assembly for an axial flow fan according to claim 3, **characterized in that** the number of the axial flow fan blades is odd.

5. The blade assembly for an axial flow fan according to claim 4, **characterized in that** the number of the axial flow fan blades is three or five.

6. The blade assembly for an axial flow fan according to claim 3, **characterized in that** the axial flow fan blades and a mounting surface of the hub intersects at a first curve, and an included angle between a tangent line at any point on the first curve and a vertical surfaces of the hub is $30\pm5°$.

7. The blade assembly for an axial flow fan according to claim 3, **characterized in that** the hub has a radius of r_3, a distance between a farthest point on the fan blade and a rotation center of the axial flow fan blade is r_4, and the ratio of r_3 to r_4 is 0.2-0.3.

8. An duct assembly for an axial flow fan, **characterized by** comprising the blade assembly for an axial flow fan of any one of claims 3-7, and also including a guide duct, the axial flow fan blades of the blade assembly for an axial flow fan being located within the guide duct.

9. The duct assembly for an axial flow fan according to claim 8, **characterized in that** the guide duct has a gradually decreased cross-sectional area along an air outflow direction.

10. The duct assembly for an axial flow fan according to claim 8, further comprising an air outflow shroud, on which an end of the guide duct is fixed.

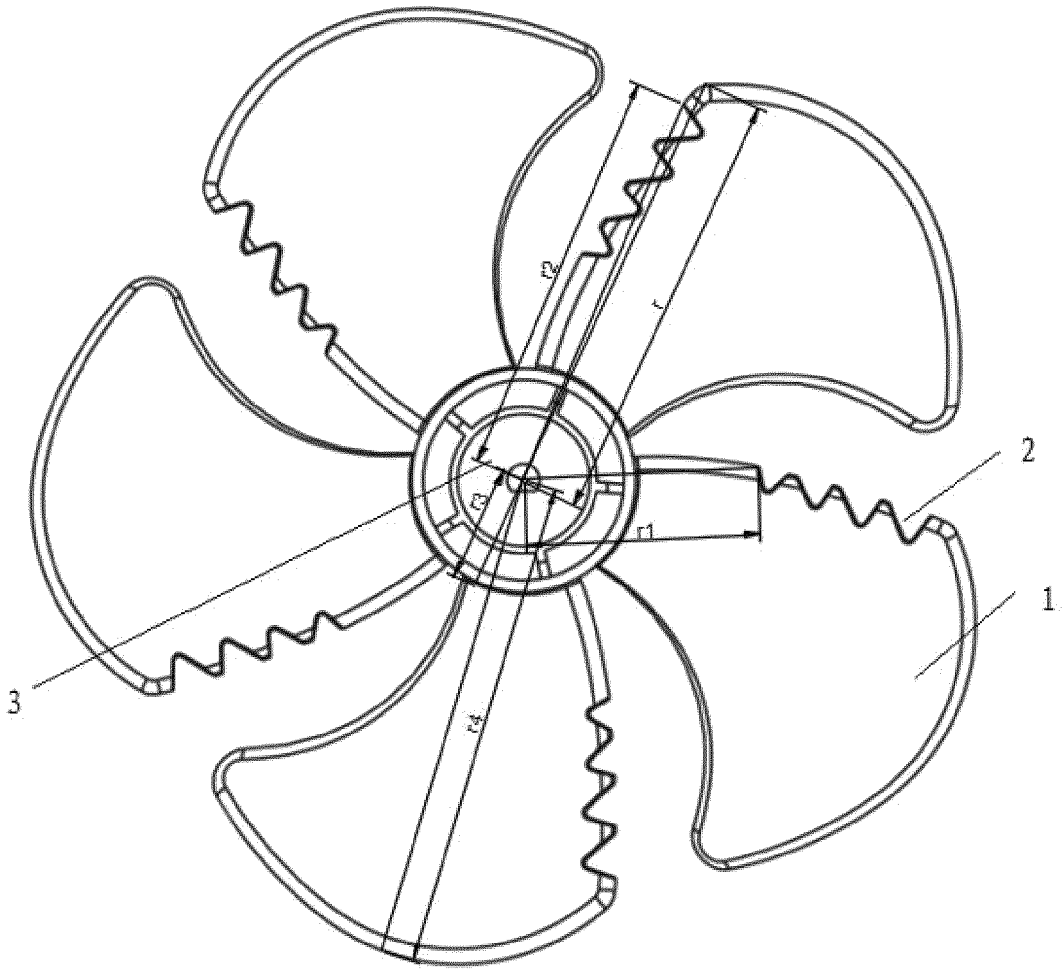

Fig. 1

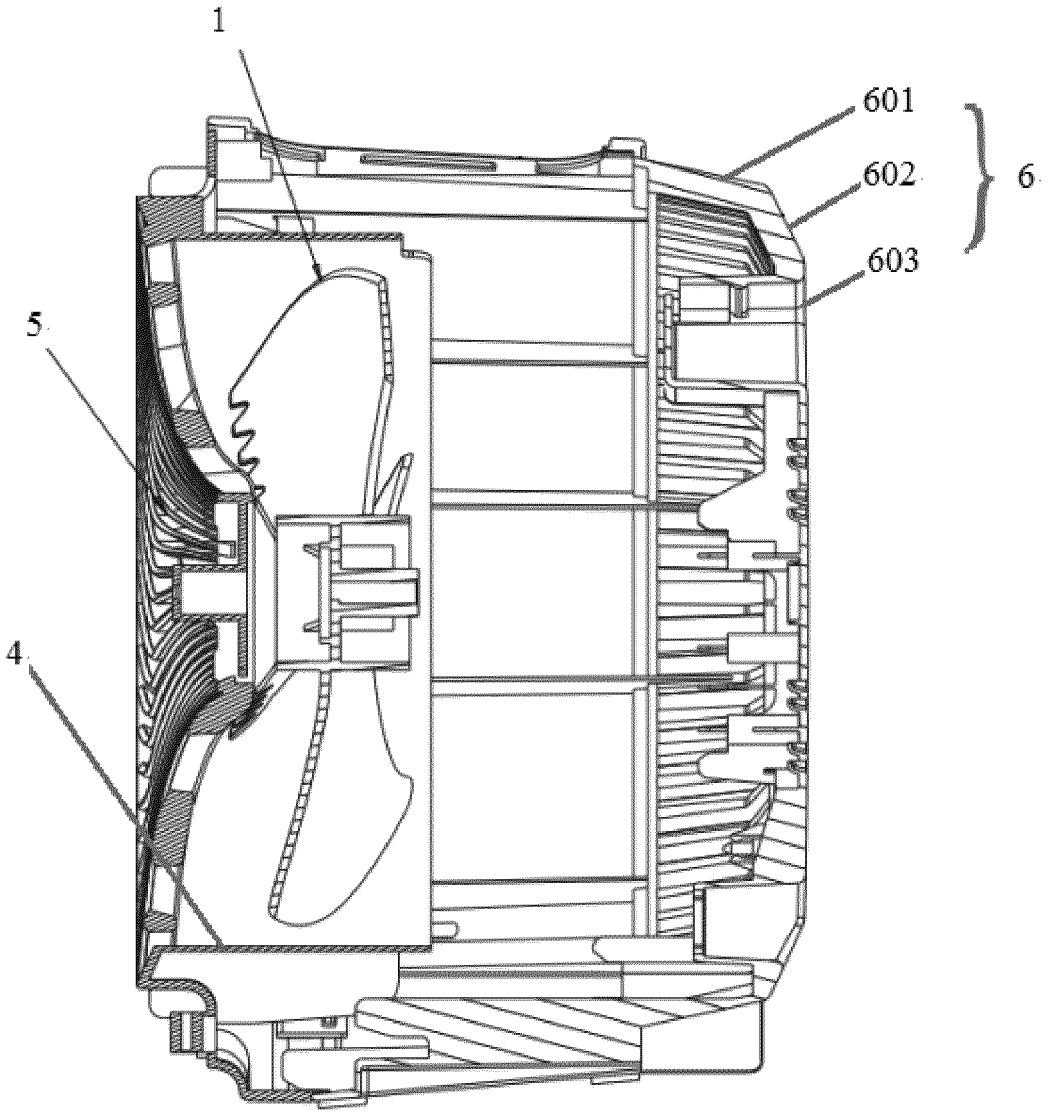

Fig. 2

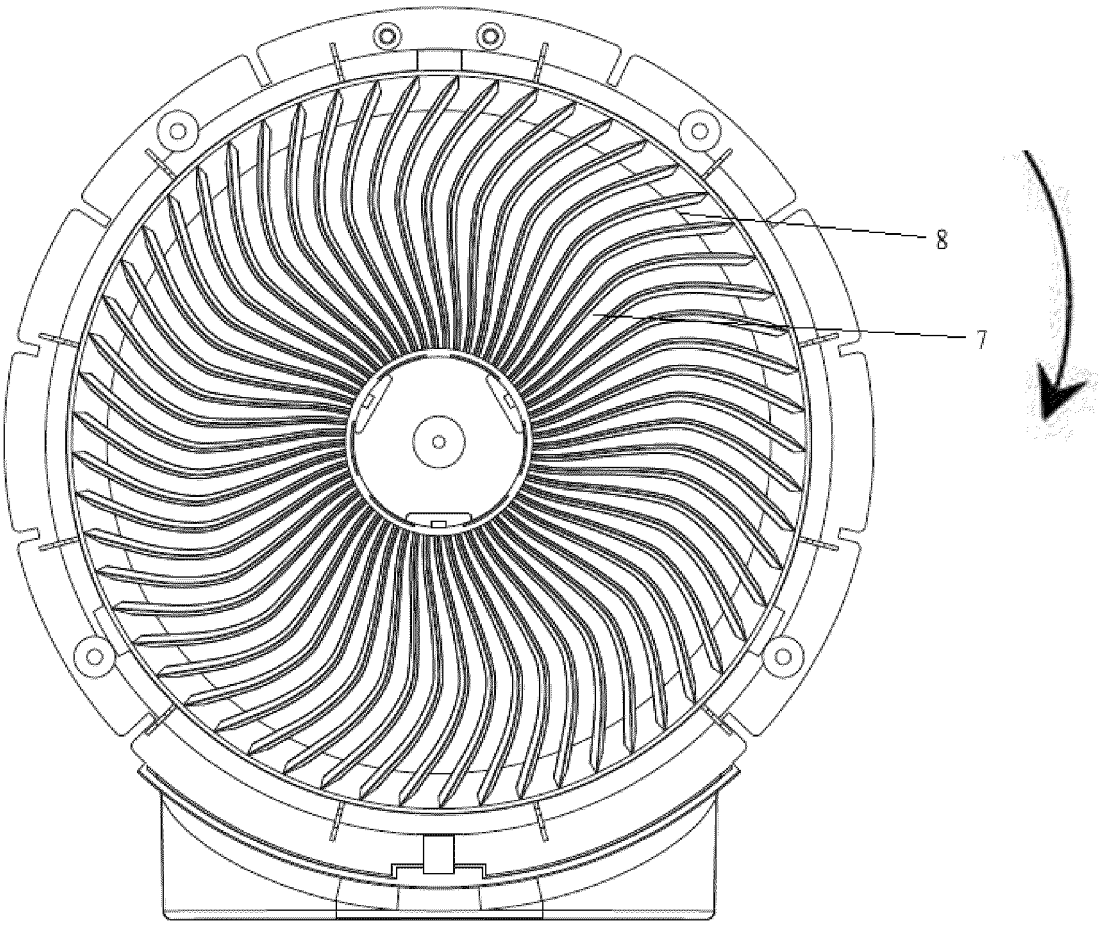

Fig. 3

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2018/093266

A. CLASSIFICATION OF SUBJECT MATTER

F04D 29/38(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)

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)

CNKI, CPRSABS, VEN: 锯齿, 槽, 进风罩, 导流罩, 出风罩, 风扇, 风机, sawtooth, zigzag, fan, blower, cover

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	CN 102588338 A (TCL AIR CONDITIONER (ZHONGSHAN) CO., LTD.) 18 July 2012 (2012-07-18) description, specific embodiment, and figure 1	1-7
Y	CN 102588338 A (TCL AIR CONDITIONER (ZHONGSHAN) CO., LTD.) 18 July 2012 (2012-07-18) description, specific embodiment, and figure 1	8-10
Y	CN 201679745 U (XINCHANG COUNTY KEMAO INDUSTRIAL CO., LTD.) 22 December 2010 (2010-12-22) description, specific embodiment, and figures 1-4	8-10
X	CN 104061187 A (GREE ELECTRIC APPLIANCES INC. OF ZHUHAI) 24 September 2014 (2014-09-24) description, specific embodiment, and figure 1	1-7
X	CN 102588339 A (TCL AIR CONDITIONER (ZHONGSHAN) CO., LTD.) 18 July 2012 (2012-07-18) description, specific embodiment, and figures 1 and 2	1-7
A	DE 3234011 A1 (BRAUN AG) 15 March 1984 (1984-03-15) entire document	1-10

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

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

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"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

"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

"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

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
31 August 2018	**25 September 2018**
Name and mailing address of the ISA/CN **State Intellectual Property Office of the P. R. China (ISA/CN)** **No. 6, Xitucheng Road, Jimenqiao, Haidian District, Beijing 100088** **China** Facsimile No. **(86-10)62019451**	Authorized officer Telephone No.

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

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2018/093266

Patent document cited in search report	Publication date (day/month/year)	Patent family member(s)	Publication date (day/month/year)
CN 102588338 A	18 July 2012	CN 102588338 B	18 November 2015
CN 201679745 U	22 December 2010	None	
CN 104061187 A	24 September 2014	None	
CN 102588339 A	18 July 2012	CN 102588339 B	03 February 2016
DE 3234011 A1	15 March 1984	None	

Form PCT/ISA/210 (patent family annex) (January 2015)

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- CN 2018200542047 **[0001]**