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(54) **CENTRIFUGAL FAN, AIR DUCT SYSTEM, AND AIR CONDITIONER**

(57) A centrifugal fan, an air duct system, and an air conditioner. The centrifugal fan includes a volute body (113) and a centrifugal fan blade (200) disposed inside the volute body (113). The volute body (113) includes a base plate (100), a front plate (308), and a side plate (101) disposed between the base plate (100) and the front plate (308). An air inlet of the centrifugal fan blade (200) is disposed in the front plate (308). A volute tongue (309) is defined by the side plate (101). The volute tongue (309) is inclined from a side of the base plate (100) toward a side of the front plate (308), and a volute tongue gap is gradually reduced from the side of the base plate (100) to the side of the front plate (308).

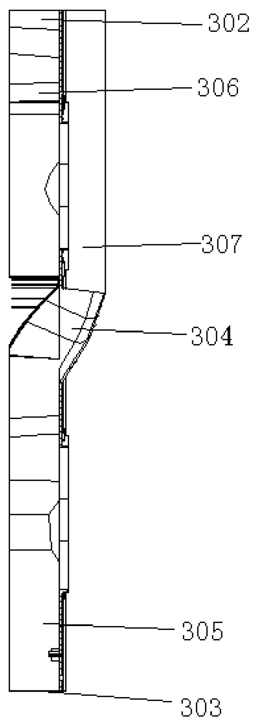

FIG. 2

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Description

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims priority benefit of Chinese Patent Application No. 201811389839.3, entitled "CENTRIFUGAL FAN, AIR DUCT SYSTEM, AND AIR CONDITIONER", filed on November 20, 2018 in the China National Intellectual Property Administration, the entirety of which is incorporated by reference herein.

TECHNICAL FIELD

[0002] The present application relates to the technical field of air conditioning, in particular, to a centrifugal fan, an air duct system, and an air conditioner.

BACKGROUND

[0003] A volute of a centrifugal fan serves to concentrate air flowing out from an impeller, guide an air flow, and convert a part of the kinetic energy of the air into a static pressure by means of diffusing. As the impeller rotates, a gas flow caused by the impeller periodically impacts a volute tongue, and the gas flow periodically passes through a minimum gap between a blade and the volute tongue, resulting in a periodical rotation noise. A conventional volute of the centrifugal fan is generally in a form of a straight volute, and a radius of the volute is constant. For example, a volute of a centrifugal fan used in an air conditioner has the following structure. An impeller is disposed in the volute. The volute includes a front plate, a side plate, a base plate, and a volute tongue. An air inlet is provided on the front plate. The base plate and the front plate face each other. An impeller axis is perpendicular to a plane where the base plate is located. A longitudinal symmetry plane of the volute tongue is parallel to the impeller axis. The longitudinal symmetry plane refers to a plane which equally divides the volute tongue into two symmetrical parts along a direction from an end having the air inlet to an end having the base plate. The volute tongue gap with such a structure, i.e., a minimum gap between an outer periphery of the impeller on a cross-section perpendicular to the impeller axis, i.e., a top end of the blade, and the volute tongue, is constant along a direction of the impeller axis. Therefore, because the volute tongue gap is constant along the direction of the axis, a periodic peak noise is generated due to a superposition of noises with a same frequency, resulting in a relatively large noise of rotation of the centrifugal fan having such a structure.

[0004] For an air conditioner using a centrifugal fan in the related art, some type of centrifugal fan has two air outlets having relatively large air blowing rates, so that the total blowing rate of the air conditioner is increased. However, the noise is correspondingly increased with the increase of the total blowing rate of the air conditioner.

SUMMARY

[0005] Therefore, the technical problem to be solved in the present application is how to overcome a defect of a relatively large noise of the centrifugal fan in the prior art, and thus a centrifugal fan, an air duct system, and an air conditioner, which have a relatively small noise, are provided.

[0006] To solve the above-described technical problem, the present application provides a centrifugal fan including a volute body and a centrifugal fan blade disposed in the volute body. The volute body includes a base plate, a front plate, and a side plate disposed between the base plate and the front plate. An air inlet of the centrifugal fan blade is disposed in the front plate. A volute tongue is defined by the side plate. The volute tongue is inclined from a side of the base plate toward a side of the front plate, and a volute tongue gap is gradually reduced from the side of the base plate to the side of the front plate. A volute tongue gap C at the front plate is smaller than a volute tongue gap D at the base plate, and a difference between the volute tongue gap D and the volute tongue gap C is E.

[0007] E is 4% to 6% of a diameter of an impeller of the centrifugal fan blade.

[0008] A curved surface of the volute tongue includes a conic curved surface. Radii of circular arcs corresponding to a volute tongue gap of the volute tongue are gradually reduced from the side of the base plate to the side of the front plate.

[0009] The radii of the volute tongue are from 15 mm to 20 mm.

[0010] A diffuser section side surface of a centrifugal air duct of the centrifugal fan is inclined from the side of the base plate toward the side of the front plate. A tangent line passing through a center of the centrifugal fan blade and tangent to a circular arc of the volute tongue located at the base plate is defined as a first tangent line. A tangent line passing through the center of the centrifugal fan blade and tangent to a circular arc of the volute tongue located at the front plate is defined as a second tangent line. An angle formed between projections of the first tangent line and the second tangent line projected onto a plane perpendicular to an axial direction of the centrifugal fan blade is an inclined angle β.

$$7° \leqslant \beta \leqslant 12°.$$

[0011] L5 denotes a volute opening degree of the air duct of the centrifugal fan. L6 denotes a diffuser section outlet distance of the centrifugal air duct. A ratio of L6 to L5 is M, and $2 \leq M \leq 3$.

[0012] The present application further provides an air duct system including:

[0013] an air duct body including a side-A air outlet and a side-B air outlet;

[0014] a plurality of centrifugal fans disposed on the air duct body and between the side-A air outlet and the side-B air outlet. The centrifugal fans include at least one first centrifugal fan, the first centrifugal fan is provided with two first air ducts, which are a first side-A air duct in communication with the side-A air outlet and a first side-B air duct in communication with the side-B air outlet, and the centrifugal fan is the above-described centrifugal fan.

[0015] Two said centrifugal fans are provided and include the first centrifugal fan and a second centrifugal fan. The second centrifugal fan has a second air duct. The second centrifugal fan is disposed proximally to a side A. The first centrifugal fan is disposed proximally to a side B. The second air duct is in communication with the side-A air outlet.

[0016] A flow guiding chamber is provided at a side of the second centrifugal fan, and the first side-A air duct of the first centrifugal fan communicates with the side-A air outlet by the flow guiding chamber.

[0017] A volute body of the first centrifugal fan is aligned with the volute body of the second centrifugal fan.

[0018] The present application further provides an air conditioner including the above-described air duct system.

[0019] The technical solutions of the present application have the following advantages:

1. In the centrifugal fan provided by the present application, as the volute tongue gap is gradually reduced from a side of the base plate to a side of the front plate, interferences between an air flow at the outlet of the centrifugal fan blade and the static volute body are different due to different spatial distances, and different noise frequency spectrums are generated, thereby effectively decreasing the aerodynamic noise of the centrifugal fan, avoiding the whistling sound caused by the resonance effect of the same frequency noises, improving the sound quality of the centrifugal fan, and effectively decreasing the total amount of noises of the centrifugal fan.
2. In the centrifugal fan provided by the present application, the diffuser section side surface of the centrifugal air duct of the centrifugal fan is inclined from a side of the base plate toward a side of the front plate, the tangent line passing through the center of the centrifugal fan blade and tangent to the circular arc of the volute tongue located at the base plate is defined as the first tangent line, the tangent line passing through the center of the centrifugal fan blade and tangent to the circular arc of the volute tongue located on the front plate is defined as the second tangent line, the angle formed between projections of the first tangent line and the second tangent line projected onto the plane perpendicular to the axial direction of the centrifugal fan blade is the inclined angle β, and the diffuser section side surface is inclined from the side of the base plate toward the side of the front plate, such that the generation of an eddy of the gas flow at this location, which will influence the normal flow, can be avoided.
3. In the centrifugal fan provided by the present application, the volute opening degree of the air duct of the centrifugal fan is L5, the centrifugal air duct diffuser section outlet distance is L6, the ratio of L6 to L5 is M, and $2 \leq M \leq 3$, such that it can be ensured that the air blowing rate of the centrifugal fan reaches an optimal value.
4. The air duct system provided by the present application includes: the air duct body including the side-A air outlet and the side-B air outlet, and the plurality of centrifugal fans disposed on the air duct body and located between the side-A air outlet and the side-B air outlet. The centrifugal fans include at least one first centrifugal fan. The first centrifugal fan is provided with two first air ducts, i.e., the first side-A air duct in communication with the side-A air outlet and the first side-B air duct in communication with the side-B air outlet, respectively, and the centrifugal fan is the above-described centrifugal fan. The first centrifugal fan is provided with the two first air ducts, i.e., the first side-A air duct in communication with the side-A air outlet and the first side-B air duct in communication with the side-B air outlet, respectively, therefore the side-A air outlet can have a suction effect on the blowing air from the first side-A air duct, and the side-B air outlet can have a suction effect on the blowing air from the first side-B air duct. The air blowing rate at the side-A air outlet is relatively large, and the air blowing rate at the side-B air outlet is relatively large, so the total air blowing rate of the air duct system is relatively large. Moreover, since the centrifugal fan is the centrifugal fan as described above, the noise of the centrifugal fan is relatively small, therefore, the air duct system not only increases the total air blowing rate but also decreases the noise.
5. In the air duct system provided by the present application, two centrifugal fans are provided, and include the first centrifugal fan and the second centrifugal fan. The second centrifugal fan has the second air duct. The second centrifugal fan is disposed proximally to the side A, and the first centrifugal fan is disposed proximally to the side B. The second air duct is in communication with the side-A air outlet, and the air blowing rate at the side-A air outlet of the air duct system is increased, thereby increasing the total air blowing rate of the air duct system.
6. In the air duct system provided by the present application, the flow guiding chamber is provided at the side of the second centrifugal fan to communicate the first side-A air duct of the first centrifugal fan with the side-A air outlet. Since a pressure distribution in the flow guiding chamber can be affected by the blowing air from the second centrifugal fan, a negative pressure is formed, and has a suction effect on the blowing air from the first side-A air duct of the

first centrifugal fan, thereby increasing an air blowing rate at the side-A air outlet.

7. In the air duct system provided by the present application, the volute body of the first centrifugal fan is aligned with the volute body of the second centrifugal fan, therefore the structure of the air duct system is compact and the occupied volume of the air duct system occupies small space.

8. The air conditioner provide by the present application includes the above-described air duct system, and the air conditioner has a relatively large air blowing rate and generates relatively small noises.

BRIEF DESCRIPTION OF THE DRAWINGS

[0020] In order to clearly illustrate specific embodiments of the present application or technical solutions in the prior art, the following drawings, which are to be referred in the description of the specific embodiments or the prior art, will be briefly described below. Obviously, the drawings in the following description are only some embodiments of the present application, and a person of ordinary skill in the art can obtain other drawings according to these drawings without any creative work.

FIG. 1 is a front view of an air duct system provided in a first embodiment of the present application;
FIG. 2 is a side view of the air duct system shown in FIG. 1;
FIG. 3 is a cross-sectional view of the air duct system shown in FIG. 1;
FIG. 4 is a schematic structural view of a centrifugal fan provided in the first embodiment of the present application;
FIG. 5 is a schematic structural view of the centrifugal fan provided in the first embodiment of the present application;
FIG. 6 is a front view of the air duct system provided in a second embodiment of the present application;
FIG. 7 is a cross-sectional view of a side view of FIG. 6;
FIG. 8 is a schematic structural view, in a front elevation direction, of the volute structure provided in a fourth embodiment;
FIG. 9 is a schematic structural view, in a rear elevation direction, of the volute structure shown in FIG. 8;
FIG. 10 is a cross-sectional view of the centrifugal fan provided in the fourth embodiment;
FIG. 11 is an exploded view of the centrifugal fan provided in the fourth embodiment;
FIG. 12 is a cross-sectional view of a heat exchanger fan assembly provided in a fifth embodiment;
FIG. 13 is a cross-sectional view of the heat exchanger fan assembly provided in the fifth embodiment;
FIG. 14 is a side view of the heat exchanger fan assembly provided in the fifth embodiment.

Description of reference numerals:

[0021] 100-base plate, 101-side plate, 102-fixing end, 103-receiving chamber, 104-motor bracket, 105-first ring-shaped reinforcing rib, 106-first connection reinforcing rid, 107-connecting post, 108-second ring-shaped reinforcing rib, 109-second connection reinforcing rid, 110-motor, 111-reinforcing block, 112, nut with washer, 113-volute body, 200-centrifugal fan blade, 201-heat exchanger, 300-first centrifugal fan, 301-second centrifugal fan, 302-side-A air outlet, 303-side-B air outlet, 304-first side-A air duct, 305-first side-B air outlet, 306-second air duct, 307-flow guiding chamber 307, 308-front plate, 309-volute tongue, 310- diffuser section side surface, 311-first side plate, 312-second side plate.

DETAILED DESCRIPTION

[0022] The technical solutions of the present application will be described clearly and completely below with reference to the accompanying drawings. Apparently, the described embodiments are merely some rather than all of the embodiments of the present application. All other embodiments obtained by a person of ordinary skill in the art based on the embodiments of the present application without creative efforts shall fall within the protection scope of the present application.

[0023] It should be understood that in the description of the present application, the orientations or the location relationship indicated by the terms such as "center", "upper", "lower", "left", "right", "vertical", "horizontal", "inner", "outer", and the like are based on the orientations or the location relationship shown in the drawings, and are merely used for conveniently describing the present application and simplifying the description, rather than indicating or implying that the referred device or component definitely has a particular orientation, is constructed and operated in a particular orientation, and thus are not to be understood to limit the scope of the present application. In addition, terms "first," "second," and "third," are merely used for description and should not be understood to indicate or imply relative importance.

[0024] It should be understood that in the description of the present application, unless expressly specified and defined otherwise, the terms "installation", "connect" and "connection" should be understood broadly, for example, may be a fixed connection or a detachable connection or an integrative connection, or a mechanical connection or an electric connection, or a direct connection or an indirect connection by means of an intermediate media, or a communication within two elements. For a person of ordinary skill in the art, the specific meanings of the above terms in the present application can be understood in particular.

[0025] Moreover, the technical features involved in different embodiments of the present application described below can be combined with each other as long as no conflict is constituted between each other.

First Embodiment

[0026] This embodiment provides a centrifugal fan, including a volute body 113 and a centrifugal fan blade 200 disposed inside the volute body 113. As shown in FIGS. 4 and 5, the volute body 113 includes a base plate 100, a front plate 308, and a side plate 101 disposed between the base plate 100 and the front plate 308. An air inlet of the centrifugal fan blade 200 is disposed in the front plate 308. A volute tongue 309 is defined by the side plate 101. The volute tongue 309 is inclined from a side of the base plate 100 toward a side of the front plate 308, and a volute tongue gap is gradually reduced from the side of the base plate 100 to the side of the front plate 308. A volute tongue gap C at the front plate 308 is smaller than a volute tongue gap D at the base plate 100, and a difference between the volute tongue gap D and the volute tongue gap C is E. E is 4% to 6% of a diameter of an impeller of the centrifugal fan blade 200. A curved surface of the volute tongue 309 is a conic curved surface. Radii of circular arcs corresponding to the volute tongue gap of the volute tongue 309 are gradually reduced linearly from the side of the base plate 100 to the side of the front plate 308. The radii of the volute tongue 309 are from 15 mm to 20 mm. A diffuser section side surface 310 of a centrifugal air duct of the centrifugal fan is inclined from the side of the base plate 100 toward the side of the front plate 308. A tangent line, which passes through a center of the centrifugal fan blade 200 and is tangent to a circular arc of the volute tongue 309 located at the base plate 100, is defined as a first tangent line. A tangent line, which passes through the center of the centrifugal fan blade 200 and is tangent to a circular arc of the volute tongue 309 located at the front plate 308, is defined as a second tangent line. An angle formed between projections of the first tangent line and the second tangent line projected onto a plane perpendicular to an axial direction of the centrifugal fan blade 200 is an inclined angle β, where $7° \leq \beta . \leq 12°$. In this embodiment, the side plate 101 includes a first side plate 311 arranged vertically and a second side plate 312 inclined relative to the first side plate 311. L5 denotes a volute opening degree of the air duct of the centrifugal fan, and is a minimum distance from the centrifugal fan blade to the first side plate 311. L6 denotes a diffuser section outlet distance of the centrifugal air duct, and is a minimum distance from the volute tongue 309 to the second side plate 312. A ratio of L6 to L5 is M, and $2 \leq M \leq 3$. As the volute tongue gap is gradually reduced from the side of the base plate 100 to the side of the front plate 308, interferences between an air flow at the outlet of the centrifugal fan blade 200 and the static volute body 113 are different due to different spatial distances, and different noise frequency spectrums are generated, thereby effectively decreasing the aerodynamic noise of the centrifugal fan, avoiding a whistling sound caused by the resonance effect of the same frequency noises , improving the sound quality of the centrifugal fan, and effectively decreasing the total amount of noises of the centrifugal fan.

[0027] The present embodiment further provides an air duct system, including an air duct body and a plurality of centrifugal fans disposed on the body. The centrifugal fans each adopt the centrifugal fan described above. As shown in FIGS. 1 to 3, the air duct body includes a side-A air outlet 302 and a side-B air outlet 303. In this embodiment, the side A is an upper side, and the side B is a lower side. The centrifugal fans include a first centrifugal fan 300 and a second centrifugal fan 301. The first centrifugal fan 300 is provided with two first air ducts, i.e., a first side-A air duct 304 in communication with the side-A air outlet 302 and a first side-B air duct 305 in communication with the side-B air outlet 303, respectively. The second centrifugal fan 301 has a second air duct 306. The second centrifugal fan 301 is disposed proximally to the side A, and the first centrifugal fan 300 is disposed proximally to the side B. The second air duct 306 is in communication with the side-A air outlet 302. A flow guiding chamber 307 is provided at a side of the second centrifugal fan 301 to communicate the first side-A air duct 304 of the first centrifugal fan 300 with the side-A air outlet 302. As shown in FIG. 2, the volute body 113 of the first centrifugal fan 300 is aligned with the volute body 113 of the second centrifugal fan 301.

[0028] Since a pressure distribution in the flow guiding chamber 307 can be affected by the blowing air at the side-A air outlet 302 of the second centrifugal fan 301, a negative pressure is formed, and has a suction effect on the blowing air from the first side-A air duct 304 of the first centrifugal fan 300, thereby increasing an air blowing rate at the side-A air outlet 302. It has been demonstrated that under the same conditions, compared with the first centrifugal fan 300 having only one air duct in the prior art, such a first centrifugal fan 300 having two air ducts has an air blowing rate increased by $150 m^3/h$ to $200 m^3/h$. Moreover, since the centrifugal fan adopts the centrifugal fan as described above, the noise of the centrifugal fan is relatively small. Therefore, the air duct system not only increases the total air blowing rate but also decreases the noise.

[0029] In an alternative embodiment, more than two centrifugal fans are disposed on the air duct body, and one or more centrifugal fans are configured as the first centrifugal fan 300 having two air ducts.

Second Embodiment

[0030] This embodiment is distinguished from the above embodiment in that: the side A is a lower side, while the side B is an upper side. As shown in FIGS. 6 and 7, the first centrifugal fan 300 located at the upper side has two air ducts, i.e., the first side-A air duct 304 in communication with the side-A air outlet 302 and a first side-B air duct 305 in communication with the side-B air outlet 303, respectively. The second centrifugal fan 301 located at the lower side has the second air duct 306, and the second air duct 306 is in communication with the side-A air outlet 302.

[0031] The first centrifugal fan 300 may blow air upward and downward simultaneously, and the second centrifugal fan 301 may blow air downward, thereby increasing the total air blowing rate, while the mutual interference between air flows, occurring when both the upper and lower centrifugal fans blow air upward and downward, is avoided. When applied to the field of air conditioning, in the working condition of heating, a proportion of the downward air blowing rate is relatively large, the "blanket-like" heating effect can be improved, and the accumulation of the hot air in an upper region in a room can be avoided, thereby increasing the comfort of the human body and providing a more comfortable experience for the user. When applied to the field of frozen storage and the like, especially when a majority of articles to be stored are located at a bottom in a room, such an air duct system can be used in the working condition of refrigeration, and a larger proportion of the downward air blowing rate can improve the bottom-up stepwise "pervading-type" refrigeration effect significantly.

Third Embodiment

[0032] This embodiment provides an air conditioner having the air duct system provided in the first embodiment 1 or the second embodiment. The air conditioner has a relatively large air blowing rate and makes a relatively small noise.

Fourth Embodiment

[0033] As shown in FIGS. 8 and 9, this embodiment provides a volute structure including a volute body 113. The volute body 113 includes a base plate 100 and a side plate 101 disposed on the base plate 100. A receiving chamber 103, configured to mount a fixing end 102 of a motor 110, and a connecting member, configured to connect a motor bracket 104, are disposed in a region on the base plate 100, and the region is surrounded by the side plate 101.

[0034] In the volute structure of this embodiment, a motor mounting plate and the volute body 113 are directly integrated together, therefore not only a development cost for additionally developing and manufacturing a new mould is saved, but also a manual transfer and a process of screw fixation for the newly added parts are omitted, thereby increasing the mounting efficiency. Moreover, after the motor mounting plate and the volute body 113 are integrated together, an abnormal sound problem caused by the friction between the motor mounting plate and the volute body will not occur, thereby improving the user's experience and enhancing the comfort.

[0035] In order to ensure that the fixing end 102 of the motor is stably and reliably mounted in the receiving chamber 103, one end of the receiving chamber 103 is arranged to protrude from an inner side wall of the base plate 100. The base plate 100 is further provided with a first reinforcing structure thereon to reinforce the protruding end of the receiving chamber 103.

[0036] More specifically, in this embodiment, the first reinforcing structure preferably includes a first ring-shaped reinforcing rib 105 arranged to surround the receiving chamber 103, and a first connection reinforcing rid 106 which has one end connected to a side wall of the protruding end of the receiving chamber 103 and another end connected to the first ring-shaped reinforcing rib 105. Such a reinforcing structure can reliably reinforce the protruding end of the receiving chamber 103 in four directions of the front, the rear, the left, and the right directions, thereby preventing the fixing end 102 from shaking in the receiving chamber 103.

[0037] The connecting member may have various structures. In this embodiment, the connecting member preferably includes a plurality of connecting posts 107. The connecting posts are disposed on the inner side of the base plate 100, surround the receiving chamber 103 and protrude from the inner wall. The connecting posts 107 each are provided with a threaded hole, and are located at an outer side of the first ring-shaped reinforcing rib 105. Four feet of the motor bracket are screwed onto four connecting posts 107 by means of screws, respectively.

[0038] Furthermore, in order to ensure that the motor bracket 104 is stably and reliably connected to the base plate, the base plate 100 is further provided with a second reinforcing structure thereon for reinforcing the connecting posts 107.

[0039] More specifically, the second reinforcing structure includes:

a second ring-shaped reinforcing rib 108 arranged to be concentric with the first ring-shaped reinforcing rib 105;

second connection reinforcing ribs 109 disposed at two sides of each of the connecting posts 107, respectively, where one side of each of the second connection reinforcing ribs 109 disposed at either side is connected to the first connection reinforcing rid 106, and another side of each of the second connection reinforcing ribs 109 disposed at either side is connected to the second connection reinforcing rib 109;

a plurality of third connection reinforcing ribs, which are connected between the connecting post 107 and the first ring-shaped reinforcing rib 105, between the connecting post 107 and the second ring-shaped reinforcing rib 108, and between the connecting post 107 and the second connection reinforcing rib 109 disposed at each side, respectively.

[0040] Such a reinforcing structure can reliably reinforce the connecting post 107 in the four directions of the front, the rear, the left, and the right directions, thereby preventing the connecting post 107 from shaking under an external force.

[0041] Furthermore, a plurality of reinforcing blocks 111 are further disposed on the base plate 100, surround the second ring-shaped reinforcing rib 108, and are spaced from each other. The reinforcing blocks 111 are arranged to reinforce the base plate 100.

[0042] Preferably, a side of each of the reinforcing blocks 111 is connected to an outer wall of the second ring-shaped reinforcing rib 108. In this case, the reinforcing blocks 111 can simultaneously reinforce the second ring-shaped reinforcing rib 108, ensuring the stability and the reliability of the connecting posts.

[0043] As shown in FIGS. 10 and 11, a centrifugal fan of this embodiment includes a centrifugal fan blade 200, the motor 110 and the motor bracket 104. The centrifugal fan further includes the above-described volute structure. The fixing end 102 of the motor 110 is mounted in the receiving chamber 103. An output shaft of the motor 110 passes through the motor bracket 104 and is connected to the centrifugal fan blade 200. The motor bracket 104 is connected to the connecting member to fix the motor 110 onto the volute structure. In this embodiment, the centrifugal fan has the above-described volute structure, therefore the generation of the abnormal sound is avoided, the user's experience is good, and the comfortability is high.

[0044] An air conditioner of this embodiment has the above-described centrifugal fan. Not only the generation of the abnormal sound is avoided, but also the comfort is high, and the development cost is low.

[0045] An assembling process of the centrifugal fan of this embodiment is as follows.

[0046] The fixing end 102 provided with an anti-vibration rubber of the motor 110 is mounted into the receiving chamber 103 on the volute structure, then the output shaft of the motor 110 goes through a through hole of the motor bracket 104, and the motor bracket 104 is fixedly connected onto the base plate 100 of the volute structure, so that the fixing end 102 is pressed against the receiving chamber 103, thereby locking the motor 110. The centrifugal fan blade 200 is mounted onto the output shaft of the motor 110, and finally a nut 112 provided with a washer is screwed into the output shaft of the motor 110 to lock the centrifugal fan blade 200.

Fifth Embodiment

[0047] As shown in FIGS. 12 to 14, in a specific embodiment, a heat exchanger fan assembly includes a centrifugal fan and a heat exchanger 201. The centrifugal fan includes a centrifugal fan blade 200 having a diameter L2. The heat exchanger 201 is disposed at an air inlet side of the centrifugal fan. The heat exchanger 201 has a width L1. In order to enable the heat exchanger 201 to be wholly within a flow field driven by the centrifugal fan blade 200 and to fully exchange heat with the air, $L2 \geq L1$ needs to be satisfied. A ratio of the width of the heat exchanger 201 to the diameter of the centrifugal fan blade 200 is F. In order to ensure the heat exchanging area of the heat exchanger 201, in this embodiment, $0.8 \leq F \leq 1$. In this embodiment, in order to increase a contact area of the heat exchanger 201 with the air, the heat exchanger 201 adopts a bent heat exchanger 201. A surface of the heat exchanger 201 proximate to the centrifugal fan blade 200 is a downward concave surface, and the width L1 of the heat exchanger 201 is defined as a distance between two endpoints of the concave surface in a direction parallel to an end portion of the centrifugal fan blade 200. A distance from a lowest point of concave surface to the air inlet side of the centrifugal fan blade 200 is L3, and $L3 < L2$. A ratio of L2 to L3 is G, in order to enable the air to smoothly pass through the heat exchanger 201 while ensuring an optimal surface air speed of the heat exchanger 201, $1.5 \leq G \leq 1.77$ needs to be satisfied. The concave surface is a curved surface. As shown in FIG. 2, an air inlet angle of the centrifugal fan blade 200 is α, $135° \leq \alpha \leq 145°$, and α is defined as an angle between two straight lines connecting a center of the centrifugal fan blade 200 and two ends of a diameter of an end face of the centrifugal fan blade 200, respectively. In this case, an effective heat exchanging area of the heat exchanger 201 is ensured. A height of the heat exchanger covered by the centrifugal fan blade is L4, and $L4 = 2 \times [L3 \times t\,an(\alpha / 2)]$ is satisfied, therefore the effective heat exchanging area of the heat exchanger 201 is a product of L4 and the width L1 of the heat exchanger 201.

[0048] More specifically, in a working process, air enters in-between space of the heat exchanger 201 and the centrifugal fan blade 200, exchanges heat with the heat exchanger 201, and then is drawn by the centrifugal fan and discharged from an upper end of the centrifugal fan. The ratio of the width of the heat exchanger 201 to the diameter of the centrifugal fan blade 200 satisfies $0.8 \leq F \leq 1$, and the ratio of L2 to L2 satisfies $1.5 \leq G \leq 1.77$, thus an optimal wind field is formed under the cooperation between the centrifugal fan and the heat exchanger 201, the air uniformly exchanges heat with the heat exchanger 201, and the capacity of the heat exchanger 201 is be fully utilized.

[0049] In an alternative embodiment, the heat exchanger 201 does not adopt the bent heat exchanger, and the width of the heat exchanger 201 is defined as a distance between two endpoints of the heat exchanger 201 proximate to the centrifugal fan blade 200 and in the direction parallel to the end of the centrifugal fan blade 200.

[0050] This embodiment further provides an air conditioner including the above-described heat exchanger fan assembly. Since the heat exchanging performance of the heat exchanger 201 is relatively good, the air conditioner also has a relatively good performance.

[0051] Obviously, the above-described embodiments are merely examples made for illustrating clearly, but not intended to limit the embodiments. For a person of ordinary skill in the art, other variations or modifications in different forms can also be made on the basis of the above description. All embodiments are not necessarily illustrated exhaustively herein. Obvious variations or modifications that are thus introduced are still within the scope of protection of the present invention.

Claims

1. A centrifugal fan, **characterized by** comprising a volute body (113) and a centrifugal fan blade (200) disposed inside the volute body (113), wherein the volute body (113) comprises a base plate (100), a front plate (308), and a side plate (101) disposed between the base plate (100) and the front plate (308); an air inlet of the centrifugal fan blade (200) is disposed in the front plate (308); a volute tongue (309) is defined by the side plate (101); the volute tongue (309) is inclined from a side of the base plate (100) toward a side of the front plate (308), and a volute tongue gap is gradually reduced from the side of the base plate (100) to the side of the front plate (308); a volute tongue gap C at the front plate (308) is smaller than a volute tongue gap D at the base plate (100); and a difference between the volute tongue gap D and the volute tongue gap C is E.

2. The centrifugal fan of claim 1, **characterized in that** E is 4% to 6% of a diameter of an impeller of the centrifugal fan blade (200).

3. The centrifugal fan of claim 2, **characterized in that** a curved surface of the volute tongue (309) is a conic curved surface, and radii of circular arcs corresponding to the volute tongue gap of the volute tongue (309) are gradually reduced from the side of the base plate (100) to the side of the front plate (308).

4. The centrifugal fan of claim 3, **characterized in that** the radii of the volute tongue (309) are from 15 mm to 20 mm.

5. The centrifugal fan of claim 3, **characterized in that** a diffuser section side surface (310) of a centrifugal air duct of the centrifugal fan is inclined from the side of the base plate (100) toward the side of the front plate (308); a tangent line passing through a center of the centrifugal fan blade (200) and tangent to a circular arc of the volute tongue (309) located at the base plate (100) is defined as a first tangent line; a tangent line passing through the center of the centrifugal fan blade (200) and tangent to a circular arc of the volute tongue (309) located at the front plate (308) is defined as a second tangent line; and an angle formed between projections of the first tangent line and the second tangent line projected onto a plane perpendicular to an axial direction of the centrifugal fan blade (200) is an inclined angle β.

6. The centrifugal fan of claim 5, **characterized in that** $7° \leq \beta \leq 12°$.

7. The centrifugal fan of claim 6, **characterized in that** L5 denotes a volute opening degree of the air duct of the centrifugal fan; L6 denotes a diffuser section outlet distance of the centrifugal air duct ; a ratio of L6 to L5 is M, and $2 \leq M \leq 3$.

8. An air duct system, **characterized by** comprising:

   an air duct body comprising a side-A air outlet (302) and a side-B air outlet (303);
   a plurality of centrifugal fans disposed on the air duct body and between the side-A air outlet (302) and the side-B air outlet (303); wherein the centrifugal fans comprises at least one first centrifugal fan (300); the first centrifugal fan (300) is provided with two first air ducts, comprising a first side-A air duct (304) in communication with the side-A air outlet (302) and a first side-B air duct (305) in communication with the side-B air outlet (303); and the centrifugal fan is the centrifugal fan of any one of claims 1 to 7.

9. The air duct system of claim 8, **characterized in that** two centrifugal fans are provided, and the two centrifugal fans comprise the first centrifugal fan (300) and a second centrifugal fan (301); the second centrifugal fan (301) has a second air duct (306); the second centrifugal fan (301) is disposed proximally to a side A; the first centrifugal fan (300) is disposed proximally to a side B; and the second air duct (306) is in communication with the side-A air outlet (302).

10. The air duct system of claim 9, **characterized in that** a flow guiding chamber (307) is provided at a side of the second centrifugal fan (301), and the first side-A air duct (304) of the first centrifugal fan (300) communicates with the side-A air outlet (302) by the flow guiding chamber (307).

11. The air duct system of claim 10, **characterized in that** a volute body (113) of the first centrifugal fan (300) is aligned with the volute body (113) of the second centrifugal fan (301).

12. An air conditioner, **characterized by** comprising the air duct system of any one of claims 8 to 11.

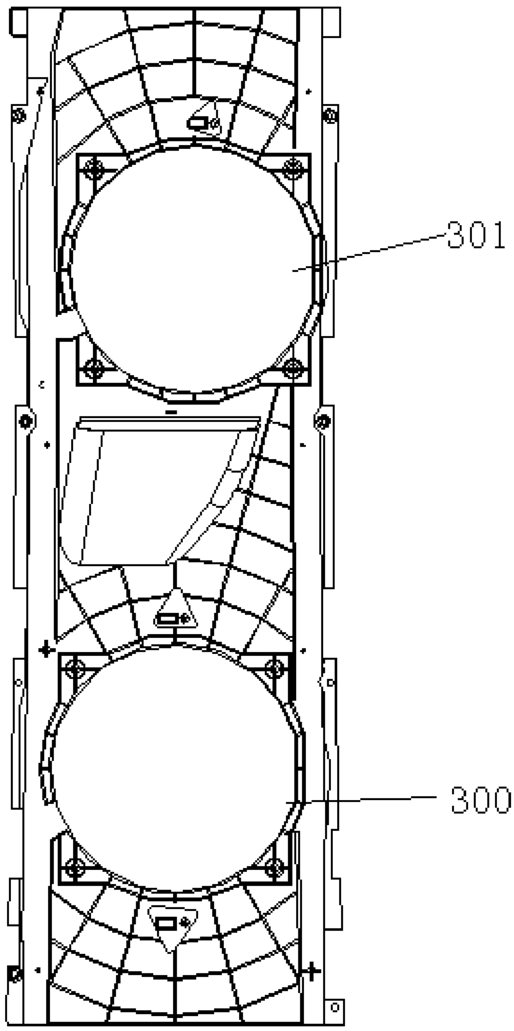

FIG. 1

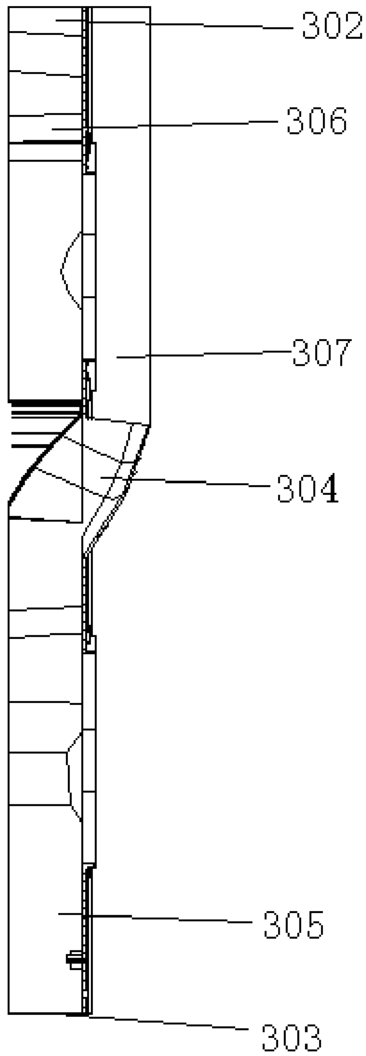

FIG. 2

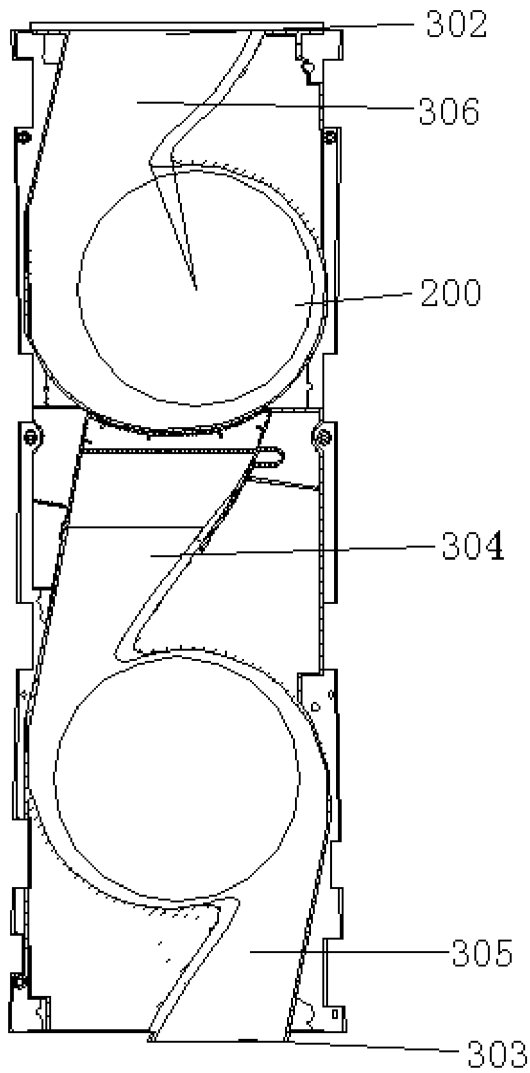

FIG. 3

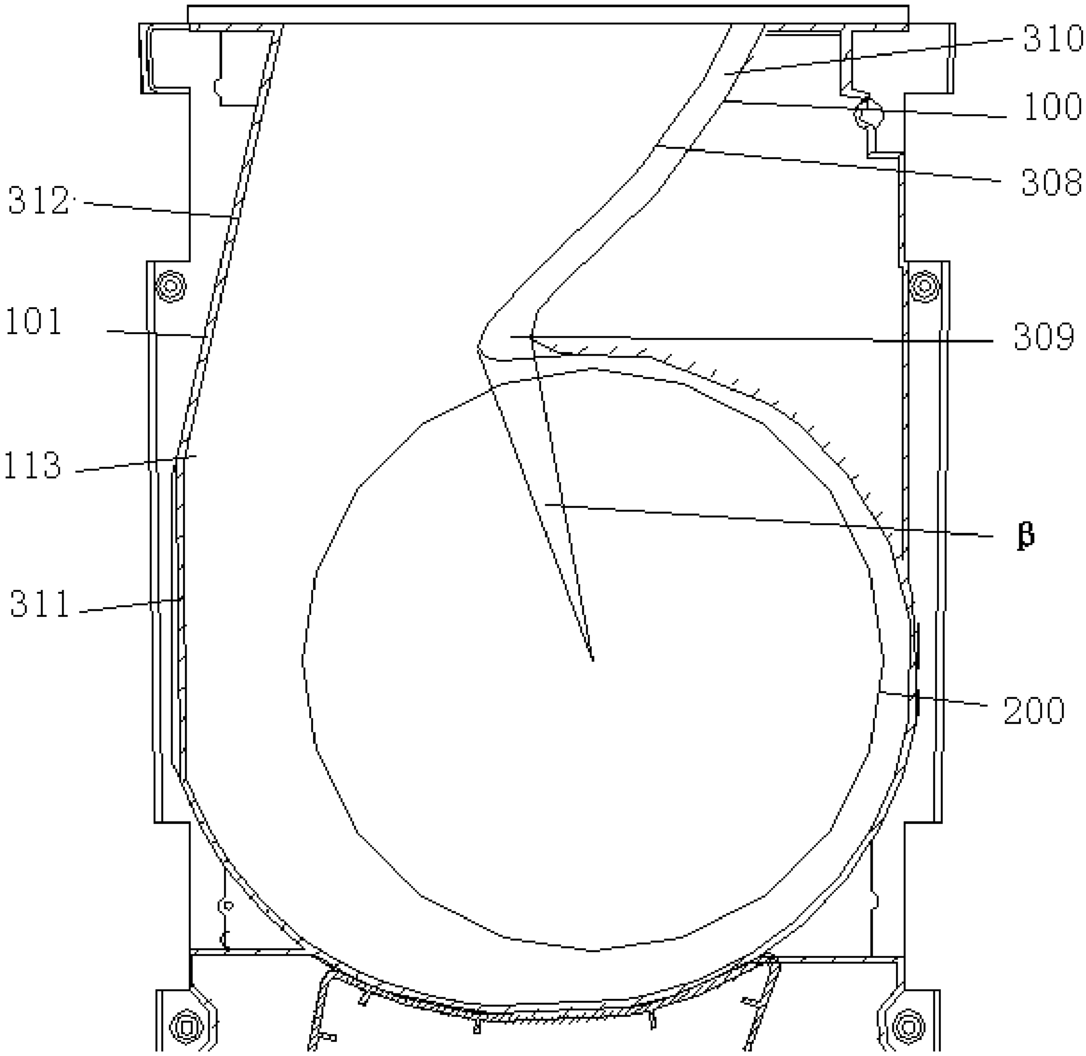

FIG. 4

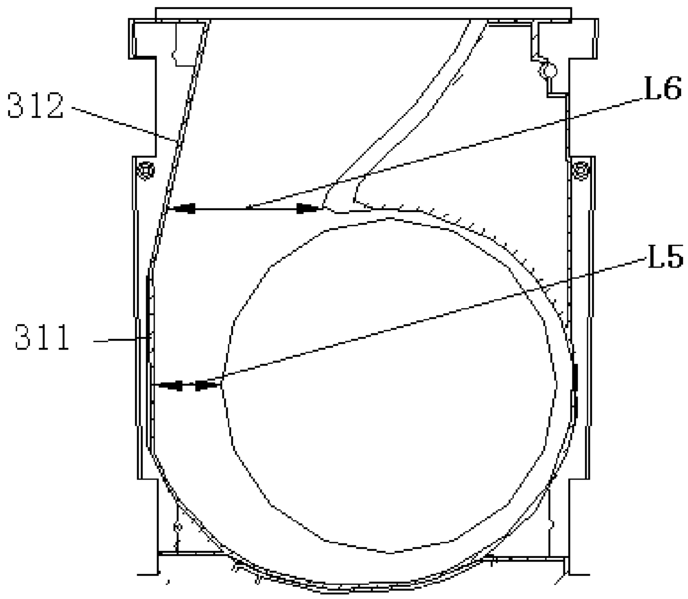

FIG. 5

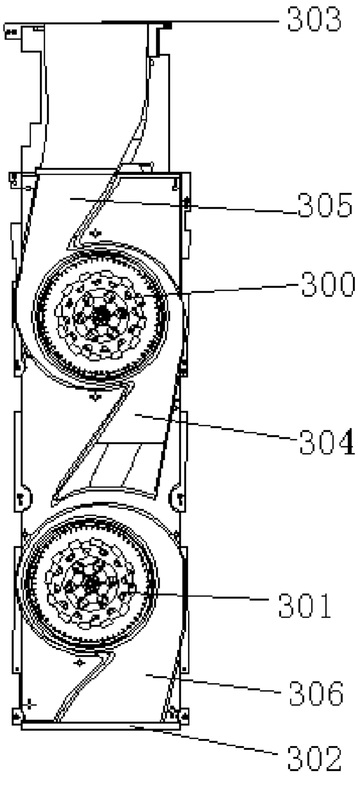

FIG. 6

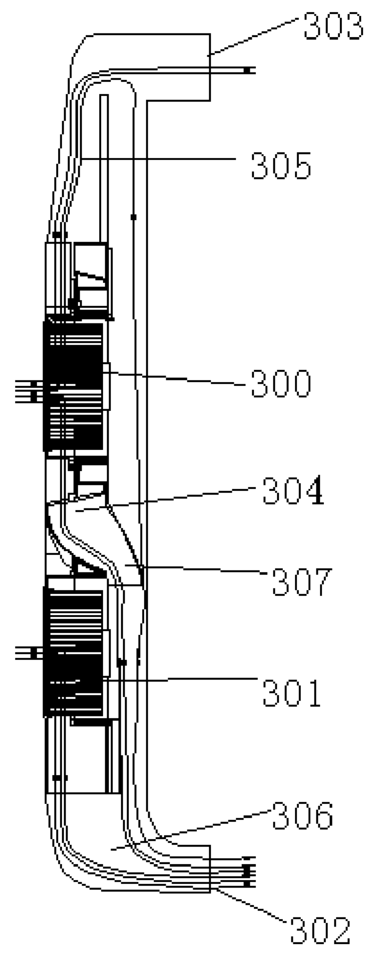

FIG. 7

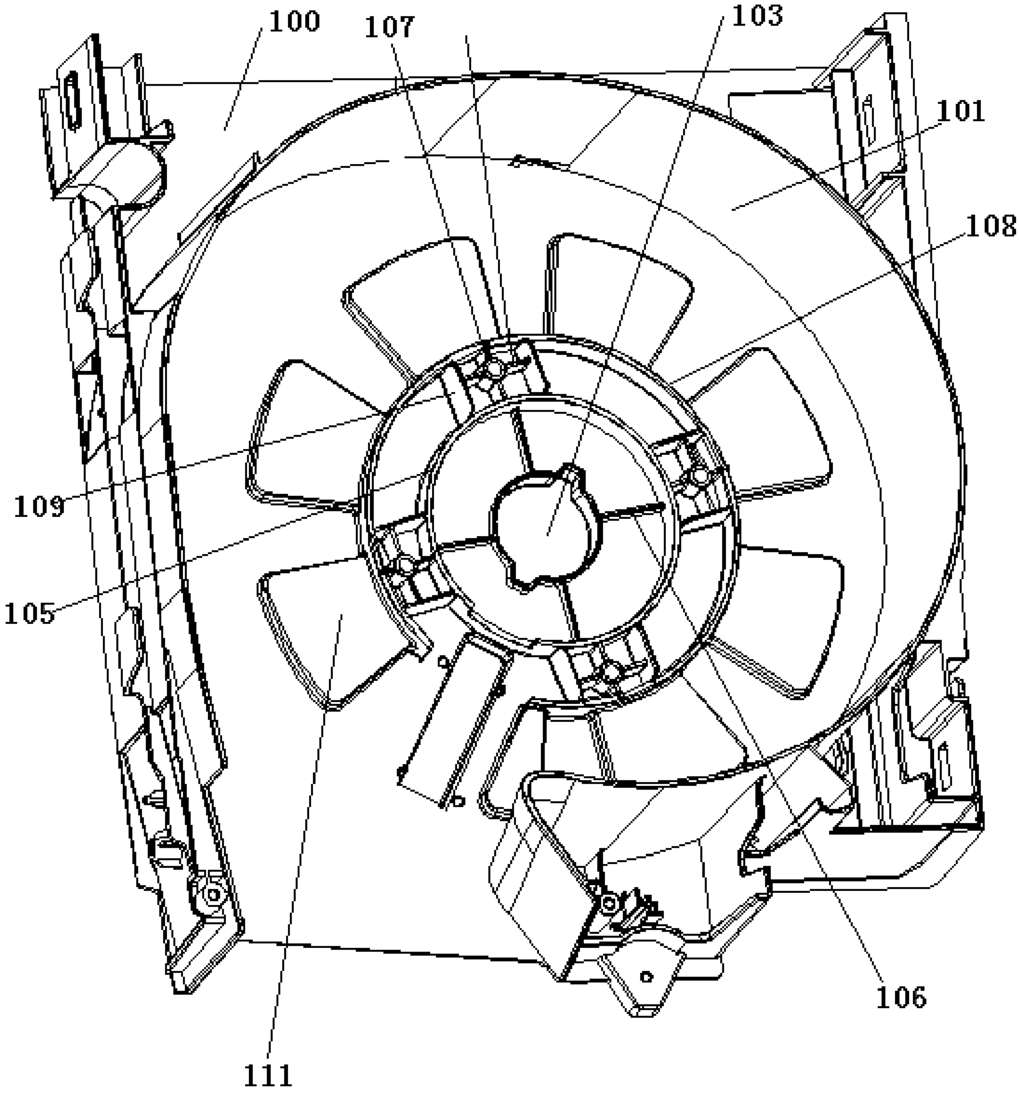

FIG. 8

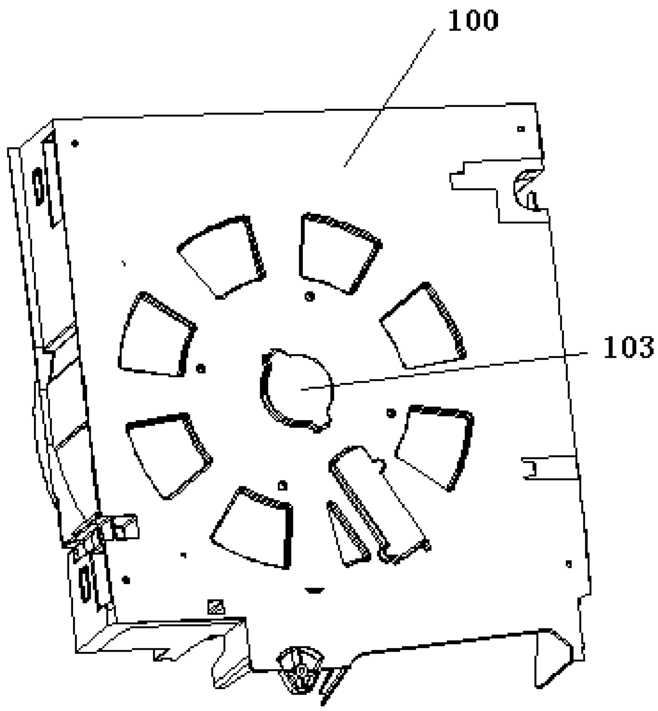

FIG. 9

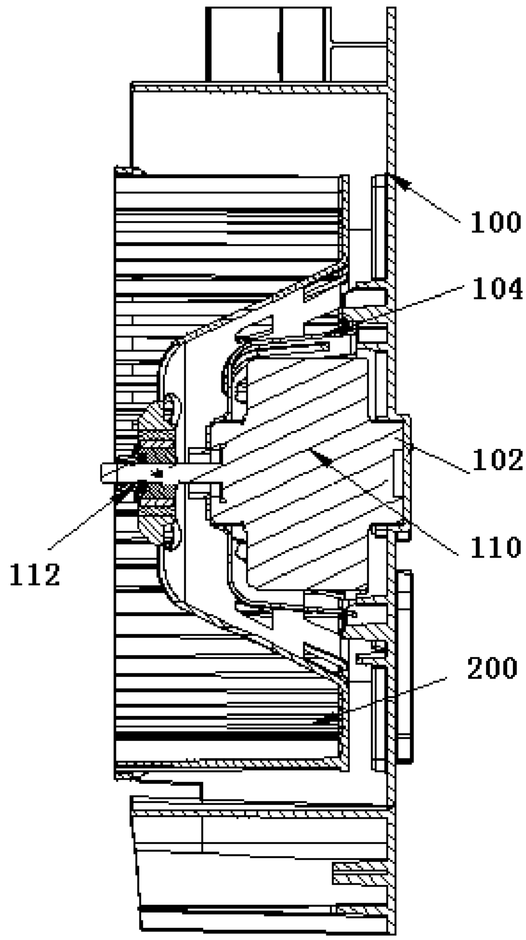

FIG. 10

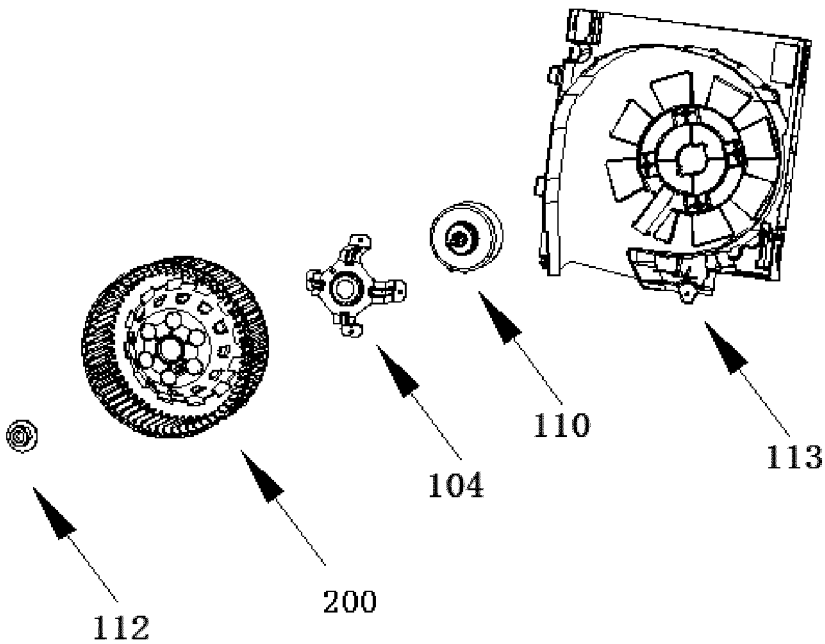

FIG. 11

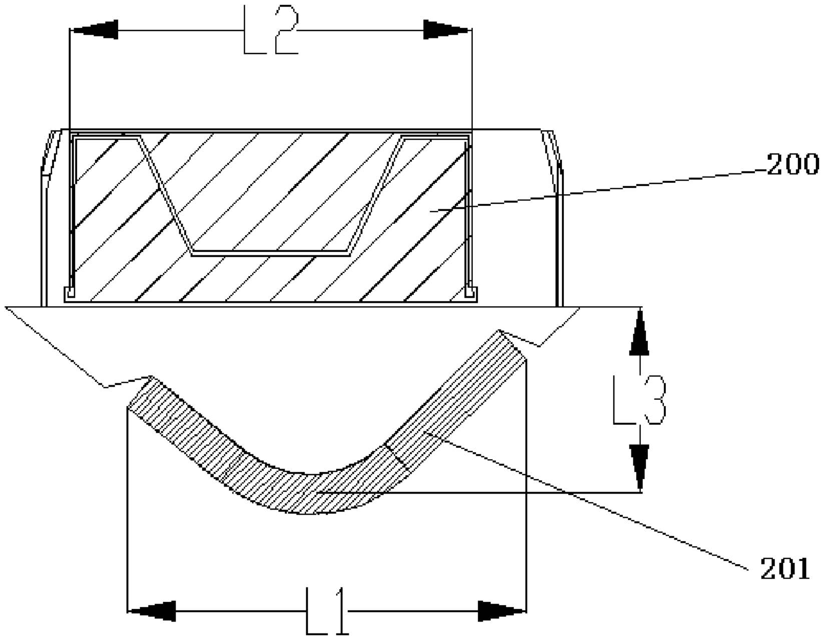

FIG. 12

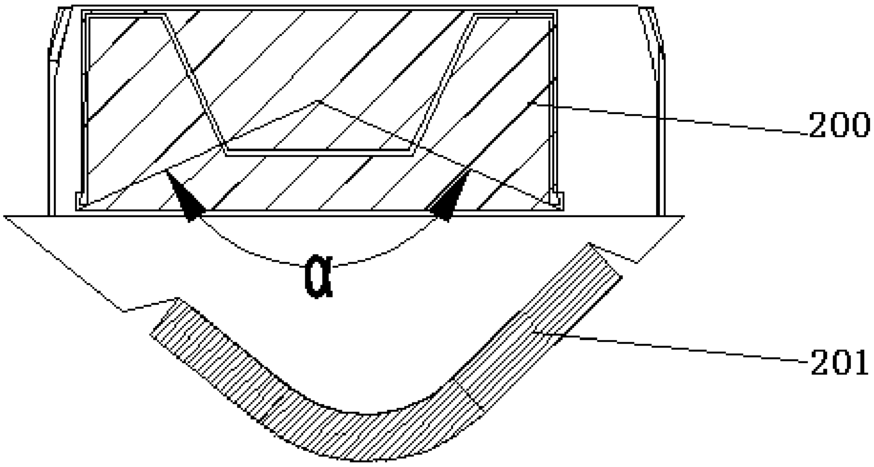

FIG. 13

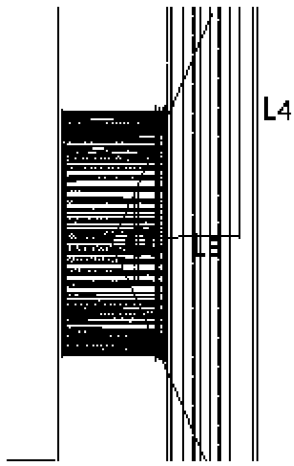

FIG. 14

INTERNATIONAL SEARCH REPORT

International application No.
PCT/CN2019/110757

A. CLASSIFICATION OF SUBJECT MATTER

F04D 17/08(2006.01)i; F04D 29/42(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)

CNABS, DWPI, VEN, CNKI, CN/EP/WO/US/GBTXT: 离心, 风机, 蜗壳, 板, 蜗舌, 倾斜, 间距, 间隙, 距离, centrifugal, fan, blower, volute, spiral, screw, scroll, plate, board, tongue, incline, slant, slope, lean, tilt, clearance, space, distance, interval

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	CN 201116543 Y (SICHUAN CHANGHONG ELECTRIC CO., LTD.) 17 September 2008 (2008-09-17) description, pp. 2 and 3, and figures 1 and 2	1-4, 8-12
A	CN 104728172 A (GREE ELECTRIC APPLIANCES, INC. OF ZHUHAI) 24 June 2015 (2015-06-24) entire document	1-12
A	CN 207333292 U (GD MIDEA AIR-CONDITIONING EQUIPMENT CO., LTD. et al.) 08 May 2018 (2018-05-08) entire document	1-12
A	EP 1744060 A2 (BOSCH ROBERT CORP et al.) 17 January 2007 (2007-01-17) entire document	1-12
A	JP 2016033338 A (KEIHIN CORP.) 10 March 2016 (2016-03-10) entire document	1-12
A	JP 2012021431 A (DAIKIN IND LTD) 02 February 2012 (2012-02-02) entire document	1-12

☐ 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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"P" document published prior to the international filing date but later than the priority date claimed
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"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 December 2019	**16 January 2020**

Name and mailing address of the ISA/CN	Authorized officer
China National Intellectual Property Administration (ISA/CN) **No. 6, Xitucheng Road, Jimenqiao Haidian District, Beijing 100088** **China**	
Facsimile No. **(86-10)62019451**	Telephone No.

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

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/CN2019/110757

Patent document cited in search report			Publication date (day/month/year)	Patent family member(s)			Publication date (day/month/year)
CN	201116543	Y	17 September 2008	None			
CN	104728172	A	24 June 2015	CN	104728172	B	12 April 2017
CN	207333292	U	08 May 2018	None			
EP	1744060	A2	17 January 2007	US	7597541	B2	06 October 2009
				EP	1744060	A3	05 August 2009
				US	2007014666	A1	18 January 2007
JP	2016033338	A	10 March 2016	None			
JP	2012021431	A	02 February 2012	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 201811389839 **[0001]**