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(54) SIROCCO FAN AND AIR CONDITIONER

SCIROCCO-LÜFTER UND KLIMAANLAGE

VENTILATEUR SIROCCO ET CONDITIONNEUR D'AIR

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Description

Technical Field

[0001] The present invention relates to a sirocco fan and an air-conditioning apparatus in which a noise is reduced and an air-blowing characteristic is improved.

Background Art

[0002] Hitherto, in a sirocco fan, a reverse flow phenomenon, in which a part of airflow that is blown out from a whorl-shaped scroll flows from an outer part of the sirocco fan to an inner part thereof occurs, is well known. When the reverse flow phenomenon occurs, since a reverse flow of air collides with a suction airflow, not only an air-blowing amount is reduced, but also a noise is increased. Therefore, it is devised that a shape of a bell mouth that forms a suction opening of the scroll is changed while dividing it into areas in circumferential directions so that such a reverse flow phenomenon is suppressed, or the like (for example, refer to Patent Document 1). Further, an example, in which an auxiliary tongue portion is provided in addition to a tongue portion, in a manner so as to protrude from the tongue portion, is also proposed (for example, refer to Patent Document 2) A further sirocco fan showing all the features of the preamble of claim 1 is known from JP 2000-240594 A.

[0003]

[Patent Document 1] Japanese Unexamined Patent Application Publication No. 9-126193 (Pages 4 and 5, Fig. 1 and Fig. 2)
[Patent Document 2] Japanese Unexamined Patent Application Publication No. 2006-138268 (Page 4, Fig. 1 and Fig. 3)

Disclosure of Invention

Problems to be Solved by the Invention

[0004] In the mean time, in the air-conditioning apparatus on which the hitherto known sirocco fan is mounted, there have been problems such as that, since an air-blowing amount of air blown out from the sirocco fan at a predetermined noise value is small and performance of a heat exchanger is lowered, a load of a compressor is increased and a COP (coefficient of performance) is lowered. In addition, if the air-blowing amount of the air blown out from the sirocco fan is increased in order to suppress the lowering of the COP, the noise value is increased and an uncomfortable feeling is given to a user.

[0005] In light of the above-described problems, an object of the present invention is to provide a sirocco fan capable of obtaining a large air-blowing amount at a time of a predetermined noise occurrence, in other words, to provide a sirocco fan capable of reducing a noise value and a number of revolutions of the sirocco fan, when obtaining a predetermined air-blowing amount, and the air-conditioning apparatus provided with the sirocco fan.

[0006] Further, another object of the present invention is to suppress a reverse flow phenomenon by devising a shape of a scroll, and thereby reducing the noise value while keeping the predetermined air-blowing amount.

Means for Solving the Problems

[0007] A sirocco fan according to the present invention is described in claim 1.

Advantages

[0008] According to the present invention, in the sirocco fan as described in claim 1 and including a scroll, a fan body that is rotatably disposed in the scroll and includes a large number of blades arranged in a cylindrical manner, and a motor for rotationally driving the fan body, the scroll includes two straight line portions being approximately in parallel with each other on a whorl-like outer shape thereof, and a rotation shaft of the motor is positioned nearer to one of the two straight line portions, which is situated nearer a tongue portion of the scroll. Thereby, the air-blowing amount at a time of a predetermined noise occurrence can be increased and in a case of an air-conditioning apparatus, a COP can be improved. Brief Description of Drawings

[0009]

[Fig. 1] Fig. 1 is composed of a schematic plan view (a) and a schematic side elevation (b) illustrating an internal

construction of an indoor unit of an air-conditioning apparatus provided with a sirocco fan in a first embodiment according to the present invention.

[Fig. 2] Fig. 2 is view illustrating a positional relationship between a center of a bell mouth and a center of a rotation shaft in the first embodiment.

[Fig. 3] Fig. 3 is a view illustrating a scroll shape in a second embodiment.

[Fig. 4] Fig. 4 is a perspective view showing an assembled body of a motor-supporting stand, a fan motor, and a fan body in a third embodiment.

[Fig. 5] Fig. 5 is a perspective view showing the motor-supporting stand in Fig. 4.

[Fig. 6] Fig. 6 is a perspective view showing a case that an airflow duct is provided in the motor-supporting stand.

[Fig. 7] Fig. 7 is a schematic view illustrating a case that a rib is provided at both ends of a tongue portion of the scroll in a fourth embodiment.

[Fig. 8] Fig. 8 is a schematic side elevation illustrating a rib of Fig. 7.

[Fig. 9] Fig. 9 is a view illustrating a velocity distribution in a blowing-out opening of the sirocco fan.

[Fig. 10] Fig. 10 is a view illustrating a reverse flow phenomenon in the blowing-out opening of the sirocco fan.

Reference Numerals

[0010]

1: sirocco fan
2: fan motor
3: heat exchanger
4: suction opening
5: blowing-out opening
6: scroll
7: rotation shaft
8: tongue portion
9: bell mouth
10: indoor unit
11: fan body
12: straight line portion
13: straight line portion
14: motor-supporting stand
15: airflow duct
16: rib
17: suction opening
18: blowing-out opening
20: reverse flow area
22: flow

Best Modes for Carrying Out the Invention

[0011] Hereinbelow, an embodiment of the present invention will be described with reference to the drawings.

First Embodiment

[0012] Fig. 1 is composed of a schematic plan view (a) and a schematic side elevation (b) illustrating an inner construction of an indoor unit of an air-conditioning apparatus provided with a sirocco fan in a first embodiment according to the present invention.

[0013] In Fig. 1, a reference numeral 10 denotes an indoor unit constituting an indoor air-conditioning apparatus, and is provided with a pair of sirocco fans 1 and 1, a fan motor 2 that rotationally drives these sirocco fans 1 and 1 simultaneously, and a heat exchanger 3 that performs a heat-exchanging operation with air that is blown out from the sirocco fan 1. The sirocco fan 1 is provided with a whorl-shaped scroll 6, and a fan body including a large number of blades that are rotatably disposed in the scroll 6 and arranged in a cylindrical manner. In the drawing, a reference numeral 4 denotes a suction opening for the air, a reference numeral 5 denotes a blowing-out opening for cool air or warm air, a reference numeral 7 denotes a rotation shaft of the fan motor 2 and a reference numeral 8 denotes a tongue portion.

[0014] The aforementioned indoor unit 10 is provided with a refrigerating circuit for a refrigerant, which is composed of a compressor, a condenser, an expansion valve, and an evaporator, all of which are not illustrated, and is configured

to perform a cooling operation, a heating operation, or the like in a room. Further, an example of specifications in the present first embodiment is as follows: the sirocco fan 1 is configured to have a fan-diameter φ of 160 mm, a width dimension of 190 mm, the number of the blades of 40, and the heat exchanger 3 is provided with a heat transmission pipe of 12 steps, and an array pitch of the heat transmission pipe is 12.7 mm and a step pitch thereof is 20.4 mm, a length in an axial direction of the heat transmission pipe is 700 mm, and a draft resistance $\Delta P1$ is 23.1 $V^{1.3}$ [Pa] (V: velocity[m/s]). Furthermore, the indoor unit 10 is configured to have a depth of 680 mm, a height of 210 mm, and a width of 960 mm.

[0015] The air in the room is sucked in from the suction opening 4 of the indoor unit 10, and is further sucked in from a suction opening of the scroll 6 in an axial direction. The air, to which a dynamic pressure and a static pressure are applied by a cylindrical blade array rotated in the scroll 6 by means of the fan motor 2, is blown out from a discharge opening that is opening into an air path of the indoor unit 10. The air is heat-exchanged with the heat exchanger 3 installed in the air trunk, and is blown out from the blowing-out opening 5 into the room while being changed into cool air or warm air.

[0016] Fig. 2 is a view illustrating a positional relationship between a center of the rotation shaft of the fan motor and a center of a bell mouth 9 in the first embodiment of the present invention. A point O denotes the center of the bell mouth 9 and a point P denotes the center of the rotation shaft of the fan motor 2 (a rotation center of the fan).

[0017] The scroll 6 of the present first embodiment is provided with two straight line portions 12 and 13 that are approximately in parallel with each other on a whorl-like outer shape of the scroll 6, and the center of the rotation shaft 7 of the fan motor 2 is offset toward the straight line portion 12 situated nearer the tongue portion 8 of the scroll 6. That is, the rotation center P of the fan is offset relatively to the center O of the bell mouth 9 and the offset position is set to be nearer the straight line portion 12 situated nearer the tongue portion 8.

[0018] In Table 1, a noise value and a number of revolutions, under the conditions that an air-blowing amount of air blown out from the indoor unit is 16 m^3/min and a length OP is set to be 0 mm and 2 mm, are shown.

[Table 1]

[0019]

Table 1 Noise Value and Number of Revolutions at 16 m^3/min

Length OP	0 mm	2 mm
Noise Value (dB)	45.8	45.3
Number of Revolutions (rpm)	1103	1092

[0020] According to Table 1, it is found that when the length OP is set to be 2 mm, the noise valve and the number of revolutions can be reduced.

[0021] Next, the reason of this result will be explained. In Table 2, a maximum air-blowing amount between the blades, under the conditions that the length OP is set to be 0 mm and the number of revolutions is 1103 rpm, and that the length OP is set to be 2 mm and the number of revolutions is 1092 rpm, are shown. Incidentally, the air-blowing amount is 16 m^3/min in both conditions.

[Table 2]

[0022]

Table 2 Maximum Air-Blowing Amount between Blades at 16 m^3/min

Length OP	0 mm	2 mm
Maximum Air-Blowing Amount between Blades (at 16 m^3/min)	0.682	0.661

[0023] According to Table 2, it is found that the maximum air-blowing amount between the blades at the length OP of 2 mm is smaller. A sound pressure energy is proportional to the sixth power of velocity, and the noise value is expressed by the following mathematical formula:

$$SPL = 10\log_{10}(p/po)^2 \ [dB]$$

where p: sound pressure energy [Pa], po: 2×10^{-5} [Pa], therefore, the noise value is reduced. That is, in order to reduce the sound pressure energy, it is effective to reduce the maximum velocity, and in the case that a distribution of the air-blowing amount between the blades is uneven as in the sirocco fan, it is preferable to reduce a maximum value of the air-blowing amount between the blades.

Second example

[0024] Fig. 3 is a view illustrating a shape of the scroll in a second example of the present invention. Incidentally, in the present embodiment, the center of the bell mouth 9 conforms to the rotation center of the fan motor 2 (in a case that offsetting amount is zero).

[0025] The scroll 6 is provided with two straight line portions FH and EB that are approximately in parallel with each other on the whorl-like outer shape, and the shortest distance between the two straight line portions being approximately in parallel with each other is defined as CG, an intersecting point of a parallel line, which is in parallel with the straight line portions FH and EB of the scroll and passes through the center O of the bell mouth 9, and the outer shape of the scroll is defined as a point A, a point on the outer shape of the scroll, at which a distance between the outer shape of the scroll and the rotation center O of a fan is a maximum, is defined as a point B, intersecting points of a perpendicular line, which is perpendicular to the straight line portions FH and EB of the scroll and passes through the rotation center O of the fan, and the straight line portions FH and EB of the scroll are defined as a point C and a point G, respectively, a fan radius is defined as R, and an angle formed by a segment OA and a segment OB is defined as θ.

[0026] As a curve FGHABCE illustrating a hitherto known scroll shape is formed of a logarithmic spiral and the fan diameter is small compared with that in the case of the present embodiment whose R/CG is set to satisfy the formula of $0.72 \leq R/CG \leq 0.82$. Therefore, the number of revolutions required to obtain a predetermined air-blowing amount is increased.

[0027] On the other hand, when the R/CG is increased, the number of revolutions required to obtain the predetermined air-blowing amount is reduced, but a segment EB comes closer to the fan, so that the air-blowing amount is concentrated on a space between the blades that are close to the segment EB. This results in increasing the noise value.

[0028] Consequently, when the R/CG is increased and a curve AB is spaced apart from the fan relatively to the logarithmic spiral, the air-blowing amount between the blades in the vicinity of the curve AB is increased and the air-blowing amount between the blades in the vicinity of the segment EB is reduced by just that much.

[0029] In Table 3, the noise value and the number of revolutions at the air-blowing amount of 16 m^3/min of the air blown out from the indoor unit, (CASE 1) and (CASE 2) are shown.

[Table 3]

[0030]

Table 3 Noise Value and Number of Revolutions at 16 m^3/min

	Case 1	Case 2
Noise Value (dB)	45.3	44.1
Number of Revolutions (rpm)	1092	1056

[0031] As shown in Table 3, the sirocco fan in the present example including the scroll shape whose condition is set as (OC-R)/R = 0.375, and $\theta = 60°$ can reduce the noise value and the number of revolutions compared with the hitherto known sirocco fan having the scroll shape formed of the logarithmic spiral, by increasing the R/CG and keeping the curve AB away from the fan.

[0032] Incidentally, as for an upper limit value of the (OC-R)/R, when a distance between the straight line portion EB of the scroll 6 and an outer circumferential end of the fan becomes 0.45 or more, the air-blowing amount is reduced and the noise value is increased. Therefore, the (OC-R)/R is set to satisfy the formula of $(OC-R)/R \leq 0.45$.

Third example

[0033] Fig. 4 is a perspective view showing a case that the fan body 11, the fan motor 2, and a motor-supporting stand

14 are assembled, Fig. 5 is a perspective view showing a case that an airflow duct 15 is not formed in the motor-supporting stand 14, and Fig. 6 is a perspective view showing a case that the airflow duct 15 is formed in the motor-supporting stand 14.

[0034] Further, in Table 4, the noise value and the number of revolutions at the air-blowing amount of 16 m^3/min of the air blown out from the indoor unit, in a case where the airflow duct is present in the motor-supporting stand and a case where the airflow duct is absent therein, are shown.

[Table 4]

[0035]

Table 4 Noise Value and Number of Revolutions at 16 m^3/min

Airflow Orifice of Motor-Supporting stand	Present	Absent
Noise Value (dB)	44.8	45.3
Number of Revolutions (rpm)	1091	1092

[0036] According to Table 4, it is found that although the number of revolutions is hardly changed, the noise value is reduced more in the case that the airflow duct 15 is present in the motor-supporting stand 14. The reason is that although a static pressure fluctuation generated from the fan is transmitted to the motor-supporting stand 14 and thereby the static pressure fluctuation is generated on a wall surface of the motor-supporting stand 14 and the noise is generated in the case where the airflow duct 15 is absent in the motor-supporting stand 14, the static pressure fluctuation generated from the fan mutually counteract in a space in the vicinity of the motor-supporting stand 14 in the case where the airflow duct 15 is present in the motor-supporting stand 14, and thereby the static pressure fluctuation on the wall surface of the motor-supporting stand 14 is suppressed.

[0037] Further, it is found that there is no change in a suction space of the sirocco fan 1 even when the airflow duct 15 is provided in the motor-supporting stand 14, because the number of revolutions is hardly changed. Incidentally, the constitution, in which the airflow duct 15 is provided in the motor-supporting stand 14 as described above, may be combined with the constitution of the above-described first embodiment or the second embodiment.

Fourth example

[0038] Fig. 7 is a schematic perspective view illustrating a case where a rib 16 is provided at each of both ends of the tongue portion 8 of the scroll in the present example, and Fig. 8 is a schematic side elevation thereof.

[0039] The rib 16 takes a form of an approximately rectangular parallelepiped shape, and the following formula is satisfied: segment XY $\leq$ segment XZ, where a point in the rib 16 most apart from the fan body 11 is defined as a point X, a point in a circular arc portion of the tongue portion 8 most apart from the fan body 11 is defined as a point Y, and a point in the rib 16 nearest to the fan body 11 is defined as a point Z.

[0040] Furthermore, in Fig. 9, a velocity component that is perpendicular to a blowing-out opening 18 in a case where the rib 16 is absent is shown. In Fig. 9, a reverse flow area 20 indicated by a dashed line in the blowing-out opening 18 a flow toward an inner part of the fan from an outer part thereof is shown. In Fig. 10, stream lines, which are formed at a time when smoke is infused from, for example, a segment 21 on the suction opening 17, are shown, so as to prove a reverse flow phenomenon.

[0041] In Table 5, the noise value and the number of revolutions at the air-blowing amount of 16 m^3/min of the air blown out from the indoor unit 10 in a case where the rib is present and a case where the rib is absent are shown.

[Table 5]

[0042]

Table 5 Noise Value and Number of Revolutions at 16 m^3/min

Rib	Present	Absent
Noise Value (dB)	44.4	45.3
Number of Revolutions (rpm)	1077	1092

[0043] As shown in Table 5, the noise value and the number of revolutions can be reduced by providing a rib. The

reason is that in a case where the rib is absent and a resistive element to the flow such as a heat exchanger or the like is present, the higher the draft resistance of the resistive element becomes, the more the reverse flow phenomenon, in which the airflow is headed toward the inner part of the fan from the blowing-out opening 18, occurs at the blowing-out opening 18 of the sirocco fan 1 as illustrated in Fig. 9, and this becomes a cause of increasing the noise value and the number of revolutions. That is, as illustrated in Fig. 10, an airflow blown out from gaps between the blades on a main plate side is headed toward both ends of the scroll along the scroll, and in the vicinity of both ends of the tongue portion 8, flows into a gap between the tongue portion 8 and the fan body 11, without flowing toward the blowing-out opening 18. The airflow further flows into the gaps between the blades, and is blown out from the gaps between the blades on the main plate side, so that a flow 22 blown out toward the outer part of the scroll is caused. When such a flow is caused, the static pressure fluctuation on the wall surface is increased in the vicinity of both ends of the tongue portion, and a flow passing through the gaps between the blades many times is caused, and an air-blowing amount of the airflow that circulates in the inner part of the fan increases. Thereby, the air-blowing amount of the airflow passing through the gaps between the blades is also increased. This results in increasing the static pressure fluctuation on the blade surface, and increasing the noise value.

[0044] On the other hand, in a case where the rib 16 is present, the airflow blown out from the gaps between the blades on the main plate side is headed toward both ends of the scroll along the scroll. An air-flowing amount flowing into the gap between the tongue portion 8 and the fan body 11 in the vicinity of both ends of the tongue portion 8, without flowing toward the blowing-out opening 18 can be reduced. Thereby, compared with the case where the rib is absent, the noise value and the number of revolutions can be reduced as shown in Table 5. Incidentally, it is appropriate for the rib 16 to have a width in the range from 5 to 10 mm. Further, the constitution, in which the rib 16 of the present example is provided, may be combined with any one of the constitutions of the above-described first to third example.

Claims

1. A sirocco fan including:

   a scroll (6);
   a fan body (11) that is rotatably disposed in the scroll (6) and includes a plurality of blades arranged in a cylindrical manner;
   a motor (2) for rotationally driving the fan body (11), and
   a bell mouth (9) that forms a suction opening of the scroll (6),
   wherein the scroll (6) includes two straight line portions (12,13) approximately in parallel with each other on a whorl-like outer shape thereof, and a rotation shaft (7) of the motor (2) is positioned nearer to one of straight line portions (12,13), which is situated nearer a tongue portion (8) of the scroll (6), **characterized in that**
   a rotation center (P) of the fan body (11) is offset relatively to a center (O) of the bell mouth (9) and the offset position is set to be nearer the straight line portion (12) situated nearer the tongue portion (8) of the scroll (6).

2. The sirocco fan of Claim 1, wherein an airflow duct (15) is provided in a supporting stand (14) for the motor (2).

3. The sirocco fan according to Claim 1 or 2, wherein a rib (16) is provided at each of both ends of the tongue portion (8) of the scroll (6).

4. An air-conditioning apparatus comprising a sirocco fan according to any one of Claims 1 to 3.

Patentansprüche

1. Scirocco-Lüfter, umfassend:

   eine Spindel (6);
   einen Lüfterkörper (11), der drehbar in der Spindel (6) angeordnet ist und eine Vielzahl von Schaufeln beinhaltet, die zylindrisch angeordnet sind;
   einen Motor (2) zum drehenden Antreiben des Lüfterkörpers (11) und eine trompetenartige Aufwerfung (9), die eine Ansaugöffnung der Spindel (6) bildet,
   wobei die Spindel (6) zwei geradlinige Abschnitte (12, 13), die etwa parallel zueinander sind, auf einer wirbelartigen Außenform davon umfasst, und eine Rotationswelle (7) des Motors (2) näher an einem der geradlinigen Abschnitte (12, 13) positioniert ist, der näher an dem Zungenabschnitt (8) der Spindel (6) positioniert ist, **ge-**

kennzeichnet dadurch, dass
ein Rotationszentrum (P) des Lüfterkörpers (11) relativ zu einem Zentrum (O) der trompetenartigen Aufwerfung (9) versetzt ist und die versetzte Lage als näher an dem geradlinigen Abschnitt (12) festgelegt ist, der sich näher an dem Zungenabschnitt (8) der Spindel (6) befindet.

2. Scirocco-Lüfter nach Anspruch 1, wobei ein Luftstromkanal (15) in einem Stützständer (14) für den Motor (2) bereitgestellt wird.

3. Scirocco-Lüfter nach Anspruch 1 oder 2, wobei eine Lamelle (16) an jedem der beiden Enden des Zungenabschnitts (8) der Spindel (6) bereitgestellt wird.

4. Klimaanlage-Vorrichtung, umfassend einen Scirocco-Lüfter nach einem der Ansprüche 1 bis 3.

Revendications

1. Ventilateur sirocco comprenant :

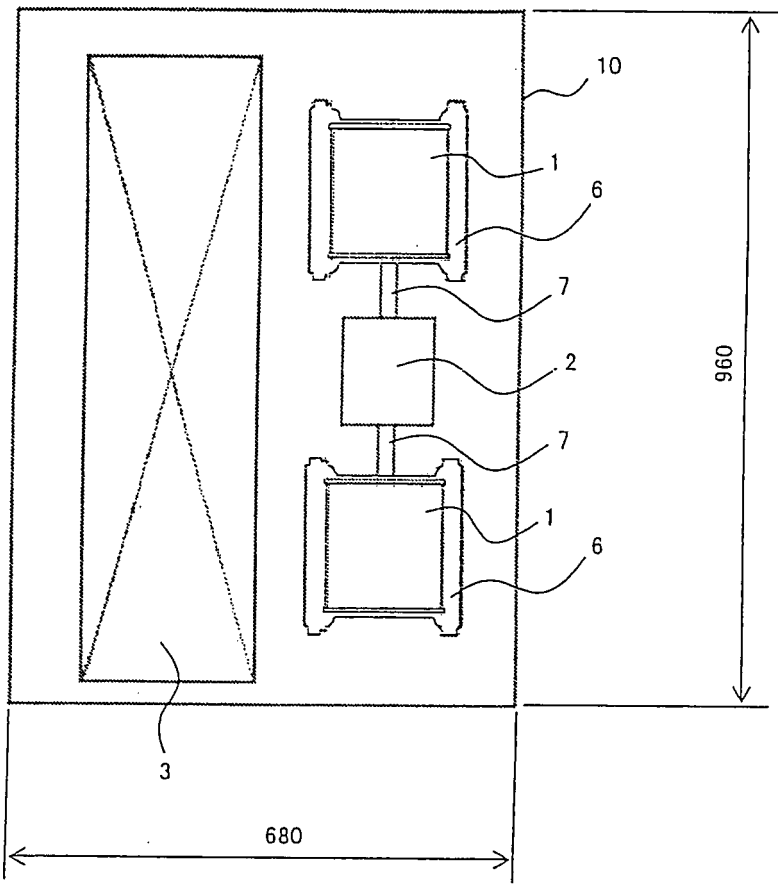
un rouleau (6),
un corps de ventilateur (11) rotatif disposé dans le rouleau (6) et comportant une pluralité de pales agencées de manière cylindrique,
un moteur (2) permettant d'entraîner en rotation le corps de ventilateur (11), et
un orifice évasé (9) qui forme une ouverture d'aspiration du rouleau (6) ;
dans lequel le rouleau (6) comprend deux parties rectilignes (12, 13) approximativement parallèles l'une à l'autre sur une partie externe de celui-ci en forme de spire, et un arbre de rotation (7) du moteur (2) est placé plus près de l'une des parties rectilignes (12, 13), laquelle est située plus près d'une partie de languette (8) du rouleau (6), **caractérisé en ce que**
le centre de rotation (P) du corps de ventilateur (11) est déporté par rapport au centre (O) de l'orifice évasé (9) et la position déportée est établie pour être plus proche de la partie rectiligne (12) située plus près de la partie de languette (8) du rouleau (6).

2. Ventilateur sirocco selon la revendication 1, dans lequel un conduit d'air (15) est prévu dans un socle de support (14) destiné au moteur (2).

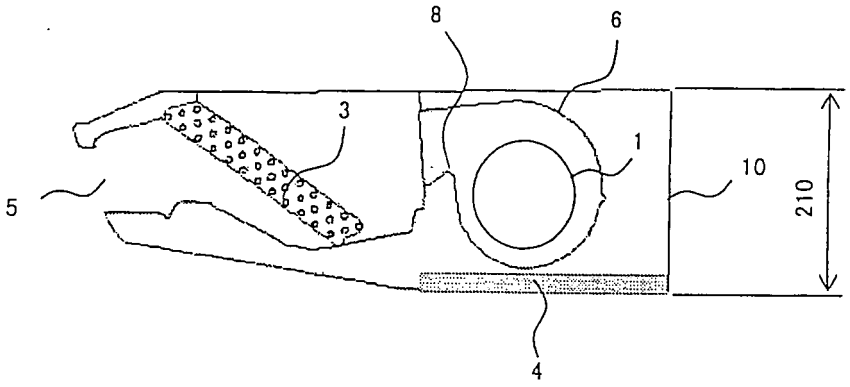
3. Ventilateur sirocco selon la revendication 1 ou 2, dans lequel une nervure (16) est prévue à chacune des deux extrémités de la partie de languette (8) du rouleau (6).

4. Appareil de climatisation comprenant un ventilateur sirocco selon l'une quelconque des revendications 1 à 3.

FIG. 1



(a)



(b)

FIG. 2

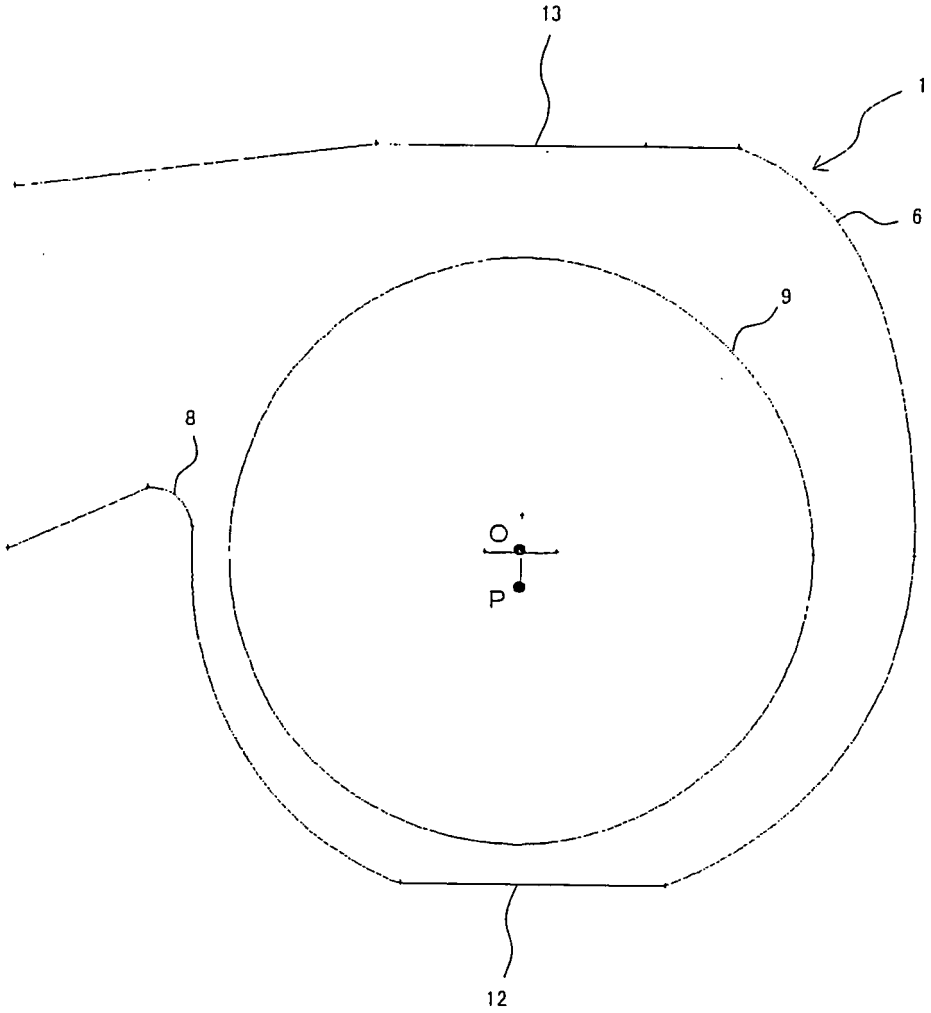


FIG. 3

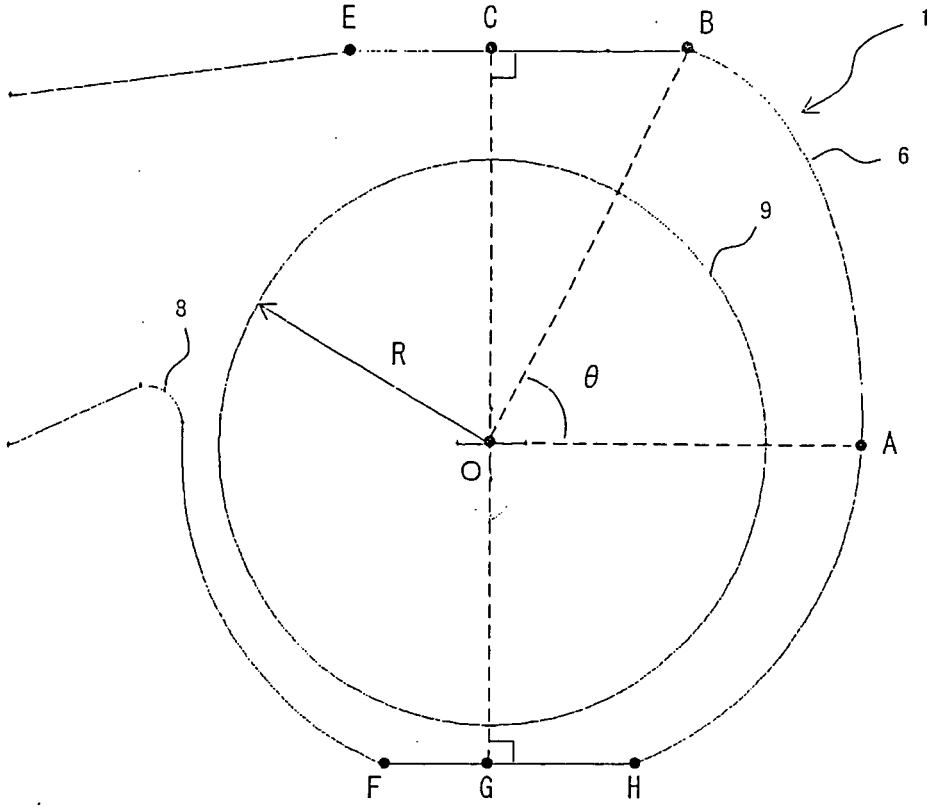


FIG. 4

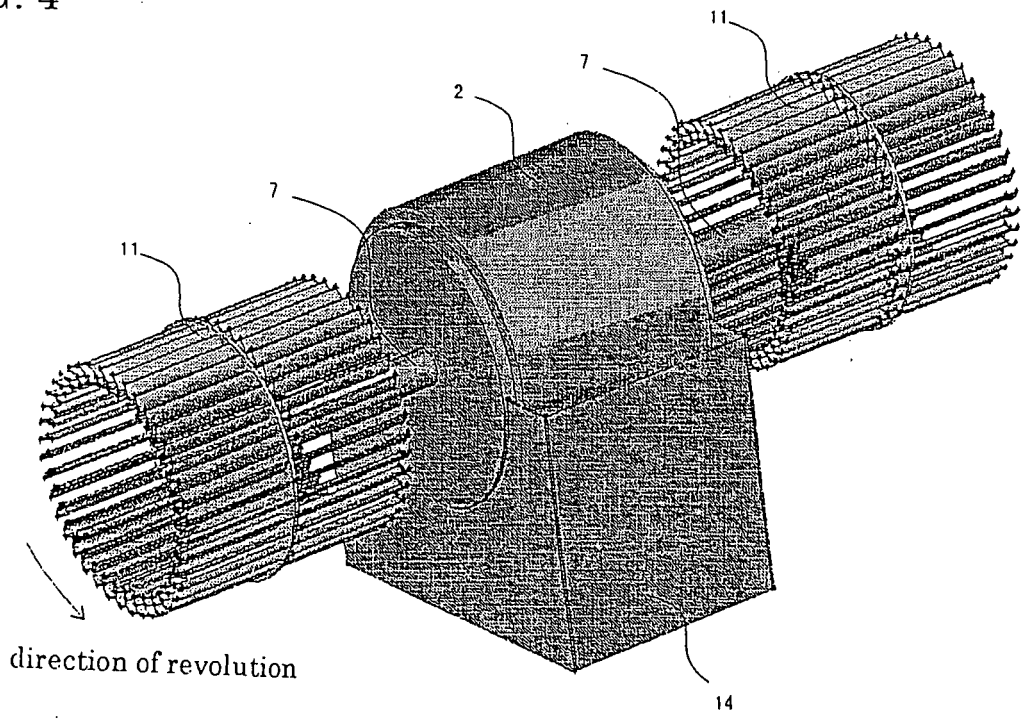


FIG. 5

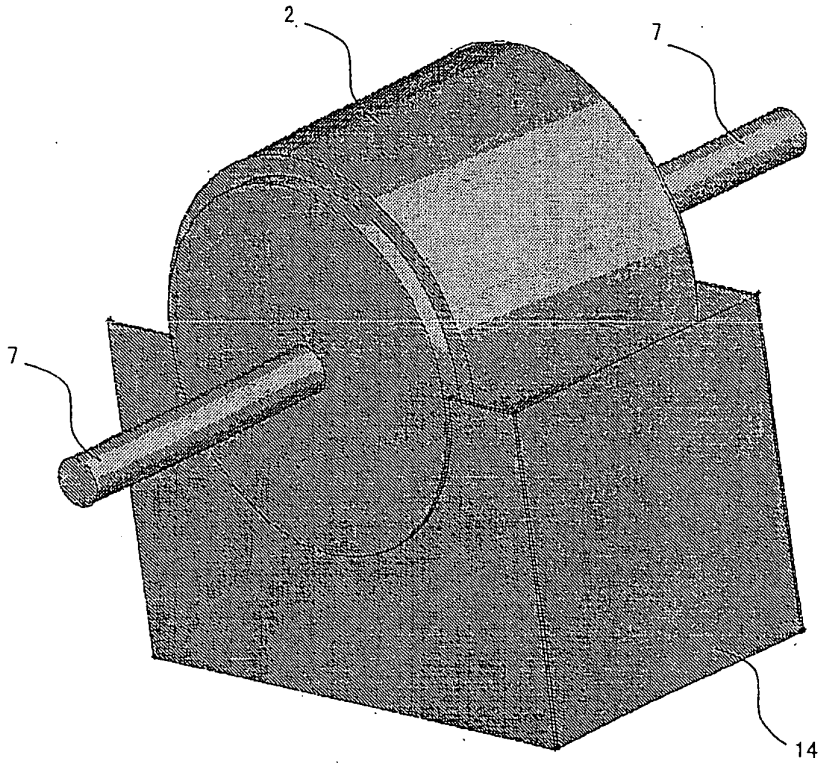


FIG. 6

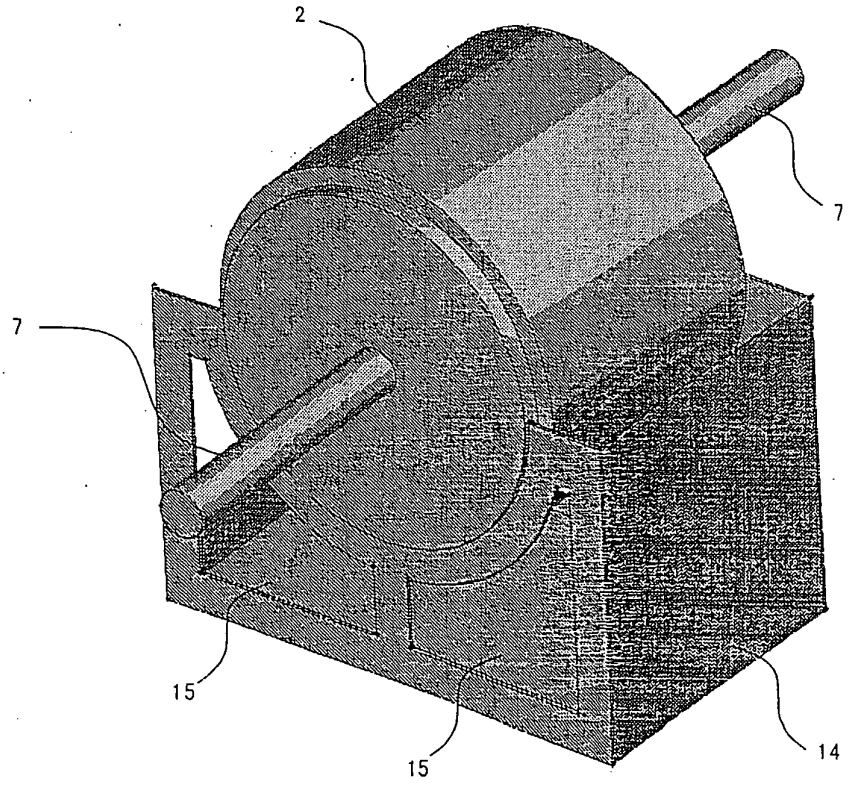


FIG. 7

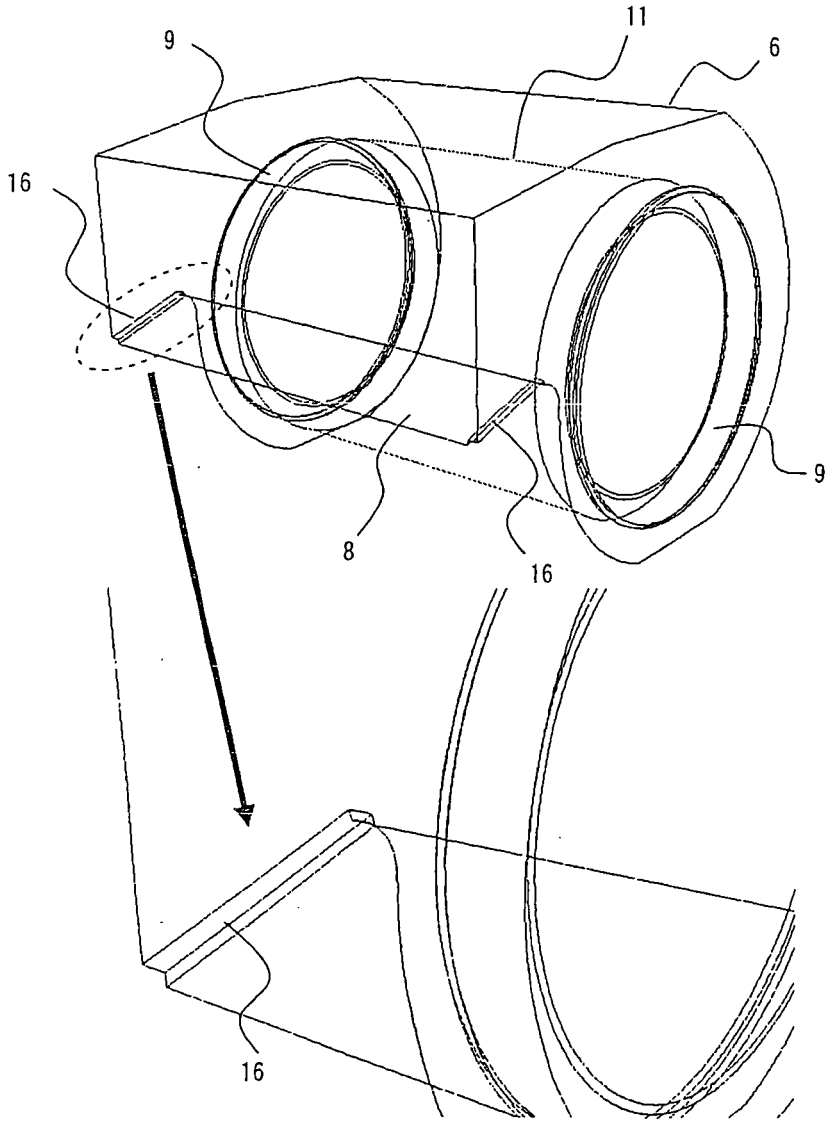


FIG. 8

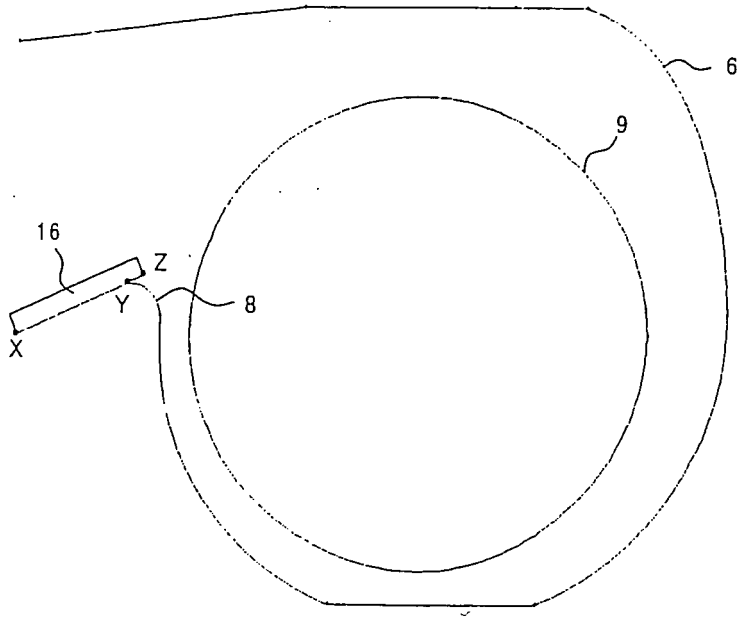


FIG. 9

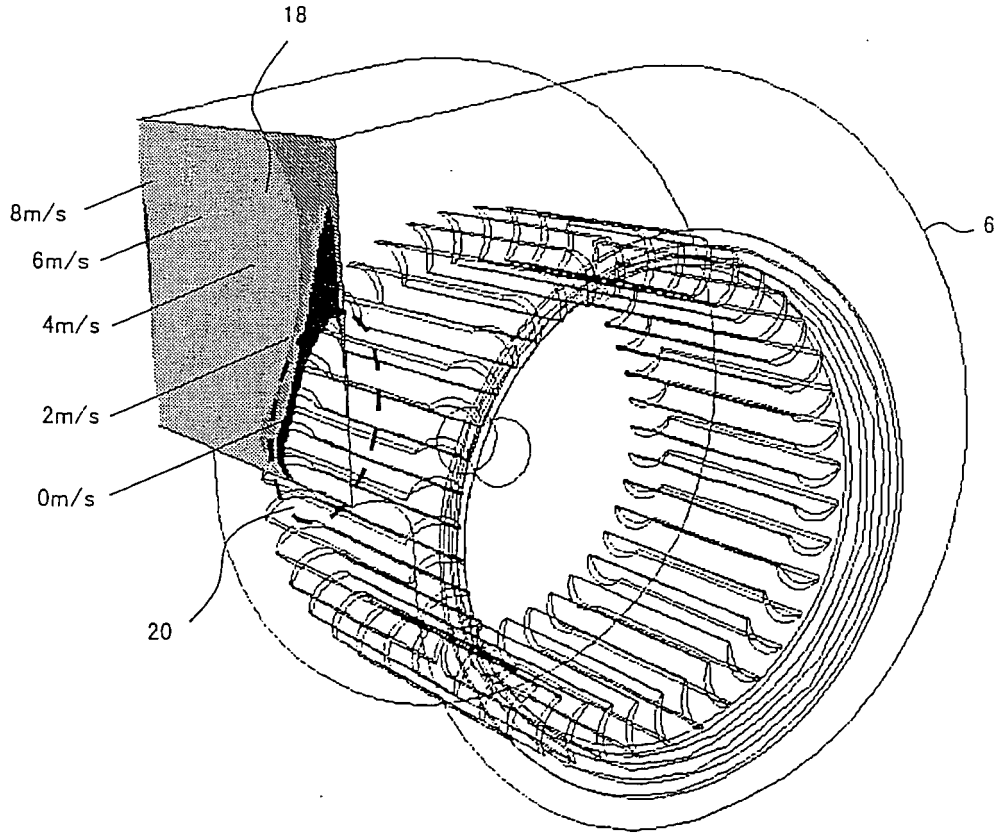
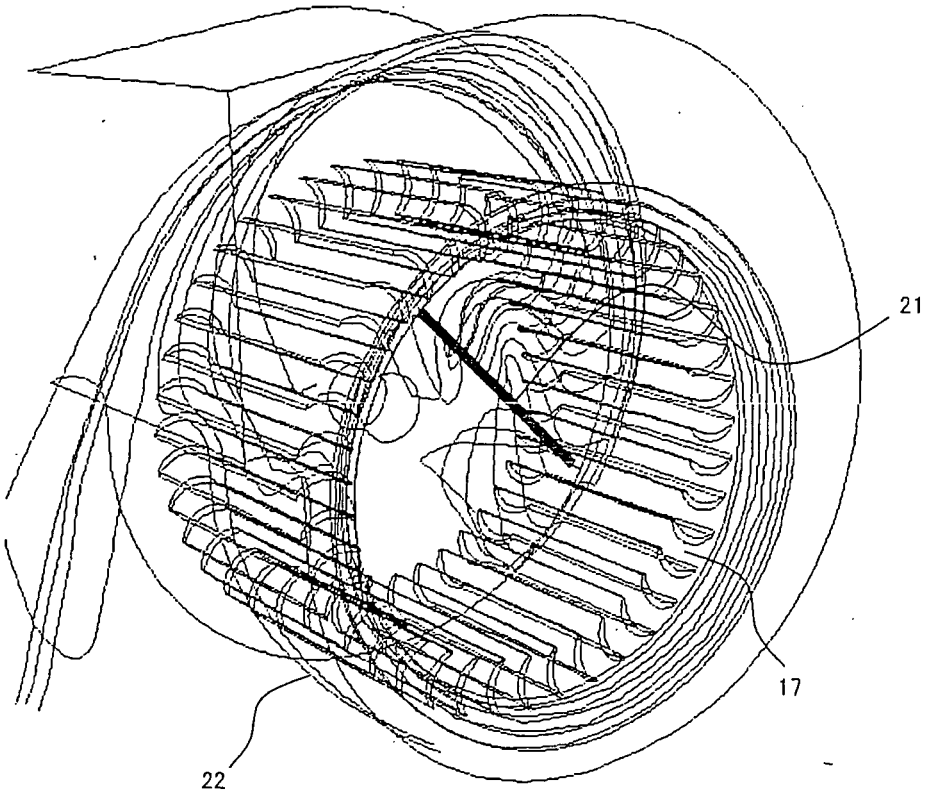


FIG. 10



REFERENCES CITED IN THE DESCRIPTION

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