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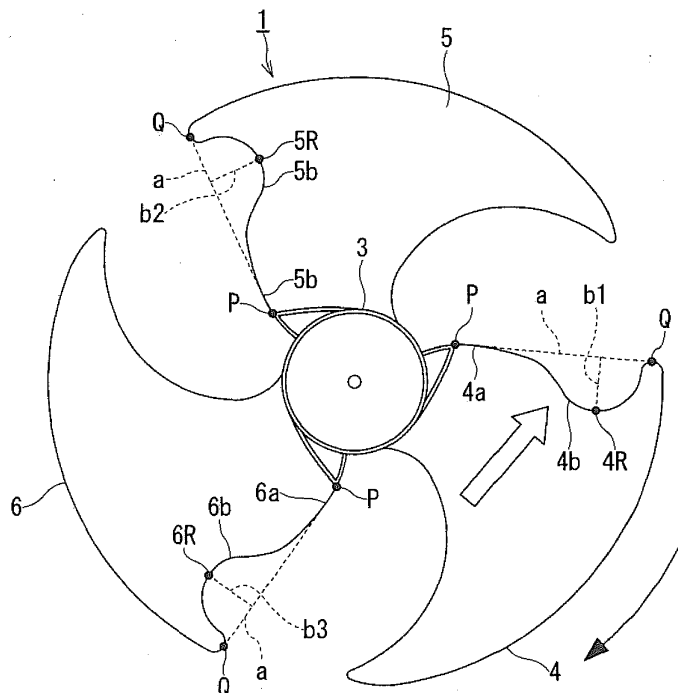
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(54) **Propeller Fan and Heat Source Unit including same**

(57) A propeller fan (1) for a heat source unit (11) is provided with a plurality of blades (4, 5, 6) fixed to a hub (3) on a rotation axis (2) of the fan (1), in which each of the blades (4, 5, 6) has a recess portion (4b, 5b, 6b) formed in a blade rear edge section (4a, 5a, 6a), in fan

rotating direction, as air blow-out portion during rotation of the fan (1), and the recess portions (4b, 5b, 6b) of the respective blades (4, 5, 6) are recessed in a direction opposite to air blow-out direction and are different in sizes thereof.



**FIG. 1**

## Description

### BACKGROUND OF THE INVENTION

#### Field of the Invention

**[0001]** The present invention relates to a propeller fan and a heat source unit provided with the propeller fan.

#### Description of the Related Art

**[0002]** Conventionally, a propeller fan has been used as a fan of a variety of heat source units such as an outdoor unit of an air conditioner, a heat source machine for a water heater with a heat pump, and an outdoor unit of a refrigerating (freezing) machine. A known example of such a conventional propeller fan is described in Patent Document 1 (Japanese Patent Laid-Open No. 2005-140081).

**[0003]** The conventional propeller is formed with substantially circular-arc shaped recesses at a blade rear edge portion as air blow-out portion during the rotation of the fan, and the circular-arc shaped recesses are recessed in direction opposite to an air blowing direction, thereby suppressing the generation of the trailing vortices from the blades to reduce noise which will be generated at the time of blowing air.

**[0004]** Such a conventional propeller fan, however, has arc-shaped recess portions which have the same shape and size in a plurality of blades, and accordingly, peak frequencies of blade pitch sound generated by trailing vortices of the respective blades are in consonance with each other, which unfortunately does not effectively reduce the blowing air noise, thus being inconvenient.

### SUMMARY OF THE INVENTION

**[0005]** The present invention was conceived in consideration of the above conventional circumstances, and an object thereof is to provide a propeller fan capable of improving the reduction in blowing (or blown) air noise and also provide a heat source unit including such propeller fan.

**[0006]** The above and other objects can be achieved according to the present invention by providing, in one aspect, a propeller fan having a plurality of blades fixed to a hub on a rotation axis of the fan, wherein each of the blades has a recess portion formed in a blade rear edge section as air blow-out portion during rotation of the fan, the recess portions of the respective blades being recessed in a direction opposite to air blow-out direction and being different in size.

**[0007]** In a preferred embodiment of the above aspect, It may be desired that the recess portions of the blades are formed such that perpendicular lines drawn from line segments joining inner endpoints and outer endpoints of the blade rear edge sections to deepest points of the recess portions are different from each other in lengths

thereof.

**[0008]** It may be also desired that the recess portions are formed such that a length of the line segments "a" and lengths of the perpendicular lines "b" of the blades satisfy relationship of " $0.1a \leq b \leq 0.5a$ " and the lengths "b" in the blades are different from each other.

**[0009]** It may be also preferred that a number of the blades is three, and the lengths of the perpendicular lines  $b_1$ ,  $b_2$  and  $b_3$  of the blades are determined so as to satisfy: " $b_1 \leq b_2 < b_3$ ", " $0.1a \leq b_1 \leq 0.35a$ ", " $0.15a \leq b_2 \leq 0.4a$ ", and " $0.2a \leq b_3 \leq 0.5a$ ."

**[0010]** In another aspect of the present invention, there is also provided a heat source unit comprising: a unit housing; a propeller fan of the structures mentioned above and housed in the unit housing; an outdoor heat exchanger housed in the unit housing through which the propeller fan blows air; and a fan motor mounted to the unit housing for driving the propeller fan.

**[0011]** According to the propeller fan of the structures mentioned above, blown or blowing air noise can be effectively reduced, and by taking particular size or dimensions of the recess portions formed to the fan blades, the above effects can be further improved. The heat source unit as outdoor unit of an air conditioner, for example, provided with the above propeller fan can attain the same or like effects as mentioned above.

**[0012]** The nature and further characteristic features of the present invention will be made clearer from the following descriptions made with reference to the accompanying drawings.

### BRIEF DESCRIPTION OF THE DRAWINGS

**[0013]** In the accompanying drawings

Fig. 1 is a front view illustrating a propeller fan according to an embodiment of the present invention; Fig. 2 is a perspective view illustrating the propeller fan in Fig. 1;

Fig. 3 is a view illustrating a blade rear edge section, in an enlarged scale, of the propeller fan in Fig. 1; Fig. 4 is a table of experimental data on air blowing performance of the three-bladed propeller fan illustrated in Fig. 1;

Fig. 5 is a graph illustrating the relative relationship between dimensions of blade rear edge recess portions and blowing air noises in the experimental data shown in Fig. 4; and

Fig. 6 is a schematic cross-sectional view illustrating a heat source unit, according to another embodiment of the present invention, including the three-bladed propeller fan in Fig. 1.

### DESCRIPTION OF THE PREFERRED EMBODIMENT

**[0014]** Embodiments of the present invention will be described in detail hereunder with reference to the accompanying drawings. Further, it is to be noted that the

same or corresponding components or parts are denoted by adding the same reference numerals throughout the drawings.

(First Embodiment)

**[0015]** Fig. 1 is a front view illustrating a propeller fan according to a first embodiment, and Fig. 2 is a perspective view thereof.

**[0016]** A propeller fan 1 is entirely made of plastic compounded of glass fiber and ASG (Acrylonitrile Styrene Glass) resin, for example, and three blades 4, 5 and 6 having similar shapes are circumferentially installed at substantially regular intervals to a hub 3 on a fan rotation shaft 2 (i.e., rotation axis of a fan motor, not shown), as illustrated in Figs. 1 and 2. Each of the blades 4, 5 and 6 has substantially arc-shaped (arcuate) blade rear edge recess portions 4b, 5b and 6b, respectively, in blade rear edge sections 4a, 5a and 6a (the term "rear edge" is used herein in the fan rotating direction as shown with a black arrow in Fig. 1). The portions 4b, 5b and 6b are recessed in direction opposite to air flow denoted by a white arrow in Fig. 1.

**[0017]** The arcuate recess portions 4b, 5b and 6b formed to the respective blades are different from each other in size. Specifically, if perpendicular lines b1, b2 and b3 are drawn from line segments "a" joining inner endpoints P and outer endpoints Q to deepest points 4R, 5R and 6R of the respective recess portions 4b, 5b and 6b, the lengths of these perpendicular lines b1, b2 and b3 (depths of the recess portions 4b to 6b) are not smaller than 0.1a and not greater than 0.5a ( $0.1a \leq b1, b2, b3 \leq 0.5a$ ), and " $b1 < b2 < b3$ ".

**[0018]** That is, different lengths of the perpendicular lines b1, b2 and b3 lead to different sizes of the recess portions 4b, 5b and 6b.

**[0019]** Furthermore, in the present embodiment, the recess portions 4b, 5b and 6b are formed so that the lengths of the perpendiculars b1, b2 and b3 and the length of line segments "a" satisfy the following relationship: " $0.1a \leq b1 \leq 0.35a$ ", " $0.15a \leq b2 \leq 0.4a$ ", and " $0.2a \leq b3 \leq 0.5a$ ". Further, the line segments "a" in the blades 4, 5 and 6 have the same length.

**[0020]** According to the present embodiment of the characters mentioned above, since the difference in the lengths of the perpendicular lines b1, b2 and b3 in the recess portions 4b, 5b and 6b of the three fan blade also lead to the difference in sizes of the recess portions 4b, 5b and 6b as previously described, the peak frequencies and phases of blade sound generated by trailing vortices from the blades 4, 5 and 6 during the rotation of the fan can be shifted to suppress consonance, and thereby the reduction in blowing (blown) air noise can be improved.

**[0021]** Fig. 4 shows experimental data on air blowing performance of the propeller fan 1 illustrated in Fig. 1.

**[0022]** In the experiment, first to sixth test models #1 to #6 were prepared, which test models each include its own propeller fan 1 of a required size, such as a diameter

of 420 mm. The dimensions of the perpendicular lines b1, b2 and b3 indicating the depths of the recess portions 4b, 5b and 6b, respectively, varied within a range from 0.1a to 0.5a ( $0.1a \leq b1, b2, b3 \leq 0.5a$ ) to satisfy the relationship " $0.1a \leq b1 \leq 0.35a$ ", " $0.15a \leq b2 \leq 0.4a$ ", and " $0.2a \leq b3 \leq 0.5a$ ".

**[0023]** These six test models #1 to #6 were then operated at 800 rpm with an amount of air being 2080 m<sup>3</sup>/h, and a blown air noise value (dB(A)) was measured at a position being 1 m (1 meter) apart from each fan in the air blowing direction.

**[0024]** Further, in this experiment, a three-bladed propeller fan, that is a conventional model, was also prepared. The three recess portions 4b to 6b of the fan were the same in depth (b1, b2, b3 : 0.2a), shape, and size. The model was operated under the same condition as that of the first embodiment and a blown air noise value (dB(A)) and the like were also shown in Fig. 4 as conventional fan in the table.

**[0025]** Fig. 5 shows the values of air noise blown from the propeller fan 1 of the present embodiment and the conventional model shown in Fig. 4, and in Fig. 5, a curve Na represents the one of the present embodiment and a substantially straight line Nb represents the conventional model fan.

**[0026]** Fig. 5 also shows relationship between dimension ratios of the perpendiculars b1, b2, and b3 (b1 : b2 : b3) denoting the depths of the recess portions 4b, 5b, and 6b, respectively, and the noise values dB(A) during the rotation of the fans. A smallest value of blown air noise, 46 dB, was given when a dimension ratio of the perpendiculars b1, b2, and b3 was " $0.2a : 0.23a : 0.26a$ ". In other words, the test model #3, whose b1 was 0.2a, b2 was 0.23a, and b3 was 0.26a, resulted in the smallest value of blown air noise. On the other hand, the conventional model fan resulted in a constant noise value of about 47.2 dB(A).

**[0027]** As the lengths of the perpendicular lines b1, b2 and b3 were gradually decreased or increased from the minimum value of the blown air noise, a value of the blown air noise gradually increases.

**[0028]** However, if the lengths of the perpendicular lines b1, b2 and b3 satisfy the following relationship of " $b1 < b2 < b3$ ", " $0.1a \leq b1 \leq 0.35a$ ", " $0.15a \leq b2 \leq 0.4a$ ", and " $0.2a \leq b3 \leq 0.5a$ ", the blown air noise does not become greater than about 46.9 dB(A), and hence, the noise is smaller than the noise value Nb, about 47.2 dB(A), of the conventional model denoted by the substantially straight line shown in Fig. 5. In addition, an input power of the motor is also smaller than that of the conventional model as illustrated in Fig. 4, thereby also improving the motor efficiency. Accordingly, it is considered to be preferable that the range of the perpendicular lines is set as mentioned above.

(Second Embodiment)

**[0029]** Fig. 6 is a schematic cross-sectional view illus-

trating an outdoor unit 11 of an air conditioner as a heat source unit according to the present second embodiment provided with the propeller fan of the structure mentioned above.

**[0030]** The outdoor unit 11 of the air conditioner has an outdoor heat exchanger 13 having a planar L-shape, the propeller fan 1 according to the first embodiment, a compressor 14, a four-way valve 15 and a controller 16 such as an inverter in a unit housing 12.

**[0031]** In Fig. 6, reference numeral 17 denotes a partition plate separating a space inside the outdoor unit 1 into a space for the propeller fan 1 and the outdoor heat exchanger 13, and a space for the compressor 14. Reference numeral 18 denotes a support member supporting a fan motor 19 that drives the propeller fan 1.

**[0032]** Since the outdoor unit 11 includes the propeller fan 1, which can improve the reduction in noise of the blown air as described with reference to the above first embodiment, the outdoor unit 11 can achieve the improved reduction in the blown air noise.

**[0033]** It is to be noted that although the present invention was explained hereinbefore with reference to the some embodiments, the present invention is not limited to such embodiments, and many other changes and modifications or alternations, particularly, in type, size, shape or like, may be made without departing from the sprits or scopes of the appended claims.

**[0034]** It is explicitly stated that all features disclosed in the description and/or the claims are intended to be disclosed separately and independently from each other for the purpose of original disclosure as well as for the purpose of restricting the claimed invention independent of the composition of the features in the embodiments and/or the claims. It is explicitly stated that all value ranges or indications of groups of entities disclose every possible intermediate value or intermediate entity for the purpose of original disclosure as well as for the purpose of restricting the claimed invention, in particular as limits of value ranges.

## Claims

1. A propeller fan (1) having a plurality of blades (4, 5, 6) fixed to a hub (3) on a rotation axis (2) of the fan (1), wherein each of the blades (4, 5, 6) has a recess portion (4b, 5b, 6b) formed in a blade rear edge section (4a, 5a, 6a) as air blow-out portion during rotation of the fan (1), the recess portions (4b, 5b, 6b) of the respective blades (4, 5, 6) being recessed in a direction opposite to air blow-out direction and being different in size.
2. The propeller fan (1) according to claim 1, wherein the recess portions (4b, 5b, 6b) of the blades (4, 5, 6) are formed such that perpendicular lines (b1, b2, b3) drawn from line segments (a) joining inner endpoints (P) and outer endpoints (Q) of the blade rear

edge sections (4a, 5a, 6a) to deepest points (4R, 5R, 6R) of the recess portions (4b, 5b, 6b) are different from each other in lengths thereof.

3. The propeller fan (3) according to claim 1 or 2, wherein the recess portions (4b, 5b, 6b) are formed such that a length of the line segments "a" and lengths of the perpendicular lines "b" of the blades (4, 5, 6) satisfy relationship of " $0.1a \leq b \leq 0.5a$ " and the lengths "b" in the blades (4, 5, 6) are different from each other.
4. The propeller fan (1) according to any one of claims 1 to 3, wherein a number of the blades (4, 5, 6) is three, and the lengths of the perpendicular lines b1, b2 and b3 of the blades (4, 5, 6) are determined so as to satisfy: " $b1 < b2 < b3$ ", " $0.1a \leq b1 \leq 0.35a$ ", " $0.15a \leq b2 \leq 0.4a$ ", and " $0.2a \leq b3 \leq 0.5a$ ".
5. A heat source unit (11) comprising:
  - a unit housing (12);
  - a propeller fan (1) according to any one of claims 1 to 4 housed in the unit housing (12);
  - an outdoor heat exchanger (13) housed in the unit housing (12) through which the propeller fan (1) blows air;
  - a fan motor (19) mounted to the unit housing (12) for driving the propeller fan (1).

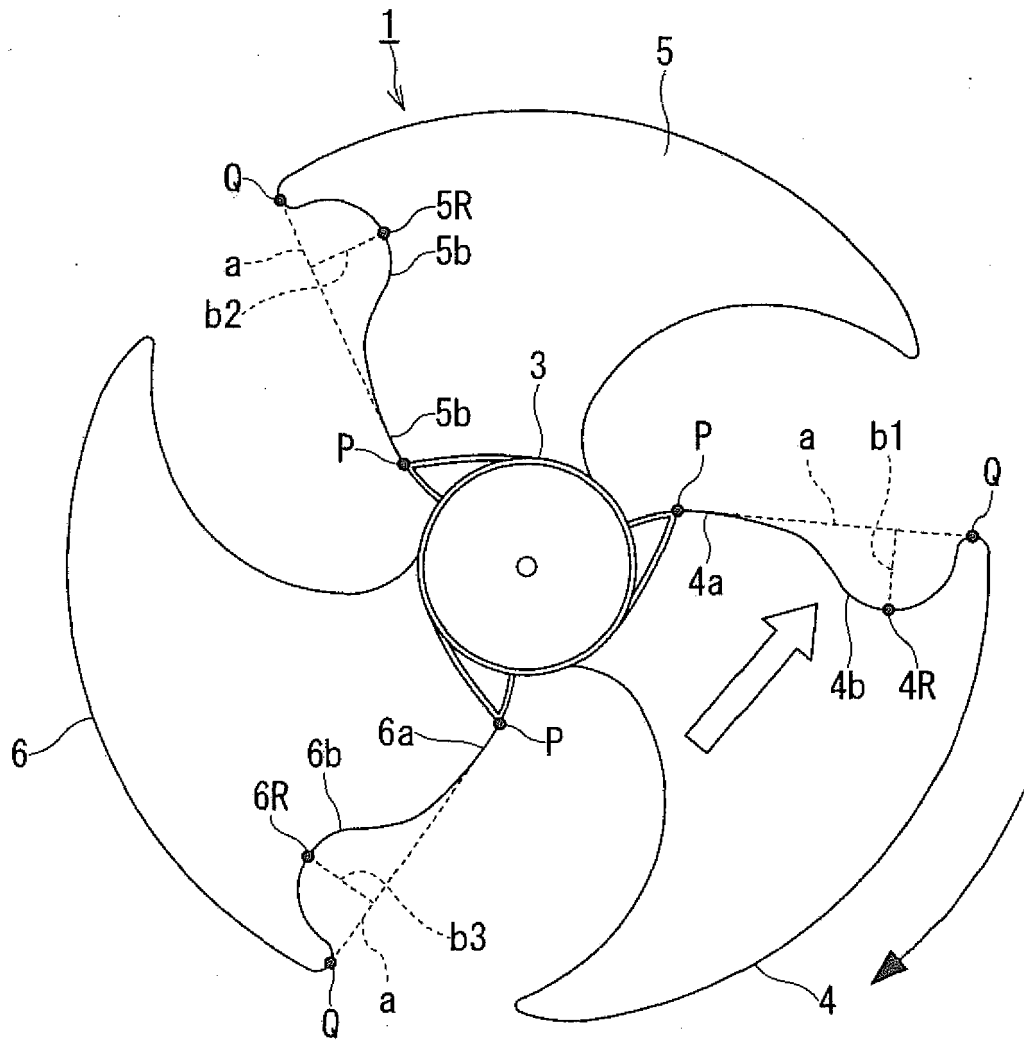


FIG. 1

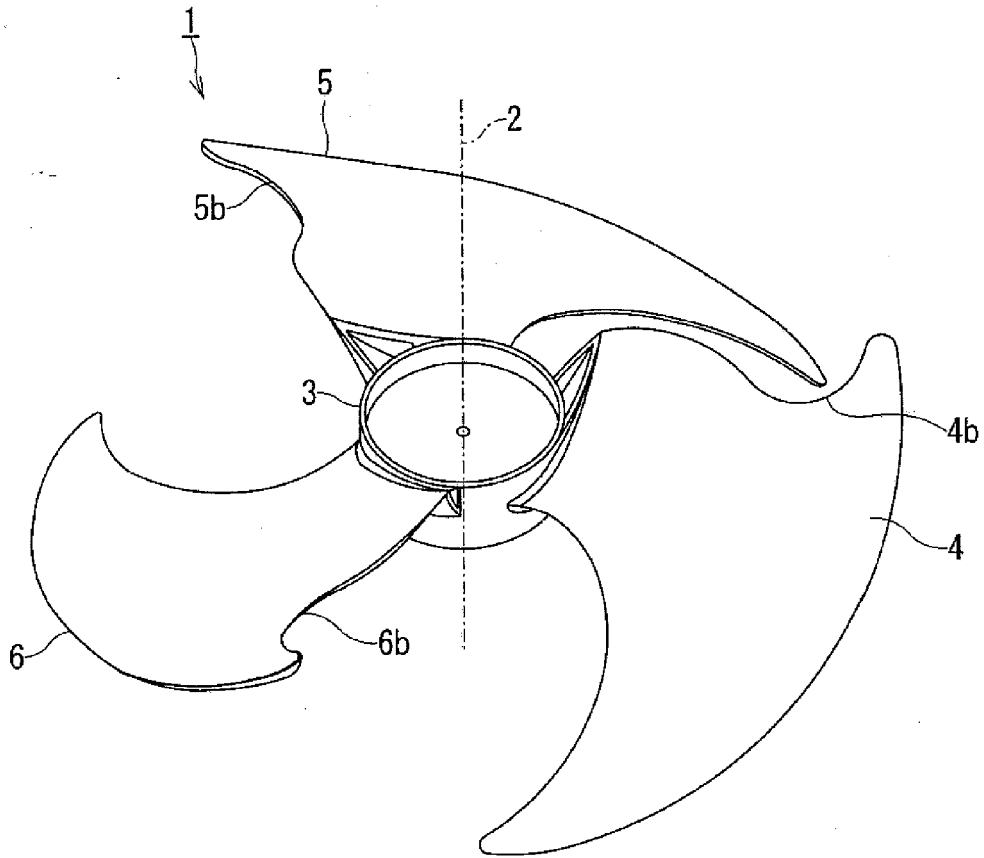


FIG. 2

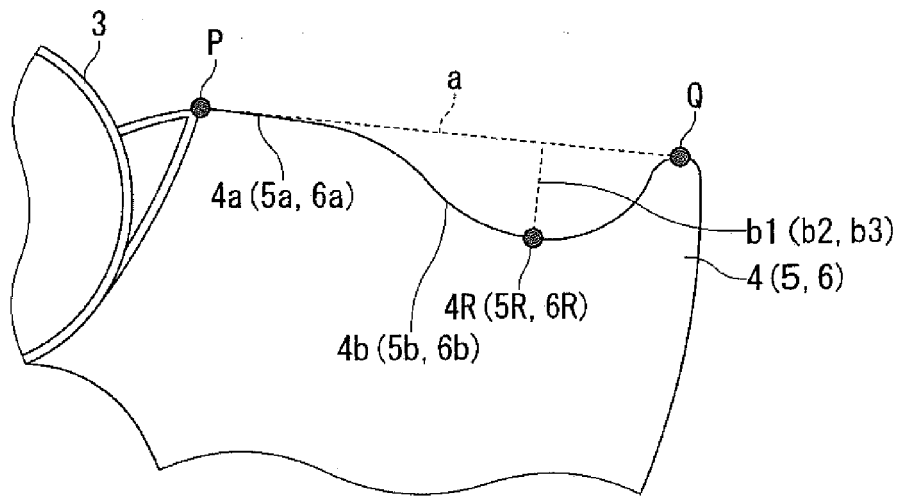


FIG. 3

TEST MACHINE (#)	DEPTH OF RECESS (b)			AIR-FLOW AMOUNT m <sup>3</sup> /h	rpm	NOISE VALUE dB (A)	MOTOR INPUT W
	b1	b2	b3				
1	0.1	0.15	0.2	↑	772	46.8	33.2
2	0.2	0.22	0.24	↑	786	46.4	33.0
3	0.2	0.23	0.26	↑	804	46	32.4
4	0.2	0.26	0.3	↑	824	46.3	32.0
5	0.2	0.3	0.4	↑	760	46.6	33.0
6	0.35	0.4	0.5	2070	810	46.9	33.2
CONVENTIONAL FAN	0.2	0.2	0.2	2070	780	47.2	33.6

FIG. 4

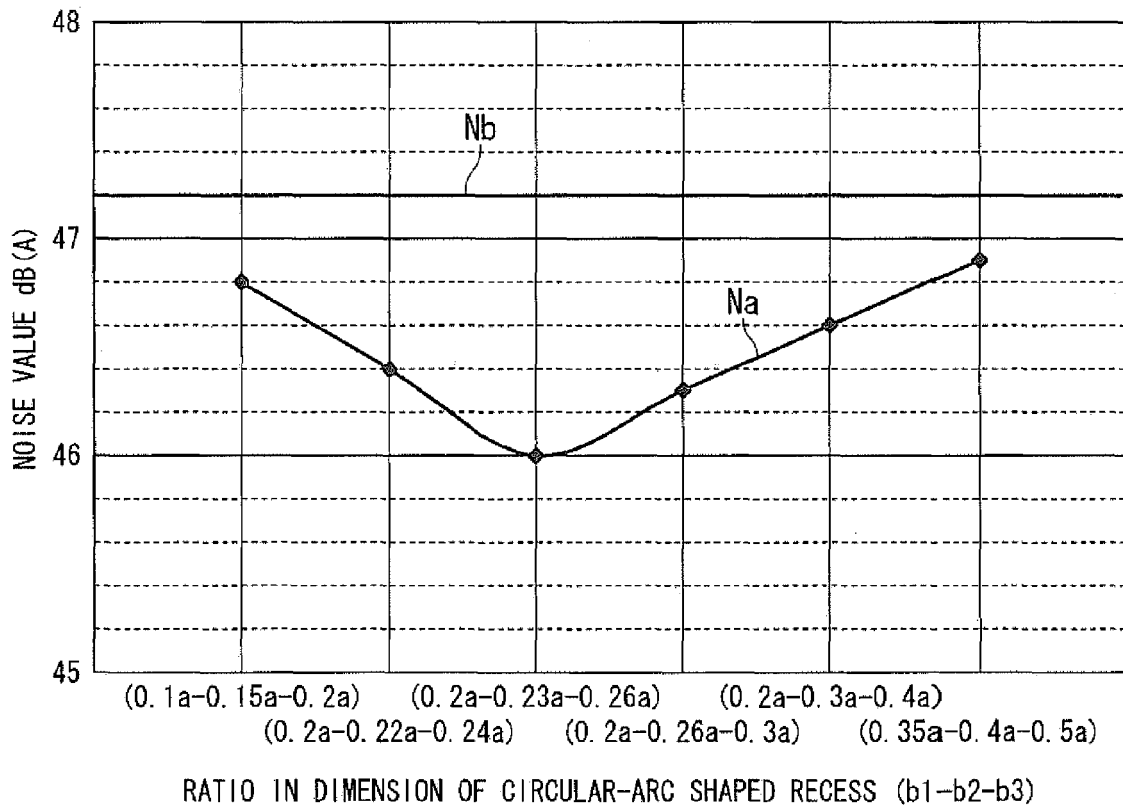


FIG. 5

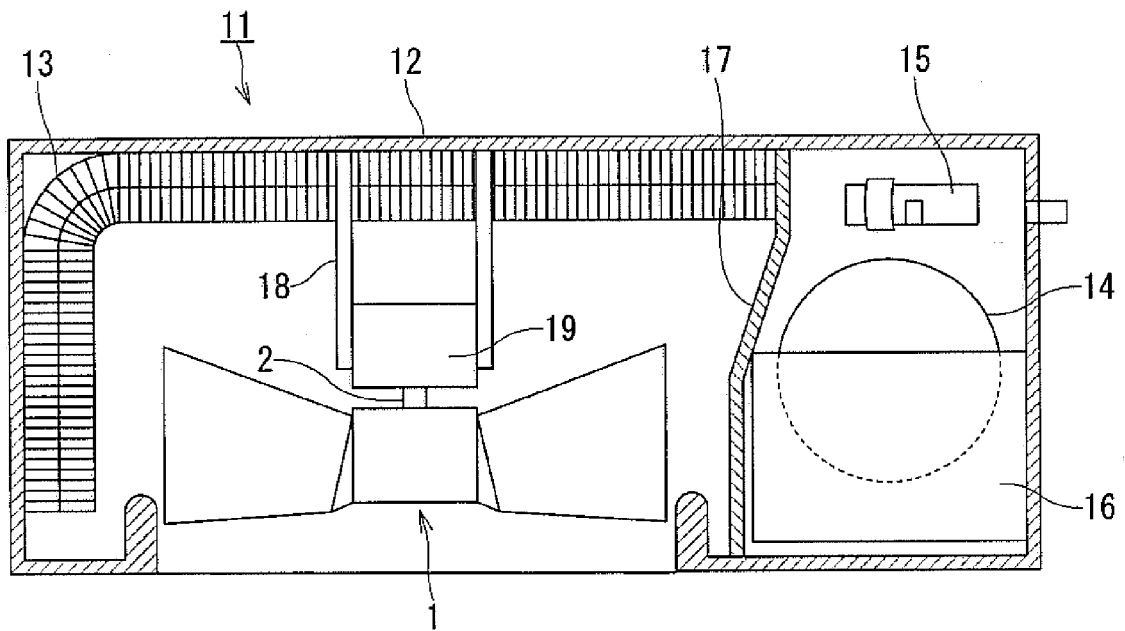


FIG. 6

**REFERENCES CITED IN THE DESCRIPTION**

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**Patent documents cited in the description**

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