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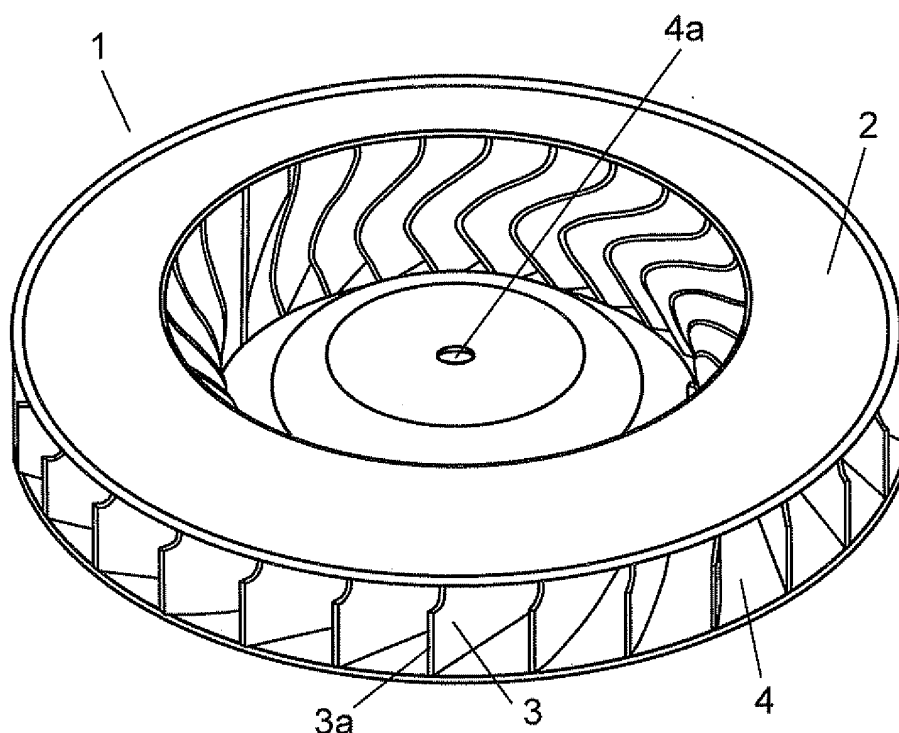
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(54) **Blowing fan and blower using the same**

(57) A blowing fan includes a hub to which a rotary shaft of a motor is rigidly mounted, a shroud confronting the hub, and multiple blades placed between the hub and the shroud. A space is formed between a trailing edge of each one of the blades and the shroud. Flowing of air

through this space allows reducing an air-speed at the outer most periphery of the blowing fan while the performance of the fan can be maintained. As a result, BPF (Blade Passing Frequency) noises can be lowered. On top of that, this simple construction allows manufacturing the blowing fan at a lower cost.

FIG. 1



Description

FIELD OF THE INVENTION

[0001] The present invention relates to a blowing fan for blowing air in a centrifugal direction, and it also relates to a blower using the same blowing fan.

BACKGROUND OF THE INVENTION

[0002] A blowing fan that blows air in a centrifugal direction is disclosed in, e.g. Unexamined Japanese Patent Application Publication No. 2007 - 170331 (Patent Literature 1), is described hereinafter. This fan is called a centrifugal fan. Fig. 12 shows a perspective view of the conventional centrifugal fan disclosed in Patent Literature 1. Fig. 13 shows a partial top view of the conventional centrifugal fan. In Figs. 12 and 13, arrow marks "R" indicate the rotating direction of the centrifugal fan.

[0003] Centrifugal fan 20 shown in Fig. 12 includes hub-plate 21, annular shroud 22 confronting hub-plate 21, multiple blades 23 placed between hub-plate 21 and shroud 22. Hub-plate 21 is formed of circular outer section 21a and center hole 21b to which a rotary shaft of a motor (not shown) is rigidly mounted. Shroud 22 is formed of circular outer section 22a and center opening 22b. Each one of blades 23 has a three-dimensional shape, and its leading edge 24 formed at an inside end of blade 23 is directed closer to the rotating direction than its trailing edge 25 formed at an outside end of blade 23.

[0004] Centrifugal fan 20 is driven by the motor, and the spin of fan 20 allows sucking air from opening 22b of shroud 22. The sucked air is guided along blade 23 from leading edge 24 to trailing edge 25, and then the air is blown off outside fan 20.

[0005] Fig. 13 shows a top view of a part of centrifugal fan 20 viewed from shroud 22. The rotation center is marked with "C". Trailing edge 25 of blade 23 is formed of hub-side trailing edge 25a and shroud-side trailing edge 25b. Edge 25a is directed closer to the rotating direction than edge 25b. In other words, trailing edge 25 slants relative to the rotary shaft. Fan 20 sucks air from opening 22b of shroud 22 and changes an airflow direction approx. at a right angle, and blows off the air to the outside. If blade 23 forms other shapes than the foregoing three-dimensional shape, the air running through fan 20 chiefly runs closer along hub plate 21. However, the foregoing shape of blade 23, i.e. hub-side trailing edge 25a is directed closer to the rotating direction than shroud-side trailing edge 25b, allows guiding the sucked air from hub plate 21 toward shroud 22 while the air travels from leading edge 24 to trailing edge 25. The foregoing shape of blade 23 thus allows air-speed distribution at trailing edge 25 to be uniformed, where trailing edge 25 works as a blow-off section of fan 20.

[0006] Leading edge 24 of blade 23 is formed of hub-side leading edge 24a and shroud-side leading edge 24b. As shown in Fig. 13, entrance angle "Bh" at hub-side

leading edge 24a is greater than entrance angle "Bs" at shroud-side leading edge 24b. In other words, the entrance angle of blade 23 tapers from hub plate 21. to shroud 22. An exit angle of trailing edge 25 of blade 23 gradually varies from hub plate 21 to shroud 22. To be more specific, blade 23 of conventional centrifugal fan 20 has a three-dimensional shape where the entrance angle and the exit angle gradually vary from hub plate 21 to shroud 22, and the thickness of blade 23 also gradually varies. This structure allows the air-speed distribution of the blown-off air to be uniformed, so that fan 20 can reduce its noises with the performance maintained.

[0007] Blade 23 of fan 20 is regularly made of sheet metal, so that blade 23 is thin. It is thus difficult to form the thin blade into the foregoing three-dimensional shape. The gradual variation in thickness among others is the most difficult work. To achieve the foregoing three-dimensional shape, use of two sheets of metal will increase the cost and make it difficult to keep balance during the rotation of the fan. If blade 23 is made of resin instead of sheet metal, the three-dimensional shape can be actually achieved; however, it increases the manufacturing cost. In order to obtain the uniform air-speed distribution, use of the blade in three-dimensional shape will thus increase the manufacturing cost, although the uniform air-speed distribution results in lower noises while the performance of centrifugal fan 20 can be maintained.

SUMMARY OF INVENTION

[0008] The present invention aims to provide an inexpensive blowing fan that can achieve uniform air-speed distribution, which results in lower noises while the performance of the blowing fan can be maintained.

[0009] The blowing fan of the present invention comprises the following structural elements:

- a hub to which a rotary shaft of a motor is rigidly mounted;
- a shroud confronting the hub; and
- multiple blades placed between the hub and the shroud.

A space is formed between a trailing edge of each one of the blades and the shroud. Air can travel through this space, so that an air speed at the outer most periphery of the fan can be reduced, and blade passing frequency noises (BPF noises) thus can be lowered. The foregoing simple structure allows manufacturing the blowing fan inexpensively.

BRIEF DESCRIPTION OF DRAWINGS

[0010]

Fig. 1 shows a perspective view of a blowing fan in accordance with an embodiment of the present in-

vention.

Fig. 2 shows a top view of the blowing fan shown in Fig. 1.

Fig. 3 shows a sectional view of the blowing fan shown in Fig. 1.

Fig. 4 shows a sectional view of another blowing fan in accordance with the embodiment of the present invention.

Fig. 5 shows a sectional view of still another blowing fan in accordance with the embodiment of the present invention.

Fig. 6A shows a top view of a blower employing the blowing fan in accordance with the embodiment.

Fig. 6B shows a sectional view cut along line 6B - 6B in Fig. 6A.

Fig. 7A schematically illustrates airflow in a fan casing at a shroud side.

Fig. 7B schematically illustrates airflow in the fan casing at a hub side.

Fig. 8 illustrates noise characteristics of a blowing fan in which no space is formed between a tailing edge of blade and a shroud.

Fig. 9 illustrates noise characteristics of a blowing fan with a second structure.

Fig. 10 illustrates noise characteristics of a blowing fan with a first structure.

Fig. 11 illustrates noise characteristics of a blowing fan with a third structure.

Fig. 12 shows a perspective view of a conventional centrifugal fan.

Fig. 13 shows a partial top view of the conventional centrifugal fan.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENT

Exemplary Embodiment

[0011] Fig. 1 shows a perspective view of a blowing fan in accordance with the embodiment of the present invention. Fig. 2 shows a top view of the blowing fan with a shroud removed. Fig. 3 shows a sectional view of the blowing fan. Fig. 4 shows a sectional view of another blowing fan in accordance with the embodiment of the present invention. Fig. 5 shows a sectional view of still another blowing fan in accordance with the embodiment of the present invention. In Figs. 3-5, the shroud is mounted to the blowing fan, and the placement of the blades is schematically illustrated. Figs. 3 - 5 show sectional views of the blowing fan including its rotary shaft. Fig. 6A shows a top view of a blower employing the blowing fan in accordance with the embodiment. Fig. 6B shows a sectional view cut along line 6B - 6B in Fig. 6A.

[0012] The blower shown in Figs. 6A and 6B is demonstrated hereinafter. Blower 50 includes blowing fan 1 and motor 6, which drives blowing fan 1, in an air duct formed by fan-casing 5 shaped like the shell of a snail. Motor 6 drives blowing fan 1, then air is sucked through

sucking port 8 of casing 5 before the air is blown off from blow-off port 9. Blower 50 of this kind can be mounted in, e.g. an air-circulation duct of a washing dryer or a clothes dryer, thereby blowing the air for drying wet clothes. A heater or a dehumidifier can be mounted in the air-circulation duct when necessary.

[0013] As shown in Fig. 1 and Fig. 2, blowing fan 1 includes hub 4, shroud 2 confronting hub 4, and multiple blades 3 placed between hub 4 and shroud 2. Hub 4 is shaped like a disc, and its center section is bowed toward shroud 2. Shroud 2 forms an annular shape having an opening at its center.

[0014] Hub 4 has hole 4a at its center, and as shown in Fig. 6B, rotary shaft 6a of motor 6 is rigidly mounted into hole 4a with screws 7. Rotation of motor 6 counter-clockwise prompts hub 4, shroud 2, and blades 3 to rotate counter-clockwise in unison, so that the air is sucked from sucking port 8 of casing 5 into the opening of shroud 2. The rotation of blades 3 allows blowing the sucked air in a radial direction toward tailing edges 3a of blades 3, and the air is then blown off from blow-off port 9.

[0015] As shown in Fig. 3, tailing edge 3a of each one of blades 3 is provided with notch 30 at a place closer to shroud 2, so that space 11a is formed between blade 3 and shroud 2. This structure is referred to as a first structure hereinafter. When blowing fan 1 rotates, air flows into space 11a, whereby an air speed around tongue 10 (refer to Fig. 6A), where the air flows at the fastest speed, can be lowered. Tongue 10 is defined as a space having the narrowest width between casing 5 and fan 1. As a result, an air-speed distribution in fan casing 5 can be uniformed.

[0016] Space 11a formed by notch 30 can be obtained with ease at a low cost when blade 3 is made of sheet metal. Space 11a allows lowering the maximum air speed in fan-casing 5, so that the BPF noises can be reduced. Space 11a is formed at a place where blade-function is least expected, so that the formation of space 11a little affects the blowing performance of blowing fan 1. As a result, the performance of blower 50 can be maintained while its noises can be reduced. In a case where blades 3 are made of resin, the presence of space 11a formed by notch 30 allows eliminating an undercut shape, namely, blowing fan 1 can be manufactured at a lower cost.

[0017] Another structure where a space is formed between blade 3 and shroud 2 is demonstrated hereinafter. This structure is referred to as a second structure. As shown in Fig. 4, the rim of shroud 2 is flared such that an exit of the air expands relative to slope 2b of shroud 2, thereby forming rim 2a and space 11b. This structure allows the air to flow into space 11b formed between blade 3 and shroud 2, so that an advantage similar to the previous case, where notch 30 forms space 11a, can be obtained.

[0018] Still another structure where a space is formed between blade 3 and shroud 2 is demonstrated hereinafter. This structure is referred to as a third structure. As shown in Fig. 5, tailing edge 3a of blade 3 is provided

with notch 30 at a place closer to shroud 2, and the rim of shroud 2 is flared such that an exit of the air expands relative to slope 2b of shroud 2, thereby forming rim 2a and space 11c. In other words, the third structure combines the first and the second structures. This structure can obtain a greater advantage than the first or the second structure. The third structure particularly effects a greater reduction in the noises. This particular point is detailed later.

[0019] Operation of blowing fan 1 discussed above and blower 50 employing fan 1 is demonstrated hereinafter. The air flowing into the opening of shroud 2 flows between each one of blades 3, and the air then changes its direction approx. at right angle. Between shroud 2 and hub 4, the air flowing closer to hub 4 changes the direction at a smaller curvature, so that the air flows smooth like a curve and incurs a little reduction in the air speed as well as a relatively little loss in the air duct. This smooth flow of the air as discussed above invites little breakaway phenomenon of air on blade 3.

[0020] The air flowing closer to shroud 2, to the contrary, changes the direction at a greater curvature, so that the flow of air is curved sharply and incurs a great reduction in the air speed as well as a greater loss in the air duct. The air flow thus invites disturbance, so that breakaway phenomenon of air on the upper side of blade 3 occurs, and the air spirals at some sections. As a result, noises tend to be generated.

[0021] The cause of the noises discussed above is this: A greater reduction in air-speed will reduce an air-speed vector directing outside, so that the air is attracted along the rotating direction of blowing fan 1. The air thus resists being blown off from fan 1. The air-speed along the outer periphery of fan 1 pulsates depending on the position of blades 3, and the pulsation generates pressure waves, thereby producing the BPF noises.

[0022] In blowing fan 1 in accordance with the embodiment, the air flowing closer to shroud 2 has a smaller air-speed vector directing outside. To make use of this feature of fan 1, a space is formed between tailing edge 3a of blade 3 and shroud 2 for the air to flow through this space, so that the air-speed along the outer periphery of fan 1 can be reduced with the aid of this feature.

[0023] The sizes of spaces 11a, 11b, and 11c are defined this way: not greater than 10% relative to the chord of blade direction (vertical direction in Fig. 3), and not greater than 50% relative to the thrust direction (lateral direction in Fig. 3). If the sizes of spaces 11a, 11b, and 11c are greater than the foregoing limits, the spaces in fact can produce the advantage in the BPF noise; however, the performance of blowing fan 1 may be lowered. To maintain the performance of fan 1 with the spaces greater than the limits, the rpm of blowing fan 1 should increase, which obliges blowing fan 1 to work at lower efficiency.

[0024] Fig. 7A schematically illustrates flows of air in fan casing 5 at shroud 2 side. Fig. 7B schematically illustrates flows of air in fan casing 5 at hub 4 side. Blowing

fan 1 showed in Figs. 7A and 7B employs the third structure discussed above, and the size of space 11c is 5% relative to blade's chord direction and 25% relative to the thrust direction. Other specifications of this fan are this: fan's diameter = 155 mm, rpm = 5800, peripheral velocity at the outer most periphery = approx. 47 m/sec.

[0025] As discussed previously, the air-speed vector of the air flowing toward the outer periphery is smaller at shroud 2 side than at hub 4 side, so that the air at shroud 2 side flows along the circular direction as indicated by arrow marks "A". When the airflow has a greater component flowing along the circular direction, the BPF noises are produced.

[0026] In a case where no space 11c is formed, the blowing fan obtains the maximum air-speed of 47 m/sec, however, blowing fan 1 in accordance with this embodiment obtains the maximum air-speed of 44 m/sec. Since a sound pressure of pressure pulsation sound is proportionate to airflow speed to the sixth power - airflow speed to the eighth power, the reduction in the max. air-speed from 47 m/sec to 44 m/sec thus effects a great advantage in noise reduction.

[0027] Noise characteristics of blowing fan 1 in accordance with this embodiment are described hereinafter with reference to Figs. 8 - 11. Fig. 9 illustrates noise characteristics of the blowing fan with the second structure. Fig. 10 illustrates noise characteristics of the blowing fan with the first structure. Fig. 11 illustrates noise characteristics of the blowing fan with the third structure. Fig. 8 is drawn for a comparison purpose and it illustrates noise characteristics of the blowing fan having no space between the blade and the shroud. Each blowing fan shown in Fig. 8 - Fig. 11 has 28 blades, 5400 rpm. The equation of $28 \times 5400 \div 60 = 2520$ (Hz) tells that the BPF noises exist at the frequency of 2520 Hz.

[0028] The blowing fan shown in Fig. 8, i.e. the fan has no notch 30, spaces 11a, 11b, 11c or rim 2a, incurs noises at 2520 Hz, i.e. BPF, with 28 dB as shown in a circle in Fig. 8. On the other hand, blowing fan 1 shown in Fig. 9, i.e. fan 1 with the second structure where rim 2a is formed on shroud 2 and space 11b is formed at blade 3, incurs noises at 2520 Hz (BPF) with 26 dB as shown in a circle shown in Fig. 9. The noises are thus reduced by 2 dB. Another fan 1, shown in Fig. 10 with the first structure where notch 30 is formed at blade 3 for forming space 11a, incurs noises at 2520 Hz with 23 dB as shown in a circle. The noises are thus reduced by 5 dB. Still another fan 1, shown in Fig. 11 with the third structure where notch 30 and rim 2a are formed for forming space 11c, incurs noises at 2520 Hz with 20 dB as shown in a circle. The noises are thus reduced by 8 dB. As discussed above, presence of space 11a, 11b or 11c formed between tailing edge 3a of blade 3 and shroud 2 allows lowering the noises.

Claims

1. A blowing fan comprising:
 - a hub to which a rotary shaft of a motor is rigidly mounted; 5
 - a shroud confronting the hub; and
 - a plurality of blades disposed between the hub and the shroud,
 - wherein a space is formed between a tailing edge of each one of the blades and the shroud. 10
2. The blowing fan of claim 1, wherein the space is formed by providing the tailing edge of each one of the blades with a notch at a section closer to the shroud. 15
3. The blowing fan of claim 1, wherein the shroud has a slope and a rim which flares relative to the slope such that the rim expands an exit for air blown from each one of the blades, so that the space is formed. 20
4. The blowing fan of claim 1, wherein the tailing edge of each one of the blades is provided with a notch at a section closer to the shroud, and the shroud has a slope and a rim which flares relative to the slope such that the rim expands an exit for air blown from each one of the blades, so that the space is formed. 25
5. A blower employing the blowing fan as defined in any one of claims 1 - 4. 30

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FIG. 1

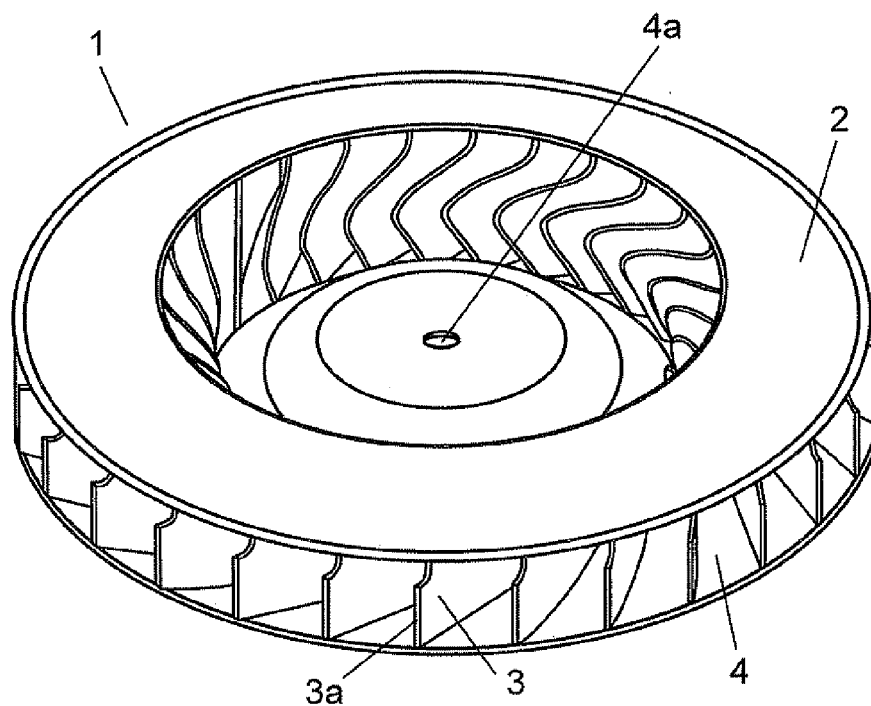


FIG. 2

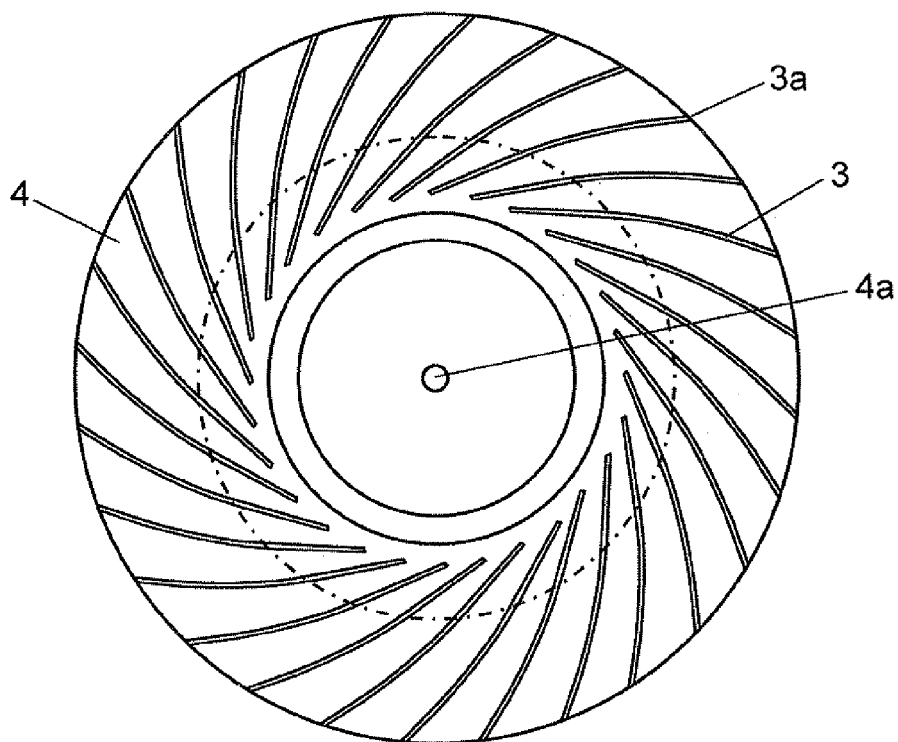


FIG. 3

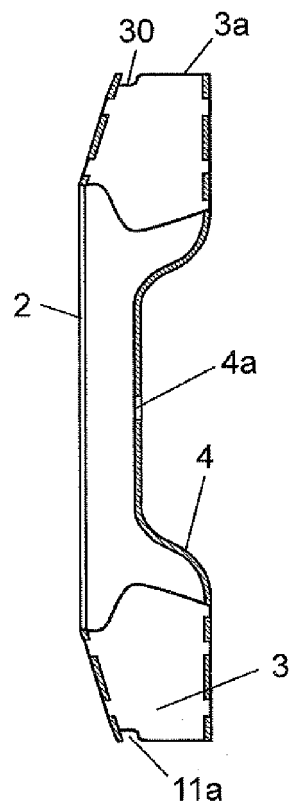


FIG. 4

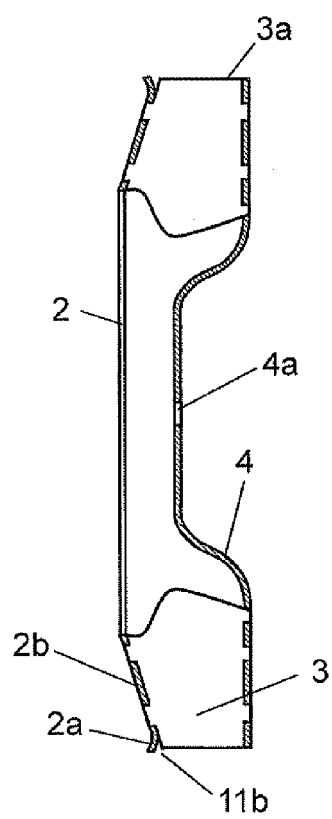


FIG. 5

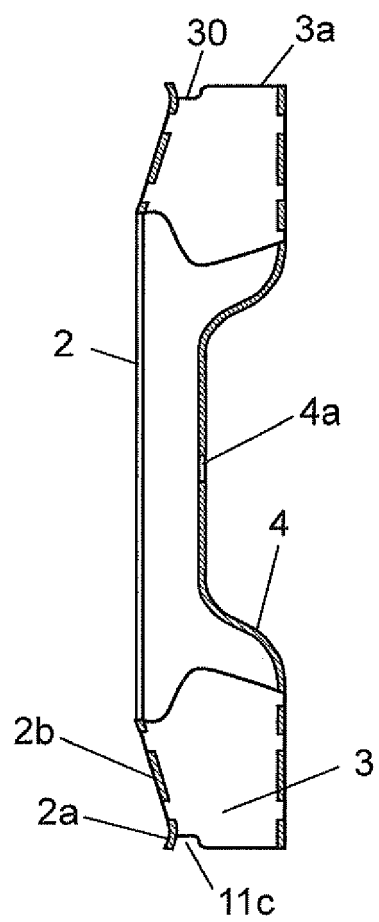


FIG. 6A

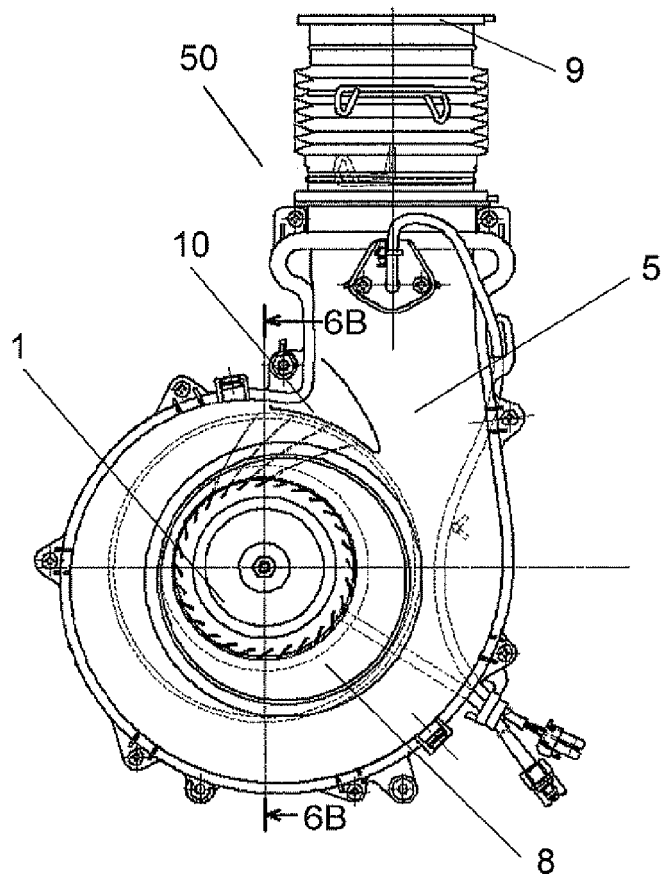


FIG. 6B

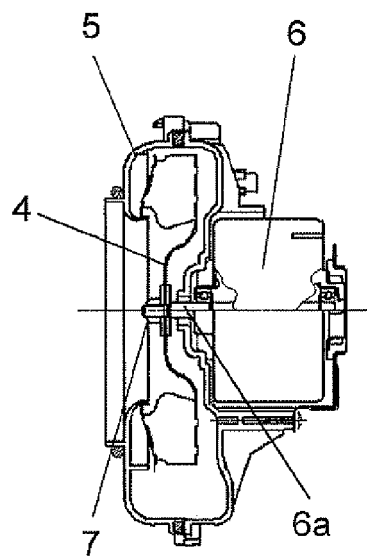


FIG. 7A

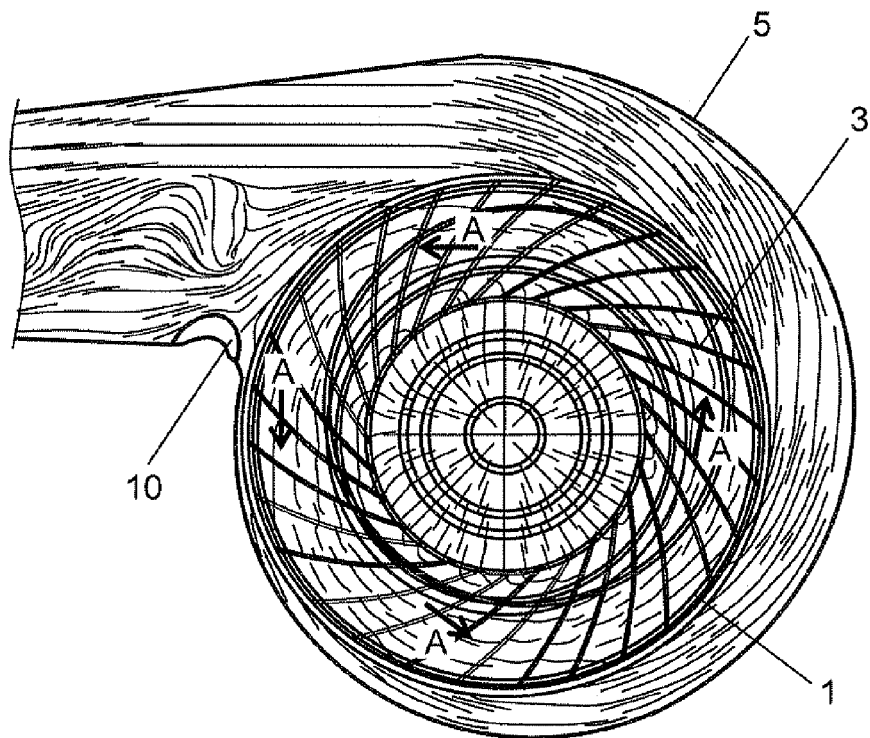


FIG. 7B

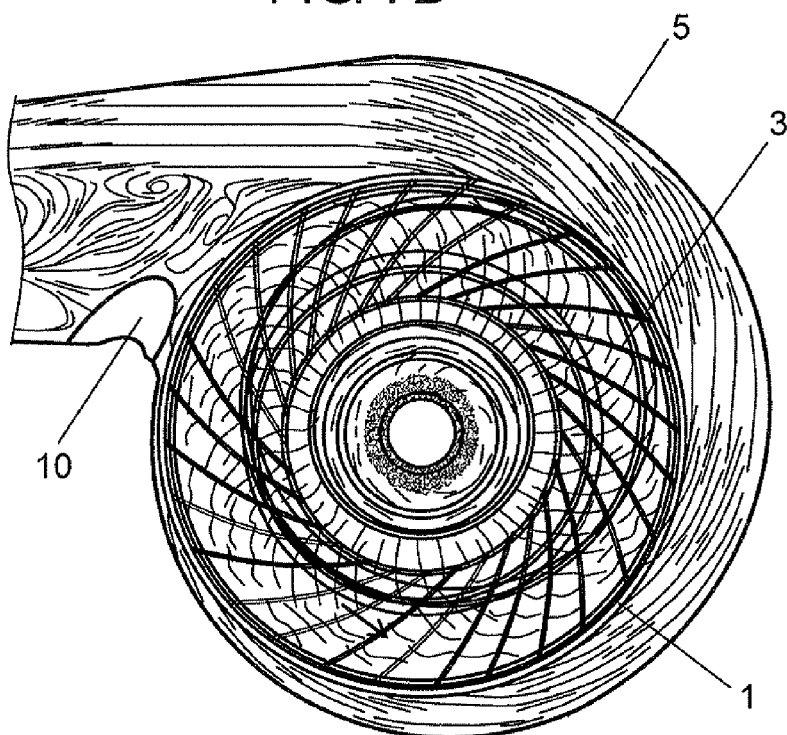


FIG. 8

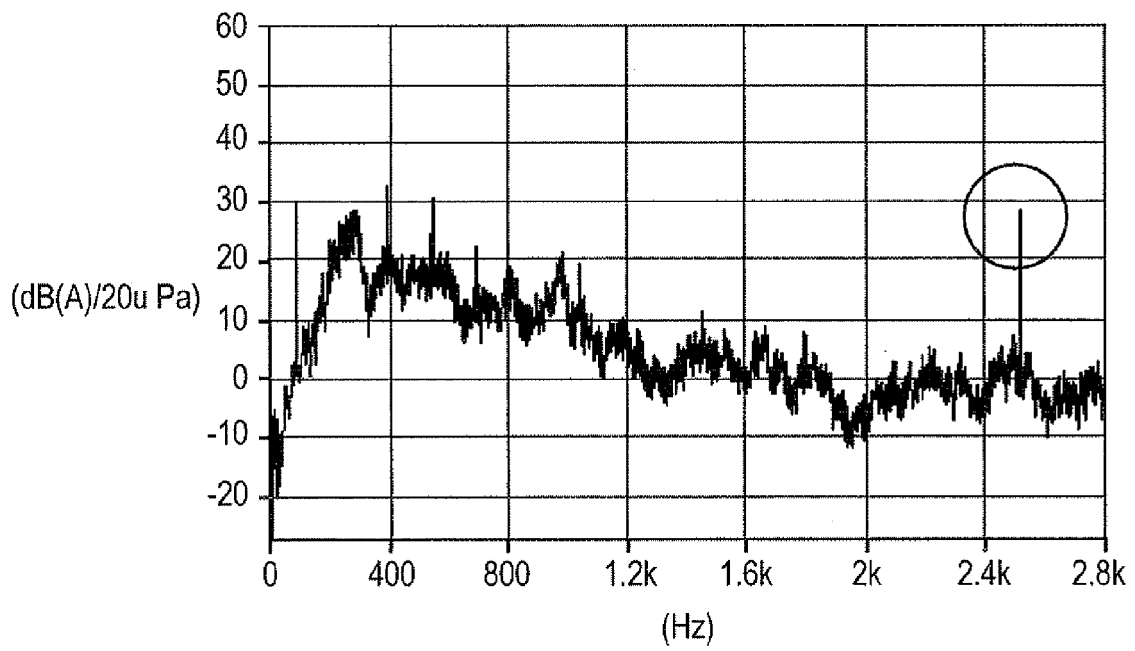


FIG. 9

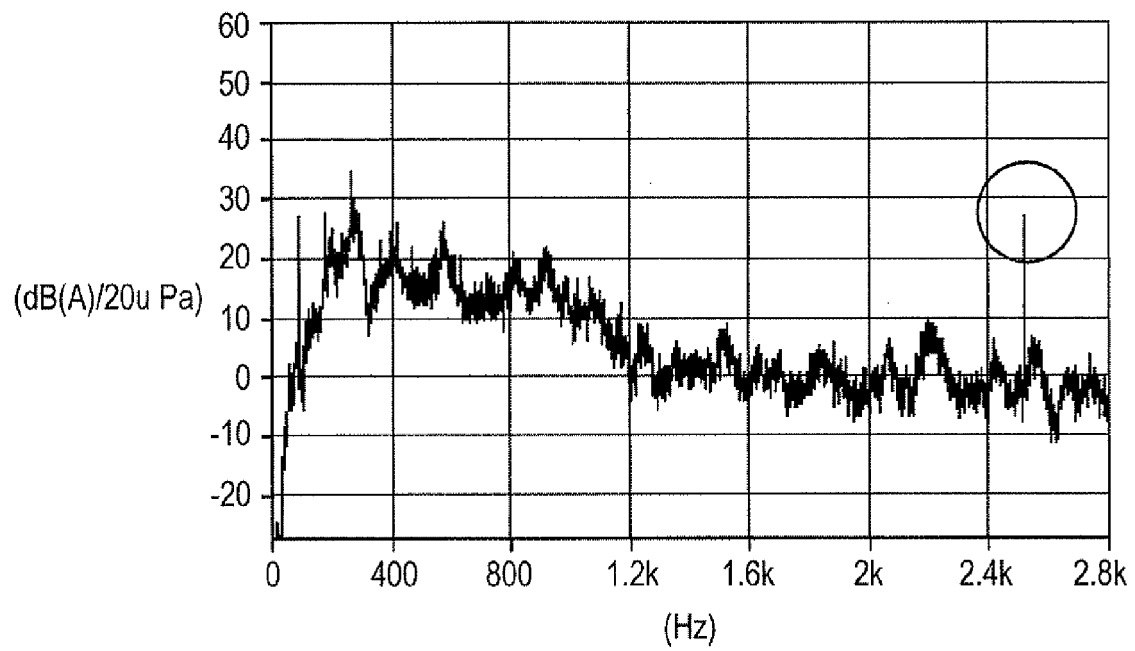


FIG. 10

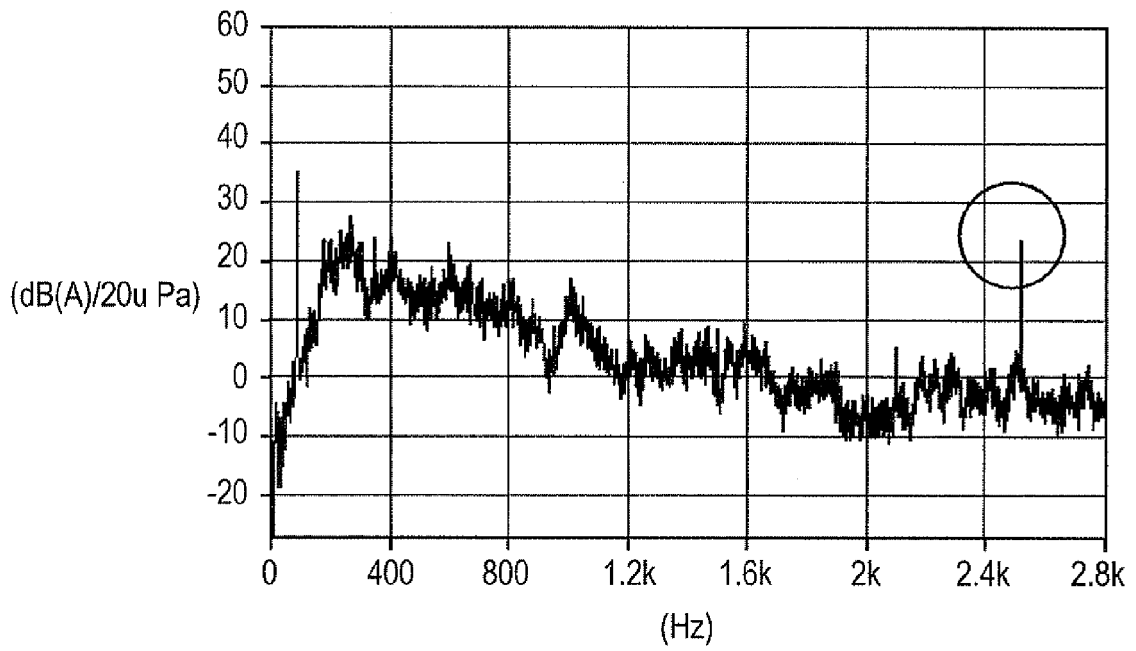


FIG. 11

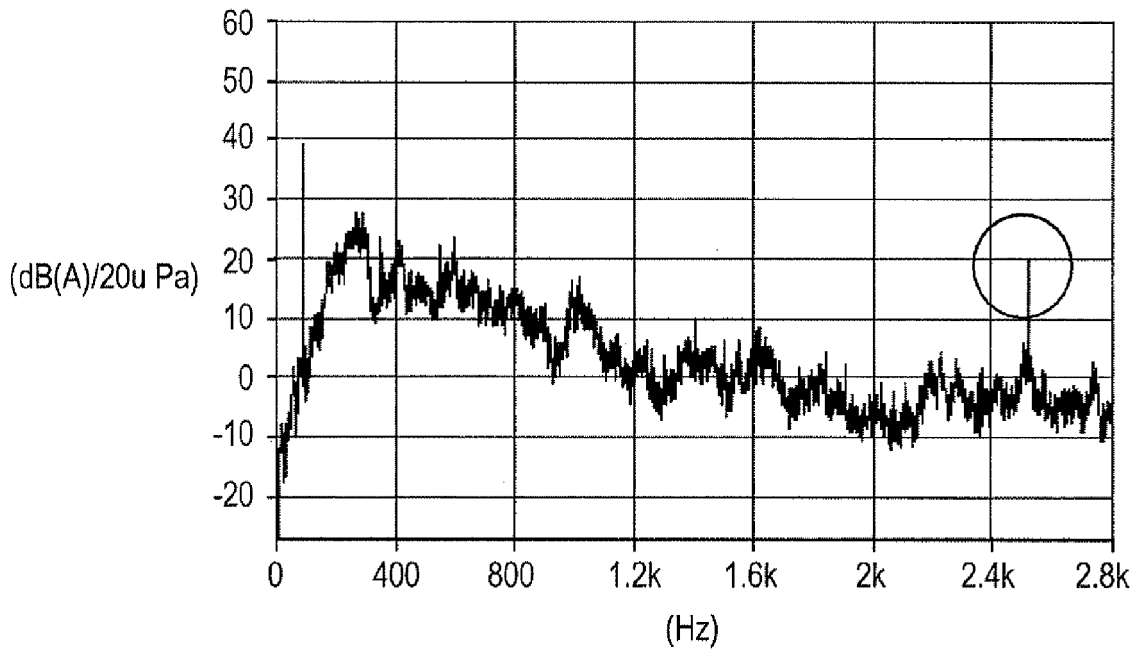


FIG. 12

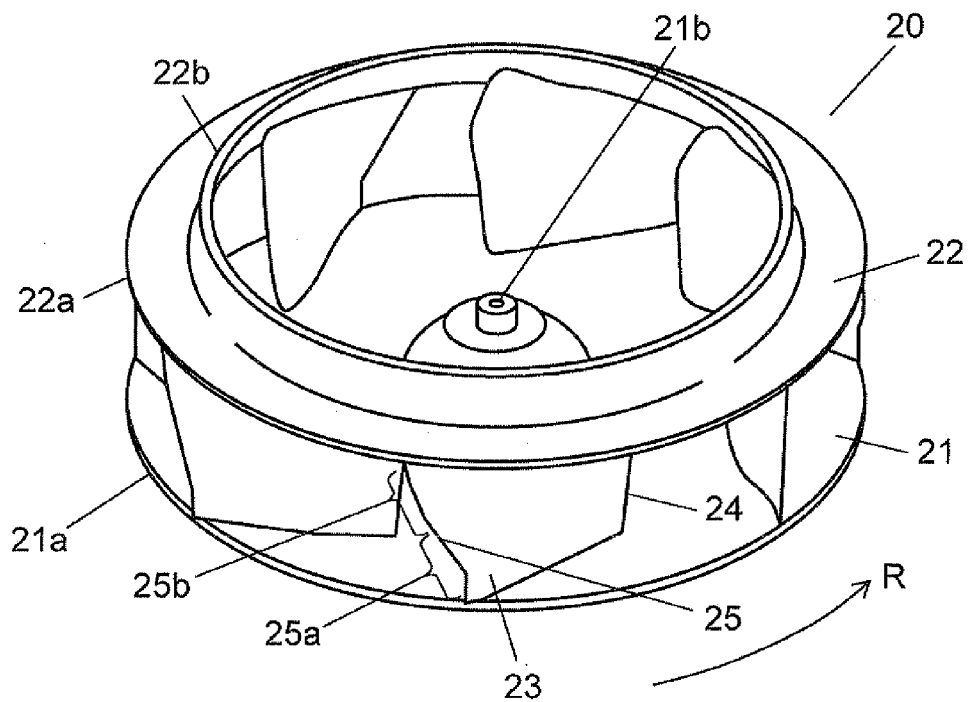
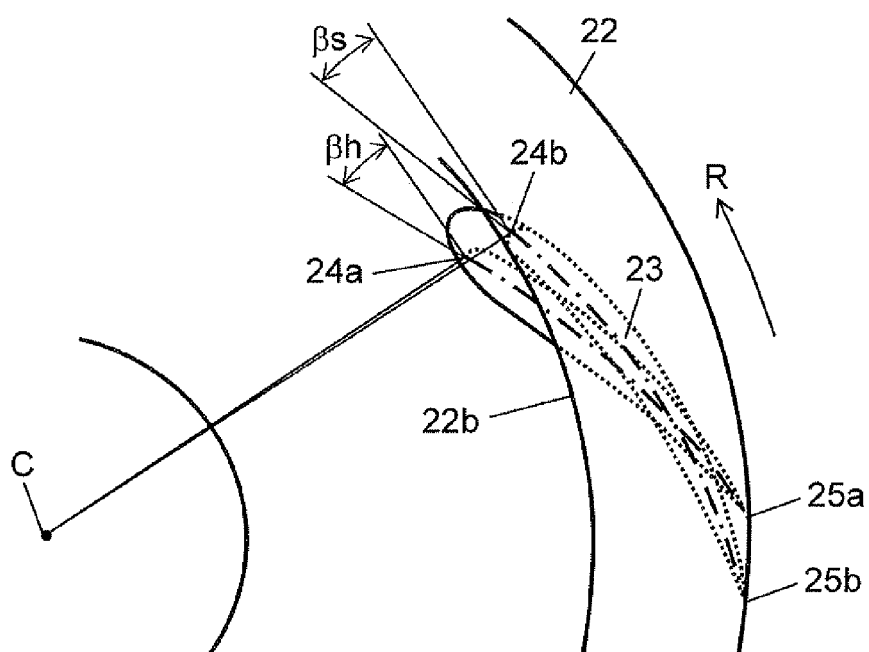


FIG. 13



REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

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