(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 0 955 469 B1

(12) **EUROPEAN PATENT SPECIFICATION**

(45) Date of publication and mention of the grant of the patent:
20.10.2004 Bulletin 2004/43

(51) Int Cl.[7]: **F04D 29/38**

(21) Application number: **99106357.9**

(22) Date of filing: **29.03.1999**

(54) **Impeller of fan**

Lüfterrad

Roue de ventilateur

(84) Designated Contracting States:
ES GR IT

(30) Priority: **14.04.1998 JP 10234498**

(43) Date of publication of application:
10.11.1999 Bulletin 1999/45

(73) Proprietor: **Matsushita Electric Industrial Co., Ltd.**
Kadoma-shi, Osaka 571-8501 (JP)

(72) Inventors:
- **Izumi, Yoshiki**
  Kyoto-shi, Kyoto, 607 (JP)
- **Sugio, Takashi**
  Kusatsu-shi, Shiga, 525 (JP)

(74) Representative: **Kügele, Bernhard et al**
Novagraaf SA
25, Avenue du Pailly
1220 Les Avanchets - Geneva (CH)

(56) References cited:
EP-A- 0 052 358
EP-A- 0 887 558
FR-A- 758 871
US-A- 3 416 725

Note: Within nine months from the publication of the mention of the grant of the European patent, any person may give notice to the European Patent Office of opposition to the European patent granted. Notice of opposition shall be filed in a written reasoned statement. It shall not be deemed to have been filed until the opposition fee has been paid. (Art. 99(1) European Patent Convention).

EP 0 955 469 B1

Description

Field of the Invention

[0001] The present invention relates to an impeller of a fan employed in air conditioners and the like, and more particularly to the shape of the impeller.

Background of the Invention

[0002] An air conditioner adjusts temperature and humidity of the air, and generally comprises an air-cooler, an air-heater, a humidifier, a fan and an air-filter.

[0003] Fig. 8 shows a conventional impeller of a mixed-flow-fan employed in the air conditioner. In the mixed-flow-fan, gas flows slantingly with regard to a rotary shaft.

[0004] In Fig. 8, impeller 21 of the mixed-flow-fan is equipped with a plurality of thin blades 22 radially mounted on hub 23 which substantially shapes as a taper stand.

[0005] Fig. 9 is a cross sectional view taken on line D-D of Fig. 8. The cross sectional view of blade 22 in the radial direction shows a substantial direct line or a curve bent toward only one direction. Impeller 21 is housed in the [same casing and driven by the rotary shaft fitted in hub 23 that is coupled to a motor. Impeller 21 is thus rotated by the motor, thereby blowing air.

[0006] However, the conventional construction discussed above cannot control blade-tip-vortex generated around outer edge portion of blade 22 on a satisfactory level during the blowing, because the cross sectional view of the blade 22 shapes as a substantial direct line or a curve bent toward only one direction.

[0007] Further, blades 22 are not equipped with any countermeasures against airflow drawn in radial direction, the airflow is generated when impeller 21 is driven by a high load.

[0008] It would thus be desirable to improve a conventional impeller as shown in Fig. 8 such as impeller 21 by requiring it to have less noise by controlling the blade-tip-vortex and to have a greater static pressure by smoothening the drawn airflow.

[0009] Reference may be made to EP-A-0 887 558 relative to which the present invention is characterised.

Summary of the Invention

[0010] The present invention addresses the problems discussed above and aims to provide a fan's impeller having less noise and greater static pressure.

[0011] The present invention thus has as object an impeller according to claim 1.

[0012] The impeller of the present invention draws a revolution locus at its leading edge. The both shapes of the locus and blade are the features of the present invention. The locus of upper half of the blade shows a valley and that of lower half of the blade shows a peak, with regard to windward. The upper half of the blade is defined as a portion between around the blade center and the outer end, while the lower half of the blade is defined as a portion between around the blade center and the hub. The cross section of the upper half of the blade in a radial direction shows a valley and that of the lower half shows a peak, with regard to windward.

[0013] The shapes discussed above allow the impeller to restrain airflow from breaking away off the blades. The blade-tip-vortex on a suction surface near the outer end of a blade is generated by the airflow that turns over from a pressure surface toward a suction surface. A valley-curved portion of the blade thus promotes the production of the vortex, thereby restraining the airflow from breaking away off the blade. As a result, the fan having less noise can be achieved. At the same time, a peak-curved portion of the blade smoothens the airflow drawn in the radial direction during high load operation, thereby increasing the static pressure.

Brief Description of the Drawings

[0014]

Fig. 1 is a plan view of an impeller of a fan in accordance with a first exemplary embodiment of the present invention.

Fig. 2 is a partial view of a revolution locus of a blade of the impeller of the fan in accordance with the first exemplary embodiment of the present invention.

Fig. 3 is a cross section taken on line A-A in Fig. 1.

Fig. 4 shows the impeller in an operation in accordance with the first exemplary embodiment of the present invention.

Fig. 5 is a characteristics-comparison-chart of the impeller in accordance with the first exemplary embodiment of the present invention and a conventional impeller.

Fig. 6 is a cross section of the blade viewed at a centerline of a passage in accordance with a second exemplary embodiment of the present invention.

Fig. 7 is a cross section of the blade of the impeller viewed in the radial direction and at the maximum thickness portion of the blade in accordance with the second exemplary embodiment of the present invention.

Fig. 8 is a plan view of a conventional impeller of a fan.

Fig. 9 is a cross section of the conventional impeller taken on line D-D of Fig. 8.

Detailed Description of the Invention

[0015] Exemplary embodiments of the present invention are described with reference to the accompanying drawings.

(Exemplary Embodiment 1)

[0016] The first exemplary embodiment of the present invention is described hereinafter with reference to Fig. 1 through Fig. 5.

[0017] Fig. 1 is a plan view of an impeller of a mixed flow fan. Fig. 4 shows the active impeller.

[0018] In Fig. 1, impeller 1 of mixed-flow-fan is mounted on hub 3 substantially shaping as a taper stand and has three thin blades 2 in the radial direction on the taper stand rim. An arrow mark indicates a rotational direction. As shown in Fig. 4, hub 3 mounted with blades 2 is fixed to a rotary shaft of motor 4, and impeller 1 is housed in casing 5. Impeller 1 blows air by driving motor 4 in a direction indicated by an arrow mark. At this time, as shown in Fig. 1, most of the airflow flows into leading edge 6 of blade 2 and flows out from trailing edge 7. Impeller 1 blows air in this manner.

[0019] Fig. 2 is a partial view of a revolution locus of blade 2 of impeller 1. In Fig. 2, the revolution locus drawn by leading edge 6 of blade 2 shows a valley in an upper half thereof and a peak in a lower half, with regard to windward. The upper half of the blade 2 is defined as a portion between around the blade center and the outer end 8 (hereinafter referred to as "tip 8"), while the lower half of the blade 2 is defined as a portion between around the blade center and the hub 3. Line B-B is drawn by connecting respective midpoints of leading edge 6 and trailing edge 7 of blade 2. Line B-B shows a center of passage through which the airflow flows in the direction indicated by the arrow mark. Line C-C shows a hub center i.e. a rotation center of impeller 1.

[0020] Fig. 3 is a cross section taken on line A-A in Fig. 1. As shown in Fig. 3, the cross section of blade 2 in radial direction shows a valley in an upper half of the blade and shows a peak in a lower half thereof, with regard to windward. The upper half of the cross sectional view of blade 2 is defined as a portion between around the line B-B and tip 8, while the lower half thereof is defined as a portion between around the line B-B and the hub 3. This structure allows tip 8 to produce airflow around tip 8 itself, and the airflow turns over from pressure surface 10 of blade 2 toward suction surface 9 thereof. The airflow produces blade-tip-vortex around tip 8 on suction side 9, and a valley-curved portion of blade 2 promotes the production so that the airflow is restrained from breaking away off the blade. As a result, impeller 1 having less noise can be achieved. At the same time, a peak-curved portion of blade 2 smoothens the airflow increasingly drawn in the radial direction during high load operation, i.e. the airflow flowed in from tip 8 side, thereby increasing the static pressure.

[0021] As such, the present invention can reduce noises, and increase static pressure during a high load operation of the impeller.

[0022] Specific advantages of the first exemplary embodiment are described hereinafter.

[0023] Fig. 5 is a characteristics-comparison-chart of the impeller of the present invention and a conventional impeller. The impeller of which blade measures 400 mm across is used in the experiment. Characteristics of static pressure and noise with regard to air volume are shown in the chart.

[0024] As this experiment tells, at an open air volume point Q1, the impeller of the present invention is less noisy by 2 dB than the conventional impeller. Further, the impeller of the present invention remains less noisy up to point Q2 where 68% of open-air volume is blown. Regarding the static pressure, the impeller of the present invention gains 32% increase compared with the conventional impeller at point Q3 where 60% of open-air volume is blown.

(Exemplary Embodiment 2)

[0025] The second exemplary embodiment of the present invention is described with reference to Fig. 6 and Fig. 7.

[0026] Fig. 6 is a cross section of the blade shown in Fig. 7 and taken on line B-B that is a centerline of a passage. Fig. 7 is a cross section of the blade of the impeller viewed in the radial direction and at the maximum thickness portion of the blade. As shown in Fig. 6, the impeller of the fan in accordance with the second exemplary embodiment has blades shaping as a wing.

[0027] Passage centerline B-B is drawn between the midpoints of the leading and trailing edges of blade 12 on a revolution locus. In this embodiment, blade 12 has the following measurements on its cross section taken on the passage center line B-B: $5\% \leq t/c \leq 12\%$,
where: t = maximum thickness of blade 12 taken on line B-B,
c = distance between the leading and trailing edges of blade 12, and the blade shapes as a wing having an arc front edge and a sharp rear edge.

[0028] Further in this embodiment, the cross sectional view of blade 12 in the radial direction shows a valley in the upper half and shows a peak in the lower half, with regard to windward. The upper half is defined as a portion between around the centerline B-B and tip 14, and the lower half is defined as a portion between around the centerline B-B and hub 13.

[0029] The structure discussed above allows a valley-curved portion of blade 12 to promote the production of blade-tip-vortex produced around tip 14 on the suction surface side by airflow taking over from pressure surface 16 toward suction surface 15 so that the airflow is restrained from breaking away off the blade 12. As a result, impeller 11 having less noise can be achieved.

[0030] At the same time, a peak-curved portion of blade 12 smoothens the airflow increasingly drawn in the radial direction during high load operation, i.e. the airflow flowed in from tip 14 side, thereby increasing the static pressure.

[0031] The second exemplary embodiment proves that less noise and greater static pressure are achieved

in impeller 11, as the first exemplary embodiment shows the same effects.

[0032] Compared with blades having a constant thickness, the blade of the second exemplary embodiment has the measurement such as 5% ≤ t/c ≤ 12%, where: t= maximum thickness, c= blade depth spanning between the mid- points of leading and trailing edges, and the blade shaping as a wing having an arc front edge and a sharp rear edge, so that the airflow is more securely prevented from breaking away off the blade. Accordingly, the noise level can be further lowered.

[0033] The following result is reported by the measurement of low noise effect on the impeller used in the second exemplary embodiment: Low noise effect is noticed starting from t/c = 5%, and is saturated at t/c=12%. In the case of the impeller measuring 400 mm across, employed in a mixed flow fan, when the blade shape of t/c =9% is used, the experiment shows that noise level is lowered by 2 dB comparing with the blade having a constant thickness.

[0034] Not limited to the impeller of the mixed flow fan, the technique of the present invention can also produce the same effect in an impeller of axial flow fan where gas flows along a rotary shaft within the impeller.

Claims

1. Impeller of a fan, said impeller including a hub (3) mounted with a plurality of blades (2), and arranged to spin the blades (2), thereby blowing air:

   wherein a cross-sectional view of the blade (2) in a radial direction shows a peak in a portion between a center portion of the blade and the hub (3) with regard to windward;

   characterized in that:

   said cross-sectional view of the blade (2) shows a valley in a portion between the center portion and the tip (8); and
   a revolution locus of a leading edge (6) of the blade (2) shows a valley in a portion between the tip (8) and the center portion of the blade (2), and shows a peak in a portion between the center portion and the hub (3), with regard to windward.

2. The impeller of a fan as defined in Claim 1 wherein the thickness of the blade (2) is constant.

3. The impeller of a fan as defined in Claim I wherein a cross sectional view of the blade (12) taken on a passage center running from the leading edge (6) to a trailing edge (7) is shaped to have a ratio of a maximum thickness at the passage center vs. a distance between the leading edge (6) and the trailing edge (7) ranging from 5% to 12% inclusive both the values.

4. The impeller of a fan as defined in Claim 1 whereinthe cross sectional view of the blade (12) taken on a passage centerline connecting the leading edge (6) and a trailing edge (7) of the blade (12) is shaped to be 5% ≤ t/c ≤ 12%, where: t = maximum thickness of the blade (12), and c = blade depth spanning between the midpoints of leading and trailing edges.

5. The impeller of a fan as defined in any one of the preceding claims, wherein said fan is a mixed flow fan.

Patentansprüche

1. Lüfterrad, wobei das Rad eine Nabe (3) umfasst, die mit einer Vielzahl von Schaufeln (2) montiert ist, und so angeordnet ist, dass die Schaufeln (2) gedreht werden, wodurch Luft geblasen wird:

   wobei eine Querschnittsansicht der Schaufel (2) in einer radialen Richtung einen Gipfel in einem Abschnitt zwischen einem mittleren Abschnitt der Schaufel und der Nabe (3) in Bezug auf die Windseite zeigt;

   dadurch gekennzeichnet, dass:

   die Querschnittsansicht der Schaufel (2) ein Tal in einem Abschnitt zwischen dem mittleren Abschnitt und der Spitze (8) zeigt; und
   eine Drehortskurve einer Vorderkante (6) der Schaufel (2) ein Tal in einem Abschnitt zwischen der Spitze (8) und dem mittleren Abschnitt der Schaufel (2) zeigt, und einen Gipfel in einem Abschnitt zwischen dem mittleren Abschnitt und der Nabe (3) in Bezug auf die Windseite zeigt.

2. Lüfterrad nach Anspruch 1, **dadurch gekennzeichnet, dass** die Dicke der Schaufel (2) konstant ist.

3. Lüfterrad nach Anspruch 1, **dadurch gekennzeichnet, dass** eine Querschnittsansicht der Schaufel (12), die auf einer Durchgangsmitte ermittelt wird, die von der Vorderkante (6) zu einer Hinterkante (7) verläuft, so geformt ist, dass sie ein Verhältnis einer maximalen Dicke an der Durchgangsmitte zu einem Abstand zwischen der Vorderkante (6) und der Hinterkante (7) aufweist, das im Bereich von 5 % bis 12 %, einschließlich beider Werte, liegt.

4. Lüfterrad nach Anspruch 1, **dadurch gekenn-**

zeichnet, dass die Querschnittsansicht der Schaufel (12), die auf einer Durchgangsmittellinie ermittelt wird, welche die Vorderkante (6) und eine Hinterkante (7) der Schaufel (12) verbindet, so geformt ist, dass 5 % ≤ t/c ≤ 12 % ist, wobei t = maximale Dicke der Schaufel (12), und c = Schaufeltiefe, die sich zwischen den Mittelpunkten von Vorder- und Hinterkante erstreckt.

5. Lüfterrad nach einem der vorhergehenden Ansprüche, **dadurch gekennzeichnet, dass** der Lüfter ein Diagonallüfter ist.

Revendications

1. Roue d'un ventilateur, ladite roue comprenant un moyeu (3) monté avec une pluralité d'ailettes (2), et agencée pour faire tourner les ailettes (2), en soufflant ainsi de l'air :

dans laquelle une vue en coupe transversale de l'ailette (2) dans une direction radiale représente un pic dans une partie entre une partie centrale de l'ailette et le moyeu (3) par rapport au côté au vent,

caractérisée en ce que :

ladite vue en coupe transversale de l'ailette (2) représente un creux dans une partie entre la partie centrale et l'extrémité (8), et
un lieu géométrique de rotation d'un bord d'attaque (6) de l'ailette (2) représente un creux dans une partie entre l'extrémité (8) et la partie centrale de l'ailette (2), et représente un creux dans une partie entre la partie centrale et le moyeu (3), par rapport au côté au vent.

2. Roue d'un ventilateur selon la revendication 1, dans laquelle l'épaisseur de l'ailette (2) est constante.

3. Roue d'un ventilateur selon la revendication 1, dans laquelle une vue en coupe transversale de l'ailette (12) prise sur un centre de passage allant du bord d'attaque (6) à un bord de fuite (7) est formée pour avoir un rapport d'une épaisseur maximum au niveau du centre de passage sur une distance entre le bord d'attaque (6) et le bord de fuite (7) allant de 5 % à 12 %, incluant les deux valeurs.

4. Roue d'un ventilateur selon la revendication 1, dans laquelle la vue en coupe transversale de l'ailette (12) prise sur un axe central de passage reliant le bord d'attaque (6) et le bord de fuite (7) de l'ailette (12) est formée pour être de 5 % ≤ t/c ≤ 12 %, où : t = l'épaisseur maximum de l'ailette (12) et c = l'écartement en profondeur de l'ailette entre les points centraux des bords d'attaque et de fuite.

5. Roue d'un ventilateur selon l'une quelconque des revendications précédentes, dans laquelle ledit ventilateur est un ventilateur hélico-centrifuge.

FIG. 1

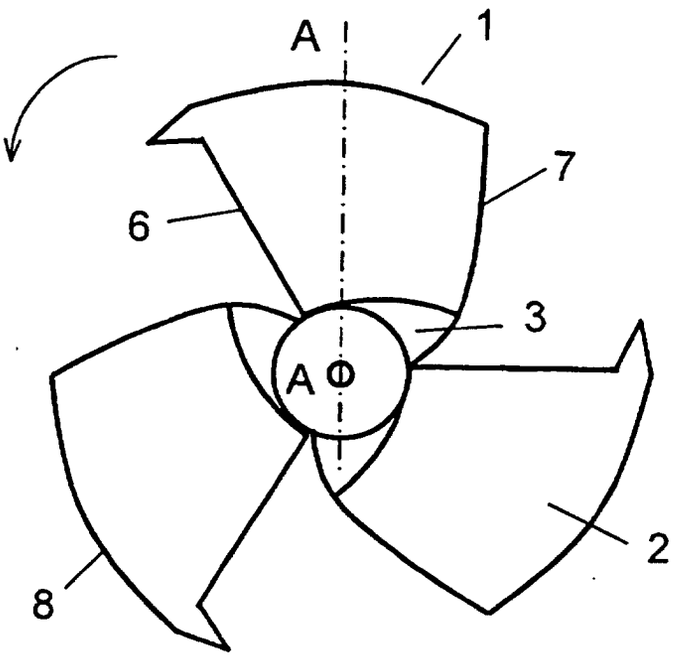


FIG. 2

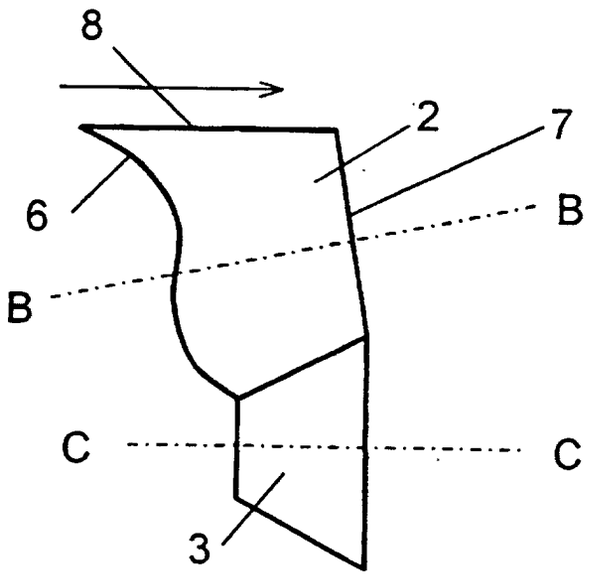


FIG. 3

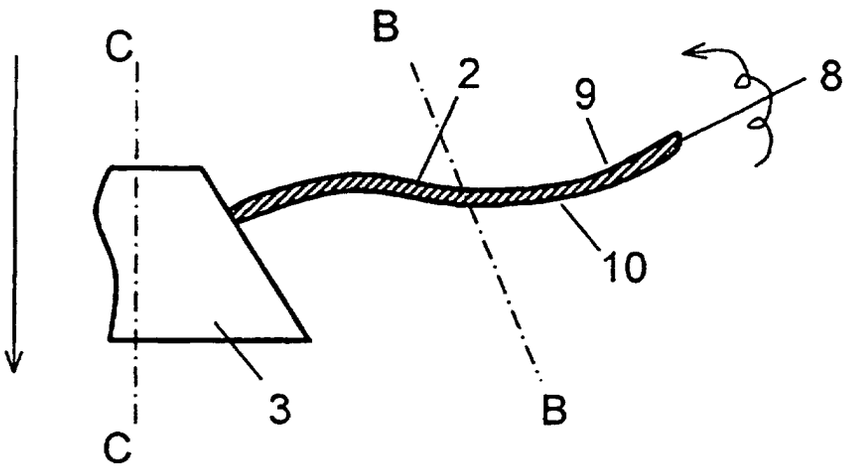


FIG. 4

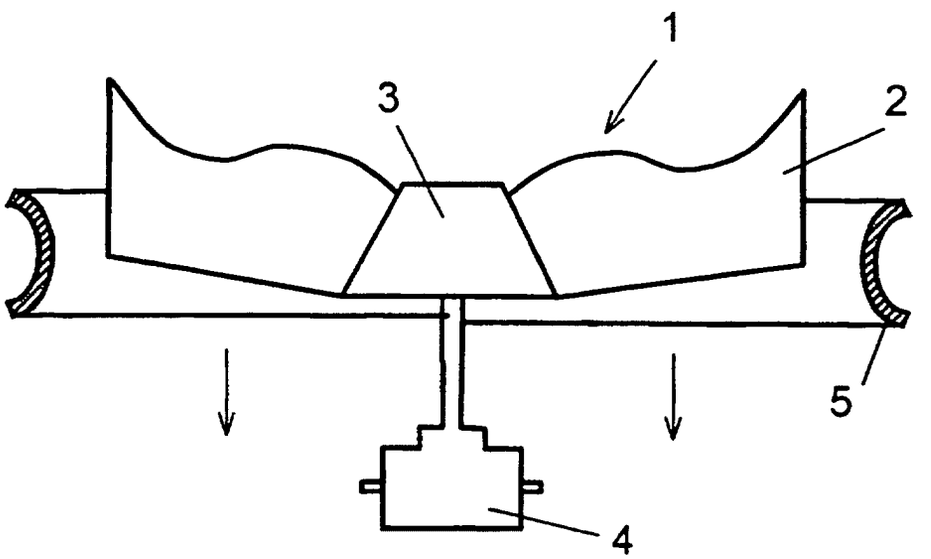


FIG. 5

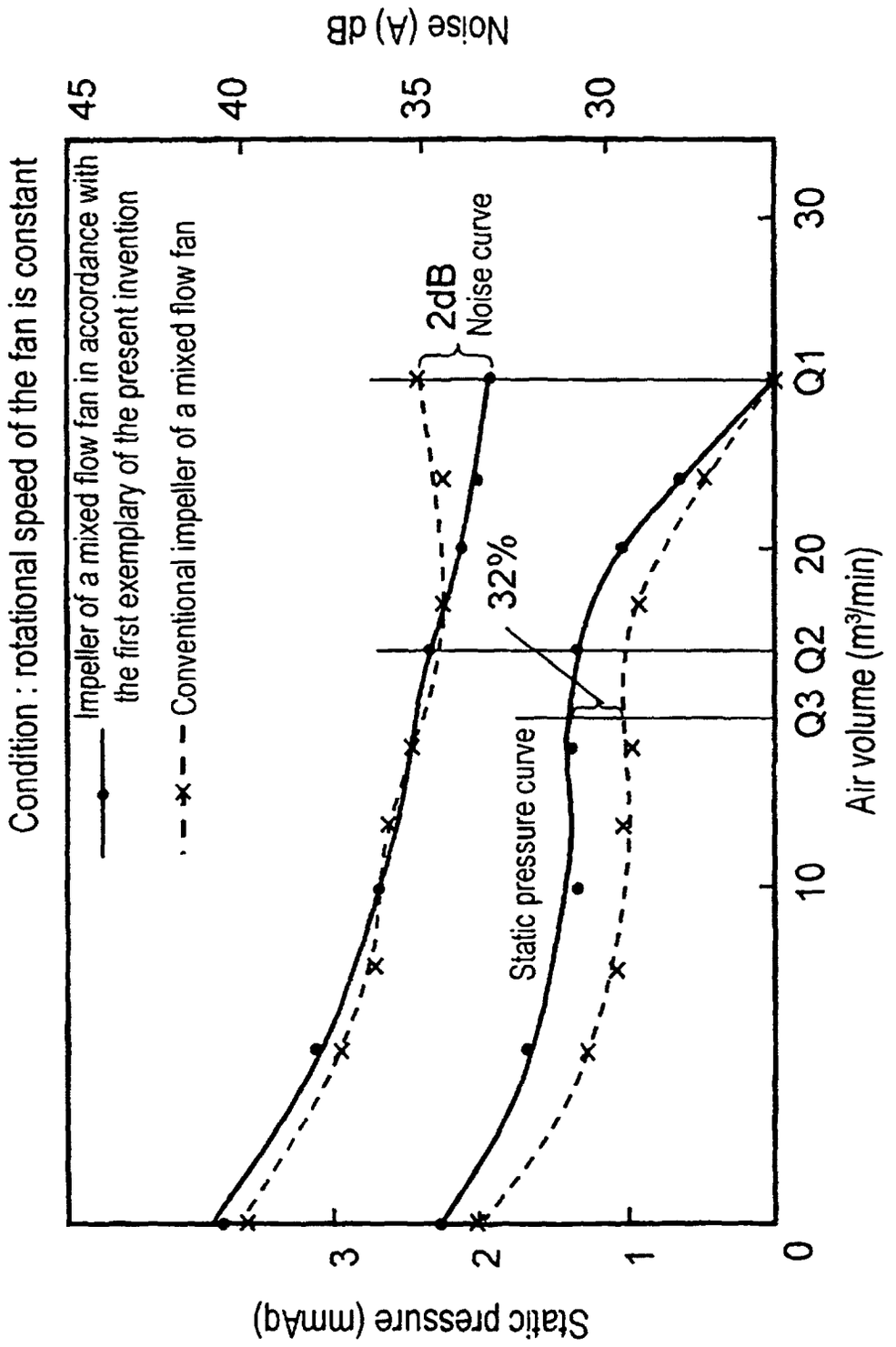

Condition : rotational speed of the fan is constant
Impeller of a mixed flow fan in accordance with the first exemplary of the present invention
Conventional impeller of a mixed flow fan
Static pressure (mmAq)
Noise (A) dB
Air volume (m³/min)
Static pressure curve
2dB
Noise curve
32%
Q1
Q2
Q3

FIG. 6

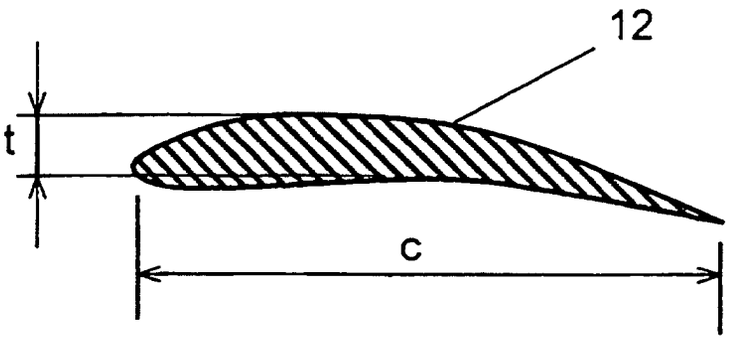


FIG. 7

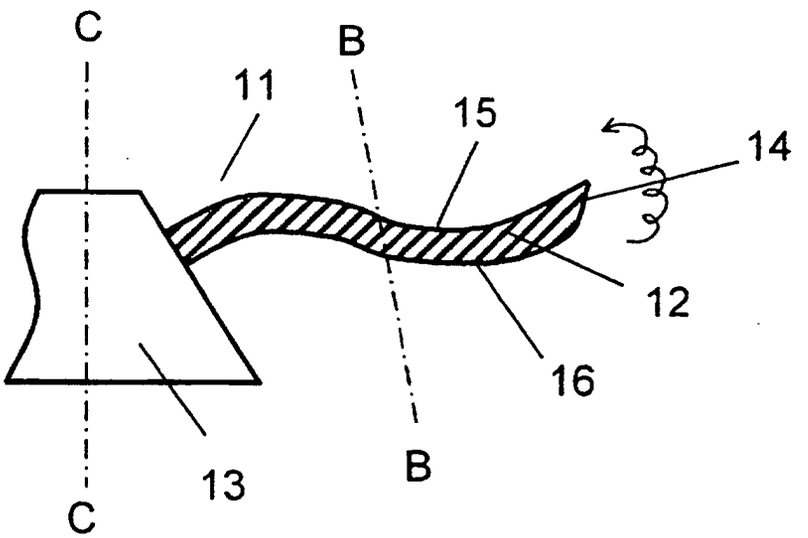


FIG. 8 PRIOR ART

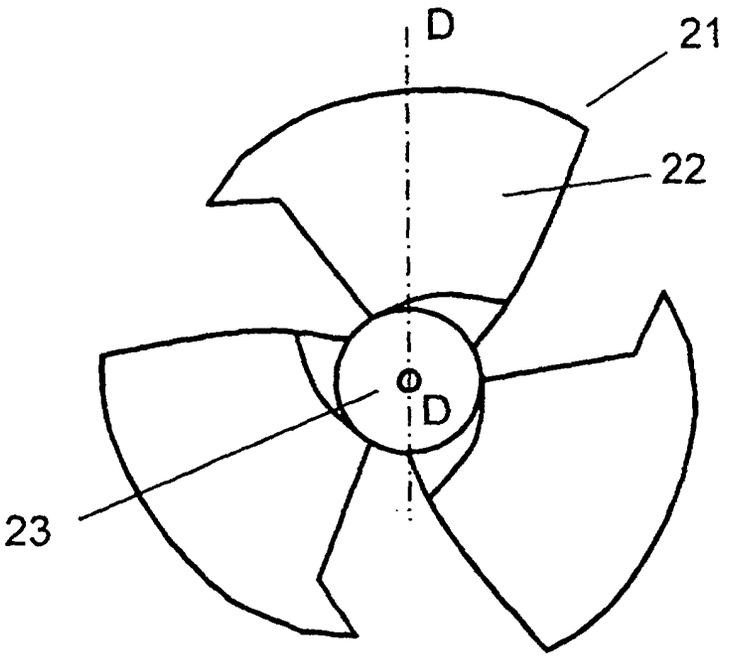


FIG. 9 PRIOR ART

