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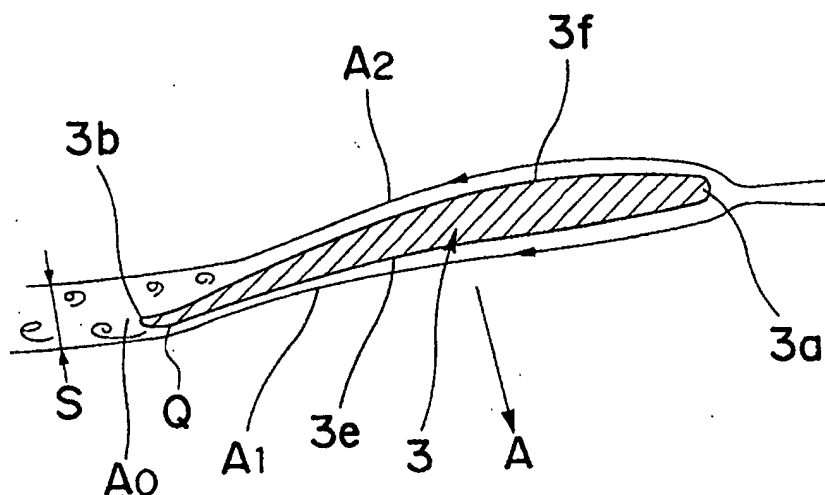
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(54) **BLOWER AND AIR CONDITIONER WITH THE BLOWER**

(57) In a blower having an impeller (1) formed by radially attaching a plurality of blades (3, 3, ...) to an outer periphery of a hub (2), a specific region (Q) that extends in a predetermined width along a trailing edge (3b) of each blade (3) in a wingspan direction is bent towards a negative pressure surface (3f) side of the blade. On the negative pressure surface (3f) side of the blade, air-

flow separation hardly occurs and turbulence of a rear stream (A_0) is suppressed. Meanwhile, on a pressure surface (3e) side of the blade, the airflow discharged rearwards from the trailing edge (3b) becomes smooth and less turbulent. The width of the rear stream (A_0) is reduced and the aerodynamic characteristics of the blades are improved.

Fig. 4



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Description

TECHNICAL FIELD

[0001] The present invention relates to a blower characterized in its blade structure and an air conditioner having the blower.

BACKGROUND ART

[0002] Fig. 17 shows a conventional common axial blower Z_0 . This axial blower Z_0 is constituted such that an impeller 21 formed by radially disposing a plurality of blades 23, 23, ... around the outer periphery of a hub 22 is driven to rotate by a motor 24, and that a bell mouth 25 is disposed in such a manner as to surround the impeller 21. Furthermore, each blade 23 of the impeller 21 is a swept-forward blade obtained by proceeding its leading edge 23a frontward in the rotation direction, and is also a thick blade wing having a cross section of a streamline shape that is attached to the hub 22 at a predetermined blade angle, as shown in Figs. 18 and 19.

[0003] Furthermore, as shown in Fig. 19, the blade 23 has a curved form with an appropriate "camber" or a curve in its chord direction. The concave side surface of the blade is a face, or pressure surface 23c, and its convex side surface is a suction surface, or negative pressure surface 23d. When the impeller 21 rotates, as shown in Fig. 20, an airflow that flows in from the leading edge 23a side of the blade 23 collides with the leading edge 23a, is divided to flow separately along the pressure surface 23c and along the negative pressure surface 23d, and then discharged from the trailing edge 23b side to the rear. At this time, the airflow is raised in pressure by a lift action at the pressure surface 23c and discharged or blown off toward a direction of arrow A.

[0004] Meanwhile, it is usual in the conventional axial blower Z_0 that the "camber" of the blade 23 is continuous from the leading edge 23a to the trailing edge 23b in one direction as shown in Fig. 19. This is based on a design idea emphasizing a static pressure characteristic of the blower that, since a lift action occurs due to this "camber" and the pressure of the airflow is raised, making the range of "camber" as large as possible is effective to obtain a higher static pressure.

[0005] However, when the "camber" of the blade 23 is continuous from the leading edge 23a to the trailing edge 23b as described above, a problem arises that the width of a rear stream A_0 discharged from the trailing edge 23b of the blade 23 rearwards is increased, and the aerodynamic characteristics of the blade 23 are deteriorated, thereby lowering the air discharge efficiency as described below.

[0006] That is, since the convex shape is continuous at the negative pressure surface 23d of the blade 23, and hence a boundary layer is gradually developed on the negative pressure surface 23d from the leading edge 23a towards the trailing edge 23b. Thus, of the air-

flows flowing on the negative pressure surface 23d side, an airflow A_2 that proceeds along the negative pressure surface 23d is separated off the blade in the vicinity of the trailing edge 23b. As a result, the rear stream A_0 discharged to the rear side of the trailing edge 23b becomes an unstable and turbulent flow. Meanwhile, regarding the pressure surface 23c side of the blade 23, the angle difference between the airflow discharge direction at the trailing edge 23b (that is, a direction of a tangent line to the curved surface in the vicinity of the trailing edge 23b) and the rotation direction of the blade 23 is large. Thus, of the airflows flowing on the pressure surface 23c side, an airflow A_1 that flows along the pressure surface 23c and is discharged from the trailing edge 23b rearwards, receives a deflecting action to flow along the blade rotation direction immediately after blown off from the trailing edge 23b. Consequently, the flow becomes unstable, and turbulence easily occurs. When this flow is merged with the rear stream A_0 , the turbulence of the rear stream A_0 is promoted, and the width of the stream in the blade thickness direction, that is, the rear stream width S is increased.

[0007] As a result, the aerodynamic resistance of each blade 23 is increased, which in turn invites deterioration of the air discharge efficiency of the blower as a whole, and accordingly power consumption of the motor 24 is increased by the degree of this deterioration of the air discharge efficiency.

[0008] The problem of the increase in power consumption of the blower is relatively easily recognized when the blower is used alone. However, if a blower is incorporated in equipment such as, for example, an air conditioner, power consumption of the blower is very low in comparison with power consumption of other component members such as, for example, a compressor. Accordingly, when power consumption of the whole air conditioner is examined in view of energy saving property, attention has been paid to the compressor with high power consumption, but the power consumption of the blower has rarely been considered as a problem.

[0009] However, against the background of the recent further increase in social needs for environment protection and energy saving, the blower is also required to have an energy saving property, and in order to achieve this requirement, development of a technique for increasing efficiency of the blower is being required.

DISCLOSURE OF THE INVENTION

[0010] Accordingly, an object of the present invention is to provide a blower in which high efficiency is achieved by improving a blade structure, and an air conditioner equipped with this blower.

[0011] In order to achieve this object, the present invention provides a blower having an impeller formed by radially attaching a plurality of blades to an outer periphery of a hub, characterized in that each blade has a specific region that extends in a predetermined width along

a trailing edge of the blade in a wingspan direction, the specific region being bent towards a negative pressure surface side.

[0012] With the above constitution, the following effects can be obtained.

(a) On the negative pressure surface side of the blade, a range of a convex surface that promotes development of a boundary layer is reduced, so that airflow separation hardly occurs and turbulence of the rear stream is suppressed by the degree of reduction of the range of the convex surface. Meanwhile, on the pressure surface side of the blade, the angle difference of the airflow discharge (blowoff) direction at the trailing edge and the blade rotating direction is reduced, so that the airflow discharged from the trailing edge to the rear becomes smooth and turbulence is reduced by the degree of reduction of that angle difference. Furthermore, as a synergistic effect of these, the stream width of the rear stream discharged from the trailing edge of the blade is reduced as much as possible, and the aerodynamic characteristics of the blades are improved by the degree of this reduction of the rear stream width. As a result, efficiency of the blower is improved and power consumption is reduced by the degree of the improvement of efficiency, thereby improving energy saving property of the blower.

(b) Since only the specific region on the trailing edge side of the blade is bent towards the negative pressure surface (suction surface) side, reduction of the lifting action of the pressure surface (acting face) can be as small as possible. As a result, while reduction of the static pressure characteristic is suppressed as much as possible, the effects described in the above item (a) are secured. Thus, it is possible to obtain higher efficiency and energy saving property of the blower at the same time.

[0013] The above effects are similarly obtained when the blade has a nearly or substantially even blade thickness from the leading edge to the trailing edge as well as when the blade has a streamline-shaped cross section.

[0014] Furthermore, according to the present invention, in an air conditioner having a heat exchanger and a blower, a blower having the above constitution is employed as the blower.

[0015] This air conditioner is imparted with both higher efficiency and energy saving property by including the blower having the above constitution.

BRIEF DESCRIPTION OF THE DRAWINGS

[0016]

Fig. 1 is a cross sectional view showing an essential part of an axial blower according to a first embodiment of the invention;

Fig. 2 is a front view showing an impeller shown in Fig. 1;

Fig. 3 is a cross sectional view along line III-III in Fig. 2;

Fig. 4 is an explanatory view showing how an airflow flows on blade surfaces;

Fig. 5 is a cross sectional view showing an essential part of a mixed flow blower according to a second embodiment of the invention;

Fig. 6 is a front view showing an impeller shown in Fig. 5;

Fig. 7 is a cross sectional view along line VII-VII in Fig. 6;

Fig. 8 is a front view showing an outdoor unit of an air conditioner equipped with an axial blower;

Fig. 9 is a cross sectional view along line IX-IX in Fig. 8;

Fig. 10 is a cross sectional view along line X-X in Fig. 8;

Fig. 11 is a cross sectional view showing a blade according to another embodiment;

Fig. 12 is a cross sectional view showing a blade according to yet another embodiment;

Fig. 13 is a cross sectional view showing a blade according to yet another embodiment;

Fig. 14 is a graph showing an "air quantity-static pressure" characteristic of the blower;

Fig. 15 is a graph showing an "air quantity-total pressure efficiency" characteristic of the blower;

Fig. 16 is a graph showing an "air quantity-shaft power" characteristic of the blower;

Fig. 17 is a cross sectional view showing an essential part of a conventional axial blower;

Fig. 18 is a front view showing an impeller shown in Fig. 17;

Fig. 19 is a cross sectional view along line XIX-XIX in Fig. 18; and

Fig. 20 is an explanatory view showing a state of an airflow that flows on the blade.

BEST MODE FOR CARRYING OUT THE INVENTION

[0017] Hereafter, embodiments of the present invention will be described with reference to Figs. 1-13 and Figs. 14-16. It is noted that like component parts are designated by like reference numerals in Figs. 1-13.

(First embodiment)

[0018] Fig. 1 shows an axial blower Z_1 according to a first embodiment of the invention. This axial blower Z_1 is a so-called "propeller fan", and is constituted such that an impeller 1 formed by radially mounting a plurality of (three in this embodiment) blades 3, 3, 3 onto the outer periphery of a hub 2 at a predetermined blade angle can be driven to rotate by a motor 4, and a bell mouth 5 is disposed in such a manner as to surround this impeller

1.

[0019] Each blade 3 of the impeller 1 is a "swept-forward blade", whose leading edge 3a extends towards the front side in the rotation direction as shown in Figs. 2 and 3. The blade 3 is also a so-called "airfoil wing", which has a relatively large blade thickness, with this thickness gradually reduced from a blade leading edge 3a towards a blade trailing edge 3b, and has a predetermined "camber" in the chord direction. A concave side surface of the blade is a pressure surface, or acting face 3e, and its convex side surface is a negative pressure surface, or suction surface 3f.

[0020] Furthermore, the most characteristic of this blade 3 is that a region extending in a predetermined width along the trailing edge 3b in the wingspan direction of the blade 3 (a region closer to the trailing edge 3b than line L in Figs. 1-3) is designated as a specific region Q, and that the blade is bent towards the negative pressure surface 3f side in this specific region Q. Therefore, in the blade 3 of this embodiment, a portion closer to the leading edge 3a and a portion closer to the trailing edge 3b relative to the line L serving as a boundary between the two portions have respective "cambers" in reverse directions. Such an arrangement of the "cambers" is novel and totally different from the one where a "camber" continues in only one direction from the leading edge 23a through the trailing edge 23b as in the conventional blade 23 shown in Fig. 19.

[0021] The following unique effects are obtained from the axial blower Z_1 having the impeller 1 with the blades 3 having such a novel constitution.

[0022] That is, as shown in Fig. 4, when the impeller 1 rotates, there take place an airflow A_1 and an airflow A_2 , which flow from the leading edge 3a side towards the trailing edge 3b side along the pressure surface 3e and the negative pressure surface 3f, respectively, of the blade 3. Furthermore, of these airflows A_1 , A_2 , the airflow A_2 , which flows along the negative pressure surface 3f, tends to be separated off the blade in the vicinity of the trailing edge 3b and generates a rear stream A_0 which is an unstable and turbulent flow. Meanwhile, the airflow A_1 , which flows along the pressure surface 3e, is discharged rearwards from the trailing edge 3b and then merged with the rear stream A_0 .

[0023] In such circumstances, in the axial blower Z_1 of this embodiment, since the specific region Q provided on the trailing edge 3b side of the blade 3 is bent towards the negative pressure surface 3f side as described above, the negative pressure surface 3f has a reduced airflow A_2 separation area on the trailing edge 3b side, and the flow of the rear stream A_0 is suppressed accordingly by the amount of reduction of the airflow A_2 separation area. Meanwhile, on the pressure surface 3e side, since the specific region Q is bent towards the negative pressure surface 3f sides, the discharge direction of the airflow A_1 to the rear at the trailing edge 3b becomes closer to the rotation direction of the blade 3, and the angular difference between these directions is reduced.

Accordingly, the discharge of the airflow A_1 becomes smoother, so that even if this flow is merged with the rear stream A_0 , increase of the turbulence in the rear stream A_0 is suppressed and stabilization of the rear stream A_0 is promoted accordingly. Thus, an increase of the rear stream width S is suppressed.

[0024] As a result, the aerodynamic characteristics of the blades 3 are improved by the degree of suppression of the increase of the rear stream width S, and the efficiency of the axial blower Z_1 is improved. By the degree of this efficiency improvement, the power consumption is reduced and the energy saving property is also improved.

[0025] Furthermore, as described above, since the axial blower Z_1 of this embodiment is constituted such that only the specific region Q on the trailing edge 3b side of the blade 3 is bent towards the negative pressure surface 23d side, reduction of the lifting action of the pressure surface 3e due to the presence of the specific region Q is suppressed as much as possible, and the static pressure characteristic is favorably maintained.

[0026] Thus, in the axial blower Z_1 of this embodiment, higher efficiency and energy saving property are simultaneously achievable by an extremely simple and inexpensive constitution that the specific region Q on the trailing edge 3b side of the blade 3 is bent towards the negative pressure surface 3f side.

[0027] Figs. 14-16 show results of various performance tests to confirm each of the above effects in the axial blower Z_1 of this embodiment.

[0028] Fig. 14 is an "air quantity - static pressure" characteristic graph. A curve La1 shows a characteristic of the axial blower Z_1 of the above embodiment. A curve Lb1 shows a characteristic of an axial blower having a conventional structure. This "air quantity - static pressure" characteristic graph in Fig. 14 shows that the static pressure performance of the axial blower Z_1 of this embodiment is lower than that of the conventional blower to some extent because, in the axial blower Z_1 of the embodiment, an effective area of the acting face 3e, that is, the area of a portion involved in the air pressure raising action is reduced by bending the specific region Q portion on the trailing edge 3b side of the blade 3 towards the negative pressure surface 3f side.

[0029] Fig. 15 is an "air quantity - total pressure efficiency" characteristic graph. A curve La2 shows a characteristic of the axial blower Z_1 of this embodiment. A curve Lb2 shows a characteristic of an axial blower with a conventional structure. It is apparent from this "air quantity - total pressure efficiency" characteristic graph in Fig. 15 that the axial blower Z_1 of the embodiment has higher total pressure efficiency than that of the conventional axial blower.

[0030] Fig. 16 is an "air quantity - shaft power" characteristic diagram. A curve La3 shows a characteristic of the axial blower Z_1 of the above embodiment. A curve Lb3 shows a characteristic of an axial blower having a conventional structure. It is apparent from this "air quan-

tity - shaft power" characteristic graph in Fig. 16 that the shaft power of the axial blower Z_1 of the embodiment is significantly lower than the shaft power of the conventional axial blower.

[0031] As is apparent from the above, in the axial blower Z_1 of this embodiment, the static pressure performance is maintained high although slightly lower than that of the conventional blower. Meanwhile, regarding both the total pressure efficiency and the shaft power, the axial blower Z_1 of this embodiment is more excellent than the blower of the conventional structure, and particularly in the shaft power the embodiment is much superior. Therefore, when these performances are compared and considered, it can be said that the axial blower Z_1 of this embodiment is highly efficient and excellent in energy saving property in total in comparison with the blower of the conventional structure.

(Second embodiment)

[0032] Fig. 5 shows a mixed flow blower Z_2 according to a second embodiment of the invention. This axial blower Z_2 is constituted such that an impeller 1 formed by radially mounting a plurality of (four in this embodiment) blades 3, 3, 3 onto the outer periphery of a hub 2 in the shape of a truncated cone at a predetermined blade angle can be driven to rotate by a motor 4, and a bell mouth 5 is disposed in such a manner as to surround this impeller 1.

[0033] Each blade 3 of the impeller 1 is a "swept-forward blade", whose leading edge 3a extends towards the front side in the rotation direction as shown in Figs. 6 and 7. The blade 3 is also a so-called "airfoil wing", which has a relatively large blade thickness, with this thickness gradually reduced from a leading edge 3a towards a trailing edge 3b, and has a predetermined "camber" in the chord direction, as shown in Fig. 3. A concave side surface of the blade is a pressure surface, or acting face 3e, and its convex side surface is a negative pressure surface, or suction surface 3f.

[0034] Furthermore, the most characteristic of this blade 3 is that, when a region extending in a predetermined width along the trailing edge 3b in the wingspan direction of the blade 3 (a region closer to the trailing edge 3b than line L in Figs. 5-7) is assumed as a specific region Q, the blade is bent towards the negative pressure surface 3f side in this specific region Q. Therefore, in the blade 3 of this embodiment, a portion closer to the leading edge 3a and a portion closer to the trailing edge 3b with the region line L as a boundary have respective "cambers" in reverse directions. Such an arrangement of the "cambers" is novel and totally different from the structure of the conventional blade 23 (see Fig. 19).

[0035] The mixed flow blower Z_2 having the impeller 1 with the blades 3 of such a novel constitution has the same effects as the first embodiment axial blower Z_1 , except that the direction of flow of the air as discharged (blown off) is different between these blowers. There-

fore, the above-description on the effects of the first embodiment is incorporated by reference as the effects of the second embodiment and further description is omitted.

(Third embodiment)

[0036] Figs. 8-10 show an outdoor unit Y of an air conditioner equipped with the axial blower Z_1 according to the first embodiment. In this outdoor unit Y, a rectangular box-like casing 10 is partitioned by a partition wall 11. One side of the wall is used as a heat exchange chamber 12, and the other side is used as a machine chamber 13. The axial blower Z_1 and a heat exchanger 6 are disposed in the heat exchange chamber 12, and a compressor 7 is disposed in the machine chamber 13. Furthermore, an outlet port 9 faced by the axial blower Z_1 is equipped with a grill 8.

[0037] In this outdoor unit Y, when the axial blower Z_1 is driven and the impeller 1 rotates, an airflow is generated that passes from the outdoor through the heat exchanger 6 and the impeller 1 and is discharged through the outlet port 9 to the outdoor, and heat exchange is allowed between the airflow and a refrigerant circulated in the heat exchanger 6.

[0038] Since the outdoor unit Y of this embodiment is equipped with, as an air supply means to the heat exchanger 6, the axial blower Z_1 according to the first embodiment, which is highly efficient and excellent in energy saving property with low power consumption, it is an ideal outdoor unit having both high heat exchange efficiency and energy saving property.

(Modified Examples)

[0039] In the axial blower Z_1 of the first embodiment, a thick "airfoil wing" as shown in Fig. 3 is adopted as the blade 3. Furthermore, in the mixed flow blower Z_2 of the second embodiment, a thin "airfoil wing" as shown in Fig. 7 is adopted as the blade 3. However, the blade 3 of the present invention is not limited to these forms, but various forms such as those shown in Figs. 11-13 can be adopted.

[0040] The blade 3 shown in Fig. 11 is an airfoil wing having a special form wherein a portion closer to its leading edge 3a is made locally thick, and the other portions are made thin.

[0041] The blade 3 shown in Fig. 12 is an airfoil wing having a special form, wherein a relatively large portion closer to its leading edge 3a is made thick, and the blade thickness is gradually reduced from this thick portion towards the trailing edge 3b.

[0042] The blade 3 shown in Fig. 13 is a plate wing formed by bending a thin plate having a certain thickness with a predetermined "camber".

[0043] In any of these modified examples of the blade 3, the same effects as those of the blowers Z_1 , Z_2 according to the first and second embodiments are ob-

tained by bending a predetermined region on the trailing edge 3b side (that is, the specific region Q) towards the negative pressure surface 3f side.

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Claims

1. A blower having an impeller (1) formed by radially attaching a plurality of blades (3, 3, ...) to an outer periphery of a hub (2), **characterized in that:** 10

each blade (3) has a specific region (Q) that extends in a predetermined width along a trailing edge (3b) of the blade in a wingspan direction, said specific region being bent towards a negative pressure surface (3f) side of the blade. 15

2. A blower according to claim 1, wherein each blade (3) has a substantially even blade thickness from a leading edge (3a) thereof to the trailing edge (3b). 20

3. A blower according to claim 1, wherein each blade (3) has a streamline-shaped cross section.

4. A blower according to claim 1, wherein the blower is provided in an air conditioner. 25

5. An air conditioner having a heat exchanger (6) and a blower (z_1 , Z_2), **characterized in that:** 30

a blower according to claim 1, 2, or 3 is adopted as the blower (z_1 , Z_2). 35

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Fig.1

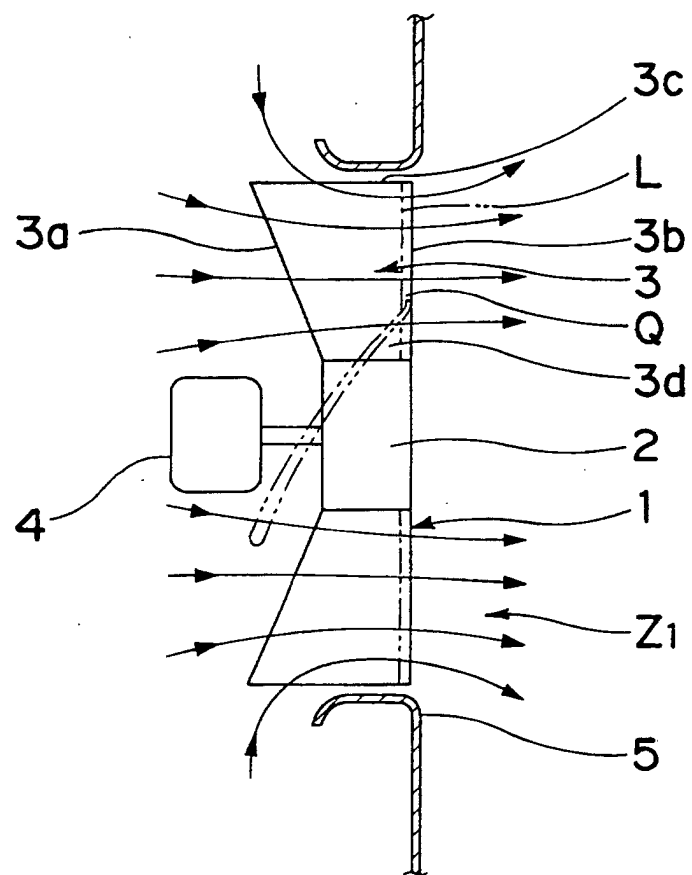


Fig.2

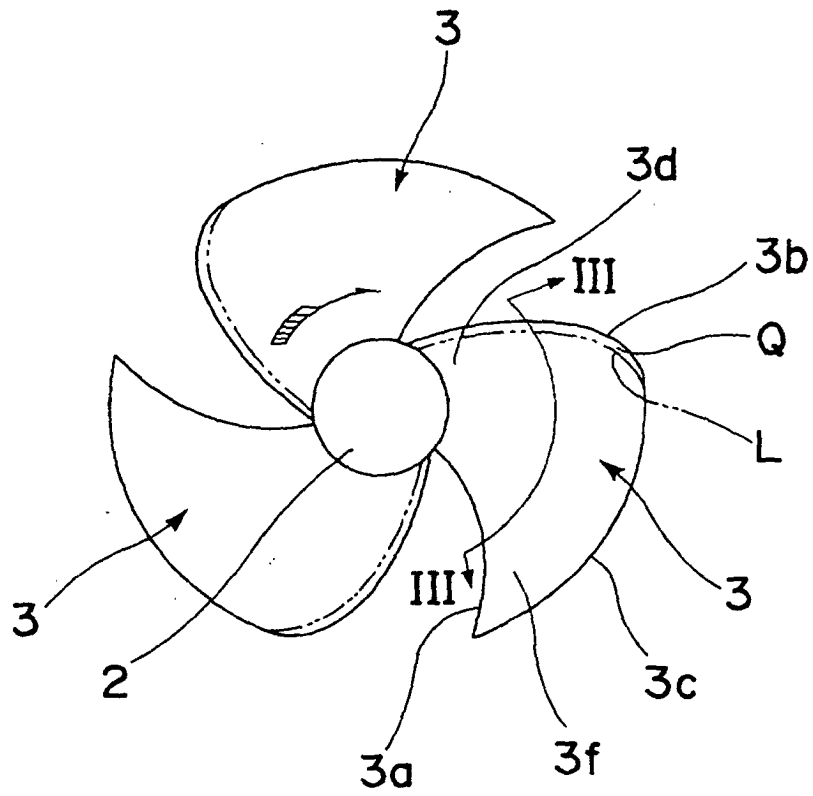


Fig.3

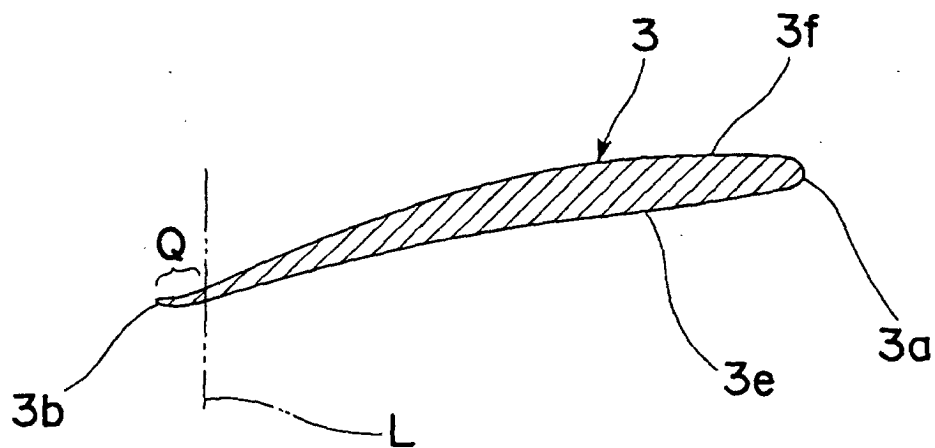


Fig. 4.

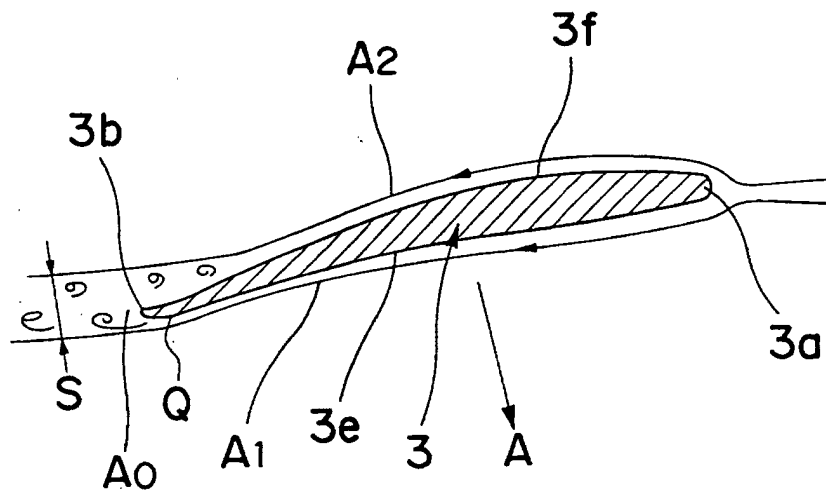


Fig.5

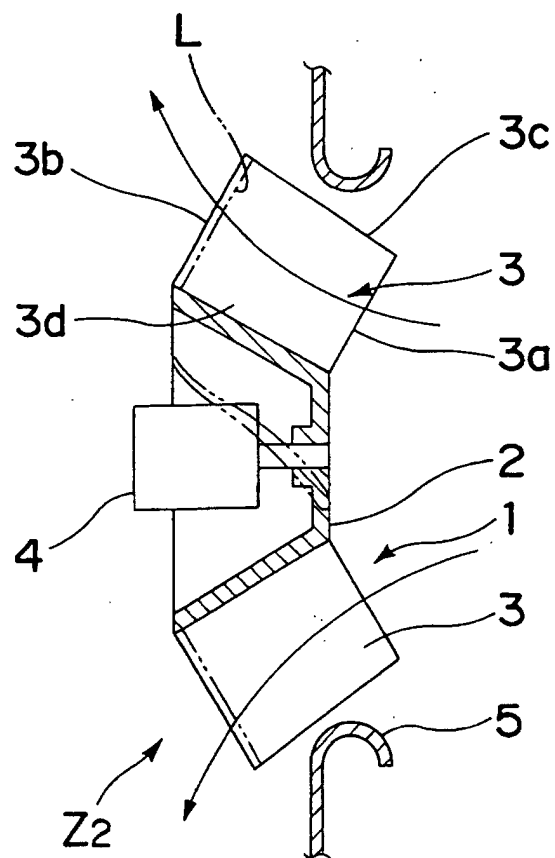


Fig. 6

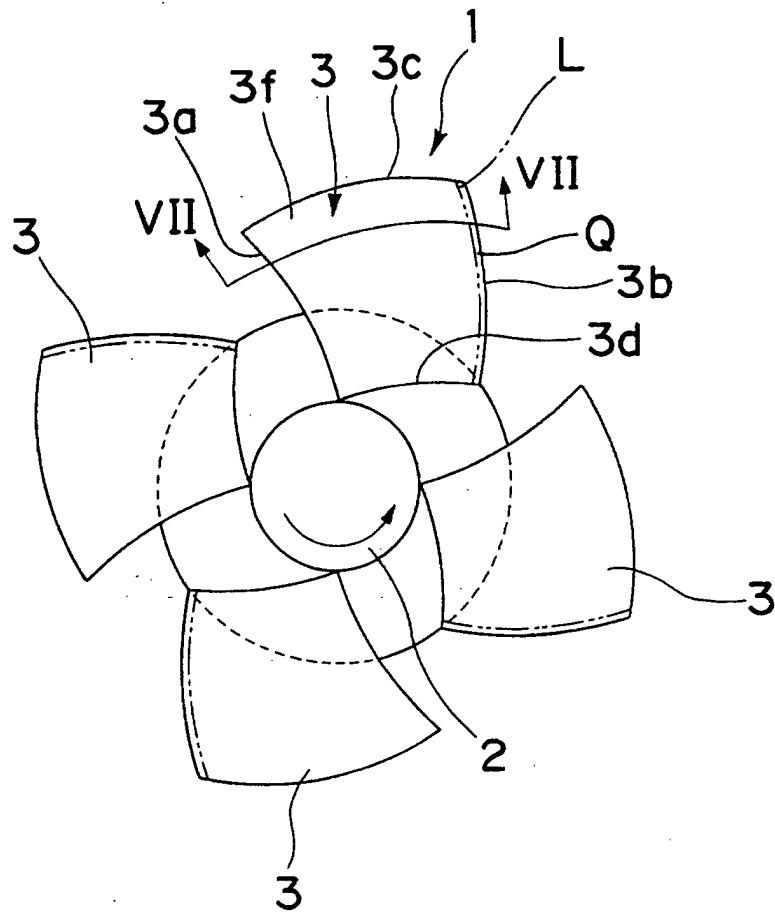


Fig. 7

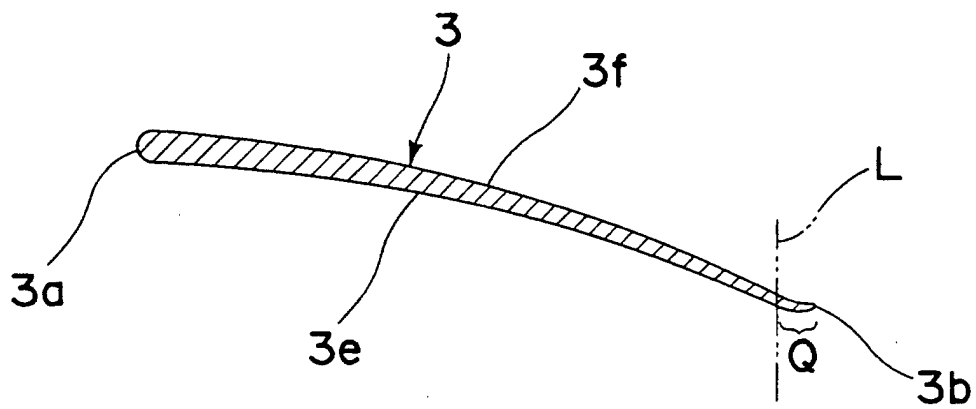


Fig. 10

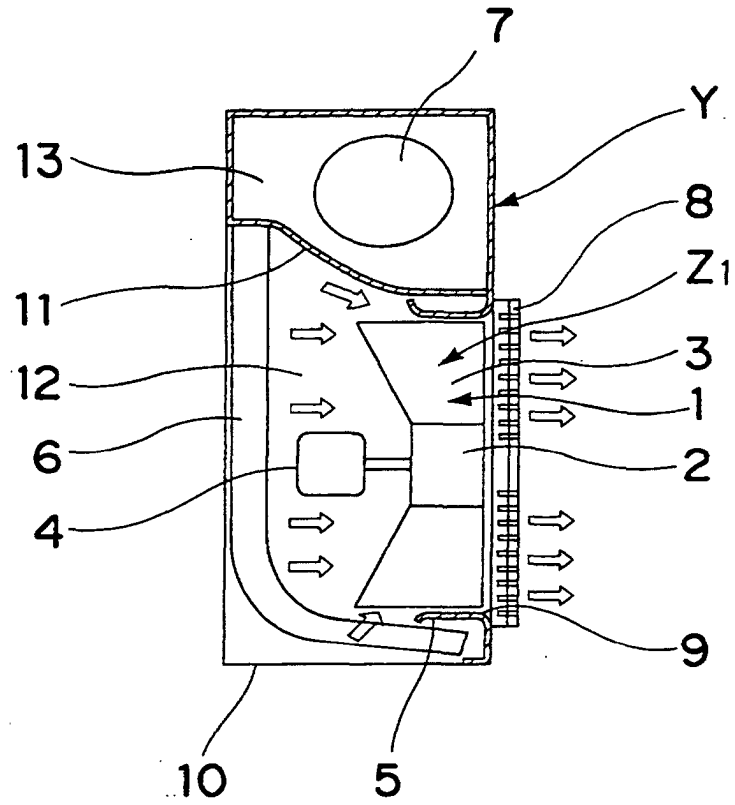


Fig.11

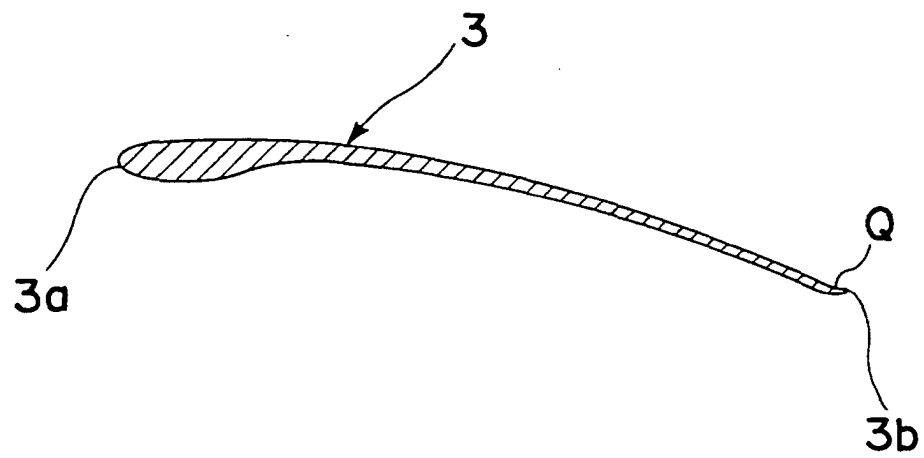


Fig. 12

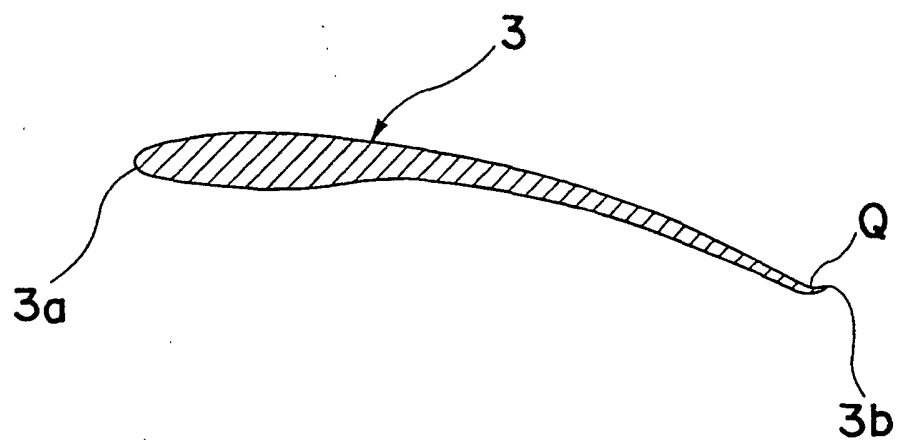


Fig. 13

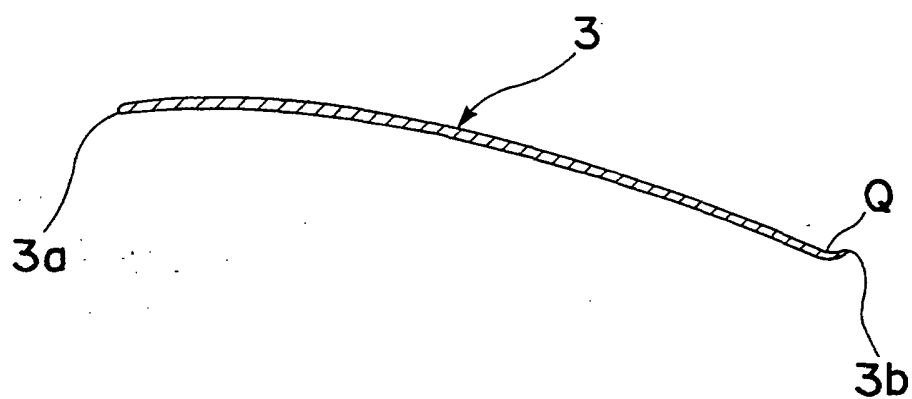


Fig. 14

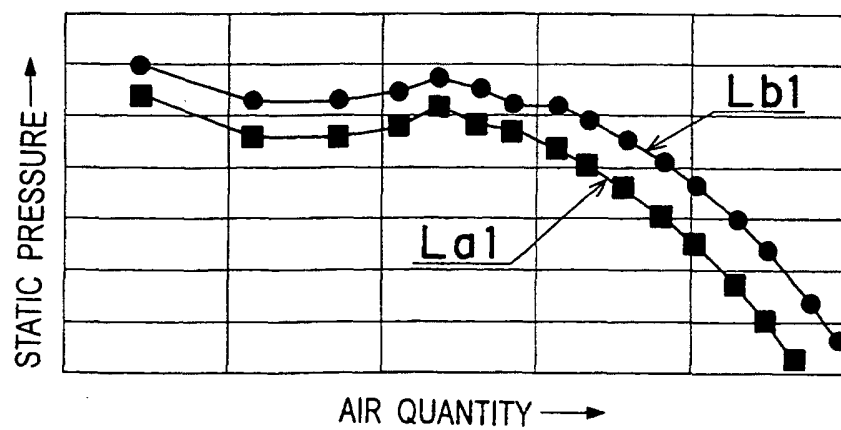


Fig.15

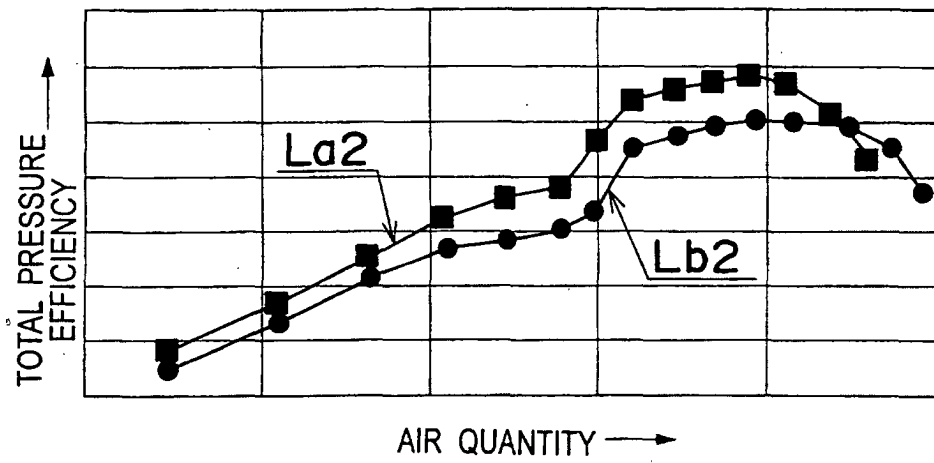


Fig.16

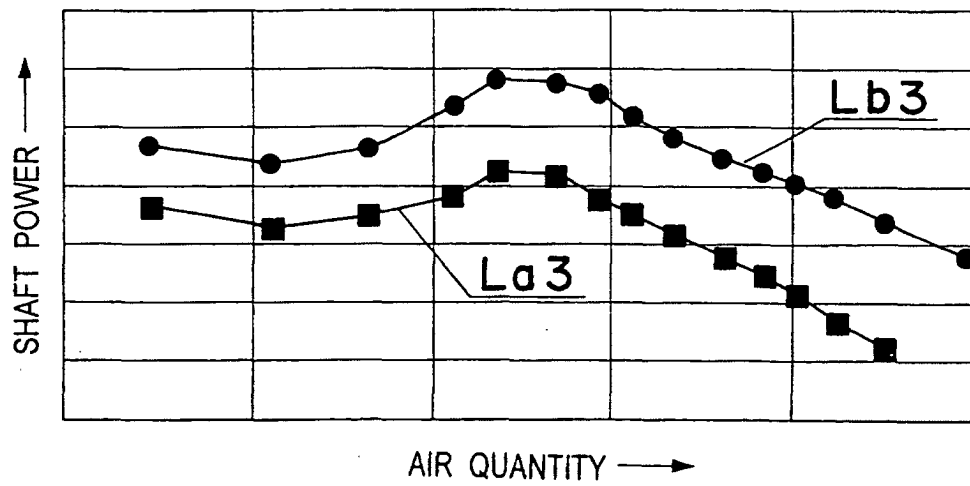


Fig. 17

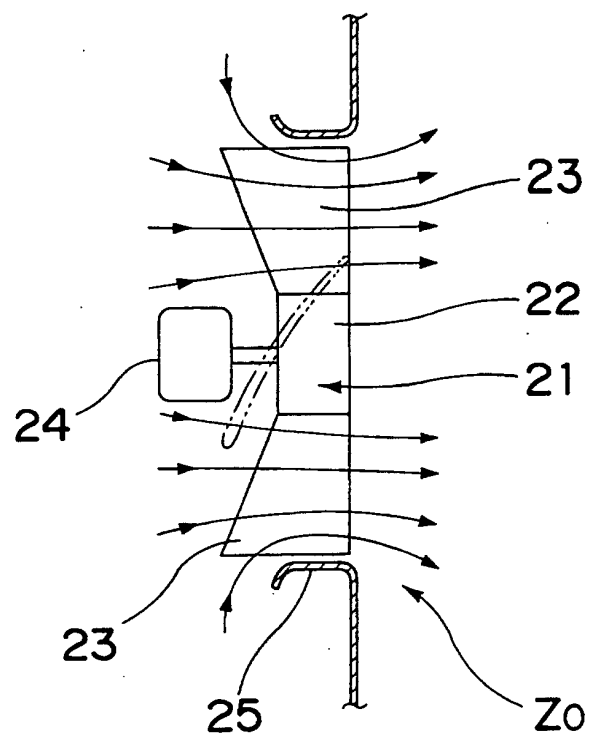


Fig. 18

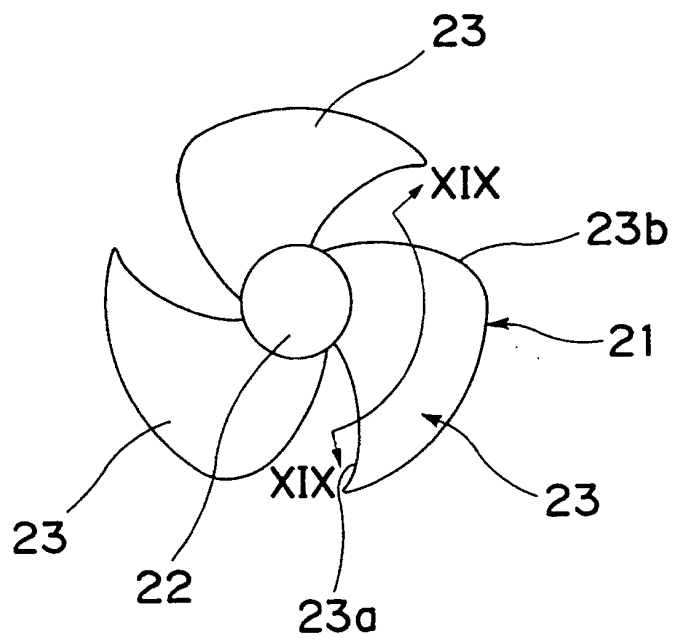


Fig. 19

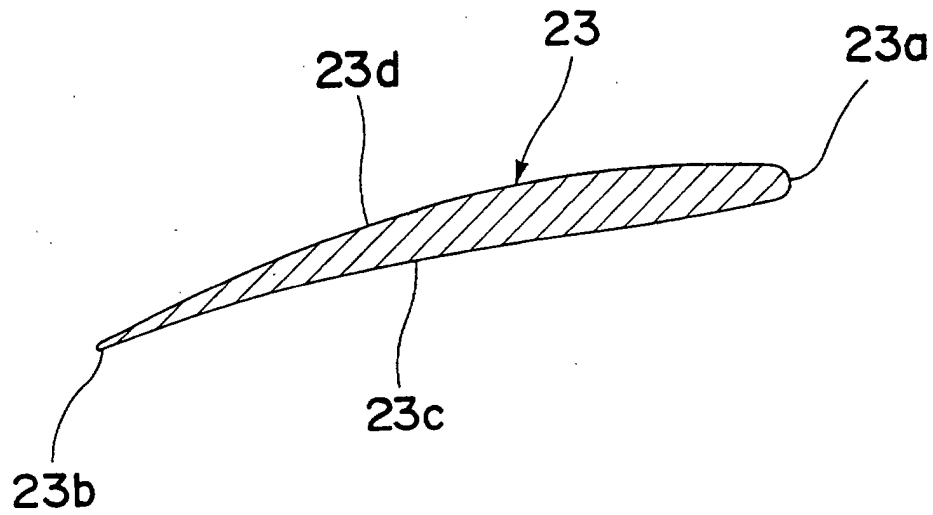
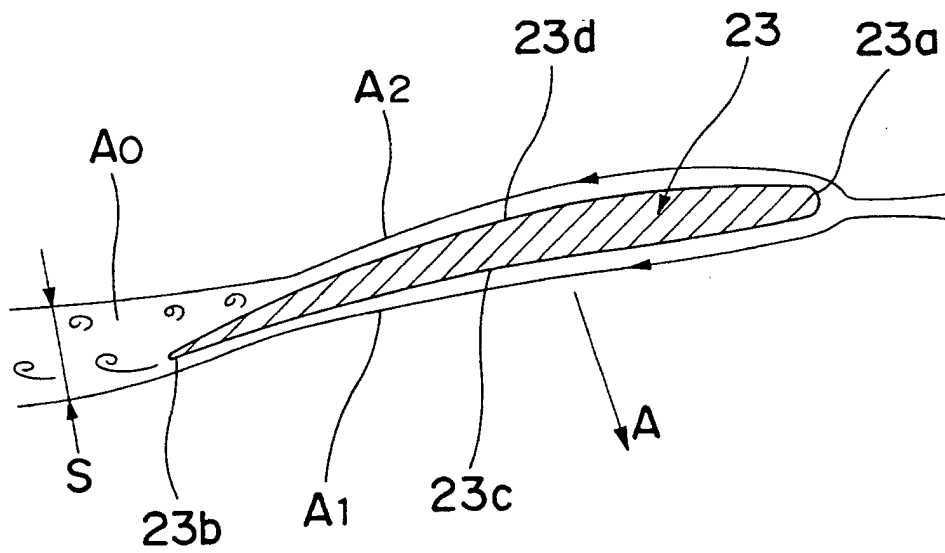


Fig. 20



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP01/11317

A. CLASSIFICATION OF SUBJECT MATTER Int.Cl ⁷ F04D29/30, F24F1/00		
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) Int.Cl ⁷ F04D29/30, F24F1/00		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched Jitsuyo Shinan Koho 1922-1996 Toroku Jitsuyo Shinan Koho 1994-2002 Kokai Jitsuyo Shinan Koho 1971-2002 Jitsuyo Shinan Toroku Koho 1996-2002		
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	Microfilm of the specification and drawings annexed	1-2
Y	to the request of Japanese Utility model Application No. 165508/1988 (Laid-open No. 85898/1990) (Matsushita Electric Industrial Co., Ltd.), 06 July, 1990 (06.07.90), Full text; Figs. 1 to 4 (Family: none)	4-5
X	Microfilm of the specification and drawings annexed	1, 3
Y	to the request of Japanese Utility model Application No. 170713/1975 (Laid-open No. 81538/1977) (Aisin Seiki Co., Ltd.), 17 June, 1977 (17.06.77), Full text; Figs. 1 to 7 (Family: none)	4-5
Y	JP, 2000-110790, A (Toshiba Corp.), 18 April, 2000 (18.04.00), Full text; Figs. 1 to 23 (Family: none)	4-5
☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.		
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