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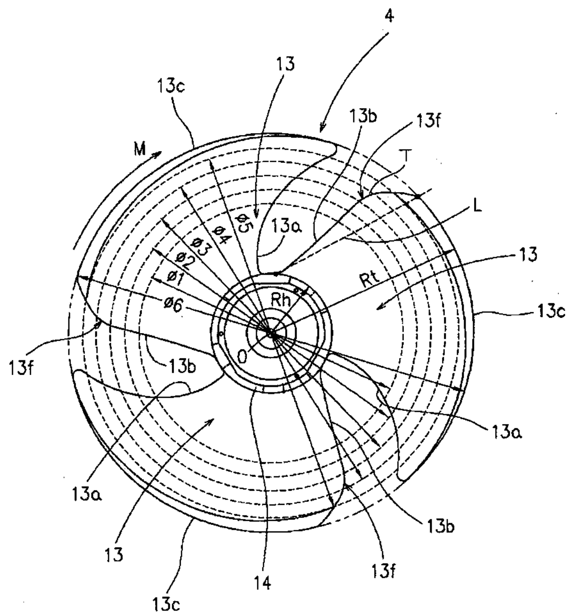
(54) **AXIAL FLOW FAN**

(57) In an axial flow fan provided with a plurality of impeller blades (13) provided in a hub (14), and a plurality of bent portions (13c) each formed by bending an outer peripheral edge of each of the impeller blades (13) toward a negative pressure surface (13e) of each of the impeller blades (13), a protruding portion (13f) is provided in a portion in which a blowing wind speed is high and a pressure rising work is most effectively carried out, in a rear edge portion (13b) of each of the impeller blades (13). Each of the protruding portions (13f) protrudes to an inverse direction to a rotating direction of each of the impeller blades (13) with respect to a straight line L connecting a proximal end and an outer peripheral end in the rear edge portion (13b) of each of the impeller blades (13). In this case, if a vane area of each of the impeller blades (13) is enlarged by setting a protruding portion (13f) at a predetermined position in the rear edge portion (13b) of each of the impeller blades (13), it is possible to effectively compensate for shortage of an amount of rise in static pressure which is lowered by bending the outer peripheral edge of each of the impellers (13).

Fig.3



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Description

TECHNICAL FIELD

[0001] The present invention relates to a structure of an axial flow fan such as a propeller fan or the like.

BACKGROUND ART

[0002] This kind of axial flow fan is used as an air blower of an outdoor unit for an air conditioner. As shown in Fig. 6, the outdoor unit for the air conditioner is provided with a box-like casing 1. An air suction port 10a is provided on a back surface of the casing 1. A heat exchanger 2 is arranged within the casing 1 so as to be adjacent to the air suction port 10a. Further, within the casing 1, a fan motor 12, and an air blowing unit 3 driven by the fan motor 12 are arranged downstream of the heat exchanger 2. The fan motor 12 is fixed to the casing 1 using a bracket (not shown).

[0003] The air blowing unit 3 is provided with a propeller fan 4 serving as an axial flow fan. As shown in Figs. 6 to 8, the propeller fan 4 is provided with a hub 14, and a plurality of impeller blades 13. Each of the impeller blades 13 is integrated on an outer peripheral surface of the hub 14. The propeller fan 4 is coupled to a driving shaft 12a of the fan motor 12. Further, the air blowing unit 3 is provided with a bell mouth 5 arranged near an outer periphery of the propeller fan 4, and a fan guard 6 arranged in a front side of the propeller fan 4. The bell mouth 5 partitions a suction region X positioned in a rear side of the propeller fan 4 and a blow region Y positioned in a front side thereof.

[0004] As a problem of the outdoor unit mentioned above, there are a noise generated from the propeller fan 4, and a noise generated by a collision of the air blown off the propeller fan 4 with the fan guard 6 or the like. In order to reduce the noises, for example, there have been conventionally carried out an optimization of a shape of the impeller blade 13 of the propeller fan 4, an employment of an air foil type vane having an excellent aerodynamic performance, and the like.

[0005] However, even in the case of employing these means, when the propeller fan 4 is rotated, an air flow (A1) heading for a negative pressure surface 13e having a low pressure from a pressure surface 13d having a high pressure is generated near an outer peripheral edge of each of the impeller blades 13 as shown in Fig. 8, and an eddy current (A2) is formed near the outer peripheral edge of each of the impeller blades 13 by the air flow (A1). Further, a turbulence of the air flow due to the eddy current (A2) is promoted toward the downstream side from the upstream side, as shown in Figs. 9 and 10, and the center of the eddy current (A2) gradually separates from the negative pressure surface 13e of each of the impeller blades 13. As a result, the eddy current (A2) comes into collision with the pressure surface 13d of each of the impeller blades 13, the inner peripheral surface of the bell mouth 5, the fan guard 6 and the like, which can further increase the noise of the blower.

[0006] In particular, if the eddy current (A2) interferes with the subsequent impeller blade 13 after separating from the negative pressure surface 13e of each of the impeller blades 13, the turbulence of the air flow becomes further large, which can further increase the noise of the blower.

[0007] For example, if the chord length of each of the impeller blades 13 is shortened for weight saving (cost reduction), a blade lattice performance generated by each of the impeller blades 13 is lowered. Accordingly, the eddy current (A2) tends to separate from the negative pressure surface 13e of each of the impeller blades 13. As shown in Fig. 11, the eddy current (A2) interferes with the subsequent impeller blade 13 early in comparison with the case in Fig. 10. Therefore, the noise of the blower tends to be further increased.

[0008] In order to cope with the problem mentioned above, as shown in Figs. 12 and 13, there has been proposed a propeller fan provided with a bent portion 13c along the outer peripheral edge of each of the impeller blades 13 (for example, refer to Patent Document 1). The bent portion 13c is formed by bending the outer peripheral edge of the impeller blade 13 toward the negative pressure surface 13e (the suction side). The width d of the bent portion 13c is set to become gradually larger toward the rear edge portion 13b from the front edge portion 13a of each of the impeller blades 13.

[0009] In accordance with this structure, as shown in Figs. 13 and 14, the air flow (A1) smoothly goes around to the negative pressure surface 13e from the pressure surface 13d through the bent portion 13c of each of the impeller blades 13. At this time, the eddy current (A2) generated by the air flow (A1) is formed near the outer peripheral edge of each of the impeller blades 13. However, since the diameter of the eddy current (A2) is small, it is possible to suppress the interference between the eddy current (A2) and the air flow (A3) of the negative pressure surface 13e of each of the impeller blades 13.

[0010] Further, as shown in Fig. 9, the diameter of the eddy current (A2) becomes gradually larger toward the rear edge portion 13b from the front edge portion 13a of each of the impeller blades 13. If the width d of each of the bent portions 13c is made larger toward the rear edge portion 13b from the front edge portion 13a of each of the impeller blades 13 in correspondence thereto, the operations and effects mentioned above can be achieved over the entire outer peripheral edge of each of the impeller blades 13, and it is hard for the eddy current (A2) to separate from the negative pressure surface 13e of each of the impeller blades 13.

[0011] Accordingly, even if the chord length of each of the impeller blades 13 is shortened for weight saving, the eddy currents (A2) do not interfere with each other between adjacent impeller blades 13, and the turbulence of the air flow is reduced in the downstream side of the blower. In other words, the noise of the blower can be effectively reduced by incorporating the propeller fan in the outdoor unit for the air conditioner.

Patent Document 1: Japanese Patent No. 3629702

DISCLOSURE OF THE INVENTION

[0012] However, in the case that the bent portion 13c is provided in the outer peripheral edge of each of the impeller blades 13, there is a problem that a warp of the vane contributing to a pressure rising work of the propeller fan 4 becomes small, and the blowing performance of the blower is lowered.

[0013] Accordingly, it is necessary to prevent the width d of the bent portion 13c from becoming too large. Conventionally, the maximum value of the width d of the bent portion 13c is preferably set to be equal to or less than 15% of the length from the center of rotation of each of the impeller blades 13 to the outer peripheral end. However, even if the width d of the bent portion 13c is optimized, a certain degree of reduction of the amount of rise in pressure is unavoidable.

[0014] As shown in Fig. 15, in the conventional propeller fan 4, the rear edge portion 13b of each of the impeller blades 13 is formed along a circular arc, and shallowly and widely protrude in an inverse direction to a rotating direction of each of the impeller blades 13 with respect to a straight line L connecting a proximal end of each of the impeller blades 13 and the outer peripheral edge. Accordingly, a vane area of each of the impeller blades 13 is sufficiently secured.

[0015] However, in each of the impeller blades 13, a portion in which a blowing wind speed becomes highest is a region shown by line F-F7' in Fig. 15. Accordingly, the amount of rise in pressure cannot be sufficiently improved unless the vane area in this region is enlarged.

[0016] Accordingly, even if the rear edge portion 13b of each of the impeller blades 13 is protruded as shown in Fig. 15, the amount of rise in pressure cannot be effectively increased with respect to the enlargement of the vane area of each of the impeller blades 13. Further, this structure acts counter to weight saving of the apparatus and reduction of the material.

[0017] An objective of the present invention is to provide an axial flow fan which effectively compensates for shortage of the amount of rise in static pressure which is lowered by bending the outer peripheral edge of an impeller blade.

[0018] In order to achieve the foregoing objective and in accordance with a first aspect of the present invention, an axial flow fan is provided that includes a plurality of impeller blades (13) provided on a hub (14), and a plurality of bent portions (13c) each formed by bending an outer peripheral edge of each of the impeller blades (13) toward a negative pressure surface (13e) of the impeller blade (13). A protruding portion (13f) is provided in a portion in which a blowing wind speed is high and a pressure rising work is most effectively carried out in a rear edge portion (13b) of each of the impeller blades (13). Each of the protruding portions (13f) protrudes to an inverse direction to a rotating direction of the impeller blade (13) with respect to a straight line L connecting a proximal end and an outer peripheral end in the rear edge portion (13b) of each of the impeller blades (13).

[0019] In accordance with the structure mentioned above, an air flow (A1) in the pressure surface 13d of each of the impeller blades 13 smoothly goes around to the negative pressure surface 13e from the outer peripheral edge of each of the impeller blades 13. As a result, an eddy current (A2) having a small diameter is formed near the outer peripheral edge of each of the impellers 13. Accordingly, it is possible to suppress an interference between an air flow (A3) of the negative pressure surface 13e of each of the impeller blades 13 and the eddy current (A2).

[0020] In this case, in the rear edge portion 13b of each of the impeller blades 13, the protruding portion 13f is provided in the portion in which the blowing wind speed is high and the pressure rising work is most effectively carried out. Further, the protruding portion 13f is protruded in the inverse direction to the rotating direction of each of the impeller blades 13 with respect to the straight line L connecting the proximal end and the outer peripheral end in the rear edge portion of each of the impellers 13. If the vane area of each of the impeller blades 13 is enlarged as mentioned above, it is possible to effectively compensate for the shortage of the amount of rise in static pressure which is lowered by bending the outer peripheral edge of each of the impeller blades 13 to the negative pressure surface 13e. Accordingly, it is possible to achieve a reduction of a blowing noise and a high efficiency of the blowing performance.

[0021] In the axial flow fan mentioned above, each of the bent portions (13c) is provided over the entirety of each of the impeller blades (13) from the front edge portion (13a) to the rear edge portion (13b). In this case, the air flow (A1) of the pressure surface 13d of each of the impeller blades 13 smoothly goes around to the negative pressure surface 13e from the outer peripheral edge of each of the impeller blades 13, the eddy current (A2) having the small diameter is formed near the outer peripheral edge of each of the impeller blades 13, and it is possible to suppress the interference between the air flow (A3) of the negative pressure surface 13e of each of the impeller blades 13 and the eddy current (A2).

[0022] In the axial flow fan mentioned above, each of the bent portions (13c) is provided in the portion from the position between the front edge portion (13a) and the rear edge portion (13b) in each of the impeller blades (13) to the rear edge portion (13b). In this case, the air flow (A1) of the pressure surface 13d of each of the impeller blades 13 smoothly goes around to the negative pressure surface 13e from the outer peripheral edge of each of the impeller blades 13, the eddy current (A2) having the small diameter is formed near the outer peripheral edge of each of the impeller blades 13, and it is possible to suppress the interference between the air flow

(A3) of the negative pressure surface 13e in each of the impeller blades 13 and the eddy current (A2).

[0023] In the axial flow fan mentioned above, the width of each of the bent portions (13c) is formed so as to become gradually larger toward the rear edge portion (13b) from the front edge portion (13a) of each of the impeller blades (13).

[0024] In this case, in correspondence to the eddy current (A2), the diameter of which becomes larger toward the rear edge portion 13b from the front edge portion 13a of each of the impeller blades 13, it is possible to effectively make the eddy current (A2) small from the front edge portion 13a to the rear edge portion 13b, and it is possible to make it hard for the eddy current (A2) to separate from the negative pressure surface 13e of each of the impeller blades 13.

[0025] Accordingly, even if the chord length of each of the impeller blades 13 is made short for the weight saving, the eddy currents (A2) do not interfere with each other between adjacent impeller blades 13, and the turbulence of the air flow generated downstream of the blower is reduced. Accordingly, it is possible to effectively suppress the noise on the basis of a synergistic effect of the operations mentioned above.

[0026] In the axial flow fan mentioned above, in each of the protruding portions (13f), the portion protruding most largely in the inverse direction to the rotating direction with respect to the straight line L is set in a region in which a value of an expression (R - Rh)/(Rt - Rh) is between 0.65 and 0.85, in which the radius of the axial flow fan is represented by Rt, the radius of the hub (14) is represented by Rh, and the distance in a radial direction from the center O of rotation of the axial flow fan is represented by R.

[0027] On the basis of results of measurement obtained by the inventors et al. of the present invention, the portion in which the blowing wind speed is highest and the pressure rising work is most effectively carried out is a region in which a value of the expression (R - Rh)/(Rt - Rh) is between 0.65 and 0.85 in which the radius of the axial flow fan is represented by Rt, the radius of the hub 14 is represented by Rh, and the distance in a radial direction from the center O of rotation of the axial flow fan is represented by R.

[0028] On the basis of the results mentioned above, the vane area of each of the impeller blades 13 is enlarged by setting the protruding portion 13f protruding in the opposite direction to the rotating direction of the axial flow fan with respect to the straight line L connecting the proximal end and the outer peripheral end of each of the impeller blades in the rear edge portion of each of the impeller blades. In accordance with the structure mentioned above, it is possible to further effectively compensate for the shortage of the amount of rise in static pressure which is lowered by bending the outer peripheral edge of each of the impeller blades to the negative pressure surface.

BRIEF DESCRIPTION OF THE DRAWINGS

[0029]

Fig. 1 is a rear view showing a propeller fan and a bell mouth in accordance with the present embodiment;
Fig. 2 is a perspective view showing the propeller fan;
Fig. 3 is a rear view showing the propeller fan;
Fig. 4 is a graph showing a relation between the position of a rear edge portion of an impeller blade and a blowing wind speed;
Fig. 5 is a partly enlarged plain view showing an impeller blade in accordance with a modified embodiment;
Fig. 6 is a vertical cross-sectional view showing the whole structure of an outdoor unit for an air conditioner using a conventional propeller fan;
Fig. 7 is a rear view showing the conventional propeller fan;
Fig. 8 is a partly cross-sectional view showing a cross-sectional structure of an impeller blade of the conventional propeller fan and its problems;
Fig. 9 is an explanatory view showing a generating mechanism of an eddy current of the conventional propeller fan;
Fig. 10 is an explanatory view showing an eddy current interference phenomenon of the conventional propeller fan;
Fig. 11 is an explanatory view showing the eddy current interference phenomenon in the case that the chord length of an impeller blade is made short in the conventional propeller fan;
Fig. 12 is a perspective view showing a basic shape of the impeller blade coping with a problem of the conventional propeller fan;
Fig. 13 is a cross-sectional view showing an eddy current suppressing effect of the propeller fan in Fig. 12;
Fig. 14 is an explanatory view showing an eddy current interference phenomenon of the propeller fan in Fig. 12; and
Fig. 15 is a partly enlarged plain view showing a problem of the propeller fan in Fig. 12.

BEST MODE FOR CARRYING OUT THE INVENTION

[0030] A propeller fan according to one embodiment of the present invention will now be described with reference to Figs. 1 to 4.

[0031] As shown in Figs. 1 to 3, a propeller fan 4 is provided with a hub 14 made of a synthetic resin, and three impeller blades 13. Each of the impeller blades 13 is integrally formed on an outer peripheral surface of the hub 14.

[0032] An outer peripheral end of a front edge portion 13a and an outer peripheral end of a rear edge portion 13b in each of the impeller blades 13 are arranged in an offset manner in a rotating direction of the impeller blade 13 in comparison with a proximal end of the impeller blade 13. The entire outer peripheral edge of each of the impeller blades 13 is bent toward a negative pressure surface 13e (a suction side) of the impeller blade 13 shown in Fig. 2, from the front edge portion 13a to the rear edge portion 13b. The width d of each of the bent portions 13c is enlarged at a predetermined rate toward the rear edge portion 13b from the front edge portion 13a of each of the impeller blades 13.

[0033] In the light of effectively suppressing the generation of the eddy current A2 without lowering the blowing performance of each of the impeller blades 13, it is desirable that the maximum value of the width d of the bent portion 13c be equal to or less than 15% of the length from the center of rotation of the propeller fan 4 (the center of the hub 14) to an outer peripheral end of each of the impeller blades 13.

[0034] A protruding portion 13f is provided in the rear edge portion 13b of each of the impeller blades 13. Each of the protruding portions 13f is provided in a portion in which a blowing wind speed is highest and a pressure rising work can be effectively carried out (a region shown by an outer peripheral line having a diameter φ1 to φ5 of the propeller fan 4 in Fig. 3). Each of the protruding portions 13f protrudes to an inverse direction to a rotating direction M of each of the impeller blades 13, with respect to a straight line L (a broken line in Fig. 3) connecting the proximal end and the outer peripheral end of the rear edge portion 13b in each of the impeller blades 13.

[0035] In each of the protruding portions 13f, a portion which most largely protrudes to the inverse direction to the rotating direction M of the impeller blade 13 is set to a maximum protruding portion T. In the case that the radius of the propeller fan 4 is represented by Rt, the radius of the hub 14 is represented by Rh, and the distance in a radial direction from the center O of rotation of the propeller fan 4 is represented by R, the maximum protruding portion T is set in a region in which a value (R - Rh)/(Rt - Rh) is between 0.65 and 0.85.

[0036] A blowing wind speed of the fan at a time of changing the value (R - Rh)/(Rt - Rh) between 0 and 1.0 is measured with respect to the impeller blade 13 of the propeller fan 4 which does not have the bent portion 13c shown in Figs. 7 and 8, and the impeller blade 13 of the propeller fan 4 which has the bent portion 13c shown in Figs. 1 to 3, and Figs. 12 and 13. The results thereof are shown in Fig. 4.

[0037] On the basis of the results in Fig. 4, it was found out that the value of (R - Rh)/(Rt - Rh) at which the blowing wind speed of the fan becomes maximum is in the region between 0.65 and 0.85 regardless of whether the bent portion 13c is provided.

[0038] In the present embodiment, the bent portion 13c is provided in a region (between outer peripheral lines having diameters φ5 and φ6 of the propeller fan 4 in Fig. 3) in which the value (R - Rh)/(Rt - Rh) is between 0.9 and 1.0. Accordingly, it is preferable that the protruding portion 13f is provided in a region in which the value of (R - Rh)/(Rt - Rh) is between 0.65 and 0.85.

[0039] It is preferable that the maximum protruding portion T of the protruding portion 13f is provided in a region in which the blowing wind speed becomes highest, in a region radially inside of the boundary (the outer peripheral line having the diameter φ5 of the propeller fan in Fig. 3) with the bent portion 13c, for example, a region in which the value (R - Rh)/(Rt - Rh) is about 0.75.

[0040] In contrast, in the case of the propeller fan 4 shown in Fig. 15, the maximum protruding portion T of the protruding portion 13f is provided in a region in which the value of (R - Rh)/(Rt - Rh) is about 0.5. In this case, the blowing wind speed is low despite the enlargement of the vane area of each of the impeller blades 13, so that the amount of rise in static pressure cannot be sufficiently enlarged.

[0041] Next, a description will be given in detail of an operation of the propeller fan 4 mentioned above.

[0042] In the case of the propeller fan 4 in accordance with the present embodiment, the entire outer peripheral edge of each of the impeller blades 13 is bent toward the negative pressure surface 13e of the impeller blade 13 from the front edge portion 13a to the rear edge portion 13b. In this case, as shown in Fig. 13, the air flow (A1) of the pressure surface 13d of each of the impeller blades 13 smoothly goes around to the negative pressure surface 13e from the outer peripheral edge of each of the impeller blades 13. As a result, the small eddy current (A2) having a small diameter is formed near the outer peripheral edge of each of the impeller blades 13. Accordingly, an interference between the air flow A3 and the eddy current (A2) in the negative pressure surface 13e of each of the impeller blades 13 is suppressed.

[0043] Further, in the rear edge portion 13b of each of the impeller blades 13, the protruding portion 13f is provided in the portion in which the blowing wind speed is high, and the pressure rising work can be most effectively carried out. Each of the protruding portions 13f protrudes to the inverse direction to the rotating direction of each of the impeller blades 13 with respect to the straight line L connecting the base and the outer peripheral end of the rear edge portion 13b of each of the impeller blades 13. If the vane area of each of the impeller blades 13 is enlarged as mentioned above, it is possible to effectively compensate for the shortage of the amount of rise in static pressure which is lowered by bending the outer peripheral edge of each of the impeller blades 13. Accordingly, it is possible to achieve a reduction of a blowing noise and a high efficiency of the blowing performance.

[0044] Further, the width d of each of the bent portions 13c is formed to become larger toward the rear edge portion 13b from the front edge portion 13a of each of the impeller blades 13. Accordingly, it is possible to effectively make the eddy current (A2) small from the front edge portion 13a to the rear edge portion 13b in correspondence to the eddy current (A2) in which the diameter becomes larger toward the rear edge portion 13b from the front edge portion 13a of each of the impeller blades 13, and it is possible to make it hard for the eddy current (A2) to separate from the negative pressure surface 13e of each of the impeller blades 13.

[0045] Accordingly, even if the chord length of each of the impeller blades 13 is made short for the weight saving, the eddy currents (A2) do not interfere with each other between adjacent impeller blades 13, and the turbulence of the air flow generated in the downstream side of the blower is reduced. Accordingly, it is possible to effectively suppress the noise on the basis of a synergistic effect of the operations mentioned above.

[0046] Further, in the case that the radius of the propeller fan 4 is represented by Rt, the radius of the hub 14 is represented by Rh, and the distance in a radial direction from the center O of rotation of the propeller fan 4 is represented by R, the position of the maximum protruding portion T is set in the region in which the value of (R - Rh)/(Rt - Rh) is between 0.65 and 0.85.

[0047] As shown in Fig. 4, in each of the impeller blades 13 of the propeller fan 4, the region in which the blowing wind speed is high and the pressure rising work can be most effectively carried out is the region in which the value of (R - Rh)/(Rt - Rh) is between 0.65 and 0.85. if the vane area of each of the impeller blades 13 is enlarged by protruding the region to the opposite direction to the rotating direction of the propeller fan 4, it is possible to effectively compensate for the shortage of the amount of rise in static pressure which is lowered by bending the outer peripheral edge of each of the impeller blades 13.

[0048] Accordingly, it is possible to stably generate the eddy current A2 having the small diameter near the outer peripheral edge of each of the impeller blades 13 by setting the bent portion 13c in the outer peripheral edge of the impeller blade 13, as in the propeller fan 4 in accordance with the present embodiment. Further, the vane area of each of the impeller blades 13 is enlarged by setting the protruding portion 13f in the region in which the blowing wind speed becomes maximum in the rear edge portion 13b of the impeller blade 13. In accordance with the structure mentioned above, it is possible to reduce the noise without lowering the amount of rise in static pressure, even if the bent portion 13c is provided in the outer peripheral edge of each of the impeller blades 13. Accordingly, it is possible to achieve both of the reduction of the blowing noise and the high efficiency of the bellowing performance. Further, since it is unnecessary to enlarge the vane area of each of the impeller blades 13 more than necessary, it is possible to suppress a generation of a material loss as much as possible, and it is possible to achieve a weight saving and a low cost of the propeller fan 4.

(Modified Embodiment)

[0049] In the present embodiment, the bent portion 13c is provided over the entire outer peripheral edge of each impeller blade 13 from the front edge portion 13a to the rear edge portion 13b. However, the bent portion 13c may be provided in a portion from a position between the front edge portion 13a and the rear edge portion 13b to the rear edge portion 13b. In this case, the position between the front edge portion 13a and the rear edge portion 13b is preferably set to a position which is offset from the front edge portion 13a to the rear edge portion 13b at about 25% of the entire length of the outer peripheral edge of the impeller blade 13.

[0050] In this case, the air flow (A1) of the pressure surface 13d in each of the impeller blades 13 smoothly goes around to the negative pressure surface 13e from the outer peripheral edge of the impeller blade 13. As a result, the eddy current (A2) having a small diameter is formed near the outer peripheral edge of each of the impeller blades 13. Accordingly, the interference between the air flow (A3) of the negative pressure surface 13e in each of the impeller blades 13 and the eddy current (A2) is suppressed.

[0051] In this case, it is possible, in the rear edge portion 13b of the impeller 13, to effectively compensate for the shortage of the amount of rise in static pressure which is lowered by bending the outer peripheral edge of each of the impeller blades 13, by setting the protruding portion 13f in the portion in which the blowing wind speed is high and the pressure rising work can be most effectively carried out. Therefore, it is possible to achieve both of the reduction of the blowing noise and the high efficiency of the blowing performance.

(Regarding the kind of the impeller blade)

[0052] In the embodiment and the modified embodiment mentioned above, the present invention is embodied in impeller blades having a thin vane structure.

[0053] However, the present invention is not limited to thin vane structures, but may be applied, for example, to a vane having a thick structure, various air foil vane and the like.

Claims

1. An axial flow fan comprising a plurality of impeller blades (13) provided on a hub (14), and a plurality of bent portions (13c) each formed by bending an outer peripheral edge of each of the impeller blades (13) toward a negative pressure surface (13e) of the impeller blade (13),
the axial flow fan being **characterized in that** a protruding portion (13f) is provided in a portion in which a blowing wind speed is high and a pressure rising work is most effectively carried out in a rear edge portion (13b) of each of the impeller blades (13), and each of the protruding portions (13f) protrudes to an inverse direction to a rotating direction of the impeller blades (13) with respect to a straight line L connecting a proximal end and an outer peripheral end in

the rear edge portion (13b) of each of the impeller blades (13).

2. The axial flow fan according to claim 1, **characterized in that** each of the bent portions (13c) is provided over the entirety of the corresponding impeller blade (13) from the front edge portion (13a) to the rear edge portion (13b).

3. The axial flow fan according to claim 1, **characterized in that** each of the bent portions (13c) is provided in a portion from a position between the front edge portion (13a) and the rear edge portion (13b) in each of the impeller blades (13) to the rear edge portion (13b).

4. The axial flow fan according to any one of claims 1 to 3, **characterized in that** a width of each of the bent portions (13c) is formed so as to become gradually larger toward the rear edge portion (13b) from the front edge portion (13a) of each of the impeller blades (13).

5. The axial flow fan according to any one of claims 1 to 4, **characterized in that**, in each of the protruding portions (13f), a portion protruding most largely in the inverse direction to the rotating direction with respect to the straight line L is set in a region in which the value of an expression of (R - Rh)/(Rt - Rh) is between 0.65 and 0.85, where a radius of the axial flow fan is represented by Rt, a radius of the hub (14) is represented by Rh, and a distance in a radial direction from a center O of rotation of the axial flow fan is represented by R.

Fig.1

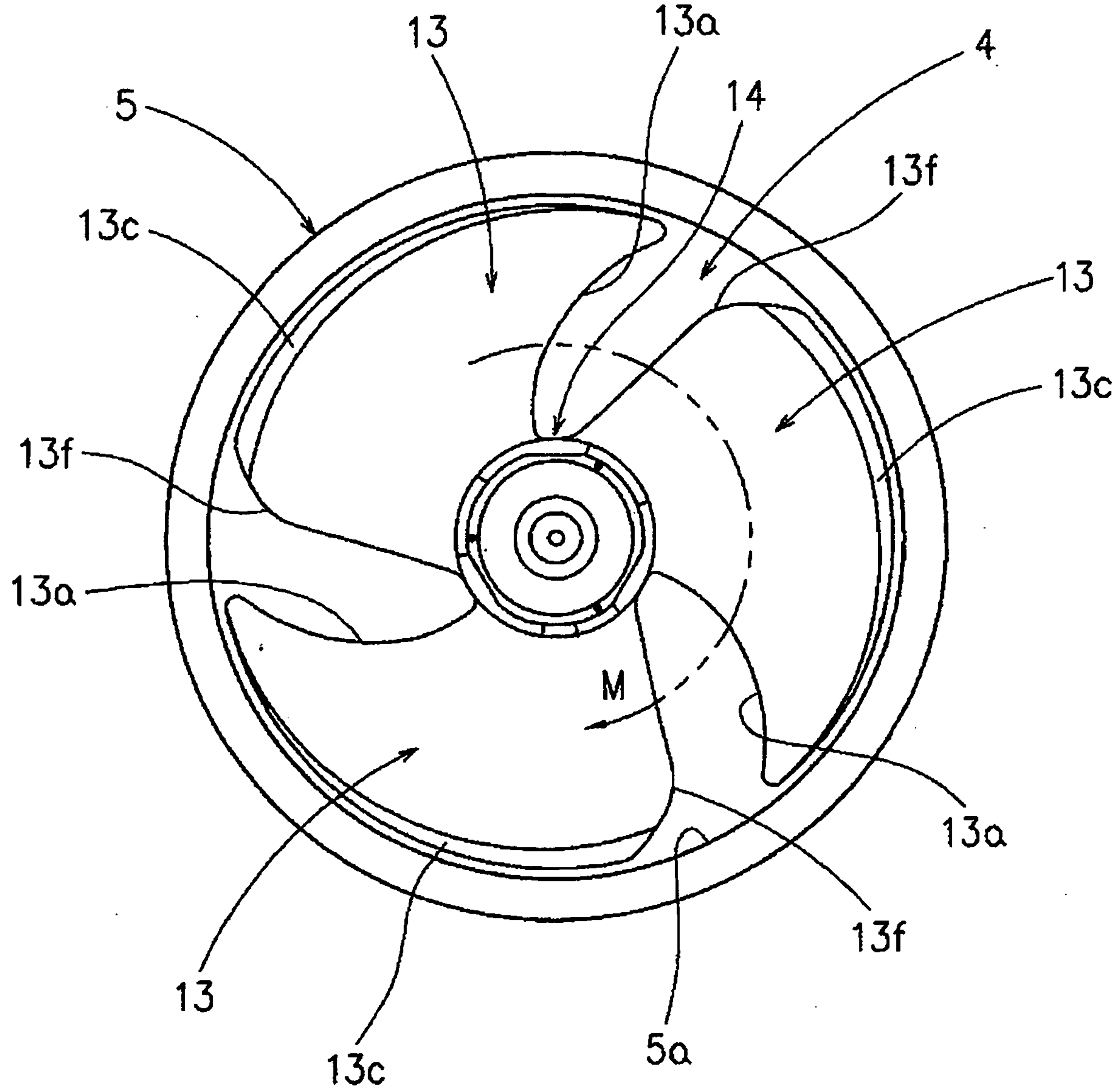


Fig.2

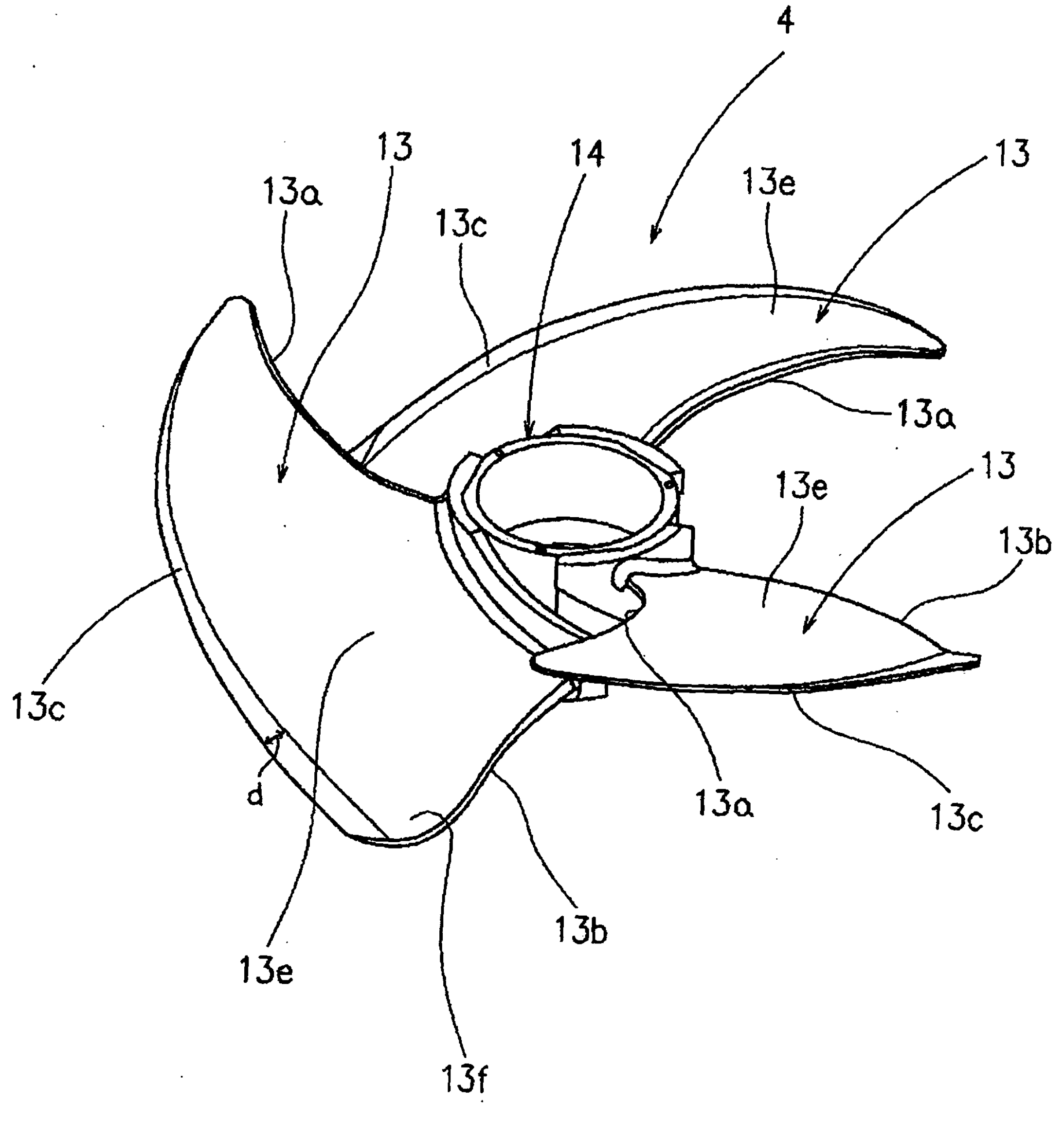


Fig.3

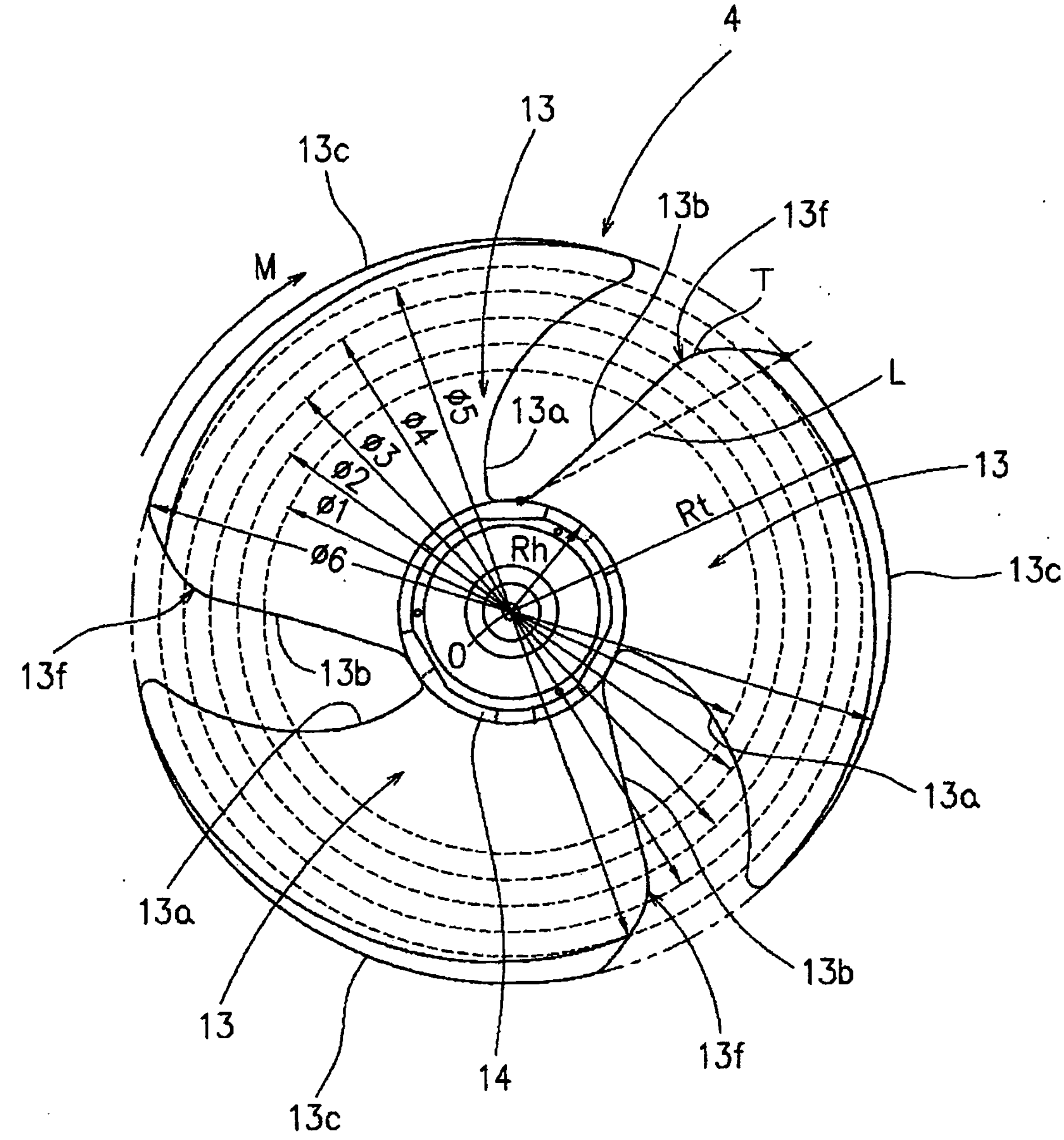

4
13
13c
13b
13f
M
T
L
13a
ø5
ø4
ø3
ø2
ø1
ø6
13
Rt
Rh
13c
13f
13b
O
13a
13a
13b
13
14
13f
13c

Fig.4

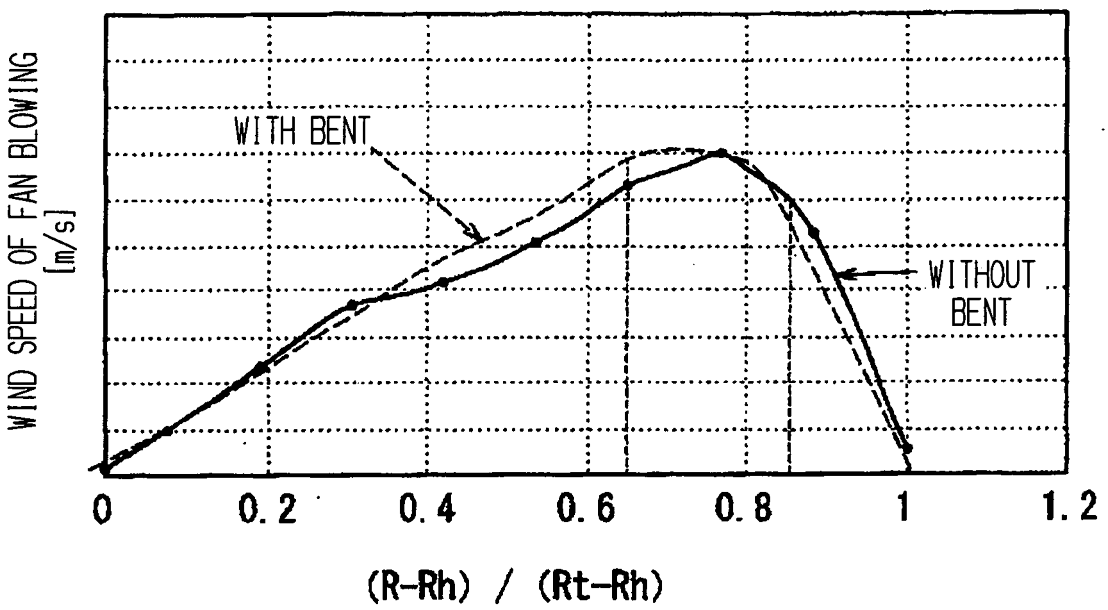

WIND SPEED OF FAN BLOWING
[m/s]
WITH BENT
WITHOUT
BENT
0
0.2
0.4
0.6
0.8
1
1.2
(R-Rh) / (Rt-Rh)

Fig.5

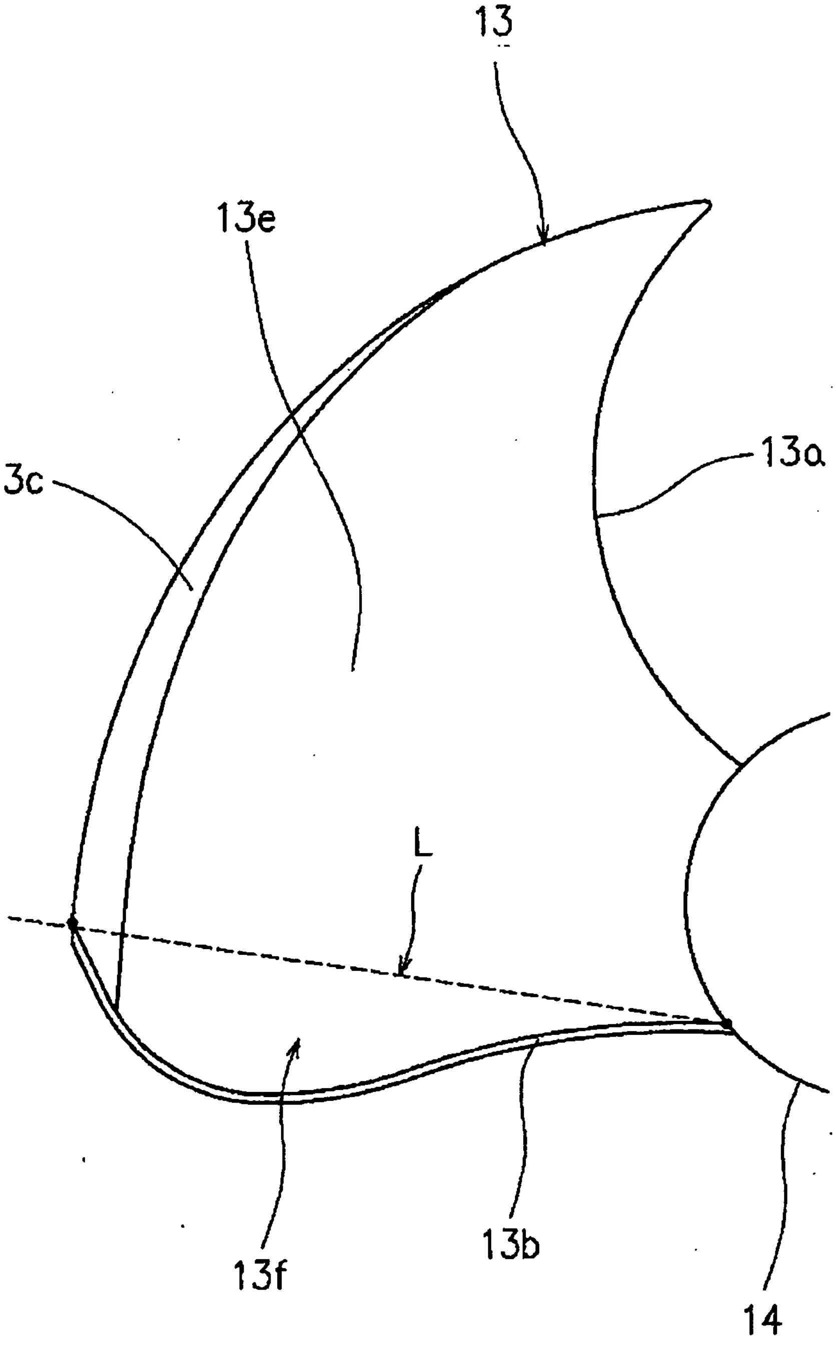


Fig.6

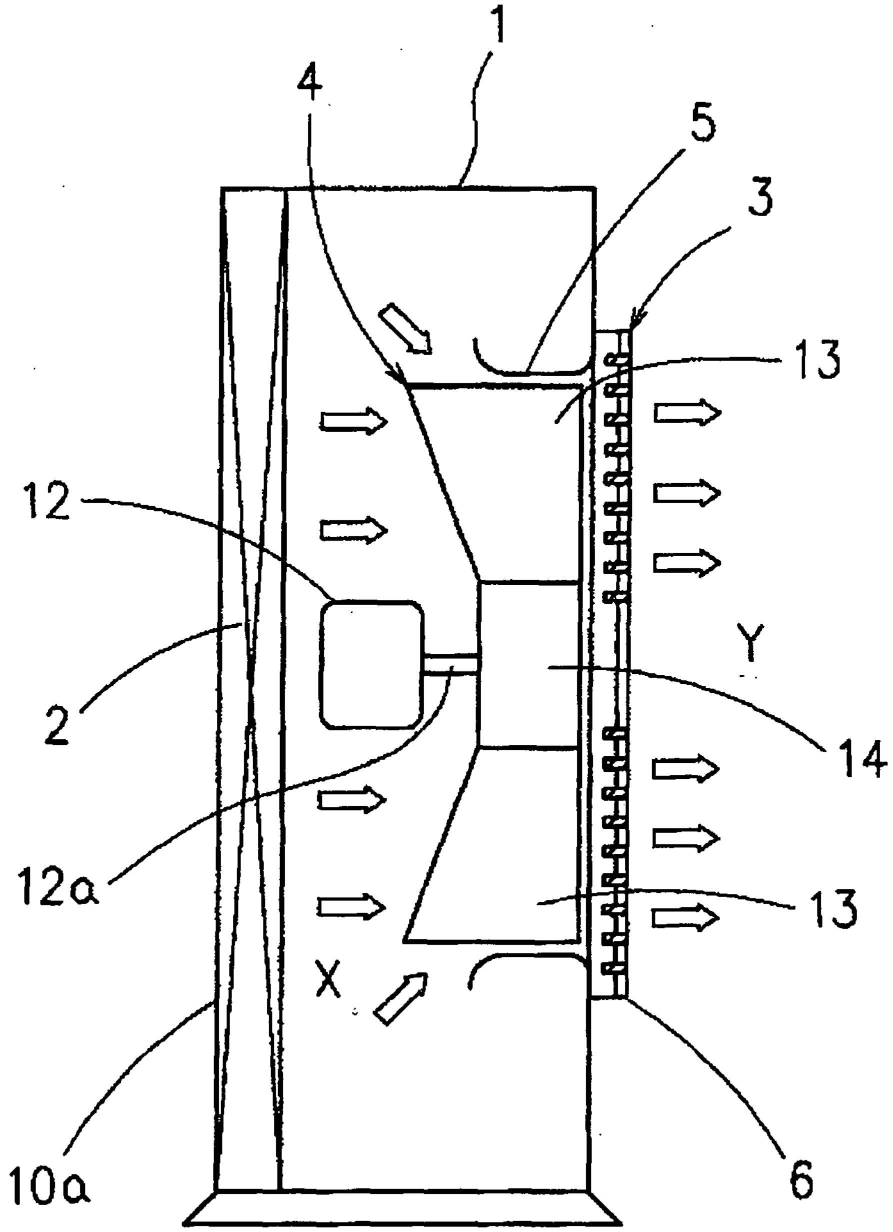


Fig.7

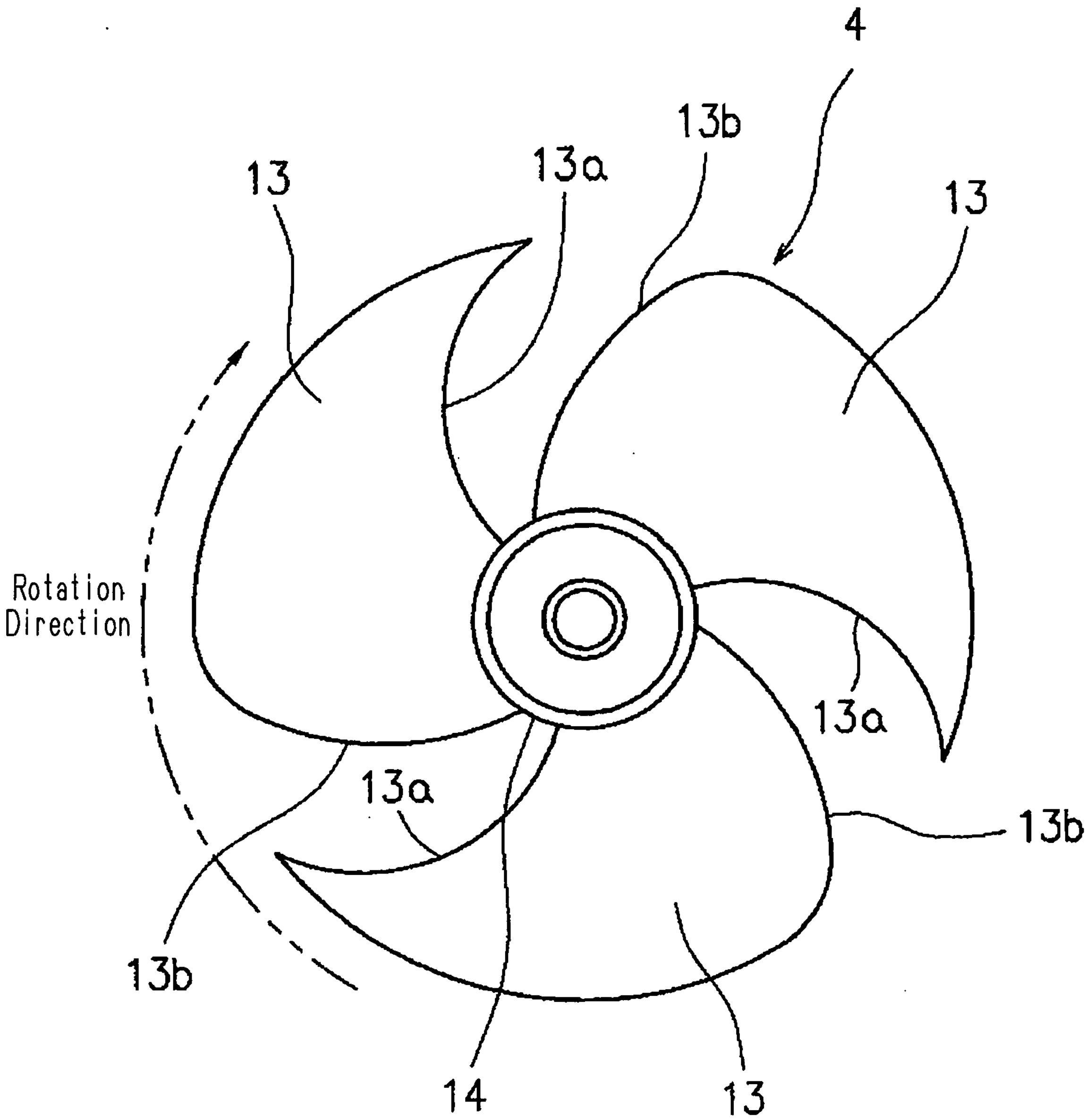


Fig.8

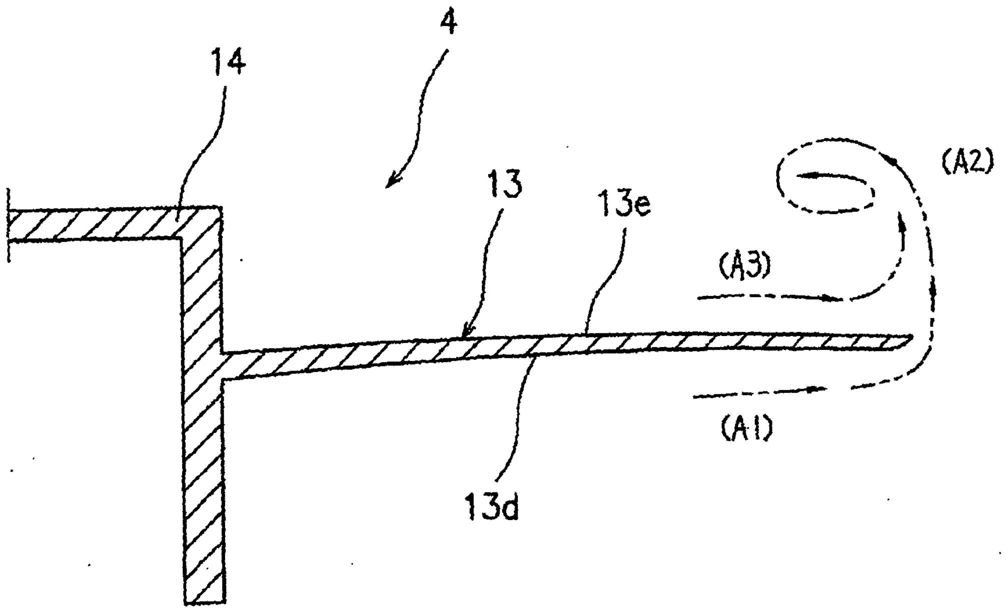


Fig.9

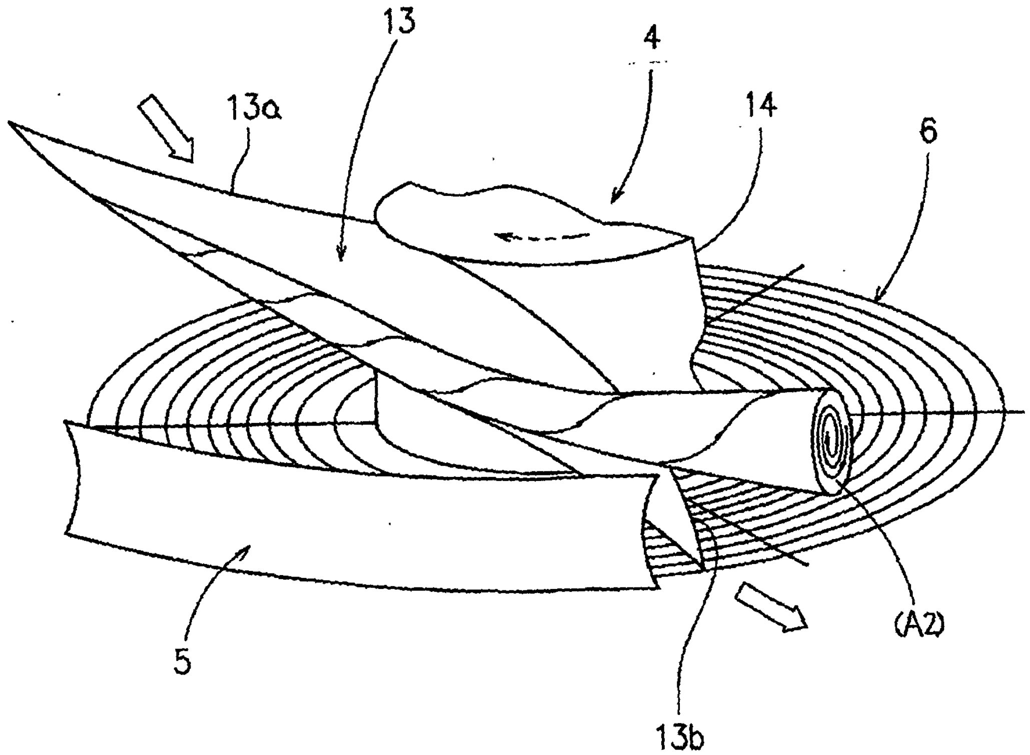


Fig.10

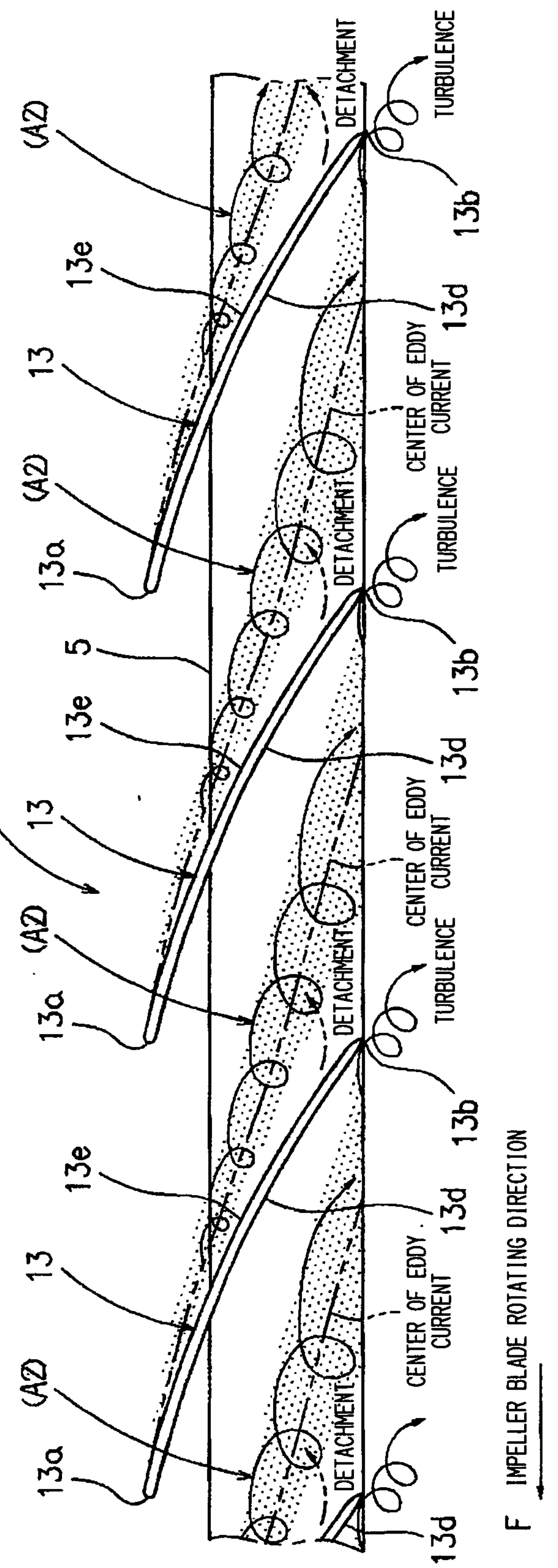

4
5
13
13a
13b
13d
13e
(A2)
DETACHMENT
TURBULENCE
CENTER OF EDDY CURRENT
F IMPELLER BLADE ROTATING DIRECTION

Fig.11

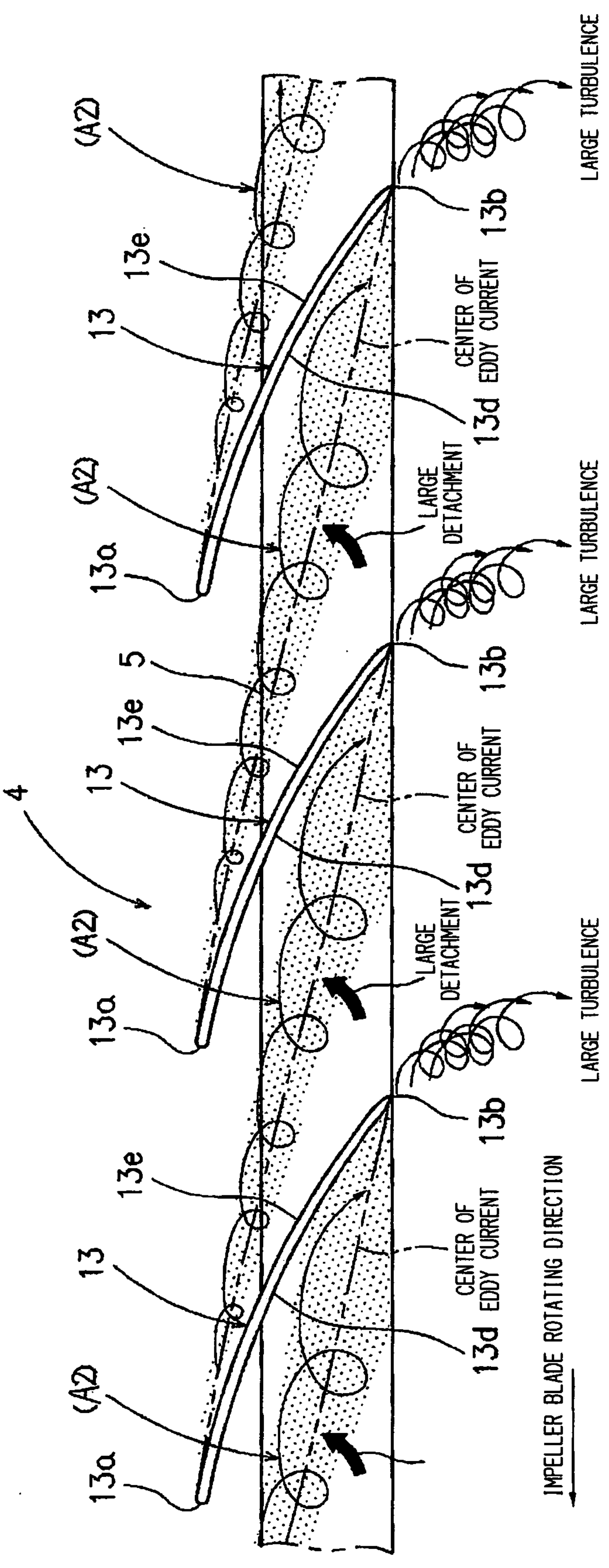

(A2)
13e
13
13a
13b
13d
5
4
CENTER OF EDDY CURRENT
LARGE DETACHMENT
LARGE TURBULENCE
IMPELLER BLADE ROTATING DIRECTION

Fig.12

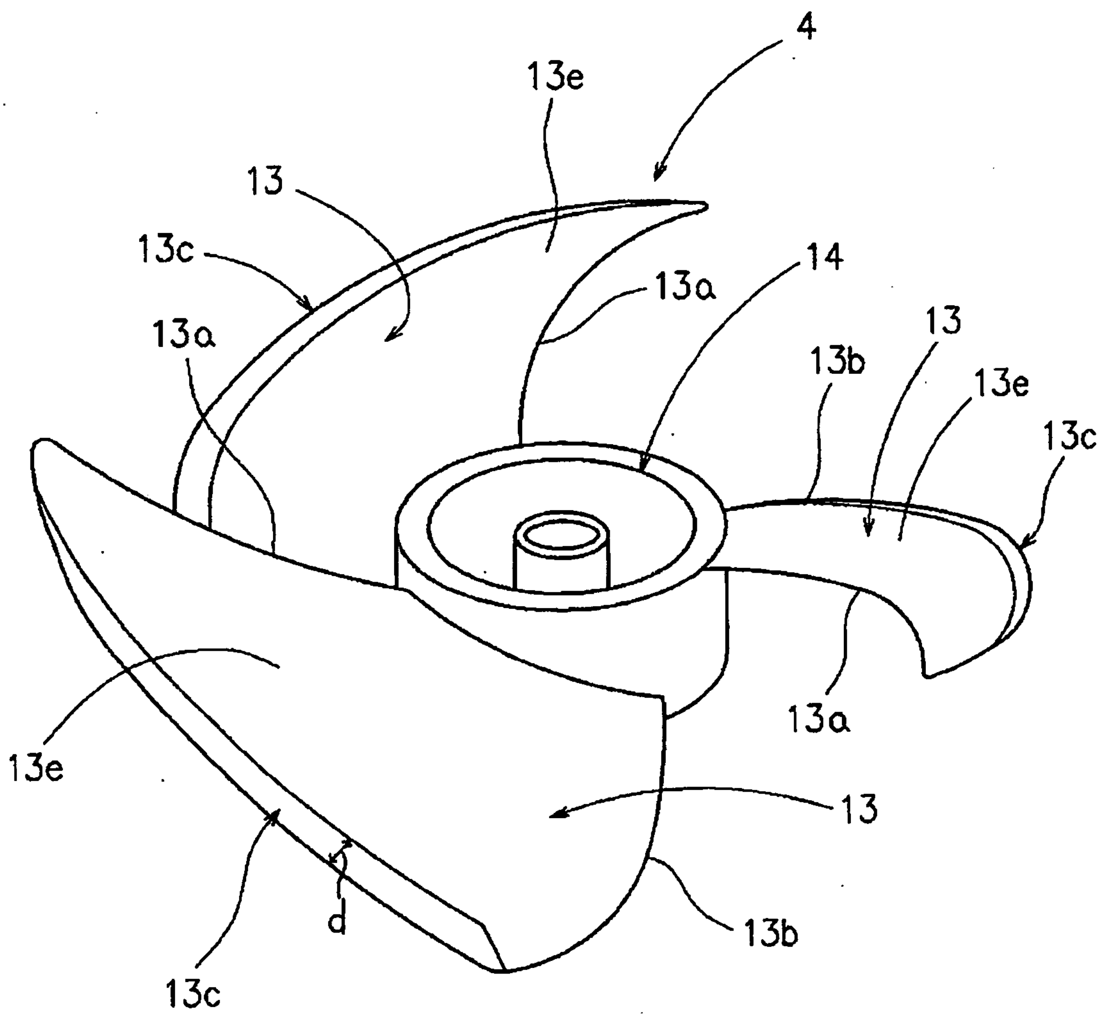


Fig.13

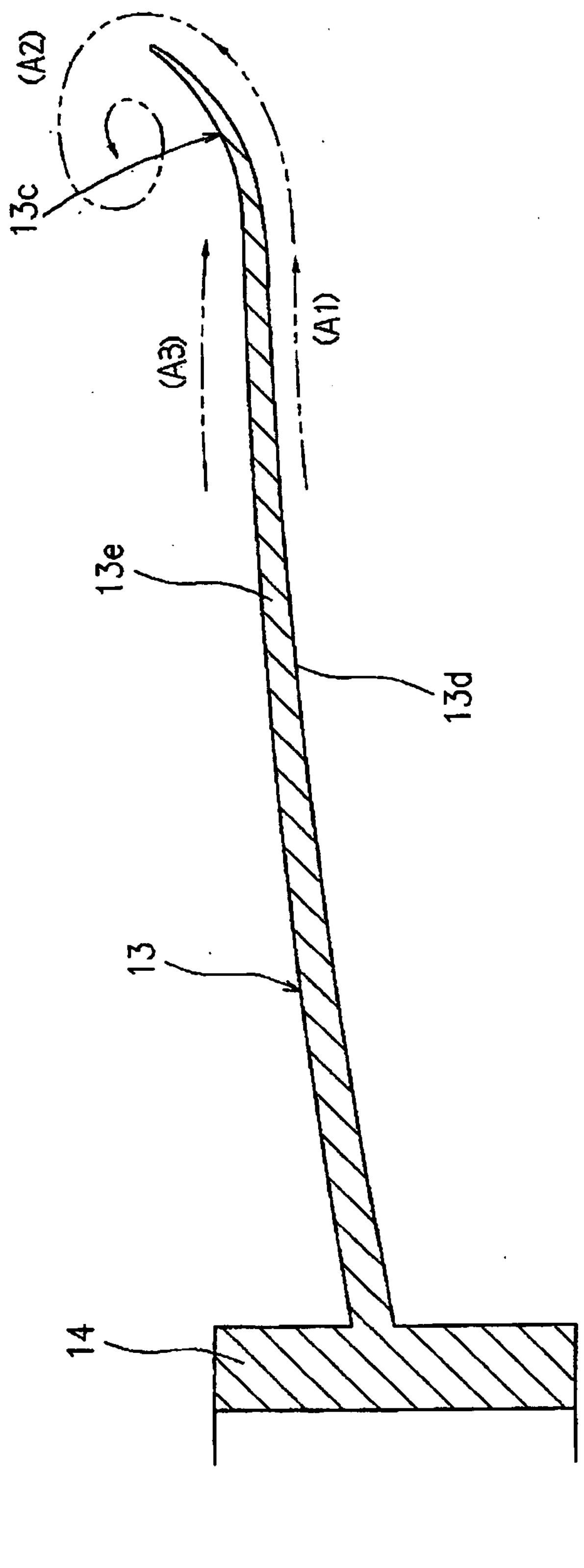


Fig.14

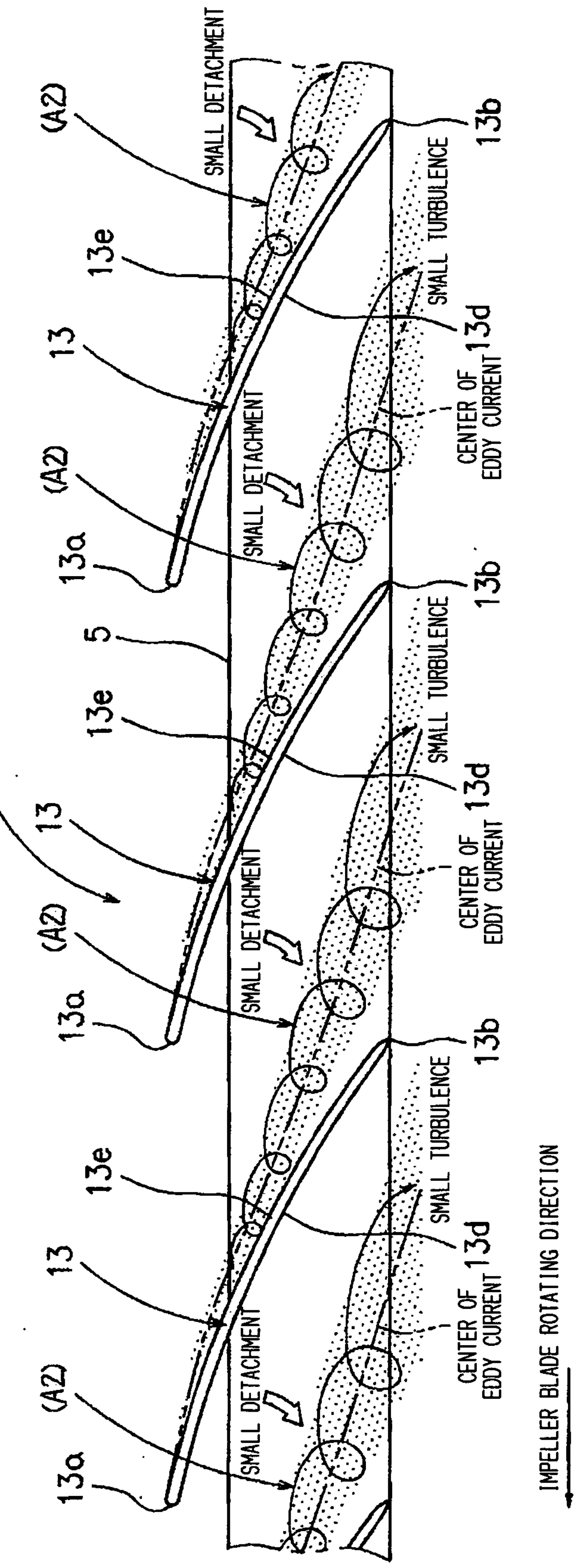
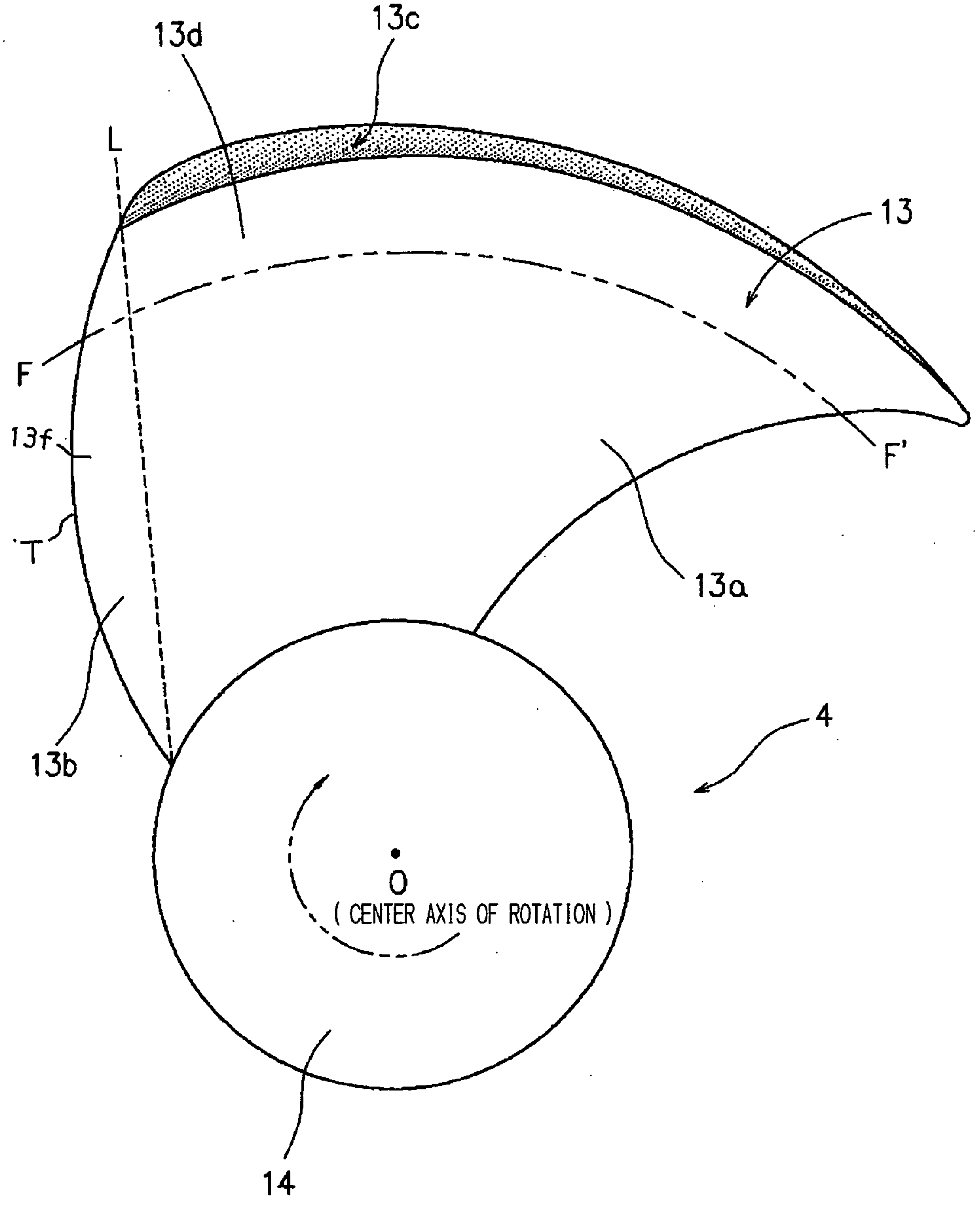

4
5
13
13a
13b
13d
13e
(A2)
SMALL DETACHMENT
SMALL TURBULENCE
CENTER OF
EDDY CURRENT
IMPELLER BLADE ROTATING DIRECTION

Fig.15



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2006/314259

A. CLASSIFICATION OF SUBJECT MATTER
F04D29/38(2006.01)i

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)
F04D29/38

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Jitsuyo Shinan Koho	1922-1996	Jitsuyo Shinan Toroku Koho	1996-2006
Kokai Jitsuyo Shinan Koho	1971-2006	Toroku Jitsuyo Shinan Koho	1994-2006

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.
Y	JP 2005-105865 A (Daikin Industries, Ltd.), 21 April, 2005 (21.04.05), Par. Nos. [0018] to [0020]; Figs. 1 to 4 (Family: none)	1-5
Y	JP 2002-357197 A (Matsushita Refrigeration Co.), 13 December, 2002 (13.12.02), Par. Nos. [0021] to [0027]; Figs. 1 to 3, 12 (Family: none)	1-5
Y	JP 6-159290 A (Valeo Thermique Moteur), 07 June, 1994 (07.06.94), Par. Nos. [0051] to [0055]; Figs. 12, 16 & US 5393199 A & EP 0583091 A2	1-5

☒ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:
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"O" document referring to an oral disclosure, use, exhibition or other means
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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
08 August, 2006 (08.08.06)	22 August, 2006 (22.08.06)

Name and mailing address of the ISA/	Authorized officer
Japanese Patent Office	
Facsimile No.	Telephone No.

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2006/314259

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 2000-18194 A (Daikin Industries, Ltd.), 18 January, 2000 (18.01.00), Par. No. [0020]; Fig. 3 (Family: none)	3

Form PCT/ISA/210 (continuation of second sheet) (April 2005)

REFERENCES CITED IN THE DESCRIPTION

Patent documents cited in the description

- JP 3629702 B **[0011]**