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(71) Applicant: **SEIKO ELECTRONIC COMPONENTS LTD.**
30-1, Nishitaga 5-chome
Sendai-shi Miyagi(JP)

(72) Inventor: **Nanbu, Kenichi**
1-1 Katahira 2-chome
Sendai-shi Miyagi(JP)
Inventor: **Ishida, Takashi**
30-1, Nishitaga 5-chome
Sendai-shi Miyagi(JP)
Inventor: **Hirama, Hideo**
30-1, Nishitaga 5-chome
Sendai-shi Miyagi(JP)
Inventor: **Kanno, Takuzo**
30-1, Nishitaga 5-chome
Sendai-shi Miyagi(JP)

(74) Representative: **Miller, Joseph et al**
J. MILLER & CO. Lincoln House 296-302 High Holborn
London WC1V 7JH(GB)

(54) Axial flow fan and fan blade therefor.

(57) A fan blade (1) for an axial flow fan, the angle of installation (X,Y,Z) of the fan blade (1) varying radially thereof, the angle of installation (X,Y,Z) being constituted by the angle between a straight line (13) connecting the leading and trailing edges (14,15) of the fan blade (1) on a predetermined cross section (16) of the latter concentric to the axis (5) of a fan adapted to be provided with the fan blade, on the one hand, and a plane (12) perpendicular to the said axis (5),on the other hand, characterised in that the angle of installation (X,Y,Z) is at its maximum (Y) in relation to a said cross section (17) which is between the radially inner and outer ends of the fan blade (1).

FIG.4

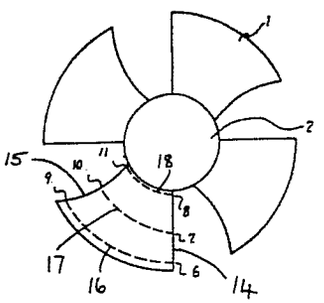
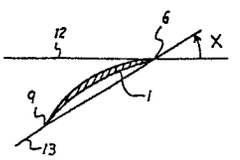


FIG.5



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"AXIAL FLOW FAN AND FAN BLADE THEREFOR"

This invention concerns an axial flow fan and a fan blade therefor.

An axial flow fan is known having a hub provided with a plurality of fan blades each of whose angle of installation varies radially thereof, the angle of installation being constituted by the angle between a straight line connecting the leading and trailing edges of the respective fan blade on a predetermined cross section of the latter concentric to the axis of the fan, on the one hand, and a plane perpendicular to the said axis on the other hand. In the known fan, the angle of installation of each blade increases gradually in a radially inward direction but this makes it difficult to achieve an air flow which is equally spread over each fan blade.

According, therefore, to the present invention, there is provided a fan blade for an axial flow fan, the angle of installation of the fan blade varying radially thereof, the angle of installation being constituted by the angle between a straight line connecting the leading and trailing edges of a fan blade on a predetermined cross section of the latter concentric to the axis of a fan adapted to be provided with the fan blade, on the one hand, and a plane perpendicular to the said axis, on the other hand, characterised in that the angle of installation is at its maximum in relation to a said cross section which is between the radially inner and outer ends of the fan blade.

Preferably the distance between the said leading and trailing edges of the fan blade is at its greatest between the radially inner and outer ends of the fan blade.

In one embodiment, the width of the blade at its radially inner end is greater than at its radially outer end.

The invention also comprises an axial flow fan having a hub provided with a plurality of fan blades each of whose angle of installation varies radially thereof, the angle of installation being constituted by the angle between a straight line connecting the leading and trailing edges of the respective fan blade on a predetermined cross section of the latter concentric to the axis of the fan, on the one hand, and a plane perpendicular to the said axis, on the other hand, characterised in that the angle of installation of each fan blade is at its maximum in relation to a cross section which is between the radially inner and outer ends of the respective fan blade.

The fan blades may be mounted within a fan casing.

The fan casing may comprise a block having a centrally disposed cylindrical aperture extending therethrough, the fan blades being disposed in the cylindrical aperture. There may also be a motor which is secured to and externally of the said block.

In one form of the invention, the fan casing comprises a duct. The duct is preferably venturi-shaped, the fan blades being disposed at the throat of the venturi-shaped duct.

The invention is illustrated, merely by way of example, in the accompanying drawings, in which:-

Figure 1 is a perspective view of a known axial flow fan,

Figure 2 is a cross-sectional view of the known axial flow fan,

Figure 3 is a perspective view of a first embodiment of an axial flow fan according to the present invention,

Figure 4 is a plan view of a rotor portion of the axial flow fan of Figure 3,

Figure 5 is a development of a cylindrical cross section of a fan blade of the axial flow fan of Figures 3 and 4,

Figure 6 is a perspective view of a rotor of a second embodiment of an axial flow fan according to the present invention,

Figure 7 is a perspective view of a rotor of a third embodiment of an axial flow fan according to the present invention,

Figure 8 is a perspective view of a fourth embodiment of an axial flow fan according to the present invention,

Figure 9 is a perspective view of a fifth embodiment of an axial flow fan according to the present invention,

Figure 10 is a perspective view of a sixth embodiment of an axial flow fan according to the present invention;

Figure 11 is a perspective view of a seventh embodiment of an axial flow fan according to the present invention, and

Figure 12 is a perspective view of an eighth embodiment of an axial flow fan according to the present invention.

A known axial flow fan comprises, as shown in Figures 1 and 2, a motor 3 which rotates, with respect to the axis of a rotor shaft 5, a rotor portion of the fan consisting of a hub 2 having a plurality of fan blades 1. The fan comprises a fan casing 4 which holds the motor 3 and accommodates the rotor portion.

In Figure 3 there is shown a first embodiment of an axial flow fan which is generally similar to that of Figures 1 and 2 but which has fan blades 1 whose angles of installation differ from those of Figures 1 and 2. The meaning of the term "angle of installation" is explained with reference to Figures 4 and 5, Figure 4 being a plan view of the rotor portion of the axial flow fan of Figure 3, and Figure 5 being a development of a cylindrical cross section of a fan blade thereof with respect to the rotor shaft 5.

A straight line 12 represents a plane which passes through a point 6 on the leading edge 14 of a fan blade 1, the plane being perpendicular to the axis of the rotor shaft 5. The point 6 is on a cylindrical cross section 16 which is concentric to the axis of the rotor shaft 5. A straight line 13 connects the point 6 with a point 9 on the trailing edge 15 of the fan blade 1, the point 9 being on the cross section 16. The angle formed by the two straight lines 12, 13 is represented by X which is designated as the "angle of installation". Similarly, an angle of installation Y is defined by the relationship between a leading edge point 7 and a trailing edge point 10 on a cross section 17, and an angle of installation Z is defined by the relationship between a leading edge point 8 and a trailing edge point 11 on a cross section 18.

In the known axial flow fan shown in Figures 1 and 2, in order to allow the air flow to be efficiently produced by the fan blades 1, the angle of installation of each fan blade 1 is made to increase gradually from the outer circumference of the fan blade 1 toward the inner circumference thereof. Thus in the known axial flow blades $X \leq Y \leq Z$ in accordance with the air velocity produced by rotation of the fan on the assumption that air flows equally between the inner and outer circumference of each fan blade 1.

In the known axial flow fan, however, the actual direction of the air flow cannot be made to turn at the portion between the inner end of the fan casing 4 and the hub 2 at which the air flow narrows, and vortices are therefore generated around the fan blades 1.

The fan blades 1 are generally capable of expelling an amount of air which is large relative to an increment in the angle of installation, but the above-mentioned generation of vortices or disturbance in the air flow leads to a deterioration in the air flow efficiency, which in turn leads to an increase in the load on the fan. Furthermore, the air flow is inverted through the gap between the fan casing 4 and fan blades 1 as a result of the differences in pressure, so that it is difficult to achieve the desired air flow which is equally spread over the whole of each fan blade from its radially inner end to its radially outer end. This is because the load increases to a greater extent than any increase in the air flow rate, that is, the efficiency of the axial flow fan deteriorates.

Furthermore, the above generation of vortices produces a problem of noise, and this problem has an adverse effect on the environment where the fan is installed.

In the case of each of the fan blades 1 of the axial flow fan shown in Figure 3, however, the angle of installation is at its maximum Y in relation to the cross section 17 which is between the radially inner and outer ends of the fan blade. That is, the angle of installation is larger at a central portion of the blade than that at the inner end and the outer end thereof.

Such an arrangement produces a desired air flow that varies at different portions of the fan blades in a suitable manner, as well as producing improved efficiency and a reduction in the noise level.

Thus, in the case of the present invention, the relationship between the angles of installation X, Y and Z of the inner portion, central portion and outer portion of each fan blade 1 of the axial flow fan is $X<Y$, $Z<Y$.

The axial flow fan shown in Figure 3 has fan blades 1 such that the rotational load is reduced by virtue of a reduction in the angle of installation at the inner portion and the outer portion of each fan blade for the purpose of decreasing the projected area of the fan blade 1 in the direction of rotation of the motor 3. Furthermore, the angle of installation can be arranged to be such as to prevent the generation of vortices.

On the other hand, the angle of installation at a central portion of each fan blade 1 can be arranged to be relatively large because the air flow is smoother here than at the inner and outer ends thereof. This allows a relatively large quantity of air to be caused to flow at this central portion, so compensating for the air flow at the inner and outer end portions. The generation of vortices is reduced in spite of the large angle of installation.

In the construction shown in Figure 3, the rotor portion of the fan consists of four fan blades 1 carried by the hub 2, the fan casing 4 both providing a mounting for the motor 3 and accommodating the rotor portion. The fan casing 4 is bored with a circular hole which surrounds the rotating fan blades 1. In order to increase the air flow rate and to reduce noise without any increase in the size of the fan, the angle of installation of each fan blade 1 is larger at a central portion thereof than at the outer end portion and inner end portion thereof.

Figures 6 and 7 are perspective views of rotor portions of second and third embodiments respectively of an axial flow fan of the present invention.

Figure 6 illustrates an embodiment in which the length of a blade, i.e. the distance from the front end of a fan blade 1 to the rear end thereof, is arranged to be long at the central portion thereof without any thickness restriction in the vertical direction in contrast to the embodiment shown in Figure 3, whereby to produce a larger air flow rate. That is to say, the distance 20 between the leading and trailing edges 14, 15 of each fan blade 1 is at its greatest between the radially inner and outer ends of the fan blade 1.

Figure 7 illustrates an embodiment in which eight fan blades 1 are provided although more fan blades can be provided, if desired. Furthermore, in the construction of Figure 7, the diameter of the hub portion 2 is small and this assists in producing a large air flow and a relatively thin fan.

Figure 8 is a perspective view of a fourth embodiment of the present invention, wherein the fan casing 4 is formed as a block 21 having the shape of a rectangular parallelopiped. This enables a large difference in pressure to be obtained because the direction of the air flow is restricted in the direction of the thickness of the device, and as a result the inverted flow can be thus restricted. In this case, the construction has the advantage of restricting the air flow to a greater extent than in the other cases, the known type of fan being inferior in this respect. The block 21 has a centrally disposed cylindrical aperture 22 extending therethrough, the fan blades 1 being disposed in the cylindrical aperture 22.

Figure 9 illustrates a fifth embodiment in which, the fan casing 4, shown in Figure 8, is reduced in size for the purpose of cost reduction, although the fan casing 4 can be completely cut out if desired.

Figure 10 illustrates a sixth embodiment in which the fan casing is constituted by a block or "ring" 23 which is arranged around the fan blades 1 and to which the motor 3 (not shown in Figure 10) can be secured externally.

Figure 11 illustrates a seventh embodiment in which the fan casing 4 is substantially omitted, i.e. reduced to a minimum, and in which the length of each fan blade 1 becomes shorter in the direction of movement from the inside to the outside, for the purpose of improvement in the efficiency at the outer portion, the improved efficiency being similar to that achieved by the reduction of the angle of installation. That is to say, the width 24 of each fan blade 1 at its radially inner end or root is greater than at its radially outer end.

Figure 12 illustrates an eighth embodiment in which the fan casing 4 comprises a Venturi-shaped duct 25, for the purpose of making the air flow smooth, as a result of which there is an improvement in efficiency. In this construction, the fan blades 1 are disposed at the throat of the venturi-shaped duct 25.

As hereinbefore described, the efficiency of an axial flow fan is improved, and the noise level thereof is reduced by reducing the generation of vortices by arranging that the angle of installation of each fan blade 1 is greater at the central portion thereof than at the radially inner and outer portions thereof.

Claims

1. A fan blade (1) for an axial flow fan, the angle of installation (X,Y,Z) of the fan blade (1) varying radially thereof, the angle of installation (X,Y,Z) being constituted by the angle between a straight line (13) connecting the leading and trailing edges (14,15) of the fan blade (1) on a predetermined cross section (16) of the latter concentric to the axis (5) of a fan adapted to be provided with the fan blade, on the one hand, and a plane (12) perpendicular to the said axis (5),on the other hand, characterised in that the angle of installation (X,Y,Z) is at its maximum (Y) in relation to a said cross section (17) which is between the radially inner and outer ends of the fan blade (1).

2. A fan blade as claimed in claim 1 characterised in that the distance (20) between the said leading and trailing edges (14,15) of the fan blade (1) is at its greatest between the radially inner and outer ends of the fan blade (1).

3. A fan blade as claimed in claim 1 characterised in that the width (24) of the blade at its radially inner end is greater than at its radially outer end.

4. An axial flow fan having a hub (2) provided with a plurality of fan blades (1) each of whose angle of installation (X,Y,Z) varies radially thereof, the angle of installation (X,Y,Z) being constituted by the angle between a straight line (13) connecting the leading and trailing edges (14,15) of the respective fan blade (1) on a predetermined cross section of the latter concentric to the axis (5) of the fan, on the one hand, and a plane (12) perpendicular to the said axis (5), on the other hand, characterised in that the angle of installation (X,Y,Z) of each fan blade (1) is at its maximum (Y) in relation to a said cross section which is between the radially inner and outer ends of the respective fan blade (1).

5. An axial flow fan as claimed in claim 4 characterised in that the width (24) of each fan blade (1) at its radially inner end is greater than at its radially outer end.

6. An axial flow fan as claimed in claim 4 characterised in that the distance (20) between the leading and trailing edges (14,15) of each fan blade (1) is at its greatest between the radially inner and outer ends of the respective fan blade (1).

7. An axial flow fan as claimed in any of claims 4-6 characterised in that the fan blades (1) are mounted within a fan casing (4).

8. An axial flow fan as claimed in claim 7 characterised in that the fan casing comprises a block (21) having a centrally disposed cylindrical aperture (22) extending therethrough, the fan blades (1) being disposed in the cylindrical aperture (22).

9. An axial flow fan as claimed in claim 8 characterised in that the fan comprises a motor (3) which is secured to and externally of the said block (23).

10. An axial flow fan as claimed in claim 7 characterised in that the fan casing comprises a duct (25).

11. An axial flow fan as claimed in claim 10 characterised in that the duct (25) is venturi shaped, the fan blades (1) being disposed at the throat of the venturi-shaped duct (25).

12. An axial flow fan having a motor (3) which rotates a rotor portion consisting of a plurality of fan blades (1) and a hub (2), and a case (4) which holds the motor (3) and accommodates said rotor portion, the axial flow fan being characterised in that an angle defined by a straight line (13) connecting the two opposite edges of the fan on a cross section cut through the fan concentrically relative to a rotor shaft (5), on the one hand, and a plane (12) perpendicular to said rotor shaft (5), on the other, is arranged in such a manner that it is at its maximum at a location between the outer edges of said fan blade and the inner edge thereof.

13. An axial flow fan comprising a motor (3) which is rotatable about a rotor axis (5), the motor (3) including a rotor part having a hub (2) provided with a plurality of fan blades (1) and an angle of installation of the fan blades (1) being larger at a centre portion than that at the inner end and the outer end; and fan casing means (4) which holds the motor (3).

14. An axial flow fan comprising a motor (3) which is rotatable with respect to a rotor axis (5), the motor (3) including a rotor part having a hub (2) and a plurality of fan blades (1), the relationship between X, Y and Z being arranged to be $X<Y$, $Z<Y$, wherein X, Y and Z are the angles of installation of the inner portion, a central portion and the outer portion of the fan blade, respectively; and fan casing means (4) which holds the motor (3) and accommodates the rotor part.

FIG. 1 PRIOR ART

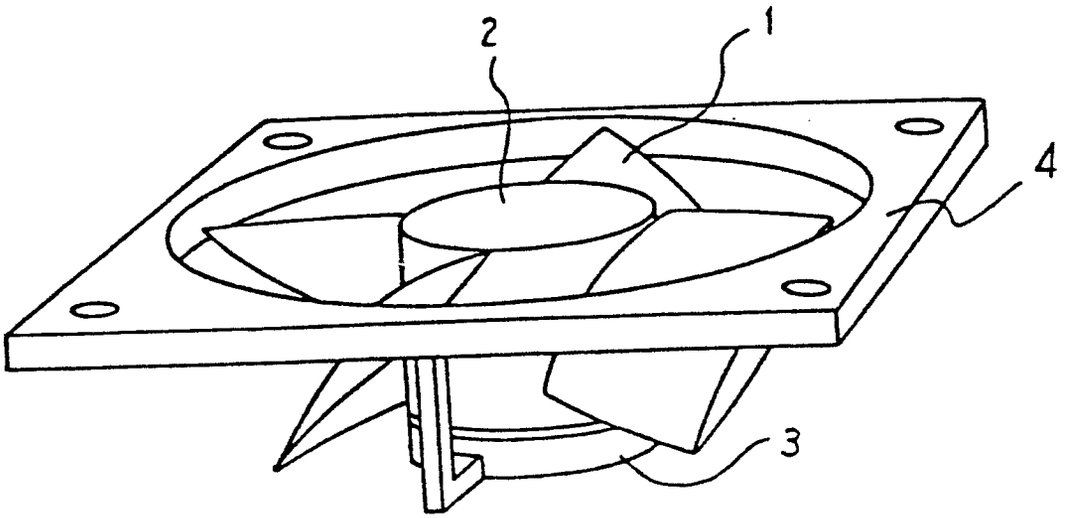

FIG. 2 PRIOR ART

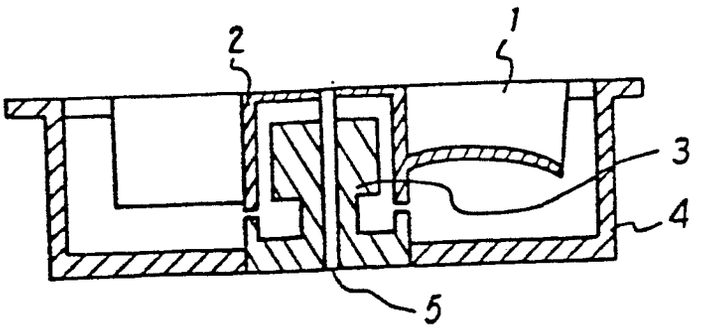

FIG. 3

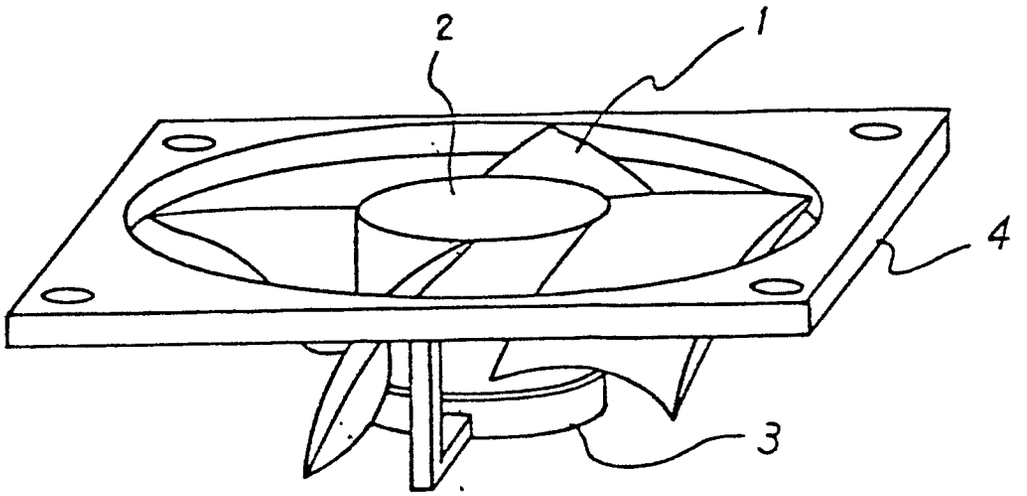

FIG.4

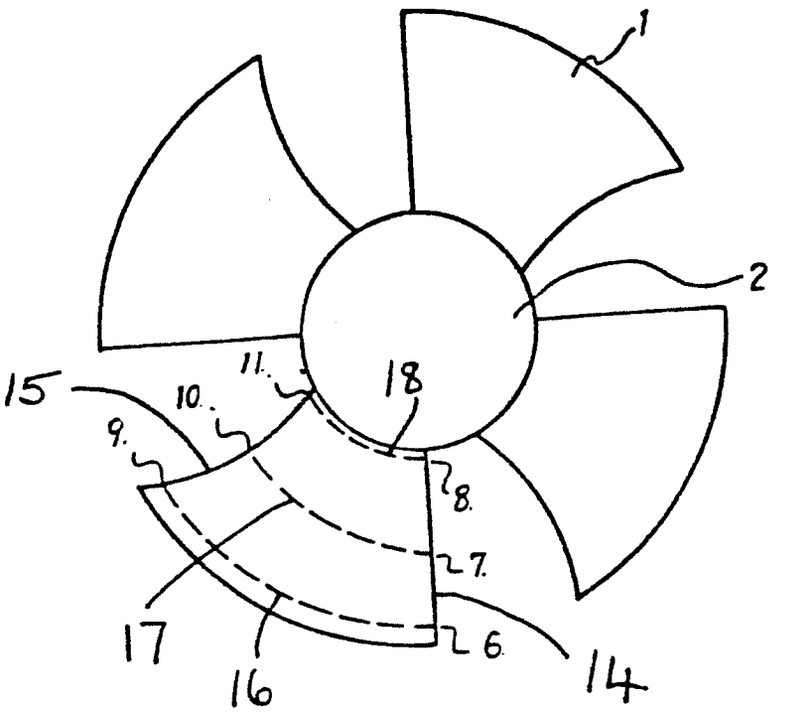

FIG.5

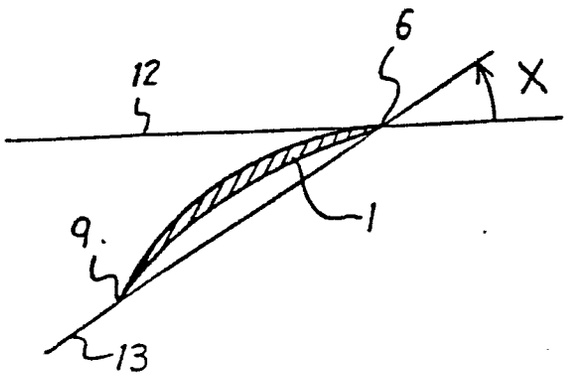

FIG.6

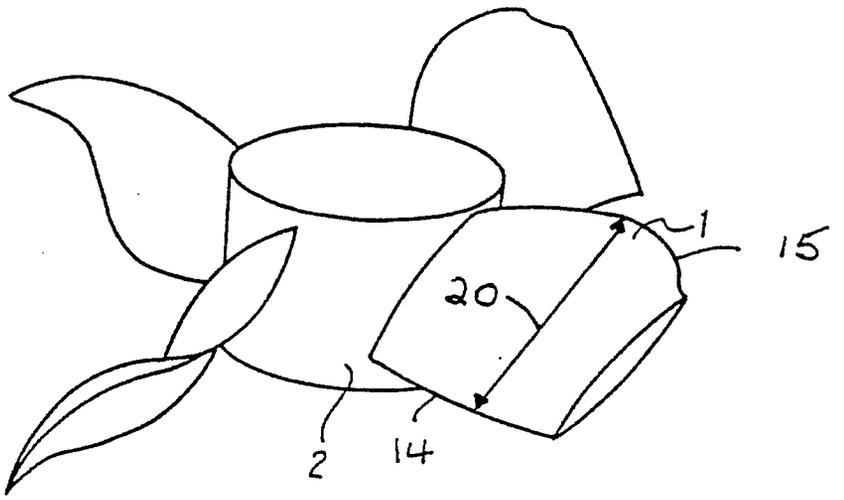

FIG.7

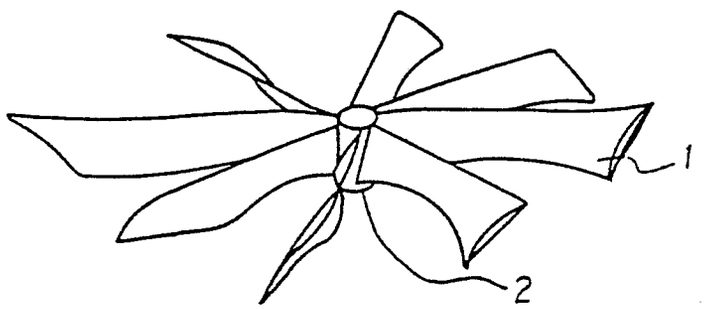

FIG.8

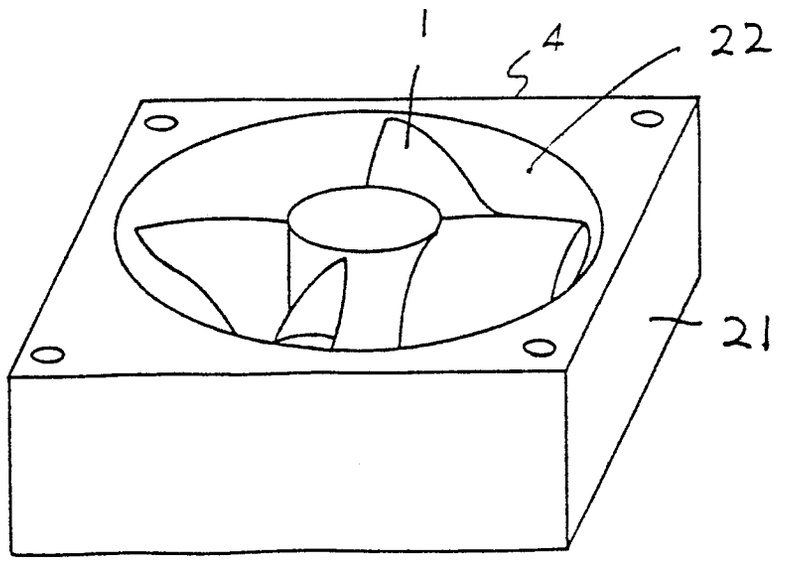

FIG.9

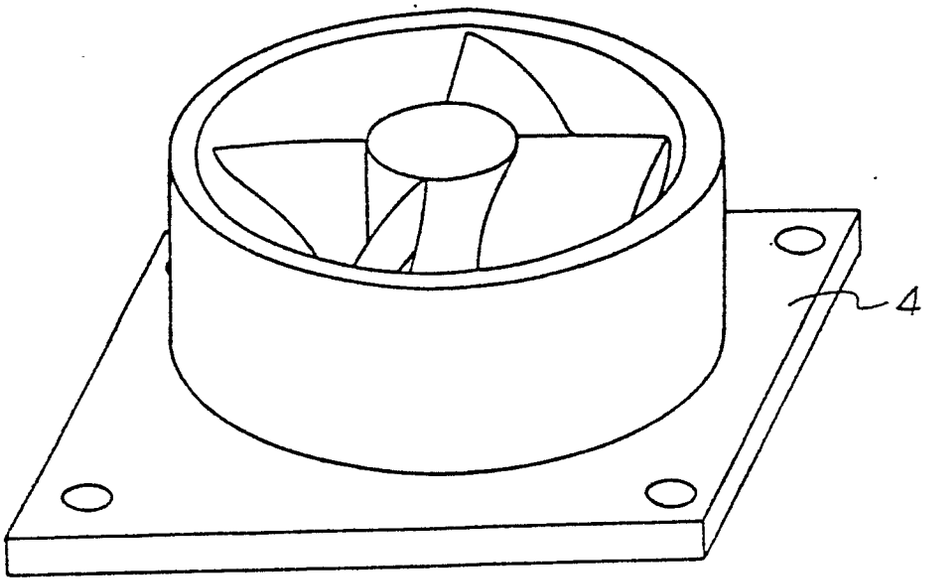

FIG.10

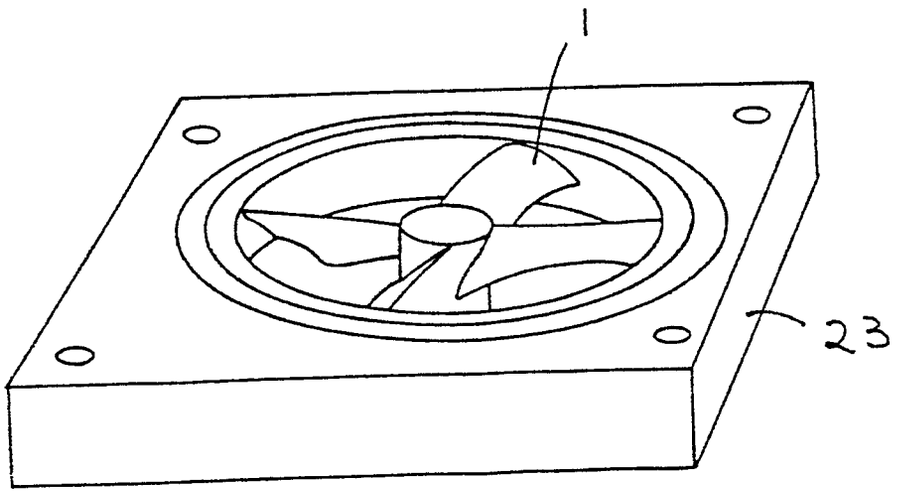

FIG.11

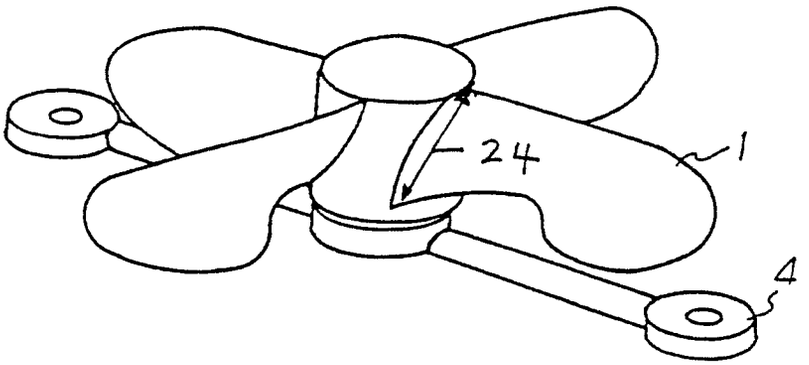

FIG.12