

July 7, 1964

NORIYOSHI FUJII
WHEELS FOR CENTRIFUGAL FANS OF THE FORWARD
CURVED MULTI-BLADE TYPE

3,140,042

Filed Aug. 15, 1961

5 Sheets-Sheet 1

Fig. 1

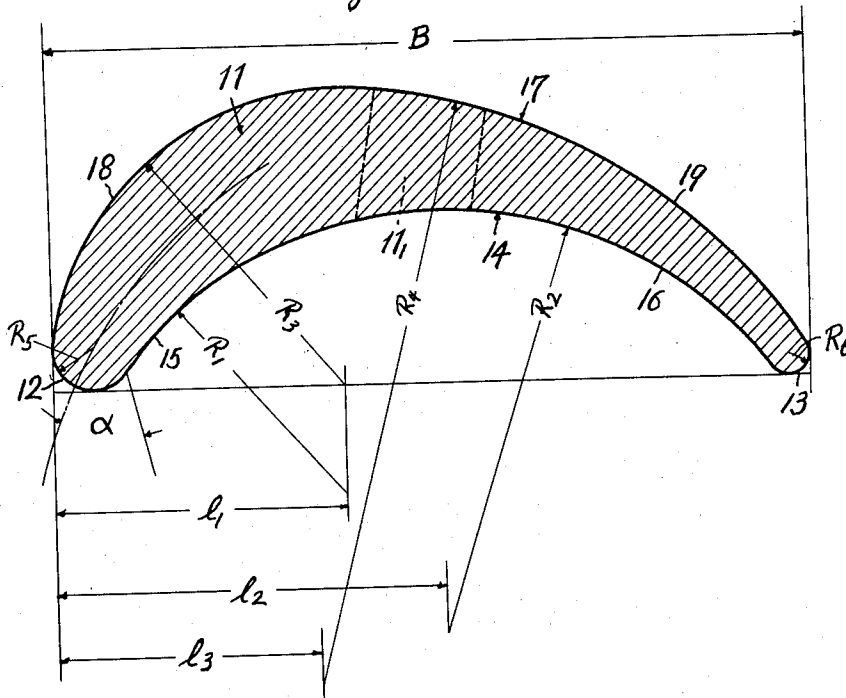
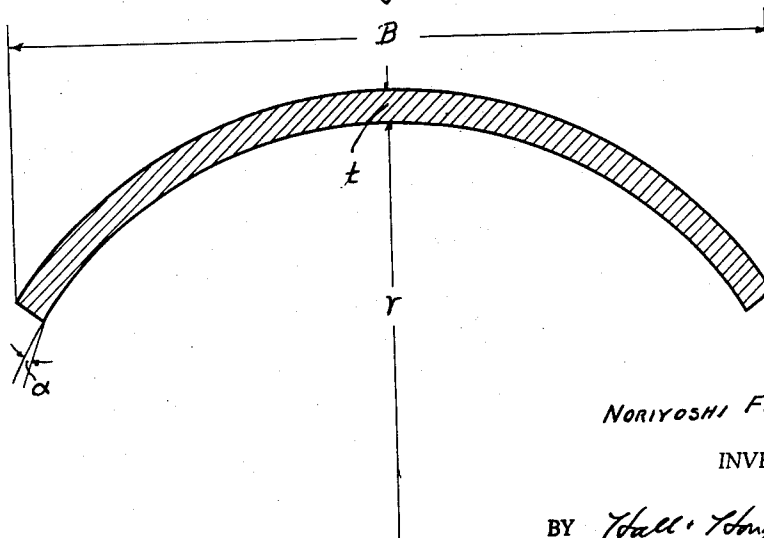


Fig. 2



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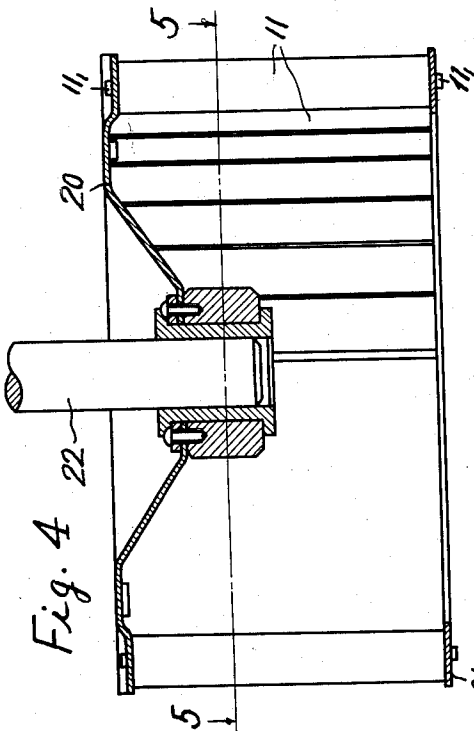
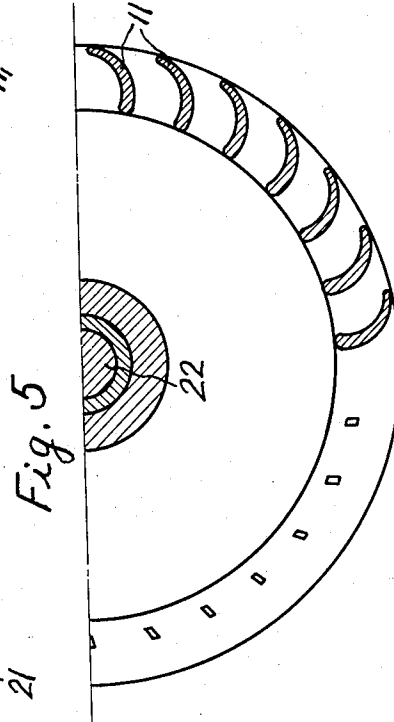
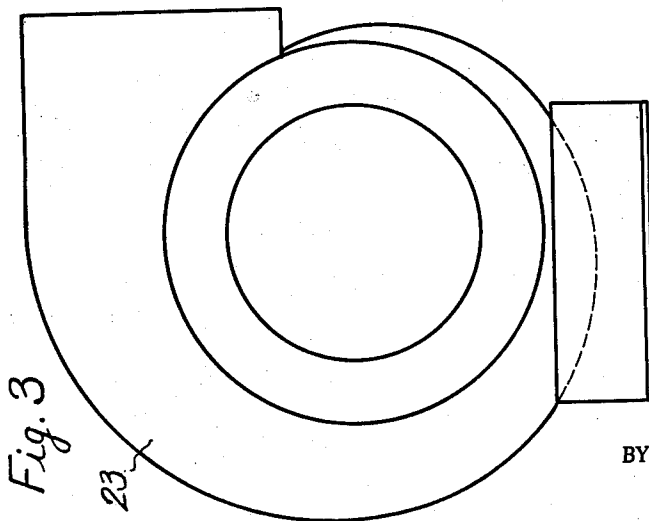
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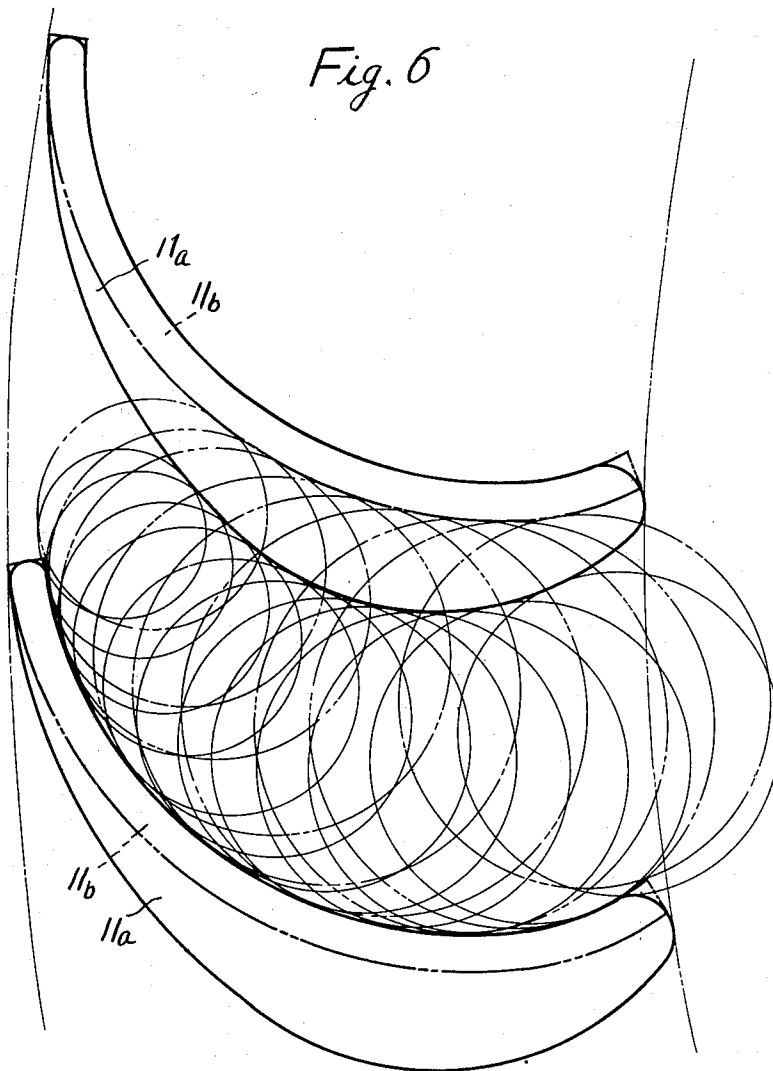
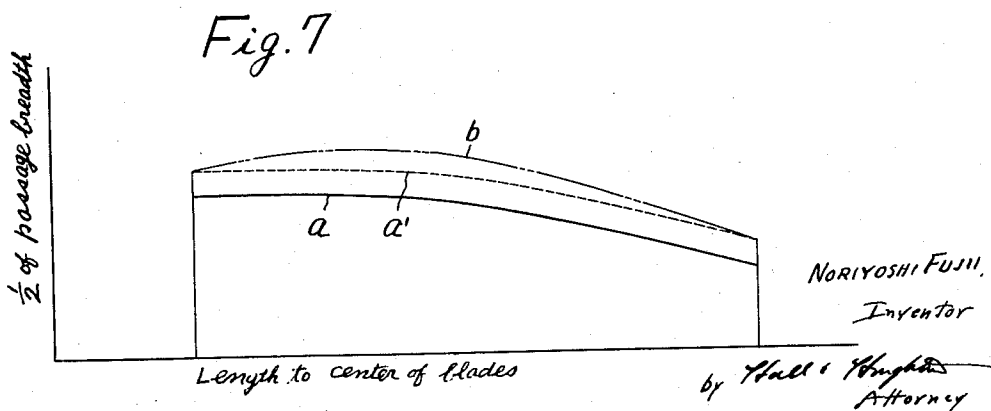
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Fig. 8

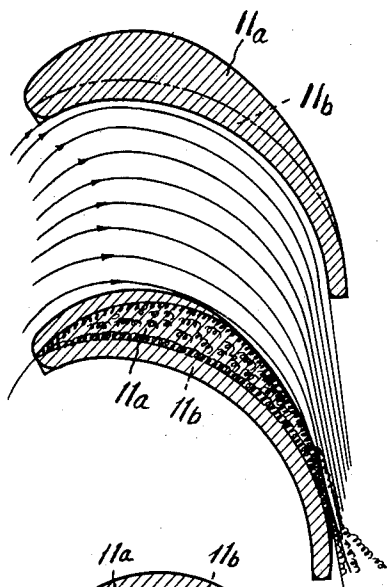
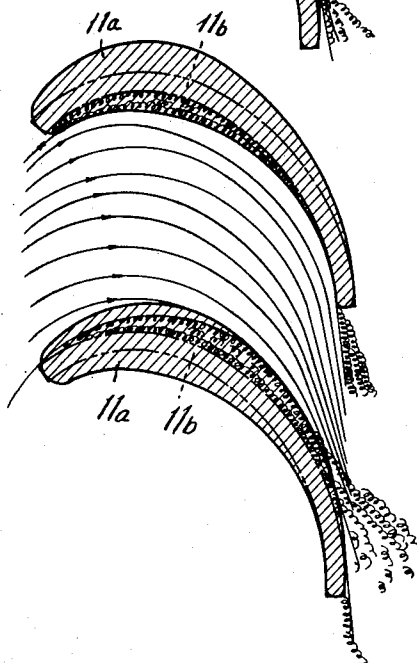


Fig. 9



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Fig. 10

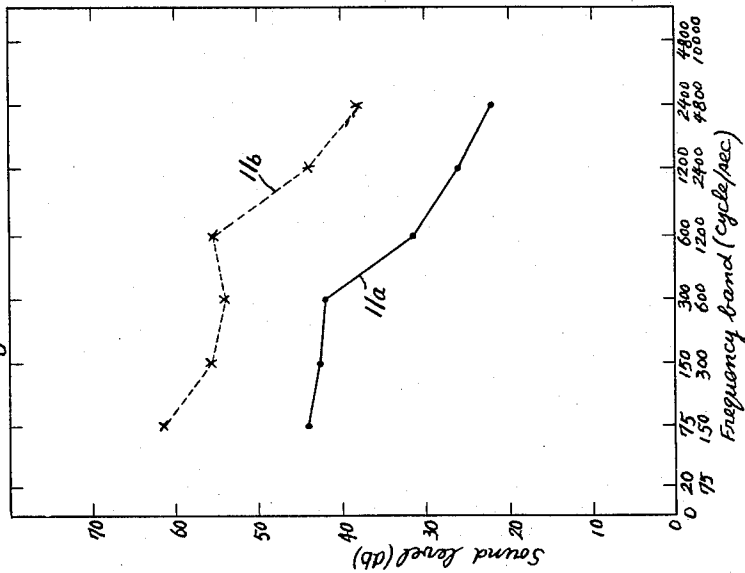
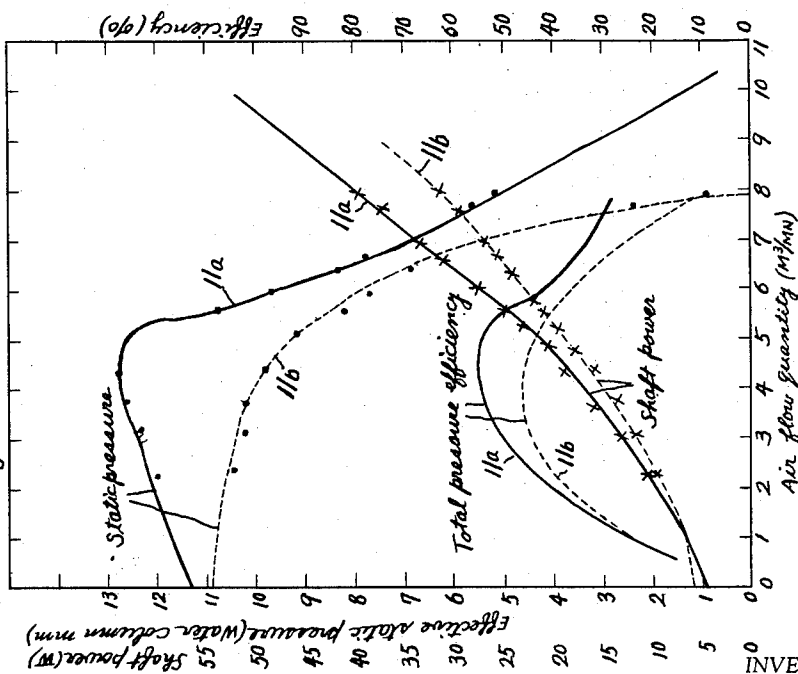


Fig. 11



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WHEELS FOR CENTRIFUGAL FANS OF THE FORWARD CURVED MULTIBLADE TYPE

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Filed Aug. 15, 1961, Ser. No. 131,600

1 Claim. (Cl. 230-134)

This invention relates to centrifugal fans of the forward curved multiblade type, and, more particularly, to wheels for centrifugal fans of the forward curved multiblade type of small size for heating, cooling or ventilation. With this type of fan it is most essential that the noise should be as low as possible, and the object of the present invention is to provide means of at once lessening the noise and increasing the efficiency of fans of this type.

In the past, each blade of a centrifugal fan of the forward curved multiblade type has been made of a metal plate which is bent in a shallow gutter shape approximately conforming to air flow in and out. But, according to this type of blade, its concave front and convex back are of identical curvature, that is, it forms concentric circular arcs in section, and the curvature itself being hydrodynamically imperfect, a passage between adjacent blades does not conform to the air current therethrough. Furthermore, at the middle of the passage is formed an enlarged part, generating break away of air flow on the blade surface together with its turbulence and branching phenomenon. Furthermore, collision of air on the inlet of the passage causes lowering of efficiency and on account of thin blades which cause inflowing loss suddenly to change when the air inlet angle varies the number of revolutions of the fan is confined within very narrow limits. Besides, air slips on the blade cause great slipping loss, and what is more, small blades are hard to manufacture.

The present invention provides a wheel for a centrifugal fan of the forward curved multiblade type of which each blade has its front formed in a shallow gutter shape conforming to air flow in and out of a passage between each two adjacent blades, with the inner edge thereof having a comparatively large curvature. Its back forms such a bulging shape as makes the passage narrower by degrees from the inner end out to the outer end thereof without giving any enlarged part therebetween, and is made of aluminium extruded by an extruding machine.

According to the present invention, not only are the above-mentioned defects of known blades of metal plate all eliminated but blades strict and uniform in form are easily provided in mass-production.

Other and further objects of the present invention will become apparent from the following specification and claim taken together with the accompanying drawings in which is shown the preferred embodiment of the runner of a centrifugal fan of the forward curved multiblade type according to the present invention.

FIG. 1 is a sectional view of a wheel for a centrifugal fan of the forward curved multiblade type embodying the present invention;

FIG. 2 is a sectional view of a wheel of this type heretofore in use;

FIG. 3 is a side view of a centrifugal fan of the forward curved multiblade type provided with a wheel embodying the present invention;

FIG. 4 is a sectional view of the wheel;

FIG. 5 is a sectional view of a part of FIG. 4 on the line 5-5;

FIGS. 6 and 7 are diagrammatic views of an air passage in the wheel according to the present invention in comparison with that in a wheel of a known type;

FIGS. 8 and 9 are sectional views of the air current in the former compared with that in the latter; and

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FIGS. 10 and 11 are comparative diagrams showing the result of a performance test on the two.

In these drawings reference numeral 11 indicates a blade made by extruding a long beam of aluminium of the sectional shape shown in FIG. 1 by an extruding machine and then cutting it in certain prescribed length, each of the cut ends being provided with a projection 11₁ for setting thereof, and the details of its sectional shape are as follows (the units are in millimeters):

$$\begin{aligned} B &= 15.5 \\ R_1 &= 5, R_2 = 8.5, R_3 = 6, R_4 = 12, R_5 = 0.8, R_6 = 0.4 \\ l_1 &= 6, l_2 = 8, l_3 = 5.5 \end{aligned}$$

The sectional shape of the front 14 of the blade 11 consists of two arcs 15 and 16 of radii R_1 and R_2 , approximately forming an arc. The inner edge 12 and the outer edge 13 form arcs of radii R_5 and R_6 and the back 17 consists of an arc 19 of radius R_4 for the most part of it and for the rest of an arc 18 of radius R_3 , which connects the arc 19 and the arc 12 of the inner edge. In this, R_4 being greater than R_2 , the blade gains thickness by degrees from the outer edge inwards. B is the chord length of the blade between the leading and trailing edges thereof and measured along a horizontal line which intersects the lower curved portions of the forward and rearward end portions of the blade. l_1 is a distance which a vertical line is spaced from a first vertical line or the reference line which passes through the very inner edge of the blade, and radii R_1 and R_3 are located along this vertical line which is spaced a distance l_1 from the reference line. In face, radius R_3 is located at the point where this line intersects the horizontal chord B which passes through the lower edges of the blades. l_2 is a distance which another vertical line is spaced from the reference line, and radius R_2 has its center on this line. l_3 is a distance which a further vertical line is spaced from the reference line and radius R_4 has its center on this line. A wheel according to the present invention is constructed by calking the projections 11₁ into holes on a side plate 20 and a circular side plate 21, and numeral 22 indicates a driving shaft and 23 a casing.

The front of each blade being shaped in a shallow gutter shape conforming to air flow in and out of the passage, no slipping loss is caused between air flow and the surface of blade, and so the velocity of the air current is greatly increased. The back of each blade being bulged in a shape gradually narrowing the air passage from the inner end outwards, the passage strictly conforms to the air currents, as is shown in FIGS. 8 and 9, without any expanded part given thereon, and in proportion to the sectional area of the passage decreasing by degrees from the inner end thereof outwards as shown in FIGS. 6 and 7, the air current gradually increases in velocity, so that the air flows with very high velocity out of the outer end of the passage, giving a "nozzle" effect.

Thus much less turbulence, branching flow, or break-away phenomenon is generated in the passage, the noise is kept low and the blowing efficiency increases greatly.

The inner edge of the blade being given comparatively large curvature, changes the air inlet angle which varies in accordance with changes in the number of revolutions of the wheel cause so little inlet collision and loss thereby that a fan can be driven with the number of revolutions of the wheel thereof varied within a wide range. The blades are made of aluminium extruded by an extruder, which enables the mass-production of light and uniform blades strict in form. Besides, these blades, having far greater section modulus than a known type made of metal plate, get enough strength, though made of aluminium, making much less vibrating noise.

FIG. 6 shows an air passage between adjacent blades

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11_a according to the present invention compared with that between known blades 11_b made by bending a metal plate in a shallow gutter shape. Circles in full lines contact with the front of a blade 11_a and the back of the next blade 11_b, and circles in chain lines contact with the front of a blade 11_b and the back of the next blade 11_b. In FIG. 7 is shown a diagram in which a curve *a* of full line denotes radii of circles in full lines in FIG. 6, and a curve *b* of a chain line radii of circles in chain lines in the same, abscissas thereof denoting respectively lengths of straight lines into which the two curves connecting centers of the two groups of circles are converted. This diagram shows that the sectional shape of a passage between blades according to the present invention gradually and evenly narrows in width while that of a passage between known blades is enlarged about at the middle part of it. The curve *a'* denotes curve *a* moved upward in parallel and the area between the curves *a'* and *b* corresponds to the difference of thickness between the blades 11_a and 11_b.

FIGS. 8 and 9 show the air current between blades according to the present invention in comparison with that between known type blades made by bending a metal plate into a shallow gutter shape. Blades according to the present invention 11_a are drawn in full lines and blades of a known type 11_b are in chain lines. In FIG. 8 blades 11_b are placed just inside the fronts of the blades 11_a and on the back of the blade 11_b is generated turbulence of air flow, and in FIG. 9 wherein blades 11_b are placed in the middle of blades 11_a, turbulence of air flow is generated on both the front and the back of each blade 11_b. These turbulences are lost to blades 11_a, with the thickened parts thereof filling the spaces to generate turbulences.

FIGS. 10 and 11 show the result of a comparative performance test of a centrifugal fan of the forward curved multiblade type furnished with blades 11_a according to the present invention and a fan provided with known blades 11_b. Curve *a* shows performance of a fan having a connected pair of wheels 160 mm. in diameter, each provided with 36 blades 75 mm. in length, of which the sectional shape is just as illustrated above, and curve *b* shows performance of a fan provided with a pair of wheels connected together, each 160 mm. in diameter and having 32 blades which are made of a metal plate 0.8 mm. in thickness, 78 mm. in length and bent in a gutter shape of 10.5 mm. inside diameter. Thus it can be said that the two fans have approximately the same condition. From what the result of the performance test shows it is apparent that a blade according to the present invention is much superior to a known type in quietness and blowing efficiency.

It is apparent that the invention and its advantages will be understood from the foregoing description and it is apparent that various changes may be made in the forms, construction and arrangement of the parts without depart-

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ing from the spirit and scope of the invention, the form hereinbefore described and illustrated in the drawing being merely a preferred embodiment thereof.

Having thus described my invention, what I claim and desire to secure by Letters Patent of the United States is:

In a centrifugal fan of the forwardly curved multiblade type, the improvement wherein each blade has its front in the shape of a shallow gutter and conforms to air flow through the passage formed between adjacent fan blades, the inner edge having a relatively large curvature, and the back having a bulging curve shape gradually diminishing the width of the passage from the inner end out, each blade having continuously curving inner and outer surfaces, each blade having a cross-sectional configuration with substantially the following proportions:

$B=15.5$	$R_5=0.8$
$R_1=5.0$	$R_6=0.4$
$R_2=8.5$	$l_1=6.0$
$R_3=6.0$	$l_2=8.0$
$R_4=12.0$	$l_3=5.5$

wherein *B* is the blade chord between the inner edge and the outer edge, *l*₁ is the distance of a first line from a reference line passing through the beginning of the blade chord at the inner edge, *l*₂ is the distance of a second line from said reference line, *l*₃ is the distance of a third line from said reference line, all of said lines being parallel to each other and perpendicular to the blade chord, *R*₁ is the radius of a portion of the inner blade surface near the inner edge and having its center on said first line, *R*₂ is the radius of a portion of the inner blade surface near the outer edge and having its center on said second line, *R*₃ is the radius of a portion of the outer blade surface near the inner edge and having its center on said first line, *R*₄ is the radius of a portion of the outer blade surface near the outer edge and having its center on said third line, *R*₅ is the radius of curvature of said inner edge, and *R*₆ is the radius of curvature of said outer edge.

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