May 17, 1938. H. F. HAGEN 2,117,416

CENTRIFUGAL FAN

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Fig. 1.

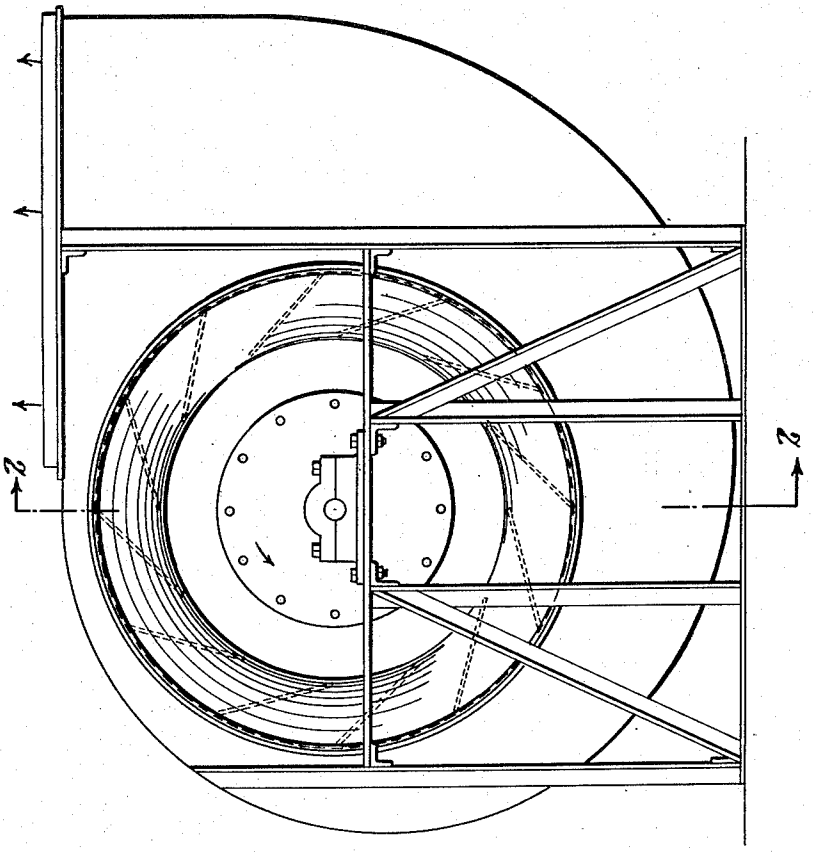
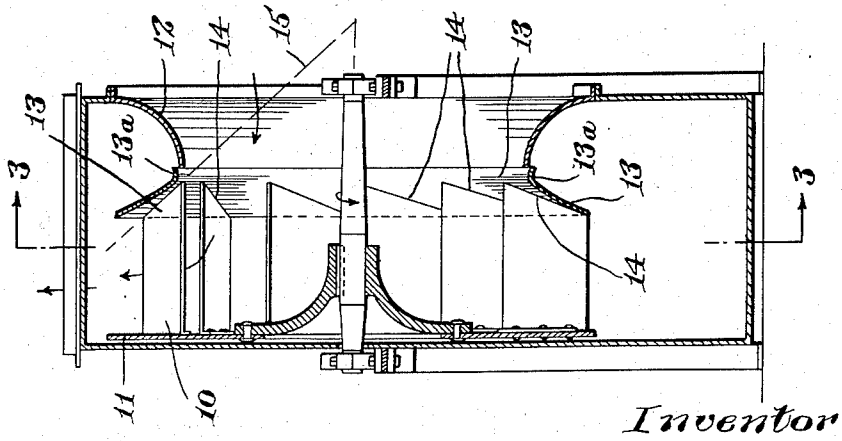


Fig. 2.



Inventor

HAROLD F. HAGEN

by Robert T. Palmer

Attorney

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Fig. 3.

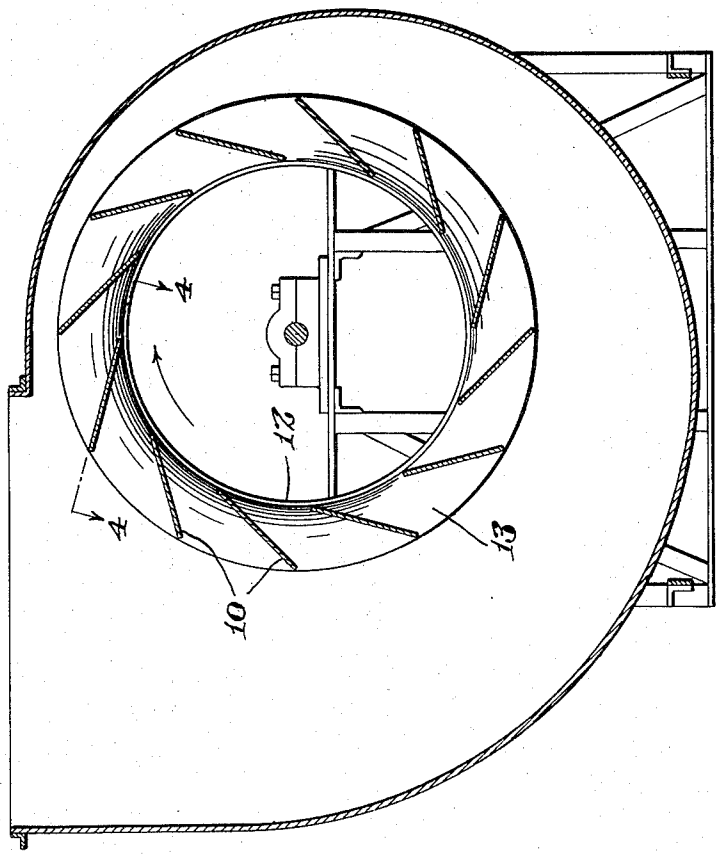
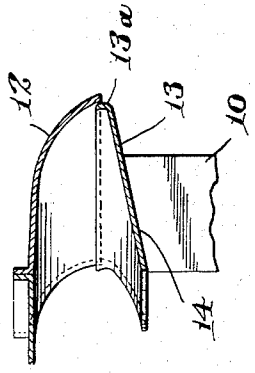


Fig. 4.



Inventor
HAROLD F. HAGEN
by Robert J. Palmer
Attorney

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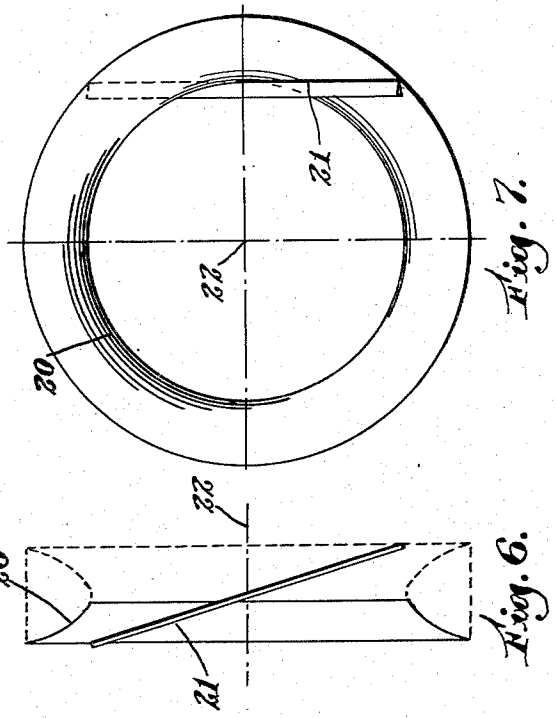


Fig. 7.

Fig. 6.

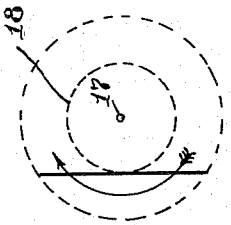


Fig. 9.

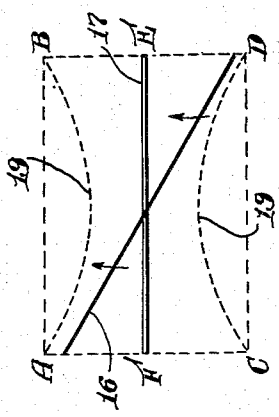


Fig. 8.

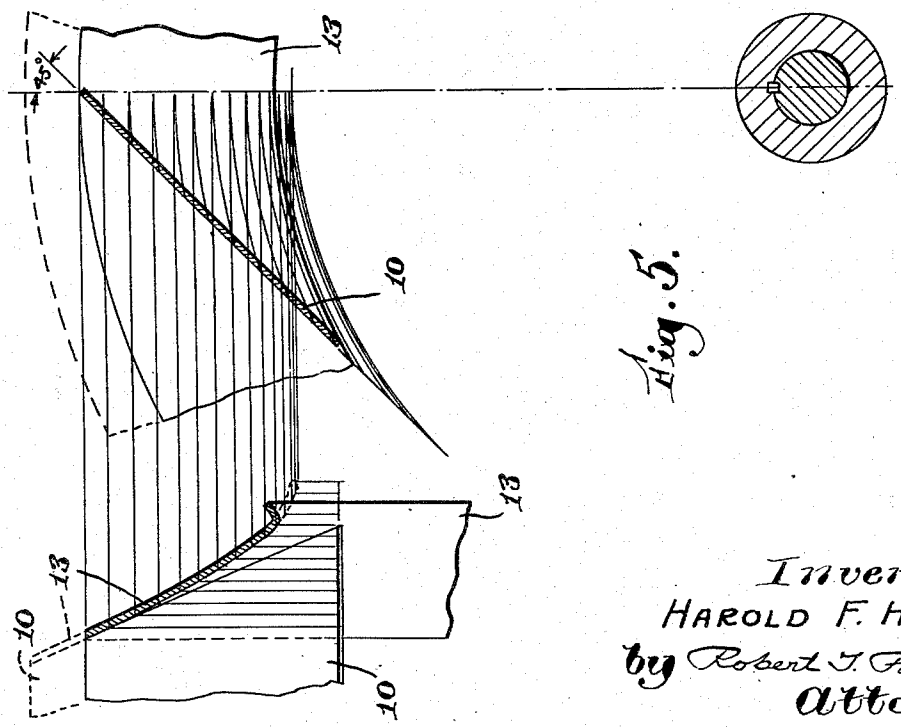


Fig. 5.

Inventor
HAROLD F. HAGEN
by Robert J. Palmer
Attorney

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UNITED STATES PATENT OFFICE

2,117,416

CENTRIFUGAL FAN

Harold F. Hagen, Dedham, Mass., assignor to B. F. Sturtevant Company, Boston, Mass.

Application June 20, 1936, Serial No. 86,385

5 Claims. (Cl. 230—134)

This invention relates to centrifugal fans and relates more particularly to centrifugal fans of the inclined blade type.

Most centrifugal fans of the inclined blade type are today, driven by electric motors, which for maximum efficiency and minimum cost rotate at fixed speeds. Since the duties of a given size fan may vary greatly, it is obviously desirable to be able to adjust the characteristics of a standard fan by varying the number, diameter and width of its blades.

In the past, centrifugal fans of the inclined blade type for example, of the type having backwardly inclined blades, have been of two general types. Both types have employed similar back plates and diverging side plates at the entering edges of the blades, which side plates have cooperated with converging inlet passages to direct the air with decreased resistance onto the fan blades. The blades of such fans necessarily decrease in width from base to tip, since their outer edges contact with a diverging side plate.

One of these two types of fans has employed curved side plates which are preferable from the standpoint of design due to providing a blade of minimum area. But, it has not been feasible in the past, to vary the width and diameter of a given impeller once the line of fans having curved side plates has been standardized for die manufacture. A further disadvantage of such a fan is that expensive dies are required not only for the side plates but for the blades, which latter have necessarily in the past, been recessed along curved lines at their points of contact with the curved side plates.

The other of the two types of fans has been provided with a conical side plate. Such a side plate is not so desirable from a design standpoint as a curved side plate, but it does, due to the constant angle, permit variations in the width and diameter of the impeller to be readily made. A conical side plate requires too wide a blade base for a desired tip width. It is desirable to have the base as short as possible for a given tip and still provide good air flow into the blade. It is possible to provide shorter blade bases for good air flow and therefore a minimum blade area, for a given duty, with a curved side plate than with a conical one.

According to this invention, a fan having all of the desirable, but none of the undesirable characteristics of both of said types of fan is provided. It has a further advantage all its own in that it has a curved side plate, but the edges of the blades contact its surface in straight lines. This provides perfect stream-lined air flow, while enabling blades of different widths and diameters to be used with one fan, and dispenses with the need for expensive blade dies. All this is accomplished by providing the side plate in the form of a hyperboloid of revolution, the surface of which is generated by a straight line rotating about the axis of the fan and inclined at a predetermined angle thereto. The inclined blades of the fan are formed with their outer edges which contact with the side plate, in straight lines, and each blade is so inclined that its straight outer edge coincides with the straight line generatrix when it is in line with the respective blade, so that the outer edges of the blades lie in straight lines along the surface of the curved side plate. Any line passing through the outer edge of any of the blades would thus serve as the generatrix of the hyperboloid.

An object of the invention is to provide an efficient inexpensive fan of the inclined blade type.

Another object of the invention is to provide an efficient adaptable fan of the inclined blade type.

Other objects of the invention will be apparent from the following description taken together with the drawings.

The invention will now be described with reference to the drawings of which;

Fig. 1 is a side elevation of a complete fan according to this invention, with the blades in dotted outline;

Fig. 2 is a sectional view along the lines 2—2 of Fig. 1;

Fig. 3 is a sectional view along the lines 3—3 of Fig. 2;

Fig. 4 is a sectional view along the lines 4—4 of Fig. 3;

Fig. 5 is an enlarged view of portions of a side plate and blade of Fig. 2;

Fig. 6 is a profile view illustrating how the curve of a side plate of a fan according to this invention may be generated;

Fig. 7 is an end view of Fig. 6;

Fig. 8 is a profile view illustrating generally the generation of a hyperboloid of revolution; and

Fig. 9 is an end view of Fig. 8.

With reference first to Fig. 2, although it illustrates a form of fan according to this invention, the general features of fans of this type as manufactured in the past, will be explained. The fan has the plurality of backwardly inclined blades 10. All of these blades are of course inclined the same degree and act in the same way. The blades are secured in any suitable manner as by riveting

to the back plate 11 which acts not only to support the back side of the blades but to turn the air for discharge from the fan. The fan has a stream-lined, curved converging inlet 12 which acts to feed the air entering the fan smoothly into the fan wheel. The fan is provided with the side plate 13 which contacts with the outer edges 14 of the blades 10. It has been usual to provide diverging side plates which cooperate with the stream-lined inlets for providing a smooth air passage on to the working surfaces of the blades. As previously explained, this has been done in the past, in two ways. One by having a curved side plate which fits into curved recesses in the outer edges of the blades. In the other type, the side plate has been conically shaped. A conical side plate could thus be provided with the fan of Fig. 2, the angle of the cone coinciding with the angles of the outer portions 14 of the blades.

The curved side plate 13 of Fig. 2 is however, given a new shape. It is formed as a surface of hyperboloid of revolution generated by a line rotating about the axis of the fan and passing through any and all of the outer edges 14 of the blades 10. Such a line is sketched in as the dashed line 15 passing through the outer edge 14 of the upper blade 10 of Fig. 2. Thus, each of the outer edges 14 of the blades 10 is in a straight line which lies upon the curved surface of the hyperboloid 13.

To the outside of the area of blade contact, the side plate is given the lip 13*a*, which cooperates in directing air from the inlet 12 onto the fan blades.

A hyperboloid of revolution is defined as a surface formed by rotating a straight line about an axis which is not parallel nor in the same plane as the straight line to the generatrix. The distance and the angle between the generatrix and the axis remain constant during the revolution. The generation of a hyperboloid may be more easily understood with reference to Figs. 8 and 9 which show the straight line 16 inclined at a constant angle to the axis 17 and remaining at a constant distance from the axis 17 as by moving around the cylinder of constant diameter 18. The line 16 generates the hyperboloid of revolution 19. This definition of a hyperboloid of revolution may be more easily understood by imagining Figs. 8 and 9 to illustrate a wooden cylinder ABCD placed between the centers of a lathe at points E and F. Then, if the straight line 16 is a knife blade and the cylinder is revolved, the knife blade will generate a spool shaped solid having the outline indicated on Fig. 8 as the hyperboloid 19. Thus, the hyperboloid is generated by the moving line if the cylinder is held stationary or by the moving cylinder if the line is held stationary.

Figs. 6 and 7 illustrate the generation of a hyperboloid of revolution 20 by the line 21 moving around the axis 22. In these, the generatrix is inclined at a much greater angle to the axis than that shown by Figs. 8 and 9. Figs. 6 and 7 represent substantially the generation of a hyperboloid of revolution of which the side plate 13 of Figs. 1 and 2 is a portion. A comparison of Figs. 2 and 6 will show that the side plate 13 of Fig. 2 is similar to the left half of Fig. 6,—the half shown in solid lines.

Figs. 3 and 4 illustrate how the straight outer edges 14 of the plates 10 lie along the surface of the curved side plate 13.

Fig. 5 is an enlargement of a portion of the side plate and lowermost blade of Fig. 2, but in inverted position, and illustrates also the preferred angle which each blade makes with a plane passing radially through the axis of the wheel and through the outermost extremity of the blade of 45°. For preferred results, this angle should not be less than 45°. Fig. 5 also illustrates side and end views of one blade lying against one side plate with interconnected lines of projection.

Since the outermost edges of the blades which contact with the side plates extend, according to this invention, in straight lines, it is obvious that blades having different dimensions can be used in a fan of standard size and design. For example, supposing a blade having greater radial depth is substituted for the one shown by Fig. 5, it is only necessary that the side plate be extended as shown by the dotted lines to enable a larger blade 10, shown by the full and dotted lines, to be used in a single design fan, using the same side plate dies.

Heretofore, in a fan having curved side plates, it has been necessary to design fans of different sizes for different loads and to prepare expensive dies for the curved side plates of each size of fan. According to the present invention, this great expense is dispensed with since the side plate dies for a given line of fan may be used to provide curved side plates of different sizes, accommodating different sized blades for different loads.

Obviously, the blades may be placed at different angles from those illustrated with the result that side plates formed as surfaces of different hyperboloids would be required in order that the outer edges of the blades lie in straight lines along the surface of the side plates.

While, one embodiment of the invention has been described for the purpose of illustration, it should be understood that the invention is not to be limited to the exact arrangement described, as many departures and modifications will suggest themselves to those skilled in the art, after having had access to this disclosure.

What is claimed is:

1. A centrifugal fan comprising in combination, a fan housing, means forming a converging passage projecting inwardly into said housing for the axial direction of air into said fan, a plurality of substantially flat, inclined, fan blades, a back plate attached to the back sides of said blades, and a curved side plate having a portion in contact with the front sides of said blades, constructed in the form of a hyperboloid, for guiding underneath its lower surface, the air received from said passage.

2. A centrifugal fan comprising in combination, a fan housing, means forming a converging passage projecting inwardly into said housing for the axial direction of air into said fan, a plurality of substantially flat, inclined, fan blades, a back plate attached to the back sides of said blades, and a curved side plate having a portion in contact with the front sides of said blades, constructed in the form of a hyperboloid, and having a non-hyperbolic second portion cooperating with the sides of said passage for guiding underneath its lower surface, the air received from said passage.

3. A centrifugal fan comprising in combination, a fan housing, means forming a converging passage projecting inwardly into said housing for the axial direction of air into said fan, a plurality of substantially flat, inclined, fan blades, a back plate attached to the back sides of said blades, and a curved side plate having a portion in con-

tact with the front sides of said blades, constructed in the form of a hyperboloid, for guiding underneath its lower surface, the air received from said passage, said side plate having a second portion extending towards said passage beyond the front edges of said blades, said second portion having an outwardly turned, non-hyperbolic, front portion terminating adjacent the inner end of said passage.

4. A centrifugal fan comprising in combination, a fan housing, means forming a passage projecting inwardly into said housing for the axial direction of air into said fan, a plurality of substantially flat, rectangular, inclined, fan blades, a back plate attached to the back sides of said blades, and a curved side plate having a portion in contact with the front sides of said blades, constructed in the form of a hyperboloid, for guiding underneath its lower surface, the air received from said passage.

5. A centrifugal fan comprising in combination, a fan housing, means forming a passage projecting inwardly into said housing for the axial direction of air into said fan, a plurality of substantially flat, inclined fan blades, a back plate attached to the back sides of said blades, and a curved side plate having a portion in contact with the front sides of said blades, constructed in the form of a hyperboloid, for guiding underneath its lower surface, the air received from said passage, said side plate having a second portion extending towards said passage beyond the front edges of said blades, said second portion having a non-hyperbolic front portion terminating adjacent the inner end of said passage.

HAROLD F. HAGEN.