May 1, 1934. W. L. UPSON 1,957,237

FAN BLADE

Filed Jan. 20, 1932

Fig. 1.

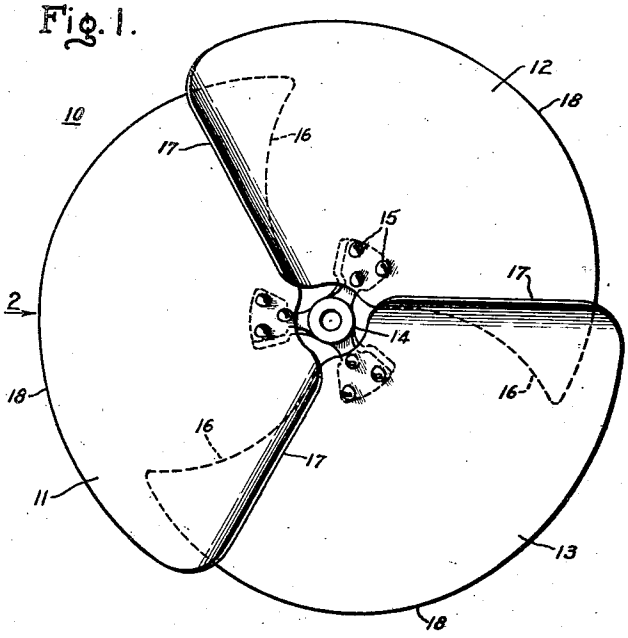


Fig. 2.

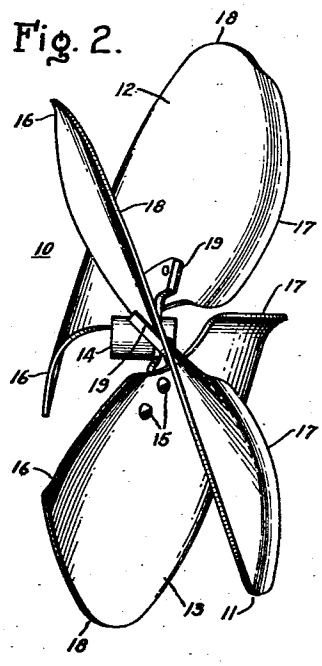


Fig. 5.

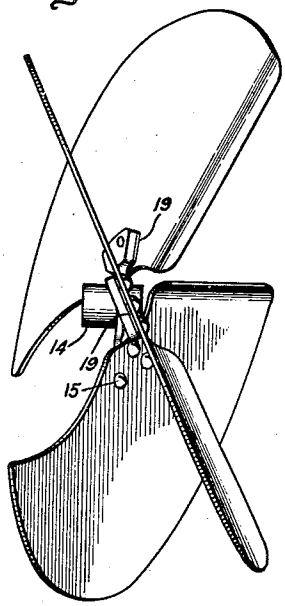


Fig. 3.

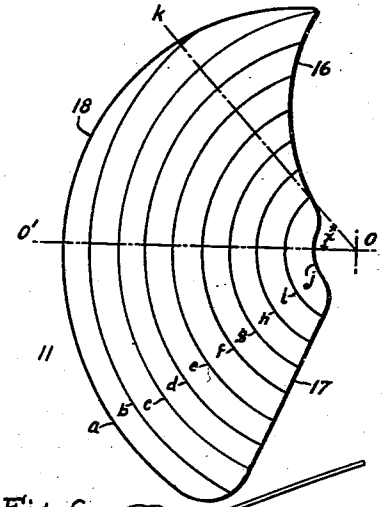


Fig. 4.

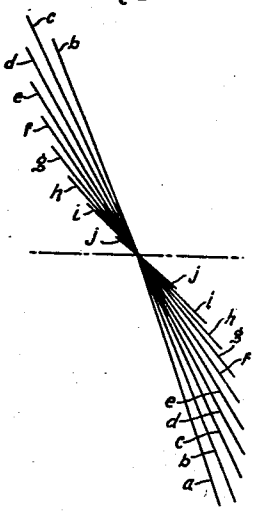
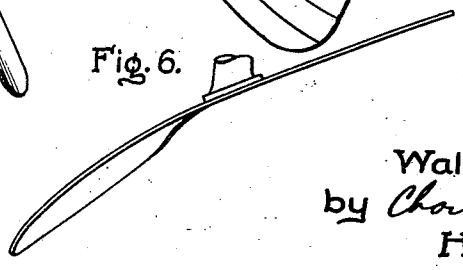


Fig. 6.



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UNITED STATES PATENT OFFICE

1,957,237

FAN BLADE

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Application January 20, 1932, Serial No. 587,709

19 Claims. (Cl. 170—159)

My invention relates to fans and more particularly to fan blades.

With the increasing demand for air conditioning equipment, especially for use in places of amusement, such as theatres, auditoriums, and the like, there has been a change in the requirements for such equipment. In places of amusement and especially in theatres since the advent of the talking movies it has become highly important that the air conditioning apparatus be as quiet in its operation as possible. Considerable difficulty has been experienced in reducing the noise incident to the operation of fans or blowers for circulating the air. In addition to this increase in demand for air conditioning equipment in what may be termed commercial establishments there has been a considerable increase in the use and application of fans in the home. Fans are now being used in the home for increasing the amount of heat radiation from a heating unit. Also, there has been a considerable increase in the application of fans to the ventilation of the home in the winter as well as in the summertime. Such applications have been particularly numerous in the kitchen where its need is the greatest. Also, fans are being used with electric refrigerating apparatus. With this increase in the use of fans in the home there has necessarily been a considerably greater importance attached to the quietness of the operation of fans. Reducing the noise of fans operating in the home has been an even greater problem than the noise reduction in commercial establishments because of the close proximity of the fan to the person, the relatively high speed operation, and the limitations on the cost and size of the equipment.

The object of my invention is to provide improved blades for fans which will make them comparatively quiet in operation and yet make them comparable in the velocity imparted to the air, the velocity distribution, and the efficiency of operation with standard fans.

My invention will be better understood by consideration of the following detailed description with reference to the accompanying drawing and the scope of the invention will be pointed out in the appended claims. In the drawing, Fig. 1 is a plan view of a fan having three blades; Fig. 2 is a side view of the fan of Fig. 1; Fig. 3 is a plan view of the blade shown in Figs. 1 and 2 with its surface divided by circular arcs drawn from the axis of the fan; Fig. 4 is a side view of the blade shown in Fig. 2 showing the relative positions of the arcs as drawn on the surface of the blade of Fig. 3; Fig. 5 is a side view of a fan with a blade of modified form, and Fig. 6 is a side view of a modified blade.

The fan is generally indicated by the numeral 10 and comprises three blades 11, 12 and 13 secured to a hub 14 by means of screws 15. The amount of noise produced by a fan increases with the number of blades providing other features of the fan remain the same. If one blade were used and its area made sufficiently large to move a relatively large quantity of air then its axial length would of necessity be too long. This would also be true of a fan with two blades. I prefer to use three blades for fans run at speeds between 1100 and 1600 R. P. M. but a greater number of blades may be desirable when it is possible to run the fan at a lower speed. The decrease in speed offsets the increase in noise which would be occasioned by the greater number of blades.

The blades 11, 12 and 13 are identical in construction and each one has a leading edge 16 which is concave and extends forward progressively from the hub to the outer periphery of the blade. The leading edge is curved so that air is picked up at a decreasing pitch with increasing peripheral velocity as will be explained later. The curved leading edge also increases the amount of air that may be picked thereby as compared to a straight line leading edge.

The trailing edge 17 of each blade is shown as a substantially straight line but it is not necessary that it be perfectly straight throughout its length and it may be desirable to round it off more near the periphery of the blade because a sharp corner has a tendency to create eddies producing noise where the linear velocity of the blade is high.

A fan blade is generally considered as being divided in two parts. The first part is called the leading end and extends from the leading edge to the central radius about which the blade is turned which is indicated in Fig. 3 as O—O'. The other part of the blade is called the trailing end and extends from the radius O—O' of Fig. 3 to the trailing edge of the blade. The peripheral edge 18 of the blade is convex and for the trailing end of the blade is a circular arc of constant radius but for the leading end is an arc of decreasing radial extent from the radius O—O' to the leading edge. Thus air may be drawn in at the peripheral edge of the blade from the leading edge to the radius O—O'. This increases the possible inflow of air in addition to the increase by the shape of the leading edge.

The shape of the surface of the blades can be better understood by reference to Figs. 3 and 4. In Fig. 3 a blade is shown with arcs drawn on its surface from the axis of the fan as a center. These arcs are indicated by the letters *a, b, c, d, e, f, g, h, i, j*. Each of these arcs lies in a plane and the angle that the plane makes with the plane of the fan increases from the outside or from arc *a* to the inside or arc *j*. The relative positions of these arcs are indicated in Fig. 4. Thus, while the surface of the blades as shown in Fig. 2 is a warped surface any arc drawn from the axis of the fan as a center lies in a plane. Thus any particle of air travelling along the surface of the blade travels in a plane. Also, the pitch along this arc increases from the leading edge of the fan blade to the radius O—O' and decreases from the radius O—O' to the trailing edge of the blade. This decrease in pitch from the radius O—O' to the trailing edge is compensated for to a certain extent by the bending up of the trailing edge of the blade as indicated in Fig. 2. The decreasing pitch may be completely compensated for by curving the whole trailing end in addition to bending up the trailing edge as shown in Fig. 6. In some cases it may even be found desirable to make the trailing end a true screw of constant pitch. The increase in angle of the arcs from the periphery of the blade toward the hub is to compensate for the difference in peripheral speed and thus to give a better distribution of the air velocity from the center of the fan to the outer periphery. Also, the increase in angle compensates for the decrease in the length of the arc.

In Fig. 5 a modified form of blade is shown which is substantially a plane surface, i. e. all the arcs *a, b, c, d, e*, etc. are in the same plane. The only deviation of the surface of this blade from a plane surface is at the trailing end where the additional bend is given to the blade to compensate for the decreasing pitch from the radius O—O' to the trailing edge of the blade. The angle of this blade with respect to the plane of the fan is the average angle of the arcs *a, b, c, d, e*, etc. of the blade shown in Fig. 2. The operation of this fan compares favorably with the operation of the preferred form of blade as illustrated in Fig. 2 and its formation is somewhat less expensive than the preferred form of blade. The main difference between the two blades in operation is that the blade of Fig. 2 has a better distribution of the velocity imparted to the air between the axis of the fan and the outer periphery of the blade.

The object of different features of construction may be better understood by a short discussion of the theoretical considerations involved. For this discussion it will be assumed that the fan blade is a perfectly plane surface. The angle between the fan blade and the plane of the fan or a plane at right angles to the axis of rotation of the fan will be taken as 25 degrees. This angle is measured at right angles to the radius O—O', Fig. 3, about which the blade is turned. Let radius O—K be laid off on the surface of the blade at an angle x to the radius O—O'. The angle between the fan blade and the plane of the fan measured at right angles to radius O—K is cos. x times the angle at the radius O—O' or 25 cos. x. This angle gives the pitch along the radius O—K. Thus along a radius at right angles to O—O' the pitch will be 25 cos. 90° or 0. When the angle x is 60° the pitch will be 25 cos. 60° or 12½°. Therefore, it may be seen that with a blade having a plane surface the pitch varies from 0 at 90° ahead of the central radius to a maximum at the central radius. In a like manner the pitch decreases past the central radius. The pitch varies from zero on a radius at right angles to the radius O—O' regardless of what the pitch angle is at the radius O—O'. Thus what has been said of a blade having a plane surface such as shown in Fig. 5 also applies to a blade composed of plane arcs with the arcs inclined at different angles to the plane of the fan as shown in Fig. 2. The fan blades are not extended to ninety degrees ahead of the radius O—O' because it would make the fan too long in its axial length. It has been found that it is quite satisfactory to extend the blade at the periphery to about 75° ahead of the radius O—O' where the pitch is sufficiently low so that the air may be picked up without noise. By thus extending the leading edge at the periphery of the blade to 75° ahead of the radius O—O' the pitch angle is made very low where the peripheral velocity is high. The shape of the leading edge as described above, is such that the blade extends forward progressively from the hub to the outer periphery and so the pitch angle decreases from the hub to the periphery of the blade. Thus, the pitch angle decreases as the linear velocity of the leading edge increases and the initial axial displacement of the air by the blade from the hub to its periphery is substantially constant. The pick-up of the air by a leading edge of this shape and at a relatively low pitch angle considerably reduces the noise of the entrance of the air into the fan. The trailing end of the blade is generally extended about 60° behind the radius O—O'. As noted above the plane surface of the blades is varied at the trailing end by turning it up to compensate for the decreasing pitch. As shown in Fig. 6, the trailing end may also be curved throughout its extent to compensate for the decreasing pitch and provide a surface of increasing pitch for this part of the blade. It is advantageous to turn up the trailing end of the blade more toward the hub of the fan than near the outer periphery of the blade to assist in more evenly distributing the air velocity. This turning up more of the trailing end near the hub does not increase the noise as much as it would at the outer periphery because of the lower linear velocity of the blade near the hub.

As best indicated in Fig. 1 the trailing end of one blade overlaps the leading end of the following blade. In other words, looking at the face of the fan, the leading end of one blade extends behind the trailing end of the blade preceding it in the direction of rotation of the fan. Thus the trailing end of one blade shields the leading end of the following blade which assists in reducing the noise of the entrance of air into the fan. The overlapping blades also makes it certain that the maximum disc area of the fan is being utilized. By thus utilizing the full disc area of the fan it is possible to considerably reduce the diameter of the fan and at the same time move a large quantity of air. The reduction in the diameter of the fan is extremely important in the noise reduction of the fan because it reduces the peripheral velocity of the tip of the blades. The high peripheral velocity of the tip is the source of much of the noise of many fans. To reduce any noise which

may be caused by the vibration of the fan blade being transmitted to the hub and motor, a resilient packing 19, as indicated in Figs. 2 and 5 may be interposed between the fan blade and the hub 14. This resilient packing may be any suitable resilient material such as rubber or preferably a coating of a flexible synthetic resin or similar material.

From the foregoing it may be seen that a blade for fans is provided which reduces the noise of their operation by causing particles of air to travel along a plane surface which is a surface of gradually increasing pitch for the leading part of the blade, by utilizing the full disc area of the fan thus reducing the diameter of the fan for a given output to decrease the peripheral speed of the blades, and by shaping the leading edges of the blades to reduce the noise of the pick-up of the air.

What I claim as new and desire to secure by Letters Patent of the United States, is:

1. In a fan, a blade having a leading edge, a trailing edge, and a surface substantially a plane, the leading edge extending at its most forward point to substantially 75° ahead of the central radius of the blade in the direction of rotation of the fan and the trailing edge extending at its most rearward point to substantially 60° behind the central radius.

2. In a fan, a blade with a leading edge curved forwardly in the direction of rotation of the fan from the hub to a point at the periphery and having a surface formed with plane arcs of increasing pitch from the periphery to the hub.

3. In a fan, a blade with a leading edge curved forwardly in the direction of rotation of the fan from the hub to its periphery and a surface of increasing pitch from the periphery to the hub adapted to cause a substantially constant initial axial displacement of the air along the leading edge.

4. In a fan, a plurality of blades each having a leading edge curved forwardly in the direction of rotation of the fan from the hub to a point near the outer periphery, a peripheral edge of decreasing radial extent from the central radius to the leading edge, and a surface formed with plane arcs of increasing pitch from the periphery to the hub.

5. In a fan, a plurality of blades, each having a leading edge curved forwardly in the direction of rotation of the fan from the hub to a point at the periphery, the peripheral edge thereof decreasing in radial extent from approximately the central radius to the leading edge, a surface formed with plane arcs of increasing pitch from the periphery toward the hub, and the trailing edge of each blade overlapping the leading edge of the following blade.

6. In a fan, a plurality of blades each having a leading end portion with a leading edge curved forwardly in the direction of rotation of the fan from the hub to a point at the periphery, a peripheral edge decreasing in radial extent from the center to the leading edge, and a surface formed with plane arcs of increasing pitch from the periphery to the hub, and a trailing end portion having a periphery of constant radial extent and a surface of increasing pitch from the center to the trailing edge.

7. In a fan, a plurality of blades each having a leading edge and a trailing edge and a surface of gradually increasing pitch from the leading edge to the trailing edge of the blade, the combined area of the blades being at least substantially equal to the disc area of the fan.

8. In a fan, a plurality of blades, each blade having a leading end with a substantially plane surface and a trailing end of increasing curvature toward the trailing edge with the maximum curvature near the trailing edge, the combined area of the blades being at least substantially equal to the disc area of the fan.

9. In a fan, a plurality of blades each having a curved leading edge, a leading end substantially a plane surface, a trailing end of increasing curvature from adjacent the leading end to the trailing edge of the blade, the combined projected area of the blades at right angles to the axis of rotation of the fan being at least substantially equal to the disc area of the fan.

10. In a fan, a plurality of blades each having a curved leading edge, a leading end having a surface of plane arcs of increasing pitch from the outer periphery of the blade toward the hub, and a trailing end of increasing curvature from the central radius of the blade to the trailing edge, the combined area of the blades being at least substantially equal to the disc area of the fan.

11. In a fan, a plurality of blades each having a curved leading edge, a leading end having a surface formed of plane arcs, a trailing end of increasing curvature toward the trailing edge of the blade, the trailing edge of one blade overlapping the leading edge of the following blade for substantially its whole radial extent.

12. In a fan, a plurality of blades, each blade having a leading edge, a turned up trailing edge, and a surface of gradually increasing pitch toward the trailing edge, the combined area of the blades being at least substantially equal to the full disc area of the fan, so constructed and arranged that the air is gradually accelerated and the full disc area of the fan is utilized.

13. In a fan, a plurality of blades, each blade having a leading edge, a turned up trailing edge, and a surface with a low pitch at the leading edge increasing gradually to the trailing edge, the combined area of the blades being at least substantially equal to the full disc area of the fan, so constructed and arranged that the air is picked up at a low initial axial velocity, gradually accelerated and the full disc area of the fan utilized.

14. In a fan, a plurality of blades, each blade having a curved leading edge, a trailing edge, a peripheral edge of increasing radial extent from the leading edge to substantially the center of the blade, and a surface of gradually increasing pitch, the combined area of the blades being at least substantially equal to the full disc area of the fan, so constructed and arranged that the air is picked up over a long leading edge and a large portion of the peripheral edge, gradually accelerated, and the full disc area of the fan utilized.

15. In a fan, a plurality of blades, each blade having a curved leading edge, a turned up trailing edge, a peripheral edge of increasing radial extent from the leading edge to substantially the central radius of the fan, and a surface with a low initial pitch at the leading edge gradually increasing to the trailing edge, so constructed and arranged that air is taken in over a large portion of the blade and gradually accelerated.

16. In a fan, a plurality of blades each having a curved leading edge, a surface substantially a plane from the leading edge to near the trailing edge, and a turned up trailing edge, the combined

area of the surfaces of the blades being substantially equal to the full disc area of the fan.

17. In a fan, a plurality of blades each having a curved leading edge, a leading end substantially a plane surface, and a turned up trailing edge, the combined area of the blade surfaces being at least substantially equal to the disc area of the fan.

18. In a fan, a plurality of blades each having a curved leading edge, a surface with the major portion substantially a plane, and a trailing end a portion of which increases in curvature toward the trailing edge of the blade, the combined area of the blade surfaces being at least substantially equal to the disc area of the fan.

19. In a fan, a plurality of blades each blade having a leading edge, a turned up trailing edge, and a surface with the major portion substantially a plane, the combined area of the blade surfaces being at least substantially equal to the full disc area of the fan.

WALTER L. UPSON.