Jan. 19, 1943.

H. F. HAGEN

2,308,685

SPIN NEUTRALIZING VANE

Filed Nov. 14, 1940

2 Sheets-Sheet 1

Fig. 1.

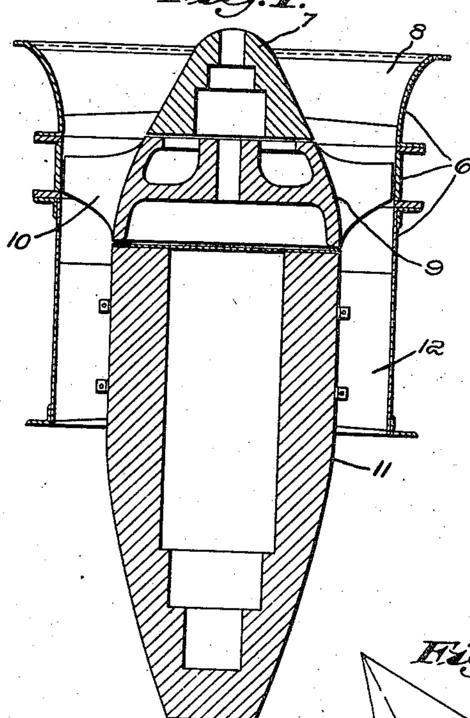


Fig. 2.

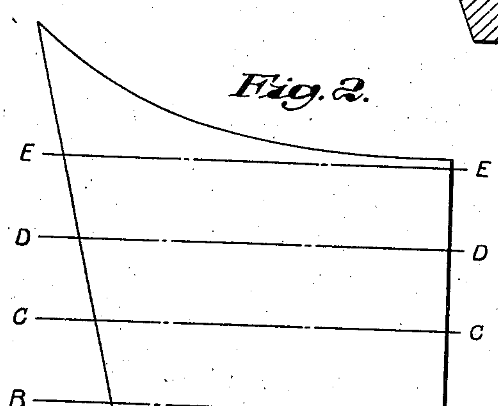
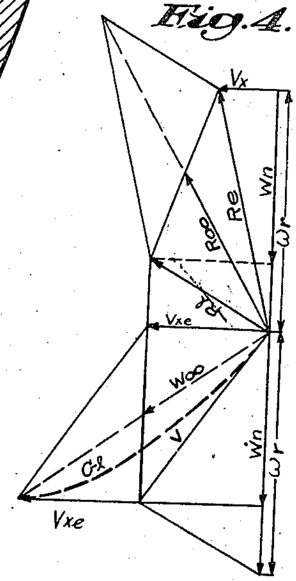


Fig. 4.



Inventor:
Harold F. Hagen,
by Robert J. Palmer
Attorney

Jan. 19, 1943.

H. F. HAGEN

2,308,685

SPIN NEUTRALIZING VANE

Filed Nov. 14, 1940

2 Sheets-Sheet 2

Fig. 3.

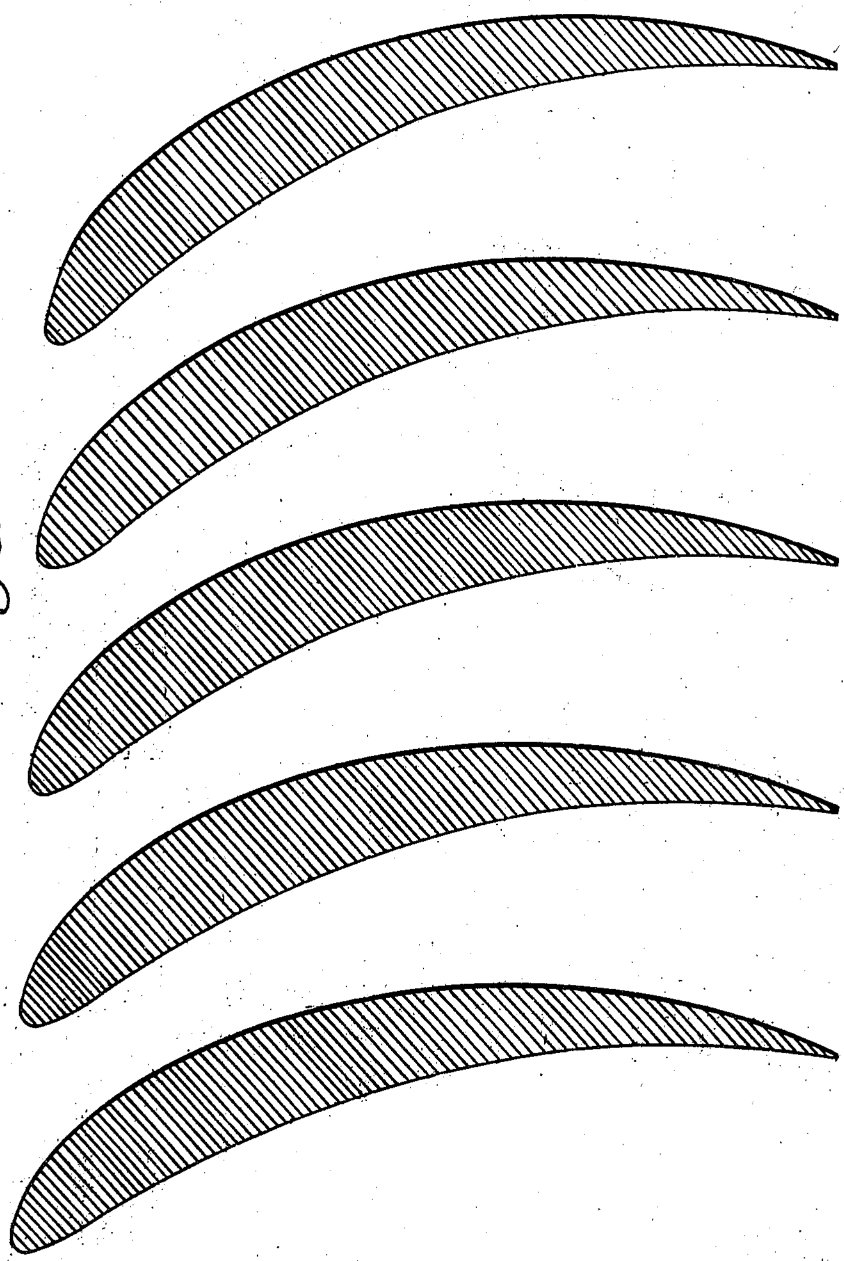


Fig 3E

Fig. 3D

Fig. 3C

Fig. 3B

Fig. 3A

Inventor:
Harold F. Hagen,
by Robert T. Palmer
Attorney

Patented Jan. 19, 1943 2,308,685

UNITED STATES PATENT OFFICE

2,308,685

SPIN NEUTRALIZING VANE

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

Application November 14, 1940, Serial No. 365,595

1 Claim. (Cl. 230—132)

This invention relates to spin neutralizing vanes and relates more particularly to vanes for neutralizing the spin velocity in the air from the wheel of a propeller fan.

It is known that the spin velocity is a necessary consequence of the operation of the wheel of a propeller fan and it has been proposed to neutralize the spin velocity by guide vanes located up-stream as well as down-stream of the propeller. The up-stream vanes have been used to produce a spin opposing that from the propeller and the prior down-stream or diffusion vanes have acted to neutralize the spin from the propeller. Both types of vanes however have been so designed that they created turbulence in the air flowing past them and caused unnecessary power losses in addition to adding undesired noises. This has resulted from a lack of understanding of the nature of the air flow. In the past as taught in the texts and is practiced by designers, the flow past the vanes, and the flow through the propeller, has been considered as if the vane and propeller elements were air foils placed in a wind tunnel. The motion of the air particles has been considered as taking place on the surfaces of cylinders coaxial with the propeller. Then when these cylindrical surfaces were developed, a series of profiles were obtained representing the sections of the guide vanes. The flow in any cylindrical surface was treated as flow through a corresponding infinite plane air foil series or grid, and the air foil theory was applied to the guide vanes. This has resulted in the prior vanes having the same or unmodified camber in all sections.

This invention provides spin neutralizing vanes which vary in camber from minimum in the outermost sections to maximum in the innermost sections and which have cambers greater than the standard sections of the originally selected air foil. This results from an appreciation of the fact that in order properly to neutralize the spin at different radii, the air particles must follow curved paths which change in curvature with the radii of the vanes as a result of the different changes in direction of the entering and leaving air velocities at different radii.

An object of the invention is to neutralize the spin velocity in a fluid with minimum energy loss.

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

Fig. 1 is a transverse section through a propeller fan with diffusion vanes embodying this invention;

Fig. 2 is a developed pattern of one of the vanes of Fig. 1;

Fig. 3A is a section view taken along the lines A—A of Fig. 2;

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

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

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

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

Fig. 4 is a vector diagram illustrating how the cambers of each diffusion vane are selected for different radii.

Referring now to Fig. 1, the air guiding casing 6 encloses the stream-lined stationary nose 7 which is supported from the casing 6 by the arms 8; the hub 9 on which are mounted the propeller blades 10, and the inner portion of the diffuser 11 on which are mounted the diffusion vanes 12.

The arms 8 may be four, equally spaced, stream-lined arms, or if desired they could be shaped to form guide vanes for producing a spin opposing that produced by the blades 10.

The propeller blades 10 may be seven equally spaced blades and may be designed as described in my copending application, Serial No. 357,767, filed Sept. 21, 1940.

The diffusion vanes may be eleven, equally spaced vanes and are designed as will now be described with reference to Fig. 4. In Fig. 4:

ω (omega) = the angular velocity of the blade elements.

r = the distance of the blade elements from the axis of the fan.

ωr = the rotative linear speed of the blade elements.

Re = the relative air velocity at the entrance to the blade elements.

R_∞ = the mean relative air velocity through the blade elements.

Rl = the relative air velocity at the delivery edges of the blade elements.

Vx = the axial velocity of the air entering the fan blades.

Wn = the rotative speed of the air at the entrance of the diffusion vanes.

V = the velocity of the air relative the earth, leaving the fan blades and entering the diffusion vanes.

W∞= the mean relative air velocity through the vane elements.

Vxl=the axial velocity of the air leaving the fan blades and entering the diffusion vanes.

c—l=the curved center line as selected for laying out the air foil profile for the vanes.

In a constant area diffusion vane passage as illustrated by Fig. 4, the axial velocity of the air leaving the diffusion vanes is equal to the axial velocity of the air entering the diffusion vanes but in fans having varying area diffusion vane passages they would not be equal.

The vectors ωr, Wn, Vx and Vxl are known from design data of the performance of the propeller blade elements and are plotted in a vector diagram and from the vectors the value of the vector V is determined. When the vector parallelograms are completed for example, as illustrated by Fig. 4, the heavy dashed curved line c—l is plotted tangent to the lower or inner end of the vector V and to the upper or outer end of the vector which is equal in value and is opposite to vector Vxl in the parallelogram in which V and Vxl form adjacent sides. This curved line is the effective path followed by the air particles flowing through the diffusion vane at a particular section.

By way of example, in a propeller fan embodying this invention, and having a 38¾" wheel operated at 3820 R. P. M., Vx=107 ft. per sec.; Vxl=160 ft. per sec.; ωr=648 ft. per sec.; and Wn 79.4 ft. per sec. From this data vector parallelograms were laid out and the curvature of the center line c—l was determined.

The profile of the desired air foil and its angle of attack is selected from published data such as given in the publications of the National Advisory Committee for Aeronautics but instead of adopting this air foil without modification and swinging it through the desired angle of attack as has been done in the past, the curved center line c—l is substituted for the chord or base line of the selected air foil and the air foil is thereby given the increased camber required by the substituted curved flow line. The air foil is then rotated as usual through the selected angle of attack.

The flow line c—l increases its curvature in sectional elements as their distance from the axis of the fan decreases with the result that the camber of the elements increases from minimum at the outermost edge to maximum in the section nearest the fan axis. This is illustrated by Figs. 2 and 3 where the outer section A—A is shown to have less camber than the inner section E—E.

With diffusion vanes so designed, the spin velocity of the air is neutralized with less noise and less power loss than with the prior vanes having uniform camber.

While the invention has been described with reference to diffusion vanes which are located downstream of the propeller wheel, it is applicable to guide vanes located upstream of the propeller wheel for producing a spin velocity to neutralize that of the propeller wheel. Both upstream and downstream vanes may be used.

What is claimed is:

In a propeller fan, spin neutralizing vanes adjacent the propeller blades, the elements of said vanes having air foil sections with curved center lines, the radii of curvature of said center lines increasing as their distance from the axis of the fan increases, comformable with the paths followed by the air particles past said elements and being formed tangent at the entrance edges of the vane elements, to the velocity vectors V and being formed tangent at the delivery edges of the vane elements, to the vectors equal to, and forming the opposite vectors to the vectors Vxl in the parallelograms of vectors including V and Vxl as adjacent sides, where

V=the velocity of the air relative the earth, entering the vane elements, and

Vxl the axial velocity of the air leaving the vane elements.

HAROLD F. HAGEN.