Oct. 26, 1937. R. DE MEY 2,097,390

FAN AND THE LIKE

Filed Oct. 23, 1933

Fig. 2.

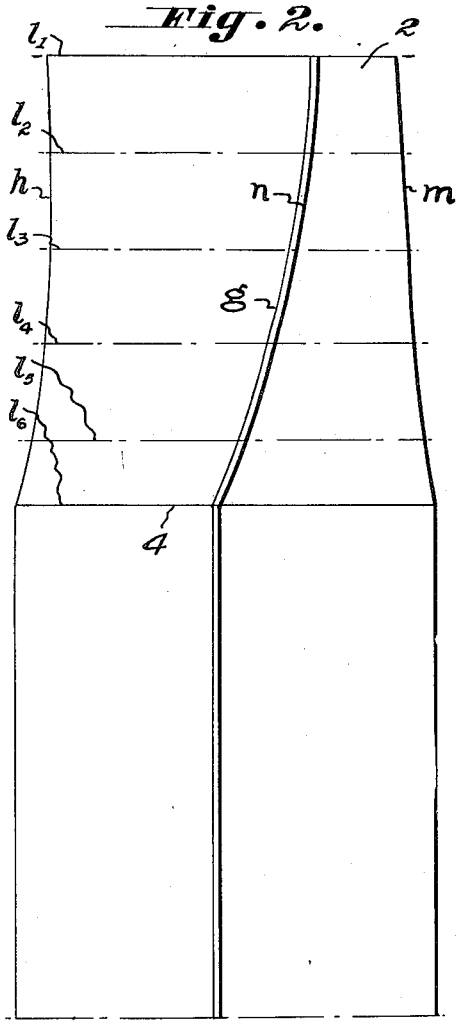


Fig. 3.

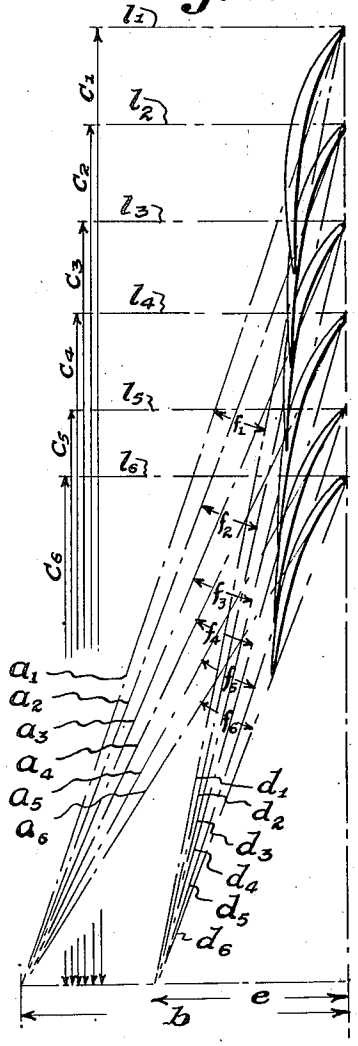


Fig. 1.

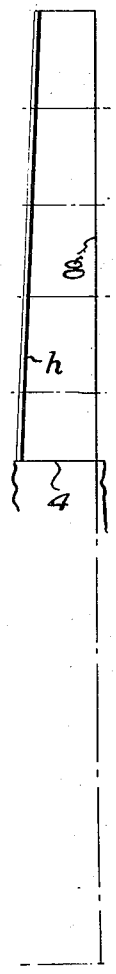
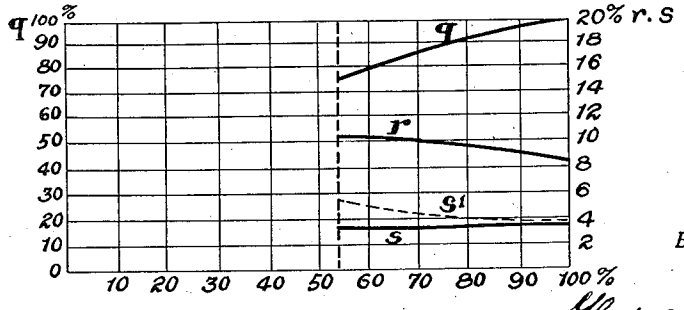


Fig. 4.



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FAN AND THE LIKE

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Application October 23, 1933, Serial No. 694,861.
In France October 25, 1932, and in Germany October 25, 1932

14 Claims. (Cl. 230—120)

The invention relates to fans and concerns more particularly the design of the guiding vanes employed in helical fans, with one or more pressure stages, for rectifying in the axial direction the fluid current created by the rotating screws.

It has for its chief object to condition the said guide vanes in a manner such that, while providing a marked efficacy, they answer better themselves and permit fans to be constructed which answer better than heretofore the requirements of practice.

It is, in fact, very important, in particular in fans comprising one or more pressure stages, to reduce the axial bulk by the maximum amount, not only in view of the resulting economy in manufacture—due more particularly to the reduction in section of the shaft and to the lighter bearings which it is possible to employ—but also to increase the critical rotary speed limit of the fan, shafts of considerable length, even thick, necessitating intermediate bearings for this purpose.

Taking into account that, in general propelling screws possess the maximum axial bulk, at the hub, it is essential, again with a view to reducing the latter in its entirety, particularly for fans with several pressure stages, to endeavour to provide the guiding vanes with a minimum development in the axial direction in the vicinity of the hub.

If, on the other hand, as in certain guiding vanes, which have been proposed and which normally possess a considerable axial development, an endeavour is made to reduce the latter by division into two, considerable constructional difficulties arise, or construction even becomes an impossibility, particularly if, in accordance with the present general tendency, recourse is had to the foundry for such construction.

The invention provides guiding vanes of reduced axial bulk, particularly at the hub, which are of a simple configuration and which may easily be constructed by existing foundry processes.

It is known that for screws which provide a uniform pressure in the entire surface swept out and hence a high efficiency, and which, for this reason, naturally afford a greater interest the speed at which the fluid is driven circularly increases progressively from the periphery to the hub.

In order to obtain a high rectifying efficiency in the case of uniform pressure screws, guiding vanes have already been proposed in which the axial geometric pitch increases progressively from the periphery to the hub and attains its maximum at the hub, while the width is preferably maintained constant throughout the entire length of such vanes.

It is precisely such propelling screws as provide a uniform pressure throughout the entire surface swept out which have an axial development most developed at the hub, and it follows that with guiding vanes according to this known arrangement the axial bulk is pronounced.

It has been found possible to obtain high rectifying efficiencies of the delivery current if, instead of increasing the axial geometric pitch from the periphery to the hub, the said geometric pitch is, on the contrary, maintained constant for successive sections of the vane from the periphery to the hub, which, all other things being equal, results in a reduction of the axial bulk of the vane, particularly at the most important place, namely the hub.

Accordingly, the invention consists in providing in combination with a screw, more particularly a constant pressure screw, guiding or rectifying vanes, in which the geometric pitch remains constant from the periphery to the hub.

If the various sections of the guiding or rectifying vanes are given a wing or aerodynamic profile, which provides a more pronounced thrust, the necessary width may, all other things being equal, be reduced still further, with consequently a reduction in the axial bulk.

The invention consists likewise in giving to the sections of the guiding or rectifying vanes in which the geometric pitch remains constant from the periphery to the hub, a wing or aerodynamic profile.

Furthermore, it is known that the thrust in the axial direction of a section of blade or vane, having a wing or aerodynamic profile increases when the angle of incidence is increased, but only up to a certain value of the said angle in the vicinity of 8°.

All other things being equal, it is possible therefore to reduce the width of the guiding or rectifying vanes by employing angles of incidence of high values, and since the resulting reduction in the axial bulk is chiefly sought in the parts of the vanes near the hub, it is in that region of the blades that the angles of incidence will be made a maximum.

Consequently, the invention further consists in providing, for the guiding or rectifying vanes, angles of incidence of high values, the maximum values of the angle of incidence being applied to the sections of the blades near the hub.

It is also known that the "thrust" exerted by a wing having an aerodynamic profile is a function of its supporting surface, its speed of translation and a coefficient "Ky" called the thrust coefficient, which depends upon the said profile; that the angle of incidence is likewise a function of its supporting surface, its speed of translation and a coefficient "Kx" called the coefficient of drag which depends upon the same factors as "Ky".

For a given aerodynamic profile, the maximum of the ratio

$$\frac{Ky}{Kx}$$

is obtained for angles of incidence comprised between 3° and 5°.

Since, in a certain region of the surface swept out by the screw, particularly at the periphery, it is important to preserve the maximum value of the flow, and since above all at that place there is a more extensive axial length available than the value of space required for the guiding or rectifying vanes, it is of advantage to adopt in such regions angles of incidence such that the ratio

$$\frac{Ky}{Kx}$$

is a maximum.

Accordingly therefore, the invention consists in adopting for the guiding or rectifying vanes angles of incidence such that the ratio

$$\frac{Ky}{Kx}$$

is a maximum in certain portions, more particularly the peripheral portions of the said vanes.

If I take into consideration the fact that, in propelling screws imparting to the delivery a constant axial speed of the fluid, the speeds at which the said fluid is driven in rotation are at given points inversely proportional to the distance of the said points from the axis of rotation; that therefore the vectors representing the absolute speeds of the fluid on leaving the screw will all be situated on a helical surface of constant axial geometric pitch, and, if the guiding or rectifying vanes are according to the invention constructed with a constant geometric pitch in the axial direction, the angles of incidence will have values which increase progressively from the periphery to the hub.

Under these conditions, while judiciously selecting the geometric pitch to be adopted for the construction of the vanes, it is possible to arrange matters so that the angles of incidence of the said vanes satisfy the optimum conditions in portions of the surface swept out, and approach one another in the other portions, while providing a simple configuration of the blade which is readily constructed by foundry processes.

Accordingly, the invention consists in constructing the guiding or rectifying vanes of constant geometric pitch in the axial direction, such that the angles of incidence satisfy the optimum conditions, at least in one portion of the surface swept out by a propelling screw imparting to the delivery a constant axial speed, and approach each other in the other portions.

In the wing or aerodynamic profiles adopted, certain elements of the said profiles may be varied.

In a wing of aerodynamic profile, each section thereof presents a thickness which varies from end to end and passes through a maximum value at an intermediate point of the length of the section. When this maximum thickness of a section is related to the width of the section, that is to the length of the chord joining the ends of said section, a ratio is obtained which is termed the relative thickness of the section.

Also if in each of these sections a median line is traced, i. e., a line located intermediate of and equally distant from the two lines bounding the section on the pressure and suction sides of the wing respectively, the distance from this line to the chord uniting the ends thereof will vary from end to end of the section and passes through a maximum value at an intermediate point of the length of the chord. When this maximum distance or maximum ordinate of the median line of a section is related to the width of the section, that is to the length of the chord joining the ends of said section, a ratio is obtained which is termed the relative curvature of the section.

If for an aerofoil of a given profile, the relative thickness or the relative curvature or both of these factors are varied, modifications of the value of the thrust produced by said aerofoil are obtained.

In the case of guiding or rectifying vanes, the variations in the relative thickness are of lesser interest inasmuch as although the increase in the relative thickness provides an increase in the thrust, such variations necessitate the employment of larger quantities of materials, while the variations in the relative curvature afford, on the contrary, a considerable interest.

Simply increasing the relative curvature, resulting in an increase in thrust, allows of a reduction in width of the vanes, all other things being equal.

The invention therefore also consists in giving to the vanes sections of wing or aerodynamic profile, and at the same time in modifying in the said profiles, either the relative thickness or more particularly the relative curvature, in order to reduce the width and hence the axial bulk of the said vanes, particularly in the sections near the hub.

It was explained in the foregoing that, according to the invention, the vanes are constructed with constant geometric pitch in the axial direction such that the angles of incidence satisfy the optimum conditions at least in one portion of the surface swept out by a propelling screw imparting a constant axial speed to the delivery, and approach each other in the other portions.

Now, if a given optimum angle of incidence corresponds to the maximum ratio

$$\frac{Ky}{Kx}$$

of a given profile, the increase in the relative curvature of the said profile determines a variation in

$$\frac{Ky}{Kx}$$

such that the maximum of this ratio corresponds to an angle of incidence of greater value.

It follows that if, in desiring to adopt in one portion of guiding or rectifying vane a greater angle of incidence, it is likewise essential to preserve in this portion a maximum value for the ratio

$$\frac{Ky}{Kx}$$

it is merely necessary to modify suitably, that is

to say to increase judiciously at that place, the values of the relative curvature.

Accordingly, the invention consists furthermore in modifying, by a modification of the relative curvature of one or more aerodynamic sections of guiding or rectifying vanes, the value of the ratio

$$\frac{Ky}{Kx}$$

for the said section or sections in order to give a desired value to the said ratio, more particularly the maximum value corresponding to the angle or angles of incidence which has or have been adopted for the said section or sections.

Consequently, the invention likewise consists in constructing guiding or rectifying vanes comprising optimum angles of incidence in their different sections and in which the relative curvatures are such that values of the desired ratio

$$\frac{Ky}{Kx}$$

are obtained and, for example, the maximum values of the said ratio in all the sections.

Finally, it is possible to give to the edges of the guiding or rectifying vanes contours which are best adapted to the blades of the propelling screws with which they are associated, in order to construct aggregates having one or more pressure stages.

The accompanying drawing represents by way of example a construction of a guiding or rectifying vane associated with a blade as defined in the patent application No. 677,746 of the 26th June 1933.

In the drawing:

Figure 1 is a front elevation of a guiding or rectifying vane.

Figure 2 is a side elevation of the said vane associated with a propelling screw blade imparting a constant axial speed to the delivery fluid.

Figure 3 is a conventional diagram drawn from Figure 1, showing the successive sections turned over into the plane of the figure. This figure indicates the absolute speeds, the speeds of rotation and the angles of incidence of the sections, the values of the said angles having been exaggerated to enable them to be shown.

Figure 4 is a diagram indicating in percentages the variations in width, relative curvature and relative thickness of the different sections of the vane for a percentage variation in the radius.

Referring to the Figures 1 to 3, the different sections are denoted by l_1, l_2, l_3 . . .; a_1, a_2, a_3 . . . are the directions of the absolute speeds of the fluid driven by the blade 2 (Figure 2) at the different sections l_1, l_2, l_3 . . .; d_1, d_2, d_3 . . . indicate the directions of the chords of the sections l_1, l_2, l_3 . . . and f_1, f_2, f_3 . . . etc., are the corresponding angles of incidence.

The lengths c_1, c_2, c_3 are proportional to the speeds of rotation of the fluid at the sections l_1, l_2, l_3 . . .; b is a magnitude proportional to the axial speed of the fluid, which speed is constant for all the sections. Finally, e is a magnitude proportional to the geometric pitch which is likewise for all the sections.

Since the absolute speeds have as component the axial speed of the fluid leaving the screw 2, and also the speeds of rotation of the fluid, which speeds are inversely proportional to the distances separating the different sections l_1, l_2, l_3 . . . from the axis of rotation, it follows, as represented, that the directions of the absolute speeds of the fluid leaving the screw 2 are all situated on a helical surface of constant geometric pitch, of which b represents the

$$\frac{\text{value}}{2\pi}.$$

By construction, the chords of the different sections of the vane are likewise situated on a helical surface of constant geometric pitch, of which e represents the

$$\frac{\text{value}}{2\pi}.$$

It follows, as shown by the remainder of the figure, that the angles of incidence f_1, f_2 . . . decrease from the base 4 (Figure 2) towards the extremity of the vane. The width of the vane, which diminishes with increase in the angle of incidence and is also a function of the moment of rotation—which decreases from the periphery to the base or hub—will therefore diminish from the periphery to the base or hub. As represented, it is a maximum in the section most adjacent the said base. The relative curvature, on the contrary, is a maximum for this section and decreases from the base to the extremity.

The relative variations in the angle of incidence and in the relative curvature have been explained hereinbefore. It is merely necessary to recall that if, for instance, the angle of incidence for the sections l_2, l_3 is adapted to give a maximum ratio

$$\frac{Ky}{Kx}$$

for this region of the vane, while the angle of incidence adopted for the section l_6 for instance would have a value for which the profile of this section does not give the maximum value to the said ratio, it will merely be necessary to increase the relative curvature by the amount necessary to attain the said value.

The relative thickness may be maintained constant for all the sections, or it is possible to modify it, more particularly by giving it values which increase towards the base or hub with a maximum in the section nearest the said base, if, for example, an additional reduction in the bulk at the base or hub is desired.

Referring to Figure 2, g denotes the inlet edge and h the rear edge of the guiding or rectifying vane, and m and n denote respectively the leading and rear edges of the associated blade.

The said blade is constructed in the manner described in the patent application No. 677,746, that is to say of constant geometric pitch and with sections of wing or aerodynamic profile having their relative curvature, relative thickness and width a maximum in the section of the blade nearest the hub.

Of course, the association of guiding blades constructed according to the invention with any other blades providing a constant speed of the delivery fluid throughout the entire surface swept out is also comprised within the scope of the invention.

The figure shows that the inlet edge of the guiding vane has been adapted to the configuration of the outlet edge of the blade, this step being known per se.

The diagram in Figure 4 shows, for the example represented in the preceding figures, how the width, the relative curvature and the relative thickness, vary respectively, the curve q indicating the variations in width and the curve r those

of the relative curvature. The straight line s indicates that the relative thickness has been maintained constant, and the curve s^1 indicates how this relative thickness would vary if it was desirable to obtain an additional reduction in bulk of the vane at the base or hub.

I claim:

1. Improvements in guiding vanes for screw fans giving a uniform pressure in the whole of the area swept out by the rotating blades consisting in constructing said vanes with sections of aerodynamic profile with a curved working face and of constant geometric pitch throughout the length of the vanes and progressively decreasing widths and increasing relative thickness in the successive sections from the periphery to the base or hub, said section having angles of incidence larger than 1° and the maximum values of the angle of incidence being applied to the sections near the base or hub.

2. A vane as claimed in claim 1, in which the angles of incidence increase progressively from the periphery to the base or hub.

3. A vane as claimed in claim 1, in which the sections towards the periphery possess angles of incidence the values of which are comprised between 2° and 5° and the sections near the base or hub have angles of incidence of greater value.

4. A vane as claimed in claim 1, in which sections possess angles of incidence such that the ratio

$$\frac{Ky}{Kx}$$

is a maximum for these sections.

5. A vane as claimed in claim 1, in which the constant geometric pitch is so selected that the angles of incidence of a portion of the vane give maximum values of

$$\frac{Ky}{Kx}$$

for a given axial speed of delivery of the fluid current to be rectified.

6. A vane having sections of aerodynamic profile with a curved working face and of constant geometric pitch throughout the length of the vane and progressively decreasing widths in the successive sections from the periphery to the base or hub, together with angles of incidence larger than 1° with the maximum values of such angles applied to the sections near the base or hub and the relative curvature and the relative thickness have increasing values in the successive sections from tip to hub.

7. A vane as claimed in claim 6 in which the relative thickness or the relative curvature or the values of both these elements are a maximum in the section near the base or hub.

8. In a vane as claimed in claim 6, the step consisting in modifying, by a modification of the relative curvature the value of the ratio

$$\frac{Ky}{Kx}$$

of sections of the vane, whereby said ratio may be given a desired value, more particularly the maximum value corresponding to a given angle of incidence.

9. A vane as claimed in claim 6 in which the values of the angles of incidence are increased from the periphery towards the base or hub, and the relative curvatures of the sections are adjusted according to the desired values of the ratio

$$\frac{Ky}{Kx}$$

10. A vane as claimed in claim 6, in which the values of the angles of incidence are comprised between 2 and 5° at the periphery and values higher than 5° towards the base or hub, and the relative curvatures of the sections are adjusted to obtain the maximum values of the ratio

$$\frac{Ky}{Kx}$$

in all the section.

11. In combination vanes as claimed in claim 6 and a screw with blades of constant geometric pitch and sections of wing or aerodynamic profile, in which the relative thickness, the relative curvature and the width are a maximum in the section of the blade nearest the hub.

12. In combination vanes as claimed in claim 6 and screws with blades of constant geometric pitch and sections of wing of aerodynamic profile in which the relative thickness, the relative curvature and the width are a maximum in the section of the blade nearest the hub, mounted coaxially in succession.

13. A guide vane for screw fans, having sections of aerodynamic profile having a curved working face and of constant geometric pitch throughout the length of the vane, and progressively decreasing widths and progressively increasing relative thickness in the successive sections from the periphery to the base or hub.

14. A guide vane for screw fans, having sections of aerodynamic profile having a curved working face and of constant geometric pitch throughout the length of the vane, and progressively decreasing widths, progressively increasing relative thickness and progressively increasing relative curvature in the successive sections from tip to hub.

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