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2,524,869

GUIDE VANE FOR AXIAL FLOW SCREW FANS, PROPELLERS, PUMPS, AND THE LIKE

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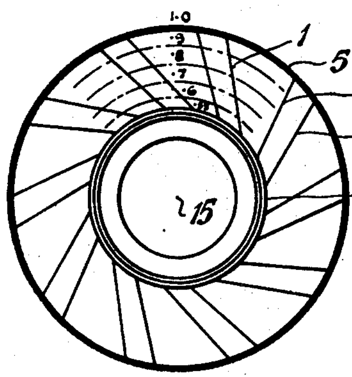

FIG. 1.

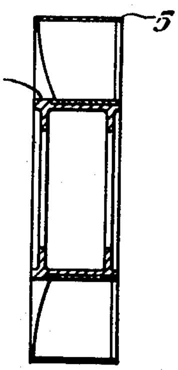

FIG. 2.

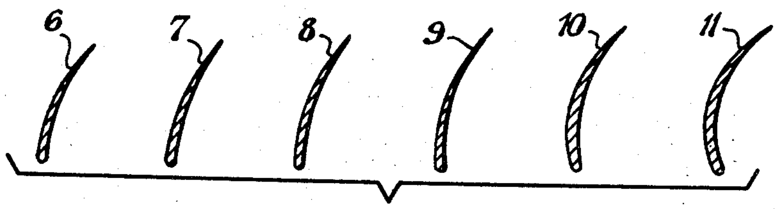

FIG. 3.

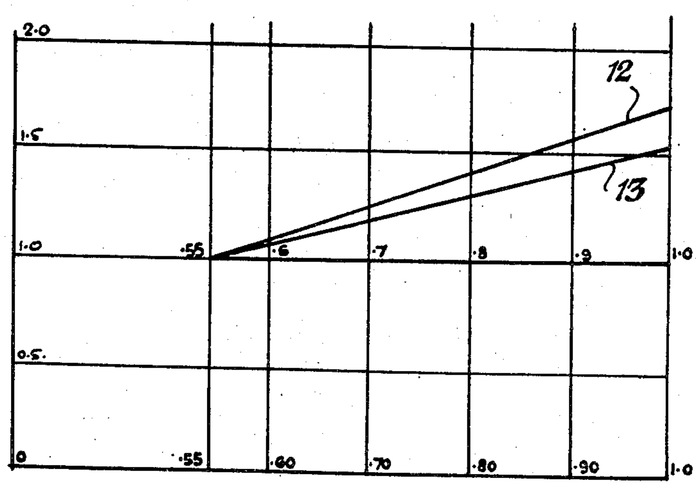

FIG. 4.

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GUIDE VANE FOR AXIAL FLOW SCREW FANS, PROPELLERS, PUMPS, AND THE LIKE

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Application September 15, 1945, Serial No. 616,562
In Great Britain January 19, 1945

3 Claims. (Cl. 103—111)

1

This invention relates to guide vanes, which operate in conjunction with acting propellers, such as rotors of axial flow fans, pumps, turbines and the like.

According to the vortex theory of the screw propeller, there is no fundamental difference between acting propellers and guide vanes. This theory can thus be applied equally to both types of propeller because the "circulation" which is produced by the acting propeller is transmitted fully to the re-acting propeller, the axial velocity of the flow being the same in both cases, whilst the relative peripheral velocity of flow may vary considerably. This is due to the fact that the relative peripheral velocity of the guide vane is equal to the rotational interference, which (as explained in my co-pending specification No. 616,563) varied from the tip to the root.

The term "circulation" in aerodynamics and hydrodynamics is defined as the integral of the tangential velocity component taken round the curve and the value is represented by the expression:

$$K=\int V \cos \theta ds$$

where

$\int$ is the integral sign,
V is the velocity around the aerofoil or hydrofoil,
θ is the angle between the aerofoil and the direction of movement of the fluid, and
ds is an element of the blade perimeter.

The "rotational interference" is the rotation of the slipstream produced by the "circulation."

The aim of the present invention is to find the most efficient guide vane for any acting propeller which produces either constant or varying circulation along the blade, for example such as described in my patent specification No. 616,563.

This specification describes a blade in which the "circulation" increases continuously from the hub to the tips of the blade.

As the rotational interference, as explained in the above mentioned co-pending specification, is proportional to the "circulation" and inversely proportional to the distance of the section from the centre, it follows that for a constant "circulation" the rotation interference decreases rapidly towards the tip.

With increasing the "circulation" towards the tip, the decrease of rotational interference is compensated, the limit to which the "circulation" can be increased being such as to produce constant rotational interference along the length of the blade.

2

The object of the present invention is to provide the most effective guide vane for operation in conjunction with the acting propeller hereinbefore mentioned.

Thus, considering the blades of the above acting propeller we have (1) increasing circulation towards the tip, (2) the axial velocity of flow increasing slightly towards the tip, (3) constant rotational interference along the blade.

It is therefore evident that the resultant relative velocity of flow towards the vanes of the guide vane, which is resultant of the rotational interference and axial velocity of flow, increases only slightly towards the tip.

The increased circulation towards the tips of the vanes can be achieved by increasing the lifting force of the vanes towards the tips. This is effected by the increase of the following parameters:

(1) The relative curvature of the section
(2) The width of the section
(3) The geometrical pitch of the section.

The relative curvature of a section is the ratio of the maximum ordinate taken from the tangent chord to the centreline of the section to the width of the chord.

The geometrical pitch is given by the formula:

$$2\pi R \text{ Tan } \varphi$$

Where

R is the distance of the section from the centre.
φ is the angle between the tangent chord and the axis.

The geometrical pitch of the guide vane is considered towards the axis, whereas that for the acting propeller is considered towards the plane of rotation.

It has been found that the most important of these three parameters is the increase in relative curvature of the section. Any considerable increase in the other two factors is liable to increase excessively the axial length of the unit which is always undesirable, but particularly so in the case of a multi-stage unit.

According to the present invention a guide vane of aerofoil or laminar section and for operation in conjunction with an acting propeller arranged in advance or behind the same has the relative curvature of the vane section increased continuously from the hub to the tip. Aerofoil is "wing-shaped body whose main function is to produce lift."

The width of the guide vane preferably increases continuously from the hub to the tip, whilst the geometric pitch preferably increases continuously from the hub to the tip.

The improved guide vane is equally applicable either at the inlet or the outlet end of the acting propeller.

In both cases the purposes of the improved guide vane is to obtain axial direction of outflow from the unit, in order to utilise fully the inevitable rotational momentum in the slipstream. Any residual rotational momentum which may remain in the outflow, in whatever direction, is liable to reduce considerably the overall efficiency of the unit.

It has been found that with axial outflow the same sections and the same angles of inclination to the axis of the vanes are essential, whatever the position of the guide vane, whether in advance of the vanes or after them.

In both cases the concave side of the vane faces the direction of rotation.

The only difference between the inlet and outlet vanes is that the outlet vanes have positive angles of inclination to the axis, whilst the inlet vanes are placed at negative angles to the axis. Positive angles are those formed with the axis and the direction of rotation, the leading edge of the vane being always assumed to lie on the axis. Negative angles are those formed in the opposite direction.

The experiments which have been made with a guide vane designed in accordance with this invention have been found to justify fully the theoretical investigation, set out above. In some instances the pressure increase obtained by the use of the guide vane was even greater than that attained with an acting propeller alone.

Referring to the accompanying drawings, which illustrate the invention by way of example:

Fig. 1 shows a front elevation of a guide vane which is adapted for use in screw fans of the medium pressure type.

Fig. 2 shows a sectional side elevation of Fig. 1.

Fig. 3 shows cross sections to a large scale of a vane

Fig. 4 is a graph in which are indicated the percentage values of the vane parameters along the vane.

Referring now to Fig. 1, the vanes 1, of a guide vane are fixed to a central hub 2, the relative diameter of which corresponds exactly with that of an acting propeller in order to ensure uninterrupted flow. The leading edge 3 and the trailing edge 4 are not directed radially in order to avoid sound interference with the rotating blades of the acting propeller, thereby reducing noise to a minimum.

The guide vane may be manufactured as a one piece casting or may be welded from separate parts, or cast blades may be bolted to the central hub 2 and to the tip shroud 5.

The cross sections 6, 7, 8, 9, 10, 11 correspond respectively with the radial distances 1.0, .9, .8, .7, .6, .55 (Fig. 1) from the centre 15 of the propeller.

In F'g. 4 the curve 12, shows the percentage increase of the relative curvature of the cross sections of the vanes from the hub to the tip.

The curve 13 shows the increase of the blade width from the hub to the tips.

What I claim as my invention and desire to secure by Letters Patent is

1. A reacting propeller having vanes of aerofoil cross sections to be used in conjunction with an acting propeller or propellers, such as rotors for screw fans, pumps, turbines and the like, wherein the relative curvature of each of the vanes of the reacting propeller increases continuously from the hub to the tip.

2. A guide vane having vanes of aerofoil cross-sections to be used in conjunction with an acting propeller or propellers, such as rotors for screw fans, pumps, turbines and the like, wherein the relative curvature of the vanes of the guide vane increases continuously from the hub to the tip, and the width of the vanes increases continuously from the hub to the tip.

3. A guide vane having vanes of aerofoil cross-section to be used in conjunction with an acting propeller or propellers, such as rotors for screw fans, pumps, turbines and the like, wherein the relative curvature of the vanes of the guide vane increases continuously from the hub to the tip, and the width of the vanes increases continuously from the hub to the tip and wherein the geometric pitch of the vanes increases continuously from the hub to the tip.

MICHAEL THADDIUS ADAMTCHIK.

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