Dec. 22, 1959 G. E. MALLINCKRODT 2,918,128

PROPELLER

Filed Aug. 8, 1955

FIG. 2.

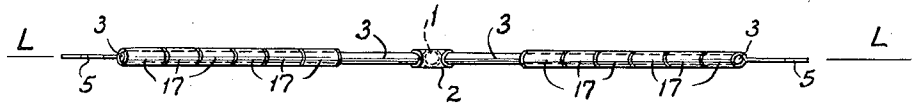


FIG. 1.

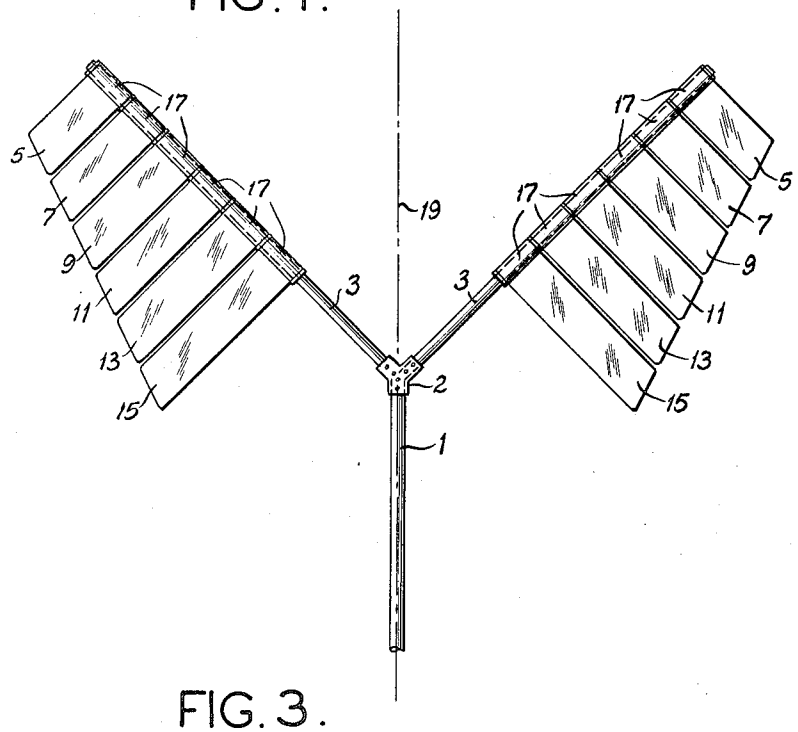
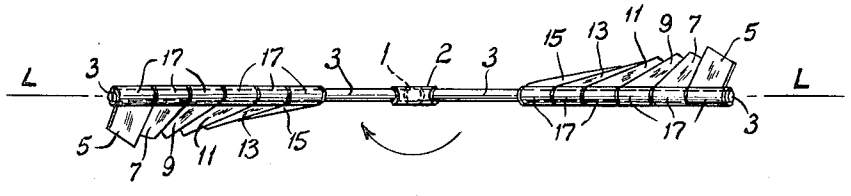


FIG. 3.



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PROPELLER

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5 Claims. (Cl. 170—160.1)

This invention relates to air propellers for fans, blowers, airplanes, helicopters, wind tunnels and the like.

Among the several objects of the invention may be noted the provision of an air propeller adapted automatically to adjust its pitch at various radii on its blades to provide optimum air thrust without the introduction of complex control members; the provision of a propeller of the class described adapted appropriately to feather in response to various relationships between relative air velocities around and along its axis; and the provision of a propeller of the class described which minimizes undesirable effects of yawing movements in applications wherein such movements occur. Other objects and features will be in part apparent and in part pointed out hereinafter.

The invention accordingly comprises the constructions hereinafter described, the scope of the invention being indicated in the following claims.

In the accompanying drawings, in which two of various possible embodiments of the invention are illustrated,

Fig. 1 is a side view of a propeller made according to one form of the invention, as it appears when upright and stationary;

Fig. 2 is a plan view of Fig. 1; and,

Fig. 3 is a view similar to Fig. 2 but showing certain air foils as they appear when the propeller is rotated.

Corresponding reference characters indicate corresponding parts throughout the several views of the drawings.

Referring now to the drawings, there is shown at numeral 1 a drive shaft, which may be in any position, for example, normally horizontal as in the case of an airplane, or normally vertical as in the case of a helicopter, and in any case driven by a suitable engine or motor. A normally vertical position is shown. Extending rigidly from a Y-shaped hub 2 on the shaft 1 is a plurality (two, in the present example) of arms indexed 3. The angle between the arms shown is 90°, but it is to be understood that other angles may be employed. Hinged on each arm is a series of adjacent air foils 5, 7, 9, 11, 13 and 15, each of quadrilateral form and the geometric sum of their areas in plan being also of quadrilateral form, as illustrated. The hinges are indicated at 17, being free swinging. The air foils 5–15 are shown as being flat in section, but it will be understood that they may be modified in this respect, i.e., streamlined. Each arm 3 and its hinged foils 5–15 constitute a propeller blade.

Operating characteristics of the propeller will be clear from the following: If, while in a vacuum, the system shown in Fig. 1 were to be either stationary or rotated around the vertical axis 19 of shaft 1, then gravity, and centrifugal force under conditions of constant angular velocity, would tend to hold the air foils 5–15 in a common plane L—L passing through the axis 19. This state of affairs is indicated in Figs. 1 and 2. If, on the other hand, rotation occurs in the atmosphere, there will be established a relative air flow against the leading face of

each air foil 5–15, causing it to be deflected rearward with respect to its path of motion, hinging action occurring at the respective hinges 17 (see Fig. 3). The deflection caused by the relative air flow will tend to offset the tendency of centrifugal force to hold the air foils in said plane L—L. Thus each foil will assume a position which is behind plane L—L. The amount of deflection from said plane of a particular foil 5, 7, 9, 11, 13 or 15 depends upon its equilibrium position as determined by the relationship of centrifugal force to the force established by the relative air flow. Thus, each air foil will assume a different angle and, as shown in Fig. 3, the arrangement is such that the angle progressively decreases from the outer smallest air foil 5 to the largest inner air foil 15.

In view of the above, it will be seen that, considered as a whole, each group of air foils 5–15 takes up a skew form around the axis of its respective arm 3, as illustrated in Fig. 3. Each air foil supplies a thrust parallel to the axis 19 which increases with increased angular velocity. The deflection of each air foil is also self-adjusting in response to the relative air speed along the axis 19. As the relative air speed velocity along axis 19 increases, the angle between each air foil and the plane L—L containing axis 19 will become smaller. Large values of thrust may be obtained at zero velocity along axis 19, as when the system is used vertically as in the case of a helicopter, or as a fan or blower. A limiting condition occurs when there is substantial relative air speed along the axis 19 and no angular velocity around it, as when an airplane is in a glide with the power off, in which case axis 19 is substantially horizontal. In such event, the air foils tend automatically to feather toward the plane L—L containing axis 19.

Among the advantages of the invention are automatic angular compensation of the angles of the air foils 5–15 in response to changes in angular velocity around the axis 19 and linear velocity along it. In aircraft applications particularly, the angles of the air foils and of the angles of arms 25 adjust to compensate for deleterious conditions caused by yawing.

It will be understood that, although two arms 3, each having a fixed apex angle of 45°, are shown in Fig. 1, various other numbers might be employed at other fixed apex angles. It will be observed that the arms 3 extending laterally from the shaft 1 are in Fig. 1 symmetrically located. Thus, they move during their rotary movements upon an imaginary cone having the axis 19.

In view of the above, it will be seen that the several objects of the invention are achieved and other advantageous results attained.

As various changes could be made in the above constructions without departing from the scope of the invention, it is intended that all matter contained in the above description or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

I claim:

1. A propeller comprising a drive shaft rotary on an axis, arms rigidly attached to and extending laterally from the drive shaft and lying upon a cone the axis of which is coextensive with said shaft axis, the apex of the cone being directed along the line of thrust of the propeller relative to the axis, and a series of freely swingable individual air foils pivoted to each arm, the air foil on each arm which is innermost relative to the shaft being the longest and the remaining air foils at successively increasing distances from the shaft being successively shorter.

2. A propeller comprising a drive shaft rotary on an axis, arms rigidly attached to and extending laterally from the drive shaft and lying upon a cone having an axis coextensive with said shaft axis, the apex of the cone being

directed along the line of thrust of the propeller relative to the axis, and a series of individual air foils pivoted to each arm, the air foil on each arm which is innermost relative to the shaft being the longest and the remaining air foils at successively increasing distances from the shaft being successively shorter, each air foil in plan being of substantially quadrilateral form and the geometric form of the areas in plan of each set of air foils being also of substantially quadrilateral form.

3. A propeller construction comprising a drive shaft rotatable on an axis, supports rigidly attached to said shaft, at least one bearing on each support fixed with respect to said shaft and having an axis oblique to the axis of the shaft, and air foils pivoted respectively on the bearings, said air foils being freely swingable in response to centrifugal forces thereon and relative air flow thereover.

4. A propeller construction comprising a drive shaft rotatable on an axis, supports rigidly attached to the shaft and extending laterally from it, fixed bearings located on said axes and establishing oblique axes fixed relative to the shaft and movable in conical paths around the shaft axis, the conical apexes being directed along the line of thrust of the propeller relative to the shaft axis, and sets

of freely swingable air foils pivoted on said bearings respectively.

5. A propeller construction comprising a drive shaft rotatable on an axis, opposed rigidly attached arms extending laterally from the drive shaft, sets of bearings on said arms respectively, the members of each set being aligned on an axis oblique to the shaft and adapted to sweep out a conical path, the apex of each conical path being directed along the line of thrust of the propeller relative to the shaft axis, and sets of freely swingable individual air foils pivoted respectively to the sets of bearings on the respective axis.

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