

July 29, 1924.

1,503,170

J. W. SMITH

PROPELLER BLADE

Filed March 16, 1918

2 Sheets-Sheet 1

FIG. I.

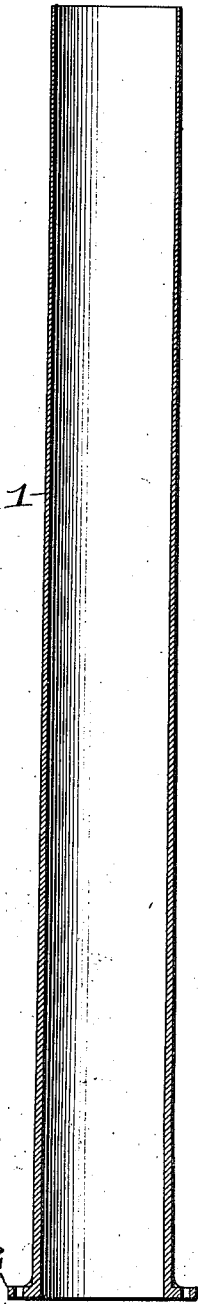


FIG. II.

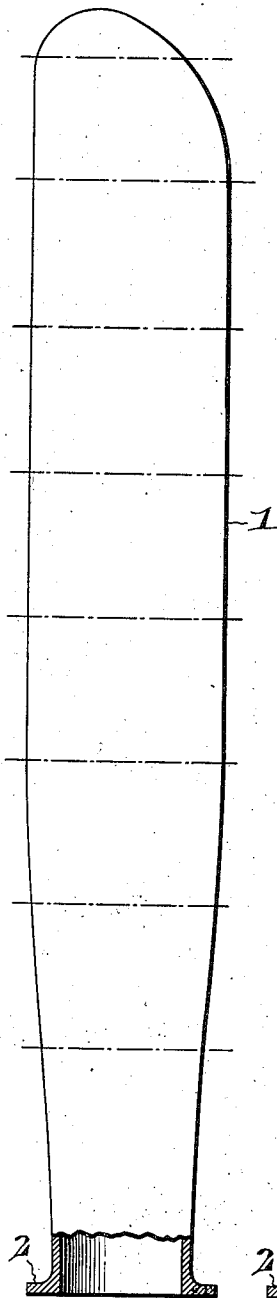


FIG. III.

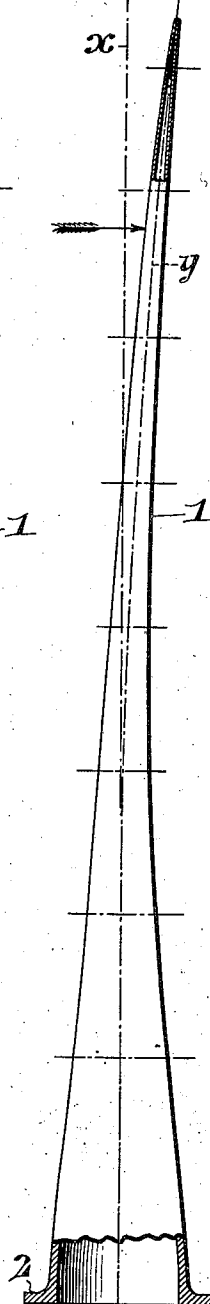
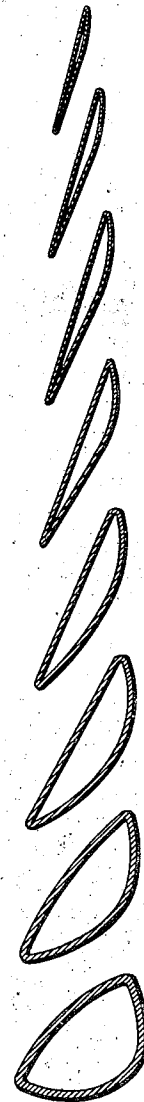


FIG. IV.



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2 Sheets-Sheet 2

FIG. V.

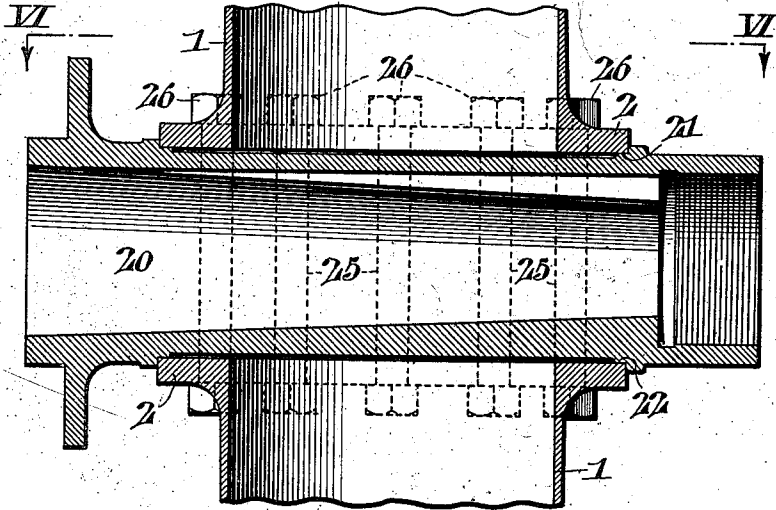


FIG. VI.

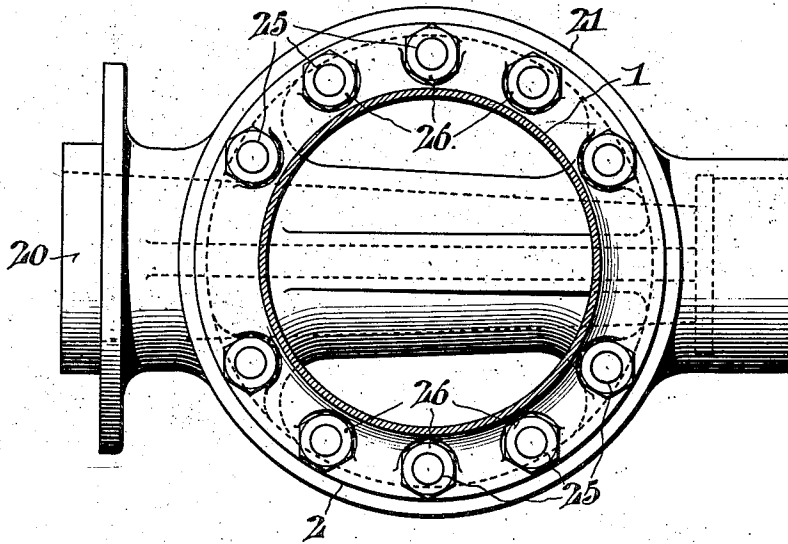
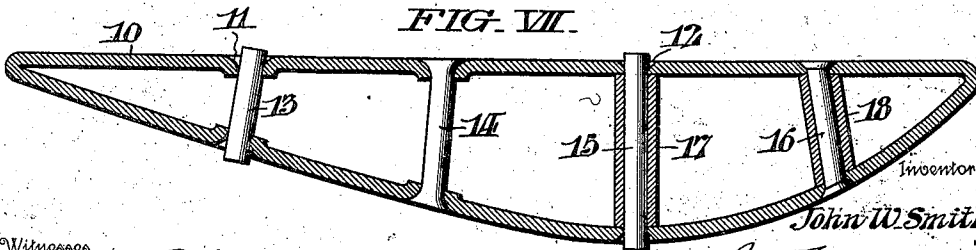


FIG. VII.



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UNITED STATES PATENT OFFICE.

JOHN W. SMITH, OF PHILADELPHIA, PENNSYLVANIA.

PROPELLER BLADE.

Application filed March 16, 1918. Serial No. 222,932.

To all whom it may concern:

Be it known that I, JOHN W. SMITH, a citizen of the United States, residing in Philadelphia, in the county of Philadelphia and State of Pennsylvania, have invented certain new and useful Improvements in Propeller Blades, whereof the following is a specification, reference being had to the accompanying drawings.

My invention relates particularly to propeller blades intended to be used upon air craft, or under conditions where minimum weight and maximum strength and stability of form are important, and where rotation at a very high speed is contemplated.

One of the objects of the invention is to permit the use of relatively thin sheet metal as the material for the blade, and, since the blade is hollow, to dispose the sheet metal in such structural form as will most effectively resist distortion under the strains characteristic of use. Furthermore, the invention has the two-fold aspect that whilst my improved blade itself possesses the desired qualities, its manufacture is very economical, with the requisite accuracy of external contour and proper structural disposition of the metal to ensure such qualities.

In the accompanying drawings, Fig. I, represents, in longitudinal section, a preferred form of tubular metallic blank which I have found advantageous for the process.

Figs. II, III, and IV, are diagrammatic views of a typical blade, embodying my invention; Fig. II, being a side elevation in isometric perspective, and Fig. III, an edge elevation in isometric perspective, the spiral contour, or twist, of the blade being ignored in both instances, in order to avoid complication. Fig. IV, represents a series of transverse sections, of the blade upon planes corresponding with prolongations of the successive transverse dot and dash lines in Figs. II, and III, the twist of the blade being also ignored in these sectional figures.

It will be understood by those skilled in the art that these three figures are intended only to exemplify certain particular structural features, and that the blade itself will embody further details of external and internal contour, such as those due to the twist of the blade, which are entirely consistent with those shown, but which are not represented by these figures.

Figs. V, and VI, are partial sectional views on an enlarged scale, representing a preferred mounting for the blades in a practical embodiment for use in an air-craft; Fig. V, being a section on the line of the axis of the driving shaft, and Fig. VI, a transverse section and partial side view on the lines VI, VI, of Fig. V.

Fig. VII, represents a transverse section, on an enlarged scale, through a propeller blade embodying my invention, illustrating certain adjunctive devices which I prefer to employ for ensuring permanence of form.

The preferred initial blank for my novel propeller blade is a steel tube 1, which may be originally formed with a circumferential flange 2, at one extremity, or said flange may be formed during the process of treatment. The wall of the tube is uniformly tapered, as indicated, the taper being preferably upon the outside. The blank may either be initially formed as an integral tube, or may be formed by welding, but should be substantially seamless.

In order to convert this tube into a blade of the desired character, I employ dies which may either shape the tube by a series of operations, or by one direct operation, the internal cavity of said dies having a contour which corresponds to the ultimate desired form. The dies will therefore be of such character as to impart to the blank not only the particular structural features indicated in Figs. II, III, and IV, but such further details as may be contemplated, as, for instance, a spiral contour, or axial twist of the blade.

In order to accomplish the necessary modification of the tube 1, without wrinkles or distortion, I fill it before the conclusion of the die-pressing operation with a core of wax, or similar plastic material, of sufficient hardness to flow only under heavy pressure at a temperature characteristic of the operation. The blank may be charged with the wax, etc. in any convenient manner before the pressing is begun, or the shaping of the blank may be partially accomplished and the shell then filled with the wax. In either case the wax is allowed to escape through a suitable hole at one or both ends of the dies, care being taken, however, that the escape shall not be so free as to permit the metal to become wrinkled. After the blade has at-

tained the final desired form, the wax is removed by melting. The base of the blade is provided with an outwardly projecting peripheral flange 2, having suitable bolt holes as shown.

Referring now to Fig. VII, I will proceed to describe certain desirable adjuncts which I prefer to use in order to ensure the stability of contour of the blade thus made.

At suitable intervals, and in such disposition as not to displace substantially the initial location of the center of gravity of the blade 10, holes are punched, such as 11, 12, etc., the metal of said holes being either forced inwards to a slight extent, as indicated at 11, or countersunk by cutting away, as indicated at 12. Transverse studs, such as 13, 14, 15, and 16, are inserted in these holes and secured in position with their ends flush with the external surface of the blade. In the case of the studs indicated at 13, and 14, the intention is to upset the ends of the stud and weld them to the metal of the blade. In the case of the studs indicated at 15, and 16, an internal distance piece, such as 17, or 18, is provided, and the ends of the stud may then be merely upset without welding. In both instances, however, the result is substantially the same, since the devices constitute both extension and compression members.

Returning now to the diagrammatic views of Figs. II, III, and IV, the first point to be noted is that the hollow blade is integral throughout substantially the whole of its longitudinal extent, only the transverse portion at, and immediately adjacent to, the upper end in said figures, having a seam, which may be closed either by welding or by rivets. A further point is that the wall is symmetrically tapered from the base to the outer end, the character and progress of the taper being predeterminable. A further point is that at any given cross-section, the thickness of the wall may be made uniform throughout the entire periphery. A further and highly important characteristic is that, irrespective of the feature of twist, the blade, as a whole, is longitudinally curved with relation to a plane radial to the axis of the propeller shaft. Preferably the tip of the blade is curved forward in the direction of flight, as shown. In Fig. III, such radial plane is indicated by the line x . The center of gravity of the blade, at each cross section, lies in a curved line y , which I will term the median line of gravity, which diverges progressively from the radial plane of the line x . Said median line of gravity may readily be determined for practical purposes by constructing a series of short annular sections, or even solid templets, corresponding to progressive sections of the blade at predetermined longitudinal intervals, and then ascertaining the center of

gravity of each section or templet. The median line of gravity will run (longitudinally with the blade) through these centers consecutively.

The departure of the median line of gravity from the true radial line is to be determined, in any given instance, by relation to the following factors:—The contemplated axial air thrust, or pressure to be exerted against the propeller blade in the direction of the axis of rotation, is known, and the contemplated total amount of centrifugal force due to the contemplated rate of rotation is also known. The arrow in Fig. III indicates the direction of flight and axial air thrust.

Other things being equal, the coefficient of air thrust will vary progressively, in a known ratio, with the rate of linear travel of the blade at any given radial distance from the axis. Such thrust tends to distort the blade mainly in a direction approximately parallel to the axis of rotation, and, ignoring the effect of centrifugal force, to be hereinafter explained, this distortion would only be limited by the resistance of the material to deformation.

Referring now to the effect of centrifugal force, if the median line of gravity lies in a radial plane perpendicular to the axis of rotation, the total stress of centrifugal force may be considered as exerted wholly in a radial direction. To the extent, however, that the median line of gravity departs from said radial plane, the stress due to centrifugal force may be resolved, i. e., one component is exerted in the direction of the median line of gravity, the other component in a direction at right angles thereto, or substantially parallel to said axis, the tendency of this latter component being to restore the median line of gravity of the blade to a truly radial position.

Within certain limits of practical accuracy, it may, therefore, be said that whilst the departure of the median line of gravity from a radial plane perpendicular to the axis of rotation is attended progressively by the increase of the axial component of centrifugal force, such departure does not substantially affect that factor of air thrust, which is exerted in an axial direction.

Supposing, therefore, that the median line of gravity of the blade should be disposed in a radial plane perpendicular to the axis, the distortion of the blade due to axial air thrust, must proceed to a substantial extent before the axial component of centrifugal force would be practically manifested, and hence, the material of the blade would be under disruptive strain, without counterbalance by the axial component of centrifugal force, until the distortion of the blade under axial air thrust had progressed (with consequent disruptive strain) to a position

of sufficient departure from a radial plane to develop the requisite increase of the axial component of centrifugal force.

If, however, the median line of gravity of the blade be initially curved away from the radial plane in the same direction as that in which the axial air thrust is exerted, the axial component of centrifugal force may be made to become effective at once, whilst the total air thrust will be no greater than before.

Hence, a condition of practical counterbalance between axial air thrust on the one hand, and the axial component of centrifugal force, on the other hand, may be established as soon as the predetermined rate of rotation has been attained, and thus the normal operative position of the blade, at such rate of rotation, may be such as to minimize the disruptive strain which would otherwise be due to axial air thrust.

Under the conditions present in a blade consisting of a hollow metallic shell, it is peculiarly important that the disruptive strains should be counterbalanced as far as possible and this may be attained by disposing the median line of gravity in a curve which progressively departs from the radial plane in the same direction as that in which the axial air thrust is exerted, the extent and progressive rate of departure being determined by reference to the intended factors above set forth for the conditions of actual service, and by the dimensions and other structural characteristics of the blade.

Hence, no more specific building directions can be given than are comprised in the foregoing statement from which any one skilled in the art and cognizant of the factors applicable to a given case, can readily lay off the median line of gravity, and can give to said line that curvature which shall best establish the desired counterbalance of axial air thrust by the axial component of centrifugal force.

Having determined this curvature, the die cavities should be so constructed as to dispose the metal of the shell, as far as is practical, symmetrically with relation to the median line of gravity.

Referring now to Figs. V, and VI, I embody these in the present application in order to illustrate a convenient organization of means for mounting my propeller blade upon the driving shaft. In said figures, 20 represents the hub of the propeller shaft, which carries in this instance two diametrically located annular seats 21, and 22. Upon these seats, the bottom flanges 2, of the propeller blades, are secured by means of a series of bolts 25, and nuts 26, which extend across the interspace between the

two seats 21, and 22, so that a pair of diametrically arranged blades may be detachably mounted and adjustably secured with a maximum of stability.

Having thus described my invention, I claim:

1. A hollow metallic propeller blade of gradually diminishing thickness from the base to its tip, said blade being longitudinally curved with relation to a plane radial to its axis of rotation and having the metal of its wall at successive cross sections symmetrically disposed to afford a continuously symmetrical median line of gravity which departs angularly from a plane radial to the axis of rotation, the direction of departure being similar to that in which the axial air thrust is exerted, and the extent of departure being such that at a predetermined normal rate of rotation, the axial component of centrifugal force shall substantially counterbalance the axial air thrust.

2. A hollow metallic propeller blade of gradually diminishing thickness from the base to its tip, said blade being longitudinally curved with relation to a plane radial to its axis of rotation and having the metal of its wall at successive cross sections symmetrically disposed to afford a continuously symmetrical median line of gravity which departs, in a progressively increasing curve, from a plane radial to the axis of rotation, the direction of departure being similar to that in which the axial air thrust is exerted, and the extent of departure being such that at a predetermined normal rate of rotation, the axial component of centrifugal force shall substantially counterbalance the axial air thrust.

3. A hollow metallic propeller blade of gradually diminishing thickness from the base to its tip, said blade being longitudinally curved with relation to a plane radial to its axis of rotation and having the metal of its wall at successive cross sections symmetrically disposed to afford a continuously symmetrical median line of gravity, in combination with stay pieces extending between the sides thereof, the respective stay pieces being of such weight and so located with relation to the median line of gravity of the blade itself, as to avoid substantial displacement or distortion of said line.

In testimony whereof, I have hereunto signed my name at Philadelphia, Pennsylvania, this ninth day of March, 1918.

JOHN W. SMITH.

Witnesses:

JAMES H. BELL,
E. L. FULLERTON.