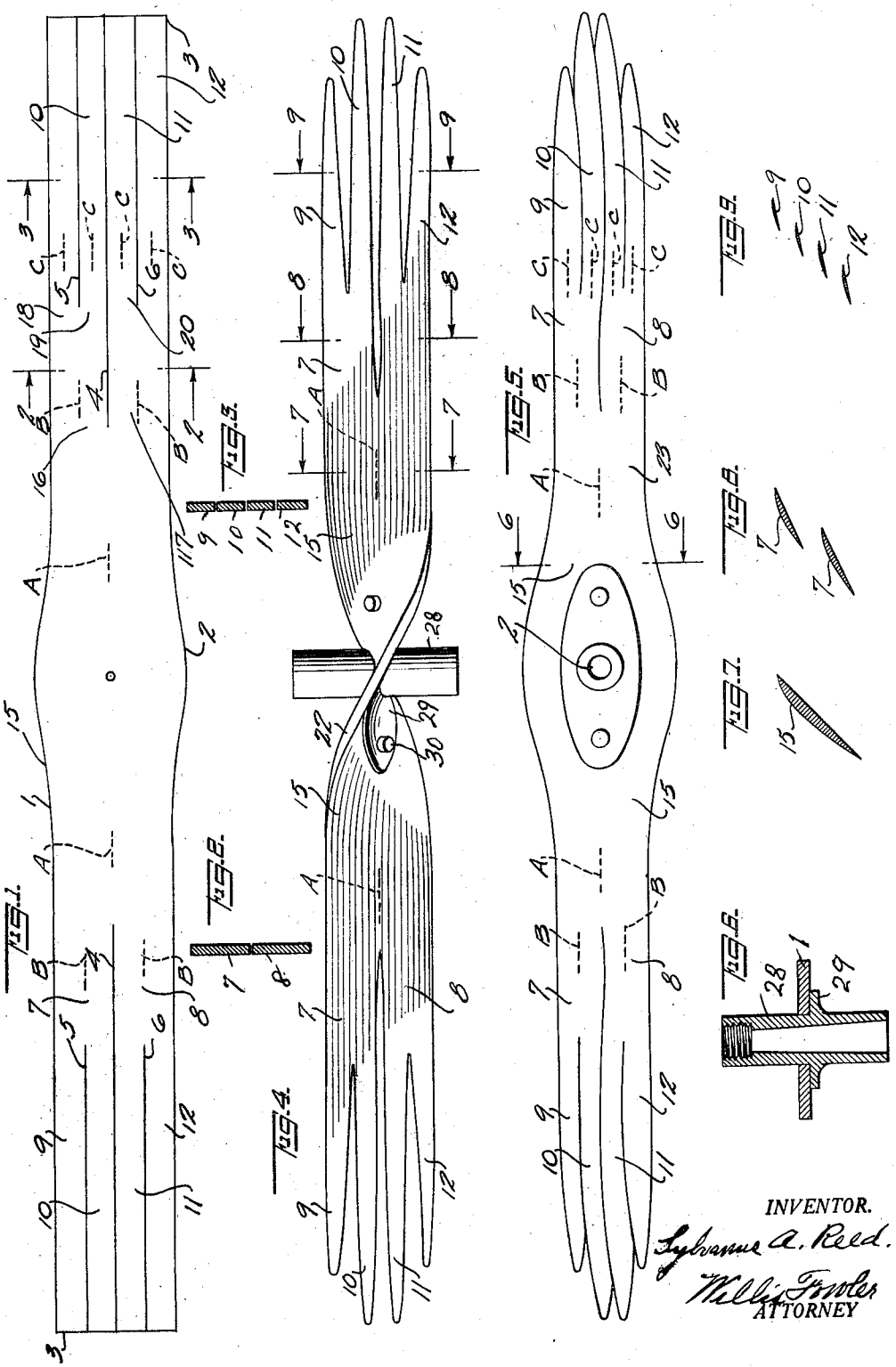
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AERONAUTICAL PROPELLER AND METHOD OF MAKING THE SAME

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AERONAUTICAL PROPELLER AND METHOD OF MAKING THE SAME

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My invention relates in general to aeronautical propellers and a method of making the same, and has reference more particularly to the type of propeller blades of metal, disclosed in U. S. Letters Patent Nos. 1,463,556 and 1,518,410, granted to me July 31, 1923 and December 9, 1924, respectively, and in which the blades are preferably solid and of forged strong light weight metal alloy and thin relatively to their thrust loads. My present improvements combine the advantages of said patented type of blade, with a reduction in weight and in some cases in increased efficiency.

Taking a blade of the above stated type, preferably in unfinished condition, I subdivide it into a plurality of comparatively narrow blades by a series of longitudinal slits, extending from the blade-tip partway to the hub, and each strip so resulting is formed to correct camber individually and twisted individually from its individual root and around its individual longitudinal axis, to its tip to desired pitch angles, and there results a plurality of blades spaced apart and in terrace or echelon grouping with interspaces. The aggregate blade area and consequently aggregate thrust is substantially the same as with a similar propeller blade not subdivided, but the weight is reduced by the amount cut away to form the new individual cambers. The decrease in thickness in the outer extremities or distal blade portions will also increase the efficiency under some conditions. Preferably each blade or branch (whether major or minor) is characterized by a minimum camber ratio consistent with stability of pitch, i. e., is as thin in relation to its depth of chord as may be considered practical and safe.

The slits are preferably progressive in length in multiples of two. For example, the first slit midway in the blade width, may extend about three-fifths of the distance from tip to hub. Then each branch is subdivided by a slit extending about two-fifths of the distance from the tip to the hub, and so on. The result of the above stated division is a metal blade made of a single piece and solid, but divided at its outer end into fingers or feathers, and the same may be defined as a pennated construction.

I have illustrated a type of my invention in the accompanying drawings, in which, for example, I show what may be considered as a ten-foot propeller. In the said drawings;

Figure 1, shows a plan view of a propeller blank with its respective ends slitted.

Figure 2, is a cross-sectional view of said blank, the plane of the section being taken on line 2—2, in Fig. 1.

Figure 3, is a cross-sectional view of said blank, the section being taken in a plane indicated by line 3—3, in Fig. 1.

Figure 4, is a side view of the finished propeller.

Figure 5, shows a plan view of the finished propeller.

Figure 6, shows a cross-section of the finished propeller, the plane of the section extending through the center.

Figures 7, 8 and 9, show cross-sections of the finished propeller, the respective planes of said sections being indicated by the lines 7—7, 8—8 and 9—9, in Fig. 4.

Referring to the drawings, in which like numerals and letters of reference indicate the same parts throughout, 1 indicates an elongated forged or rolled plate, made of metal, preferably duralumin or similar light, strong metal alloy. Figure 1, shows the plate in blank form, with dimensions, say for example, about ten-feet three-inches long, about ten-inches wide, about one and one-half inches thick at the center 2, and tapering in thickness to about one-quarter of an inch at the tips 3, 3. The blank is in annealed condition and the respective ends are divided by slits 4, 5 and 6, made preferable by a saw, and extending from the tip 3, to distances partway in the direction of the center 2, where the hub is afterward to be located. The slit 4, may be carried three-fifths of the distance from tip 3, to point 2, and slits 5 and 6, two-fifths of said distance. The blank ends are thus divided, branched or pennated, by the slits into two major branches 7, 8, and four minor branches or fingers 9, 10, 11 and 12 having roots 16, 17,

18, 19, 20 and 21, respectively. 15 is the main root of the pennated blade.

The blank and each branch individually is then cut or otherwise formed to desired profiles, as shown in Figs. 7, 8 and 9, and the branches are tapered in width from their individual roots to their tips.

The branches may be bent each from its own root, considerably out of the plane of the blank for convenience of access while forming to desired profiles and then after forming, rebent to their original positions.

The pitch being say A feet, and the blade radius for illustration, 60 inches, the blade angles from the rotation plane which must be had at respective blade radii, in order to produce the pitch of A feet, are calculated by the familiar rule for pitch, and may be denominated as follows:

1/5 or 12 inches *a* degrees
2/5 or 24 inches *b* degrees
3/5 or 36 inches *c* degrees
4/5 or 48 inches *d* degrees
5/5 or 60 inches *e* degrees

The entire propeller is then twisted at the center to the form shown at 22, Fig. 4, so that at 15, 15, namely 12 inches radius, considered as the blade main roots, the angles of each blade to the plane of rotation are about *a* degrees.

Each blade is then twisted in an angular direction the reverse of the first or central twist, and this blade twist is made about the first twisting axis A, Figs. 1, 4 and 5, which is subsequently the central longitudinal axis of the propeller, and this twist is continued progressively until at 16 and 17, Fig. 1, being 2/5 blade radius, the angle is about *b* degrees, and the attitudes at about midway between 1/5 and 2/5 radius is shown in Fig. 7.

Each branch 7 and 8, is then twisted individually and progressively in the same angular direction as the preceding, but each about respectively two new twist axes B, B, Figs. 1 and 5, and from two new roots 16, 17, Fig. 1, until 3/5 radius the angles are about *c* degrees.

It is obvious that such shifting of the twist axis from A to B, B, has caused the adjacent edges of slit 4, of branches 7 and 8, to separate, so that at 3/5 radius the cross sections are in echelon and with interspaces. Fig. 8, shows the new aspect, attitude or position of the previously adjacent edges, taken across the blades, about midway between 2/5 and 3/5 radius.

Next, each of the four branches 9, 10, 11 and 12, is twisted individually and progressively in the same angular direction as previously, and each from its respective root 18, 19, 20, 21, Fig. 1, and around its new twist axis C, C, C, C, Figs. 1 and 5, until at 4/5 radius the blade angles to the rotation plane are *d* degrees, and at 5/5 radius *e* degrees.

It is quite obvious that the shifting of the twist axes from B, B, to C, C, C, C, has caused the adjacent edges of the slits 5 and 6, to separate, so that, for example, at the 4/5 radius the cross-sections will have an echelon attitude with interspaces, as shown in Fig. 9, taken about 4/5 radius.

The separation of the branches into echelon formation or attitude, with interspaces, while maintaining nevertheless the appropriate pitch angles at each radial distance, is thus demonstrated to follow necessarily upon the shifting of the twist axes respectively from A to B, B, and from B, B, to C, C, C, C, and to show also that no special bending is needed other than the above to bring the branches into said echelon attitude or position.

Additional bending may however be done if desired to adjust the interspacing in a different manner.

The entire blank is then heat-treated or aged, according to the requirements of the particular alloy used. Holes are then drilled as shown at 26, 27 and 27, Figs. 4 and 5, and a metal hub 28, preferably of steel, is attached. This hub has preferably a twisted flange 29, fitting the central twist 22 and is secured to the propeller by bolts 30, 30. See also Fig. 6, which is a central cross section through the hub.

The branches 9 and 12, are then preferably shortened by cutting off at 32, 33, Fig. 1, and all four branches may then be rounded at their tips, as shown in Figs. 4 and 5. All four branches are also brought to a considerable degree of sharpness at their edges.

The branches will probably then be of such small inherent rigidity, due to their thinness, that each will be dependent materially upon centrifugal force for the rigidity required to maintain in flight an efficient attitude in spite of the thrust stresses tending to deflect the branches forward, but will be dependent entirely upon the inherent rigidity of the material for maintenance in the angular attitudes and aspects imparted in their construction.

I do not confine myself to the particular central formation set forth herein, nor to a propeller made integrally and entirely from a single piece of metal and with integral blades, but I may make my propeller with detachable integral blades whose roots, hub and blade anchorages may be of any well known convenient form. My novel construction of the pennated or finger-ends may be applied to the ends of aerial lifting surfaces.

Having thus described my invention what I claim and desire to secure by Letters Patent is;

1. An aeronautical solid forged metal propeller blade, divided into a plurality of blades by longitudinal slits of progressively increasing length from the edges inwardly toward the longitudinal center of the blade, the slits, in each instance extending from the blade tip only part way to the blade root and through from one face of the blade to the other.

2. An aeronautical solid forged metal propeller blade, divided into a plurality of blades by longitudinal slits, extending from the blade tip part way to the blade root, the slits extending through from one face of the blade to the other face, and each branch twisted to a varying angle from its own root to tip and about its own longitudinal axis to a position adapted to individual propulsive operation.

3. An aeronautical solid forged metal propeller blade, divided into a plurality of blades by longitudinal slits, extending from the blade tip part way to the blade root, the slits extending through from one face of the blade to the other face, and each branch twisted to pitch from its own root and about its own longitudinal axis to a position adapted to individual propulsive operation, and each blade and branch being of the minimum camber ratio consistent with stability of pitch.

4. A pennated solid forged metal aeronautical propeller blade, divided into a plurality of blades by longitudinal slits, extending from the blade tip part way to the blade root, the slits extending through from one face of the blade to the other face, the inner portion of said blade between the hub and the inner ends of said slits being formed with a substantially streamline contour and each branch being formed of a contour geometrically substantially similar to the contour of said inner portion and each branch being torsionally displaced to a position substantially parallel to but not in alignment with the other branches.

5. The herein described method of making a solid metal propeller blade which consists in providing a solid metal plate blank, slitting the outer end thereof to form a gang of distal radial fingers, then forming the blank with desired cross-sectional profiles, tapering each finger from its root to its tip, then twisting the main part to provide necessary pitch angles, and then twisting each finger individually from root to tip progressively to provide pitch angles therefor.

6. A pennated solid forged metal aeronautical propeller blade having its branches torsionally displaced to a position of interspaced echelon.

7. An aeronautical propeller blade comprising a main inner end part formed with a pitch angle, and having distal multiple blade portions extending radially therefrom, and formed with individual pitch angles, each said blade portion having a gradually decreasing depth of chord from root to tip.

8. An aeronautical propeller made with integral solid blades of forged or rolled strong light weight metal alloy, the blades throughout a substantial portion of their length being longitudinally slit to provide two major branches, and each major branch being longitudinally slit, tho to a lesser inward depth, to provide a plurality of minor branches, said blades and blade branches, throughout the unslit portion of their respective lengths, being individually twisted to the desired pitch angle and individually shaped to true aerofoil section.

9. An aeronautical propeller made with integral solid blades of forged metal, each blade being formed with a ratio of length to chord of at least as great as three to one and each blade being divided into a plurality of branches, the blade adjacent to the hub being undivided and of substantially streamline contour and each of the branches being also of streamline contour and having a length to chord ratio also at least as great as three to one, and each branch being torsionally displaced to a position in interspaced echelon with the other branches.

Signed at New York city, in the county of New York and State of New York this 26th day of December, 1928.

SYLVANUS A. REED.