Oct. 23, 1923.

1,471,590

S. W. CARTER

PROPELLER

Filed Oct. 2, 1922

2 Sheets-Sheet 1

Fig. 2.

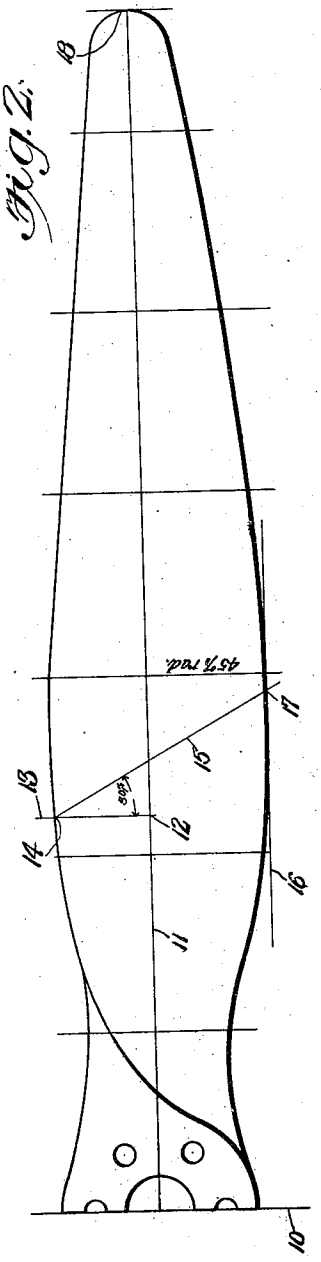


Fig. 3.

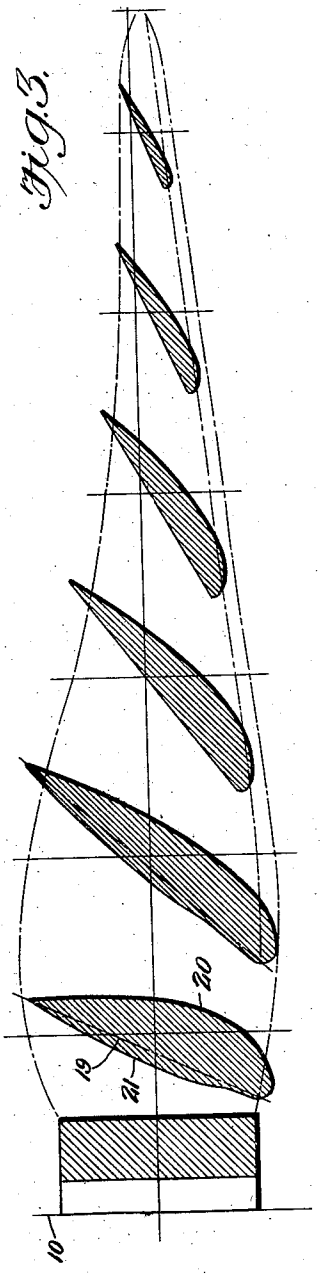
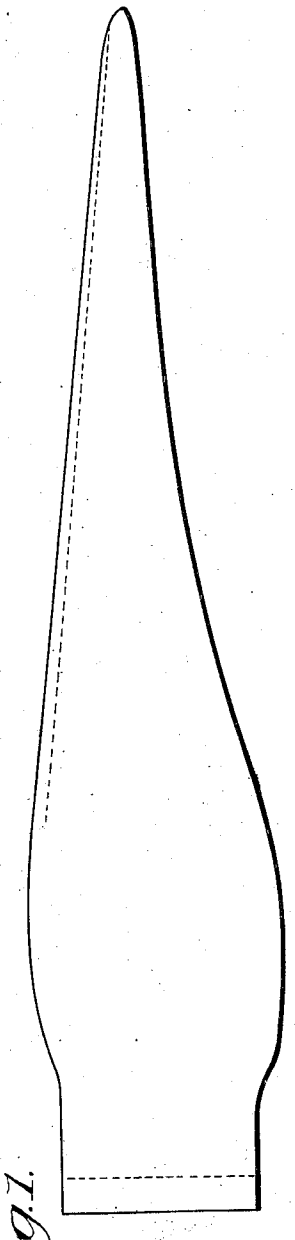


Fig. 1.



Inventor

Samuel W. Carter.

By L. B. James

Attorney

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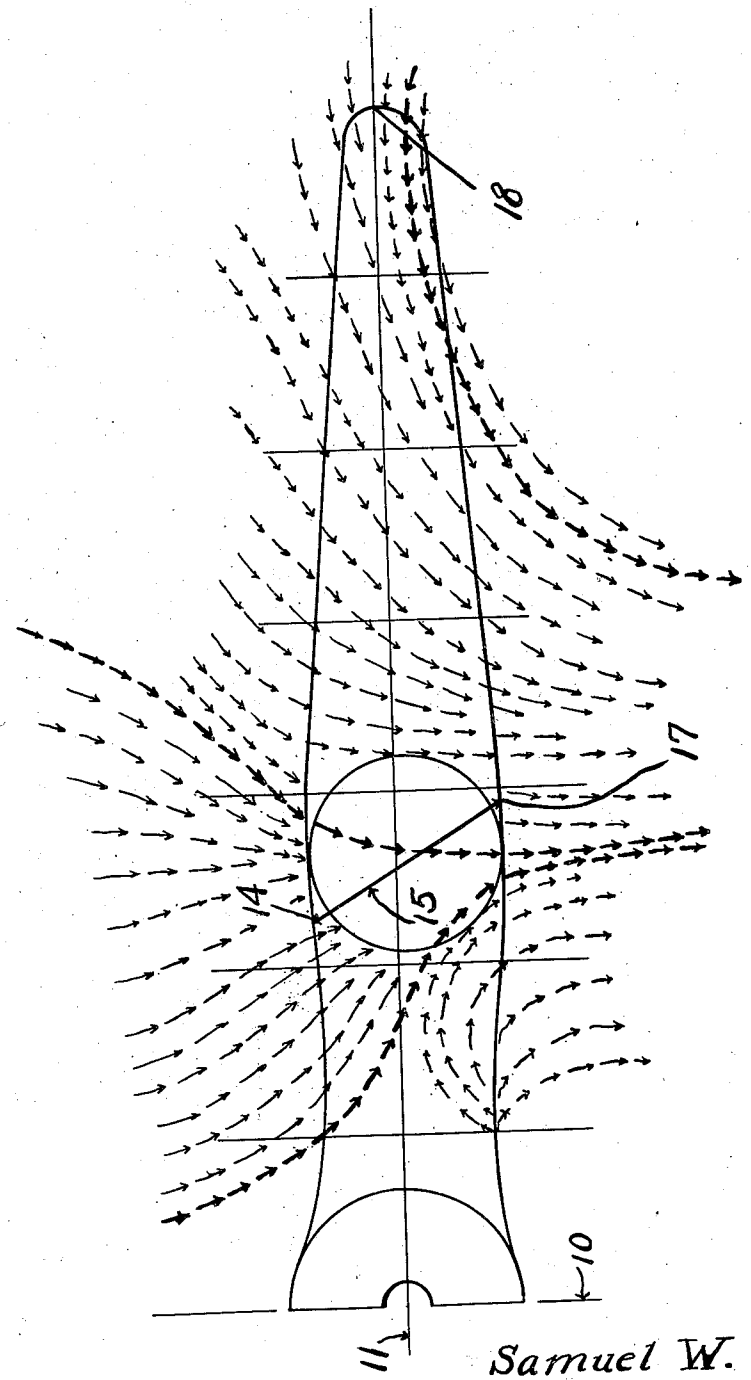
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2 Sheets-Sheet 2

Fig. 4.



Inventor

Samuel W. Carter

By L. B. James

Attorney

Patented Oct. 23, 1923. 1,471,590

UNITED STATES PATENT OFFICE.

SAMUEL W. CARTER, OF WASHINGTON, DISTRICT OF COLUMBIA.

PROPELLER.

Application filed October 2, 1922. Serial No. 591,927.

REISSUED

To all whom it may concern:

Be it known that I, SAMUEL W. CARTER, a citizen of the United States, residing at Washington, District of Columbia, have invented new and useful Improvements in Propellers, of which the following is a specification.

This invention relates to propellers and has special reference to the design and construction of propeller blades.

More particularly the invention relates to an improved method of designing propeller blades and to a blade constructed in accordance with such method.

Heretofore it has not been considered that there was any particular relation between the points on the leading edge of the blade furthest from the horizontal line passing through the center of the hub in the elevational aspect of the blade and the similar points on the trailing edge.

I have discovered that there is, in order to obtain a maximum efficiency, a certain very definite relation between these points. Furthermore, I have discovered that a certain very definite relation exists in the location in distance from the center of the hub to these points and that whenever such relationships are departed from to any material extent there is a corresponding loss of efficiency in the propeller. The reason for this is that, when proper cambers are given to the inner and outer portions of the blade a fluid stream will travel from the tip of the blade towards the hub and another stream will travel from the hub toward the tip. Now, if the points in question are in proper relationship these two opposing fluid streams will operate to produce a vortex circle or cyclone action at their junction so that rearward flow of the two streams tends to be obtained without dispersion, and thus the reaction on the propeller blade becomes very great whereby the propulsive effect is greatly enhanced.

One important object of the present invention is to provide a method of laying out a propeller blade whereby to determine the location of these points or apices on the leading and trailing edges of the blades in their proper relation to the center of the hub and to each other.

A second very important object of the invention is the provision of a propeller so constructed that the apices of the leading and trailing edges will bear definite relation to each other and to the center of the hub or axis of rotation of such propeller.

It has also been customary in the design of propellers, to so shape the various blade sections that the rearward moving fluid current from a rotating propeller would be concentrated as nearly as possible at the center. I have discovered that a more highly efficient propeller is produced when the rearwardly extending fluid current from a stationary propeller takes the form of a vortex circle located at a certain distance from the axis of rotation of the propeller. The advantage of this lies principally in the fact that the stresses are removed from the tip portion of the blade where it is thinnest and the reaction is concentrated in the strong portion of the blade, and the fluid stream set up by the blade does not tend to disperse. This action is obtained by properly arranging the cambers of the inner and outer portions of the blades and designing the propeller, in a manner hereinafter described, so that certain relationships exist between the points on the leading and trailing edges.

A third important object of the invention is to provide a method of design wherein the proper position of this vortex circle may be obtained.

A fourth important object of the invention is to provide a propeller so constructed that the air or other fluid will have a slip along the blade from the center or axis of rotation outward with relation to the inner portion of the blade and inward from the tip with relation to the outer portion of the blade.

With the above and other objects in view as will be hereinafter apparent, the invention consists in general of certain novel details of construction and combinations of parts, hereinafter fully described, illustrated in the accompanying drawings and specifically claimed.

In the accompanying drawings like characters of reference indicate like parts in the several views, and:—

Figure 1 is a top plan view of a propeller blade constructed in accordance with the improved design.

Figure 2 is a side elevation of such a blade.

Figure 3 is a bottom plan view of such a blade with the layout of various sections

shown thereon, Figures 2 and 3 being connected in order to show the entire blade layout.

Fig. 4 is a diagrammatic view showing in elevation a blade constructed in accordance with this invention and the flow of fluid currents in relation thereto.

In the laying out of a propeller blade by the improved method the length of the blade from the center of rotation to its tip, the width of the blade in elevation, the pitch and the cambers are determined by calculation in the usual manner. Also, the hub dimentions may be likewise determined but with these dimensions the present invention is not concerned. In order to lay the propeller out from the required dimensions as calculated to suit the particular case, there is first drawn a vertical center line through the axis of rotation of the propeller, and then through the point of intersection with the axis there is drawn a horizontal section line for the elevation of the propeller. At a certain point on this line a perpendicular is then erected. In the drawings the vertical center line is indicated at 10, the horizontal center line at 11, and the point at which the perpendicular is erected at 12, the perpendicular itself being indicated at 13. The calculated width of the blade is then divided into a number of equal fractional parts of which certain numbers of these parts are laid off on the line 13 to determine the point 14 which is the apex of the curve of the trailing edge that is to say, the furthest point on said curve from the line 11 as measured perpendicularly to said line in the elevation of the propeller. From this point 14 a line 15 is laid off angularly to the line 11 and extending downwardly and outwardly from the point 14 along the blade. A line 16 is now laid off parallel to the line 11 and at a distance therefrom corresponding to the remainder of the calculated width after the line 13 has had its length determined. This line 16 intersects the line 15 at a point 17 which point is the apex of the curve of the leading edge of the propeller.

Experience has shown that, while a certain variation may be allowed in the distance of the point 14 from the line 10 relative to the length of the blade, the distance of said point from the line 11, the angle between the line 15 and line 11, and the distance of the point 17 from the line 11, yet there is a certain definite and fixed relation between these points and lines which must be closely adhered to in order to obtain the maximum efficiency. In actual practice the length of the blade, measured from the line 10 to the tip 18 is divided into three equal parts and one of these parts is laid off from the line 10 along the line 11 to obtain the point at which to erect the line 13. Also it is found that the width of the blade in elevation, as determined by calculation, should be divided into nine equal parts and four of these parts laid off above the line 11 to determine the location of the point 14 while the remaining five are measured downward from that line to determine the location of the line 16. In addition it is found that the angle between the line 15 and the line 11 should be 60°. When these peculiar dimensions are used it is found that the resulting blade possesses extremely high efficiency especially when the camber of the various blade sections is properly calculated.

In laying off the blade sections, the pitch center of the blade is determined in the usual manner, and from this center a series of radial lines 19 are laid out in the bottom plan view, these lines being at regularly decreasing angles to the line 11 from the center of the hub to the tip of the blade and identified by the angle which they make with said line 11. Thus, the radial line which makes an angle of 45° with the line 11 is known as the 45° radius. Also the upper camber or distance between these lines and the lines 20 is calculated as well as the lower camber or the distance between these lines and the lines 21, care being taken to so proportion these cambers and the curves of the lines 21 that slip will take place from the line 10 outward along the blade on the inner third of said blade and inward along the outer two thirds of the blade, so that substantially at the point of 45° radius the inwardly and outwardly flowing currents will meet and a vortex will be formed as shown by the arrow in Fig. 4. It will be obvious that these cambers are designed in a manner based on the old and well known principles and vary in accordance with the uses to which different propellers are to be put. For instance, the cambers in the propeller for a heavy freight carrying aeroplane, such as a bombing plane, will be different from the cambers in a propeller for a light high speed aeroplane such as a scout.

Furthermore, it will be observed that from these laid-off blade sections the width of the blade at various points in elevation can be obtained and these widths are laid off above and below a horizontal center line on the elevation at corresponding points in the same proportions as the maximum widths, that is to say, in the proportions of from 4/9 to 5/9 of the respective widths.

It will be observed that the displacement of the points on the leading edge outwardly from the center with respect to the corresponding points on the trailing edge can be mathematically calculated as the displacement in any case is equal to four-ninths of the width at the point multiplied by the tangent of the selected angle preferably the tangent of 60° For example, if the width

at the points be 4 inches the displacement of the point along the leading edge will be 1.73×4 in., or 6.92.

By this method it is possible to quickly lay out the proper points and when these points are so laid the propeller constructed in accordance therewith is of very high efficiency, tests having shown an efficiency of 95%.

Having thus described the invention what is claimed as new is:—

1. That method of determining the apex points of the leading and trailing edges of propeller blades which consists in determining the length and maximum width in elevation of the desired blade, describing the vertical and horizontal center lines of the elevation of the propeller, erecting a perpendicular at a point on the horizontal center line a predetermined distance from the vertical center line, dividing the predetermined width into a number of equal fractional parts, laying off on the perpendicular a predetermined number of said parts to determine the apex point of the curve of the trailing edge of the blade, laying off a line from said apex point inclined at a predetermined angle to the horizontal center line and crossing the same, measuring the remainder of the width downward from said horizontal center line perpendicularly thereto to determine the distance from said horizontal center line of the apex point of the leading edge, and laying off a line at such distance through the angular line to determine by the intersection of said lines said apex point.

2. That method of determining the apex points of the leading and trailing edges of propeller blades which consists in determining the required length and maximum width of the blade in elevation, describing the vertical and horizontal center lines of the propeller, erecting a perpendicular on the horizontal center line one-third the length of the blade from the vertical center line, laying off a point on the perpendicular at a distance equal to four ninths the said width from the horizontal center line, the point thus determined being the apex point of the trailing edge, laying off a line through said point and extending outwardly and crossing the horizontal center line at an angle of sixty degrees, and determining a point on said line five ninths of said width below the horizontal center line to constitute the apex point of the leading edge.

3. That method of laying out propeller blades which consists in determining the apex points of the leading and trailing edges of the blade by determining the length and maximum width in elevation of the desired blade, describing the vertical and horizontal center lines of the elevation of the propeller, erecting a perpendicular at a point on the horizontal center line a predetermined distance from the vertical center line, dividing the predetermined width into a number of equal fractional parts, laying off on the perpendicular a predetermined number of said parts to determine the apex point of the curve of the trailing edge of the blade, laying off a line from said apex point inclined at a predetermined angle to the horizontal center line and crossing the same, measuring the remainder of the width downward from said horizontal center line perpendicularly thereto to determine the distance from said horizontal center line of the apex point of the leading edge, laying off a line at such distance through the angular line to determine by the intersection of said lines, said apex points determining the widths in elevation of the blade at a number of other points in its length, laying off, dividing each of said widths into the same number of fractional parts as the first mentioned width, utilizing a number of the fractional parts of each width equal in number to the fractional parts of the maximum width used in determining the respective apex points to determine points on the respective edges opposite the points at which the last mentioned widths are determined.

4. That method of laying out propeller blades which consists in determining the apex points of the leading and trailing edges of the blade by determining the required length and maximum width of the blade in elevation, describing the vertical and horizontal center lines of the propeller, erecting a perpendicular on the horizontal center line one-third the length of the blade from the vertical center line, laying off a point on the perpendicular at a distance equal to four-ninths the said width from the horizontal center line, the point thus determined being the apex point of the trailing edge, laying off a line through said point and extending outwardly and crossing the horizontal center line at an angle of sixty degrees, determining a point on said angular line distant perpendicularly five-ninths of said width from the horizontal center line, said last point being the apex point of the leading edge, determining the widths in elevation of the blade at a number of points in its length, laying off at each of said points four-ninths of the respective width to determine trailing edge points and five-ninths of said width to determine leading edge points.

5. A propeller blade having the apex point of its trailing edge at a predetermined distance from the center of rotation of the propeller and the apex point of its leading edge located further from the center by an amount approximately equal to a predetermined fraction of the greatest width of the blade in elevation multiplied by the

tangent of an angle formed by a line passing through the point on the trailing edge and having a predetermined angular relation with the center line of the blade, the angle being that between said line and the center line.

6. A propeller plade having the apex point of its trailing edge located at a distance from the center of the propeller equal to one-third the distance from said center to the tip of the blade and the apex point of its leading edge located further from the center by a distance equal to a predetermined fraction of the greatest width of the blade in elevation multiplied by the tangent of sixty degrees.

7. A propeller blade having the apex point of its trailing edge at a predetermined distance from the center of rotation of the propeller and the apex point of its leading edge located further from the center by an amount approximately equal to a predetermined fraction of the greatest width of the blade in elevation multiplied by the tangent of a predetermined angle, said angle being that between a line passing through the point on the trailing edge and the center line of the blade in predetermined angular relation to said center line, said apex point of the leading edge being located a predetermined fractional part of the maximum width of the propeller on one side of the center line of the blade in elevational aspect and the apex point of the trailing edge being located the remainder of the greatest elevational width on the other side of said line.

8. A propeller blade having the apex point of its trailing edge located at a distance from the center of the propeller equal to one-third the distance from said center to the tip of the blade and the apex point of its leading edge located further from the center by a distance equal to the greatest width of the blade in elevation multiplied by the tangent of sixty degrees, said apex point of the trailing edge being located at 4/9 the maximum width of the blade in elevation from the horizontal center line of the blade in elevational aspect and the apex point of the leading edge being located 5/9 of said maximum width on the other side of said center line.

9. A propeller blade having the apex point of its trailing edge at a predetermined distance from the center of rotation of the propeller and the apex point of its leading edge located further from the center by an amount approximately equal to a predetermined fraction of the greatest width of the blade in elevation multiplied by the tangent of a predetermined angle, said angle being that between a line passing through the point on the trailing edge and the center line of the blade in predetermined angular relation to said center line, said apex point of the leading edge being located a predetermined fractional part of the maximum width of the propeller on one side of the center line of the blade in elevational aspect and the apex point of the trailing edge being located the remainder of the greatest elevational width on the other side of said line, the remaining point on said leading and trailing edges being located in corresponding pairs at distances on opposite sides of said center line proportionate to the distances of the apex points.

10. A propeller blade having the apex point of its trailing edge located at a distance from the center of the propeller equal to one-third the distance from said center to the tip of the blade and the apex point of its leading edge located further from the center by a distance equal to the greatest width of the blade in elevation multiplied by the tangent of sixty degrees, said apex point of the trailing edge being located at 4/9 the maximum width of the blade in elevation from the horizontal center line of the blade in elevational aspect and the apex point of the leading edge being located 5/9 of said maximum width on the other side of said center line, the remaining points on said leading and trailing edges being located in corresponding pairs at distances on opposite sides of said center line proportionate to the distances of the apex points.

11. A propeller blade including an inner and an outer portion, said inner portion being cambered to cause slip of the fluid on which the blade acts in an outward direction and the outer portion being shaped to cause slip inwardly of the blade of said fluid, said blade being further shaped to produce a vortex at the junction of said inner and outer blade portions.

12. A propeller blade including an inner and an outer portion, said inner lower portion being cambered to cause slip of the fluid on which the blade acts in an outward direction and the outer portion being shaped to cause slip inwardly of the blade of said fluid, said inner and outer portions being respectively 1/3 and 2/3 the length of the blade.

13. A propeller blade having an angle of attack greater than 45° adjacent its inner end and an angle of attack less than 45° at its outer end, the angle of attack varying progressively from one end of the blade to the other whereby the angle of attack at one point equals 45°, said blade having the outer portion beyond the said point shaped to direct a fluid stream inwardly along the blade and having the inner portion shaped to direct a fluid stream outwardly along the blade whereby said streams meet at approximately said point.

14. A propeller blade having an angle of attack greater than 45° adjacent its inner

end and an angle of attack less than 45° at its outer end, the angle of attack varying progressively from one end of the blade to the other whereby the angle of attack at one point equals 45°, said blade having the outer portion beyond the said point shaped to direct a fluid stream inwardly along the blade and having the inner portion shaped to direct a fluid stream outwardly along the blade whereby said streams meet at approximately said point, said inner and outer blade portions being further shaped to cause formation of a fluid vortex at the point of meeting of the fluid streams.

In testimony whereof I affix my signature.

SAMUEL W. CARTER.