May 13, 1924.

1,493,928

E. F. GALLAUDET

AEROFOIL

Filed July 21, 1921

Fig. 1.

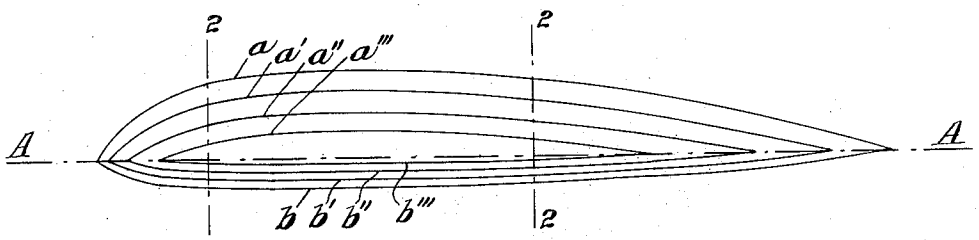


Fig. 2.

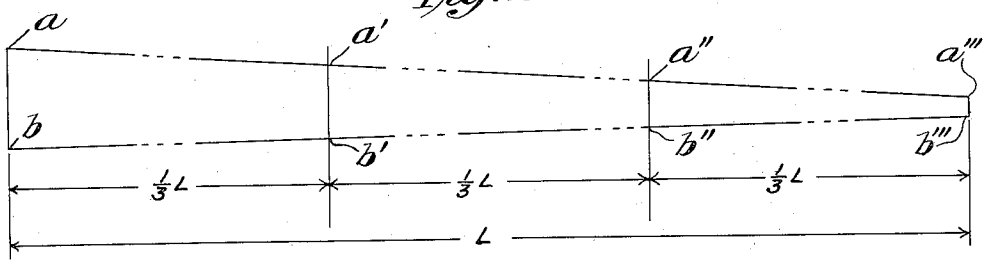


Fig. 3.

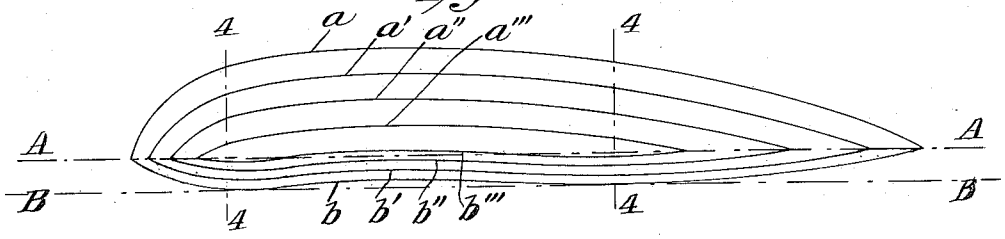
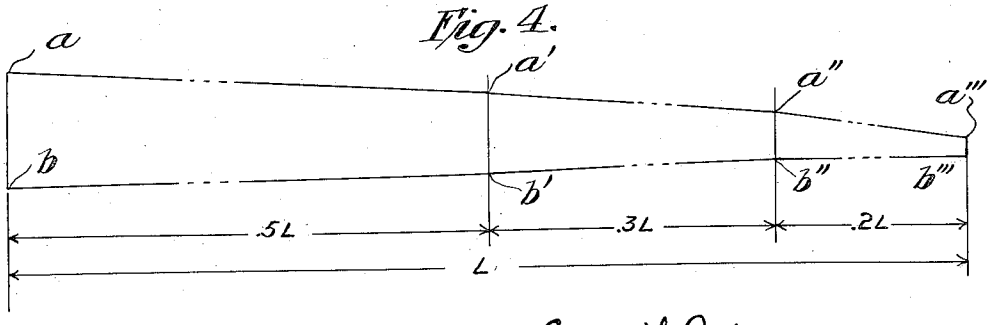


Fig. 4.



Edwin F. Gallaudet Inventor

By his Attorney W. B. Whitney

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UNITED STATES PATENT OFFICE.

EDSON F. GALLAUDET, OF PROVIDENCE, RHODE ISLAND.

AEROFOIL.

Application filed July 21, 1921. Serial No. 486,416.

To all whom it may concern:

Be it known that I, EDSON F. GALLAUDET, a citizen of the United States, and a resident of the city of Providence, in the county of Providence and State of Rhode Island, have invented certain new and useful Improvements in Aerofoils, of which the following is a specification.

This invention relates to aerofoils, and more particularly to tapered aerofoils or wings of airplanes.

Tapered aerofoils possess certain distinct advantages over straight aerofoils. In the first place, since in the tapered aerofoils the lifting surface is greatest at its base or inner end and smallest at the tip, the air forces impressed thereon in flight act nearer the body of the airplane than in the case of a straight aerofoil. Again, the thickness of the aerofoil being greater at the base than at the tip, the spars and ribs at and adjoining the base of the aerofoil may be made deeper, and consequently lighter, than the similar parts of a straight aerofoil. Furthermore, the tapered form distributes the mass of the aerofoil structure nearer the body of the airplane than in the case of a straight aerofoil, so that the inertia forces set up by the mass of the aerofoil itself act nearer to the airplane body and hence contribute less to the sum total of the forces the aerofoil must be designed to carry. In general, therefore, the tapered aerofoil form, by causing all the forces impressed on or set up in the aerofoil to act nearer the body of the airplane than in the case of a straight aerofoil, is favorable to the lightness and strength of the entire structure.

These advantages are, however, in large measure offset by the complexity of the tapered aerofoil which, as heretofore constructed, is difficult of design and stress analysis and is poorly adapted for quantity production. No two ribs in a tapered aerofoil are the same. Even where all of the ribs are made to the same contour the dimensions will be different for each one, and, in case the ribs are not all of the same contour, the design is different for each and both design and construction become very laborious. Moreover, the spars, if parallel, cannot pass through the ribs with any uniformity, as they do in a straight aerofoil, and, conversely, if they pass through the ribs at the same relative points therein, they will not be parallel. Hence, as the contour at the base of the aerofoil is seldom suitable for the tip, different members for attaching the ribs to the spars will be required at every rib.

By my present invention I have obviated all of the above disadvantages, while at the same time realizing aerofoil forms of the highest efficiency.

My new tapered aerofoil is characterized by a maximum or base section which is bounded by intersecting upper and lower contour lines, variable at will and so laid out as to give to the aerofoil the contour best adapted to the particular purpose in view, and, from base to tip, by successively reduced sections which are established by successively reducing the distance between the upper and lower contour lines of the base section, moving the lines towards each other without changing either their angular relationship or their curvature. The front and rear intersections of the two lines form, respectively, the entering and trailing edges of each section.

The aerofoil may be defined as formed by two curved surfaces in which the generating lines describing the two surfaces respectively are inclined toward one another at an angle equal to the angle of taper. Where the angle of inclination of these generating lines remains constant throughout, the aerofoil will have a uniform taper from end to end. In the event that uniform taper is not desired, however, the angle, starting from a zero angle if desired, may be changed from time to time, thus giving to the aerofoil different degrees of taper through different portions of its length.

In all cases, the aerofoil will have a thick section at the base, a thin tip section, and will both sweep back along its entering and forward along its trailing edge. At two points in each section, one near the entering edge and the other towards the trailing edge convenient for the location of the spars, the thickness of the aerofoil, or the vertical distance between its upper and lower contour lines, is the same, and these points are constant in distance apart and position throughout the length of the aerofoil. Consequently, by placing the spars at these points two spars which are exactly alike can be used and will, or may, be parallel one to the other. Moreover, since the curvature of the sectional contour lines of any given aerofoil

never changes, the cap strips for the ribs can all be bent in the same formers; and, where the two spars are parallel, all the ribs will meet them at a uniform angle. The spars, while parallel to each other in vertical planes, may, if desired, be set at different angles to the horizontal, the rear spar for example at a dihedral angle relative to the front spar so as to give a so-called "washout" to the aerofoil.

The new aerofoil is easy to design, analyze, and construct, either singly or in quantity production, and can be made of the required strength with a minimum weight of material.

The invention will be understood by reference to the accompanying drawings, in which—

Figure 1 is an end view of an aerofoil embodying my invention, showing the upper and lower contour lines at the base, tip, and two intermediate points in the length of the aerofoil; Fig. 2 is a section, more or less diagrammatic, on either of the two lines 2 2 of Fig. 1; Fig. 3 is a view, similar to Fig. 1, of a modified form of aerofoil adapted for a different type of airplane; and Fig. 4 is a section, one either of the two lines 4 4, of the modified aerofoil shown in Fig. 3.

As illustrated in Figs. 1 and 2, the upper and lower contour lines *a b* of the inner base section of the aerofoil are laid out from a base or datum line A A, which is here coincident with the chord line, in outwardly convex curves which produce an aerofoil, relatively thin and with a low head resistance secured at a small sacrifice in lift, adapted to small machines of great speed and moderate lifting capacity. In this aerofoil the outer sections are shown as established by moving the contour lines *a b* towards each other by successively equal amounts for successively equal distances, the upper line however at a more rapid rate than the lower line. Hence, the lines *a' b'*, *a'' b''*, and *a''' b'''*, show the contour of sections at one-third of the length of the aerofoil from its base, at two-thirds of its length from its base, and at the tip, respectively; and the spars, located at the spar positions represented by the fore and aft section lines 2 2 in Fig. 1, will be exactly alike, will be parallel, and will have in side elevation the uniform taper shown in Fig. 2.

The modified form of aerofoil illustrated in Figs. 3 and 4 is one particularly adapted for large machines of moderate speed and high lifting capacity. The convexedly curved contour line *a* and convexly-concavely-convexly, or compound, curved contour line *b* give it a thick section heavily curved on its upper surface and with a hollow camber on its lower surface which produces a chord line B B separate from the datum line. To establish the outer sections of this aerofoil, the upper and lower contour lines of its base section are brought towards each other by steps not proportioned to distance from the base. Thus, the contour lines *a' b'* show the section midway of the length of the aerofoil, the contour lines *a'' b''* give the section four-fifths of the distance out from the base, and the tip section is represented by the contour lines *a''' b'''*. The two spars, located at the fore and aft section lines 4 4 of Fig. 3, will accordingly have a broken taper as shown in Fig. 4.

It is obvious that the contour lines of the aerofoil may be further modified, as desired, without departing from the spirit or sacrificing the advantages of my invention.

What I claim as new, and desire to secure by Letters Patent, is—

1. In an airplane a framed and enclosed structure which is tapered through a portion at least of its length and which at the base of such tapered portion has a section bounded by two contour lines both curved convexly outward and intersecting each other at opposite points in the section and from the base to the tip of the tapered portion has successively reduced sections bounded by contour lines determined by successively moving nearer and nearer together the two said curved lines without change either in their curvature or in the angular relationship of one to the other.

2. A tapered aerofoil having a base section bounded by suitably curved upper and lower contour lines which intersect fore and aft to form its entering and trailing edges and give to the section equal depth at two points one fore and one aft suitable for the location of spars and through its tapered outer portion having successively reduced sections established by successively bringing nearer and nearer together the two contour lines of the base section without change in the angular relationship of one to the other.

3. A tapered aerofoil having a base section bounded by suitably curved upper and lower contour lines which intersect fore and aft to form its entering and trailing edges and give to the section equal depth at two points one fore and the other aft suitable for the location of spars and from base to tip having successively reduced sections established by moving the contour lines of the base section towards each other by successively equal amounts for successively equal distances without change in the angular relationship of one to the other.

4. An aerofoil which is tapered through the outer half at least of its length and which has a base section bounded by suitably curved upper and lower contour lines intersecting each other fore and aft to form the entering and trailing edges and through its tapered outer portion has successively

reduced sections established by successively bringing nearer and nearer together the two contour lines of the base section, the upper contour line being moved at a more rapid rate than the lower, without change in the angular relationship of one to the other.

5. A tapered aerofoil which has a thick base section and a thin tip section, which throughout the outer portion at least of its length sweeps both back along its entering and forward along its trailing edge, and which in each section from base to tip is of like thickness at two points one fore and the other aft which are constant in distance apart throughout the length of the aerofoil.

6. A tapered aerofoil having parallel longitudinal sections fore and aft of the center of pressure respectively in which at each transverse section lines perpendicular to the chord line are of the same length.

7. A tapered aerofoil having parallel fore and aft spar positions which are of the same depth at each transverse section of the aerofoil.

EDSON F. GALLAUDET.