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[22] Filed **May 18, 1970**
[45] Patented **Dec. 7, 1971**

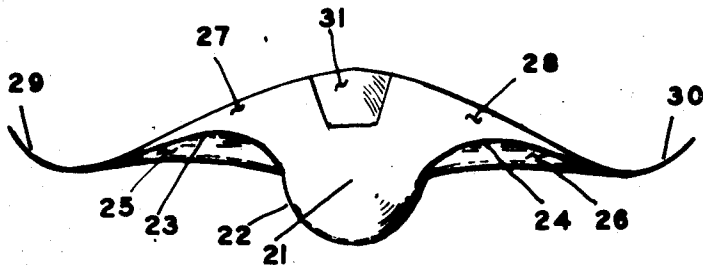
[54] **AIRFOIL DESIGN**
4 Claims, 15 Drawing Figs.

[52] U.S. Cl..... 244/35,
244/36
[51] Int. Cl..... B64c 3/02
[50] Field of Search..... 244/35, 36,
35.6, 1, 1 SS

[56] References Cited			
UNITED STATES PATENTS			
2,303,713	12/1942	Thompson.....	244/35 X
2,670,155	2/1954	Sahl.....	244/35 X
2,775,419	12/1956	Hlohil.....	244/35
3,276,722	10/1966	Eggers, Jr. et al.....	244/36 X

Primary Examiner—Milton Buchler
Assistant Examiner—Carl A. Rutledge

ABSTRACT: A new delta-wing aircraft wherein airflow effectively alters geometry with airspeed to produce high lift at low speed and low-induced drag at high speed.



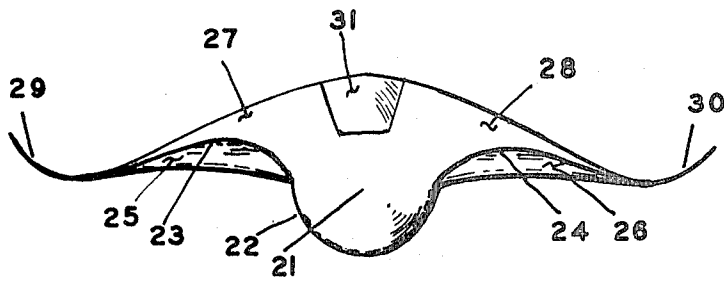


FIG. 1

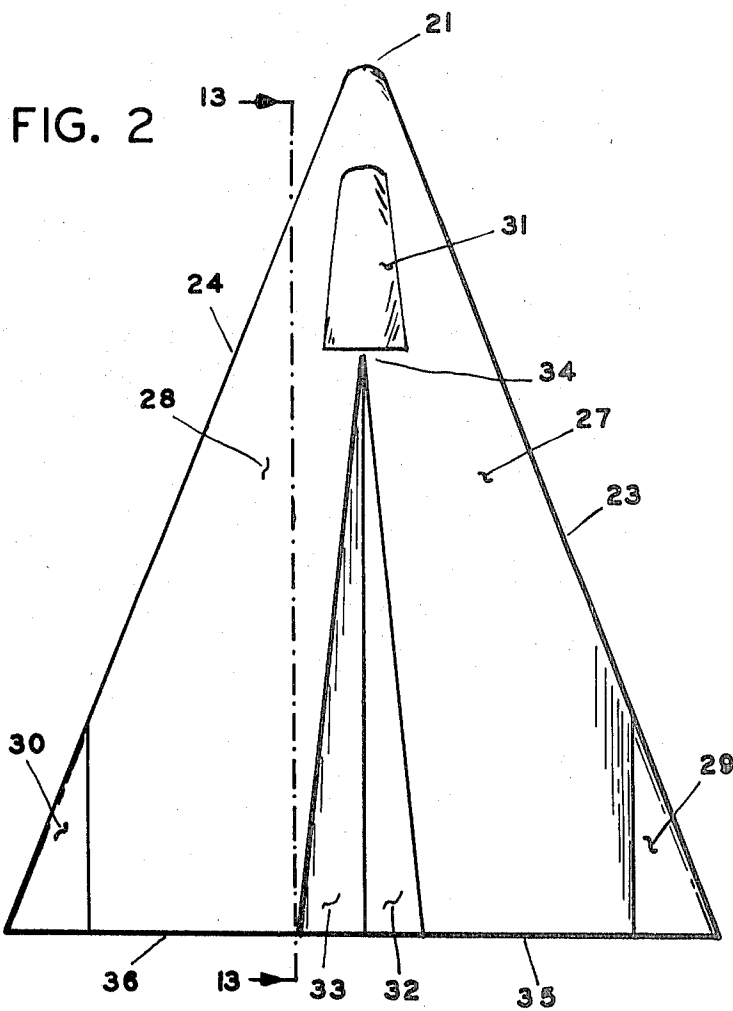


FIG. 2

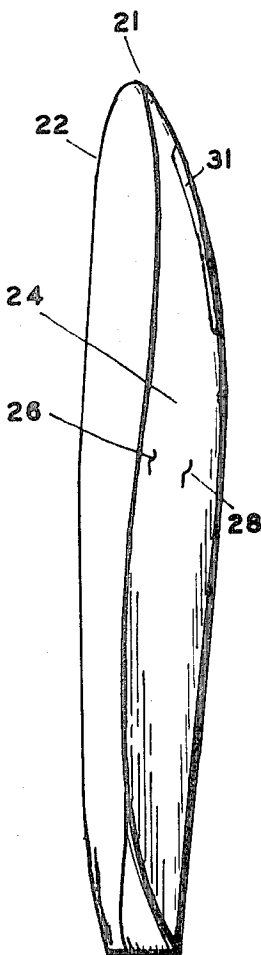


FIG. 3

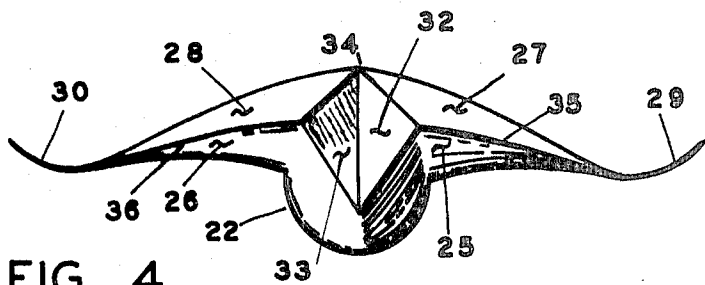


FIG. 4

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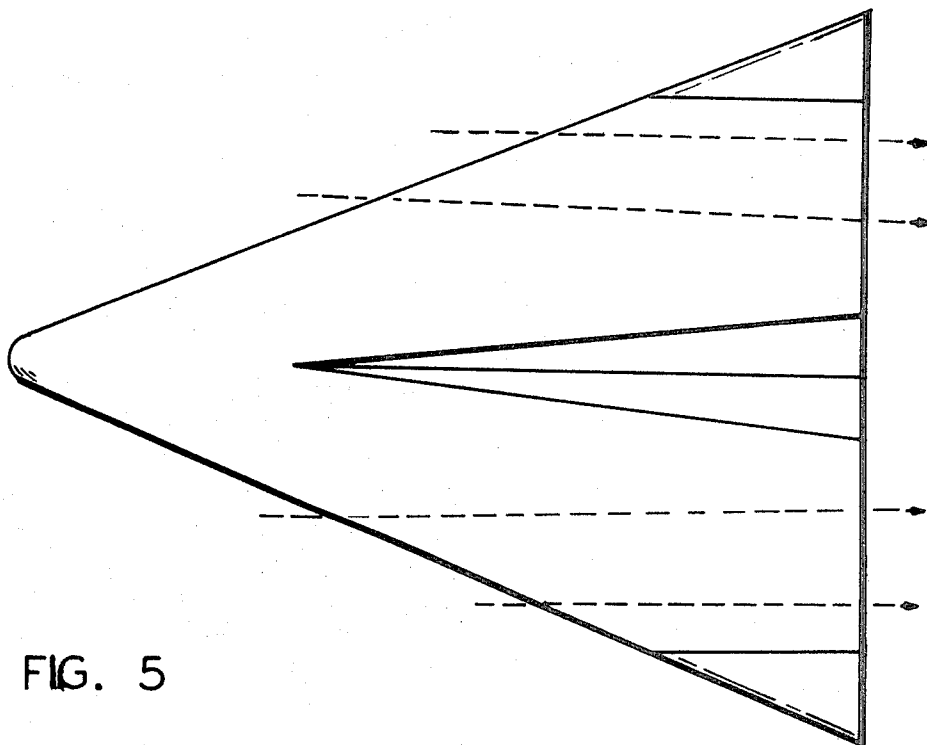


FIG. 5

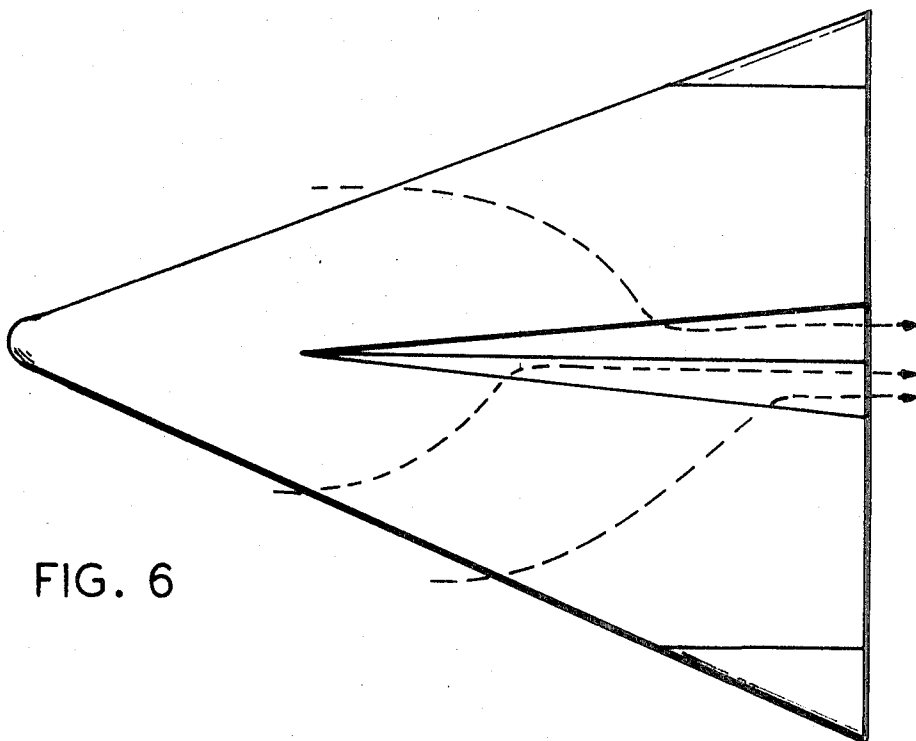


FIG. 6

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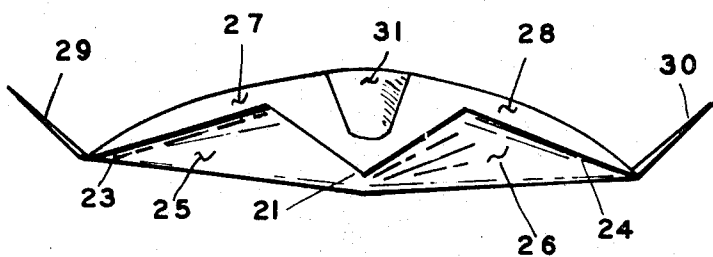


FIG. 7

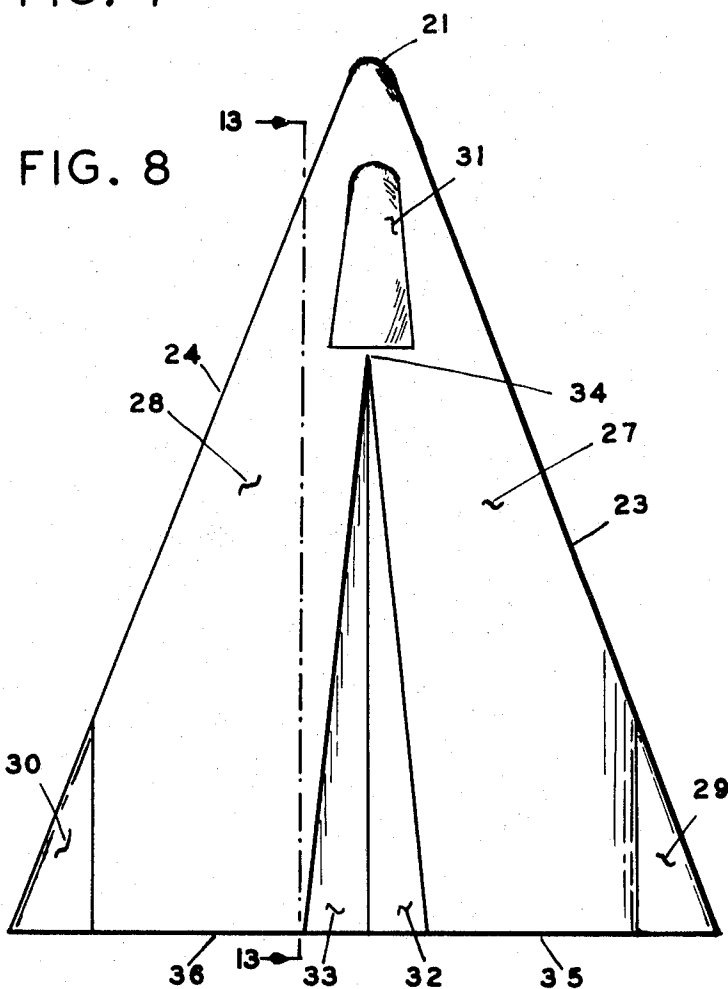


FIG. 8

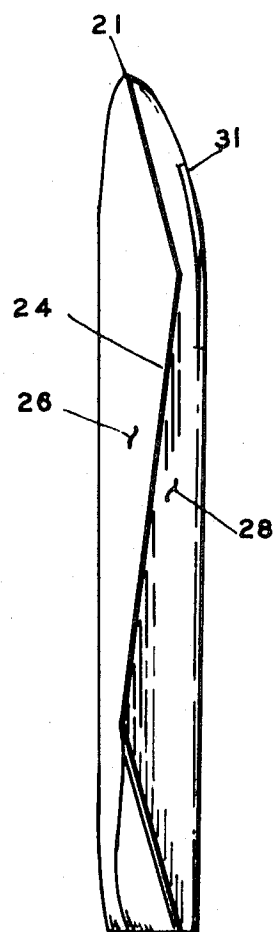


FIG. 9

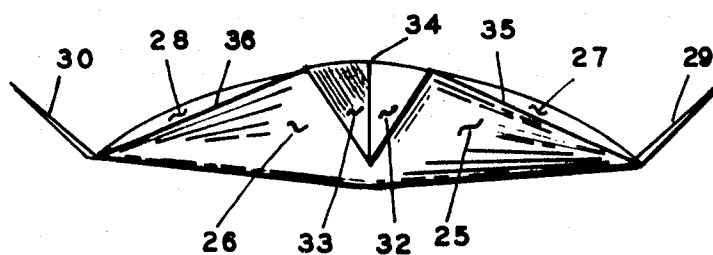


FIG. 10

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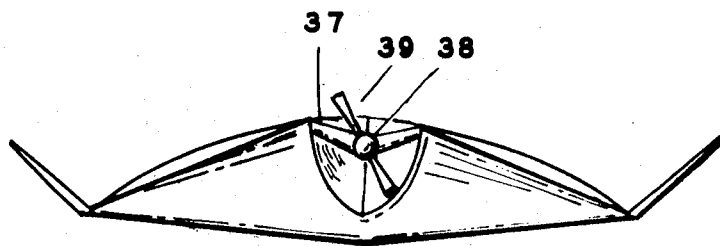


FIG. 11

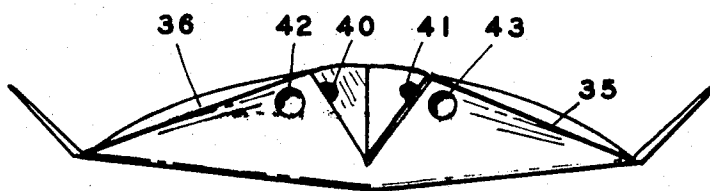


FIG. 12

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FIG. 13



FIG. 14



FIG. 15

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AIRFOIL DESIGN

This patent relates in general to aircraft and more particularly to an improved airfoil.

In the past, conventional airfoil design has been based upon the hypothesis that, in order to create substantial lift, the airfoil had to be of a configuration including an upper surface of substantially curvilinear form and an opposite lower surface of essentially rectilinear form, so that the airflow path length along the wing would be greater than the path beneath the wing. This assumption has been largely based upon the postulation of Bernoulli's theorem to explain the case of the underpressure created above an airfoil.

While Bernoulli's theorem, which relates pressure and velocity in fluids is everywhere true, it does not explain the cause of the underpressure developed above a forward moving airfoil, but merely relates the effect. Some texts on the subject describe this application as "the weak case" of Bernoulli's theorem. In the course of developing the present invention, airfoil cross sections have been made for the specific purpose of disproving the long accepted hypothesis, which they did to the satisfaction of this writer. Newtonian physics, properly applied, amply explains the cause of underpressure development above the airfoil as well as the overpressure beneath the wing.

Present aircraft based upon the hypothesis take many forms; but, basically they use straight wing, swept wing, or delta-wing airfoils of similar cross section. Many variations in airfoil cross section have been designed, but they are substantially similar, relying upon the greater upper surface airpath lengths.

I deduce that all fixed wing aircraft airfoils, propeller blades, rotary wings based upon the accepted hypothesis exhibit less than optimum lift-to-drag ratio. Because of the high induced drag of fixed-wing aircraft within the present state of the art, excessive power is required in takeoff, landing, and to maintain cruising speed. In fact, jet engine thrust in commercial airliners is a very substantial percentage of gross weight borne and most of this thrust is needed not to overcome parasitic drag, but to overcome the induced drag produced in obtaining the necessary lift. Delta-wing planes generally exhibit lower induced drag, but have dangerously high stalling speed and must land at a high attack angle which poses other problems.

The present invention employs a delta-shaped airfoil having opposed upper and lower surfaces which follow contours that are substantially sinusoidal, and which has a V-shaped depression or channel in the upper surface center, such channel generally increasing in width and depth along its centerline. This channel has little effect at high speed, but at low speed, acts to extend the chord of lateral cross sections so that air can continually transverse the upper lifting surfaces of the airfoil. This feature uses "spill-over" (which destroys lift above a conventional wing) to create lift.

A channel of similar configuration is disclosed in U.S. Pat. No. 2,670,155 by Moody S. Sahl, which teaches use of such channel in a planar wing.

I have observed an analogous use of such a channel in nature: the gackle bird, common to eastern United States, configures its long tail in a V-shaped channel during takeoff and landing. I have deduced that this configuration enables the bird to develop additional lift from its back and tail surfaces.

The present invention exhibits high lift at low speed, very low stall speed, and yet has low induced drag. At high speed, it behaves similarly to a conventional delta-wing plane. At low speeds above stall, it behaves similarly to a high aspect ratio airfoil but with lower induced drag. In a stall, it behaves similarly to a parawing glider or other lifting body.

A secondary object of the present invention is to provide a new cross section design for any fixed-wing aircraft, for aerodynamic and hydrodynamic propellers, and for rotary wing aircraft.

A tertiary object of the invention is to provide an aircraft with airfoil interior volume substantially filled with lighter-than-air gas for increased high-density payload capability.

Referring to the accompanying drawings wherein:

FIG. 1 is a frontal elevation view of the invention, shown in an embodiment thereof having merged fuselage and airfoil and sinusoidal contours.

FIG. 2 is a plan view of the invention.

FIG. 3 is a side elevation view of the invention.

FIG. 4 is a rear elevation view of the invention.

FIG. 5 is a plan view of the invention showing airflow at high speed.

FIG. 6 is a plan view of the invention showing airflow at low speed.

FIG. 7 is a frontal elevation view of a "flying wing" embodiment of the invention wherein the fuselage is integral to the airfoil and having segmented rectilinear leading edge configuration which approximates the sinusoidal configuration.

FIG. 8 is a plan view of the "flying wing" embodiment.

FIG. 9 is a side elevation view of the "flying wing" embodiment.

FIG. 10 is a rear elevation view of the "flying wing" embodiment.

FIG. 11 is a rear elevation view of a "flying wing" embodiment showing typical propeller and engine mounting.

FIG. 12 is a rear elevation view of a "flying wing" embodiment showing typical jet engine emplacement.

FIG. 13 is a longitudinal cross section of the merged wing-fuselage embodiment, but is applicable to any airfoil requirement.

FIG. 14 is a modified longitudinal cross section of the merged wing-fuselage embodiment, but is applicable to any airfoil requirement.

FIG. 15 is a modified longitudinal cross section of the merged wing-fuselage embodiment, but is applicable to any airfoil requirement.

Referring to FIG. 1, nose 21 is the front terminus of fuselage 22, near the delta apex point at which leading edges 23 and 24 are convergent. In practice, nose 21 may be rounded off short of the apex as shown. It may form a point at the apex, or it may protrude beyond the apex. Leading edges 23 and 24 are sinusoidal in elevation along their length and also form the leading edge of rudder-stabilizers (rudderizers) 29 and 30. Also 27 and 28 are the upper lifting surfaces. Further 25 and 26 are the lower lifting surfaces. Windshield 31 is shown for reference.

Referring to FIG. 2, upper lifting surfaces 27 and 28 merge with recessed channel surfaces 32 and 33, which surfaces originate from channel apex 34. Channel apex 34 is typically located at 33.3 percent of the delta length, but may be located from 25 to 35 percent of delta length. Channel surfaces 32 and 33 form an angle which is nominally 53°, but could be from 45° to 70°. Channel width-to-length ratio is nominally 16 percent, but may be 12 to 20 percent. The primary longitudinal cross section of the airfoil 13 is at the fuselage side. Trailing edges 35 and 36 are sinusoidal and together with sinusoidal leading edges 23 and 24, respectively, determine pitch and twist of the airfoil.

FIG. 3 shows a side elevation view wherein sinusoidal leading edge 24 is clearly seen.

Referring to FIG. 4, sinusoidal trailing edges 35 and 36 are clearly seen.

Referring to FIG. 5, notice that at high airspeed, airstreams are parallel to airfoil line of flight.

Referring to FIG. 6, notice that at low speeds, airflows diagonally across the upper lifting surfaces and down the channel.

Referring to FIG. 7, all components illustrated for this "flying wing" embodiment correspond to those shown in FIG. 1 for the merged body-fuselage embodiment, except that the fuselage is integral to the airfoil. Referring to FIG. 8, all components illustrated correspond to those of FIG. 2.

Referring to FIG. 9, all components illustrated correspond to those of FIG. 3, except that the fuselage is integral to the airfoil.

Referring to FIG. 10, all components illustrated correspond to those of FIG. 4, except that the fuselage is integral to the airfoil.

Referring to FIG. 11, a turboprop, reciprocating, or other engine is mounted by struts 37 in the after portion of the channel. Propeller (or propellers) 39 not only propels the plane, but further increases lift by increasing the velocity of air in the channel.

Referring to FIG. 12, jet intakes 40 and 41 typically located inboard of channel surfaces 32 and 33, feed jet engines 42 and 43, typically located outboard of the channel exterior trailing edge surfaces and below trailing edges 35 and 36.

Referring to FIG. 13, primary longitudinal cross section 13 is bounded by sinusoidal upper and lower contours with the upper contour beginning at 0° and lagging the lower contour nominally, by 90°, but could lag from 60° to 120° phase lag also creates a 90° phase shift between the upper contour high point and lower contour low point ($180^\circ - 90^\circ = 90^\circ$). Chord length of primary cross section 13 may be from 200° to 270°, with 270° chord being illustrated in FIG. 13. Peak amplitudes of upper and lower sinusoids are equal as are their wavelengths. Airfoil thickness is nominally 12 percent of chord dimensional length, but could be as low as 5 percent or as high as 20 percent. Parasitic drag must, of course, vary proportionately to cross section thickness, but this is not true of induced drag-versus-airspeed. Notice that in FIG. 13, airpaths above and beneath the wing are equal, but unlike any symmetrical cross section, the stagnation point cannot change with angle of attack. This cross section, presently accepted theory not withstanding, flies exceptionally well.

Referring to FIG. 14, an improved airfoil cross section is shown wherein chord length is 225°. The upper sinusoidal contour begins at 0° and lags the lower contour by 90°.

Referring to FIG. 15, an improved airfoil cross section is shown wherein the chord is 225°. The upper sinusoidal contour begins at 30° and the lower begins at 135°, so that a 75° phase difference exists ($180^\circ - 105^\circ = 75^\circ$).

The embodiments described above are merely illustrative of the principles of the invention and the invention should not be construed as limited to such embodiments.

Some of the advantages of the present invention are:

1. low induced drag at high speed.
2. high lift and controllability at low speed.
3. very low and predictable stall speed with excellent controllability in stall and immediate recoverability.
4. good inverted flight characteristics.
5. excellent crosswind handling.
6. center of lift is at center of length so that loading and balance problems are minimized.
7. excellent pilot visibility at any speed because angle of attack required in landing is low, unlike other delta-wing planes.
8. inherent directional stability yet excellent maneuverability
9. lifting body glide path in stall.
10. structure is inherently strong yet light because weight is distributed by numerous wing spars.
11. readily adaptable as flying boat without adding excessive parasitic drag. Wingtip floats and boat fuselage would provide excellent water handling. Engine air intakes would be shielded by the channel to preclude water ingestion.

12. large useable interior space in wings and fuselage.
13. ideal placement of landing gear for either 3-point or 4-point configuration.
14. leading edge spoilers may be included to further increase lift at low speed.
15. control surfaces can be any combination of flaperons, rudderators, vertical rudders astride the V-shaped channel, wingtip spoilers, or leading edge canards near the delta apex.
16. excellent survivability in wheels-up landing.
17. excellent cruise economy resulting from aerodynamically clean and integrated design.
18. military versions could carry much armament beneath the wing with minimal added parasitic drag.

What I claim is:

1. In combination, an elongated support member having a pair of upwardly projecting surface opposed walls defining an upwardly open space, a first lifting surface portion affixed in transverse relation to upper extremity portions of one in the pair of said walls in position thereon projecting beyond the space defined by said pair of walls, and second lifting surface portion affixed in transverse relation to the opposite wall of said support member; said first and second lifting surface portions having a leading edge in angularly disposed convergent relation to said main support member and having a trailing edge in transverse relation to each in the pair of wall portions of said support member, said trailing edge portions being in surface aligned relation to trailing edge portions of said central support member.

2. A delta-wing aircraft as claimed in claim 1, and in which leading edge and trailing edge of said first lifting surface portion and leading edge and trailing edge of said second lifting surface portion have sinusoidallike configuration.

3. A delta-wing aircraft as claimed in claim 2 and in which the sinusoidlike configuration of leading and trailing edges of said first and second lifting surface portions describe the chord extremities of longitudinal airfoil cross sections comprising an upper lifting surface of sinusoidlike configuration and an opposed lower lifting surface of sinusoidlike configuration; said upper lifting surface sinusoidlike configuration differing from said lower lifting surface sinusoidlike configuration in phase relationship, with said upper lifting surface sinusoidlike configuration in lagging phase relationship to said lower lifting surface sinusoidlike configuration; said lagging phase relationship being in reference to angular rotation in progression along the plane containing the cross section, with said progression in a direction parallel to the line of flight.

4. An airfoil or hydrofoil cross section comprising in combination an upper lifting surface having sinusoidlike configuration and an opposed lower lifting surface having sinusoidlike configuration, said upper lifting surface sinusoidlike configuration differing from said lower lifting surface sinusoidlike configuration in phase relationship with said upper sinusoidlike configuration in lagging phase relationship to said lower sinusoidlike configuration; said lagging phase relationship being in reference to angular rotation in progression along the plane containing the cross section with said progression in a direction parallel to the line of flight.

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