M. R. WOLFARD.

SELF STABILIZING AEROPLANE STRUCTURE.

APPLICATION FILED APR. 10, 1918.

1,301,083. Patented Apr. 15, 1919.

Fig. 1.

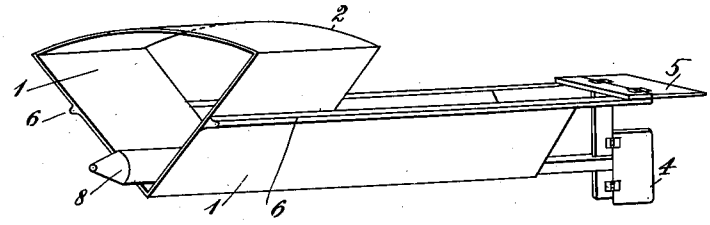


Fig. 2.

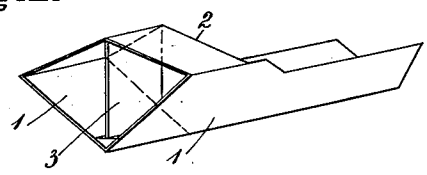


Fig. 3.

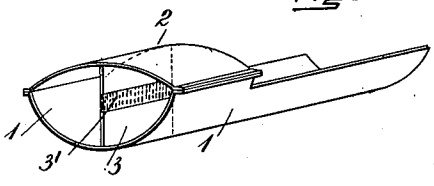


Fig. 4.

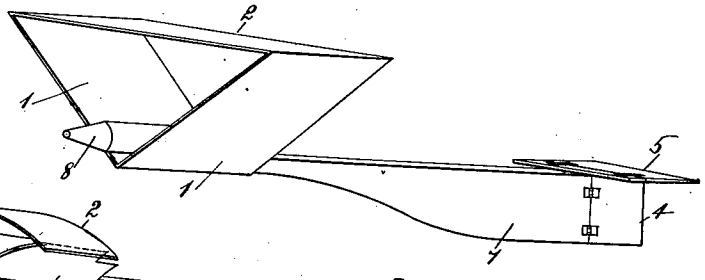


Fig. 5.

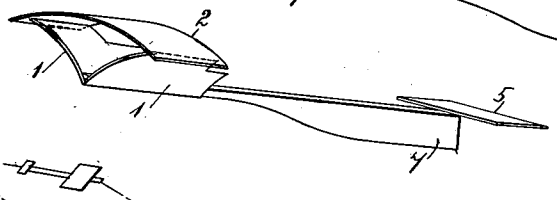


Fig. 6.

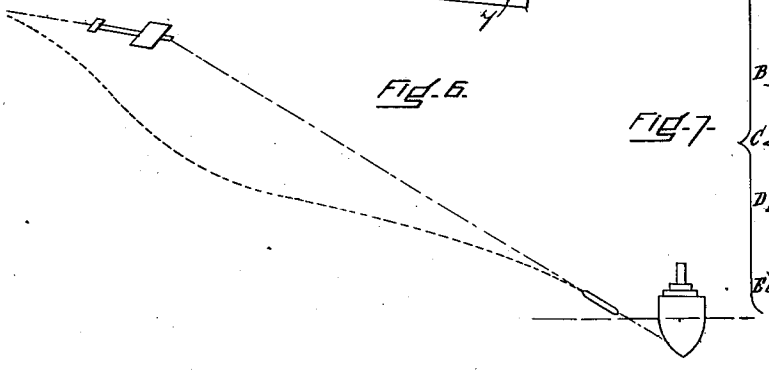
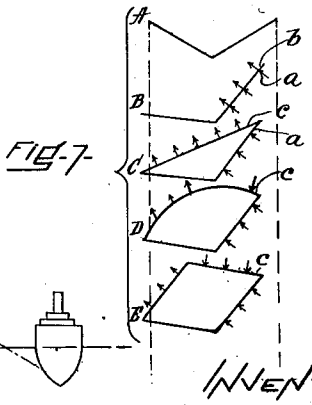


Fig. 7.



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MERL R. WOLFARD, OF CAMBRIDGE, MASSACHUSETTS.

SELF-STABILIZING AEROPLANE STRUCTURE.

1,301,083. Specification of Letters Patent. Patented Apr. 15, 1919.

Application filed April 10, 1918. Serial No. 227,638.

To all whom it may concern:

Be it known that I, MERL R. WOLFARD, a citizen of the United States, residing at Cambridge, in the county of Middlesex and State of Massachusetts, have invented new and useful Improvements in Self-Stabilizing Aeroplane Structures, of which the following is a specification.

This invention relates to improvements in aeroplanes. It relates more specifically to a self-stabilizing aeroplane structure, and includes the adaptation of this structure for use as a gliding, or flying torpedo. By virtue of the inherent stability of this structure it is practically impossible for air currents to overturn the torpedo while in flight; therefore, if it be equipped with an elevator and a rudder, and both of these adapted to be controlled by wireless, then the torpedo can be directed precisely into the desired objective.

The fundamental structural and stabilizing feature of this invention, epigrammatically stated, is a covered V-wing arrangement, in which the wing tips of the V are directly attached to the cover, thereby securing novel and effective stabilizing characteristics in combination with desirable flexibility of structure and extreme lightness of construction.

These stabilizing characteristics and other features of the invention are illustrated in the annexed drawings and more fully described in the following specification.

Referring to the drawings:

Figure 1 is an embodiment of the invention, shown in perspective, adapted to be used as a gliding torpedo.

Figs. 2 to 5, inclusive, show some of the structural variations which may be made in wing arrangements within the scope of the invention. These are also shown in perspective.

Fig. 6 illustrates the method of using the gliding torpedo, and shows the salient characteristics of its path.

Fig. 7 is a series of diagrams intended to illustrate stabilizing features of the invention.

The term "V," "V-wing arrangement" or "V structure," as used in the specification and claims of this invention, is intended to include any areoplane structure in which the wings extend outward and upward in such manner that a tilting of the aeroplane, sidewise, increases the wing surface exposed to upward reaction or lift on one side of the center of gravity (said wing surface being the one which is depressed by the tilting action) irrespective of the geometric contour of the wings themselves.

In the drawings the numeral 1 designates wing structures extending outward and upward and will usually be referred to as simply the sides of the V; 2 is a cover wing attached in any convenient manner to tips of the sides of the V; 3 is a longitudinal web extending from the central portion of the V to the central portion of the cover wing, and 3′ is an elastic portion secured in this same web whereby it may elongate vertically when the upward pressure on the cover wing becomes abnormally high; 4 is a rudder for steering the aeroplane to the right or left; 5 is a horizontal rudder, or, as it is usually termed, an "elevator" for causing the aeroplane to ascend or descend. In Fig. 1 side keels 6 are shown, which stiffen the structure longitudinally and appear to steady the flight. These may be extended to support the elevator, as indicated; 7 is a keel structure extending backward and below the horizontal projection of the bottom of the V, as indicated in Figs. 4 and 5; 8 represents the position of the bomb when the areoplane is adapted for use as a gliding torpedo.

The leading stabilizing feature of this invention is the cover wing 2, and some of its characteristics seem to be accounted for by assuming, in so far as sudden eddies, whirlpools and gusts are concerned, that the pressures exerted within the inclosed space between the sides of the V and the cover are balanced, then the action of the external forces caused by a side wind may be analyzed as follows: In Fig. 7, A indicates the ordinary V structure in normal position; B is the same tilted sidewise; C shows a plane cover, D a curved arch-like cover, and E an angular arch-like cover; these last three are all shown in the tilted position also, and the small arrows indicate the resultant action of the wind normal to the surfaces. In B the density of the air is increased on the surface *a*, and decreased on the surface *b*, and, furthermore, both of these tend to overturn the aeroplane. In C the forces acting on *c* replace those which acted before on *b*, and the sum total of these has a less overturning tendency than before; in other words, the cover has a stabilizing tendency.

In D and E this stabilizing tendency is even more pronounced, and indeed, a positive righting tendency may be realized from the cover considered alone, if the altitude of the arch is not too great. This should be evident when one considers the fact that if the altitude of the arch is too great, the vertical projection of the surface exposed to the action of a side wind becomes excessive. I am aware that the assumption of balanced pressure inside is not wholly tenable for a steady side wind, and may not be strictly so for gusts, etc., but whatever the explanation may be, my experiments have demonstrated conclusively that this cover wing, when properly proportioned and supported, has very effective stabilizing characteristics. It might be added here that if we assume a steady side wind to continue to move with the same velocity inside the covered V as outside, then the righting tendency of the arched cover considered alone still persists, and is increased approximately two-fold; but the plane cover theoretically ceases to have any stabilizing tendency save such as may be due to its biplane effect when considered in conjunction with the V itself. If, however, the plane cover wing does not project appreciably beyond its junction at either end with the tips of the V, *i. e.* if projecting wing tips are avoided, and if the mechanism as a whole is properly proportioned, then a very considerable stabilizing effect can be realized, practically.

It appears that for extreme stability, the longitudinal width of the cover wing may be from three-fourths to approximately equal the slant height of the V for the general form of structure shown in Fig. 4, and this same dimension may be reduced to one half of the slant height of the V for the general form of structure shown in Fig. 1. Here, however, the length of the lower portion of the V extended to the rear of the cover should be proportioned according to the longitudinal width of the cover, if this extended portion is relied upon to secure directional and longitudinal stability without the aid of a rudder and an elevator. The extended portion equal in length to one and one half to twice the width of the cover, has given good results. The height of the extended portion of the V is also important, and may be between fifty and seventy per cent. of the height of the V. In the general form of structure shown in Figs. 4 and 5, directional stability is obtained by the keel 7 extending backward and below the horizontal projection of the bottom of the V, and the elevator, or an elevator plane, to which the real elevator is attached, is relied upon to secure longitudinal stability.

An appreciable arching in the cover wing over the center of gravity of the load carried seems to be very desirable. This may be obtained either by making the cover wing a rigid arch, or by making the cover wing essentially a plane with sufficient flexibility so that when subjected to its normal load in flight, it will become appropriately arched. Appreciable flexibility in both the cover and the sides of the V supporting it, seems to be desirable. The probable explanation of this is that the flexible construction forms a kind of shock absorber when struck by a gust of wind; the form of the structure is such that practically any deformation which the wind can cause, tends to sharpen the V, *i. e.*, to decrease the angle of the V, and, therefore, to increase its stability, in so far as shape is important; furthermore, this flexible construction permits the main wing structure, when struck by a sudden gust of wind on one side, to sway sidewise with reference to the load carried, and thus the main wing structure tends to reach a position of equilibrium without abruptly changing the direction of motion of the load carried. Lateral or sidewise flexibility relative to a longitudinal axis passing through or near the center of gravity of the load carried is the desirable consideration here. Longitudinal stability is secured by proper proportioning of the wing or elevator surface secured in the rear of the covered V as already pointed out. In fact, it should be clearly appreciated that any considerable longitudinal flexibility, instead of increasing, will tend to destroy inherent stability. This lateral flexibility in conjunction with longitudinal rigidity may be easily obtained with the simple plate-like construction for all wing surfaces as clearly indicated in the drawings. For example, in a small model the wings may be cardboard or similar material, without struts, stays or cross-wires of any kind. In larger models similar plate-like material, of suitable weight and strength, may be used with a longitudinal web of the same material near the center, or this web may have an elastic portion as hereinbefore set forth. It is common knowledge that a plate-like structure cannot be readily flexed or deflected relative to two intersecting axes at the same time; and furthermore, that the greater the flexure relative to one axis, the greater the difficulty of initiating flexure relative to a second and intersecting axis; especially is this true if the second axis is approximately at a right angle with the first. Therefore, any curvature or arching of a plate-like wing structure about a longitudinal axis tends to increase the longitudinal rigidity of said wing structure. These thin, plate-like wing structures, assembled in such manner that thick stiffening beams, struts, stays and cross-wires may be eliminated, reduce the "drift" or head resistance to a minimum. Therefore, this aeroplane structure is admirably adapted to attain very high speeds, as well as

being inherently stable. It should be clearly appreciated, however, if efficient action at high speeds is desired, that "fluttering" or rapid vibration of the wings must be avoided. Here, again, the thin plate-like structure referred to above is admirably adaptable to the end in view, because it may be made sufficiently flexible to permit the desired deflection, and at the same time, sufficiently elastic and appropriately sluggish in its movement so that fluttering or rapid vibration is avoided.

Flexure may be either elastic or inelastic, but as used in the specification and claims of this invention, a degree of elasticity is usually implied. The more inclusive term is generally used, however, because, the wings might not be sufficiently elastic to return wholly to their original position after being deflected, without being forced back by the action of the air in the opposite direction, and yet be sufficiently sluggish in vibratory movement to prevent fluttering. A fabric such as is commonly used in the construction of kites, if extending loosely between supports, may flutter, because, between one extreme position and the other, there is no inherent resistance to travel as the wind pressure alternates in direction. In other words, it vibrates rapidly from one extreme position to the other. A lively elastic material, if stretched between supports fixed at a definite distance apart, may also vibrate rapidly under favorable conditions, because the velocity attained, while moving from one extreme position to the middle, or neutral position, is sufficient to carry it well beyond the neutral position on the opposite side. On the other hand, a sluggishly elastic material extending between fixed supports may be adapted to prevent fluttering, and otherwise fulfil requirements of this invention. In general, however, I prefer the self-supporting plate-like structure as illustrated and described. This structure is extremely simple; its flexibility as a whole is increased, inasmuch as the points of support for the cover wing are not fixed relative to the center of gravity of the load carried; and besides, with this form of structure, I believe it is possible to use a more lively elastic material without danger of fluttering.

It should be evident, to one skilled in the art, that this general form of structure combined with the tendency to automatically adjust itself to the stresses sustained in different parts of the structure, permits a kind of automatic camber while in flight, and also, introduces new possibilities in maneuvering, etc., but the detailed setting forth of these things belongs to an argumentative discussion relating to the advantages of the invention, rather than to the disclosure of its fundamental structural characteristics.

In use, the gliding torpedo may be secured in any convenient manner, beneath an aeroplane, so that it can be suddenly and freely released by the aviator, after being carried to any desired altitude. When the aviator sights the desired objective and has secured a favorable position, he may steer his aeroplane directly toward the objective, and diving somewhat at the same time, at high speed, he may release the torpedo, which is adapted to dive still more rapidly until it acquires a prodigious speed, when it will automatically take a more nearly horizontal course, as indicated by the broken line in Fig. 6. The aviator, meanwhile, may slow down his aeroplane, and when the torpedo appears some distance in front of him, if his aeroplane and the torpedo are properly equipped with wireless directing mechanism, he may steer the torpedo precisely into the desired objective, because, if he keeps the torpedo directly in his line of vision when looking at the objective, he must register a sure hit without any exact estimate of its distance away. Moreover, the torpedo may carry a depth bomb, and this directly beneath the water line, as indicated in Fig. 6, may destroy the most heavily armored battleship. The effectiveness of this gliding torpedo against submarines, ammunition depots, etc., should be evident.

This invention has been illustrated and described primarily with reference to its adaptation as a gliding torpedo, but its fundamental characteristics are, by no means, confined to this use. It makes possible a flying projectile; it may be positively propelled, thus making a flying torpedo, in contradistinction to a gliding torpedo; it may be used as an improved parachute; and indeed, may be incorporated in aeroplane design in a most general and inclusive sense.

The adaptation of the self-stabilizing aeroplane structure herein disclosed, is contemplated for use in an aerial torpedo disclosed and claimed in my co-pending application for patent for aerial torpedo, Serial No. 248,301, filed August 5, 1918.

I claim:

1. In a self-stabilizing aeroplane structure, a V-wing arrangement in combination with a cover wing attached directly to the tips of the V, said cover wing terminating at either end substantially at its junction with the tips of the V, and less extensive wing-like structure being attached in the rear of said V-wing arrangement, whereby longitudinal stability is secured, while still permitting the covered V-wing portion to predominate in the structure as a whole.

2. In a self-stabilizing aeroplane structure, a V-wing arrangement in combination with a cover wing attached to the tips of the V, and said cover wing being constructed and arranged to prevent fluttering.

3. In a self-stabilizing aeroplane structure, a V-wing arrangement in combination with a cover wing attached to the tips of the V, said cover wing being constructed to have appreciable inherent resistance to flexure combined with sufficient flexibility to permit a substantial upward deflection while carrying its normal load in flight, whereby flexure without fluttering is obtained.

4. In a self-stabilizing aeroplane structure, a V-wing arrangement in combination with a cover wing attached to the tips of the V, said cover wing being sufficiently elastic to rise and fall gradually as the stresses in said cover-wing increase and decrease while in flight.

5. In a self-stabilizing aeroplane structure, a V-wing arrangement in combination with a cover wing attached to the tips of the V, the sides of said V having appreciable elasticity, thereby permitting a gradual to and fro deflection as the pressure varies against the sides of the V.

6. In a self-stabilizing aeroplane structure, a V-wing arrangement in combination with a cover wing attached to the tips of the V, said V-wing arrangement and its cover forming a main wing structure which is fabricated and arranged to permit temporary deformation of said wing structure as a whole, when struck by a gust of wind from one side, and said main wing structure being adapted and arranged to prevent fluttering.

7. In a self-stabilizing aeroplane structure, a V-wing arrangement in combination with a cover wing attached to the tips of the V, and a longitudinal web extending from the middle portion of the V to the middle portion of the cover, adapted to strengthen the structure, said web being sufficiently flexible to permit sidewise deflection.

8. In a self-stabilizing aeroplane structure, a V-wing arrangement in combination with a cover wing attached to the tips of the V, and a longitudinal web extending from the middle portion of the V to the middle portion of the cover, adapted to strengthen the structure, said web being sufficiently elastic to permit the middle portion of the cover wing to rise when subjected to an abnormal upward pressure.

9. In a self-stabilizing aeroplane structure, a V-wing arrangement in combination with a cover wing attached to the tips of the V, and means to yieldably support the middle portion of said cover wing.

10. In a self-stabilizing aeroplane structure, a V-wing arrangement in combination with a cover wing attached to the tips of the V, the lower portion of the V being extended to the rear of the said cover wing, and the height of this extended portion of the V being less than three-fourths of the height of that portion of the V to the tips of which the said cover wing is attached.

11. In a self-stabilizing aeroplane structure, a V-wing arrangement in combination with a cover wing attached to the tips of the V, the lower portion of the V being extended to the rear of said cover wing, the height of this extended portion of the V being less than three-fourths of the height of that portion of the V to the tips of which the said cover wing is attached, and longitudinal side keels secured to the sides of the V, substantially as illustrated.

12. In a self-stabilizing aeroplane structure, a V-wing arrangement in combination with a cover wing attached to the tips of the V, and an elevator, the lower portion of the V being extended to the rear of said cover wing, and longitudinal side keels secured to the sides of the V, said keels being adapted to support the elevator, substantially as illustrated.

13. In a self-stabilizing aeroplane structure, a V-wing arrangement in combination with a cover wing attached to the tips of the V, said cover wing being arched in form, the altitude of said arch being less than one-fourth of the linear distance from one end of the cover wing to the other, and said cover wing being constructed and adapted to prevent fluttering.

In testimony whereof I have affixed my signature.

MERL R. WOLFARD.