244-47 SR USS REFERENCE SEARCH ROOM
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AERODYNE WITH WINGS HAVING VARIABLE SWEEP-BACK

Filed Jan. 17, 1955 5 Sheets-Sheet 1

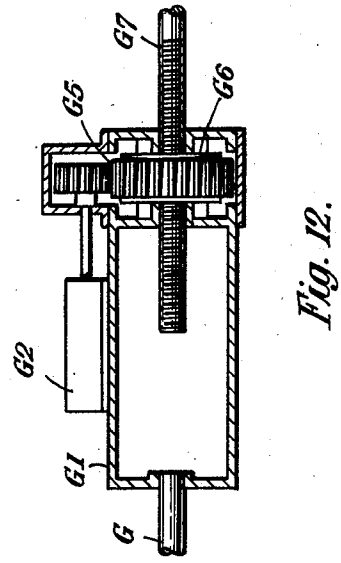


Fig. 12.

Fig. 1.

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Dec. 1, 1959 B. N. WALLIS 2,915,261

AERODYNE WITH WINGS HAVING VARIABLE SWEEP-BACK

Filed Jan. 17, 1955 5 Sheets-Sheet 2



Fig. 2.



Fig. 3.

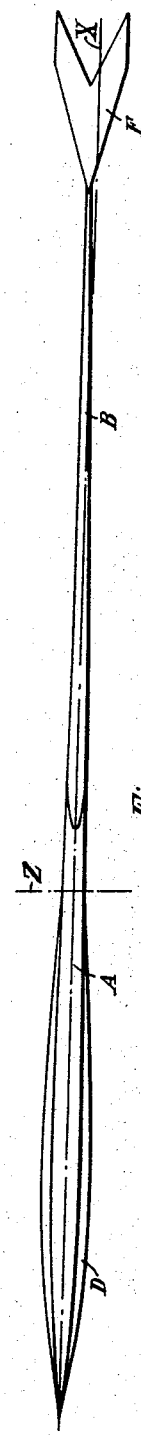


Fig. 6.

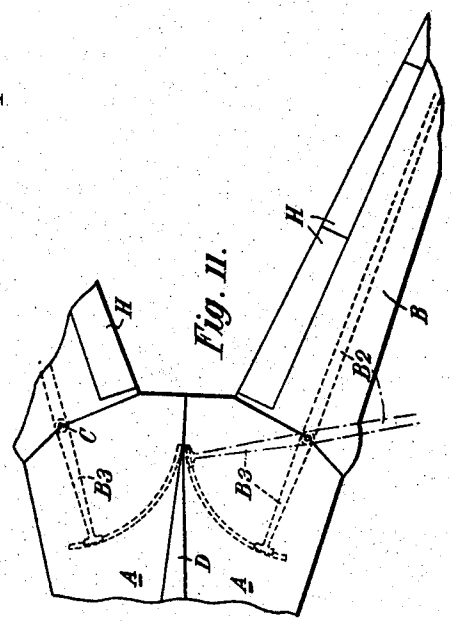


Fig. 11.

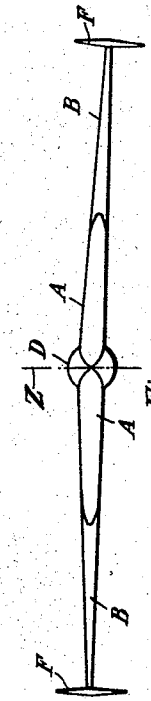


Fig. 5.

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Dec. 1, 1959 B. N. WALLIS 2,915,261

AERODYNE WITH WINGS HAVING VARIABLE SWEEP-BACK

Filed Jan. 17, 1955 5 Sheets-Sheet 3

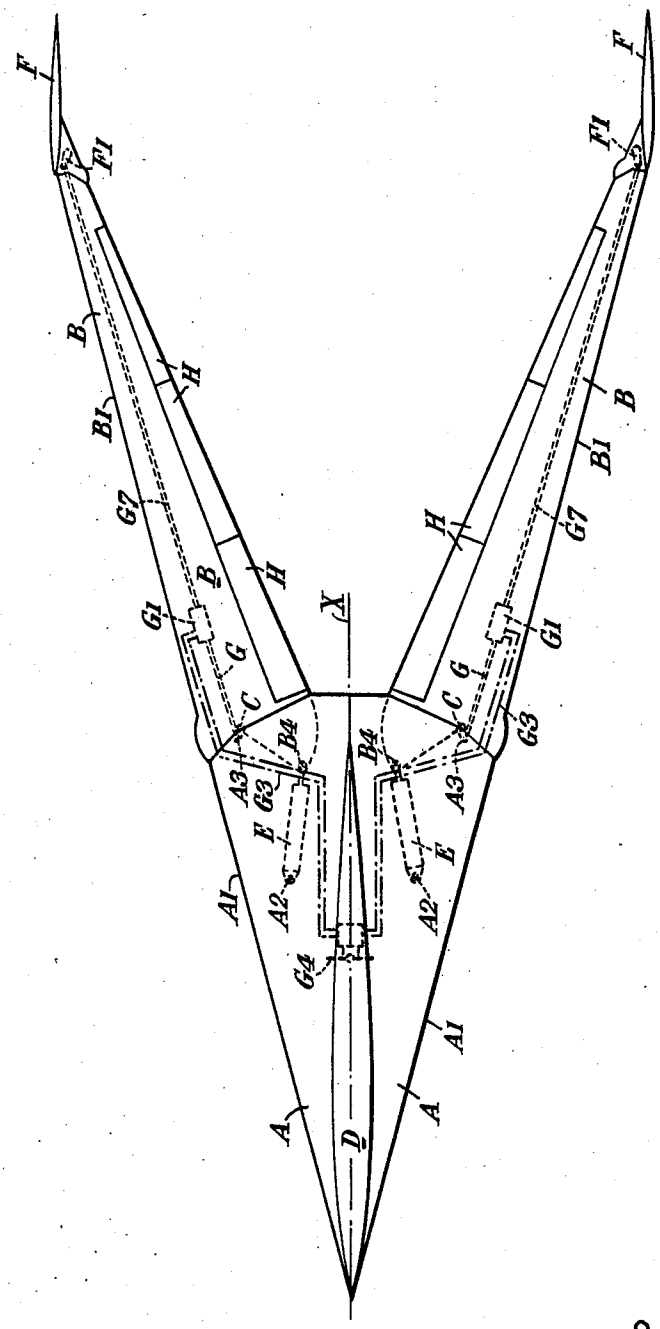


Fig. 4.

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Dec. 1, 1959 B. N. WALLIS 2,915,261

AERODYNE WITH WINGS HAVING VARIABLE SWEEP-BACK

Filed Jan. 17, 1955 5 Sheets-Sheet 4

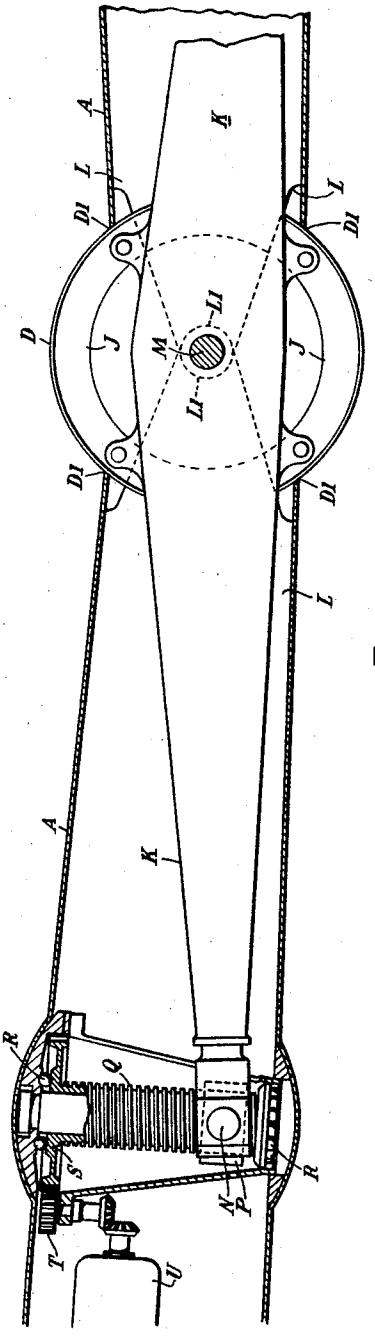


Fig. 7.

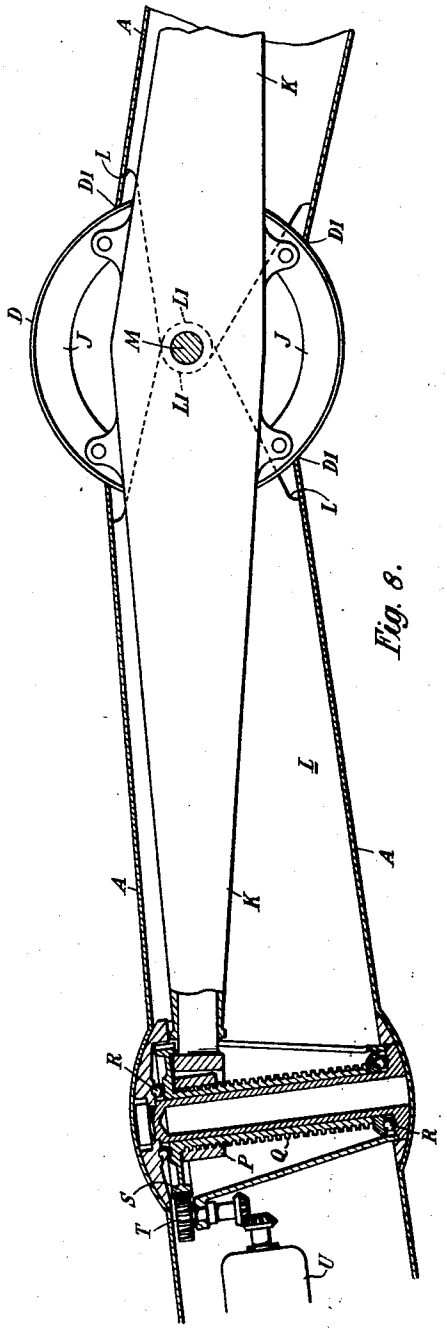


Fig. 8.

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Dec. 1, 1959 B. N. WALLIS 2,915,261

AERODYNE WITH WINGS HAVING VARIABLE SWEEP-BACK

Filed Jan. 17, 1955 5 Sheets-Sheet 5

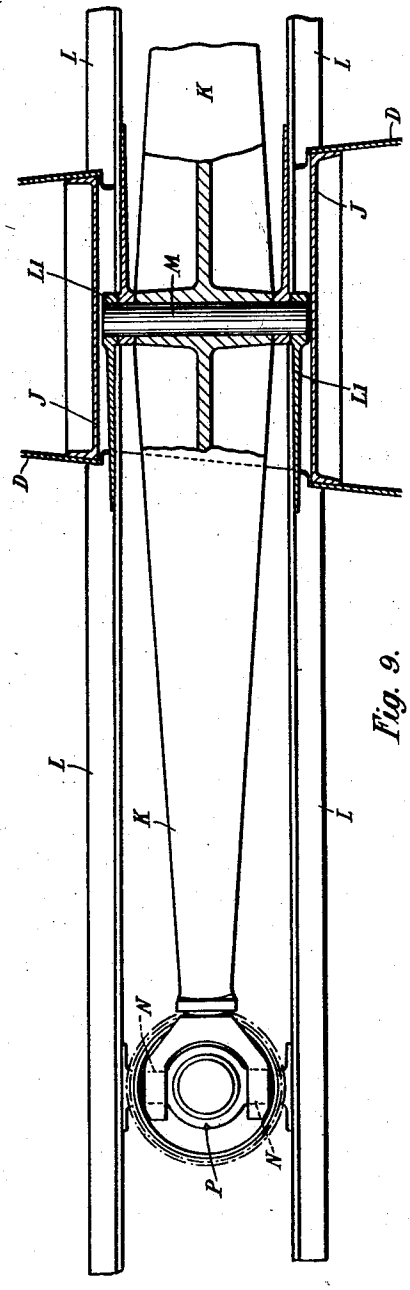


Fig. 9.

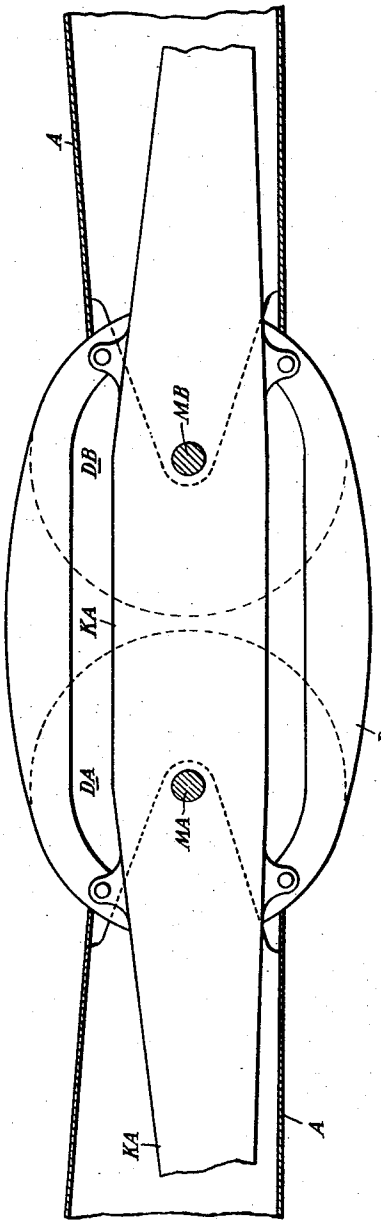


Fig. 10.

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United States Patent Office 2,915,261 Patented Dec. 1, 1959

2,915,261

AERODYNE WITH WINGS HAVING VARIABLE SWEEP-BACK

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Application January 17, 1955, Serial No. 482,249

Claims priority, application Great Britain January 26, 1954

10 Claims. (Cl. 244—46)

The object of this invention is to provide an improved form of aerodyne which can be flown and controlled at both subsonic and supersonic speeds, and which will also be capable of being launched and landed at a lower speed than has hitherto been contemplated in aircraft designed for supersonic flight.

According to the invention an aerodyne fulfilling these conditions comprises essentially fore-wing means of delta-shaped plan-formation, and two main-wings respectively extending from the ends of the base of said fore-wing means, said main-wings being adjustable in sweep during flight.

When such an aerodyne is in uniform horizontal flight, the pitching moment due to the lift forces exerted upon the fore-wing means acts in the opposite sense to that due to the lift forces exerted upon the main-wings to obtain equilibrium. Pitch stability can be maintained because the pitching moment due to lift on the main-wings changes with change of angle of incidence more rapidly than does the pitching moment due to lift on the delta-shaped fore-wing means and in the opposite sense.

An aerodyne as hereinbefore defined comprises essentially a lifting element which is articulated to form a fore-wing means and two main-wings, the fore-wing means being of delta-like configuration and the main-wings extending from the ends of the base of the fore-wing means, said main-wings being capable of movement between an outspread position for subsonic speeds, and a swept-back position for supersonic speeds, in which latter position their leading edges are substantially aligned with the respective leading edges of the fore-wing means. When the main-wings are outspread, the configuration preferably possesses relatively great span, and at its centre is the forward extending delta-shaped formation composed of the fore-wing means. When the main-wings are swept back, the whole configuration conforms in plan approximately to the shape of an isosceles triangle having a fine apex angle. Whilst the extreme swept-forward and swept-back positions are chosen to give the optimum configurations for low subsonic and high supersonic speeds, respectively, the main-wings may be adjusted to give any plan form between these two extremes. The object of adjusting the main-wings in sweep is to obtain the greatest possible value of the lift/drag ratio at all conditions of speed and height.

The manner in which the invention may be carried into effect is hereinafter more fully described with reference to the accompanying diagrammatic drawings, in which Figs. 1, 2 and 3 are respectively a plan, a front elevation and a side elevation of the improved aerodyne in a low-speed flight position, and Figs. 4, 5 and 6 are respectively similar views to Figs. 1 to 3, showing the aerodyne in a position assumed in flight at supersonic speed. Fig. 7 is a fragmentary transverse sectional view, drawn to a much larger scale, illustrating the manner in which the fore-wing means is divided into sections which are adapted to rotate relatively to each other for adjustment of their lateral dihedral angle when the main-wings are

adjusted from a low speed to a high speed position or vice versa; in this figure the sections of the fore-wing means are shown in the relative positions occupied with respect to the longitudinal axis for low speed. Fig. 8 is a similar view to Fig. 7, showing the relative positions occupied by the sections of the fore-wing means for high speed. Fig. 9 is a sectional plan of the structure shown in Figs. 7 and 8. Fig. 10 is a similar view to Fig. 7 (on a smaller scale), illustrating the use of a double-bubble body configuration. Fig. 11 is a fragmentary detail of the plan view of Fig. 4, showing the structure of the main-wing. Fig. 12 is a detail sectional view of the gear through which the pilot may over-ride the automatic mechanism for adjusting the wing-tip fins.

As will be seen from the drawings, the aerodyne comprises a lifting element divided into two fore parts A, A and two after parts B, B, the corresponding fore and after parts being articulated at C, C. The two fore parts A, are separated by a component or fuselage D which conforms externally to a solid of revolution, generated along the longitudinal axis, said fore parts A merging tangentially with the finely pointed nose of the component D on either side thereof. The fore-wing means hereinbefore referred to is constituted by a combination of the parts A and said component D, forming in plan a continuous surface of delta-like shape from the base of which the after parts B extend as main-wings which are capable of being rotated about the axes C between an outspread position shown in Figs. 1 to 3 and a swept-back position shown in Figs. 4 to 6.

The outspread position of the main-wings B, in which the aerodyne possesses great span and high aspect ratio, presents the optimum configuration for flight at low subsonic speeds, more especially for take-off, landing and other low-speed manoeuvres. When the main-wings B are swept aft to the position shown in Fig. 4, they form two rearward extensions of the delta-shaped combined fore parts A, such that the leading edges B1 of the main-wings B are substantially aligned with the leading edges A1 of the fore parts A, the whole configuration conforming in plan to the shape of an isosceles triangle having a fine apex angle, the main-wings B being adjusted to the angle of sweep which will give the greatest possible lift/drag ratio according to the conditions of speed and height. Any intermediate plan form which may be required to alter the lift/drag ratio for different conditions may be obtained by a suitable adjustment in sweep.

It is known that an aircraft consisting solely of a delta-shaped body is unstable both directionally and in pitch, and that such aircraft have hitherto only been rendered practicable by the provision of a fin or fins for directional stability and flaps and like members pivoted along the trailing edge of the delta for pitch stability. This arrangement is disadvantageous inter alia (*a*) because the short lever arm through which such members develop their stabilising moments requires that they shall be of large surface area, and (*b*) because it is found that the aircraft must nearly always be flown with the pitch stabilizing members projecting into the airstream, so that the drag effects due to friction and lift are substantially augmented. The addition of wings to a delta-shaped fore-wing means in the manner proposed by the present invention enables directional stability to be obtained by the use of small drag-producing surfaces, whilst inherent stability in pitch follows automatically from the fact that the pitching moment due to lift on the main-wings changes more rapidly than does the pitching moment due to lift on the fore-wing means. The invention not only secures the essential characteristics of inherent directional and pitch stability, but also improves the lift/drag ratio, since the addition of main-wings contributes substantially to the total lift as

compared with the drag-producing tail organs which degrade the lift/drag ratio of conventional and delta aircraft.

The use of a delta-shaped fore-wing means affords an additional advantage which is of the ultmost importance, viz. that it provides a wide base across which the pivots C may be spaced. By these means it is possible to augment the span of the aircraft, and if, as in the preferred embodiment of the invention, the main-wings are capable of being adjusted in sweep, this adjustment may be effected without importing the disadvantages, such as loss of area or mutual interference of the wings, which are encountered where the wing pivots cannot be spaced widely apart. Further, it is possible to attain a higher lift/drag ratio than hitherto at supersonic speeds, by reason of the fact that when the main-wings are swept back they combine with the fore-wing means to describe a plan-form outline conforming to that of a delta-shaped aerofoil from which a substantially isosceles triangular region based on the trailing edge has been removed.

As will be seen from the plan views of Figs. 1 and 4, and Fig. 11, it is proposed to construct each main-wing upon a main spar B2 which intersects the axis of the pivot C and the stub-extension B3 of which may be made of considerable length, being approximately equal at least to half the distance between the pivots CC.

The sweeping movements of the main-wings B may be effected by means of jacks E, the cylinders of which are anchored to fixed pivots A2 on the foreparts A and the rams of which are attached to the main-wings at points B4 off-set from the axes C, the jacks being extended to sweep the main-wings forward to low-speed positions and vice versa.

The axes of the hinges C are slightly tilted relative to the XY plane of the aerodyne. The arrangement is such that a small longitudinal dihedral angle (not perceptible in the drawings) is formed between the part A and the part B of each section of the lifting element in all positions of sweep. It is known that the lifting force on a delta-shaped body varies more slowly with change of incidence than does that on wings. To allow for this, the direction in which the axes C are tilted is such as to impart to the forward or delta-shaped fore-wing means AA of the aerodyne a slightly greater angle of incidence than that of the main-wings BB at all degrees of sweep. By this means the pitching moment, due to lift forces developed by the fore-wing means AA, may be balanced by the pitching moment due to the lift force acting on the main-wings. This arrangement also ensures pitch stability at flying speeds.

To give stability in yaw, each main-wing B carries at its tip a fin F which is mounted for pivotal movement about a vertical axis. A lever F1 fixed to said fin is connected by a link G with a lever A3 mounted on the relative fore part A for pivotal movement about the wing pivot axis C, the length of said lever F1 being greater than that of the lever A3 by an amount such that when the main-wings B are sufficiently swept aft said fins F lie parallel to the ZX plane of the aerodyne (Figs. 4 and 5), but with forward movement of the main-wings B towards the low speed position, the fins F become progressively toed-in, that is to say their leading edges are automatically moved inwards towards the vertical plane of symmetry of the aerodyne (Figs. 1 and 2). When so toed-in, the fins F create a differential drag force when the aerodyne is deflected in yaw, by which directional stability is maintained, since a yawing movement increases the drag force on the fin carried by the forward-moving main-wing tip and decreases the drag force on the backward-moving main-wing tip. When the wings are only partially swept back, the fins F may be adjusted intermediate the toed-in position of Figs. 1 and 2 of the fore-and-aft position of Figs. 4 and 5. In swept-back positions, approximately to that shown in Figs. 4 and 5, directional stability is ensured in the conventional manner by lateral forces acting well aft of the centre of gravity. In all positions of the main-wings B the automatic adjustment of the fins F can be overridden by the human or automatic pilot, thus enabling the fins F to be used as rudders. For example, means may be provided in each link G at G1, whereby the effective lengths of the links may be altered by the pilot for the purpose of steering the aerodyne. Said means G1 may consist of a mechanism as illustrated in Fig. 12, where an electric motor G2 actuated through the circuit G3 by the pilot's operation of the rudder-bar G4, is geared at G5 to a nut G6 on a screw-threaded outboard section G7 of the link G. The casing of the unit G1 is attached to the inboard section of the link G and the arrangement is such that the operation of the motor G2 will be effective to shorten or lengthen the link G according to the direction of movement of the rudder-bar G4. It will, of course, be understood that the electric motors G2 of port and starboard wings operate differentially to ensure that both fins F turn in the same direction simultaneously when operated for steering purposes. This arrangement of terminal fin for purposes of yaw control affords the valuable advantage that it improves the performance by augmenting the lift/drag ratio in the region of the main-wing tips.

Each main-wing B is provided along the full length of its trailing edge with a flap H for which suitable control means of conventional character may be provided. When moved in the like sense, i.e. both up or both down, said flaps H can be used as elevators to provide control in pitch, and when moved in unlike sense, i.e. one up and the other down, they can be used as ailerons to provide control in roll.

The contrasting conditions for securing lateral stability respectively observed in aircraft having spanwise disposed wings, and in aircraft having swept-back wings, are satisfied in the present aerodyne by providing means whereby a small lateral dihedral setting of the spanwise disposed main-wings, with the wing tips higher than the roots, is altered to a reversed dihedral setting of the swept-back main-wings. In the illustrated embodiment of the invention, the two sections of the lifting element (each comprising the parts A and B) are made rotatable relative to each other about the longitudinal axis of the aerodyne, and the requisite adjustment of the dihedral angle is made during flight simultaneously with the sweeping movement of the main-wings B from a low-speed position to a high speed position, and vice versa. For this purpose the structure of the component D incorporates at each of two spaced points on its longitudinal axis two transverse circular frames J between which is suspended a transverse beam K, the ends of which extend within the parts A as shown in Figs. 7 to 9. Each part A includes in its structure a pair of parallel rib-like members L, disposed respectively fore and aft of the beam K, which are provided with bearing connections L1 with a pivot pin M located at the centre of the beam K in alignment with the longitudinal axis. The outer extremity of each arm of the beam K is bifurcated and slotted to engage trunnions N on a nut P which is threaded on a lead-screw Q rotatably supported between bearings R in the structure of the part A. A spur wheel S fixed to said screw Q is geared to a pinion T which is adapted to be driven by a motor U, and the arrangement is such that whilst the component D is supported on the parts A and B through the medium of said rib-like members L, the parts A are capable of being pivoted in relation to the component D and to each other in such manner as to vary the lateral dihedral angle by the selective operation of the motors U. As will be understood, an operation of the motors U in such manner as to raise the nuts P upon the lead-screws Q will be effective to lower the planes A into the reversed dihedral position appropriate to swept-back wing positions. Since the shell of the component D is concentric with the axes of the pivot pins M, the edges of the skin plating of the parts A maintain

a close fit at D1 with the sides of said shell whatever the dihedral angle setting.

The terms "X axis," "Y axis," "Z axis," "XY plane," "YZ plane" and "ZX plane" as used herein have conventional meanings, believed to be universally recognized in the aeronautical industry. The "X" axis is the longitudinal axis of the aircraft through the center of gravity; the "Y" axis is at right angles to the "X" axis, intersecting the latter in the center-of-gravity, and is horizontal when the aircraft is in straight horizontal flight; the "Z" axis is at right angles to the "X" axis, intersecting the latter at the center-of-gravity, and is vertical when the aircraft is in horizontal flight. The "XY" plane is the plane containing the "X" and "Y" axes and the "ZX" plane is the plane containing the "Z" and "X" axes.

Means ((not shown) may be provided for adjusting the fins F about axes parallel to the X axis of the aerodyne, so that with the main-wings swept aft said fins are maintained parallel to the ZX plane of the aerodyne at all values of the lateral dihedral angle of the sections of the lifting element.

A modified embodiment of the invention illustrated in Fig. 10 incorporates a body or fuselage of the double-bubble configuration, in which two compartments DA and DB are disposed side by side. In this instance the rib-like members L of the lifting element fore parts A are connected to the body structure for pivotal movement about pins MA, MB which are aligned with the respective longitudinal axes of said compartments, being supported in the transverse beam KA.

In operating the aerodyne, for take-off and landing the main-wings B are moved outwardly until they reach the position shown in Figs. 1 to 3, in which they are spread substantially normal to the line of flight, imparting to the aircraft a high aspect ratio and the ability to fly at low speed without an excessively large angle of attack. When swept back to the position shown in Figs. 4 to 6, the leading edges B1 of the main-wings B may assume a position in relation to the Mach line which affords optimum conditions for flight at supersonic speeds.

Mechanisms, operable by the pilot, are provided for performing the several functions of adjusting the sweep of the main-wings B, and for varying the lateral dihedral angle of the lifting fore parts A, as required for the respective purposes hereinbefore set forth. Alternatively, these control movements may be effected by mechanism responding automatically to changes in air-speed.

What I claim as my invention and desire to secure by Letters Patent is:

1. An aerodyne for flight at supersonic and low subsonic speeds comprising fore-wing means of delta-shaped plan formation, two main-wings respectively extending from the ends of the base of the fore-wing means and pivotally connected thereto, and means for adjusting the main-wings in sweep during flight.

2. An aerodyne for flight at supersonic and low subsonic speeds, comprising fore-wing means of delta-shaped plan formation and two main-wings respectively extending from the ends of the base of the fore-wing means, pivot means for pivotally connecting each main wing to the fore-wing means, and means for adjusting the main-wings in flight about said pivot means between an outspread position for subsonic speeds and a fully swept back position for supersonic speeds such that the combined plan-formation of the fore-wing means and main-wings in the latter position conforms to the out-line of a delta-shaped aerofoil from which a substantially isosceles triangular region based on the trailing edge has been removed.

3. An aircraft comprising a lifting element which is articulated to form a fore-wing means and two main-wings, the fore-wing means being of delta-shaped plane-formation and the main-wings extending from the ends of the base of the fore-wing means and pivotally connected thereto, and means for adjusting the main-wings during flight between an outspread position for subsonic speeds, and a swept-back position for supersonic speeds in which latter position their leading edges are substantially aligned with the respective leading edges of the fore-wing means.

4. An aerodyne as claimed in claim 2, wherein the main-wings are articulated to the fore-wing means in such manner that the fore-wing means has a slightly greater angle of incidence than the main-wings in the fully swept back position, the axes of said pivot means being tilted forwardly, so that at all degrees of sweep the angle of incidence of the fore-wing means is slightly greater than the angle of incidence of the main-wings.

5. An aerodyne as claimed in claim 2, wherein the fore-wing means comprise port and starboard sections which are rotatable relative to each other about the X axis of the aerodyne, or about axes parallel to said axis and disposed symmetrically at either side thereof, and comprising means for adjusting the lateral dihedral angle between said sections during alteration for different angles of sweep of the main-wings.

6. An aerodyne as claimed in claim 5, comprising a body conforming externally to a solid of revolution described about the X axis of the aerodyne, said body having a finely pointed nose into either side of which the sections of the fore-wing means merge to preserve a delta-shaped plan form, and wherein the sections of the fore-wing means are rotatable for variation of lateral dihedral angle about said axis.

7. An aerodyne as claimed in claim 5, including a component having a plurality of compartments disposed side by side in double-bubble configuration and their axes located symmetrically with respect to the X axis of the aerodyne, the whole being enclosed in an envelope having a finely pointed nose into either side of which the sections of the fore-wing means merge to preserve a delta-shaped plan form, and wherein the sections of the fore-wing means are rotatable for variation of lateral dihedral angle about the respective longitudinal axes of the outer compartments.

8. An aerodyne as claimed in claim 6, comprising transverse beams fixed in the fore-wing means at points spaced along the longitudinal axis thereof, each such beam including a pivot, and wherein each section of the fore-wing means has a bearing connection with said pivot, and comprising within each said section means associated with the ends of the beams for rotating the section about the axis of the pivots in such fashion as to alter the lateral dihedral angle of said section.

9. An aerodyne as claimed in claim 3, wherein directional stability is achieved by means of rudder-like fins respectively mounted for pivotal movement about axes parallel to the Z axis on the extremities of the main-wings, means being provided for adjusting the fins automatically in response to the positioning of the main-wing so that for low speed main-wing positions they will be toed in, and for high speed main-wing positions they will be substantially parallel to the ZX plane of the aerodyne.

10. An aerodyne as claimed in claim 9, wherein there is provided over-riding pilot-actuated mechanism, and means connecting said mechanism to operate said fins as rudders, for achieving directional control.

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