March 28, 1950 M. STEIGEL 2,501,920

FOLDING AIRFOIL

Filed May 31, 1946 4 Sheets-Sheet 1

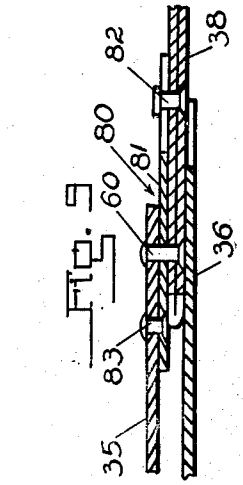


Fig. 5

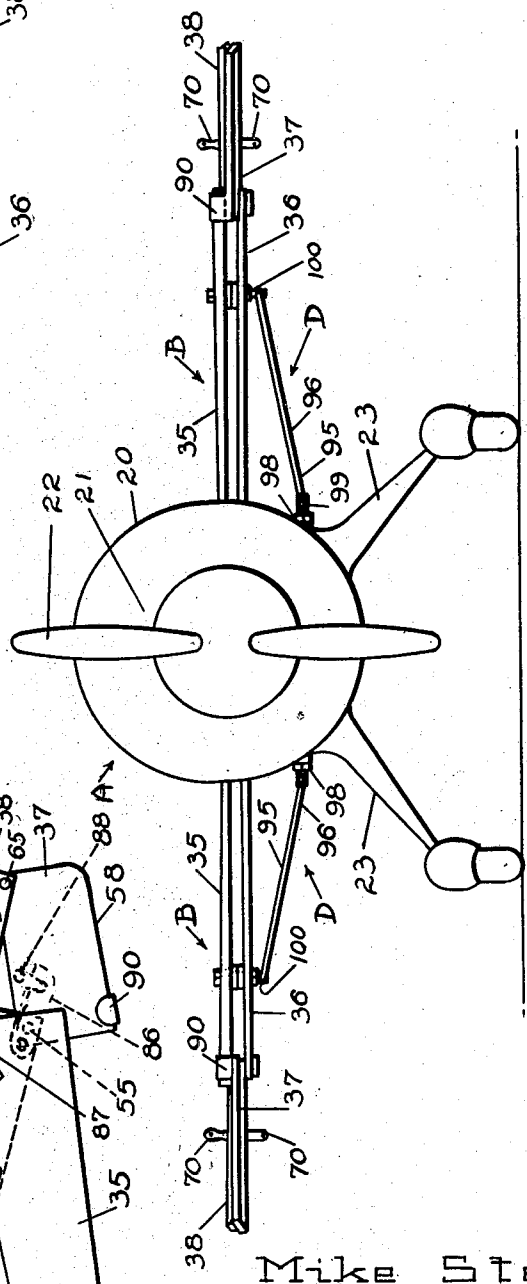


Fig. 1

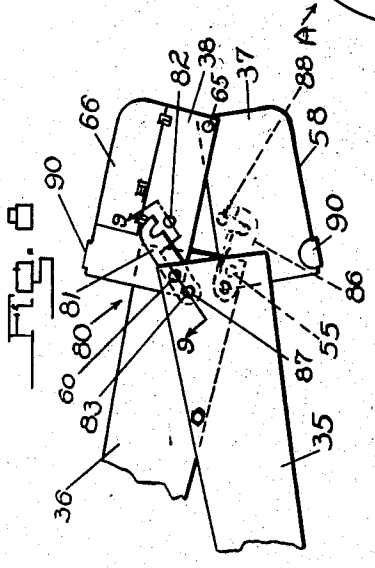


Fig. 8

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FOLDING AIRFOIL

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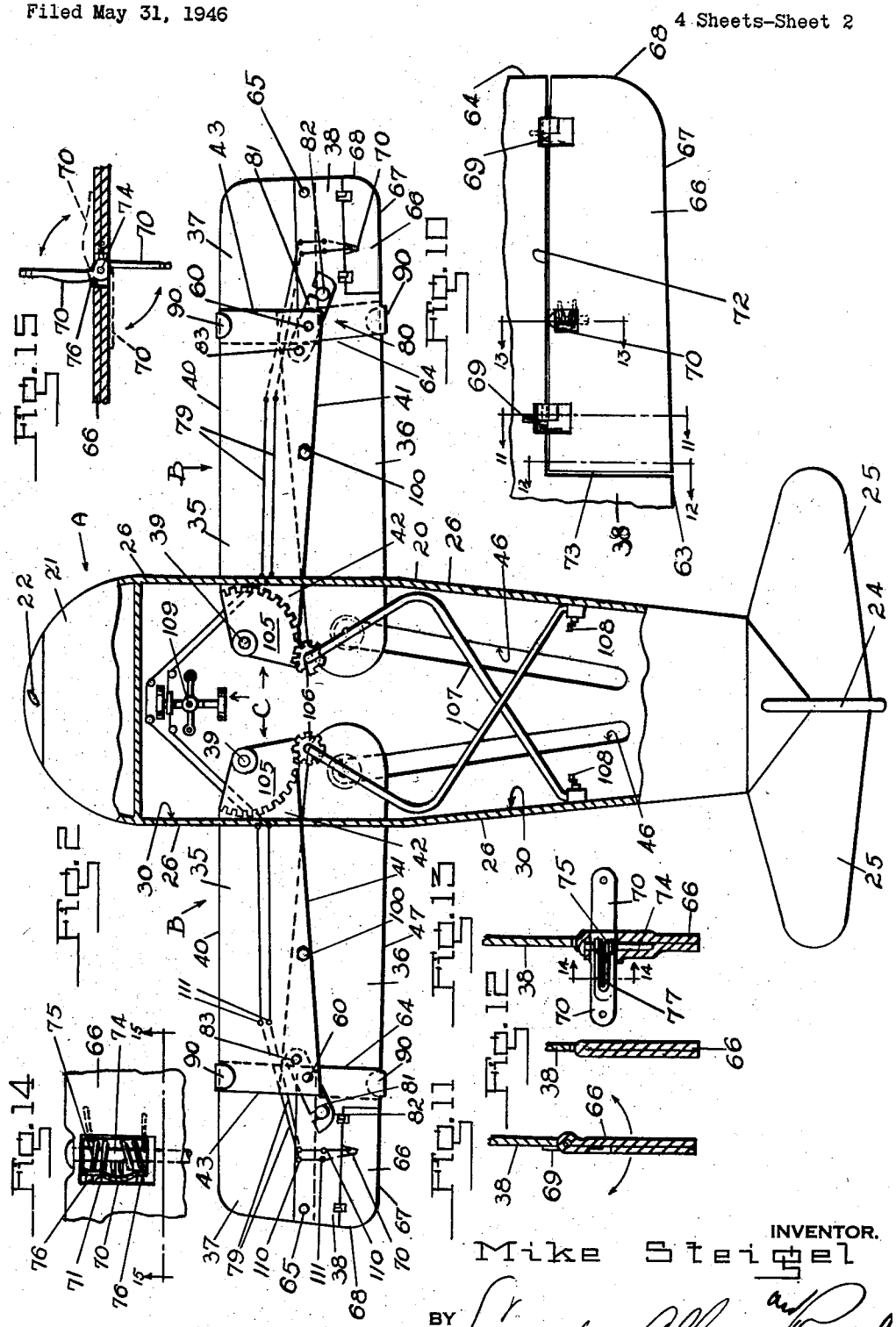


Fig. 2

Fig. 10

Fig. 11

Fig. 12

Fig. 13

Fig. 14

Fig. 15

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FOLDING AIRFOIL

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Fig. 3

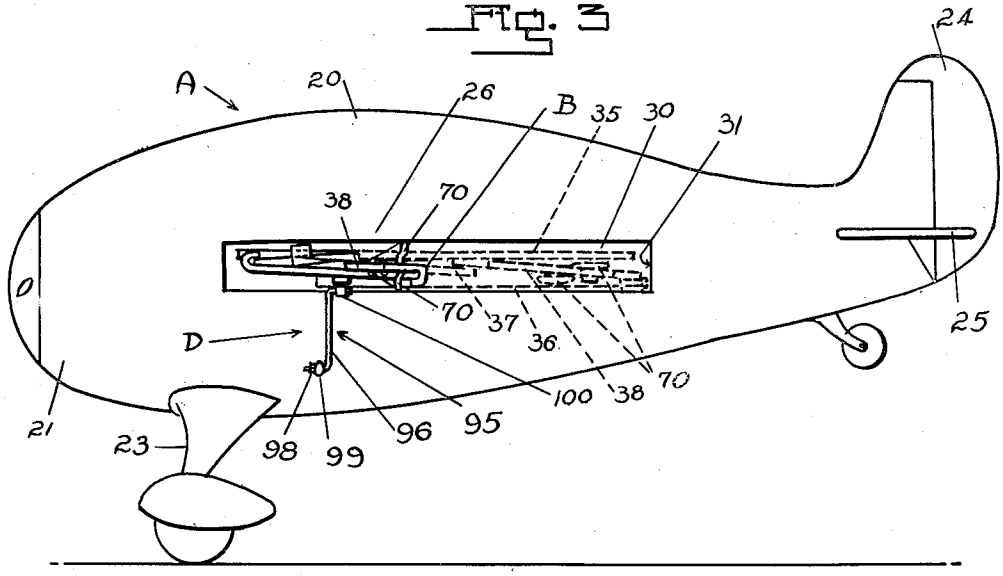


Fig. 16

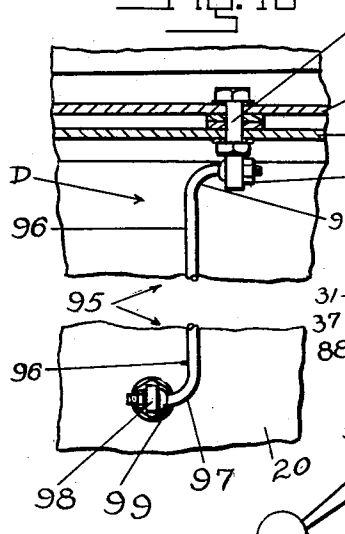
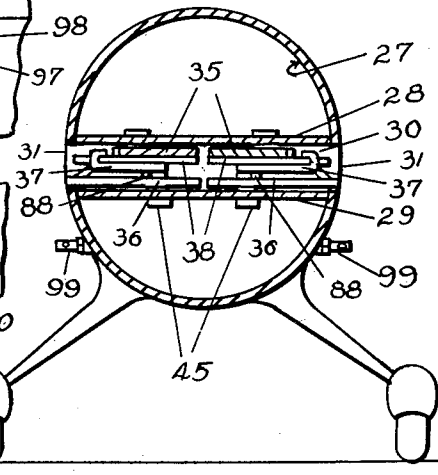


Fig. 4



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FOLDING AIRFOIL

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Fig. 5

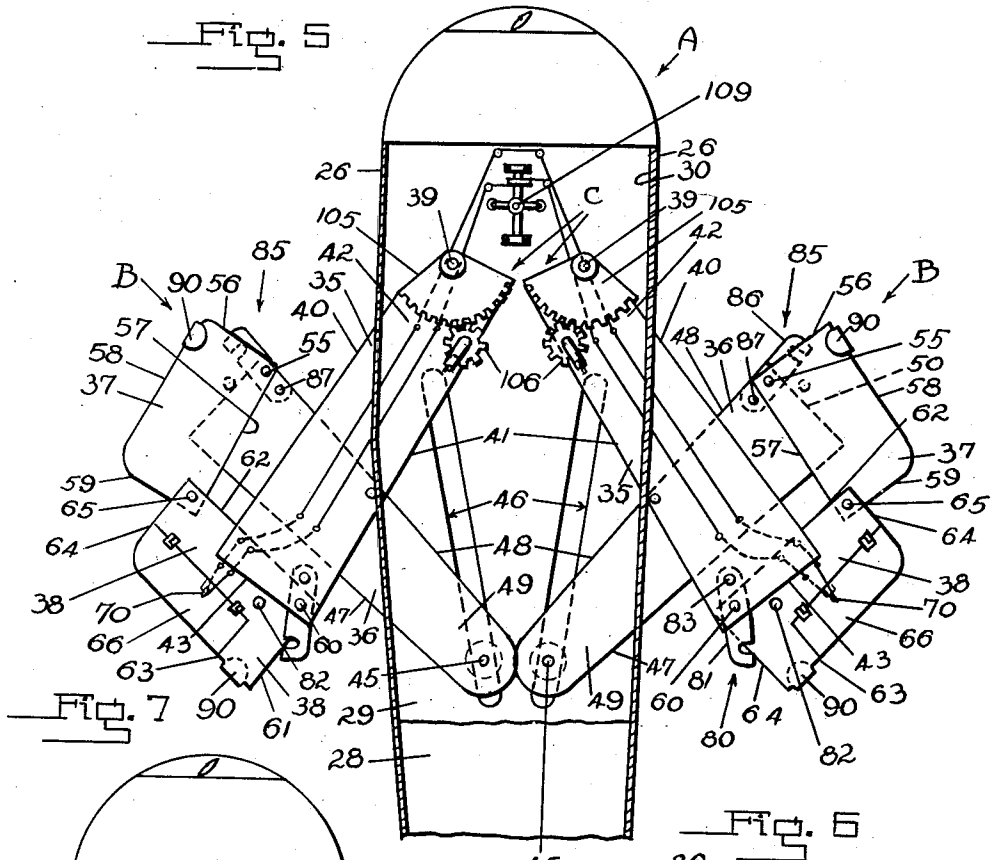


Fig. 7

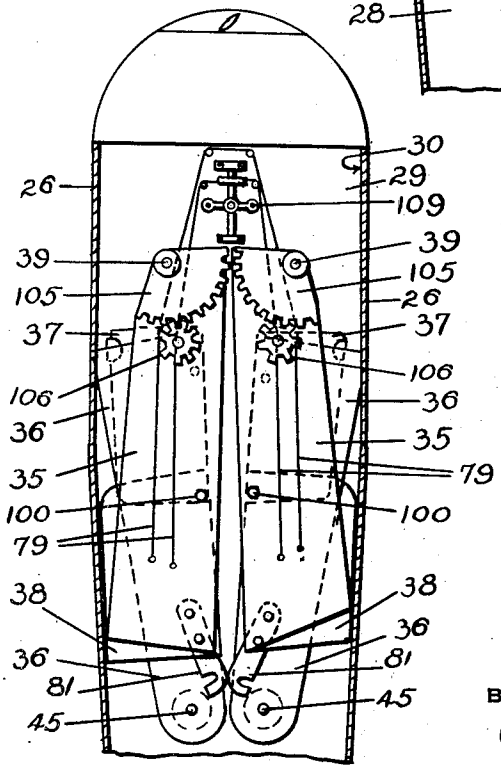
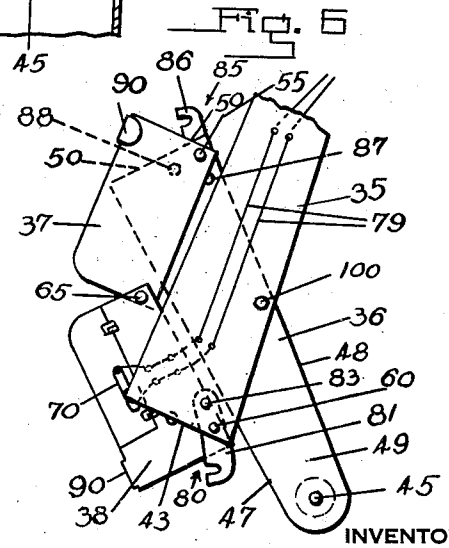


Fig. 6



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UNITED STATES PATENT OFFICE

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FOLDING AIRFOIL

Mike Steigel, Deville, La.

Application May 31, 1946, Serial No. 673,571

7 Claims. (Cl. 244—49)

1

This invention relates to folding airfoils for aeroplanes and other vehicles.

An important object of the invention is to provide a foldable airfoil which may be manipulated to extend outwardly of or wholly within the fuselage or other housing to which it is attached.

Another important object is to provide such a foldable airfoil which, when folding, moves along horizontal planes, rather than along vertical planes or planes inclined from the horizontal. When constructed to so operate, the vehicle to which the airfoils are attached may be housed in a particularly low hangar or similar structure, and the airfoils may be folded or extended while in such a hangar or the like. In addition, if desirable, the vehicle may be concealed by use of a low canopy, and the airfoils fully extended while thereunder, so that the vehicle may emerge therefrom in a condition to take off at once. This is not the case where foldable airfoils fold in vertical planes or planes sharply inclined from the horizontal.

Still another object is to provide a folding airfoil for association with a suitable vehicle which airfoil, while being folded or extended and, encountering stiff winds, will not tend to tip the vehicle.

An object of importance is to provide a foldable airfoil, including a plurality of sections, one carrying an aileron having horns, which horns are constructed and arranged to fold automatically upon folding of the sections making up the airfoil.

Another object is to provide a foldable airfoil, made up of pivoted sections, some of the pivots of which have dual functions.

Other objects and advantages will be apparent during the course of the following detailed description of the invention, taken in connection with the accompanying drawings, forming a portion of this specification, and in which drawings

Figure 1 is a forward plan view of a vehicle, being an aeroplane for example, equipped with the novel foldable airfoils, the latter being fully extended.

Figure 2 is a view, partly in top plan of the aeroplane of Figure 1, with parts of the latter broken away to better illustrate portions of the airfoils and their operating means.

Figure 3 is a side elevation of the aeroplane and airfoils of Figures 1 and 2.

Figure 4 is a transverse section of the aeroplane of Figures 1, 2 and 3 with the airfoils folded.

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Figure 5 is a fragmentary top plan and horizontal section somewhat like Figure 2, but illustrating partial folding of the sections making up the airfoils and partial retraction of the airfoils.

Figure 6 is a top plan of sections making up one airfoil in positions taken when more nearly folded than as in Figure 5.

Figure 7 is a fragmentary top plan and horizontal section somewhat like Figures 2 and 5, but showing the airfoils completely folded, as in Figure 4.

Figure 8 is a top plan of several fragments of airfoil sections, illustrating a retaining means for the extended sections.

Figure 9 is a horizontal section, substantially on the line 9—9 of Figure 8.

Figure 10 is an enlarged fragment of an airfoil section, carrying an aileron.

Figures 11, 12 and 13 are sections substantially upon their respective lines of Figure 10.

Figure 14 is a view, mostly in top plan of an aileron horn control means.

Figure 15 is a section substantially upon the line 15—15 of Figure 14.

Figure 16 is a fragment of the aeroplane in side elevation with portions of the airfoil sections in vertical section and showing another retaining means, this view being associated with Figures 3 and 4 for comparison therewith.

In the drawings, wherein for the purpose of illustration is shown a preferred embodiment of the invention and wherein similar reference characters designate corresponding parts throughout the several views, the letter A designates a vehicle, equipped with the novel folding airfoil B, which is operated by the means C and braced by the means D.

The vehicle A is shown by way of example as an aeroplane having a body or fuselage 20, cowling 21, propeller 22, landing gear 23, rudder 24 and elevators 25. The fuselage includes side walls 26 and defines a compartment 27, which compartment is preferably divided, as shown in Figure 4, by a pair of spaced-apart, horizontally extending partitions 28 and 29 which extend across the compartment 27 and may be secured to the side walls 26. The partition 28, which may be termed the upper partition and the partition 29 which may be designated as the lower partition, provide a recess 30 for the airfoils B, when folded, as well as for portions of the means C. As may be seen, in Figures 3 and 4, the side walls 28 are provided with longitudinally extending, horizontal openings 31 to the recess 20.

By way of illustration, the vehicle A is shown equipped with two airfoils B disposed, when fully extended, as in Figures 1 and 2, transversely of the vehicle and on opposite sides thereof.

Referring to Figure 2, it will be seen that each airfoil B includes two major pivoted sections 35 and 36, and two minor pivoted sections 37 and 38.

Of the two major pivoted sections, the section 35 may be termed the fixed-pivot section, in that the axis of its pivot 39 does not move with respect to the fuselage 20. The section 35 is, preferably, elongated having a leading edge 40, an edge 41 opposite the edge 40, which edges may diverge, from the fuselage-enclosed portion 42 (within the recess 30) of the section 35, to an outer edge 43. The pivot 39 of each airfoil section 35 extends into suitable bearings, preferably carried by the partitions 28 and 29 at the forward end portion of the recess 30 and well inwardly of the fuselage walls 26. Of course, the axes of the pivots 39 extend normal to the partitions 28 and 29 and parallel one another.

The major pivoted section 36 may also be designated as the movable-pivot section, for its pivot 45 is constructed and arranged to slide longitudinally of the fuselage 20 and recess 30, since the pivot 45 extends through a narrow opening, as slot 46 arranged longitudinally therefor, in the partition 29. The section 36 is, preferably, elongated, has a trailing edge 47 and an edge 48, opposite the edge 47, which edges may diverge from the fuselage-enclosed portion 49 (within the recess 30) of the section 36, to an outer edge 50.

Pivotally carried by the major section 36 is the minor section 37, which constitutes the tip part of the leading edge portion of the airfoil B, and the pivotal connection is, preferably, the pivot means or pin 55, adjacent a corner formed by the juncture of the edges 56 and 57 of the section 37. In addition, this section has a leading edge 58 and a tip edge 59. It will be noted, as in Figures 5 and 6 that, in overlapping, the section 37 is above the section 36.

The minor section 38 may also be termed the tip part of the trailing edge portion of the airfoil B. This is pivotally connected, as at 60 to the section 35 at adjacent one corner of the former, formed by the juncture of its edges 61 and 62. In addition this section 38 has a trailing edge 63 and a tip edge 64. Adjacent the corner formed by the edges 62 and 64, the section 38 is pivoted, as at 65, to the section 37 with the section 37 under the section 38 at this corner, but the corner formed by the juncture of the edges 61 and 62 is beneath the section 35, all as may be seen as in Figures 2 and 5. The section 38 pivotally carries an aileron 66 which is provided for by removing a part of the material of the section 38. The aileron has an edge 67 merging into the trailing edge 63 and an edge 68 merging into the tip edge 64 as may be seen in Figure 10. Any suitable means, as springs 69 may be employed to retain the aileron in its normal position, as in Figures 10 and 11, and to restore it to this position when it has been operated to control roll or bank of the vehicle A, as is well known in the art.

To effect controlled operation or flapping of the ailerons there is provided a novel aileron horn 70. Obviously, for most efficient operation, the two horns of the aileron should extend with their longitudinal axes normal to the upper and lower faces of the aileron body. However, horns, so disposed, would interfere with a compact folding of an airfoil within a confined space. To effect such folding, the horns 70 are pivotally carried by the aileron 66, by providing an opening or slot 71 in the aileron body, preferably adjacent the inner edge 72 of the aileron, paralleling the edge 67 and extending toward the latter, and intermediate the edge 68 and its paralleling edge 73. Extending across the slot 71 and paralleling the edges 68 and 73, is a pivot pin 74 carried by the aileron body, which pin extends through the central portion of a length of suitable rigid material, such as metal, forming the two upper and lower horns 70 of the aileron.

Normally, the horns 70 are retained in the conventional position described by means of a coil spring 75, as is shown in Figures 13 and 14 and a stop 76. That is, the convolutions of the spring 75 extend about the pivot pin 74, the intermediate portion 77 of the spring bears against one face of one horn 70 constituting a part of the length of rigid material, and the free ends of the spring bear against a suitable surface as the surface of the aileron opposite that from which the horn (against which the intermediate portion 77 of the spring bears) extends.

It is important that the portion 77 of the spring is correctly positioned to enable the horns to pivot, since the section 35, as may be seen in Figures 5 and 6, causes the horns 70 to take the positions as in the dash lines of Figure 15, after pivoting in the directions of the arrows.

Since the spring 75 bears against one horn 70 it would tend to urge that horn and the associated horn into pivoting beyond positions where the longitudinal axes of the horns were normal to the surface of the aileron. To limit movement of the horns in one direction, a suitable stop 78 may be provided, carried by the length of material constituting the horns 70 and bearing against the aileron.

It will be noted that the horns pivot in directions transverse of the vehicle A but, of course, paralleling the longitudinal axes of the airfoils. For this reason the cables 79 to the horns 70 do not tend to cause the horns to pivot, when the cables are manipulated to effect operation of the aileron, since the cables extend from their connections with the horns in the conventional direction, i. e., transversely of the longitudinal axis of the aileron, while the pivotal directions of the horns are longitudinally of the ailerons.

In order to retain the sections 35, 36, 37 and 38 in a rigid assembly when the airfoil is extended, suitable retaining means may be provided. These are shown especially in Figures 2 and 8 and 3 and 16.

The first of the retaining means includes a latch 80, having a latch arm 81 secured to the under side of the section 35 adjacent the corner formed by the edges 41 and 43, and extending outwardly of that corner and adapted to engage a keeper 82 extending a short distance from the upper side of the section 38 inwardly of the corner thereof formed by the edges 62 and 64 thereof. In order to doubly secure the latch arm 81, it may be fastened to the section 35 as by the rivet 83 and by the pivotal pin 60 which extends through it. Preferably, each airfoil has a second latch 85, like the latch 80, having a latch arm 86 secured to the under side of the section 36 adjacent the corner formed by its edges 48 and 50 as by the rivet 87 and the pivotal pin 55 which extends through it, thereby doubly securing the latch arm 86 against tearing loose. The latch arm 86 extends outwardly of the corner mentioned and is adapted to engage, in a

latched relation, a keeper 88 extending outwardly a short distance from the under side of the section 37. Of course, the latch arms 81 and 86 engage their keepers 82 and 88 when the sections 35 to 38 inclusive are extended as in Figure 2, and the levers and keepers automatically move into and out of latched positions as the airfoil is extended or folded.

The second of the retaining means includes one or more keepers 90. Two are shown for each airfoil and one is carried by the section 37 closely adjacent the corner formed by its edges 56 and 58 and extending from the edge 58 and overhanging the upper face of the section 37 being spaced therefrom a distance very slightly greater than the thickness of the section 35 at its edge 40, since the edge 40 of this latter section is adapted to slide into the space between the upper face of section 37 and keeper 90 of sections 37.

A similar keeper 90 may be carried by the section 38 to extend under the lower face of that section from the edge 63 and receive, within the space provided, a portion of the section 36, at the edge 47 of the latter, when the airfoil is extended.

The third of the retaining means constitutes the means D and is specially so designated since a portion of the means D unlike the first and second means described, is removable when folding the airfoils. The means D includes braces 95 shown more particularly in Figures 3, 4 and 16. Each brace 95 (two being provided in the example given) includes an arm 96 having one free end 97 extending therefrom, forming substantially a right angle, and the other free end 97 extending therefrom in the opposite direction. The free ends may be screw-threaded to receive nuts 98 or the like after these ends are extended through openings in suitable projections 99 and projection-pivots 100. The projections 99 extend outwardly from each side of the fuselage 20, below the longitudinally-extending openings 31 therein and above the landing gear 23, while a projection-pivot 100 is carried by each airfoil, and extends downwardly from the lower face of the section 36. The projection-pivots 100 have dual functions for, in addition to serving as retainers for one ends of each brace arm 96, they provide pivot pins for the sections 35 and 36, since these sections are pivoted together, intermediate their lengths and adjacent the edges 41 and 43 respectively. It will be seen that the brace arms 96 are removable upon unscrewing the nuts 98 in order to fold the wings but the projection-pivots 99 function as pivots, whether or not the brace arms 96 are employed.

The operating means C for the airfoils, in addition to the cooperation therewith of the pivots 45, 55, 60, 65, the projection-pivots 100 and the walls of the slots 46, include a segmental gear 105 suitably secured to, preferably, the upper face of each section 35 at its inner end and disposed as shown particularly in Figures 2, 5 and 7. The pivots for the gears 105 are, of course, the pivots 39 for the sections 35 and extend to bearings in the partitions 28 and 29. Meshing with each gear 105 is a pinion 106 rotated, for example, by means of conventional flexible shafts 107 associated with cranks 108 for rotating the shafts. From Figure 2 it will be seen that rotation of the right-hand pinion 105 anti-clockwise will cause folding of the right-hand airfoil B and rotation of the left-hand pinion 106 will cause folding of the left-hand airfoil B.

Progressive folding of the airfoils B is shown

in Figures 5, 6, and 7. In Figure 5 it will be seen that that the several latch means 80, 85 and 90 have become unlatched and that the edge 43 of each section 35 is approaching the upper horns 70, while the pivots 45 have moved along their slots 46, from the forward end thereof to adjacent the rearward ends thereof.

In Figure 6 it will be seen that the edge 43 of the section 35 has contacted the upper horn 70 and depressed it, against the tension of the spring 75, while in Figure 7 the airfoils B are folded, with the sections 35, 36, 37 and 38 within the recess 30 (that is, wholly within the fuselage 20), and disposed in substantial parallelism, with the various sections overlapping or one above another. As may be seen in Figure 4, the entire airfoil is within the planes defined by the edges of the slots 31.

Any suitable means may be provided to carry the cables 79 from the aileron horns 70 to the controls 109 thereof. In the example shown, the cables 79 may extend through conventional, spaced-apart eyes 110 carried by the sections and perforations 111 extending through the sections from one face to the other.

From the foregoing, it will be seen that horizontal folding of the airfoils is effected and the latter, when folded, occupy relatively small space, while the openings from which the airfoils project are generally narrow. In folding or unfolding, the only brace means which need be manually removed or applied is that portion of the means 95 represented by the braces 96.

Parts, such as the pivots 55, 60 and 100 have dual functions in the construction disclosed and the aileron horns are automatically moved to non-interfering positions when the airfoils are being folded.

Various changes may be made to the form of the invention herein shown and described without departing from the spirit of the invention or scope of the claims.

What is claimed is:

1. In combination with a vehicle provided with walls defining a compartment, one of said walls having an opening leading from said compartment to the exterior of said vehicle and another wall, normal to said first wall, having a slot, a foldable-section airfoil including four airfoil sections comprising a forward, elongated major section, a rearward, elongated major section, a forward minor section, disposed with a corner thereof overlapping a corner of said rearward major section, and a rearward minor section, disposed with a corner thereof overlapping a corner of said forward major section, and a corner thereof overlapping a corner of said forward minor section, means pivotally connecting said forward major section to the rearward minor section adjacent the overlapping corners thereof, means pivotally connecting said rearward major section to the forward minor section adjacent their overlapping corners, means pivotally connecting the two minor sections together at their overlapping corners; means pivotally connecting the two major sections together adjacent an edge of each, intermediate their lengths; means pivotally connecting one of said major sections to a wall of said compartment, including a fixed pivot, means pivotally connecting the other of said major sections to a wall of said compartment including a pivot slidable longitudinally of said slot; and means to move said sections into and out of said opening.

2. In a sectional airfoil for connection to a

fuselage with the sections of said airfoil constructed and arranged to move in substantially horizontal planes while being folded, said airfoil including a forward major airfoil section, a rearward major airfoil section, a forward minor airfoil section, a rearward minor airfoil section, means pivotally connecting said forward major airfoil section to said rearward minor airfoil section, adjacent a corner of each, means pivotally connecting said rearward major airfoil section to said forward minor airfoil section adjacent a corner of each, means pivotally connecting said minor airfoil sections together adjacent a corner of each, means pivotally connecting said major airfoil sections together adjacent an edge of each, each of said means including a pivot pin with the axes thereof substantially normal, at all times, to the longitudinal axes of said sections, means to pivotally support said major airfoil sections upon said fuselage, and means to pivot said sections upon their pivotal connections.

3. In a sectional airfoil for connection to a fuselage with the sections of said airfoil constructed and arranged to move in substantially horizontal planes while being folded, said airfoil including a forward major airfoil section, a rearward major airfoil section, a forward minor airfoil section, a rearward minor airfoil section provided with an aileron having a pivotal connection therewith, means pivotally connecting said forward major airfoil section to said rearward minor airfoil section, adjacent a corner of each, means pivotally connecting said rearward major airfoil section to said forward minor airfoil section adjacent a corner of each, means pivotally connecting said minor airfoil sections together adjacent a corner of each; means pivotally connecting said major airfoil sections together adjacent an edge of each, each of said means including a pivot pin with the axes thereof substantially normal, at all times, to the longitudinal axes of said sections, and the axis of said pivotal connection between said rearward minor airfoil section and its aileron, means to pivotally support said major airfoil sections upon said fuselage, and means to pivot said sections upon their pivotal connections.

4. In a sectional, foldable airfoil, an elongated, forward, major airfoil section having a leading edge, a second edge opposite said leading edge, with said edges diverging outwardly, and a third edge substantially normal thereto; an elongated, rearward, major airfoil section having a trailing edge, a second edge opposite said trailing edge, with said two last-named edges diverging outwardly, and a third edge substantially normal thereto; means pivotally connecting said sections together adjacent their second edges and intermediate their lengths; a forward minor airfoil section having a leading edge, a tip edge, a third edge normal to said last-named leading edge, and a fourth edge, normal to said tip edge, a rearward minor airfoil section having a trailing edge, a tip edge, a third edge, normal to said last-named trailing edge, and a fourth edge normal to said last-named tip edge; means pivotally connecting said minor airfoil sections together adjacent the corners formed by their tip edges and the edges normal to their tip edges; means pivotally connecting the forward major airfoil section to the rearward minor airfoil section adjacent the corners formed by the second and third edges of said forward major airfoil section and the third and fourth edges of said rearward minor airfoil section; means pivotally connecting the rearward major airfoil section to the forward minor airfoil section adjacent the corners formed by the second and third edges of said rearward major airfoil section and the third and fourth edges of the forward minor airfoil section, all of said pivotal connections having their axes normal to the longitudinal axes of said sections; and means to move said sections to pivot upon their pivotal connections.

5. In combination with a vehicle provided with a body portion having walls defining a compartment and provided with an opening leading from said compartment to the exterior of said body portion, a foldable-section airfoil including four airfoil sections comprising two elongated major sections and two minor sections, said minor sections comprising the tip portion of said airfoil, means pivotally connecting one of said major sections to one of said minor sections, means pivotally connecting the other of the major sections to the other of the minor sections, means pivotally connecting the two minor sections together, means pivotally connecting the two major sections together intermediate their ends, each means including a pivot pin with its axis intersecting the planes of the upper and lower surfaces of said sections, the pivot pin connecting the two major sections together having a downwardly-extending projection, brace means for said airfoil including a brace, a connection between said brace and said body portion and a removable connection between said brace and said projection, and means to effect movement of said sections through said opening and into and out of said compartment.

6. In a sectional, foldable airfoil, an airfoil section having a leading edge and an edge normal thereto; a second airfoil section having a trailing edge, an edge normal thereto and an aileron-accommodating opening, an aileron normally within said opening and pivoted to said second airfoil section, a horn for said aileron, means pivotally connecting said horn to said aileron to move said horn from the vertical to the horizontal with the pivotal axis of horn being normal to the pivotal axis of said aileron, and means resiliently urging said horn into a vertical plane; means pivotally connecting said sections together at the overlapping corners formed by said edges of said first-named airfoil section and said edges of said second-named airfoil section; and means to pivot said sections upon their pivotal connection so that said edge normal to said leading edge of said first-named section, will normally substantially parallel said edge which is normal to said trailing edge of said second-named section, when said sections are in one position, and so that said edge normal to said leading edge, will engage said horn and pivotally move said horn into a substantially horizontal plane, when said sections are in other positions.

7. In a foldable airfoil section, a body portion having a tip edge and a trailing edge, a recess in said body portion at said trailing edge, an aileron in said recess, provided with upper and lower opposite faces and an opening extending from one face to the other face, a pivotal connection between said section and its aileron, including a pivot pin with its axis parallel to said trailing edge, an upper horn and a lower horn for said aileron, said horns comprising a single length of material, means pivotally connecting said length of material to said aileron intermediate the length of the former, and extending through said opening to project from said opposite faces, including

a pivot pin with its axis substantially paralleling said tip edge, and resilient means urging said length of material to a position with its longitudinal axis substantially normal to said faces of said aileron.

MIKE STEIGEL.

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The following references are of record in the file of this patent:

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Number	Country	Date
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Certificate of Correction

Patent No. 2,501,920 March 28, 1950

MIKE STEIGEL

It is hereby certified that errors appear in the printed specification of the above numbered patent requiring correction as follows:

Column 5, line 19, for the word "sections" read *section*; column 8, lines 53 and 58, before "normal" insert *which is*;

and that the said Letters Patent should be read with these corrections therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 11th day of July, A. D. 1950.

[SEAL]

THOMAS F. MURPHY,
Assistant Commissioner of Patents.

Certificate of Correction

Patent No. 2,501,920 March 28, 1950

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