

Feb. 15, 1944.

D. C. LAW ET AL

2,341,997

AIRFOIL

Filed Nov. 9, 1942

2 Sheets-Sheet 1

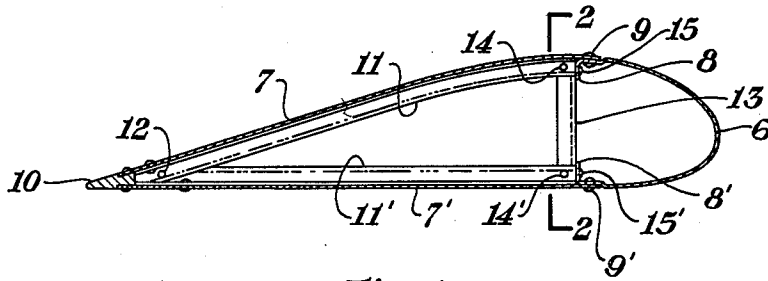


Fig. 1

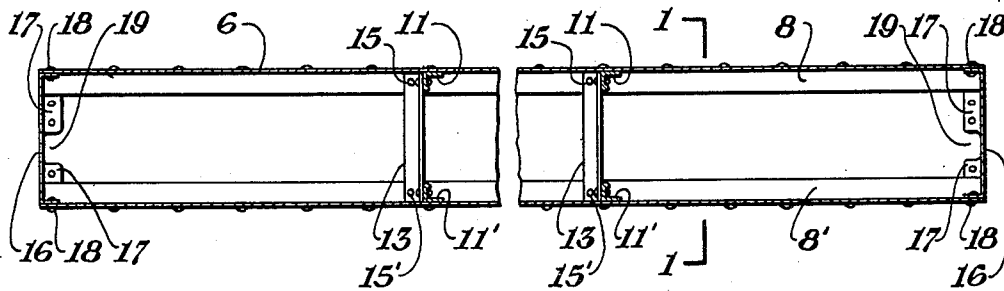


Fig. 2

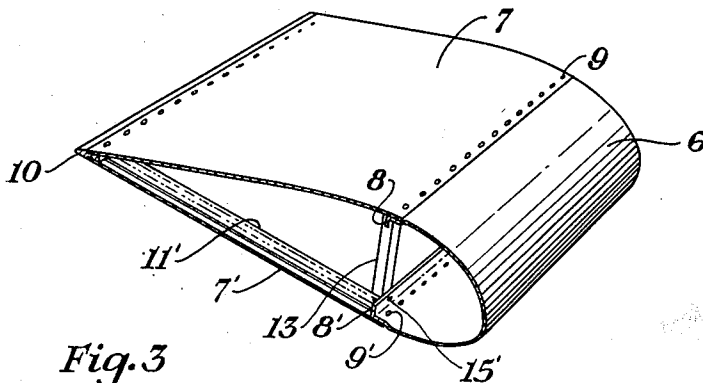


Fig. 3

INVENTORS
Don C. Law
John T. Ellis
BY

Griswold & Burdick
ATTORNEYS

Feb. 15, 1944.

D. C. LAW ET AL

2,341,997

AIRFOIL

Filed Nov. 9, 1942

2 Sheets-Sheet 2

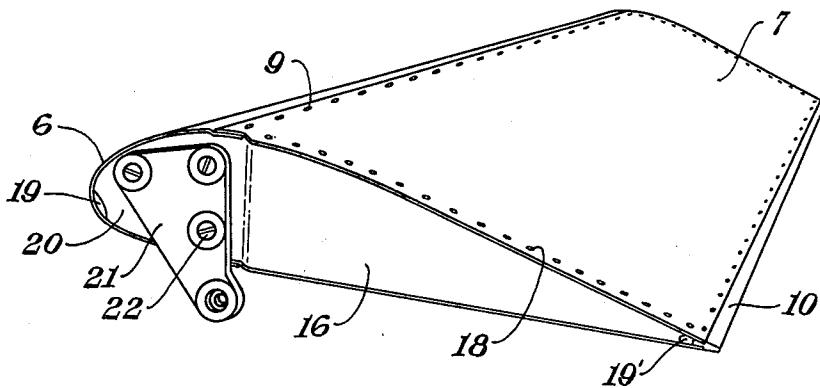


Fig. 4

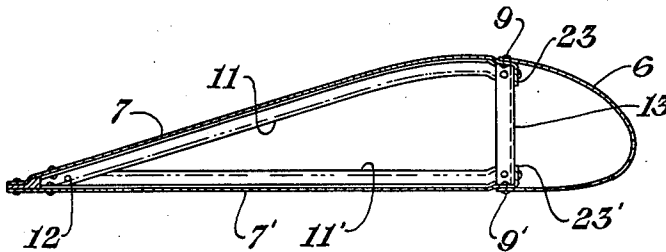


Fig. 5

INVENTORS

Don C. Law

John T. Ellis

BY

Griswold & Burdick
ATTORNEYS

UNITED STATES PATENT OFFICE

2,341,997

AIRFOIL

Don C. Law and John T. Ellis, Bay City, Mich., assignors to The Dow Chemical Company, Midland, Mich., a corporation of Michigan

Application November 9, 1942, Serial No. 464,962

6 Claims. (Cl. 244-123)

This invention relates to airfoils, and more particularly concerns a simplified construction for ailerons, elevators, rudders, tabs, and like movable control surfaces for aircraft.

In conventional practice, an airfoil consists essentially of a basic stress-resisting structure, usually formed of one or more spars to which are secured ribs and other supporting members, and a fabric, plywood, or sheet metal covering or skin. This construction is somewhat disadvantageous, however, in that it requires the fabrication of a large number of separate fittings, cannot ordinarily be assembled rapidly, and may require considerable maintenance during service.

The airfoil of the present invention, in contradistinction to prior practice, is of a stressed-skin or monocoque construction, the airfoil surface sheets themselves largely constituting the stress-resisting elements, and is characterized by the complete absence of any spar. It may be readily assembled from a comparatively small number of easily formed parts, requires little maintenance, and may advantageously be constructed of ultra-light metals, such as magnesium-base alloys.

The details of the new airfoil construction may be understood with reference to the accompanying drawings, in which:

Fig. 1 is a transverse section of an aileron embodying the principles of the invention, taken along the line 1-1 in Fig. 2;

Fig. 2 is a longitudinal section of the aileron along the line 2-2 in Fig. 1;

Fig. 3 is a perspective view of a section of the aileron;

Fig. 4 is a perspective view of the assembled aileron, illustrating particularly the end construction; and

Fig. 5 is a transverse section of another aileron showing an alternative structure.

The aileron illustrated in Figs. 1-4 consists essentially of a nose-section 6 and two aft skin sections 7 and 7', which define the airfoil surface, together with end sections and stiffener members, as will be explained.

The nose-section 6 consists of a single curved elongated sheet of metal, such as a magnesium-base alloy, formed with an approximately semi-ovoid contour to define a leading-edge surface, and joggled slightly along the rearwardly extending portions to receive the overlapping aft skin section, as shown, the sheet being of thickness such that in the assembled aileron it is sufficiently stiff to retain its shape under operating stresses without requiring internal supporting

ribs. At its rearward edges, the nose-sheet is bent inwardly to form spanwise flanges 8 and 8' having a width at least several times the sheet thickness. These flanges provide lateral stiffness and are capable of withstanding the spanwise bending stresses which are normally borne by a spar or beam in conventional airfoil construction.

Each of upper and lower aft skin surfaces 7 and 7' is formed of a relatively flat elongated metal sheet which should be sufficiently thick to withstand the stresses to which it is subjected, but ordinarily need not be as thick as that constituting the nose-section. The lower sheet 7' is substantially plane, while the upper sheet 7 is curved slightly at its forward portions to provide the desired camber. At their forward edges, the aft skin surfaces overlap the upper and lower rearward portions of the nose-section 6, the overlapping sheets being held together firmly by rows of rivets 9 and 9'. At the rear edges, the skin surfaces 7 and 7' are secured together to form the trailing edge of the aileron. In a particularly convenient and strong construction, as shown, the trailing edge itself is formed of a metal stiffener strip 10 extending laterally along the aileron, the rear edges of the aft skin surfaces overlapping and being riveted to this strip.

The aft skin surfaces are reinforced and held to the proper contour by stiffener ribs 11 and 11' formed of extruded "bulb angle" stock spot-welded or otherwise fixed in chordwise direction to the inner side of each aft skin section at intervals along its length. The individual ribs 35 of the lower skin surface are arranged below and opposite those of the upper surface to define rib-pairs, the ribs of each pair being fastened together at their rearward ends by a rivet 12.

Vertical stiffeners 13 or angles extending between the upper and lower nose-section flanges at positions adjacent to the aft skin surface ribs, and are secured at each end to the contiguous rib 11 or 11' by a rivet 14 or 14' and also to the contiguous nose-section flange 8 or 8' by another rivet 15 or 15'. The vertical stiffeners 13 thus hold the ribs of each rib-pair spaced at their forward ends and likewise act as spacers to maintain the exact contour of the nose-section. The stiffeners 13 are not highly stressed in service, but with the rivets 14 and 15 and the nose-section 6 provide a sort of gusseted construction which acts as a partially closed torsion box imparting considerable added strength to the entire structure.

At each end, the aileron is closed by an end section or head 16, as shown particularly in Figs. 2

and 4. The head is formed of a single flat sheet of metal shaped to the contour of the aileron and bent inwardly along its edges to provide a flange 17 which fits into the end of the aileron and is held firmly to the nose section 6 and aft skin surfaces 7 and 7' by rows of rivets 18. Notches 19 and 19' are cut in the head at front and back to allow for escape of condensed moisture from the inside of the aileron. The forward portion 20 of the head is joggled inwardly to receive a bracket 21 on which the aileron is hinged, the bracket being held in place by bolts 22 extending through the head 16.

In making the aileron, the nose-section, end heads, and aft skin sections are formed to shape, and the stiffener ribs are spot welded to the latter. The nose-section, heads, and one aft skin section are then riveted together, the vertical stiffeners secured in place, and the other skin section then riveted on.

The alternative construction shown in Fig. 5 is closely similar to that already described, except that spanwise stiffness is provided by inwardly extending flanges 23 and 23' which are integral with the joggled forward edges of the aft skin sections 7 and 7', instead of being formed on the nose-section as in the aileron of Figs. 1-4. An alternative trailing edge construction is also shown, the upper aft skin surface 7 being joggled slightly at its rear edge to impart added stiffness.

It will be appreciated that in the construction of both Figs. 1-4 and Fig. 5 the lateral bending stresses are absorbed by spanwise stiffener flanges which are formed integrally with at least one of the sheets constituting the airfoil surfaces and which extend laterally along the inside of the airfoil at the junctures of the nose-section with the aft skin surfaces. While it is highly preferable that the flanges be integral with the airfoil surface sheets, separate spanwise stiffener members may be secured to the inner airfoil surfaces in place of integral flanges if desired in special instances. As already explained, these stiffener flanges together with the nose-section, act as a major stress-resisting element of the airfoil and thus are instrumental in eliminating the necessity of the spar deemed essential in prior practice.

It will be understood that the foregoing description is illustrative rather than strictly limitative, and that variations in the airfoil structure which would obviously occur to those skilled in the art, such as the substitution of welded or cemented construction in place of riveting, are within the scope of invention.

What is claimed is:

1. In a stressed-skin airfoil characterized by the absence of a spar, in combination: a nose-section comprising a sheet of approximately semi-ovoid contour; a stiffener strip extending along the trailing edge of the airfoil; upper and lower aft skin sections, each formed of an elongated sheet, secured at their forward edges to the upper and lower rearward portions, respectively, of the nose-section, and at their rear edges to the trailing edge strip; upper and lower lateral stiffener members fixed to and extending along the inside of the airfoil at the junctures of the nose-section with the upper and lower aft skin surfaces; pairs of stiffening ribs spaced at intervals along the inner side of the aft skin surfaces, the ribs of each pair being fixed one to the upper and the other to the lower aft skin surface and being fastened together at their rearward ends; and vertical stiffeners secured between the upper and lower lateral stiffener members and holding the

ribs of each rib-pair spaced at their forward ends.

2. In a stressed-skin airfoil characterized by the absence of a spar, in combination: a nose-section comprising a sheet of approximately semi-ovoid contour, said sheet being sufficiently stiff to retain its shape without internal support; upper and lower aft skin sections each formed of an elongated sheet and stiffener ribs fixed to the inner surface thereof at intervals along its length; means securing the forward edges of the aft skin sections to the upper and lower rearward portions, respectively, of the nose section, and means securing the rear edges of the said section together to form a trailing edge of the airfoil; upper and lower lateral stiffener flanges formed integrally with at least one of the sheets constituting the airfoil surface, and extending along the inside of the airfoil at the junctures of the nose-section with the upper and lower aft skin surfaces; vertical stiffeners, one for each pair of aft skin surface ribs, extending between the upper and lower lateral stiffener flanges at positions adjacent to the ribs; and means at each end of each vertical stiffener securing the same to the contiguous flange and rib.

3. In a stressed-skin airfoil characterized by the absence of a spar, in combination: a nose-section comprising a sheet of approximately semi-ovoid contour having its rearward edges bent inwardly to form flanges; a stiffener strip extending along the trailing edge of the airfoil; upper and lower aft skin sections, each formed of an elongated sheet, secured at their forward edges to the upper and lower rearward portions, respectively, of the nose-section, and at their rear edges to the trailing edge strip; pairs of stiffening ribs spaced at intervals along the inner side of the aft skin surfaces, the ribs of each pair being fixed one to the upper and the other to the lower skin surface and being fastened together at their rearward ends; and vertical stiffeners secured between the upper and lower nose-section flanges and holding the ribs of each rib-pair spaced fixedly at their forward ends.

4. In a stressed-skin airfoil characterized by the absence of a spar, in combination: a nose-section comprising a sheet of approximately semi-ovoid contour and an inwardly-projecting flange formed integrally therewith along each rearward edge, said sheet being sufficiently stiff to retain its shape without ribs; upper and lower aft skin sections, each formed of an elongated sheet and stiffener ribs fixed on the inner side thereof at intervals along its length; means securing the forward edges of the aft skin sections to the upper and lower rearward portions, respectively, of the nose-section, and means securing the rear edges of the said sections together to form a trailing edge of the airfoil; vertical stiffeners, one for each pair of corresponding aft skin section ribs, extending between the upper and lower nose-section flanges at positions adjacent to the said ribs; and means at each end of each vertical stiffener securing the same to the contiguous flange and rib.

5. In a stressed-skin airfoil characterized by the absence of a spar, in combination: a nose-section comprising a sheet of approximately semi-ovoid contour; a stiffener strip extending along the trailing edge of the airfoil; upper and lower aft skin sections each formed of an elongated sheet having its forward edge bent inwardly to form a flange, said sections being secured near their forward edges to the upper and lower rearward portions, respectively, of the nose-section,

and at their rear edges to the trailing edge strip; pairs of stiffening ribs spaced at intervals along the inner side of the aft skin surfaces, the ribs of each pair being fixed one to the upper and the other to the lower aft skin surface and being fastened together at their rearward ends; and vertical stiffeners secured between the upper and lower nose-section flanges and holding the ribs of each rib-pair spaced fixedly at their forward end.

6. In a stressed-skin airfoil characterized by the absence of a spar, in combination: a nose-section comprising a sheet of approximately semi-ovoid contour, said sheet being sufficiently stiff to retain its shape without ribs; upper and lower aft skin sections, each formed of an elongated

5 sheet, an inwardly-projecting flange formed integrally therewith along its forward edge, and stiffener ribs fixed to the inner side of the sheet at intervals along its length; means securing the forward portions of each aft skin section to the corresponding rearward portion of the nose-section; means securing the rear edges of the aft skin sections together to form a trailing edge of the airfoil; vertical stiffeners, one for each pair of corresponding aft skin section ribs, extending 10 between the upper and lower aft skin surface flanges at positions adjacent to the said ribs; and means at each end of each vertical stiffener securing the same to the continuous flange and rib.

DON C. LAW.

JOHN T. ELLIS.