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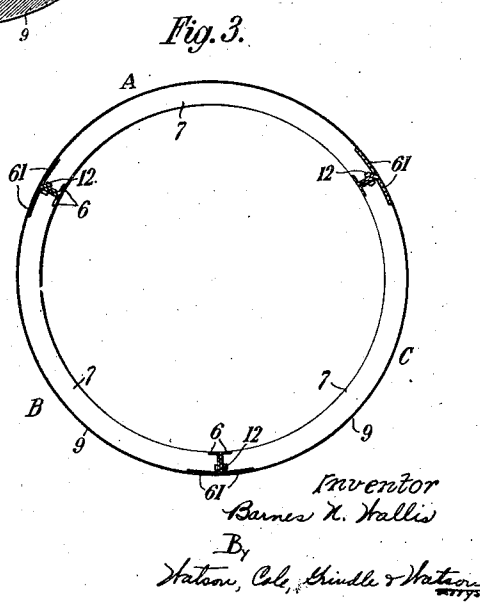
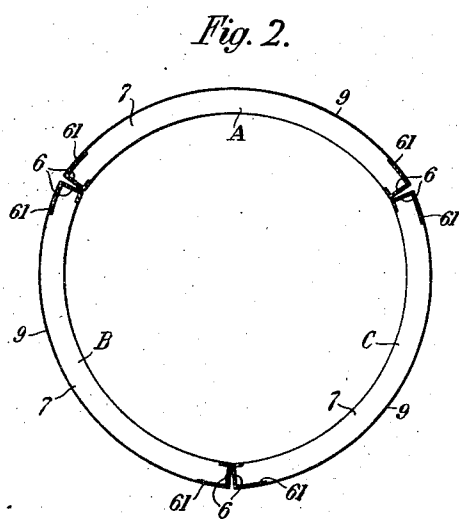
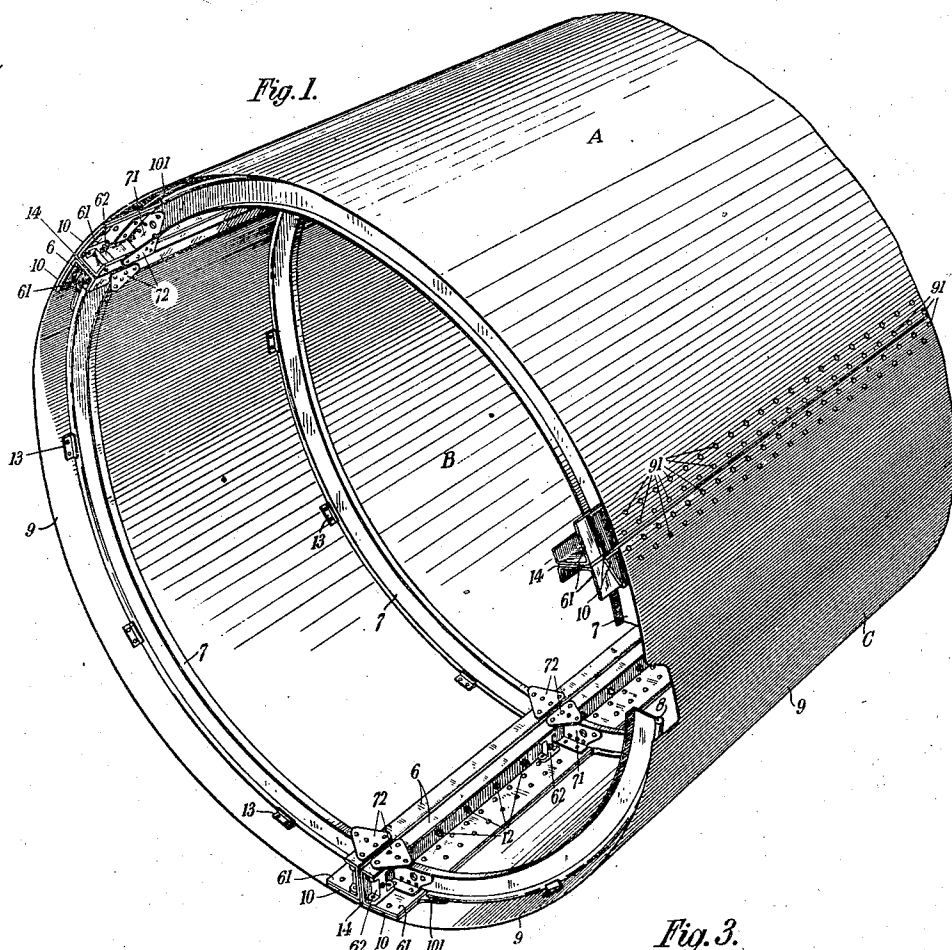
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AIRCRAFT STRUCTURE

Filed June 17, 1942

2 Sheets-Sheet 1



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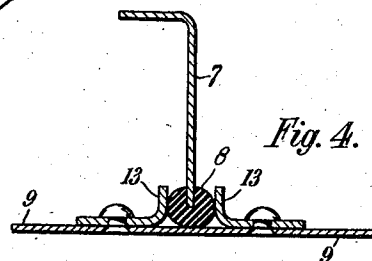
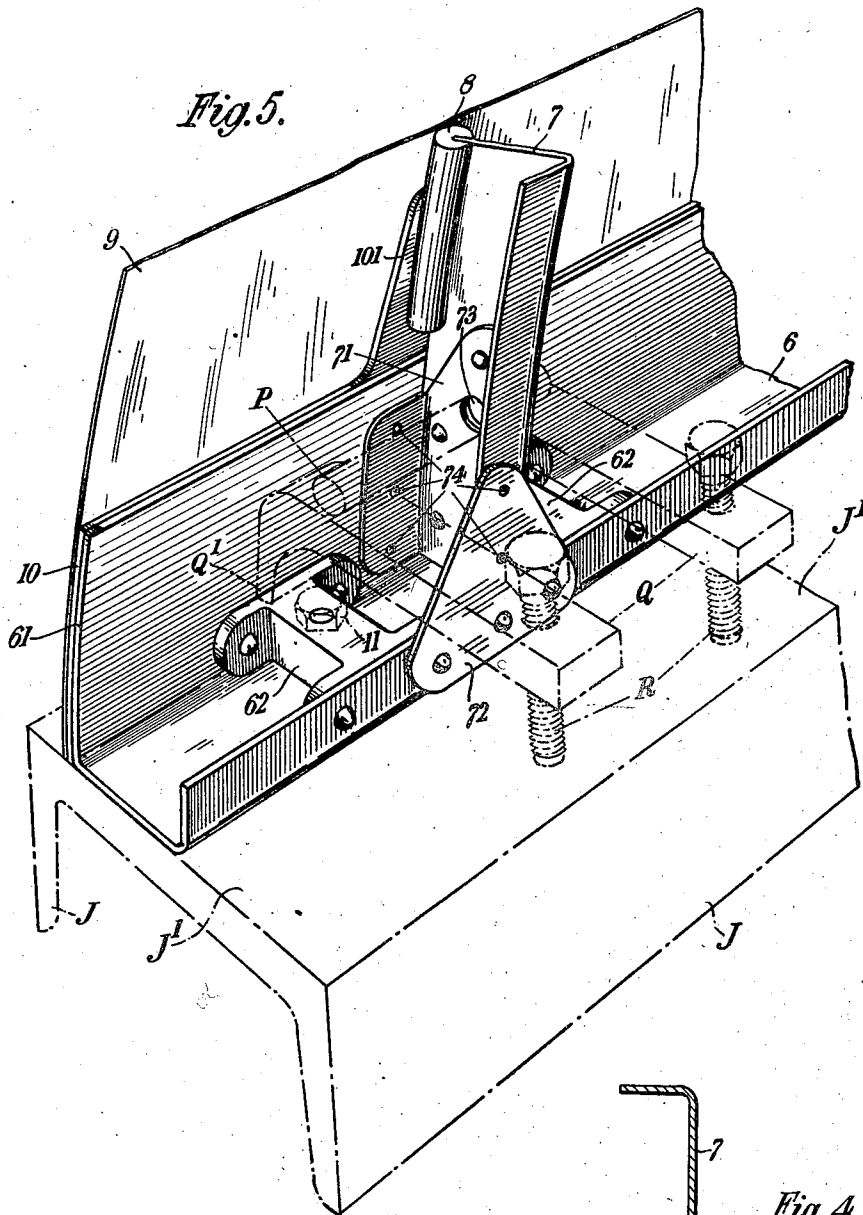
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AIRCRAFT STRUCTURE

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AIRCRAFT STRUCTURE

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6 Claims. (Cl. 244-117)

The invention has reference to the construction of stressed skin structures for aircraft fuselages and wings. It has heretofore been the custom to divide the surface of the outer plating into a series of relatively small panels by riveting or welding the plating to closely pitched longitudinal spars or stringers and transverse ribs or intercostal members in order to enable the relatively thin plating to develop a high proportion of the inherent shear strength which it is capable of developing in bulk form. The attachment of the plating to the frames at frequent intervals serves to stabilise the plating against the formation of wrinkles which tend to occur in thin plate under the action of shear stress, but this form of construction is disadvantageous in that the multiplicity of riveted joints involves a large amount of skilled labour, while the use of a large number of closely pitched longitudinal members results in these members being correspondingly thin in cross-section with consequent instability and reduction of the compressive strength which the material is capable of developing in bulk form, as a result of which the overall weight of the structure is appreciably increased.

In the case of an aircraft fuselage (or a restricted portion thereof) which is supercharged to compensate for the low external atmospheric pressure prevailing at high altitudes, there is the added disadvantage that local bulging of the skin is caused by the high pressure difference within and without the structure; such bulging not only impairs the aerodynamic qualities of the fuselage, but also originates stresses in the rivets at the points of attachment of the plating to the structural members, thereby "starting" the joints, producing air-leaks and weakening the structure.

Alternative constructional methods have been proposed, consisting in attaching the plating either to the longitudinal members only, or to the transverse members only, but the structural difficulties have not been remedied, because in each case the plating is still free to bulge, i. e. either fore and aft between the longitudinal members, or transversely between the ribs, so that the tensile loading upon the rivets is accentuated rather than relieved, and the bulges in the plating become disproportionately more pronounced by the reduction in the number of points of its attachment to the skeletal structure. The first alternative of attaching only to the longitudinal members does not have the effect of reducing the number of transverse members as these are required in any case to

support the slender longitudinals. The second alternative of attachment to transverse members only is particularly disadvantageous in the case of pressure cabins, since it gives rise to an exaggerated form of the worst kind of bulging, when the furrows are at right angles to the air stream. In neither case is the total amount of riveting required very greatly reduced.

The object of the present invention is to provide an improved method of construction, whereby (a) the longitudinal members may be reduced in number to the minimum, to enable them to be made of thick and robust cross-sectional proportions and consequently improve their ability to withstand compressive loading, whilst also permitting a corresponding reduction in the riveting of plating to longitudinals, (b) the riveting of the transverse members to the plating (previously considered necessary) may be entirely eliminated, and (c) in a "pressure cabin" both forms of bulging will be precluded. This method improves the structural efficiency by achieving a considerable reduction in overall weight, and uses proportionately less labour during construction. A further important advantage possessed by the invention lies in the elimination of the bulging of the plating in the case of the upper surface of wings where the pressure distribution is below the static pressure of the atmosphere in the locality.

In a fuselage or wing structure in accordance with the invention, the skin plating is attached to longitudinal members between which it is stretched over shaped ribs in such manner that it is subjected to a circumferential tensile stress running in the direction of the planes containing the ribs, and so that said ribs also serve to support the plating against inward collapse by strong centrifugal pressure against the plate, there being however no attachment of the plating to said ribs.

The imposition of centrifugal pressure upon the plating in this manner enables it to withstand a high degree of shear stress, and thereby to resist the shear and torsional loads to which the structure is subjected in use. In the application of the invention to a non-pressure cabin or fuselage, or to a wing, the plating remains tightly held against the supporting ribs, but in a "pressure cabin" the absence of any attachment of the plating to said ribs permits the skin, together with the longitudinal members to which it is attached, to "breathe" by free cylindrical expansion under variations of air pressure within the structure. The capacity of the skin to withstand

shear stress increases as the internal pressure rises in relation to the external atmospheric pressure, so that when such dilatation occurs the inward support of the ribs is no longer required, although the ribs are ready to resume their duty of supporting the plating against inward collapse when the internal and external air pressures are equalised.

The invention is hereinafter more fully described with reference to the accompanying drawings, which illustrate by way of example the application of the invention to the construction of a "pressure cabin" for use in an aircraft intended for flight at high altitudes. In said drawings, Fig. 1 is a sectional perspective view of a "pressure cabin" of circular cross-section. Figs. 2 and 3 are diagrammatic views showing the relative dispositions of the component sections of the fuselage during the process of their assembly, i. e. respectively as seen before and after the longeron channel-members are bolted together. (In Fig. 2 the extent to which the sections have reverted from the form in which they were held during the riveting of the ribs to the channel-members, and which they resume when bolted together as shown in Fig. 3, has been exaggerated for the purpose of illustration). Fig. 4 is a detail view depicting the manner in which the ribs are located laterally in relation to the skin plating, and Fig. 5 is a fragmentary perspective illustration of a jig suitable for the purpose of imposing circumferential stress in the plating whilst clamping the ribs and channel-members in position for their attachment.

The structure of the "pressure cabin" illustrated in the drawings is divided longitudinally into three segments A, B and C of equal arc dimension, and the present description is confined to a structure of this kind, although it will be understood that the invention is not so restricted in its application.

The longerons are composed of pairs of channel-section members 6, 6, respectively attached to the opposing edges of adjacent segments of the fuselage, the individual members of each pair being bolted together during the assembly of the separately constructed segments, so that they combine to form complete longerons. Alternatively, angle-bars may be employed in lieu of channel-section members, if desired. The stiffening-ribs, which are spaced along the length of the fuselage, are each constituted by three individual arcuate segments 7 fabricated from L-section bars rolled to the appropriate curvature and provided along the edge of the outer flange with a cushioning or anti-chafing pad or bead 8 of vulcanized fibre, india-rubber or other suitable non-metallic material. It will be understood that the number of the arcuate segments which constitute the stiffening-ribs at each cross-sectional pitch will correspond with the number of longitudinal sections which are to compose the structure. Before proceeding to a description of the erection of the fuselage, there follows an explanation of our preferred method of manufacture of one of the component sections thereof.

The plating of a sectional unit is first formed from a sheet 9 which, after it has been wrought to the requisite cylindrical or part-spherical curvature, is riveted at 91 along each of its longitudinal borders to one of the flanges 61 of one of said channel-members 6, so that the plating lies upon the outside face of said flange, the free edge of which is directed towards the middle of the plate. A longitudinal reinforcing plate 10 is preferably

interposed between the flange 61 of the channel-member 6 and the underside of the plating 9 along the boundary of the latter, in order to assist in distributing the stresses to be transmitted between the plating and the longerons. The said reinforcing plates 10 may have tongues 101 extending inwardly wherever a segmental stiffening-rib 7 occurs.

The incomplete section constituted by the plating 9 and its longitudinal channel-members 6 is then supported upon a jig comprising two members having surfaces which, as in the present case of a fuselage to be erected from three component sections of equal arc dimension, are relatively inclined at an angle of 120°. One of the two members of the jig is indicated at J in Fig. 5, and it will be seen that the outwardly directed back of the web of one of the channel-members 6 is constrained to lie flush against the inclined surface J¹ of said jig member J by means of temporary service bolts 11. Said bolts 11 are passed through pads 62 which are riveted between the flanges of the channel-members. The other channel-member 6 of the section is bolted in similar fashion to the other jig member (not shown). It will be understood that the relative inclination of the surfaces J¹ of the jig members J will be varied to suit the case of a three-section fuselage of which the sections are not all of the same arc dimension, or to suit fuselages or wings composed of a different number of sectional units.

The segmental stiffening-ribs 7 required for the unit under construction, being provided at their extremities with gusset-plates 71 and 72, are assembled in parallel arrangement beneath the plating 9, with their ends suitably disposed in relation to the flanges of the channel-members 6, and with the parts assembled in this condition each rib 7 is subjected to an endwise force so as to press it outwards to the required degree. The means employed to impose said force upon the rib comprises, in association with each jig, an abutment bar P detachably fitted transversely through a hole 73 drilled in the web of the rib near its extremity, and two cranked levers Q, Q which are arranged so that they bear with their toes Q¹ upon the pads 62 as closely as possible to the underside of the outer flange 61 of the channel-member 6, whilst their other ends are pressed upwardly against said bar P by operation of set-screws R, R. The effect of tightening the set-screws R against the face of the jig member J is thus to impose a strong outward pressure upon the arcuate rib 7, through the medium of the abutment bars P, whilst the reaction of the outward-pressing force serves to intensify the pressure of the web faces of the channel-members 6 against the inclined jig-surfaces J¹. The outward motion of the ribs 7 is resisted by the plating 9 attached between the members 6, and a tension is thus set up in the plating 9 by the radial outward pressure of the ribs 7, the degree of such tension being readily determined by adjustment of the magnitude of the endwise force impressed upon the ribs 7 by the set-screws R. In this condition of the parts, with the plating 9 stressed at the appropriate circumferential tension, holes are drilled in the channel-members 6 to register with holes 74 already drilled in the gussets 71 and 72, and the gussets are then riveted to the members 6, which latter are thereby securely attached to the ribs 7, before the set-screws R are released.

When the unit section is removed from the jig, it reverts partially from the arcuate cross-section

tional form in which it has been held by the pressure of the levers Q against the bars P, the tension in the plating 9 being reduced by a slight straightening of the ribs 7 until a balance of forces is attained.

Three sectional units A, B and C constructed in this manner are then assembled with the outer faces of the webs of their channel-members 5 in juxtaposition. It will be evident that, owing to the aforesaid reversion in shape of the units when released from the jig, the outer faces of the channel-members 6 are no longer inclined at an angle at which two such members can make flush contact to constitute a single longeron; rather is the disposition of said channel-members 6 relative to one another, substantially as shown in Fig. 2, in which the faces of the members 6 gape to a greater or less degree. The requisite condition is however restored by bolting said pairs of channel-members 6 together by means of bolts 12 situated near to the outer edge of the web of the longeron, said bolts 12 being tightened until the opposing faces of the channel-members 6 are uniformly forced into contact when the fuselage re-assumes a circular cross-section as depicted in Fig. 3; in this manner the circumferential tension, to which the plating 9 was subjected in the jig, is re-imposed in the complete structure.

The plating 9, being now pressed strongly against the rib members 7, is prevented from buckling inwards should the application of shear or torsional loads tend to make it do so by passing the limit of stability of the plate in the free state. By this means the thin plating is enabled to develop the same degree of shear stress as if it were actually attached to the rib members by rivets or bolts, but it will be understood that no mechanical connection between the plating and the segmental ribs does in fact exist, so that the plating is not held against cylindrical expansion if and when the pressure of the internal atmosphere of the fuselage is raised above that of the surrounding air.

Thus, should the internal pressure of the fuselage rise to such a degree that the resultant hoop stress in the plating is equal to or greater than that imposed during construction by a method such as that hereinbefore described, the plating is free to expand to a greater size than the internal skeletal structure, by pure cylindrical dilatation, and no bulges are formed such as those which would result from a mechanical attachment of the plating and the ribs or stringers. In order to locate the ribs 7 in their correct positions in relation to the longitudinal axis of the fuselage, pairs of cleats or the like 13 may be provided, which are fixed upon the inner face of the plating 9 and between which the ribs 7 are free to slide when cylindrical expansion of the skin occurs.

The joints between the adjoining faces of the channel-members of the longerons are rendered air-tight by the interposition of strip rubber or other suitable jointing material 14 before they are bolted together.

The method of construction hereinbefore described is equally suited to the construction of non-pressure cabins and fuselages and wings, the customary ovoid or elliptical cross-section being achieved by means of suitably curved internal stiffening-ribs, or by suitably disposing the longerons.

An aircraft wing manufactured in accordance with the invention is conveniently formed in two component sections, each of which is so disposed

along its leading and trailing edges as to form a half-longitudinal member, one section forming the upper part of the wing and the other section the lower part thereof, and the arrangement being such that when the corresponding edges of the sections are joined, they combine to compose the leading and trailing longitudinal spars of the wing. As in the method of construction previously described, the act of bolting said half-members together imparts the requisite transverse tensile stress to the skin plating which is stretched between the spars over the arcuate internal ribs. Additional main spars may be introduced into the wing, in which case they may be utilised to maintain the correct location of the ribs and thereby permit the aforesaid cleats to be dispensed with.

It will be evident that the method of construction herein described possesses the additional advantage that it is possible to complete the attachment of all fittings and equipment on the interior of a sectional unit before it is assembled for erection with the other component units, the only operations remaining to be carried out after assembly being the connection of pipe lines, electric leads and the like. In this manner it is possible to avoid the wastage of time occupied in inserting such fittings and equipment which would otherwise occur by reason of the restricted space within the structure and the consequent difficulty of access to its interior and the limited number of persons who can be employed within the structure at the same time.

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

1. The method of making and assembling stressed skin structures for aircraft or the like, which comprises warping a sheet of skin plating to an appropriate curvature, anchoring the sheet at its opposite edges respectively to two longitudinal elements of the skeletal portion of said structure, applying transverse skeletal elements at spaced intervals against the inner surface of the skin with their ends abutting said longitudinal elements at intervals therealong while maintaining said skin in contact with but free from connection with said elements, stretching said skin over said transverse elements without attachment thereto, and securing the ends of said transverse elements to their respective adjacent longitudinal elements while the skin is stretched.

2. The method of making and assembling hollow substantially tubular stressed skin structures for aircraft or the like which comprises forming longitudinal segmental sections of said tubular structure by anchoring two longitudinal skeletal elements, having a substantial radial dimension, in the approximate spaced apart positions they will occupy in the completed structure, warping a sheet of skin plating to the desired curvature of said section, and securing it along its opposite longitudinal edges to the radially outward edges of said longitudinal elements, applying a series of longitudinal spaced curved ribs against the inner surface of said sheet without attachment thereto, with the ends of said ribs disposed adjacent said longitudinal elements, applying endwise compression to said ribs whereby they are caused to press radially outwardly against said sheet, and securing the ends of said ribs while thus stressed to the longitudinal elements, releasing the stress on the ribs, removing said longitudinal elements from their anchored position, whereupon they will be sprung to a somewhat non-radial position as the tension in the attached plating and the

compression in the adjacent ribs are balanced, then securing the segmental sections together edge to edge, drawing the longitudinal elements together and joining them firmly, whereby they again assume a substantially radial position and the previous tension in the plating is reimposed.

3. A pressure cabin for high altitude aircraft or the like, of substantially circular cross section, comprising circumferentially spaced longerons, a plurality of arcuate ribs spaced apart and extending between said longerons, skin plating attached to said longerons and applied over said ribs in initial and normal contact therewith but not attached thereto, said skin plating being in a condition of circumferential tensile stress and the ribs in a corresponding condition of endwise compression, whereby they exert strong radial outward pressure against the plating, and guide means on the plating to locate the ribs laterally with respect thereto but to permit cylindrical dilatation of the skin independently of the ribs.

4. A stressed skin structure for an aircraft fuselage, wing, or like walled structure comprising a hollow, continuous-walled construction constituted by a plurality of unitary segmental prefabricated sections and including, in combination, peripherally spaced longitudinally extending bracing members, each comprising a pair of abutting elements of some substantially radial extent, secured firmly together, the adjoining elements of adjacent pairs comprising the bounding margins of said segmental sections, each of said sections including also a plurality of arcuate ribs spaced apart and secured between the bounding longitudinal elements of said section, a curved sheet of skin plating secured marginally to the radially outward edges of the said longitudinal elements of the section and being normally in firm contact with the outer surfaces of said arcuate ribs but free for circumferential movement with relation thereto, said ribs being under

endwise compression substantially along the chords of the arcs they represent, whereby they exert a continuous pressure radially outwardly against the sheet which is therefore in a condition of corresponding tension, the firm attachment of the marginal longitudinal elements of adjoining sections serving to maintain them in substantially radial positions and maintaining the stress in the ribs and sheet.

5. The structure set forth in claim 4 in which there is additionally provided guide means on the plating to locate the ribs laterally with respect thereto but to permit relative movement of the plating over the ribs in a circumferential direction.

6. An aircraft wing of hollow construction comprising two outwardly bowed complementary sections respectively forming the upper and lower surfaces of the wing, said sections being joined at the leading and trailing edges, each section comprising a longitudinal element adjacent each of said edges, a plurality of spaced arcuate transversely extending ribs, secured between said longitudinal elements of the section, said ribs being in a state of endwise compression substantially along the chords of the arcs which they represent, a curved sheet of skin plating secured marginally to the radially outward edges of the said longitudinal elements of the section and being normally in firm contact with the outer surfaces of said arcuate ribs whereby said ribs exert a continuous pressure radially outwardly against the sheet which is therefore in a condition of corresponding tension, and means for rigidly securing together, in abutting relationship, the adjoining longitudinal elements of the two sections at the leading and trailing edges thereof to compose the wing spars at the leading and trailing edges of the wing.

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