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APPARATUS FOR PREVENTING THE ACCUMULATION OF ICE

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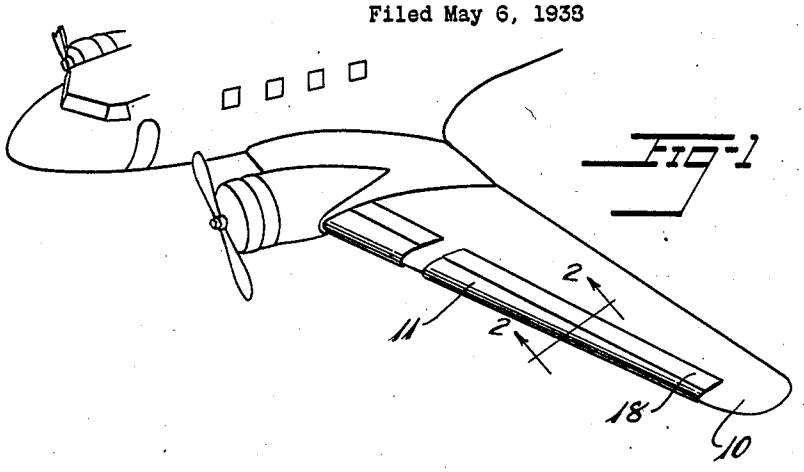


Fig-1

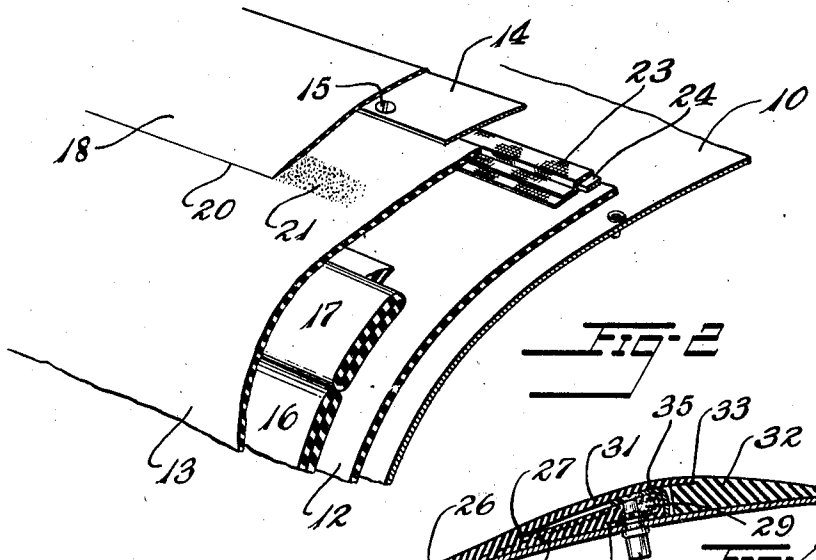


Fig-2

Fig-4

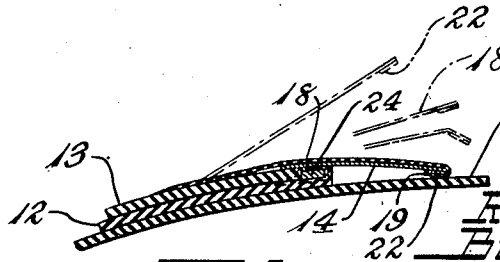


Fig-3

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APPARATUS FOR PREVENTING THE ACCUMULATION OF ICE

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16 Claims. (Cl. 244—134)

This invention relates to apparatus for preventing the accumulation of ice on bodies and is especially useful where ice forms upon parts of aircraft during flight.

Inflatable shoes for the leading edges of wings and other airfoils have been effective for the removal of ice throughout the extensible areas of the shoes. However, non-extensible attaching parts such as fairing strips at the margins of the shoes have at times tended to accumulate ice undesirably, the ice requiring only a small edge or abrupt change in contour for a base on which to accumulate.

The principal objects of the invention are to provide for preventing the accumulation of ice upon fairing strips and in the region thereof, to provide simplicity of construction, efficiency of operation, and facility of attachment. Another object is to provide a secondary structure attached to and operated by a primary structure for preventing the accumulation of ice.

These and other objects will appear from the following description and the accompanying drawing.

Of the drawing:

Fig. 1 is a perspective view of an airplane having an embodiment of the invention in its preferred form mounted upon a wing thereof, parts of the airplane being broken away.

Fig. 2 is a detail perspective view to a larger scale showing a portion of the wing structure with the ice-removing equipment attached thereto, parts being broken away to show the construction.

Fig. 3 is a sectional view of the skin of the wing, the edge of the primary ice-removing equipment, the fairing strip for securing the same, and the secondary ice-removing means over the fairing strip.

Fig. 4 is a similar view showing a modified construction.

Referring to the drawing, the numeral 10 designates a wing surface or skin, to which apparatus in the form of an inflatable shoe 11 is attached. This apparatus is illustrated as being of a construction in which a foundation layer of rubber material 12, and a covering layer of rubber material 13 cover the leading edge of the wing and have their margins which are reinforced as by fabric 23 and a metal strip 24, secured to the wing by metal fairing strips 14 secured to the skin of the wing by screws 15. Preferably this shoe is mounted in a condition of tension between its upper and lower attached margins. A plurality of inflatable tubes 16, 17 are secured between the foundation layer 12 and the cover 13 and are adapted to be inflated so as to change the contour of the cover 13 and thereby to loosen or break up ice formed thereover for its automatic removal.

While such a shoe is very efficient in dislodging ice formed directly thereover, it has been found in practice that at times ice forms upon an abrupt change of contour of the airfoil, even when a metal fairing strip is employed. The forward edge of the strip, even when it is quite thin, apparently acts as a nucleus upon which the ice builds.

To provide for preventing the accumulation of ice upon the fairing strips and in the region thereof, a sheet 18 of elastic material such as soft vulcanized rubber, or other rubber-like material is applied over the fairing strip in stretched condition, the rear margin 19 thereof being turned under the rear edge of the fairing strip and clamped thereby while the forward margin 20 is secured to the covering layer 13 of the primary shoe at a distance forward of the fairing strip as by cement 21. The sheet 18 is made quite thin, preferably about .020" thick, and is preferably applied when stretched about 30%. The margin which is cemented to the primary ice removing equipment is skived to a sharp edge so as to avoid an abrupt shoulder and provide a substantially continuous and smooth surface in this region.

In the operation of the apparatus, the primary ice removing member is distorted by inflation of the tubes 16, 17, the sheet 18 is lifted slightly from the fairing strip and is also stretched due to its attachment to the layer 13. This stretching and lifting is effective to crack and dislodge ice that has formed on the sheet 18. As the secondary ice dislodging member is actuated entirely by the movements of the primary ice dislodging member, it requires no other mechanism for its operation.

In order to secure the margin 19 of the sheet 18 firmly beneath the fairing 14, a narrow metallic strip reinforcement 22 may be vulcanized or cemented to the margin of the sheet and may be engaged under the margin of the fairing strip as shown in Fig. 3.

In assembling the apparatus, the primary shoe 11 preferably is first mounted upon the wing or other airfoil. The forward skived margin 20 of the sheet 18 is then adhered at 21 to the cover 13 of the primary shoe, and when the cement or other adhesive has become thoroughly dry the sheet is stretched rearwardly in the manner

illustrated by the broken lines of Fig. 3, and its rear, reinforced edge is tucked under the rear edge of the fairing strip 14 which, being secured only at its forward edge, may be flexed up slightly at its rear edge to permit this. The sheet is thus held in a fore-and-aft tensioned condition and as its forward edge is secured to a flexed region of the shoe cover 13, the sheet partakes of the flexing and stretching of the shoe when the latter is inflated and deflated, for effective removal of ice from the region of the fairing strip as well as from the shoe proper.

In order to attain, to a greater degree, the advantages of the invention, the primary and secondary ice dislodging members may be constructed as an integral unit, as illustrated in Fig. 4, wherein the covering layer 26 of the ice dislodging member is bifurcated at 27 lengthwise thereof, to provide a lower leaf 28 which is longitudinally reinforced by a batton 29 of metal or other rigid material and a strip of fabric 30 looped thereabout, and an upper leaf 31 which extends beyond and over the edge of the leaf 28 and is anchored to the skin of the plane in stretched condtion. To avoid even the slightest shoulder when the upper leaf meets the surface of the wing or other body member, a strip 32 of rubber composition is molded of substantially triangular cross-section and rebated, as at 33, to receive the margin of the upper leaf 31 which is cemented to the strip within the rebate so as to provide an uninterrupted surface. The triangular strip 32 is cemented to the skin of the wing with its sharp edge directed away from the fairing strip, its upper surface being at such a slight angle to the surface of the wing as to constitute only a slight angular departure therefrom having little or no effect upon the air currents along the wing. The leaf 28 is fastened to the wing by screws engaging internally threaded tubular rivets 34, and passing through a metal fairing strip 35 which reduces the friction of the leaf 31 with respect to the leaf 28. While the screws and the fairing strip supply the primary anchorage for the covering layer 26 to prevent its being torn from the supporting surface by the wind, the leaf 31 acts as a secondary ice dislodging member, assumes a part of the load on the covering layer 26, and insulates the metal fairing strip 35 from exposure to the cold atmosphere where, due to its conductive composition it would reduce the temperature if exposed and thereby induce formation of ice at the fairing strip.

These and other variations may be made without departing from the scope of the invention as it is defined by the following claims.

I claim:

1. Apparatus for dislodging ice comprising a primary ice-dislodging member including an inflatable element and an elastic cover thereover, and a secondary ice-dislodging member comprising an elastic sheet having a margin thereof secured to the elastic cover of the primary ice-dislodging member whereby the elastic sheet is stretched by movement of the elastic cover of the primary member upon inflation of the inflatable element.

2. Apparatus for dislodging ice from a structure comprising a primary distortable ice-dislodging member, a fairing strip for securing a margin thereof to the structure, a secondary ice-dislodging member comprising a sheet of elastic material extending over the fairing strip and united with the primary ice-dislodging member so as to be stretched by the operation of the primary member.

3. Apparatus for dislodging ice from a structure comprising a primary deformable ice-dislodging member, a fairing strip for securing a margin thereof to the structure, a secondary ice-dislodging member comprising a sheet of elastic material having a marginal strip reinforcement adapted to be retained by the fairing strip, said sheet extending across the fairing strip and having its opposite margin secured to said primary member so as to be stretched by deformation of the primary member.

4. The combination with an extensible sheet covering, of an extensible sheet element overlying a margin of said covering and means for intermittently varying the configuration of said covering and element.

5. A combination as defined in claim 4 in which the configuration of said element is varied by movement of the said covering.

6. Apparatus for protecting a surface from accumulation of ice thereon comprising a deformable covering sheet for said surface having one margin slit lengthwise to provide a pair of leaves, the lower leaf being secured to the surface by a fairing strip of rigid material, and the upper leaf extending over and beyond said fairing strip and being secured to and merged into the said surface under tension, means being provided for deforming the unsplit portion of the covering sheet to dislodge ice therefrom and thereby moving the tensioned leaf over the fairing strip.

7. Apparatus for preventing the accumulation of ice, said apparatus comprising a distortable sheet structure adapted to be mounted at a margin thereof, an extensible sheet element overlying the margin of said sheet structure and united with the structure in a manner to present a smooth continuous outer surface, and means for extending said extensible sheet element.

8. Apparatus for preventing the accumulation of ice, said apparatus comprising an extensible sheet structure adapted to be mounted at a margin thereof, means for extending said structure, and an extensible sheet element overlying said margin of the structure and united with the structure in an extensible region thereof in a manner to present a smooth continuous outer surface and to cause extension of said sheet element upon extension of said structure.

9. Apparatus for preventing the accumulation of ice, said apparatus comprising a distortable sheet structure, means for agitating the same, means for mounting said structure at a margin thereof, and extensible material united with said structure and overlying the mounting means and providing a smooth surface thereover.

10. Apparatus for preventing the accumulation of ice, said apparatus comprising a stretchable sheet structure, means for stretching the same, means for mounting the structure at a margin thereof, and extensible material united with said structure and stretchable upon operation of the stretching means and overlying the mounting means, providing a smooth surface thereover.

11. Apparatus for preventing the accumulation of ice, said apparatus comprising a stretchable sheet structure divided at a margin thereof into an underlying portion and an overlying portion, means for mounting the structure by attachment through said underlying portion, and means for securing the overlying portion beyond the said means for mounting the structure in a manner to present said overlying portion as a stretchable

smooth surface of the sheet structure continuing over the mounting means.

12. Distortable surface means for aircraft comprising a distortable element for a surface of the aircraft, a fairing strip at a margin of said element, a distortable element overlying said strip, and means for distorting said elements.

13. Extensible surface means for aircraft comprising an extensible sheet element for a surface of the aircraft, a fairing strip at a margin of said element, an extensible element overlying said strip and inflatable means for extending said elements.

14. Surface means for aircraft comprising a sheet structure adapted to be mounted at a margin thereof upon a surface of the aircraft, an extensible sheet element overlying the margin of said sheet structure and united therewith in a manner to present a smooth continuous outer surface, and means for extending said extensible sheet element.

15. Apparatus for preventing the accumulation of ice, said apparatus comprising a sheet structure divided at a margin thereof into a rearwardly extending underlying portion and a rearwardly extending overlying portion and having an undivided stretchable portion forwardly of said margin, and means for mounting the structure by attachment through said underlying portion, the overlying portion being held rearwardly of the mounting means in a manner to present said overlying portion as a smooth continuous surface of the sheet structure continuing over the mounting means.

16. Apparatus for preventing the accumulation of ice, said apparatus comprising a sheet structure divided at a margin thereof into a rearwardly extending underlying portion and a rearwardly extending overlying portion and having an undivided stretchable portion forwardly of said margin, means for mounting the structure by attachment through said underlying portion, the overlying portion being held rearwardly of the mounting means in a manner to present said overlying portion as a smooth continuous surface of the sheet structure continuing over the mounting means, and a fairing element of rearwardly tapering thickness associated with the rearwardly extending margin of said overlying portion.

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