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DEICING DEVICE FOR AIRFOILS

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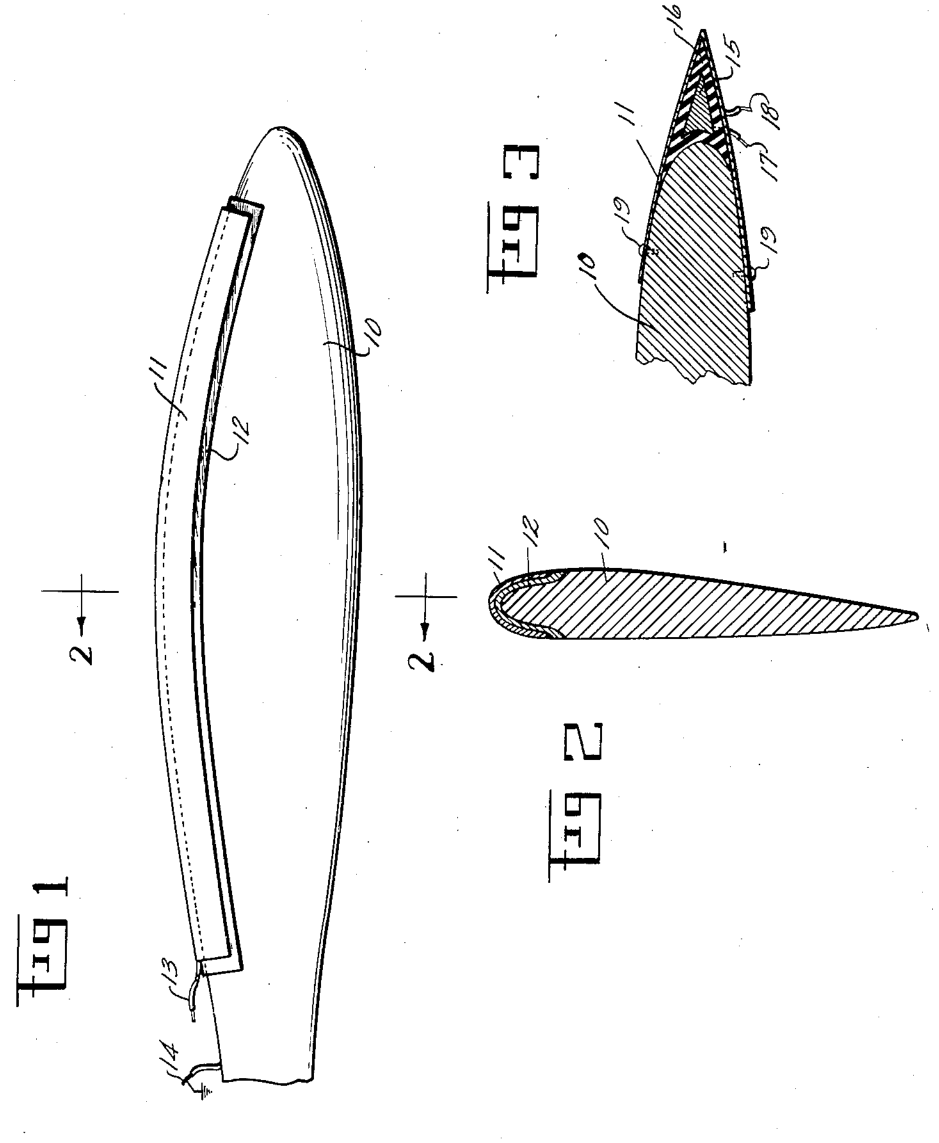

Fig 1 Fig 2 Fig 3

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DEICING DEVICE FOR AIRFOILS

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The invention described herein may be manufactured and used by or for the Government for governmental purposes without payment to me of any royalty thereon.

This invention relates to an electrical device for de-icing airfoils.

In the past, trouble has been encountered when propellers or the leading edges of wings were provided with electrical de-icing equipment. The rapid abrasion which occurs under such conditions of use soon made the de-icers inoperative. Other troubles encountered were due to uneven distribution of heat, which in turn was due to uneven distribution of current through the resistance elements. For example, it was attempted to use conductive rubber strips of considerable length and to supply current to such strips by connecting high voltage leads to the ends of the strips. Poor distribution of electrical conductivity resulted from such construction and the heat distribution was consequently very uneven. The resistance of the conductive rubber did not stay constant when it was exposed to the weather directly. This was due partially to the fact that prior attempts used low resistance conductive rubber which had a high carbon content.

One object of the present invention is to combine abrasion resistant means with de-icing means on an airfoil edge or surface whereby both may exert beneficial effects simultaneously and in combination.

Another object is to so connect the abrasion resistant means and the electrical resistor so that an even distribution of current and a substantially uniform voltage drop takes place over the length of these elements.

Another object is to provide an electrical installation that will function well on a low voltage or high voltage current supply.

Another object is to provide a structure that is suitable for use to provide very sharp leading edges on airfoils and may be applied to existing constructions.

In the drawings:

Fig. 1 is a side elevation of a metal propeller blade or airplane wing showing my de-icing device mounted adjacent the leading edge;

Fig. 2 is an enlarged cross section of the blade or wing taken along the line **2—2** of that figure; and

Fig. 3 is also an enlarged cross section of a blade or wing having thereon my device and showing a modified form thereof. This modification is especially adapted to extremely high speed operation.

While the above forms of the invention will be described as applied to a propeller blade, it is to be noted that an airplane wing or any other airfoil surface exposed to possible icing can be substituted for the blade. Only those adaptations which skilled airplane mechanics can make will

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be necessary to shift the invention from the use on a blade to use on a wing or tail surface.

10 is the body of the blade, which may be made of forged "Duralumin" metal, steel, or other high strength, low-resistance material. **11** is a cover of low electrical resistance abrasion-resistant metal which may be copper, brass, stainless steel, "Monel" or terne-plate with the outer surface preferably chromium plated. The length of the cover **11** is slightly short, on both ends thereof, of the length of high-resistance electrical conductor **12** such as "Nichrome" metal or conductive rubber which covers the leading edge as shown in Fig. 2. The conductor **12** is preferably in the form of a U-shaped shoe, the inner surface of which conforms substantially to the leading edge of the airfoil that is to be de-iced. The length of the conductor **12** is such that it will supply sufficient heat over that part of the propeller upon which ice is prone to form. Its temperature, when heated, should be such that it will at least fully counteract the adhesive action or quality of the ice when the propeller is rotated at high speed. Centrifugal or translational force is depended upon to throw the ice off the blade after the adhesion of the ice has been overcome.

Electrical energy is supplied to the elements **11** and **12** as follows: Current is supplied to each blade **10** through leads **13** and **14**. Any suitable means for supplying such energy may be used, for example, an electrical generator (not shown) which is connected to the leads **13** and **14** through slip rings (not shown) which are well known in the art and are illustrated in Patent No. 2,402,770. Lead **13** is connected to the inner end of strip **13**. Lead **14** is grounded to the propeller blade **10** near or at the shank thereof. The current path is therefore such that a crosswise flow takes place along low-resistance cover **11** and across high-resistance strip or shoe **12** to the blade **10**, to the shank thereof. It will be apparent then that the strip **11** acts as a distributor or a manifold, and that the highly-resistant part of the current path is very short. It will also be apparent that the high-resistance shoe **12** is fully protected from ice-abrasion by the strip **11**. The current-distributing abrasion-resistant cover **11** is slightly shorter than the high resistance shoe **12**, so that dirt lodging on the ends cannot electrically bridge cover **11** to the blade, thus constituting a short circuit.

The strip **11** and the shoe **12** may be attached to each other by conductive adhesives. These are specially prepared rubber-containing cements having a high proportion of carbon particles. The brand name of one such cement is "314" made by Ault and Wiborg Company, Cincinnati, Ohio. The exact composition of these substances is not known, but they are believed to be self vulcanizing rubber cements containing a high proportion of gas carbon. Such a cement is disclosed in Patent No. 2,406,367, column 4, lines 17 to 29 inclusive. Other suitable means of attachment well known in the art may also be used such as synthetic resin screws. The shoe 12 may be attached to the leading edge of the blade 10 as described or the surfaces of the strips may be placed in direct contact and held together by electrically insulated screws or the like.

In Fig. 3, a de-icer in the form of a sharp edge for a wing or propeller is shown adhesively or mechanically attached to the leading edge of a conventional propeller or wing 10. Centrally embedded in the de-icer is a bus-bar 15 which is preferably of triangular section and of light metal, preferably aluminum. It is supplied with current by a lead 17. Surrounding the bus-bar 15 is a triangular-sectioned sheath 16 of conductive rubber. Such rubber has sufficient resistance to generate enough heat, when supplied with an appropriate current, to keep the temperature of a leading edge above freezing, even at high speeds of movement. The composition of such a rubber is given in Patent No. 2,406,567, column 3, line 65 to column 4, line 2. The rubber resistance element 16 is enclosed by a metallic cover 11 of copper, brass, steel, "Monel" or the like. It is included in the electric circuit by means of a lead 18. The conductive circuit therefore traverses the bus-bar 15, the sheath 16, the cover 11 and the airfoil 10. Between the cover 11 and the airfoil 10 there extend a plurality of conductive screws 19 which act both as electrically conducting and mechanical fastening devices.

In operation, the modified de-icer shown in Fig. 3 is also supplied with electricity through slip rings. In this form, the leads 17 and 18 may be recessed into the trailing edge of the airfoil in the case of its use on a propeller and into the leading edge, in the case of the wing. Current should be directed into the de-icer on wings in advance of ice formation rather than after the ice has formed. That is not to say that the de-icer will not rid the airfoil of ice after the latter has formed, but rather that the results are more satisfactory on wings when the de-icer is used as a preventive rather than a cure. In the case of propellers, the opposite is true since after a build-up of ice on the leading edge the, ice layer acts as heat-insulation against the air. Therefore, less heat is needed to melt the inner surface of the ice and permit centrifugal force to get it off than to prevent it from forming.

What I claim is:

1. A de-icer comprising an outer thin sharp-edged cover of abrasion-resistant metal of high electrical conductivity, an inner shoe of high resistance material slightly longer than said cover, said elements being in contact throughout the length of the cover and connections including both of said elements in an electric circuit whereby to pass current between said cover in said shoe substantially throughout the length of the cover to heat the shoe substantially throughout its length.

2. In combination in a de-icer, an extensive shoe of electrically high resistant material, said shoe conforming on its one side to the contour of the leading edge of an airfoil, an abrasion-resistant cover of a metal of low electrical resistance extending over and conforming substantially in shape to said shoe, said cover and said shoe being conductively and adhesively joined together, and means for supplying said cover with electric current whereby to provide a substantially even flow of current and consequent heating current supply to said shoe substantially throughout its length.

3. In combination, an electrically conductive airfoil, a U-shaped shoe of high electrical resistance attached over that portion of the leading edge of said airfoil upon which ice is most prone to form, an abrasion-resistant cover of low electrical resistance attached to the leading edge of the airfoil over said U-shaped shoe and an electrical circuit, one lead of which is attached to said abrasion-resistant strip and another lead of which is grounded to the conductive airfoil whereby to keep said airfoil substantially free of ice when it is rotated at high speed under icing conditions.

4. The combination set forth in claim 3 in which the abrasion-resistant cover is made of electrically conductive metal of low resistance.

5. In combination, a metallic airfoil, an electric circuit one arm of which is grounded thereto, a high-resistance shoe mounted on the leading edge of said airfoil, a current distributing, abrasion-resistant cover mounted over said shoe, and another arm of said electric circuit attached to said cover, said arm being of opposite polarity, whereby passage of current takes place largely along the abrasion resistant cover and across the high resistance shoe to the airfoil, so that the adhesion of ice to the leading edge of said airfoil is substantially prevented when the airfoil is moving at high speed.

6. The combination according to claim 5 in which the current-distributing, abrasion-resistant cover is slightly shorter than the high-resistance cover and is arranged over the latter to leave small margins of the high-resistant cover projecting beyond the current-distributing abrasion-resistant strip.

7. A de-icer capable of being attached to a conventional metal airfoil on the leading edge thereof which comprises in combination, a central bus-bar, a sheath of conductive rubber about said bus-bar, said sheath having a substantially triangular shape, one side of which conforms to the shape of the leading edge of the airfoil to which it is to be attached, an acute angled cover of abrasion-resistant metal of high electrical conductivity coextensive with said bus-bar and said rubber sheath, and means for supplying electric current to said bus-bar and said cover.

8. In combination, an airfoil, a triangular edge of electrically conductive rubber conductively cemented to the leading edge thereof, a triangular bus-bar embedded symmetrically within said conductive rubber edge, a thin wedge-shaped strip of abrasion-resistant electrically conductive metal enclosing said conductive rubber edge and said bus-bar and attached by its ends to said airfoil, and electrical leads each extending to said wedge-shaped metal strip and to said bus-bar.

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