United States Patent [19]

Damron

[11] **3,781,526**

[45] **Dec. 25, 1973**

[54] **HEATING APPARATUS**

[75] Inventor: **John W. Damron**, Dallas, Tex.

[73] Assignee: **Dana International Ltd.**, Dallas, Tex.

[22] Filed: **Oct. 26, 1971**

[21] Appl. No.: **191,989**

[52] **U.S. Cl.**..... **219/538**, 219/213, 219/528, 219/535, 219/549, 219/553

[51] **Int. Cl.**..... **H05b 3/02**

[58] **Field of Search**..... 219/213, 345, 528, 219/535, 536, 538, 546, 548–549, 552, 553

[56] **References Cited**

UNITED STATES PATENTS

3,657,516	4/1972	Fujihara	219/213 X
3,397,302	8/1968	Hosford	219/549 X
2,503,457	4/1950	Speir et al.	219/552 X
3,178,560	4/1965	Mapp et al.	219/549 X
3,156,813	11/1964	Trainor	219/202 X

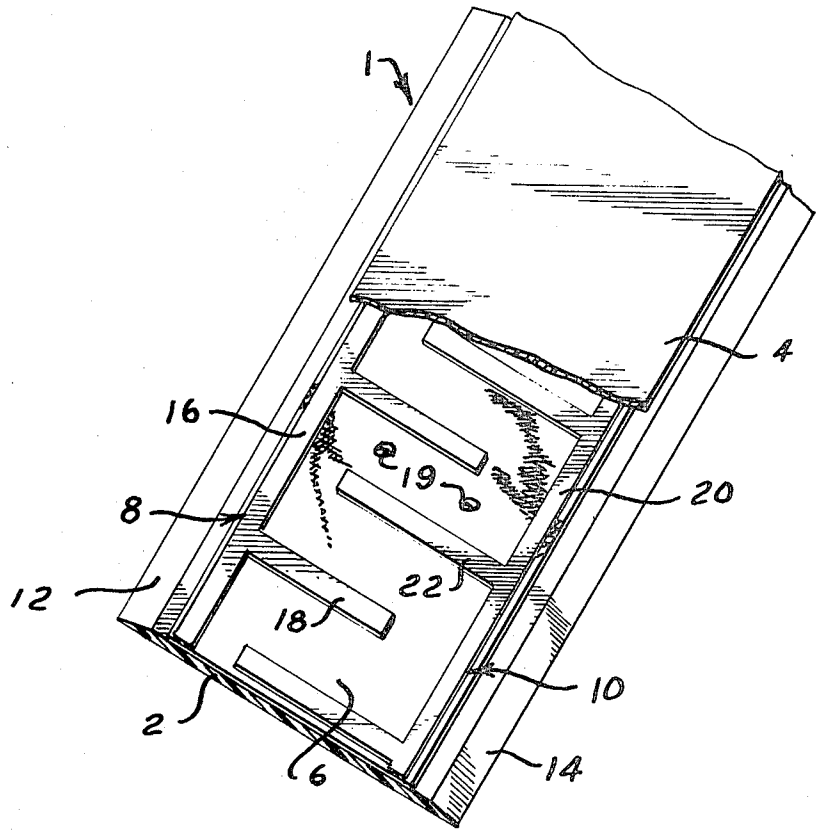
Primary Examiner—C. L. Albritton

Attorney—Howard E. Moore et al.

[57] **ABSTRACT**

Heating apparatus for use as an airplane wing de-icer comprising spaced sheets of impervious electrical insulator material bonded to opposite sides of a sheet of conductive paper having a finite internal resistance. Spaced primary conductors extend along opposite sides of the sheet of paper, each having spaced branch conductors extending transversely therefrom and each branch conductor extending from one primary conductor being positioned between branch conductors extending from another primary conductor.

9 Claims, 5 Drawing Figures



PATENTED DEC 25 1973

3,781,526

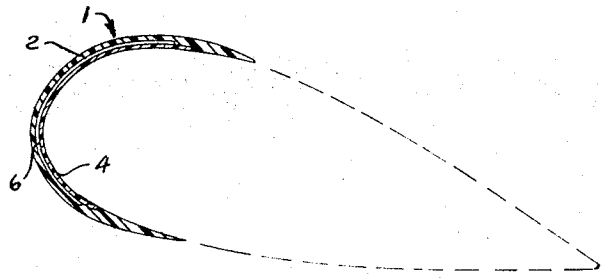


Fig. I

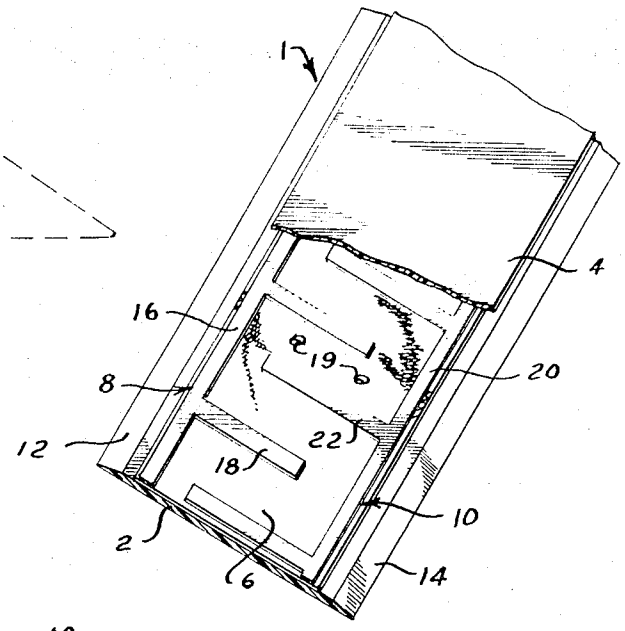


Fig. II

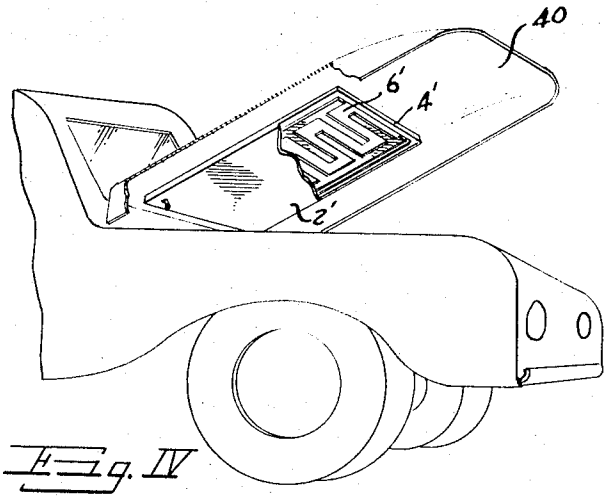


Fig. IV

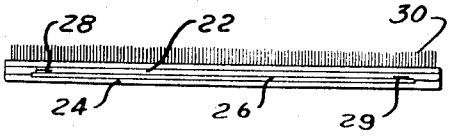


Fig. III

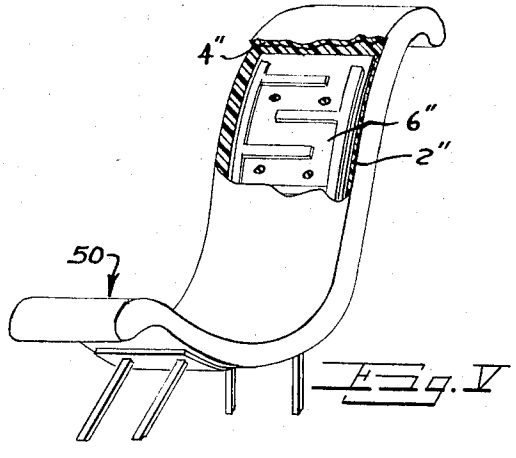


Fig. V

INVENTOR
JOHN W. DAMRON

BY Howard E. Moore
Gerald G Crutsinger
ATTORNEYS

HEATING APPARATUS

BACKGROUND OF INVENTION

Super cooled water droplets striking leading surfaces of airfoils, airplane wings, fins, and stabilizers, change instantly into ice, forming rime ice which is a porous and opaque ice having irregular rough shapes. Icing of leading edges of airfoils increases the weight of the aircraft and changes critical profiles of structural members which adversely affects lift, maneuverability and stability of the airplane.

Various types of de-icing devices for airplane wings have been devised heretofore. The most commonly used de-icer comprises a mechanism consisting of spaced hollow tubes, or boots, overlying leading edges of wing and tail surfaces, which are alternately inflated and deflated for cracking ice formed thereon. Such devices are relatively expensive to install and to maintain. Pneumatic type de-icers are primarily composed of a perishable natural rubber which deteriorates, forming cracks in stretch surfaces of the inflatable tubes. Air is supplied from air pumps driven from engines of the airplane and motor driven distributor valves and pilot control valves are required to control air flow. Congealed oil causes sticking of control and distributor valves requiring removal and cleaning.

Other approaches to prevent formation of ice have involved apparatus to spray antifreeze or to heat wings by various methods. Such methods have been unduly expensive and otherwise impractical for use on small aircraft because of space and weight limitations.

SUMMARY OF INVENTION

I have developed heating apparatus for use as an airplane wing de-icer comprising a sheet of electrically conductive paper having a finite internal resistance. Conductive impurities, for example, 50 to 75 percent carbon, are added to other ingredients during the paper making process to provide a conductive sheet having a finite electrical resistance. Spaced primary conductors extend along opposite edges of the sheet of paper and branch conductors extend transversely across a portion of the sheet. Branch conductors on a first primary conductor are spaced between branch conductors extending from a second primary conductor such that electrical current passes from a branch conductor connected to a first primary conductor, through the paper to a branch conductor connected to a second primary conductor producing heat. The primary conductors are connectable to the electrical system of the aircraft.

The sheet of conductive paper, having conductor elements fastened thereto, is enclosed in an impervious closure, for example, sandwiched between sheets of neoprene, which is secured about a portion of the leading edge of the wing of the aircraft for maintaining same at a temperature sufficient to prevent formation of ice thereon. The heating element covers a substantial portion of the leading edge of the aircraft and is positioned such that a substantial portion of water blown from the heating element will be lifted by the air stream away from trailing surfaces of the wing. The temperature of the heating element is such that the small amount of water engaging trailing edges of the wing will be sufficiently warm to prevent freezing during the time the water engages trailing portions of the wing.

A primary object of the invention is to provide a heating element for use as an airplane wing de-icer

which is particularly adapted for use on small aircraft.

Another object of the invention is to provide a heating element particularly adapted to uniformly increase the temperature of a relatively large area, the heating element being inexpensive to construct and maintain.

Another object of the invention is to provide a heating element for use as an airplane wing de-icing device enclosed in an insulated cover constructed of elastomeric material which is capable of withstanding substantial impact and abrasive forces without materially damaging the heating capability thereof.

A still further object of the invention is to provide a heating element particularly adapted for use as an airplane wing de-icing device comprising conductive paper capable of providing heating though the paper may be torn or openings may be formed therethrough.

A still further object of the invention is to provide a heating element constructed of electrically conductive paper having an impervious insulated coating thereabout positionable over or under surfaces upon which formation of ice creates a hazardous condition, such as airplane wings, sidewalks and bridges, to prevent freezing.

A still further object of the invention is to provide a heating element constructed of electrically conductive paper having openings formed therethrough about which formable plastic is bonded to form an article, such as a stadium seat, which can be maintained and at a substantially constant temperature.

Other and further objects of the invention will become apparent by referring to the detailed description hereinafter following and the drawings annexed hereto.

DESCRIPTION OF DRAWINGS

Drawings of a preferred embodiment of the invention are annexed hereto so that the invention may be better and more fully understood, in which;

FIG. I is a schematic view of the profile of an airplane wing having a heating element attached thereto;

FIG. II is a fragmentary perspective view of the heating element, portions being broken away to more clearly illustrate the details of construction;

FIG. III is a cross-sectional view of the carpet having the heating element attached to the backside thereof;

FIG. IV is a fragmentary perspective view of a vehicle having the heating element mounted inside the hood thereof; and

FIG. V is a fragmentary perspective view of a stadium seat having the heating element laminated therein.

Numeral references are employed to designate like parts throughout the various figures of the drawing.

DESCRIPTION OF A PREFERRED EMBODIMENT

Referring to FIGS. I and II of the drawing, the numeral **1** generally designates a heating element comprising spaced sheets **2** and **4** of elastomer material having a sheet **6** of conductive paper positioned therebetween.

Sheets **2** and **4** of insulator material are preferably impervious to prevent passage of moisture therethrough in sufficient quantities to cause conduction of electricity therethrough and to prevent accumulation of moisture between sheets **2** and **4** which might cause arcing between conductor elements **8** and **10** secured to a surface of conductive paper **6**.

Sheets **2** and **4** are preferably constructed of neoprene, for example, material of the type commercially

available from B. F. Goodrich Company, Akron, Ohio, distributed under the trademark "CR-70 Neoprene Sheet" which is resistant to oil, heat, abrasion and ozone. Such material has a tensile strength of approximately 1,200 pounds per square inch at an average elongation of 350 percent. Such sheet material, having a thickness of 1/32 of an inch, weighs approximately 2.3 pounds per square yard.

Outer sheet **2**, constructed of the above indicated neoprene material, is preferably approximately one thirty-second inch in thickness and has tapered edges **12** and **14** providing a smooth transition of the outer surface of sheet **2** toward the outer surface of the wing of an airplane.

Inner sheet **4**, constructed of the above indicated neoprene material, is preferably approximately one-sixteenth inch in thickness for insulating conductors **8** and **10** from the surface of the wing of the aircraft.

The sheet **6** of conductive paper comprises binder material having conductive elements mixed therein to provide a sheet having conductive properties while exhibiting a finite electrical resistance. The resistance of the paper is preferably approximately 400 ohms per square foot, though the resistance may be varied depending upon the conductive elements incorporated in the paper during the manufacture thereof. Resistance should preferably be maintained in a range between 100 and 1,500 ohms per square foot.

The following table lists a mixture of conductive elements present in a suitable embodiment of the paper.

CONDUCTIVE ELEMENT	
Boron	.0001
Manganese	.0003
Lead	.0002
Chrome	.0021
Magnesium	.0232
Silicone	.0192
Galium	.0001
Iron	.0143
Aluminum	.2000
Copper	.0003
Silver	.0001
Titanium	.0003
Sodium	.0428
Zerconium	.0001
Carbon	.6500

The traces of the elements shown in the above table are generally found in commercial grades of carbon and the quantities of the trace elements vary by approximately 10 percent.

The paper is preferably approximately one thirty-second inch thick and is formed by mixing approximately 80 percent commercial grade carbon, referred to as "conductive element" in the table, with approximately 201 paper fiber during the manufacture of the paper, providing conductive paper having a resistance of approximately 300–400 OHMS per square. Such paper can be readily heated to 120°–130°F.

The paper fibers serve as a binder for the conductive carbon. The thickness of the sheet and the percentage of conductive element in the paper will control resistance.

It should be appreciated that the components of the conductive material set forth in the above table may be varied to increase or decrease the resistance of the sheet **6**.

Referring to FIG. II of the drawing, conductor elements **8** and **10** are preferably flat flexible ribbons of conductive material extending longitudinally of sheet **6** and are disposed adjacent edges thereof. The ribbons preferably have a substantial width for example, one-fourth inch, to provide sufficient area of contact between each ribbon and the paper to prevent excessive heating which could burn the paper.

Primary conductor **16** has spaced branch conductors **18** extending laterally therefrom across a portion of the width of sheet **6**. Conductor element **10** is similarly constructed comprising a primary conductor **20** having branch conductors **22** extending laterally therefrom. Branch conductors **22** are positioned between branch conductors **18** which extend laterally from primary conductor **16**. It should be appreciated that electrical current passes from branch conductors **18** through paper **6**a to branch conductor **22**. Resistance of the paper **6** is such that heating results when current is passed therethrough.

Conductor elements **8** and **10** may be constructed of strips of metallic conductive material joined in the configuration illustrated in the drawing and bonded to paper **6** with a suitable electrically conductive bonding material. An alternate method of forming conductive elements **8** and **10** comprises spreading conductive epoxy paste-like material, of the type employed for forming printed circuit boards, which when heated is converted to a silver based conductive material.

In fabricating the heating apparatus, hereinbefore described, it is desirable that the quantity of air trapped between the sheets **2** and **4** be minimized to reduce defective bonding, to prevent expansion and contraction of entrapped gas, and to minimize formation of ozone. Therefore, a preferred manufacturing process comprises forming sheets **2**, **4** and **6** of desired dimension and attaching conductors **8** and **10** to the sheet **6** of conductive paper. A suitable bonding agent is neoprene putty, for example, that commercially available from Minnesota Mining and Manufacturing Company of St. Paul, Minn., distributed under the trademark, "1300 L Adhesive". The bonding agent is applied to surfaces of sheets **2**, **4** and **6** and the sheets are joined in a vacuum chamber such that when removed from the vacuum chamber atmospheric pressure urges sheets **2** and **4** together and the bonding agent is drawn into surface pores thereof.

If it is deemed expedient to do so, apertures **19** may be formed in sheet **6** permitting bonding of surfaces of sheets **2** and **4** through intermediate portions of sheet **6**.

From the foregoing it should be readily apparent that the heating element illustrated in FIG. II, when attached to the wing of an aircraft as illustrated in FIG. I, provides uniform heating of the leading edge of the wing of the airplane.

A modified form of the heating apparatus, illustrated in FIG. III, comprises a sheet **26** of conductive paper of the type designated by numeral **6** in FIG. II of the drawing. Sheet **26** of conductive paper is sandwiched between sheets **22** and **24** of impervious material such as neoprene bonded together. Conductor elements **28** and **29** having branch conductors connected thereto as illustrated in FIG. II are employed for delivering electrical current to spaced portions of sheet **26** of conductive material to provide heating as hereinbefore described.

A sheet of conventional floor covering, such as carpet material **30**, is bonded to sheet **22** to provide a surface having good traction particularly adapting the embodiment of the heating element illustrated in FIG. III

for use as a heated carpet for use on sidewalks and other paths where ice and snow tend to accumulate creating a hazardous condition.

The third form of the invention is illustrated in FIG. IV connected inside the hood **40** of a vehicle. The heating element is similar to that illustrated in FIG. II comprising a sheet **6'** of conductive material electrically insulated between sheets **2'** and **4'** of electrical insulating material.

A fourth form of the invention is illustrated in FIG. V wherein a sheet **6''** of electrically conductive material of the type hereinbefore described is laminated between sheets **2''** and **4''** of plastic material to provide heating for a stadium seat **50**, for example, of the type installed in football stadiums and the like. Conductive elements are arranged as illustrated in FIG. II for delivering electrical current to spaced portions of sheet **6''**.

From the foregoing it should be readily apprent that the heating element which I have developed has several uses in addition to those illustrated in the drawing. For example, it is contemplated that the heating device, employing a sheet of electrically conductive paper **6**, be employed to prevent freezing of ice onto surfaces of bridges by installing a sheet **6** of conductive paper over a road surface and covering same with a layer of bituminous material.

It should be appreciated that other and further embodiments of the invention may be devised without departing from basic concept of the invention hereinbefore described.

Having described my invention I claim:

1. Heating apparatus comprising, a sheet of electrically conductive paper having a finite electrical resistance, said sheet of paper having apertures extending therethrough; spaced conductor elements extending along opposite edges of said sheet of paper; first and second sheets of impervious electrical insulator material positioned on opposite sides of the sheet of paper and having edges extending beyond edges of the sheet of paper; and bonding material securing surfaces of each of the sheets of insulator material to surfaces of the sheet of paper and securing surfaces of the sheets of insulator material together adjacent edges thereof to form an impervious electrically insulated covering around the paper, the spaced conductor elements being connectable to a source of electricity to pass electrical current through said paper to heat said impervious sheets, wherein the bond between the sheets of impervious material extends through said apertures.

2. The combination called for in claim **1** wherein the spaced conductor elements comprise substantially flat elongated ribbons of conductive material, each of said ribbons having a width of at least one-fourth inch in engagement with the surface of the said sheet of paper.

3. The combination called for in claim **1** wherein each of the conductor elements comprises an elongated primary conductor extending along opposite edges of the sheet of paper and with the addition of spaced branch conductors extending laterally from each primary conductor, said branch conductors extending from one primary conductor being positioned between branch conductors extending from the other primary conductor to induce an electrical potential across the paper extending therebetween.

4. The combination called for in claim **1** wherein the impervious sheets are constructed of flexible elastomeric material.

5. The combination called for in claim **1** wherein the sheets of impervious material comprise sheets of neoprene.

6. The combination called for in claim **1** wherein the sheets of impervious material comprise molded polyester material.

7. The combination called for in claim **1** wherein the sheets of impervious material comprise bituminous material, at least one of said sheets being arranged to form a road surface.

8. The combination called for in claim **1** with the addition of tapered surfaces adjacent edges of at least one of said sheets and means to secure said sheet of impervious material to a leading edge of a wing of an airplane.

9. Heating apparatus comprising, a sheet of electrically conductive paper having a finite electrical resistance; spaced conductor elements of electrically conductive epoxy extending along opposite edges of said sheet of paper; first and second sheets of impervious electrical insulator material positioned on opposite sides of the sheet of paper and having edges extending beyond edges of the sheet of paper; and bonding material securing surfaces of each of the sheets of insulator material to surfaces of the sheet of paper and securing surfaces of the sheets of insulator material together adjacent edges thereof to form an impervious electrically insulated covering around the paper, the spaced conductor elements being connectable to a source of electricity to pass electrical current through said paper to heat said impervious sheets.

* * * * *