

April 23, 1935.

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1,998,809

MEANS AND METHOD FOR CONTROLLING THE ACCUMULATION OF ICE
UPON SURFACES EXPOSED TO ICE FORMING CONDITIONS

Filed July 7, 1930

3 Sheets-Sheet 1

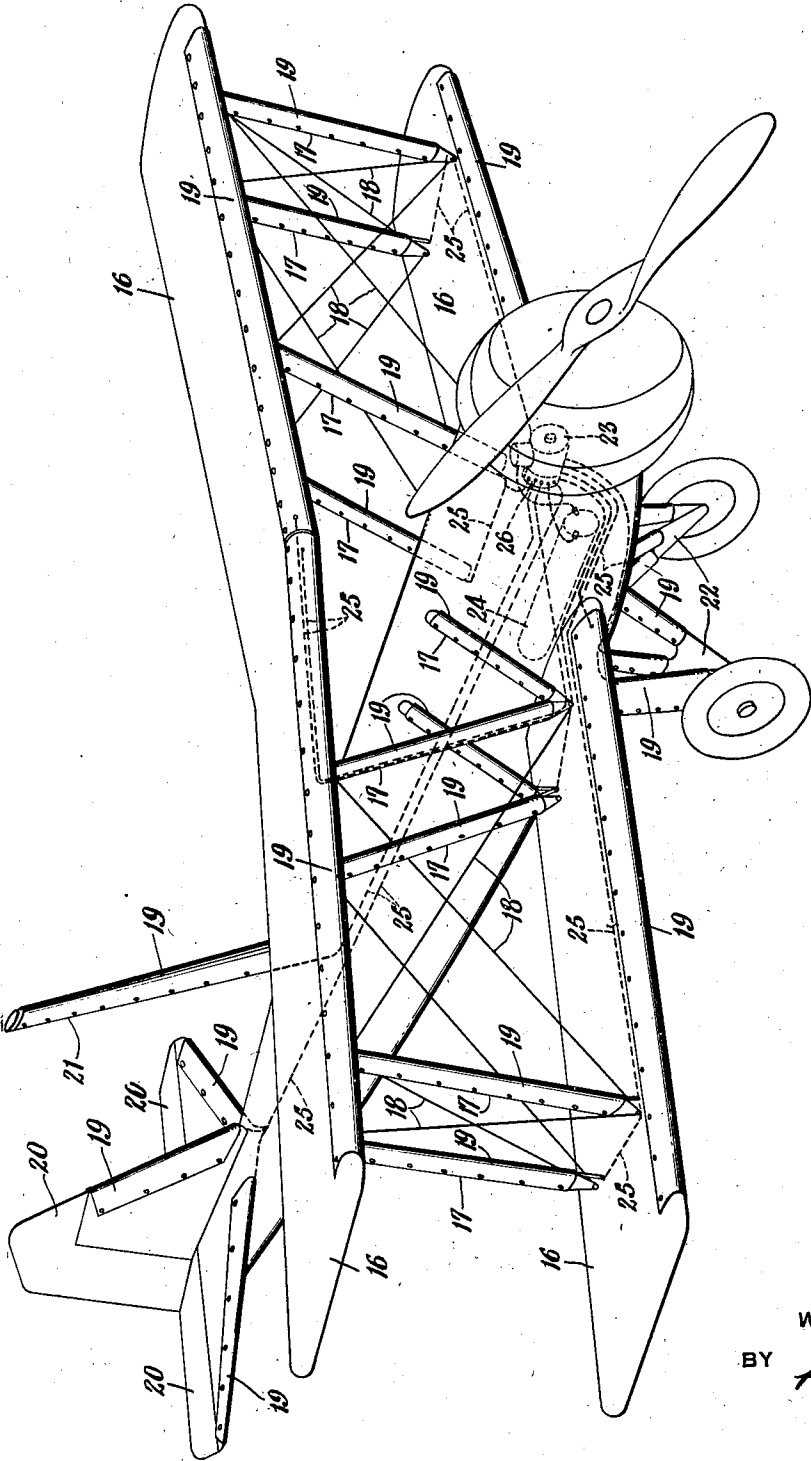


Fig. 1.

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3 Sheets-Sheet 2

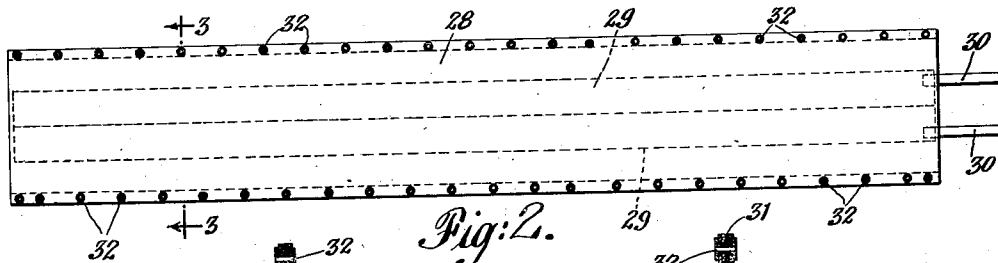


Fig. 2.

Fig. 3.

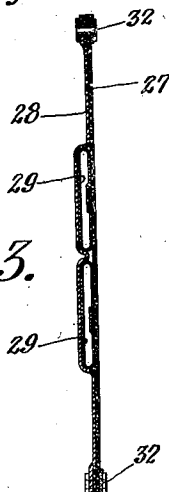


Fig. 4.

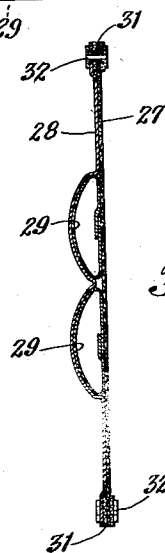


Fig. 5.

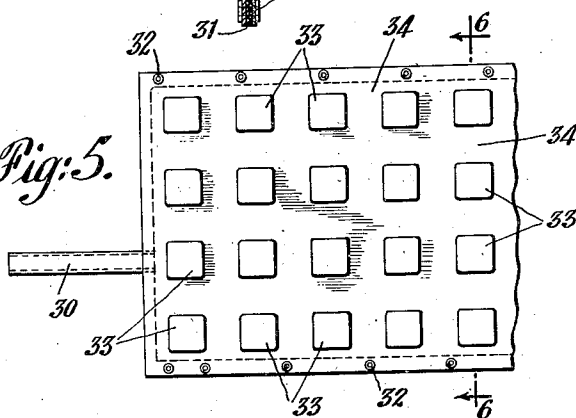


Fig. 6.

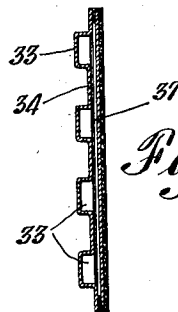


Fig. 7.

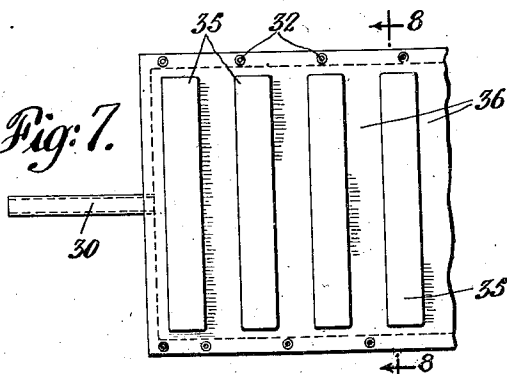
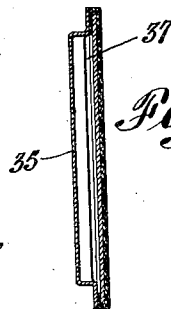


Fig. 8.



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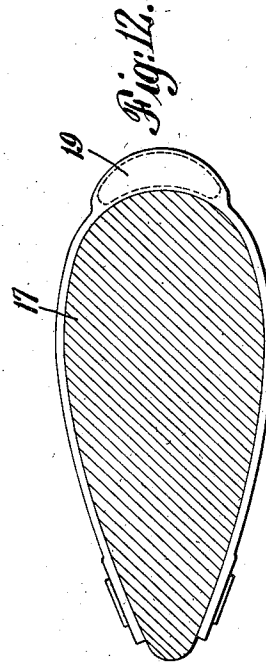
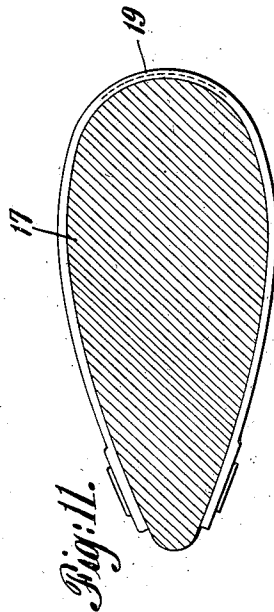
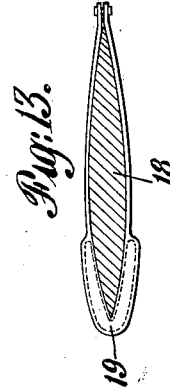
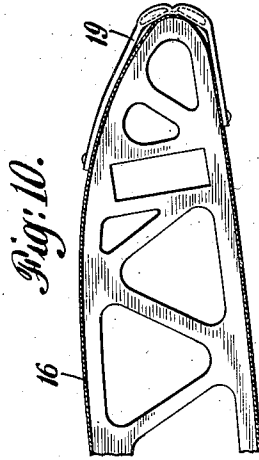
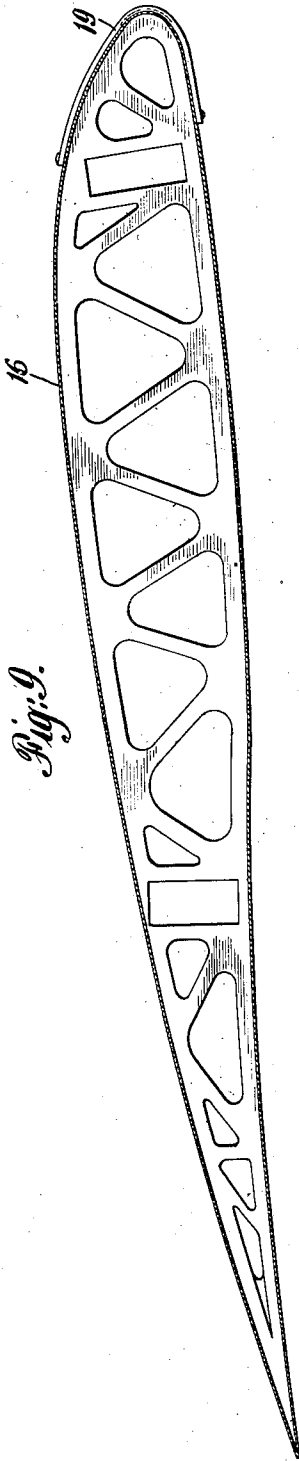
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MEANS AND METHOD FOR CONTROLLING THE ACCUMULATION OF ICE
UPON SURFACES EXPOSED TO ICE FORMING CONDITIONS

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3 Sheets-Sheet 3



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1,998,809

MEANS AND METHOD FOR CONTROLLING
THE ACCUMULATION OF ICE UPON SUR-
FACES EXPOSED TO ICE FORMING CON-
DITIONS

William C. Geer, Ithaca, N. Y.

Application July 7, 1930, Serial No. 465,970

28 Claims. (Cl. 244—31)

This invention relates to the removal of ice from surfaces exposed to ice forming conditions and more particularly to the prevention of excessive deposits of ice upon the exposed surfaces of aircrafts.

In using airplanes in cold, foggy weather, considerable difficulty and danger have been encountered because of the formation of ice upon the wings, struts, wires and other exposed portions of the airplanes. This ice is formed from the freezing of rain, sleet or by precipitation from a saturated atmosphere. As the aircraft rushes through the ice laden atmosphere it cleaves only a portion of it, that is, the portion included within the maximum thickness or camber of the wings, struts, wires, etc. Since the ice is removed from that section of the atmosphere included within the maximum thickness of the surfaces by the leading portions thereof, the rearward portions of the wing or strut are protected by these forward portions with the result that no ice is deposited thereon. The ice deposited upon the leading edges, being formed from small droplets or from vapor, comes at once in intimate contact with all the irregularities of the surface upon which it locates. It is then held there by the action of three forces: the atmospheric pressure or suction, the wind forces, and the adhesive tension between the ice and the material of which the surface is composed.

Upon passing through an ice depositing atmosphere, therefore, the ice is soon built up upon the leading edges of the lifting and controlling sections to such an extent that the shapes of these surfaces will be so changed that they will no longer produce the differential pressures required to sustain the weight of the airplane. This change in surface shape, together with the added weight of the ice, will cause the airplane to quickly lose altitude with the result that it may be suddenly forced to land in rough, dangerous territory. Furthermore, the building up of ice upon the wires of the airplanes will change their period of vibration and cause them to break.

A more complete discussion of this problem may be found in the Technical Notes of the National Advisory Committee for Aeronautics No. 293 entitled "The formation of ice upon exposed parts of an airplane in flight."

It is impracticable to prevent the formation of ice upon these surfaces and the present invention has to do with lessening the adhesion of the ice to the surface and accomplishing its removal before it has become thick enough to become a hazard to the pilot.

Many attempts have been made to avoid this difficulty, among them it has been proposed to apply an oil directly to the exposed surface of the airplane. Such efforts have not been successful, however, due to the fact that the oil is quickly scrubbed from the surface by the force of the wind and also that the oils used have had too high a freezing point and have been sticky at the ice forming temperatures with the result that instead of lessening the adhesion of the ice, the application of such oils will assist in the formation and building up of an ice coating.

An object of the present invention is to provide an improved method and means for removing the ice deposits which may be built up upon the exposed portions of articles subjected to ice forming conditions.

It is a further object of the invention to provide a covering or overshoe which may be applied to the exposed portions and to which a material may be applied which will render the surface non-adhesive to ice. Another object is to avoid the danger of ice formations upon exposed surfaces, without adding an excessive weight to the airplane or other device which is being protected.

A further object of the invention is to provide a method and means for loosening any ice which may be deposited upon the surface and to do so without materially disturbing the equilibrium of the plane.

Other objects and benefits will become apparent from studying the following description and drawings and from the use of the means and methods defined in the claims.

The invention contemplates the application of a covering or overshoe to the portions of the exposed metal or other surfaces where the ice is most likely to form, and the application of a suitable non-adhesive liquid to the overshoe, which liquid will substantially reduce the adhesion between the ice and the surface of the overshoe, or, in other words, will lubricate the surface upon which the ice is most likely to form. The invention further contemplates the provision of means for disturbing any ice which may be deposited upon the surface of the overshoe by suddenly changing the shape of the surface upon which the ice is deposited.

Although it will be apparent that the invention may be applied to many different uses, it will be illustrated by its application to airplane surfaces. It is not intended, however, to thereby limit it to the particular embodiments described.

Where the word rubber is used in the descrip-

tion and claims it is intended to indicate a correctly vulcanized rubber mixture of any desired composition.

In applying the invention, an overshoe, preferably having its exposed surface of rubber, is applied to the portions of the wing, wire, strut, etc. surfaces to which the ice has the greatest tendency to adhere. This will ordinarily include the leading edge back as far as the maximum camber or maximum thickness of such part. The rubber surface is then soaked with an oil mixture which is miscible with it and which will be retained by it and will reduce the adhesion of the ice to the surface to a low value. As the oil mixture may gradually be removed from the surface by the action of wind and rain, and with the ice which is removed, more oil will come to the surface. From time to time, between flights, fresh oil may be applied to the rubber. In place of the vulcanized rubber, some other vehicle for the oil might be applied, which vehicle should have a surface substantially devoid of irregularities into which water could penetrate and, upon freezing, anchor itself. Such material may of itself have a surface to which ice will not readily adhere and will therefore reduce or avoid the necessity of applying a non-adhesive material. Celluloid is an example of such a material. In some embodiments of the invention it is also important that this surface should be of extensible elastic material.

The liquid to be applied to the overshoe should be one which is fluid at the ice forming temperatures and which has a freezing point below the ice forming temperatures. It should be of low viscosity at these temperatures and should not be sticky and hence adhesive toward ice. Furthermore, it should be a material which will be absorbed into the rubber but which will not swell or weaken the rubber to such an extent that it would have insufficient tensile strength for the use to which it is applied. It is not intended, however, to limit the liquid to a non-swelling oil in rubber, for such swelling merely shortens the life of the rubber and it is well known that rubber may be swollen and weakened by oil but will regain its strength after removal of the oil. The amount of oil absorbed into the rubber need not be up to the saturation point as the reduction in adhesion is greater than in direct ratio to the volume of oil absorbed. It is also important that the liquid be of relatively high boiling point in order that it will not evaporate from the surface at the higher temperatures to which it may be subjected.

It is not intended to limit the invention to the application of oil to the rubber after the latter is manufactured and vulcanized since good results have also been obtained with oils mixed into the composition before vulcanization, more oil being subsequently added to make up for any loss.

The following materials, or mixtures of them, have been found to be satisfactory for use in this connection.

	Freezing point	Boiling point
Tetrahydronaphthalene.....	-25° C.	+206° C.
Dekahydronaphthalene.....	-125° C.	+193.3° C.
Pine oil.....	-25° C.	+150-185° C.
Ethyl benzoate.....	-34.6° C.	+213.2° C.
p-Cymene.....	-73.5° C.	+176.5° C.
Castor oil.....	-12° C.	Above 300° C.
Lubricating oil from petroleum selected for low freezing point.	-15° C.	Above 250° C.

liquids and I have found the following mixture very satisfactory for this purpose:

Pine oil.....	4 parts
Diethyl phthalate.....	4 parts
Castor oil.....	1 part

No claim is made however in this application to the specific liquid to be employed to the rubber since this is the subject matter of a copending application. Serial No. 466,049 filed July 7, 1930 by William C. Geer.

In selecting the rubber for the exposed surface of the overshoe, a pure gum mixture which is compounded and cured normally to give a high cutting resistance, is preferred. Such a mixture may be produced as follows:

Smoked sheets.....	100 parts
Zinc oxide.....	10 parts
Sulphur.....	3 parts
Accelerator.....	1 part

The above compound is merely illustrative, the main requirement being that the mixture contains little or no oil soluble sticky material which could diffuse to the surface and render the surface sticky and adhesive toward ice.

Even though the adhesion between the ice and surfaces of the overshoes on the leading edges has been reduced to a low value the ice formed upon them is so perfectly shaped to the surfaces, with each microscopic portion in perfect contact with the surface, that it will be held firmly in position by the atmospheric pressure or suction between the ice and the surfaces and by the very substantial pressure resulting from the air forces created when the plane is in flight. Furthermore, these surfaces are usually curved so that the ice would not be easily dislodged even though no additional pressure were active.

I have found, however, that by providing means for slightly and suddenly moving the layer of ice deposited upon a surface of reduced adhesion, the ice will quickly be released from the surface upon which it is deposited. In order to accomplish this an air tube may be positioned beneath the rubber surface, which air tube will normally be deflated but which may suddenly be inflated by applying an air pressure to the tube connected to it. A low pressure, for example, about 10 to 20 pounds per square inch, will expand the tube against the pressure upon it and will serve to move the ice sufficiently to loosen it from the surface. The ice will then be blown away by the air forces. The expanding tubes may be of many different shapes depending upon the surface to which they are to be applied and the manner in which it is preferred to remove the ice formation, and one tube or a plurality of tubes may be used for this purpose. In producing the tubes it is preferred to use a rubberized fabricated material rather than pure rubber because of its greater regularity of expansion as compared to pure rubber. Such a material as a thin elastic stockinette or a bias-cut fine thread fabric may be rubberized and used in making these tubes, or a rubber tube may be enclosed within and strengthened by such a uniformly expanding fabric.

For the purpose of describing the invention I have illustrated certain embodiments of it in the drawings but it is not intended to restrict the invention to the particular embodiments shown.

In the drawings Figure 1 is a diagrammatic sketch illustrating an airplane with the overshoes attached. Figure 2 is a plan view of an

It is preferred however to use a mixture of

overshoe spread out in a flattened position. Figures 3 and 4 are enlarged sections taken on the lines 3—3 of Figure 2 with the air tubes deflated and inflated, respectively. Figure 5 is a fractional plan view of a modified form of overshoe and Figure 6 is a section taken upon lines 6—6 of Figure 5 with the air tube inflated. Figure 7 is a fractional plan view of another modified form of overshoe and Figure 8 is a section taken on line 8—8 of Figure 7 with the air tube inflated. Figure 9 is a vertical section of a wing with an overshoe applied to its leading edge. Figure 10 is a fractional vertical section of the leading portion of the wing structure shown in Figure 9 with the air tube in the overshoe inflated. Figure 11 is a sectional view through a strut with the overshoe applied thereto. Figure 12 is a view similar to Figure 11 with the air tube expanded. Figure 13 is a sectional view through an elongated wire with an overshoe attached to it, the air tube being inflated.

In the several figures the numerals 16, 16 indicate the wing of an airplane which are supported by struts 17, 17 and wires 18, 18. In Figure 1 the overshoes 19, 19 have been shown as applied to the leading surfaces of wings 16, 16, the struts 17, 17, the elevators 20, 20, the radio mast 21 and the landing gear 22. A compressor 23 may be used to supply compressed air to the air tank 24 and the air in the tank 24 may be distributed to the air tubes in the various overshoes through the copper tubing 25, 25, each tube being connected to a separate outlet from the rotary air valve 26.

Referring now to the detail drawings of the overshoe, the numeral 27 denotes a base fabric which serves as a support for the rubber surface 28 and the expansion tubes. The base fabric 27 may be impregnated with a material adapted to check the penetration of oil in order to prevent the oil from coming into contact with and softening the nitrodope upon the wing structures. A coating of glue may be used for this purpose. The base fabric may be of extensible material, inextensible material or it may be a material cut on the bias to give slight extensibility. The movement of the rubber surface 28 in the embodiment of the invention illustrated in Figures 2, 3 and 4 is brought about by means of the two elongated tubes 29, 29 having their ends sealed and having inlet tubes 30, 30 connected to the interior portion of one end of each tube. Each air tube may be pre-formed by rolling it upon a mandrel and cementing the overlapped edges in the position shown in the drawings, or it may be formed by cementing the edges of a flattened strip of rubberized material to a piece of rubberized material so that an air space is formed between the two pieces. If the air tubes 29, 29 are pre-formed they may be cemented to the base fabric 27. The rubber surface 28 is cemented to the outer surfaces of the tubes 29, 29 and beyond them, to the base fabric 27. The outer edges of the overshoe may be reinforced by the stiff fabric strip 31 cemented to and extending around the edges of the base fabric 27 and between the edges of the base fabric 27 and the rubber surface 28. Lacing eyes or grommets 32, passing through the rubber surface, reinforcing strip and base fabric, or other means of attachment, may be positioned at spaced points along the edges of the overshoe.

When the overshoe is applied to a wing section it is placed along the leading edge of the wing section and may be held in place by suitable connecting devices extending through the eyes 32,

for example, by pins fixed to the wing or by lacings extending around the trailing edge of the wing surface or connected to it at some other suitable fastening point, preferably behind the point of maximum camber.

Instead of using two air tubes as described above, one wide tube may extend over the entire width of the leading edge. This tube may be positioned at the middle of this width or it may be offset from such middle position.

When the overshoe is used upon a smaller surface such as a strut or wire it may extend entirely about the strut or wire and be fastened to or behind the trailing edge in some suitable manner, as illustrated in Figures 11, 12 and 13. It may be desirable in such cases to reduce the weight of the overshoe by using lighter materials and lighter construction. On the other hand, if the overshoe is to be positioned where it is exposed to ice which may be thrown from the revolving propeller it may be advisable to reinforce it to prevent the puncturing of the air tube by flying ice. This reinforcement may be accomplished by applying a layer of resistant material, for example, such as is used in preparing the tread of a tire, to the surface covering the air tube. It may also be advisable to reinforce the air tube by covering it with a layer of extensible fabric.

The details of construction described above may be altered materially in order to provide an overshoe of suitable shape and constructed for application to the particular surface upon which it is to be used. For example, by altering the shape and size of the overshoe it may be applied to wires of circular cross section. In all cases where stream line configuration is essential, suitable configuration should be given to the overshoe to avoid spoiling the stream line effect.

A rubber surface may also be applied to the propeller in order to retain a lubricant upon the surface of the leading edges of the propeller and to prevent excessive ice formation on these edges. In such a use the air tubes may be omitted because the revolution of the propeller will create sufficient centrifugal force to dislodge any ice which might form upon the non-adhesive surface. In this embodiment of the invention the fabric layer may be cemented to the metal or wooden surface of the propeller by a suitable cement. When used in this connection, it is advisable to insert a layer of oil resisting material, such as glue, upon the layer of fabric in order to prevent the oil from soaking into the propeller. Another layer of fabric material may be cemented to the oil resisting layer and the rubber surface may be fixed to this layer of fabric. A similar application may be made to other surfaces, such as the shutters of the radiator, from which the ice may be shaken by opening and closing the shutters.

Instead of using the longitudinal air tubes under the rubber surface for suddenly changing the shape of the surface, this may be accomplished by having intermittent portions of the surface of relatively extensible material. In Figures 5 and 6 a cellular type of overshoe is illustrated in which the squares 33 are of extensible material and the surrounding portions 34 are of relatively non-extensible material. In Figures 7 and 8 the extensible portions are in the form of elongated strips 35 separated by the less extensible strips 36. In each of these modifications the

cells may be connected to a common air space 37 which communicates with an air tube 30.

The size and shape of the inflatable tubes should be carefully chosen in order to avoid unnecessary loss of lifting force when the tubes are expanded. In the deflated position the tube may follow the normal shape of the surface to which it is attached, but it is apparent that when the tube is expanded its shape will be materially altered, thus changing the effective shape of the wing or other surface to which it is attached. In order to prevent bumping or loss of lifting power when the tubes are expanded, it is preferable to have them divided longitudinally into sections, for example, about 10 feet long, and to have separate tubes leading to the several sections in order that they may be expanded separately and in the desired order. As described above the several tubes may be connected to a rotary valve in the pipe leading from the air supply tank, which valve may be continuously or intermittently operated by a clockwork or other suitable means. As the rotary valve is rotated, the several tube sections will be alternately connected with inlet and outlet pipes in order that the tube sections may be expanded and deflated in the desired order. If any air tube should become punctured it may be cut off by a valve in the cockpit. The several air tubes may, of course, each be inflated from one end or from both ends or at numerous points.

The overshoes described to illustrate an application of my invention provide means for protecting the surfaces against ice formations, which means may be readily attached to and detached from the surfaces and which add only a relatively small amount of weight to the plane.

It is apparent that my invention may be applied to many other types of moving or still surfaces which are exposed to ice forming conditions and it is not intended to restrict it to the particular embodiments described.

What I claim is:

1. A method for reducing the accumulation of ice upon a surface exposed to ice forming conditions, comprising applying to such surface a covering having an exposed surface impregnated with a nonadhesive material.

2. A method for reducing the accumulation of ice upon a surface exposed to ice forming conditions, comprising applying to such surface a covering having a colloidal surface impregnated with a material adapted to reduce the adhesion of ice to the colloidal surface.

3. A method for reducing the accumulation of ice upon a surface exposed to ice forming conditions, comprising applying to the surface a covering having a rubber surface impregnated with a liquid adapted to reduce the adhesion of ice to the rubber surface.

4. A method of removing ice from a surface exposed to ice forming conditions, comprising applying a covering having a surface impregnated with a liquid adapted to reduce the adhesion of ice to the surface, and altering the configuration of the impregnated surface.

5. A method of removing ice from a surface exposed to ice forming conditions, comprising applying a covering having a surface impregnated with a liquid adapted to reduce the adhesion of ice to the surface and intermittently altering the configuration of the impregnated surface.

6. A method of removing ice from a surface exposed to ice forming conditions, comprising applying a covering having a resilient surface and

intermittently stretching and relaxing said surface.

7. A method for reducing the accumulation of ice upon a surface exposed to ice forming conditions, comprising applying a cover having a rubber surface impregnated with a liquid adapted to reduce the adhesion of ice to the surface without substantially deteriorating the rubber.

8. A method for reducing the accumulation of ice upon a moving surface, comprising applying to such surface a covering having its outer surface impregnated with a liquid which will reduce the adhesion of ice to the surface.

9. A method of removing ice from a moving surface, comprising applying to such surface a covering having its outer surface impregnated with a liquid which will reduce the adhesion of ice to the surface and altering the configuration of said impregnated surface.

10. A method of removing ice from the exposed portions of an aircraft, comprising applying to leading surfaces of the aircraft a covering having a surface impregnated with a material adapted to reduce the adhesion of ice to said covering surface and varying the configuration of said covering surface.

11. A method of removing ice from the leading surfaces of an aircraft, comprising applying to said surfaces an extensible covering material impregnated with a material adapted to reduce the adhesion of ice to the covering material and intermittently varying the configuration of separate sections of said covering material.

12. A covering for surfaces exposed to ice forming conditions, comprising a colloidal surface impregnated with a material adapted to reduce the adhesion of ice to the colloidal surface.

13. A covering comprising a rubber surface impregnated with a liquid adapted to reduce the adhesion of ice to the rubber surface without substantially deteriorating the rubber.

14. A covering comprising a colloidal surface impregnated with a liquid adapted to reduce the adhesion of ice to the colloidal surface and having means for varying the configuration of the surface.

15. A detachable covering for leading edges of an aircraft, comprising an air tube of rubberized extensible fabric covered by a colloidal surface.

16. A covering adapted to be applied to a leading edge of an aircraft, comprising an air tube of material which is uniformly extensible throughout its length, said tube being covered with a colloidal surface.

17. A covering adapted to be applied to a leading edge of an aircraft, comprising an inflatable tube strengthened by an extensible fabric, said tube being covered by a colloidal surface capable of absorbing a non-adhesive liquid.

18. The combination with a covering comprising an extensible surface, of means for intermittently varying the configuration of the surface.

19. The combination with a covering comprising an extensible surface and an inflatable tube positioned to vary the configuration of said surface upon inflation, of means for inflating said tube.

20. The combination with a covering comprising an extensible surface and an inflatable tube positioned beneath said extensible surface, of means for intermittently inflating said tube.

21. The combination with a covering comprising an extensible surface and a plurality of inflatable tubes positioned to vary the configura-

tion of said surface, of means for inflating said tubes.

22. The combination with a surface of an aircraft of a covering extending along a leading edge of said surface, said covering having a surface impregnated with a material adapted to reduce the adhesion of ice to the surface, and means for varying the configuration of said covering surface.

23. The combination with a surface of an aircraft of a covering extending along the leading edge of said surface, said covering having a surface impregnated with a material adapted to reduce the adhesion of ice to the surface, and means for intermittently varying the configuration of separate sections of said covering.

24. Means for reducing the accumulation of ice upon an airplane comprising a shield applied to parts of an airplane, said shield having an exposed surface impregnated with a non-adhesive substance.

25. Means for preventing formation of ice and to break up ice formations on the wings of aeroplanes comprising a flexible sheath and means for agitating the same.

26. Means for preventing formation of ice and to break up ice formations on the wings of aeroplanes comprising a flexible sheath and mechanical means for agitating the same.

27. A method for reducing the accumulation of ice upon a surface exposed to ice forming conditions, comprising applying to the surface a covering having a rubber surface impregnated with a liquid comprising castor oil.

28. A method for reducing the accumulation of ice upon a surface exposed to ice forming conditions, comprising applying to the surface a covering having a rubber surface impregnated with castor oil.

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