May 25, 1943. A. W. SPICER 2,320,017

APPARATUS FOR PREVENTING THE ACCUMULATION OF ICE

Filed July 12, 1940

Fig-1

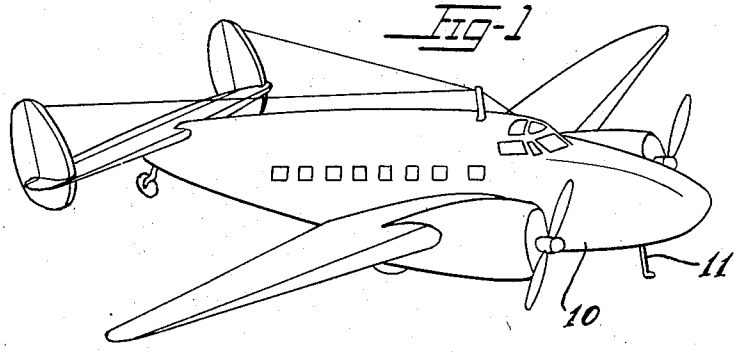


Fig-2

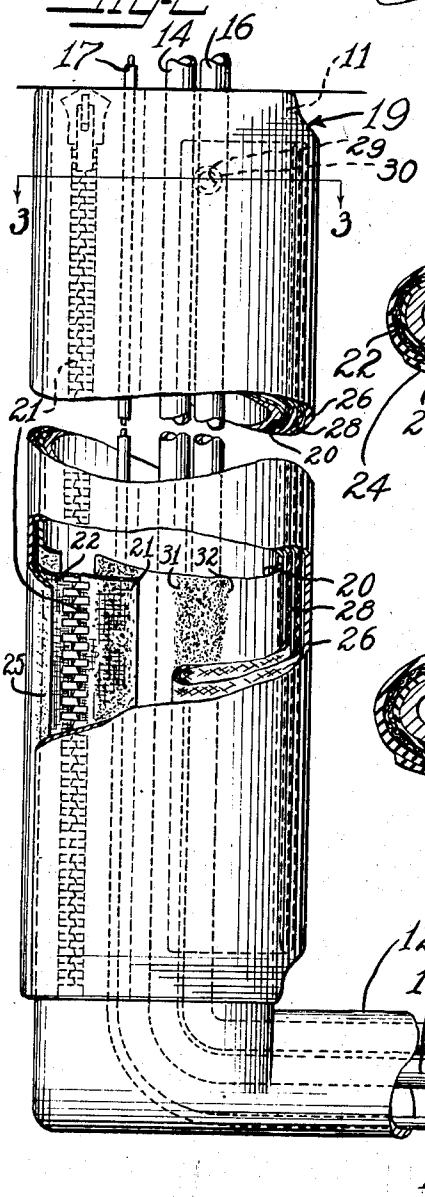


Fig-3

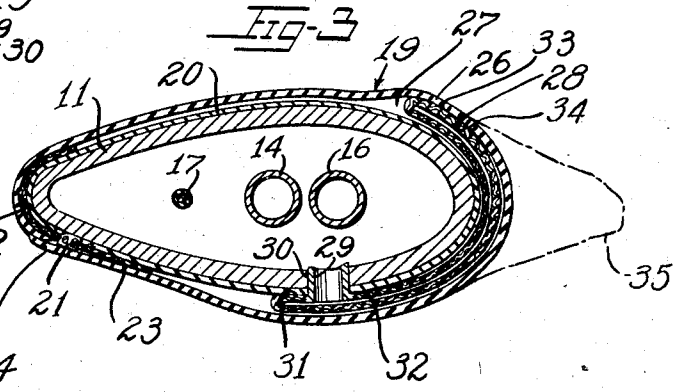
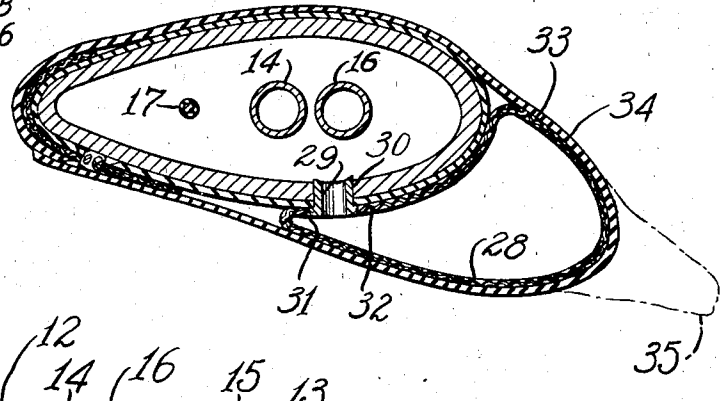


Fig-4



Inventor
Alvin W. Spicer
By Willis F. Avery
Atty

Patented May 25, 1943 2,320,017

UNITED STATES PATENT OFFICE

2,320,017

APPARATUS FOR PREVENTING THE ACCUMULATION OF ICE

Alvin W. Spicer, Cuyahoga Falls, Ohio, assignor to The B. F. Goodrich Company, New York, N. Y., a corporation of New York

Application July 12, 1940, Serial No. 345,147

7 Claims. (Cl. 244—134)

This invention relates to apparatus for preventing the accumulation of ice and is especially useful in preventing the accumulation of ice upon exposed surfaces of small cross section including air foils or other elements of aircraft such as masts, Pitot tubes, struts and the like, where it is desired to remove the ice by varying the contour of the surfaces.

Ice has been successfully removed heretofore at the leading edges of wings and other elements of relatively thick section by inflatable shoes mounted upon such leading edges. Owing to the thickness of the elements the broken pieces of ice resulting from the inflation of the shoe have readily become unbalanced with respect to the air flow and have been quickly dislodged and removed. The same considerations do not apply, however, at the leading edges of elements of small cross section where the lack of thickness of the section renders it less likely that the ice that is moved outwardly from the leading edge upon inflation of the shoe will be positioned in an unbalanced relation to the air flow and on such small section elements ice removal by prior inflatable means has been less effective.

It is also desirable to provide ice removal means of simple construction which may be readily removed and replaced at will and it is also desirable to provide means whereby the accumulated ice will be moved bodily with respect to the central fore and aft plane of the element from which the ice is to be removed so as to move the ice laterally to a position of unbalance in the air stream without excessively increasing the air resistance of the part to which the ice removing equipment is attached, and it is also desirable to avoid the use of complicated inflating structures, and to provide simplicity of air connections for accomplishing inflation.

The principal objects of the present invention are to provide improved means for effectively preventing the accumulation of ice, especially upon small sectioned elements of aircraft; to provide means of attachment permitting quick installation and detachment; to provide controlled extensibility; to provide for effective lateral movement of the surface of the ice preventing means with respect to the central fore and aft plane of the part to which the ice removing element is attached; to provide unbalance of the accumulated ice without excessive increase of air resistance, and to provide neatness of appearance, simplicity of construction and facility of manufacture. 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 showing the location of the aerial mast and Pitot tube.

Fig. 2 is a side elevation of the Pitot tube illustrating the apparatus of the invention for preventing the accumulation of ice as applied thereto and in deflated condition, parts being broken away and parts shown in section.

Fig. 3 is a cross section thereof taken on line 3—3 of Fig. 2 showing the apparatus for preventing the accumulation of ice in deflated condition.

Fig. 4 is a similar view showing the apparatus for preventing the accumulation of ice in inflated condition.

Referring to the drawing:

The numeral 10 designates an airplane having a Pitot tube 11 extending therefrom. The Pitot tube comprises a hollow mast of streamline cross section having a forwardly projecting tube 12 on its outer end. The tube 12 is provided with an end aperture 13 facing into the air stream and connected to measuring instruments within the craft by a tube 14 extending through the mast. The tube 12 is also provided with side apertures 15 which are connected by a tube 16 through the mast to the instruments within the craft. An electrical heating element 18 may be provided within the tube 12 around the opening 13 and adapted to be heated by an electric current from the craft through a wire 17, extending through the mast, the other connection being grounded on the Pitot tube. As the heating element 18 keeps the tube 12 above freezing temperatures at all times in order to prevent the formation of ice in the aperture 13, no other ice removing apparatus is necessary about the tube 12. It is desirable. however, to provide ice removing apparatus about the mast of the Pitot tube so that ice will not accumulate to impair operation or create objectionable vibration of the parts.

The apparatus for the prevention of the accumulation of ice is designated generally by the numeral 19 and is formed as a removable jacket applied over the surface of the mast. It comprises an inner wall 20 of elastic rubber-like material closely embracing the surface of the mast so as to provide adequate resistance against slipping thereon, and split lengthwise of the mast near the rear edge thereof for removability and secured by a slide fastener 21, the fastener elements of which are fixed to stringer tapes 22, 23 embedded in the jacket. A flap 24 of rubber-like material extends from one margin of the

wall 20 across the slide fastener to protect and conceal the same and may be temporarily secured to the opposite margin of the wall 20 by rubber cement 25 to keep out moisture and provide a smooth surface. A second or outer wall 26 of rubber-like sheet material extends about the wall 20 and is separated therefrom except at its margins which are united to the margins of the wall 20 adjacent the slide fastener, the arrangement being such that a pocket 27 is provided between the two walls of rubber-like material.

Within this pocket and extending about the forward edge of the Pitot tube is a normally flattened inflatable tube 28 of rubberized fabric extensible substantially only in the direction laterally of the tube and preferably comprising a layer of stockinet or other one-way stretch fabric. The fabric is adapted and arranged to prevent stretching lengthwise of the inflatable tube or lengthwise of the Pitot tube or other surface to which it is applied and to permit being stretched crosswise thereof.

To provide for inflation of the flattened tube in order to change the contour of the wall 26 of rubber-like material an inflating nipple 29 may be built into the wall of the tube 28 so as to communicate therewith and to extend through a side opening 30 in the wall of the Pitot tube where it may be connected to a source of inflating pressure from within the body of the craft. Upon inflation of the tube 28 the wall 26 of rubber-like material will be stretched to change the contour of the jacket.

In order to provide for positive lateral shifting of the tube 28 during its inflation and an oblique shifting of its fore and rear axis without excessive change of thickness such as to materially increase air resistance, the tube 30 is secured to the inner wall 20 only along a zone near one of its margins when the tube is flattened, as along a zone extending from a point 31 to a point 32 in Figs. 3 and 4, and is secured to the outer wall 26 of rubber-like material only along a narrow zone near its opposite margin when flattened, as along the zone from the point 33 to the point 34 in Figs. 3 and 4, the tube 28 being otherwise unsecured to said walls of rubber-like material 20 and 26. The arrangement is such that the tube 28 tends to rotate about its axis during its inflation so that it moves laterally to substantially the position indicated in Fig. 4 thereby causing an accumulation of ice, such as that indicated about the nose and jacket in Fig. 3 by the numeral 35, to move to the position it occupies in Fig. 4 where it is in an unbalanced position with respect to the air stream.

To further assist in effecting such a movement of the inflatable tube during inflation thereof, the flattened tube is so positioned about the nose of the jacket as to extend further about the nose in the direction of desired movement of the accumulated ice, or at the side where it is attached to the wall 20, than about the opposite side thereof where it is attached to the wall 26. The elasticity of the rubber wall 26 permits lateral movement of the inflatable tube under inflation by reason of its stretchability and acts quickly to restore the tube to its original position when deflated.

As the wall 20 should closely embrace the wall of the Pitot tube and need not be distorted during inflation of the tube 28, it may be made relatively non-extensible as by employing a stiff composition or by making it relatively thick-walled, or by fabric reinforcement. The wall 26, however, should be more extensible and may advantageously be made more extensible over its narrower zone between its line of attachment near the slide fastener and its line of attachment 33 to the tube 28, than over the wider zone between its line of attachment 34 to the tube 28 over the tube to its other margin secured near the slide fastener to the wall 20, as by being made of more extensible rubber in the zone between its first margin and line 33 than in the remainder of its extent or by making its normal span from its first attached margin to the line 33 greater than its span from the line 34 to its second attached margin, although that portion of the wall 26 overlying the tube 28 and in contact therewith but unattached thereto, due to its large area of contact over the tube and its convex contact, will slip very little with relation to the tube wall and a narrower zone of the wall between the line of attachment 34 and the slide fastener will be practically available for stretch than between the line 33 and the slide fastener on the opposite side thereby providing sufficient differential stretch with a wall 26 of uniform construction.

To lubricate the working surfaces of the tube 28 and the walls of the jacket, a powdered substance such as mica, graphite, or other suitable materials, or mixtures thereof, may be dusted on the surfaces.

In operation, the tube 28 is alternately inflated and deflated to change the contour of the outer wall and as the tube inflates it moves to the side of its uninflated position by a rolling movement controlled by its zone of attachment to the jacket and expands forwardly more than it narrows, as shown in Fig. 4. Upon deflation, the stretched wall 26, quickly returns the tube to the position shown in Fig. 3. The ice deposited on the jacket is moved laterally into the air stream and is blown away by the force of the air.

While the invention has been described as applied to a Pitot tube, it may be used on struts, aerial masts or other parts of the craft where ice might be deposited. The slide fastener provides for quick mounting and removability but may be omitted and other fastening means may be used for securing the margins of the jacket to each other or to the stretched part of the craft.

Variations may be made without departing from the invention as it is defined by the following claims.

I claim:

1. Apparatus for preventing accumulation of ice upon a surface, said apparatus comprising an inflatable element adapted in its uninflated, collapsed condition to occupy an area of said surface and to present an outer portion overlying said area, said element being attached to said surface only in a zone located at one side of the center of said area to compel displacement of an outer portion of the element toward the side of said area having such attachment as the element expands outwardly from said surface upon inflation thereof, and means for inflating the element.

2. Apparatus for preventing the accumulation of ice upon a surface, said apparatus comprising an outer flexible layer, an inflatable element beneath said layer adapted in its uninflated, collapsed condition to occupy an area of said surface, means for attaching said element to said surface only at one side of the center of said area and said layer being attached to said element only at the other side of said center to compel displacement of the outer layer toward the

side of said area having the attaching means as the element expands outwardly from said surface upon inflation thereof, and means for inflating the element.

3. Apparatus for preventing the accumulation of ice upon a surface, said apparatus comprising an outer flexible layer, an inner layer, an inflatable element between said layers adapted in its uninflated, collapsed condition to overlie an area of said surface, means for attaching said element to said inner layer only at one side of the center of said area, and said outer layer being attached to said element only at the other side of said center to compel displacement of the outer layer toward the side of said area having the attaching means as the element expands outwardly from said surface upon inflation thereof, and means for inflating the element.

4. Apparatus for preventing the accumulation of ice upon an object having a leading edge, said apparatus comprising surface means disposed across the leading edge and at the sides of said leading edge, an inflatable element between said surface means and said object, said inflatable element being attached to said object only at one side of said leading edge and to said surface means only at the other side of said leading edge to compel displacement of said surface means toward the side of the leading edge having the first stated attachment as the element expands outwardly from said object upon inflation thereof, and means for inflating the element.

5. Apparatus for preventing the accumulation of ice upon a surface, said apparatus comprising an outer flexible layer, an inner attaching layer therebeneath, an inflatable tube between said layers adapted in its uninflated, collapsed condition to overlie an area of said surface, means for attaching said tube to said inner attaching layer only at one side of the center of said area, and said outer layer being attached to said element only at the other side of said center to compel displacement of the outer layer toward the side of said area having the attaching means as the element expands outwardly from said surface upon inflation thereof, and means for inflating the element.

6. Apparatus for preventing the accumulation of ice upon a surface, said apparatus comprising an outer flexible layer, an inner attaching layer therebeneath, an inflatable element between said layers adapted in its uninflated, collapsed condition to overlie an area of said surface, an inflation nipple attaching said element to said inner attaching layer only at one side of the center of said area, and said outer layer being attached to said element only at the other side of said center to compel displacement of the outer layer toward the side of said area having said nipple as the element expands outwardly from said surface upon inflation thereof, and means for inflating the element through said nipple.

7. Apparatus for preventing the accumulation of ice upon a surface, said apparatus comprising a jacket having an outer extensible layer, an inner flexible attaching layer therebeneath, said layers being secured to each other along margins thereof to provide a pocket therebetween, an inflatable tube between said layers in said pocket adapted in its uninflated, collapsed condition to overlie an area of said surface, an inflation nipple attaching said tube to said inner attaching layer only at one side of the center of said area and said outer layer being attached to said tube only at the other side of said center to compel displacement of the outer layer toward the side of said area having said nipple as the tube expands outwardly from said surface upon inflation thereof, and means for inflating the element through said nipple.

ALVIN W. SPICER.