

July 12, 1949.

W. B. POND
ICE DETECTOR MEANS

2,476,217

Filed Aug. 11, 1943

2 Sheets-Sheet 1

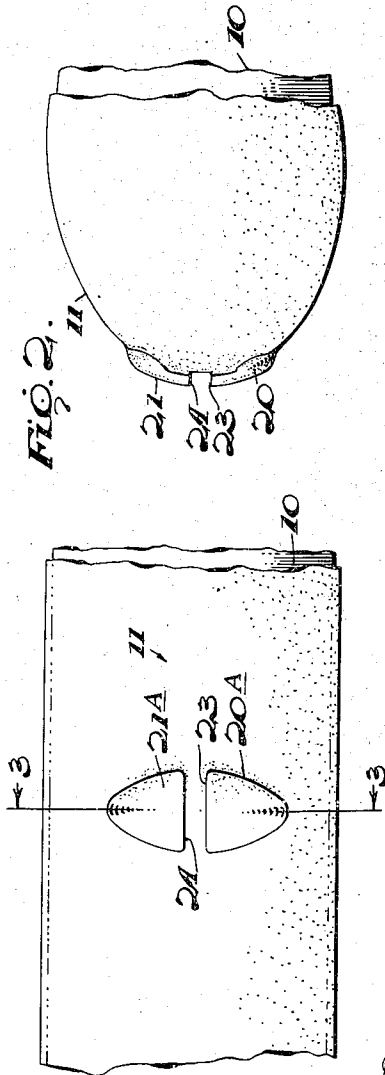


FIG. 1.

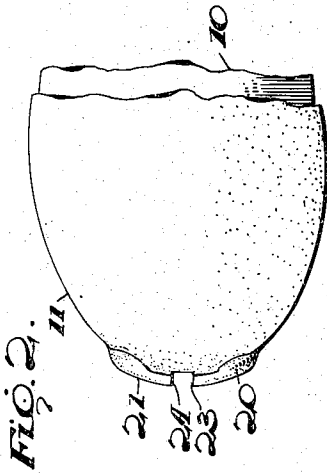


FIG. 2.

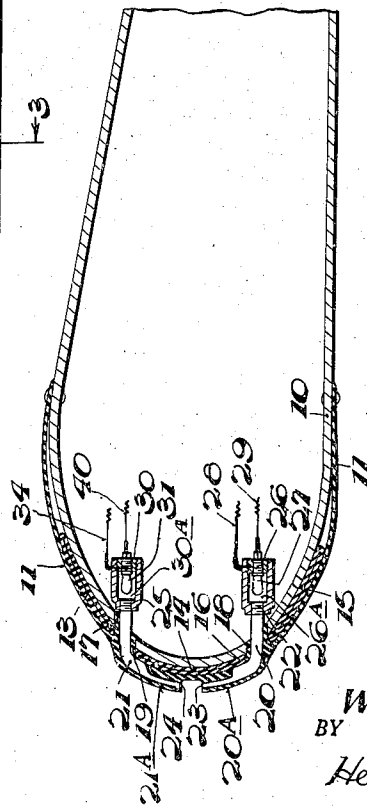


FIG. 3.

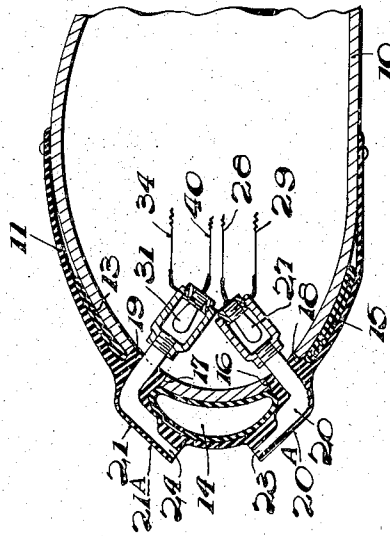


FIG. 4.

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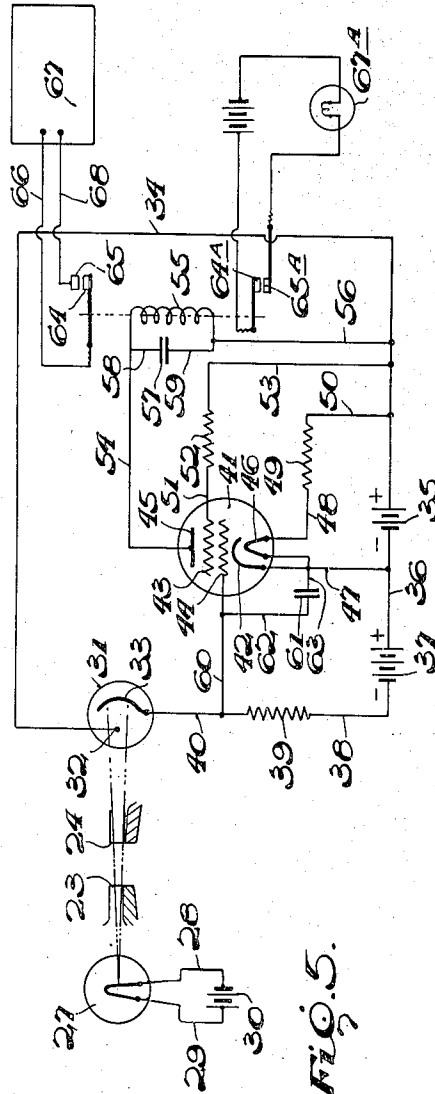
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ICE DETECTOR MEANS

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Application August 11, 1943, Serial No. 498,247

2 Claims. (Cl. 244—134)

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My present invention relates to control devices and more particularly to light conducting means responsive to icing conditions prevailing on an exposed aircraft surface for operating inflatable ice eliminating units for aircraft or suitable indicator means.

It has been observed that such units or boots give better ice removal if approximately an eighth of an inch of ice is allowed to accumulate before the boots are inflated. This is because the ice must build to a definite thickness in order to develop enough tensile strength to overcome adhesion. If the inflatable ice eliminating boots are operated with insufficient ice accumulated on them, the stretch of the rubber cracks the thin layer of ice, breaking it into many very small pieces, some of which are dislodged, but most of which remain. Further accumulation of ice builds on the little particles which remain and thus develops a flexible ice which is really composed of a number of separate little islands. Once such a condition has been established, additional cycles of inflation and deflation are relatively ineffective because further ice formation tends to accumulate only on the remaining particles and the stretch of the rubber naturally localizes in the areas between the islands without disturbing them. However, if the ice be permitted to accumulate to a greater thickness, it becomes increasingly more difficult to apply sufficient pressure through the boots to effect the cracking of the ice to facilitate its removal.

It is therefore of extreme importance that the operator of the plane be so advised or that the inflatable ice eliminating boots be operated when the ice has accumulated to the optimum thickness for its removal.

An object of my invention therefore is to provide control means responsive upon such predetermined optimum icing conditions prevailing on an aircraft surface to operate suitable ice eliminating means for removing the accumulated ice from such surface, whereby said control means is simultaneously conditioned for reoperation upon a recurrence of such optimum predetermined condition.

Another object of my invention is to provide electronic control means directly responsive to the thickness of an ice accumulation for performing a control function.

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Another object of my invention is to provide novel light conducting means responsive to ice thickness for performing a control function.

Another object of my invention is to provide means mounted directly upon a boot responsive to an ice accumulation thereon for initiating the operation of the boot.

Another object of my invention is to provide novel light conducting means mounted directly upon a boot and so arranged that the light conducted thereby may be interrupted by the formation of a predetermined thickness of ice upon the boot so as to initiate the operation of the boot for removing the same.

Another object of my invention is to provide control means responsive to ice thickness and means for removing the ice from the control means operated by the said ice thickness responsive means.

Another object of my invention is to provide a novel light responsive means and means for conducting light to said light responsive means from a fixed source of light, so arranged that upon the formation of a predetermined thickness of ice upon a boot the said conduction of light rays to said light responsive means will be interrupted by said ice formation for causing said light responsive means to perform a control function.

A further object of my invention is to provide a compact control device responsive to ice thickness of great efficiency in comparison to its size and of such simplicity in construction as to adapt it for manufacture and installation at low cost.

Other objects and advantages of this invention are set forth in the following description, taken with the accompanying drawings; and the novel features thereof are pointed out in the appended claims. The disclosure, however, is illustrative only and we may make changes in detail, especially in matters of shape, size and arrangement of parts within the principle of the invention to the full extent indicated by the broad and general meanings of the terms in which the appended claims are expressed.

In the accompanying drawings which form a part of this specification like characters of reference indicate like parts in the several views wherein:

Figure 1 is a view of a portion of the forward

edge of a wing of a plane illustrating the application of one form of my control device.

Figure 2 is an end view of Figure 1.

Figure 3 is a cross sectional view of Figure 1 taken along the lines 3—3 and looking in the direction of the arrows.

Figure 4 is a cross sectional view similar to Figure 3 showing the boot in an inflated position.

Figure 5 is a diagrammatic view illustrating a form of control circuit which may be utilized with my control device.

In the form of my invention illustrated in Figures 1 through 5 there is indicated by numeral 10 an airplane wing provided with an inflatable ice eliminating boot 11 formed of resilient rubberlike material and positioned along the leading edge of the wing 10.

The boot 11 may be of the type shown for example in the co-pending application of Donald M. Lawrence, David Gregg, and Myron L. Taylor, Serial No. 498,248 dated August 11, 1943 and owned by the assignee of the present application and has provided inflatable tubes 13, 14, and 15.

The tubes 13, 14, and 15 are expanded and contracted in a recurring cycle of operation at intervals which may be determined by a timing arrangement such as shown in the co-pending application of Myron L. Taylor, William B. Bond, and Herbert A. Eayrs, Serial No. 498,250 dated August 11, 1943, now matured into Patent No. 2,444,208, issued June 29, 1948.

The leading edge of the wing 10 is suitably apertured at 16 and 17 and has disposed therein the inwardly projecting cushion members 18 and 19 formed integral with the boot 11.

Projecting through the boot 11 and the cushion members 18 and 19 are light conducting rods 20 and 21. The rod 20 has provided longitudinal ends 22 and 23 while the rod 21 has formed similar longitudinal ends 24 and 25. The rods 20 and 21 are formed of a suitable light conducting material, such as glass, quartz, or light conducting plastic material such as lucite having as is well known in the art its outer surfaces with the exception of the longitudinal ends thereof so treated or so coated with a suitable material as to prevent light rays from emerging from the sides of the rods 20 and 21.

The rods 20 and 21 are thus so arranged that light rays entering one of the longitudinal ends thereof will be conducted by internal reflection through the said rod and out the opposite longitudinal end thereof.

The rods 20 and 21 are curved and so positioned that upon the tube 14 being deflated as shown in Figure 3 the longitudinal end 23 of rod 20 will be disposed opposite and in spaced relation to the longitudinal end 24 of the rod 21.

Screw threadedly engaged at the longitudinal end 22 of the rod 20 is a plastic holder 26 formed of non-light-conducting material in which is formed a channel 26A having mounted therein in a suitable screw threaded socket a minute electric bulb 27. The electric bulb 27 has provided the electrical conductors 28 and 29 which, as shown in Figure 5, are connected to the opposite terminals of a suitable source of electrical energy 30.

The electric bulb 27 thus forms a source of light rays which are directed into the longitudinal end 22 of the light conducting rod 20. The said light rays are conducted by means of internal reflection through the rod 20 and out the opposite longitudinal end 23.

There is similarly screw threadedly engaged at the longitudinal end 25 of the rod 21, a plastic holder 30 formed of non light conducting material in which is formed a channel 30A having mounted therein in a suitable screw threaded socket a photoelectric cell 31 responsive to light rays directed out the longitudinal end 25 of the rod 21 into the channel 30A.

The rod 21 is arranged so that light rays directed into the longitudinal end 24 are conducted by internal reflection through the rod 21 and out the longitudinal end 25.

The outer exposed surfaces of the rods 20 and 21 are protected from the weather by suitable covers 20A and 21A, respectively formed of rubber or other suitable material which may be readily vulcanized to the boot 11.

The photoelectric cell 31 has provided as best shown in Figure 5 an anode 32 and cathode 33 which are connected to a suitable control circuit.

In the control circuit illustrated in Figure 5, the anode 32 is kept at a positive potential with respect to the cathode 33 by connecting the anode 32 by means of an electrical conductor 34 to the positive terminal of a suitable source of electrical energy 35.

The negative terminal of the source of electrical energy 35 is connected by a conductor 36 to the positive terminal of another source of electrical energy 37 which has the negative terminal thereof connected by a conductor 38 to a resistance element 39. The resistance element 39 is connected at the opposite terminal by a conductor 40 to the cathode 33 of the photoelectric cell 31.

There is further provided in the control circuit an electronic valve 41. The electronic valve 41 has provided a cathode 42, a shield grid 43, control grid 44, an anode or plate 45 and a heater or filament 46.

The cathode 42 is connected by an electrical conductor 47 to the conductor 36 and is thus connected to the negative terminal of the source of electrical energy 35 and the positive terminal of the source of electrical energy 37.

One terminal of the filament 46 is connected to the conductor 47 leading to the negative terminal of the source of electrical energy 35, while the opposite terminal of the filament 46 is connected by a conductor 48 to a resistance element 49 which is in turn connected by an electrical conductor 50 to the conductor 34 leading to the positive terminal of the source of electrical energy 35.

The shield grid 43 is connected by a conductor 51 to one terminal of a resistance 52. The opposite terminal of the resistance 52 is connected by a conductor 53 to the conductor 34 leading to the positive terminal of the source of electrical energy 35.

The anode or plate 45 is further connected by an electrical conductor 54 to one terminal of an electromagnetic coil 55. The opposite terminal of the coil 55 is connected by a conductor 56 to the conductor 34 leading to the positive terminal of the source of electrical energy 35. The electromagnetic coil 55 is connected across a condenser 57. The opposite plates of the condenser 57 are connected by electrical conductors 58 and 59 respectively to conductors 54 and 56.

The control grid 44 is connected by a conductor 60 to the electrical conductor 40. Opposite plates of a condenser 61 are connected by conductors 62 and 63 respectively to the control grid 44 and the cathode 42.

The electromagnet 55 is arranged to actuate switch arms 64 and 64A for controlling switch

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contacts 65 and 65A respectively. The switch arms 64 and 64A are arranged to open the switch contacts 65 and 65A upon energization of the electromagnet 55 and are biased under spring tension so as to close the switch contacts 65 and 65A respectively upon the deenergization of the electromagnet 55.

An electrical conductor 66 connects the switch arm 64 preferably into a timer circuit of the type shown in the above mentioned Patent No. 2,444,208, and indicated generally in Figure 5 by the numeral 67, while the contact 65 is also connected into the timer circuit by a conductor 68. As described in the latter application the switch arm 64 may be arranged for closing a circuit for initiating a cycle of operation. Similarly the switch arm 64A is arranged to control a circuit for operating a suitable indicator 67A such as a light, alarm or whistle.

In operation, the circuit shown in Figure 5 is so arranged that upon an uninterrupted passage of light from the source 27 across the space between the ends 23 and 24 of the rods 20 and 21 and thus through the light conducting rods 20 and 21 to the photoelectric cell 31 an electronic flow will be set up by the light rays striking the photoelectric cell 31 causing the negative bias effective on the control grid 44 to be reduced. Such reduction in the potential of the control grid 44 will cause the electronic flow within the electronic valve 41 to the plate 45 to be increased sufficiently for causing the energization through the plate circuit of the electromagnet 55 for actuation of the switch arms 64 and 64A to an open relationship with the contacts 65 and 65A, respectively.

However, upon the passage of light across the space between the ends 23 and 24 of the rods 20 and 21 being obstructed as upon an accumulation of ice on the boot 11 of sufficient thickness to close the space between the said ends the reduction in the light conducted to the photocell 31 will cause a decrease in the electronic flow from the photocell 31 so as to cause the negative bias of the grid 44 to be increased. Upon such increase in the negative bias of the grid 44, the electronic flow within the electronic valve 41 to the plate 45 will be decreased sufficiently so that the energization of the electromagnet 55 will be insufficient to hold the switch arms 64 and 64A in an open relation to the contacts 65 and 65A, respectively, against the spring biasing force exerted by the switch arms 64 and 64A whereupon the switch contacts 65 and 65A, respectively, will be closed by switch arms 64 and 64A, under such spring biasing force.

The rods 20 and 21 are positioned in relation to the surface of the boot 11 so that the passage of light will be obstructed by a formation of ice of the predetermined optimum ice thickness desired.

Thus upon the accumulation or formation of the predetermined ice thickness, the switch arm 64 will close the contact 65 so as to cause the initiation of a cycle of operation such as explained in the above mentioned Patent No. 2,444,208, whereupon the tube 14 will be inflated as shown in Figure 4 causing the expansion of the boot 11 and the pivotal movement of the light conducting rods 20 and 21 freely mounted in the boot 11 as shown. The boot 11 will then be deflated after a time interval determined by the timer 67 as explained in the latter co-pending application.

Such inflation and deflation of the boot 11 as

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will be readily apparent will cause the cracking of the ice formed thereon which will in turn be carried away by the airflow.

The tubes 13 and 15 will likewise be inflated and deflated as well as the remaining boots of the plane as explained in the aforementioned co-pending applications until the cycle of operation is completed, whereupon operation of the inflatable boots will cease until initiated once again by the formation of an ice accumulation of sufficient thickness to obstruct the passage of light across the space between the ends 23 and 24 of the light conducting rods 23 and 24.

While in the illustrations herein I have shown my control device as controlling a timer of a type disclosed in the U. S. Patent No. 2,444,208, it will be readily apparent that if desired, the same may control any suitable type of electronic control or may control an indicator and the inflatable ice eliminating system may be controlled manually by the pilot.

Furthermore, suitable light responsive cells such as for example, photo-voltaic cells, selenium-cells or infra red ray cells and suitable control circuits therefore may be readily substituted for the photoelectric cell and control circuit provided herein.

Moreover, while I have disclosed a specific circuit for use with my control device, it will be readily apparent that any suitable control circuit may be readily substituted therefor.

Thus, although only one embodiment of my invention has been illustrated and described, various changes in the form and relative arrangement of the parts, which will now appear to those skilled in the art, may be made without departing from the scope of the invention. Reference is therefore to be had to the appended claims for a definition of the limits of the invention.

What is claimed is:

1. The combination, with an aerofoil surface and means for removing ice therefrom, of a source of light carried within said aerofoil surface, a light responsive means carried with said aerofoil surface, means controlled by said light responsive means for operating said ice removing means, and internal reflecting rod means for conducting light from said source to said light responsive means, said light conducting means extending from said source of light and said light responsive means to the exterior of said aerofoil surface and arranged in relation to said aerofoil surface in such a manner that upon the accumulation of a predetermined thickness of ice on said aerofoil surface the conduction of light from said source to said light responsive means will be interrupted for causing operation of said ice removing means by said operating means.

2. In combination with an airplane, a mechanism including an expansible member secured to the airplane structure for removing an accumulation of ice from said structure, and means for operating said expansible member, of a pair of light conducting rods mounted on the outer surface of said expansible member, and said light conducting rods extending through said expansible member and having inner ends thereof positioned within said airplane structure and outer ends thereof positioned in spaced relation to each other on the outer surface of said expansible member, a source of light fastened at said inner end of one of said light conducting rods, a light responsive means fastened at said inner end of the other of said light conducting rods, said light conducting rods arranged for conducting light

rays from said source of light to said light responsive means, and said outer ends of said light conducting rods being so spaced apart that an accumulation of a predetermined thickness of ice on said expansible member within the space separating said light conducting rods will cause an obstruction to the conduction of light from said source of light to said light responsive means for causing operation of said expansible member.

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REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
1,794,690	Horni	Mar. 3, 1931
1,999,930	Hirschl	Apr. 30, 1935
2,123,073	Bell	July 5, 1938
2,159,186	Tyler	May 23, 1939
2,165,198	Baer	July 11, 1939
2,171,450	Langley	Aug. 29, 1939
2,182,547	Tumey	Dec. 5, 1939
2,231,653	Baxter	Feb. 11, 1941
2,297,370	Siedle	Sept. 29, 1942
2,358,406	Lichtgarn	Sept. 16, 1944
2,359,787	Peters et al.	Oct. 10, 1944
2,373,255	McGoldrick	Apr. 10, 1945