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NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

Special Report #39

ICE PREVENTION ON AIRCRAFT BY MEANS OF IMPREGATED
LEATHER COVERS

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NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

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LEATHER COVERS

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SUMMARY

The National Advisory Committee for Aeronautics is testing the effectiveness of a method to prevent the formation of ice on airplanes. The system makes use of a leather cover that is attached to the leading edge of the wing. A small tube, attached to the inner surface of the leather, distributes to the leading edge a solution that permeates throughout the leather and inhibits the formation of ice on the surface. About 25 pounds of the liquid per hour would be sufficient to prevent ice from forming on a wing of 50-foot span. The additional gross weight of the system will not be excessive.

The tests are not yet completed but the method is thought to be practicable for the wing and it may also be adaptable to the propeller.

INTRODUCTION

The development of effective methods for preventing the formation of ice on airplanes has for several years been a subject of research in both Government and private laboratories. To date, these combined researches have indicated that: (1) insoluble paints are of no direct benefit (reference 1); (2) soluble coatings applied prior to flight may prevent ice formations for short periods but they are likely to be washed off by rain and are impractical (reference 1); (3) rubber coverings secured to the leading edges and arranged to be deformed by air pressure, literally break up the ice by stretching out from under it (reference 2) (these "overshoes" are now being used on many airplanes); and (4) plenty of heat is available from the engine exhaust gases to protect the entire airplane from ice. The most efficient method to distrib-

ute this heat to the airplane parts is by means of a vapor heating system, although a hot-air system may also be practicable. Successful flight tests have been made using a vapor heating system and its practical application depends only on adaptable design. The application of heat by other methods is not practicable (reference 3).

The use of thinner propeller blades with their attendant vibration characteristics necessitates the prevention of ice formation on propellers. Owing to the mechanical difficulties involved, the adaptability of any of the afore-mentioned methods to the propeller is doubtful. The object of this paper is to describe another method that may, pending further research, be suitable for propellers as well as for the wings and tail surfaces.

From tests made several years ago in the N.A.C.A. refrigerated wind tunnel, it was recognized that the continuous application of a soluble liquid to the leading edge of an airfoil would prevent ice formation (reference 1). In fact, a test was made at that time in which alcohol was fed directly onto the leading edge of a model from orifices in a tube placed along the leading edge. This method of distribution was unsatisfactory and, after a few preliminary attempts to improve the distribution, further research with such liquids was postponed in favor of other tests.

These tests have recently been resumed and a study is being made of the efficacy of different soluble liquids in combination with an efficient distributing arrangement. A covering of leather has been found to serve as an excellent distributor as it provides a wick to absorb the liquid from a reservoir and spread it evenly over the surface. For this purpose, the leather must be porous and absorbent; it must also be reasonably tough and hold its shape when in a saturated condition. Several such leathers are available.

TESTS AND RESULTS

Preliminary tests were made in the N.A.C.A. refrigerated wind tunnel using a model strut section to which a strip of leather was secured so as to cover the front portion of the model. A tube with several orifices along its length was embedded in the leading edge of the strut underneath the leather to distribute the liquid that was

forced through the orifices along the span. The tests were made to determine a satisfactory grade of leather and to ascertain the ice inhibitive effect of different chemical solutions. All of this work has not been completed yet but some flight tests have been made to check the more important results found from the wind-tunnel tests.

Several liquid solutions might be employed to reduce the adhesion of the ice to the leather. However, glycerin and glycol monoacetate produced the desired effect to such a marked degree that all the ice which formed could easily be pushed off; in fact, the adhesion in shear was practically zero. The flow of the air stream over an airfoil, however, gives little or no assistance in removing ice in a shearing direction but actually assists the normal air pressure in creating sufficient adhesion in tension to keep the ice cap secure to the leading edge, even though the whole formation may be floating on a film of liquid.

Alcohol, when used alone, also reduced the adhesion in shear and prevented ice from forming on the leading edge when a sufficient quantity was used to dissolve in and lower the freezing temperature of the impinging drops. In fact, the alcohol would even melt thin formations of ice that had previously formed on the leading edge. The alcohol, however, did not distribute as well throughout the leather as did the glycerin. In addition, it also evaporated rapidly and caused the leather to become dry and hard; whereas the glycerin preserved the leather and kept it soft and pliable.

The foregoing results indicated that mixtures of alcohol with glycerin or glycol monoacetate would be more appropriate. Tests showed that alcohol mixtures containing about 15 percent of either glycerin or glycol monoacetate gave very good results. The glycerin was sufficient to preserve the leather and reduce the ice adhesion while the alcohol prevented ice from accumulating on the leading edge. The glycol monoacetate solution was slightly better than the glycerin but, owing to the present high cost of manufacture, its use is not recommended.

Figure 1 shows views of the model under test in the wind tunnel, using the alcohol-glycerin solution. The leather cover was attached to only one half of the model to illustrate the effectiveness of the system. The quantity of liquid used indicated that approximately 25 pounds per hour would be necessary to keep ice from forming on a 50-foot wing.

In order to check the effectiveness of this system under full-scale conditions a large wing-section model having a span of 2 feet and a chord of 4 feet was mounted on a monoplane as illustrated in figure 2. A water-spraying device was mounted ahead of the model to simulate rain conditions and, in this way, the airplane could be flown at a sufficient altitude to obtain freezing temperatures and preventative measures could be studied. This same model was used in previous ice prevention studies and, for want of a recent photograph, figure 2 which was made during the previous tests is reproduced to show the character of the ice formation obtained with such spraying equipment when no preventative means is employed. The irregular formation of ice on the model was caused by an unequal distribution of the water spray. The leather cover used in the present test was 1/8-inch thick and covered the entire leading edge of the model. A sheet of rubberized fabric was cemented to the entire under surface of the leather with a small perforated rubber tube inserted along the leading edge between the leather and the fabric to feed liquid to the inner side of the leather. An extended strip of linen was sewn along the upper and lower edges of the cover to provide a means for attaching the cover to the model with airplane dope.

Figure 3 shows this model under full operation in flight using a mixture of 15 percent glycerin and 85 percent alcohol. During this test it was found that ice would not form on the leading edge as long as the liquid was fed continuously to the leather. Small leading-edge formations could even be removed by feeding the liquid intermittently. In either case, however, small formations of ice accumulated on the upper surface of the leather aft of the leading edge and were not removed. (See fig. 3.) A post-flight inspection, however, revealed that no liquid had been absorbed into the after portions of the leather. A remedy for this condition has not been determined as the tests have been temporarily suspended. As this treatment was the first that had been made on this leather, it is believed that a more thorough treatment with a stronger glycerin solution prior to the test might have conditioned the leather sufficiently to effect a better distribution of the liquid.

The flight test indicated that the consumption of liquid was approximately the same as that calculated from the wind-tunnel tests; i.e., 25 pounds per hour for a span of 50 feet.

DISCUSSION

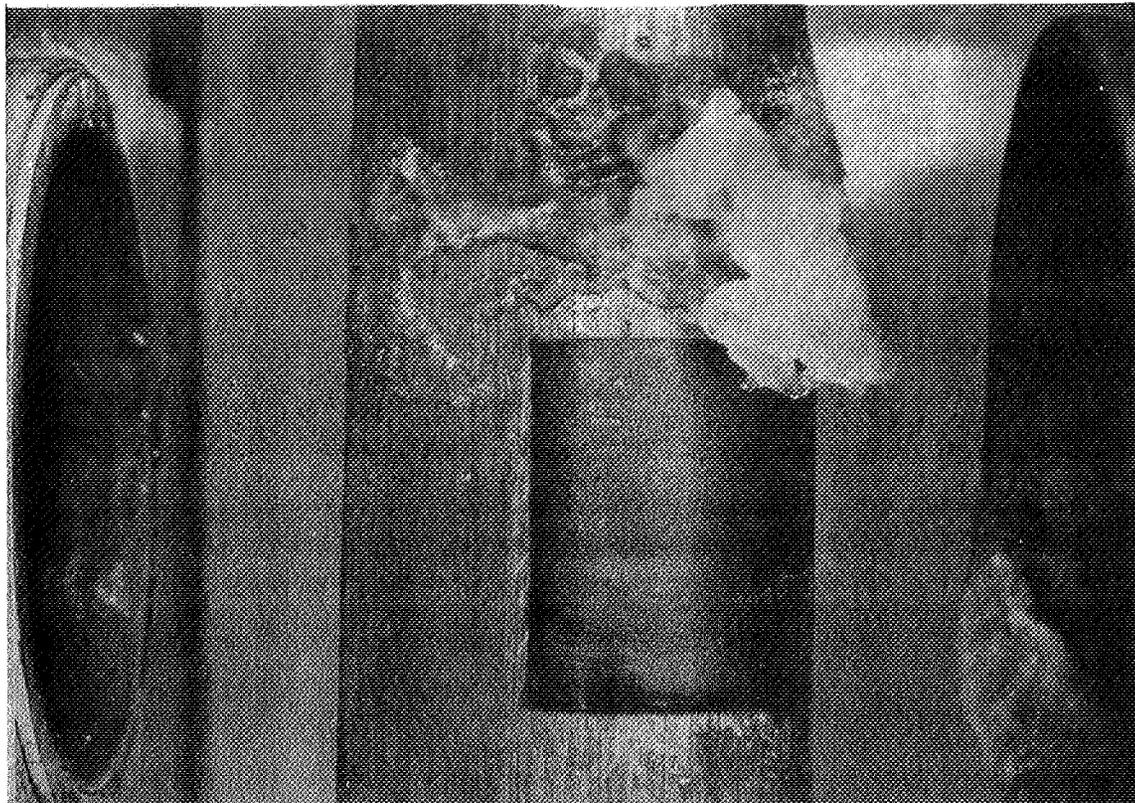
As previously mentioned, the study of impregnated leather coverings to prevent ice formation is not completed. The increase in the weight of an airplane due to such equipment does not appear to be excessive but future tests in flight will provide information with regard to the minimum thickness and the most efficient form of the leather cover for practical operation.

A similar use of leather coverings to prevent ice formation on propellers appears to be practicable and research on this problem is already under way.

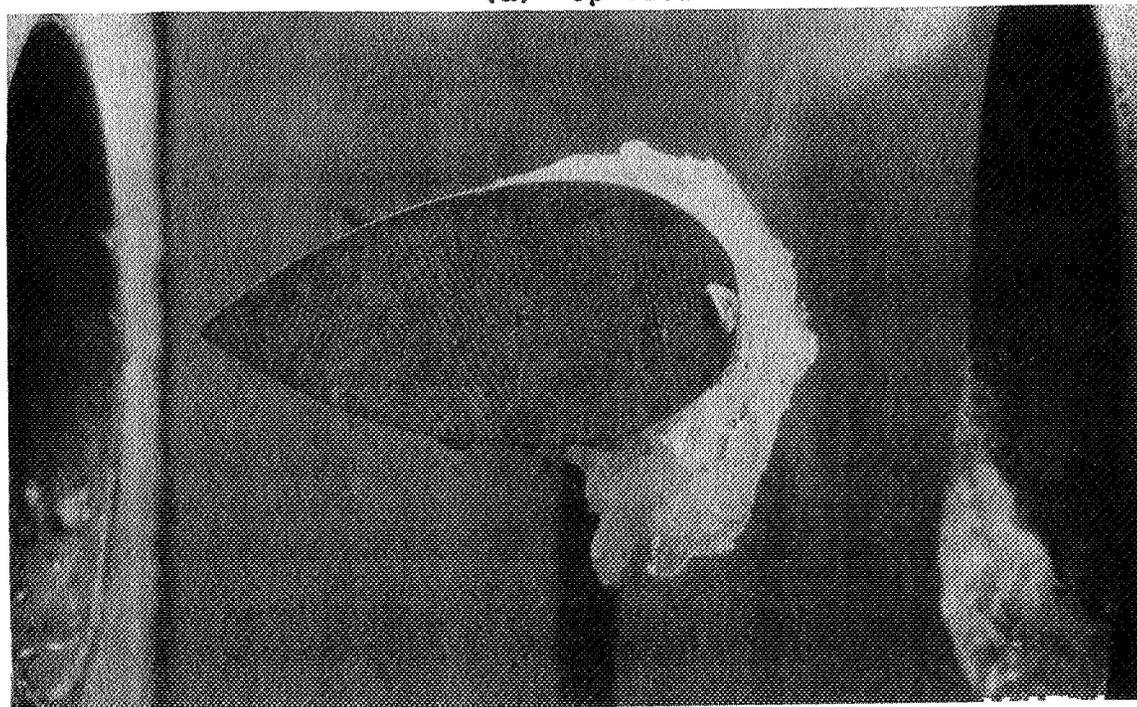
Langley Memorial Aeronautical Laboratory,
National Advisory Committee for Aeronautics,
Langley Field, Va., July 17, 1935.

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(a) Top view



(b) Side view

Figure 1: Prevention of ice formation on a leather covering by a mixture of alcohol and glycerin. N.A.C.A. refrigerated wind tunnel.

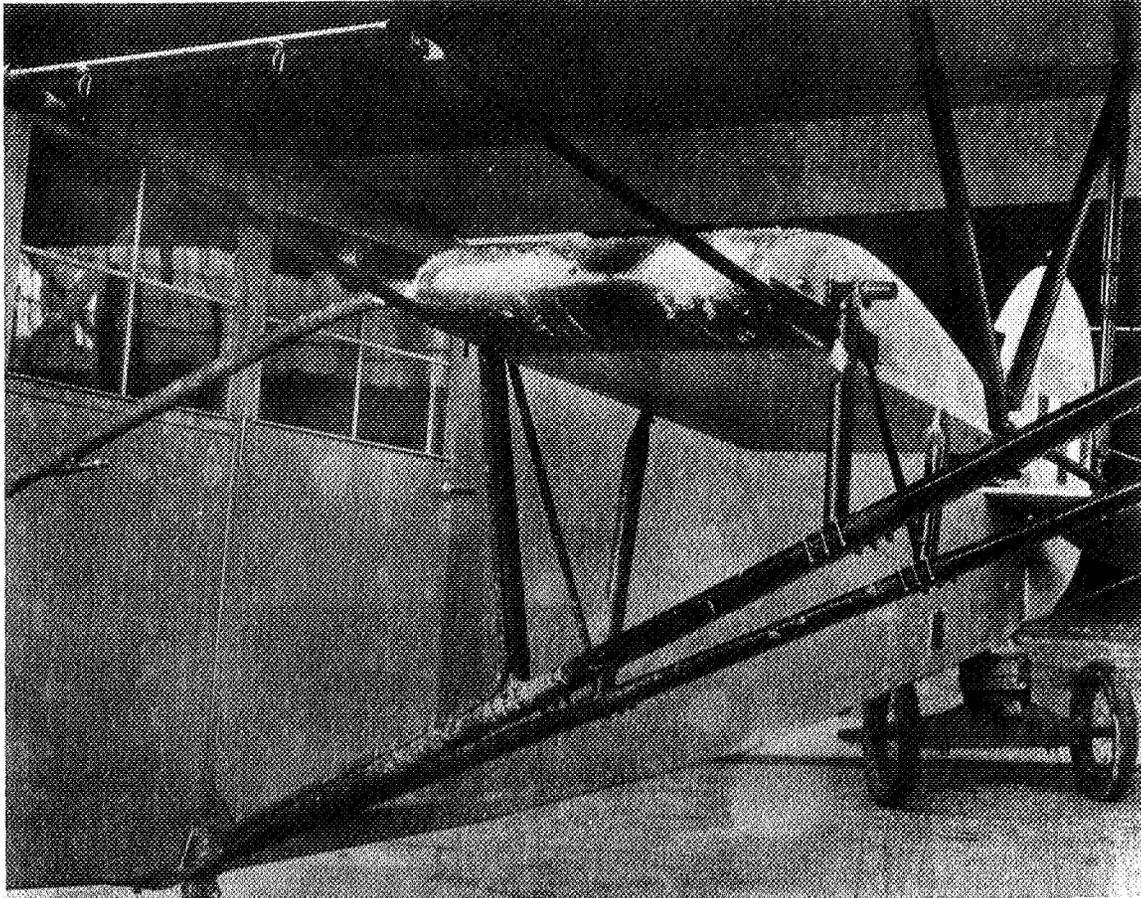


Figure 2.-Ice formation obtained with spray in flight tests when no preventative means is employed.

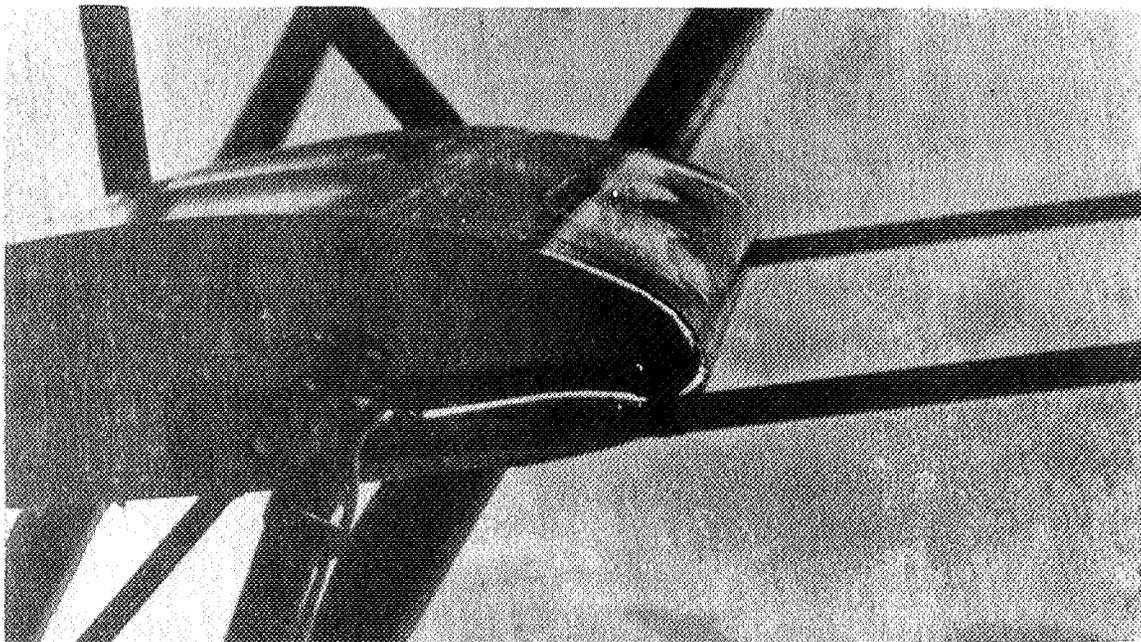


Figure 3.-Flight tests on leather covering with alcohol and glycerin.