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AEROPLANE PROPELLER HAVING AN ICE PREVENTING COATING

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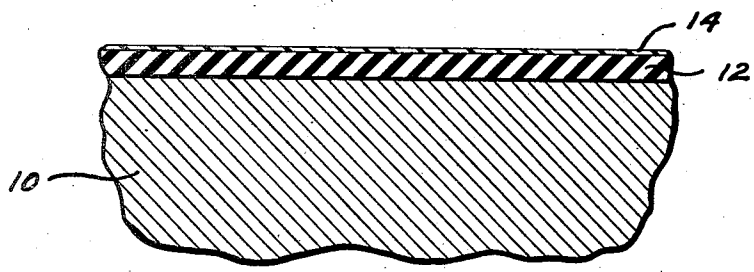


Fig. 1

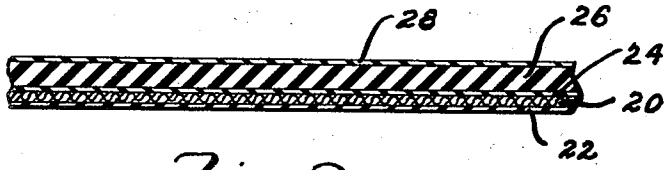


Fig. 2

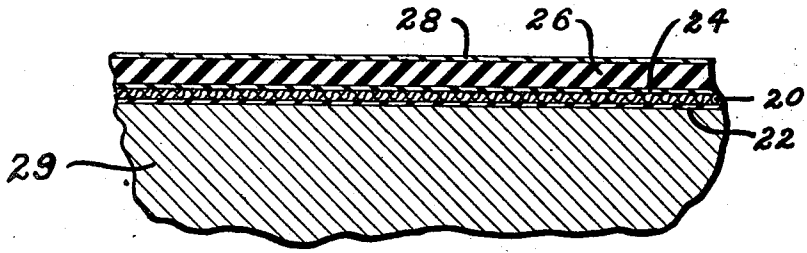


Fig. 3

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AEROPLANE PROPELLER HAVING AN ICE PREVENTING COATING

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5 Claims. (Cl. 244—134)

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This invention relates to aeronautical apparatus, and more particularly to means for preventing the formation of ice in detrimental quantities on propeller blades.

This application is a continuation in part of our earlier application Serial No. 513,641, filed Dec. 8, 1943, now abandoned, which in turn is a continuation in part of our application Serial No. 484,310, filed April 23, 1943, now abandoned.

One object of this invention is to provide means for de-icing propellers without the use of boots, slinger rings, de-icing fluid or other accessory equipment which of necessity handicaps the performance of aircraft.

Another object of this invention is to provide means for preventing the accumulation of ice on a propeller which is of as permanent a material as possible and which overcomes the disadvantages of paint films, anti-icing paste films of the freezing point depressant type, or other films of the type containing a chemical agent which dissolves in the water.

A further object of this invention is to provide means for de-icing purposes which may be applied by dipping, spraying or brushing, or which may be applied to the propeller blade in sheet form.

It was formerly considered that surface treatments which were very hard and water repellant were the most satisfactory for preventing the accumulation of ice on propellers, but we have discovered that a surface treatment which is pliable or elastic at icing temperatures and which is readily wet by water at these temperatures is superior to the surface treatments formerly used. Thus we have found that the propeller blade should be coated with a material which is sufficiently flexible at icing temperatures to permit temporary deformation of the interface between the ice and the film tending to release ice, yet possessed of sufficient elasticity to restore itself when the ice has been released.

Thus, a further object of this invention is to provide a material which, when applied to an aeroplane propeller, will result in a film of appreciable thickness which is readily wet by water and which has sufficient flexibility at icing temperatures to release the ice by virtue of the centrifugal force acting on the ice.

Another object of this invention is to provide such a coating which is pliable or elastic at icing temperatures and which tolerates water on its surface only and resists penetration of water.

More particularly it is an object of this invention to treat a synthetic elastomer, such as polyisobutylene, so as to promote swelling or softening thereof and to add to it a synthetic resinous substance of phenyl or cyclohexyl origin to promote surface wetting. We have found that a synthetic elastomer thus treated provides a material which when applied to a propeller causes the water striking the propeller to form a coating of ice having crystalline orientation such that the ice is more readily fractured upon the deformation of the elastomer due to the centrifugal force acting on the ice.

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Further objects and advantages of the present invention will be apparent from the following description, reference being had to the accompanying drawing, wherein a preferred form of the present invention is clearly shown.

In the drawing:

Fig. 1 of the drawing is a fragmentary sectional view on an enlarged scale showing a propeller coated with our de-icing material;

Fig. 2 shows the de-icing material applied to a fabric backing so as to form a prefabricated composite sheet for application to a propeller blade or the like; and

Fig. 3 shows the composite sheet applied to a propeller blade.

The de-icing may be accomplished satisfactorily on a relatively temporary basis by using a mixture of equal parts by weight of vinylidene chloride and vinyl chloride co-polymer (such as Saran B–130), and a polymerized glycerol ester of sebacic acid (such as Paraplex G–20), dissolved in a mixture of 80% methylethyl ketone and 20% dioxane. If desired, the surface of the flexible film can be activated to promote wetting by water by incorporating a suitable surface active agent into the top coat or the surface active agent may be applied as a separate coat. An example of a suitable surface active agent is triethanolamine, 5 to 10% by weight of total solids. The triethanolamine which is used as the surface active agent in the coating more fully described in application S. N. 484,310 is a water soluble agent and does not give as permanent protection as the de-icing materials which are non-water soluble.

Films containing water soluble agents, either for surface activation or for depressing the freezing point of the water, will operate satisfactorily for a limited time. These films could be classified as chemical de-icing coatings or chemical agents, since minute quantities of some chemical agents dissolve in the water to change the physical properties of the water. The amount of chemical which can be incorporated into any given film or coating is limited, and the de-icing effect is then

limited by the exhaustion of the supply of such chemical in the film. We have found that for durability and performance of de-icing we can depart from this type of chemical activity and depend on the physical properties of our improved coating to release the ice. We have found that a coating with good surface wetting properties does not require as much flexibility as a coating which does not have the good surface wetting properties. However, the good wetting property should not be produced by a wetting agent, as such, dissolving into the water but should be the inherent property of the material used for coating. The wetting of the coating should take place in much the same manner as a clean piece of glass is wet by water without any of the glass dissolving in the water and without any of the water penetrating the glass.

In order to obtain a permanent propeller de-icing coating or film having the properties which we have discovered are necessary, we have found it desirable to combine numerous synthetic organic compounds. In making such a material, the bulk of the film or coating is composed of a synthetic elastomer. This elastomer is combined with certain modifying agents, including some plasticizing agent, as will be explained hereinafter.

In selecting the synthetic elastomer, it is chosen for its conformity to the following physical properties:

1. It should be flexible at temperatures as low as −60° F. without excessive additions of the plasticizing agent.
2. It should resist water penetration.
3. It should be compatible with various addition agents mentioned hereinafter.
4. It should have general stability of physical and chemical properties under all climatic conditions for which the material is designed.

Examples of such synthetic elastomers are polyisobutylene (commercially known as Vistanex) having an average molecular weight range of 60,000 to 180,000, polymer of chloroprene (commercially known as neoprene), co-polymer of isobutylene and butadiene (commercially known as butyl rubber), co-polymer of butadiene and acrylonitrile (such as commercially known as Buna N or Perbunan), the ester types of condensation polymers (one of which is commercially known as Paracon).

One of the modifying agents used with such elastomers is a synthetic resin or oil having favorable water wetting properties as explained hereinabove. This is chosen for its conformity to the following desirable physical properties:

1. It should be able to impart to the synthetic elastomer better water wetting properties at temperatures below 32° F.
2. It should resist water penetration and should be insoluble in water.
3. It should be compatible with the elastomer and the other addition agents.
4. It should be flexible at low temperatures or susceptible to plasticization for low temperatures.
5. It should have general stability of physical and chemical properties within the required temperature range.

Examples of such synthetic resins or oils are some of the chlorinated diphenyls or chlorinated terphenyls (known in the trade as the Aroclor series of oils and resins), and the hydrogenated phenyl compounds. We have found that chlorinated diphenyl, while itself is non-water soluble, tolerates water on the surface only and resists

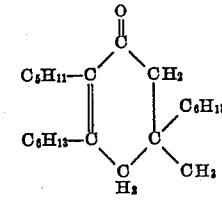
penetration of water into the main body of the material. The chlorine content should preferably be between 42% and 54%. The chlorinated diphenyl is especially desirable because of this characteristic and because of its low evaporation loss in air.

Another modifying agent which may be used with such elastomer is chosen for certain physical properties, such as the following:

1. The substance should remain fluid at temperatures as low as −60° F.—either on its own accord or by virtue of mixing with the chlorinated or hydrogenated phenyl compounds.
2. It should have a softening or swelling action on the synthetic elastomer in much the same manner as gasoline or oil will soften and swell natural rubber. This swelling action should have the effect of increasing the low temperature flexibility of the elastomer.
3. The substance should be insoluble in water and water should be insoluble in the substance.
4. It should be compatible with the elastomer and the other addition agents.
5. It should have physical and chemical stability within the required temperature range.

Examples of such modifying agents are:

(1) A ketone $C_{24}H_{44}O$, which is a 24 carbon atom cyclic ketone, a derivative of isophorone and having a probable structure which may be written as follows:



(2) Ester type of plasticizer, such as methyl "Cellosolve" ricinoleate, tributoxy ethyl phosphate, dioctyl phthalate, and tricresyl phosphate.

(3) An aliphatic nitrile.

(4) Non-volatile aliphatic hydrocarbons having a low pour point such as −10° F. to −15° F. and a boiling range of 400° F. to 505° F. and having a viscosity range of 30 to 35 Saybolt at 100° F.

The modifying agents may be added to the synthetic elastomer in various proportions to produce the most advantageous de-icing combination. The proportions used in each case will, of course, depend to a certain extent upon the combination of modifying agents selected.

The preferred de-icing material comprises approximately 75% polyisobutylene, having an average molecular weight of 100,000, 15% chlorinated diphenyl, having an average chlorine content of 42%, and 10% ketone. (These percentages are given in terms of weight.)

It has been found that 10% or less of chlorinated diphenyl is rather ineffective in promoting wetting of the surface by water, whereas the addition of more than 20% of chlorinated diphenyl appears unnecessary.

After the main de-icing coating has been applied it may be protected by the application of a top finish. This top finish may be less flexible than the main coating but should have better wetting properties than the main coating. A preferred blend for such a top finish is 85% by weight of polyisobutylene and 15% by weight of chlorinated diphenyl. By applying such a top finish to the main de-icing material, a more permanent finish is provided which will better withstand

abrasion and the like. When using the two coatings, the first coating may be between .015 and .025 inch thick, and the second coating should be somewhat thinner than the first coating, and the combined coatings should be not more than .030 inch thick.

When using a single coating we have found it desirable to use a film having a thickness in the neighborhood of .015 and .025 inch. The degree of elasticity of the film should correspond to the elasticity of a corresponding film of rubber of Shore hardness less than No. 30 tested at a temperature of 75° F.

In Fig. 1 of the drawing we have shown a fragmentary sectional view on an enlarged scale of a propeller blade 10 having a main coating 12 and a top finish 14 applied in the manner indicated hereinabove.

While the di-icing material may be applied by dipping, spraying or brushing, it may also be applied to the propeller in sheet form, either with or without a backing fabric. It has been discovered that the time and effort required to coat a propeller with de-icing material of uniform thickness may be reduced considerably by the use of a backing fabric which has been precoated with the de-icing material. Thus the most satisfactory method of applying the de-icing material to a propeller is to first apply the material to a backing fabric such as balloon cloth and then applying the resultant product to the propeller.

We have discovered that it is best to coat the one side of the balloon cloth with neoprene (polymer of chloroprene) and to coat the other side of the balloon cloth with butyl rubber (co-polymer of isobutylene and butadiene) before applying the de-icing material to the balloon cloth. The neoprene promotes good adhesion to the metal blade whereas the butyl rubber promotes adhesion of the de-icing material to the balloon cloth. The de-icing material is then applied over the butyl rubber in the manner indicated hereinabove. The composite sheet is then applied directly to the blade and is held onto the blade by means of any of the well known adhesives used for bonding neoprene to metal.

In Fig. 2 of the drawing we have shown a composite sheet of de-icing material prepared in the above manner. As shown in the drawing, the balloon cloth 20 is coated on the one side with a thin coating of neoprene 22 and on the other side with a thin layer of butyl rubber 24. The main de-icing coating 26 is applied to the butyl rubber 24 as shown and a top finish 28 protects the coating 26 in the manner previously explained. Fig. 3 of the drawing shows the composite sheet applied to a propeller blade 29. The composite sheet should preferably have a thickness of approximately .040 inch. The balloon cloth should preferably have a maximum weight of 2.05 ounces per square yard and should preferably have 120 threads per inch in each direction.

The balloon cloth treated in the manner indicated is sufficiently elastic to permit stretching to conform to the contour of the propeller blade and adds enough strength to the de-icing material to prevent tearing of the material during application to the blade. Another advantage of first applying the de-icing material to balloon cloth is that the thickness of the coating can be very closely controlled at the factory during the fabrication of the composite sheet.

While reference has been made to coatings of neoprene and butyl rubber for the balloon cloth,

these coatings are preferably compounded in any of several well known ways for increasing the physical strength thereof and to otherwise improve the properties of the materials.

While the form of embodiment of the invention as herein disclosed constitutes a preferred form, it is to be understood that other forms might be adopted, as may come within the scope of the claims.

What is claimed is as follows:

1. A propeller for an aeroplane comprising a metallic blade and a permanent water insoluble coating thereon composed of a mixture of substantially 75% by weight of polyisobutylene having an average molecular weight within the range of 60,000 to 180,000, substantially 15% by weight of chlorinated diphenyl, and substantially 10% by weight of a plasticizer, said chlorinated diphenyl being selected from the group consisting of oily chlorinated diphenyls and resinous chlorinated diphenyls.

2. In combination, an aeroplane propeller, a de-icing material bonded to said propeller for at least partially covering said propeller, said material comprising a balloon cloth backing fabric, a neoprene coating on the one side of said balloon cloth in contact with said propeller, a butyl rubber coating on the other side of said cloth, and a water insoluble coating on said butyl rubber coating composed of a mixture of substantially 75% by weight of polyisobutylene having an average molecular weight within the range of 60,000 to 180,000, substantially 15% by weight of chlorinated diphenyl and substantially 10% by weight of a plasticizer, said chlorinated diphenyl being selected from the group consisting of oily chlorinated diphenyls and resinous chlorinated diphenyls.

3. A propeller for an aeroplane comprising blade means; a first water insoluble coating thereon composed of a mixture of substantially 75% by weight of polyisobutylene having an average molecular weight within the range of 60,000 to 180,000, substantially 15% by weight of chlorinated diphenyl and substantially 10% by weight of a plasticizer; said chlorinated diphenyl being selected from the group consisting of oily chlorinated diphenyls and resinous chlorinated diphenyls; and a second water insoluble coating thereon composed of a mixture of substantially 85% by weight of polyisobutylene having an average molecular weight within the range of 60,000 to 180,000, and substantially 15% by weight of chlorinated diphenyl, said last named chlorinated diphenyl being selected from the group consisting of oily chlorinated diphenyls and resinous chlorinated diphenyls.

4. A propeller for an aeroplane comprising a blade and a permanent water insoluble coating thereon composed of a mixture of substantially 75% by weight of polyisobutylene having an average molecular weight within the range of 60,000 to 180,000, substantially 15% by weight of an oily chlorinated diphenyl, and substantially 10% by weight of a plasticizer which is compatible with the other ingredients of the mixture.

5. A propeller for an airplane comprising a blade means and a permanent non-metallic water insoluble coating at least .015" thick completely bonded thereto composed of a substance having a Shore hardness number of less than 30 at 75° F. and having water wetting properties and resistance to water penetration and elasticity

and resiliency throughout icing temperatures as low as 10° F. substantially corresponding to that of a mixture composed of substantially 75% by weight of polyisobutylene having an average molecular weight within the range of 60,000 to 180,000 and substantially 15% by weight of a resinous chlorinated diphenyl and substantially 10% by weight of a plasticizer.

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