April 5, 1949. W. C. HALL 2,466,024

APPARATUS FOR PREVENTING RADIO INTERFERENCE

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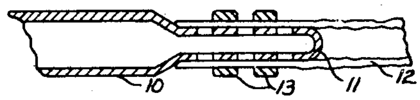


FIG. 1

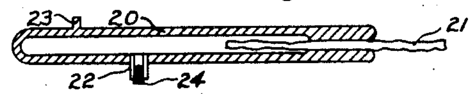


FIG. 2

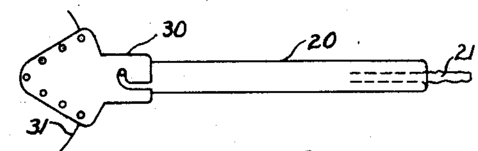


FIG. 3

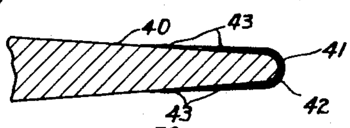


FIG. 4

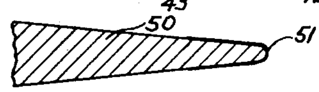
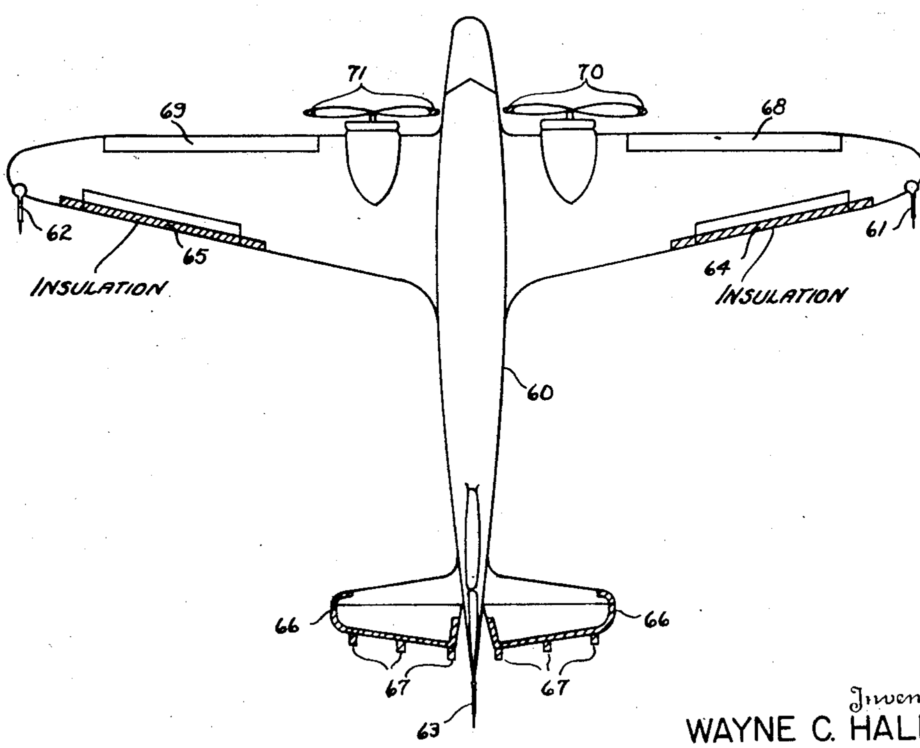


FIG. 5

FIG. 6



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UNITED STATES PATENT OFFICE

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APPARATUS FOR PREVENTING RADIO INTERFERENCE

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4 Claims. (Cl. 175—264)

(Granted under the act of March 3, 1883, as amended April 30, 1928; 370 O. G. 757)

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This invention relates to an apparatus for reducing interference to radio reception in the vicinity of highly charged bodies, and it is particularly concerned with the reduction of interference to reception on aircraft in flight.

It is well known that large metallic bodies, such as ships, aircraft and other structures, become highly charged when in the vicinity of electrical storms or certain types of wind storms such as dust storms, or drifting snow. Aircraft in particular accumulate very high charges when traveling through certain types of clouds. The large electrical fields about such bodies cause corona discharges to take place from those parts of the body which are subject to the strongest electrical fields, such as masts of ships, wing tips, propellers and tails of aircraft and the like. This corona discharge produces an extremely noisy interference in any nearby radio receiving equipment, often causing complete failure of communication at times when such communication is vital. For example an aircraft pilot flying through storm areas quite often meets these conditions in an overcast where the temperature is near freezing, and he may find himself unable to receive beam or other radio signals at a time when he must depend on instruments alone for his course.

This invention provides a method of facilitating the discharge of electricity from charged bodies in a manner which causes little or no radio interference, and it includes novel apparatus for accomplishing the same. Due to the greater discharge rate obtainable without appreciable radio interference by the method of this invention and the prevention of noisy discharge from certain exposed portions of the structure the potential, or free charge, of the body affected is maintained below that necessary to cause noisy corona discharges. In this way the method and apparatus herein disclosed permit radio communication under conditions heretofore difficult, and often impossible, by reducing the interference caused by corona discharge to a negligible amount.

The method of this invention comprises causing the electricity to discharge into the atmosphere in a noise-free manner from one or more selected parts of the charged body at a potential too low to initiate noisy discharge from the major portion of the body. If necessary, additional steps are taken to prevent discharges from other exposed parts of the body. The discharging means must operate to conduct electricity from the body before other parts thereof break into corona, and in a manner which does not create appreciable electrostatic or electromagnetic disturbances.

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The method here employed is based on the discovery that electricity can be discharged into the atmosphere with only a negligible amount of electrostatic and electromagnetic disturbance if it is discharged from a fibrous surface of non-conducting material moistened by a liquid of suitable electrical conductivity. In my co-pending application, Serial No. 726,194, filed February 3, 1947, there is disclosed a discharger wherein the fibrous material is coated with a solid rather than a liquid conductive material, and the apparatus is claimed broadly enough to include both solid and liquid conductive coatings. For best results the current should be discharged from a great number of fine fibers close together. A porous surface with a multitude of fine points projecting outwardly such as chamois skin, cotton, wool, glass and synthetic fibers, is satisfactory as a discharger when wet by a conducting liquid. However, no matter what material is employed, it is necessary to prevent the formation of continuous liquid surfaces such as exist over a droplet of liquid. Whenever a sufficient field is applied to such a surface the liquid is observed to form a blunt point from which a noisy electrical discharge occurs. The preferred form involves the use of a fibrous rope or wick which has been soaked in a suitable liquid, one end of the wick being fastened to the charged body and the other end supported (mechanically, or by air flow) away from the body and extending into the atmosphere. In order that the discharge will preferentially take place through the wick and so avoid corona discharge from other parts of the body, it is necessary to fasten the wick (or electrode) to the body in a region where a high electrical field surrounds the charged body. In the case of surface craft such points would logically be the mast and other projections, and in aircraft they would be mainly the ends of the wings and the tail. The propellers also are areas of high electric field, but it is seldom desirable to place these dischargers on them. At certain points or regions, such as the ailerons, where rigidly projecting dischargers might be objectionable a fibrous material such as cotton flannel may be used as a noise-free discharger by cementing it to the edge of the surface and then moistening it with a suitable liquid. Whenever a wick type discharger is used, which projects outwardly from the structure, the electrical shielding provided by the wick will be sufficient to prevent discharge from adjacent areas over a distance equal approximately to the distance from the end of the wick to the surface of the structure. Under severe conditions a reasonable number of these wicks, or noise-free dischargers, may not keep the potential of the entire structure low enough to prevent a noisy discharge from certain edges or similarly favorably located parts. In this event the discharge is prevented from those edges or parts by insulating them, such as by painting or covering the edge, point or region with some material of high dielectric strength. Such a material may be any of several suitable synthetic resins, waxes or tars and other commercially available prepared materials such as a thin rubber sheet glued to the surface. When the part has been so covered, no discharge from the protected region or part will take place. Ceresin wax and beeswax have been found particularly effective in preventing discharge, but have the disadvantage of cracking away from the metal surface at low temperatures. Synthetic resins of particular usefulness for this purpose are the vinyl and acrylic ester resins, including polystyrene, phenol-formaldehyde resins and alkyd resins. Combinations of layers of different materials such as synthetic resins and beeswax, or ceresin wax, have been tried and found better than either ceresin or beeswax alone but these multiple layers are prone to break away from the metal at low temperature. Various coating thicknesses may be used. However, experiment has shown that a layer approximately .030" to .040" thick offers sufficient protection and that a good grade of insulating tar is quite satisfactory. This method of insulation for the prevention of noisy corona discharge is particularly applicable to the edges of propellers.

Certain large insulated areas which are exposed to the weather, such as windshields, and de-icer boots of rubber, in contrast to the very small, deliberately insulated areas described above, may cause objectionably loud static through charging and sparking over to the surrounding metallic parts of the plane due to their size. Such static will be prevented if the surface is painted with a conducting paint. A conducting paint suitable for the rubber de-icer boots may be made by mixing rubber cement and colloidal carbon with a suitable thinner, or it may be made by any of the well known methods. With respect to the windshield a film of glycerol and water may be sprayed on from the outside by means of a pressure sprayer controlled from the cabin. Any of the conducting non-freezing liquids such as aqueous alcohol may also be sprayed on, but a liquid of low vapor pressure, such as glycerol and the glycols, is preferable to avoid undue loss through evaporation.

In the event that the type of storm through which the aircraft is flying involves water above its freezing point, the water itself will conduct some of the electricity away from the insulated area to the surrounding parts of the plane.

Several embodiments of the apparatus of this invention and their application to aircraft are described in detail with reference to the accompanying drawings in which:

Fig. 1 shows in simplified form one embodiment of the discharging device of this invention;

Fig. 2 shows a modification of the device shown in Fig. 1 and adapted to be removably mounted;

Fig. 3 shows the apparatus of Fig. 2 in a mounting;

Fig. 4 shows another embodiment of the discharging device of this invention, mounted at the edge of an airfoil;

Fig. 5 shows a method of preventing electric discharge from taking place from a conducting surface, and

Fig. 6 is a top view of an aeroplane showing suitable placement of the devices illustrated in Figs. 1 through 5.

Referring to Fig. 1, a metal reservoir **10** is provided with a perforated nipple **11** over which a tubular wick **12** of felt or other fibrous material is fastened by rubber bands **13** and which extends for a short distance from the nipple **11**. The liquid is placed in the reservoir **10** and soaks into the wick **12** until the latter is saturated.

In Figs. 2 and 3 a modification of the device of Fig. 1 (which may be referred to as an electrode) is shown which is adapted for lock mounting. A reservoir **20** is shaped so as to hold a standard wick (e. g. a ¼ inch lamp wick) at one end and has mounting lugs **22** and **23** at the other end. The lug **22** is provided with a small hole which may be closed by a screw **24**, to provide an opening through which the reservoir **20** may be filled (or any of several gun-type fittings may be used). In Fig. 3 the electrode or device of Fig. 2 is shown mounted in a standard lock mounting **30** rigidly fastened to a wing tip **31** and making electrical contact therewith. The size of the electrode is not critical, and it has been found that a tube or reservoir from 12 to 18 inches long with about 2 or 3 inches of protruding wick is a convenient size.

In Fig. 4 a cross-sectional view of an edge **40** at which corona discharge may take place is shown with two layers of cloth (e. g. cotton flannel) **41** and **42** or other fibrous material cemented in place at spots **43**. In use the cloths **41** and **42** are dampened with the conducting liquid to be used. Discharge from this form of discharger may be facilitated by having one piece of material project into the air in the form of a number of small strips or ribbons (see Fig. 6). The distance back from the edge which the cloth must extend to permit substantially noise-free discharge is not great, one-half to one-inch generally being sufficient. If desired several layers of cloth may be cemented on the edge to provide greater capacity for holding the liquid. However, very many thicknesses may interfere with the air flow or cause excessive drag. In most cases a single layer of cloth will hold sufficient liquid for all but the longest flights. Where it is inconvenient or impractical to use a discharger of the type shown in either Figs. 3 or 4, it is often desirable to prevent any discharge from the edge, point or surface considered. In this event a surface **50** (Fig. 5) is covered by an insulating material **51**. The material **51** may be applied as a sheet cemented or otherwise held in place, such as a sheet of rubber or plastic, or it may be an insulating varnish or paint sprayed, brushed or baked in place. It is not necessary to extend the insulation more than about an inch back from the edge, and usually a shorter distance is enough.

It is clear that the above described embodiments of the invention may be used in a number of different ways. However, a typical application of them to an aircraft is shown in Fig. 6. In Fig. 6 a metal plane 60 is provided with electrodes or dischargers 61, 62 and 63, illustrated in Figs. 2 and 3, at the wing tips and tail. Saturated cloth strip type of dischargers 64, 65 and 66, illustrated in Fig. 4, are provided at the trailing edges of the ailerons and elevators, with small chamois tabs 67 extending a few inches from the latter.

The plane 60 is provided with wing de-icers 68 and 69 which are conventional inflatable rubber boots. These boots are painted with a conducting paint (such as may be prepared by mixing graphite or other forms of carbon, or finely dispersed metal, in a vehicle) to prevent spark discharge to the plane 60.

Since it is not practicable to place dischargers on the tips 70 and 71 of the propellers, the latter may be insulated by applying a coating of a hard-baked insulating varnish, or an air-drying insulating paint or varnish, as described with reference to Fig. 5.

The choice of liquid for use in the discharging apparatus will depend to some extent on the conditions under which the apparatus is to be used. However, there is an indefinitely large number of liquids which may be successfully used. Insulating liquids, such as various hydrocarbon oils, are not suitable, as the wick or porous material is itself an insulator, and there would be no way to conduct the charge to the ends of the fibers. In general, those liquids which are hydrophilic, particularly those which are completely miscible with water, are suitable for use in this invention because a low resistance conductor is not needed in view of the extremely low discharging currents encountered (e. g. 50 to 100 microamperes per electrode). Various salt solutions or even tap water itself, may be used but these have the disadvantage of evaporating readily in an air stream. Also, salt crystals on the wick and highly conducting liquids tend to make the discharge noisy in nearby radio receivers. Some liquids are more efficacious than others. Thus solutions of glycerol and water not only do not evaporate quickly in an air stream but also they permit a silent electrical discharge of either positive or negative potential. Other liquids or mixtures thereof are satisfactory in discharging a negative charge quietly but not a positive one, and vice versa. As a guide to the selection of suitable liquids the following table indicates as "unlimited" certain typical liquids which produce a silent discharge with either a positive or negative potential, and as "limited" those liquids which may be satisfactory for discharging a negative or positive potential, but not both, or are less effective than the "unlimited" liquids.

Unlimited	Limited
aqueous ethyl alcohol	isoamyl alcohol
aqueous glycerol	isopropyl alcohol
aqueous acetone	aqueous sodium chloride
aqueous glycerol containing calcium chloride	aqueous acetic acid
aqueous glycerol containing dissolved sugar	aqueous glycerol containing ferric chloride

For application to air craft, liquids should be used which will not readily evaporate and which have low freezing points. In this respect the various polyhydric alcohols, such as the glycols and glycerol, are preferred and mixtures comprising glycerol and water are most satisfactory, with or without the addition of sugars or various salts.

The design of the electrode, which may or may not include the liquid reservoir, may be modified to suit each particular installation. However, for attachment to parts of aircraft the end of the wick should extend at least several inches from the body of the aircraft for maximum discharge from the wick, and where the electrode is fastened so as to protrude from a surface of the aircraft it should preferably extend about a foot to permit efficient electrical discharge at comparatively low potentials. The optimum number of electrodes, their shape and their precise distribution are matters of design in each case, but the principles to be followed have been herein described, and radio interference can be reduced accordingly without further experimentation.

If desired, the electrodes can be supplied through connecting tubes with liquid from a common reservoir centrally located within the aircraft, but the rate of evaporation of such hygroscopic liquids as glycerol and the glycols, even in aqueous solution, is so low that the expense and complexity of a common large reservoir is not generally warranted.

Other variations will be apparent to those skilled in the art and the invention should not be limited other than as defined by the appended claims.

The invention described herein may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

I claim:

1. In combination with a conductive surface of an aircraft for the purpose of discharging static electricity from said surface, a discharge element conductively secured to said surface and comprising an exposed mass of normally non-conductive fibrous material having myriad projecting fibers with free ends having radii of curvature of microscopic order, said fibers carrying highly resistive films of conductive liquid, which films have in the area of said free ends a thickness of microscopic order.

2. The combination as claimed in claim 1 wherein said liquid has a low volatility and low freezing point.

3. An electrode for discharging static electricity from an aircraft in flight comprising a reservoir of conductive material having means for conductive connection to said aircraft, said reservoir having an opening and containing a conductive liquid and an electrical discharge element carried by said reservoir in communication with said opening, said discharge element comprising an exposed mass of normally non-conductive fibrous material having myriad projecting fibers with free ends having radii of curvature of microscopic order, said fibers carrying highly resistive films of said liquid, which films have in the area of said free ends a thickness of microscopic order.

4. In combination with an aircraft, means for preventing electrical discharge from certain portions of the conductive surface of said aircraft in regions of high electrical field comprising a coating of non-conductive material overlying said surface, and means for providing discharge from another portion of said aircraft comprising a discharge element conductively secured to a conductive surface at said other portion of said aircraft and including an exposed mass of normally non-conductive fibrous material having myriad projecting fibers with free ends having

radii of curvature of microscopic order, said fibers carrying highly resistive films of conductive liquid, which films have in the area of said free ends a thickness of microscopic order.

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