April 10, 1956 R. A. GAISER 2,741,570

ELECTROCONDUCTIVE ARTICLE

Filed March 5, 1953

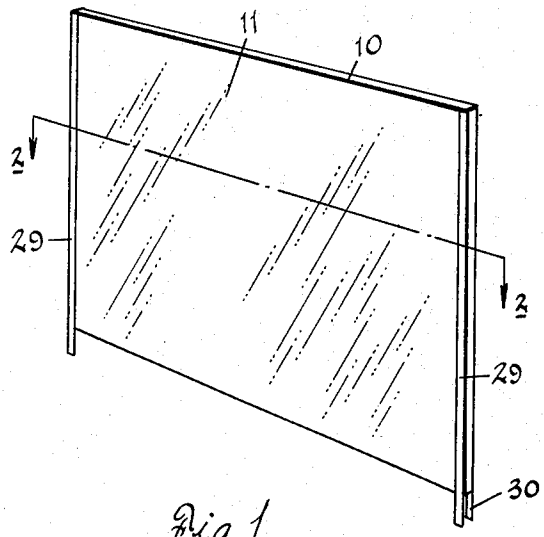


Fig. 1

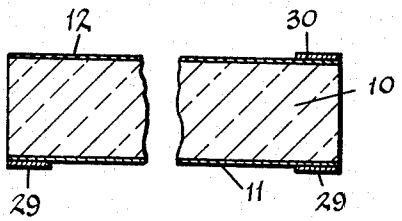


Fig. 2

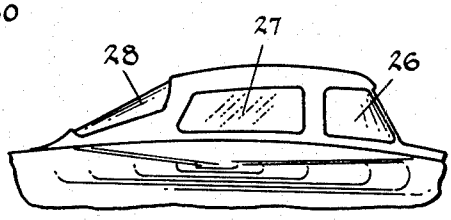


Fig. 5

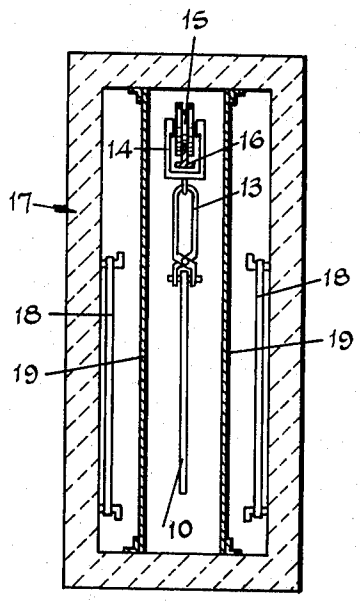


Fig. 3

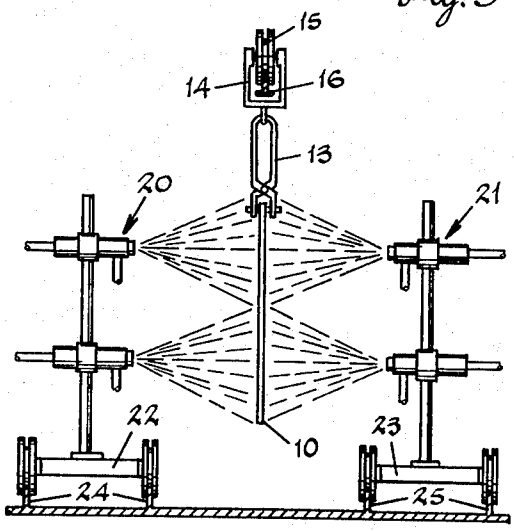


Fig. 4

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ELECTROCONDUCTIVE ARTICLE

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Application March 5, 1953, Serial No. 340,548

3 Claims. (Cl. 117—211)

The present invention relates broadly to transparent, electrically conducting films, and more particularly to a glass sheet or plate provided with electrically conducting films of different characteristics on opposite surfaces thereof, and to a method of producing such a plate.

It has already been known that a transparent, electrically conducting film of tin oxide (such as shown in Patent 2,429,420 to H. A. McMaster, dated October 21, 1947) can be produced on glass surfaces by first heating the glass to substantially its point of softening and then subjecting one or both surfaces to the action of a tin compound in fluid form.

However, to date films of this character have found their greatest commercial utility when used on aircraft glazings, for removing ice, frost and fog by heat, and the aircraft manufacturers have insisted that glass for this purpose be filmed on one side only. In commercial production of such electrical conducting glass this has necessitated going to rather intricate and expensive means to eliminate film from the outboard surfaces of lights that are to be used in glazing sight openings or windows, including windshields, in aircraft.

Recently, however, it has been realized that static electricity charges building up on the glass and plastic surfaces of aircraft canopies cause serious problems in connection with radio reception and transmission to and from these aircraft. This is particularly true on the newer high-speed aircraft in which the antenna is placed within the cockpit in order to reduce air drag. Also, with the higher speed aircraft, the greater impingement energy of the air particles on the non-conducting surface of the aircraft, results in larger static charges. In fact, these charges become so great that not only is radio reception and transmission almost totally impaired, but corona discharges may occur around metal-housed instruments within the cockpit. It has been found that the electrostatic charge on a high-speed aircraft windshield may produce corona and interference effects are far as eleven feet distant from the windshield surface.

It is an important aim of the present invention to provide a windshield or other window which has on its outboard surface a transparent, substantially colorless, electrically conducting film of good optical properties and a sufficiently low resistivity for the purposes of electrostatic dissipation.

Another object is the provision of a relatively thin outboard film of the above character that exhibits stable resistivities.

Another object is to provide a window or windshield which is provided with a transparent electrically conducting film of uniform thickness and relatively high resistivities for electrostatic dissipation on one surface thereof, and a transparent electrically conducting film of relatively low resistivity, for defrosting, on the opposite surface thereof.

Another object is the provision of a method of producing windows or windshields of the above character in

which the relatively low resistance film is applied to one surface of a glass sheet, while the relatively high resistance film is being simultaneously applied to the opposite surface thereof, under controlled conditions.

Still another object is to provide a method of producing such windows or windshields in which one side of a heated glass sheet is sprayed for a predetermined length of time with a predetermined volume of air and spray solution to produce a transparent electrically conducting film of relatively low resistivity, while at the same time the opposite side of the sheet is being sprayed for the same length of time and with the same volumes of air and spray solution to produce a transparent electrically conducting film of relatively high resistivity.

Further objects and advantages of the invention will become more apparent during the course of the following description, when taken in connection with the accompanying drawings.

In the drawings, wherein like numerals are employed to designate like parts throughout the same:

Fig. 1 is a perspective view of a filmed light of electrically conducting glass produced in accordance with this invention;

Fig. 2 is a fragmentary sectional view taken substantially along the line 2—2 in Fig. 1;

Fig. 3 is a vertical, sectional view through one type of heating furnace which may be used in carrying out the method of the invention;

Fig. 4 is an end view of an apparatus that may be used to spray the glass sheet after it has been heated; and

Fig. 5 is a side elevation of an aircraft enclosure or canopy glazed in accordance with this invention.

An electrically conducting coating that has a sufficiently low resistivity for static dissipation can be produced in a number of different ways. In fact, I have found that, by removing the masking devices or hoods that have heretofore been used in commercial production to protect the opposite side of the sheet when one side only is being sprayed for deicing purposes, a back spray of the filming compound will form a film on the reverse side of the sheet that could be considered adequate from the standpoint of static dissipation (50,000 to 500,000 ohms).

However, such a film is inadequate from an optical standpoint because, since it is formed under uncontrolled conditions, it is usually spotty, foggy and almost certainly of improper thickness to give the light reflection characteristics necessary for aircraft glazings.

It is a premise of this invention that the film on the reverse or outboard side of the glass (the static dissipating film) must be applied under controlled conditions. In other words, according to the invention, at the same time a deicing film is being applied to the inboard surface of a windshield light in a manner to achieve a resistivity of perhaps 100 ohms per square, another film is being applied to the outboard surface of the same light or pane in a manner to provide a resistivity in the order of 100,000 ohms per square.

By "in the order of" in this connection is meant a resistivity that may vary from 10,000 ohms to 1,000,000 ohms, or 1 megohm per square area. These values are given for ideal static dissipation purposes only. It is conceivable that within the range given it may be necessary to widely vary the relative resistances of the films on the opposite sides of the glass pane to meet varying conditions of use.

Referring now more specifically to the drawings, there is disclosed in Figs. 1 and 2 a pane of glass 10 filmed in accordance with the invention, and in Figs. 3 and 4 apparatus which may be employed to produce the desired films on the glass.

Thus, the glass sheet 10, which may be employed as

the outboard pane in an aircraft windshield, is provided with a film 11 of relatively low resistivity on the side of the pane that is to become the inboard surface and a film 12 of relatively high resistivity on the opposite or outboard surface of the pane.

In order to produce such films, the glass sheet 10 after being thoroughly cleaned may be suspended as shown in Fig. 3 from tongs 13 hung from a carriage 14 which is provided with wheels 15 running on a monorail 16. The carriage 14 is then moved along the rail 16 to carry it into a furnace 17, within which it can be heated to the temperature necessary for filming.

The furnace 17 will be heated in any suitable manner, such as by means of electric resistance heaters 18, and may be provided with baffles 19 to provide a more uniform temperature throughout.

Within the furnace, the sheet 10 is heated to substantially the softening point of the glass. Actually, of course, glass varies and has no precise softening point, and for this reason it is not practicable to give any exact temperature requirements for the heating step. However, in securing substantially colorless, transparent, electrically conducting surfaces on average glass, I have found that exposure to temperatures between 500 degrees to 700 degrees centigrade for from 1 to 10 minutes gives very satisfactory results.

Obviously, these temperature and time factors are influenced by the type of glass, and should run higher as the softening point of the glass rises. When using soda-lime-silica glass in ⅛" thick automotive plate, I prefer to heat the plate for two minutes at 1200 degrees Fahrenheit and, after it is withdrawn from the furnace, to position it between the spray guns 20 and 21 where the opposite surfaces of the sheet will be simultaneously sprayed with a filming solution to provide electrically conducting coatings of the desired resistivities.

Various tin compounds, including the tin halides, dissolved in suitable solvents can be used as the spray solution to produce the electrically conducting films and, generally speaking, I prefer stannic tetrachloride in an organic solvent such as isopropyl alcohol for the purpose.

In order to obtain a uniform coating of the spray solution over the surfaces of the sheet 10, it is desirable to reciprocate the sprays back and forth over the sheet, and for this purpose the spray guns 20 and 21 are mounted on wheeled carriages 22 and 23 running on tracks 24 and 25. The carriages 22 and 23 are moved back and forth over the tracks a sufficient number of times to give films of the desired thickness on the glass surfaces as shown at 11 and 12 in Fig. 2. The filmed sheet is then preferably cooled in the atmosphere, at room temperature, or it may be otherwise and more rapidly and uniformly chilled, after which it is ready for use.

Ideally, in connection with aircraft glazings, it is desired to film the inboard glass surface of the outboard glass pane to a low resistivity in order that sufficient current may be passed through the film at an available voltage to produce heat for deicing purposes. However, a film that has a resistivity in the order of 100 ohms (10 to 1000 ohms per square) is too good a conductor to allow the passage of radio frequency energy. In other words, such a film would ground out radio frequency energy, thus interfering with the transmission of radio signals to or from the airplane, through that glass area. For this reason it may be desirable to coat some surfaces of an aircraft canopy, such as is shown in Fig. 5 and which may embody a windshield 26 and side and rear windows 27 and 28 respectively, for deicing, while other areas of the canopy are filmed for electrostatic dissipating alone. Thus, at one and the same time, electrostatic charges on the glass canopy can be eliminated, deicing can be achieved and radio frequency energy will be allowed entrance and exit from the canopy.

The areas coated for static dissipation alone, will be

coated on the outboard surfaces. However, according to the preferred embodiment of this invention the areas coated for deicing and electrostatic dissipation will be coated on both the inboard and outboard surfaces of the outboard pane.

I have employed two types of coatings of films for static dissipation purposes, one of these is comparatively thick (approximately ½ to ⅝ wave length of light at 5600 angstroms), but of high resistance; while the other is much thinner (less than ¼ wave length of light at 5600 angstroms) and is also of high electrical resistance. The purpose of choosing such thicknesses is that thicknesses that are multiples of ½ wave lengths on soda-lime-silica glass give lower light reflections than do thicknesses that are multiples of ¼ wave length. However, thicknesses below ¼ wave length will also give lower light reflection.

The first or thicker type of film is more iridescent than the second or thinner type, but offers greater abrasion resistance to cleaning and to foreign particle impingement. I can produce this thicker film by use of a 10% solution of stannic chloride in isopropyl alcohol, to which an iron compound has been added as a conductivity inhibitor. The iron content is adjusted according to the teaching in the copending application of Romey A. Gaiser and James W. McAuley, Serial No. 327,722, filed December 24, 1952, to give a filming solution that will produce a film of the desired resistivity.

The second method of obtaining high resistivities involves the use of spray solutions containing smaller amounts of tin. For example, I have successfully used .5% to 2% of tin chloride in isopropyl alcohol solution for this purpose; and spray times with this solution vary from 1 to 20 seconds, depending upon the thickness of the film and the temperature of the glass.

Originally I found one difficulty with the thin coating. This involved the stability of resistivity. I found that thin, high resistivity films, particularly of one megohm or higher, were apt to have unstable resistivities varying both upward and downward from day to day as much as several hundred per cent of the original resistivity. The thin films appear to have much greater photo-conductive effects than the thicker films. However, I also found that the addition of gallium compounds to the spray solution act as resistivity stabilizers, and that thin films produced from spray solutions containing gallium will maintain their original resistivity within 25%.

To insure greatest mechanical strength in the finished product, it is advisable to spray both surfaces of the hot glass plate with approximately equal volumes of air and spray solution, when the spraying of both surfaces is done simultaneously. In practice, therefore, it is recommended that the deicing surface be sprayed with a tin chloride-isopropyl alcohol solution with a tin halide content between 10 and 30%, while the opposite surface of the glass is being simultaneously sprayed for the same length of time, either with the same solution to which the optimum of iron has been added, or with a weak solution containing from .5% to 10% tin compound (with or without iron) and approximately .10% gallium metal. The former procedure will give films of equal thickness on both sides of the glass while the latter will give a relatively thick deicing film and a relatively thin static dissipating film.

By spraying both surfaces for the same length of time and by using approximately the same amount of alcohol in the spray solution, the compression layer on both surfaces of the glass will be equal and therefore minimum warpage and maximum strength will result. Also with this method the glass will remain clear, with a minimum of haze, and will have the desired resistivities.

As indicated above it is preferred that the deicing films have a resistivity in the order of 100 ohms (10 to 1000 ohms) while the static dissipating films have a resistivity of the order of 100,000 ohms (10,000 to 1,000,000 ohms per square).

Suitable marginally arranged electrodes **29** and **30** can be secured to the opposite surfaces of the glass sheet **10**, and in electrical contact with the films **11** and **12**, in any well known manner. The pair of electrodes **29** on opposite margins of the glass serve to supply electrical current to the deicing film **11**, while the single electrode **30** provides a ground connection from the static dissipating film **12**.

Although this invention has been specifically described in connection with sheets or panes of glass, it will be apparent that it is also applicable to a window pane of plastic to the surface or surfaces of which transparent electrically conducting films can be applied. In fact, it is to be understood that the form of the invention herewith shown and described is to be taken as an illustrative embodiment only of the same, and that various changes in the shape, size and arrangement of parts, as well as various procedural changes may be resorted to without departing from the spirit of the invention or the scope of the subjoined claims.

I claim:

1. In a glazing unit for aircraft or the like, the combination with a transparent pane forming part of said unit of a transparent electrically conducting film having a resistivity of the order of 100 ohms per square area on one surface of said pane, and a transparent electrically conducting film having a resistivity of the order of 100,000 ohms per square area on the opposite surface thereof.

2. In a glazing for an aircraft enclosure or canopy including at least one pane of glass, a transparent electrically conducting film having a resistivity of the order of 100 ohms per square area on an inboard surface of said glazing, and an electrically conducting coating having a resistivity of the order of 100,000 ohms per square area on an outboard surface thereof.

3. A sheet or plate having opposed vitreous surfaces, a transparent electrically conducting film of tin oxide of predetermined thickness and having a resistivity of the order of 100 ohms per square area on one of said surfaces, and a transparent electrically conducting film of tin oxide of substantially the same thickness as said first mentioned film but having a resistivity at least 10 times as great on said opposite surface.

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2,429,420	McMaster	Oct. 21, 1947
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