Dec. 16, 1969 H. E. SHAW, JR 3,484,584

COMBINATION OF ELECTRICALLY HEATED TRANSPARENT WINDOW AND ANTENNA

Filed July 23, 1968 3 Sheets-Sheet 1

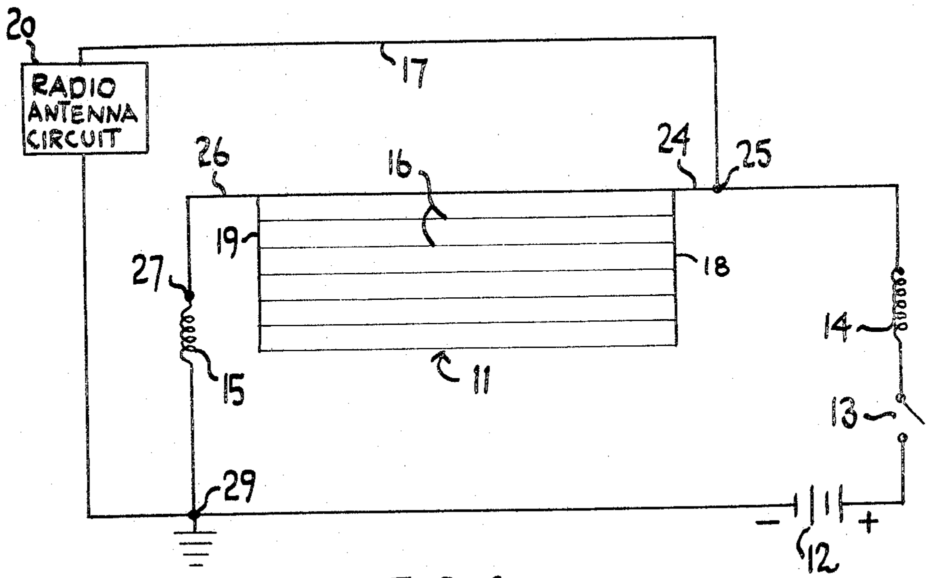

FIG. 1

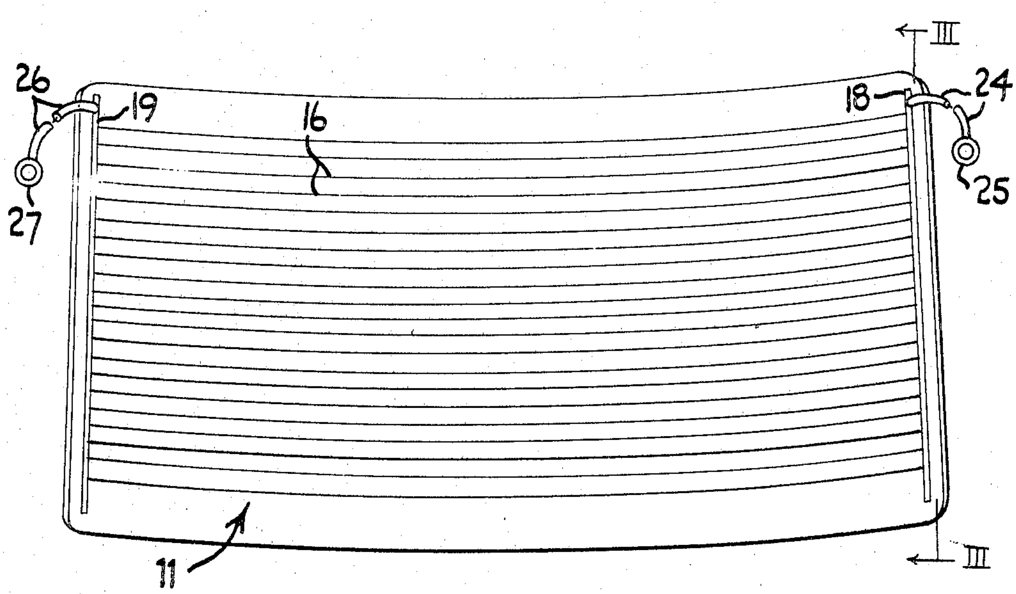

FIG. 2

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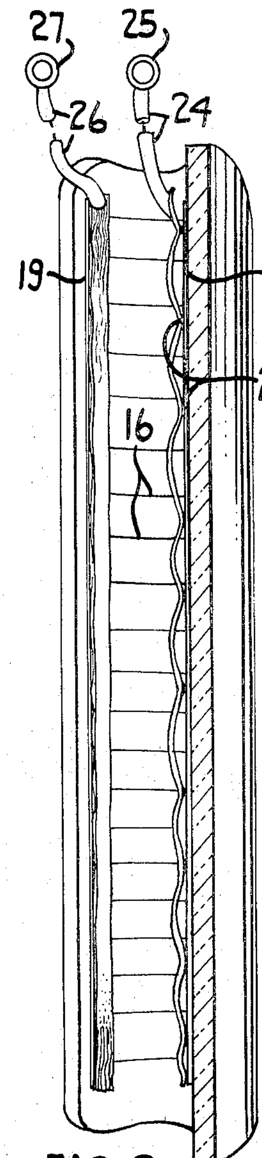

FIG. 3

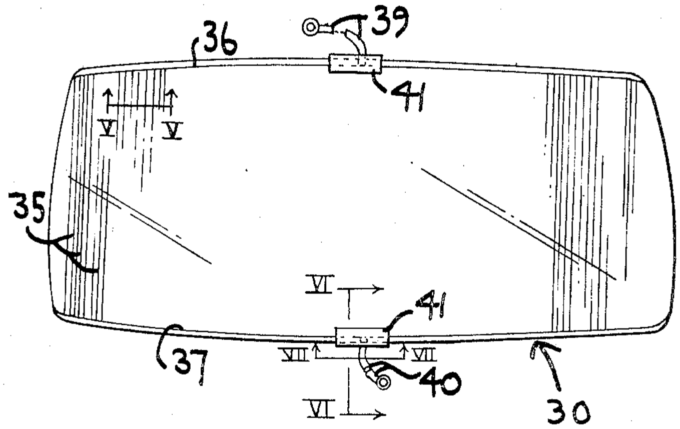

FIG. 4

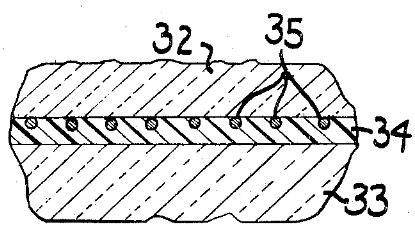

FIG. 5

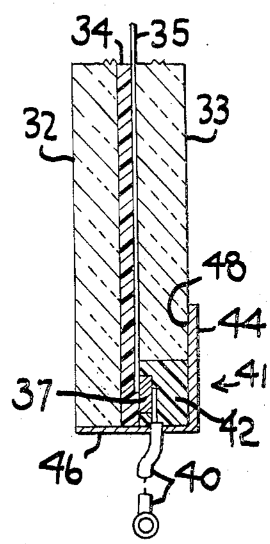

FIG. 6

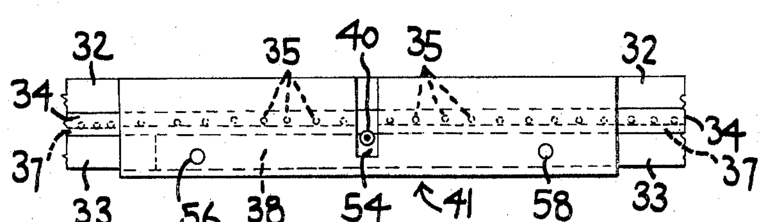

FIG. 7

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COMBINATION OF ELECTRICALLY HEATED TRANSPARENT WINDOW AND ANTENNA

Filed July 23, 1968 3 Sheets-Sheet 3

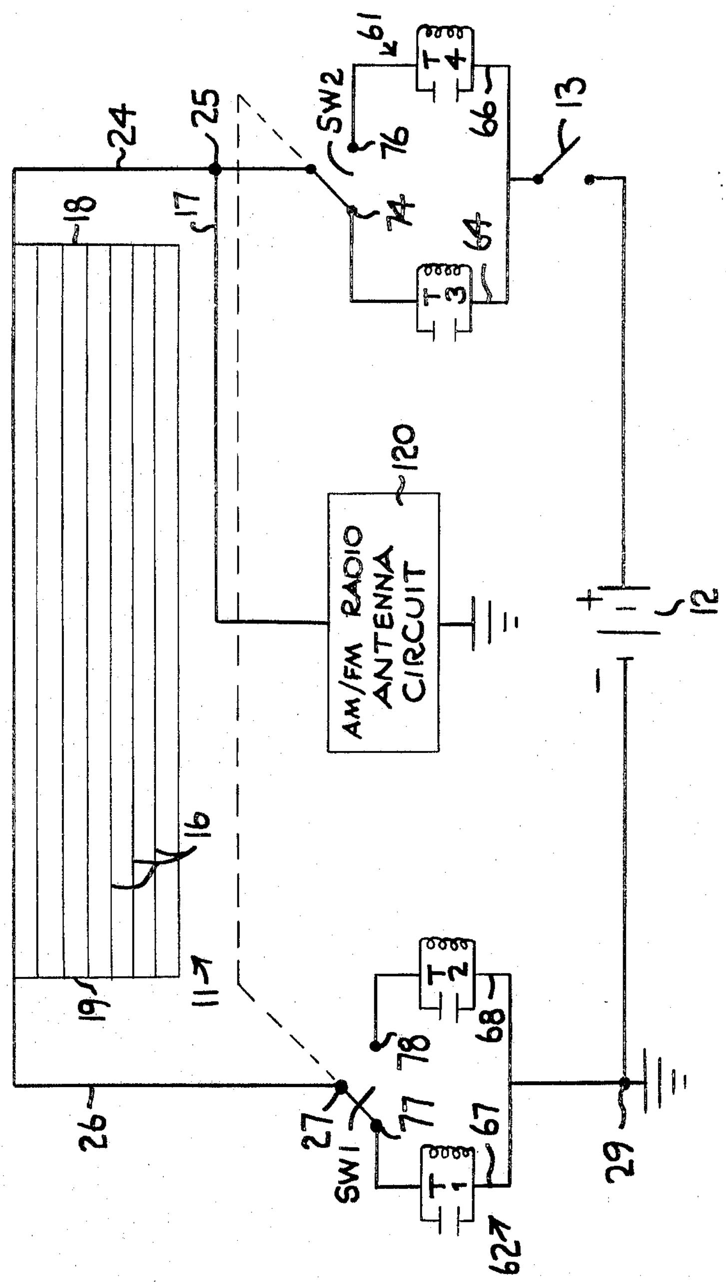

FIG. 8

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3,484,584

COMBINATION OF ELECTRICALLY HEATED TRANSPARENT WINDOW AND ANTENNA

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Filed July 23, 1968, Ser. No. 746,953
Int. Cl. H05b *3/06;* B60l *1/02*
U.S. Cl. 219—522 10 Claims

ABSTRACT OF THE DISCLOSURE

A combination antenna and heater, specifically adapted for use in an automobile. A heating circuit is connected between a pair of bus bars disposed adjacent the opposite edges of a heating area, such as all or part of a windshield or a rear window, preferably comprising an electroconductive element interconnecting the bus bars, is coupled to a direct current source. Means isolate the conductive element from ground, permitting the conductive element to serve also as an antenna for the automobile radio. The isolating means preferably are elements having low D.C. resistance and high impedance at radio frequencies.

The present invention relates to a combination antenna and heater. While the article described herein has particular use in an automobile window, and will be described in such an environment, it is understood that it is adaptable for use in any environment where it is desirable to have an article serve a dual function of heater and antenna.

It is well known to use a heating circuit in windows of automobiles or aircraft to remove fog or frost that forms on a window surface. If the window is laminated, the circuit comprises heating wires carried by a thermoplastic interlayer. The heating wires extend between a pair of bus bars that are disposed along opposite side edges of the area of the window to be heated. When an electric current is passed through the wires, they heat the area, thus removing any surface film of moisture or ice. It is also possible to apply a transparent, electroconductive film to one of the transparent sheets and use a current that is passed through the film to heat the sheet for the same purpose.

Monolithic glass or plastic transparent sheets suitable for use as windows have been used as surfaces for supporting electroconductive heating circuits. For example, a pair of bus bars interconnected by either spaced heating elements, such as metallo-ceramic lines matured onto a glass surface, or electroconductive metal oxide coatings formed by pyrolyzing a metal salt on a heated glass surface have been used as heating circuits on glass sheets and vacuum evaporated metal coatings and the like have been used on glass and transparent plastic sheets.

It has also been known to embed a wire or a series of wires or other conductive elements in the interlayer or on the surface of one of the sheets forming a laminated windshield of an automobile or an airplane and to connect them to a radio antenna circuit of a radio within the vehicle to provide an antenna. However, prior to the present invention, no attempt has been made to employ the same elements that are used for a heating circuit to serve a second purpose as an antenna. The reasons for this are obvious to any student of electricity. Radio waves which are received by an antenna must be effectively shielded from ground. The heating circuit of an automobile or an aircraft utilizes the vehicle body as a ground. Therefore, a conventional heating circuit that uses the vehicle body as part of the circuit would ground

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an antenna and prevent the reception of signals to a radio circuit.

Despite the obvious difficulties of having a circuit carried by a window serve both purposes simultaneously, the present invention has devised means for isolating the high-frequency radio signals from the vehicle frame and still permit the passage of direct current from the automobile battery supply system when desired without affecting the alternating current high-frequency signal and vice versa.

The invention will be better understood after the reader has studied a description of certain illustrative embodiments of the present invention which follows.

In the drawings which form part of the description, and wherein like reference numbers refer to like structural elements,

FIG. 1 is a schematic circuit diagram of a typical electrical circuit incorporating the gist of the present invention;

FIG. 2 is an over-all view of a monolithic glass sheet used as a curved rear window of an automobile, wherein the electroconductive circuit is supported directly on a glass surface of said rear window;

FIG. 3 is a sectional view taken along the lines III—III of FIG. 2;

FIG. 4 is an over-all view of an alternate embodiment of the present invention wherein the electroconductive circuit is carried by the interlayer of a laminated glass-plastic assembly typical of an automobile windshield;

FIG. 5 is an enlarged fragmentary sectional view of a portion of the laminated windshield of FIG. 4, showing how heating wires forming part of the electroconductive circuit are embedded in the interlayer of the laminated windshield;

FIG. 6 is an enlarged view taken along the lines VI—VI of FIG. 4;

FIG. 7 is an enlarged view taken along the lines VII—VII of FIG. 4, and

FIG. 8 is a schematic circuit diagram showing use of the heater-antenna combination in a vehicle provided with an AM–FM radio.

Referring to the drawings, an electroconductive circuit **11** is shown in FIG. 1. The circuit comprises a battery **12**, a switch **13**, a pair of low-DC resistance coils **14** and **15** interconnected to one another through an electroconductive element **16** comprising lines of electroconductive material.

A pair of bus bars **18** and **19**, extending across the opposite margins of the heating area, are in electrical contact with the opposite ends of the lines of electroconductive material **16**. In addition, a lead line **17** forms a branch from bus bar **18** to a radio receiver **20**.

A lead wire **24** connects bus bar **18** to a coupling **25**. An additional lead wire **26** connects bus bar **19** to an additional coupling **27**. Coupling **25** connects the lead wire **24** to two wires, one of which is the antenna lead wire **17** and the other of which is connected to the coil **14** and via the battery switch **13** to the hot terminal of the battery **12**. The latter is grounded at its negative terminal. It is also acceptable to reverse the polarity of the battery **12** so that battery switch **13** is connected to the negative terminal of the battery and its positive terminal is grounded.

In order to isolate the radio antenna from the ground (depicted as a terminal **29**), the coils **14** and **15** are interposed between both ends of the antenna heating circuit **11** and the ground. To accomplish this end, coil **14** is coupled to ground at its end remote from the end coupled to bus bar **18**, and coil **15** is grounded at its end remote from the end coupled to bus bar **19**.

While coils **14** and **15** have very small resistance to direct current, they have a large impedance to alternating current, particularly at radio frequencies. It will thus be seen that the coils **14** and **15** act as high impedances to isolate the radio antenna circuit from the ground for signals of radio frequency. However, when the battery switch **13** is closed, coils **14** and **15** present a very low resistance to the DC power feeding current into the heating wires **16** through the bus bars **18** and **19**. This permits the circuit **11** to serve as both a radio antenna and a heating circuit to remove moisture, such as fog or ice, from the surface of a window on which it has deposited.

Since the electromotive lines **16** and the bus bars **18** and **19** are preferably composed of a ceramic silver material, and the lead-in wires **24** and **26** are composed of a copper braid having a much higher coefficient of thermal expansion than the ceramic silver, it has been found most beneficial to spot solder the copper lead-in wires **24** and **26** at spaced intervals **28** along the length of the bus bars, leaving the copper wires sufficiently loose between the spaced solder points to enable the copper and the ceramic silver to change their dimensions at different rates in response to the changes of temperature that result from actuating or deactivating the heating circuit without inducing stress that weakens the bonds between the lead-in wires and the bus bars.

In commercial embodiments of the invention such as automobile rear windows or backlights, the resistance heating elements **16** and the bus bars **18** and **19** are formed of a typical ceramic conductive coating material comprising a highly conductive metal powder, such as silver, and a vitrifying binder. Typical ceramic conductive coating compositions which may be used may have the following compositions:

COMPOSITION I

Ingredient:	Percent by weight
PbO	7.5
B_2O_3	1.0
SiO_2	1.5
Flake silver	70.0
French fat oil	12.5
Turpentine	7.5

COMPOSITION II

Ingredient:	Percent by weight
Finely divided silver	72.6
PbO	9.3
SiO_2	1.7
B_2O_3	1.4
H_2O	7.5
Ethyl alcohol	7.5

COMPOSITION III

A typical commercial composition is a mixture containing 90 percent by weight of a ceramic silver composition sold under the trade name AB Silver by the O'Hommell Company of Carnegie, Pennsylvania, and 10 percent of a nonconducting mixture of metallic oxides sold under the trade name K 736 Black by the Ferro Corporation of Cleveland, Ohio.

The electroconductive stripes **16** form narrow lines approximately $\frac{1}{32}$ inch wide and the bus bars **18** and **19** form transversely extending rows interconnecting the ends of the stripes **16** in widths of ¼ inch. The silver ceramic mixture is preferably applied through a stencil to form the stripes **16** and the bus bars **18** and **19** by a process known as "silk screening" to form a pattern .0005 inches thick on a surface of an automobile rear window or backlight.

The particular material described has an electrical resistance of 0.35 ohms per linear inch along the electroconductive stripes **16** whereas the bus bars **18** and **19** so deposited have an electrical resistance of 0.04 ohms per linear inch along their length. When the backlight to be coated with such a design is rectangular or a quadrilateral having substantially straight and parallel upper and lower longitudinal edges, the elongated electroconductive heated stripes **16** are spaced about one inch apart and are parallel to one another and straight. When the upper and lower edges of the backlight are bowed or are of different configurations from one another, automotive stylists prefer the elongated electroresistant heating stripes **16** to extend between the opposed bus bars **18** and **19** in slightly changing paths, the uppermost stripe conforming in curvature substantially to the curvature of the upper longitudinal edge of the backlight and the lowest elongated electroconductive heated stripe conforming to the shape of its lower edge.

The ends of adjacent stripes **16** at their points of contact with the bus bars are spaced approximately one inch from the adjacent stripe connected to the same bus bar and the configuration of the intermediate stripes is graduated from stripe to stripe to provide a gradual change from the configuration of the uppermost stripe to that of the lowest stripe. The heating pattern resulting from subjecting the opposite bus bars **18** and **19** to a potential difference of 12 volts results in a substantially uniform heating pattern of about 25 to 30 watts per square foot throughout the entire extent of the vision area of the backlight.

To protect the heating element and bus bars from excessive exposure to atmospheric conditions, the stripes **16** and bus bars **18** and **19** are all applied to the inner surface of the backlight when installed. Under such circumstances, no protective coating has been found necessary.

The stripes **16** and the bus bars **18** and **19** are applied simultaneously through the silk screening technique described previously. The coated glass sheet is then mounted on a bending mold having an outline shaping rail of concave elevation conforming in elevation and outline but of slightly smaller area than the glass sheet after bending.

The glass laden mold is introduced into a furnace where the glass is heated to a temperature sufficient to sag the glass sheet into conformity to the mold shaping surface. During this heating, the finely divided metal ceramic frit fuses onto the glass surface which faces upward and which becomes curved concavely during the bending operation. When the glass bending is completed, the glass sheet is removed from the hot atmosphere and chilled as rapidly as possible to produce a tempered glass sheet. Since the stripes **16** and the bus bars **18** and **19** have fused onto the upper, concave glass surface during the heating operation, they remain in the exact configuration in which they were applied to the cold glass through the stencil in the silk screening process when the glass is chilled.

Preferably, each lead-in wire is a flat copper braid of sufficient current carrying capacity, such as the equivalent of No. 14 solid copper wire, to minimize any loss of power in the bus bars which result in heated bus bars rather than the heat being dissipated throughout the extent of the stripes **16**. The free ends of the lead-in wires **24** and **26** are loosely laid over the attached ceramic silver bus bar **18** or **19** and attached to its adjacent bus bar by spaced solder connections **28**, preferably at about 2 inch intervals. For example, a flat tin copper braid sold as Preparation No. 1231, equivalent to No. 14 AWG, made by the Alpha Wire Corporation of Elizabeth, N.J., is soldered to the ceramic silver bus bars **18** and **19** using a tin-lead-silver solder containing 70 percent by weight of lead, 27 percent of tin and 3 percent of silver, sold by the Belmont Smelting and Refining Company of Brooklyn, N.Y. as No. 5701 solder. A suitable flux for the solder is sold under the trade name Nokorode solder paste made by the M. W. Dunton Company of Providence, R.I.

The multiple attachments of the lead-in wires to each of the bus bars reduces the length of the current path through any part of the bus bar to a reasonable distance which does not cause undue loss of electrical energy to heat the bus bars. The looseness of the attachment of the lead-in wires to the bus bars permits the lead-in wires to extend loosely between the spaced connections **28**. At the same time, only the portions of lead-in wires **24** and **26** that are not disposed over the bus bars **18** and **19** are covered with insulation **30**. This increases the area of contact between the lead-in wires **24** and **26** and the bus bars **18** and **19** to reduce the heat loss in the bus bars even further, thus enabling the heating elements **16** to provide as large a proportion of the total resistance of the heating circuit as possible.

As stated previously, the use of the high impedance, low-resistance coils **14** and **15** in the circuit as depicted in FIG. 1 isolates the radio antenna circuit from ground at radio frequencies. Thus, whenever the radio receiver is operated, the coils **14** and **15** isolate the radio antenna circuit from ground and permits the circuit **11** comprising bus bars **18** and **19** and the electroconductive elements **16** to serve as a radio antenna by its connection to the radio antenna circuit **20** through the antenna wire **17**, regardless of whether the circuit **11** is connected to the battery **12** by closing the battery switch **13**.

The embodiment depicted in FIGS. 4 to 7 shows a laminated windshield **30** comprising a first glass sheet **32**, a second glass sheet **33** and a thermoplastic interlayer **34** of a material such as plasticized polyvinyl butyral bonded between the glass sheets. Electroconductive wires **35** of a material such as nichrome or tungsten or the like are embedded on the surface of the plastic interlayer **34** and extend between a pair of electrodes or bus bars **36** and **37** extending adjacent the opposite elongated side edges of the area of the interlayer **34** to be heated.

The glass sheets **32** and **33** and the interlayer **34** have matched curvatures and substantially identical outlines except for a notched portion **38** along each longitudinally extending side margin of the glass sheet **33**. The notched portion has a laterally dimension sufficient to enable it to extend laterally inward of the inner boundary of the bus bar **36** or **37**.

Wires **35** have a small diameter, .0002 inch to .002 inch being preferred. They are arranged in parallel, substantially equi-distant, arrangement, about 8 to 12 to the inch, and extend from bus bar **36** to bus bar **37**. The bus bars are preferably thin strips of conductive metal, such as copper, superimposed over the opposite ends of the wires **35**. The copper strips are about $\frac{5}{16}$ inch wide and about .005 inch thick and extend with their outer sides about $\frac{1}{16}$ inch inside the windshield margin.

An angle member **41** of moisture-impervious material, such as a thin bent sheet of aluminum, encloses the notched portion **38** to form a chamber that is filled with a resin **42**, as will be described later. Member **41** comprises a solid wall **44** parallel to a major surface of the laminated windshield **30** and an apertured, slotted wall **46** disposed at an angle to the solid wall **44** to engage the edge surfaces of glass sheets **32** and **33**. A layer of pressure sensitive adhesive **48** is located on the inner surfaces of the walls **44** and **46**. The angle member **41** is slightly longer than the notched portion **38**, with solid wall **44** slightly higher than the width of the notched portion and apertured slotted wall **46** having a width substantially equal to the thickness of the laminated windshield **30**.

Bus bars **36** and **37** are adhered by pressure and an adhesive comprising a thin film of polyvinyl butyral dissolved in chloroform along the length adjacent the opposite sides of the interlayer including the portion of the interlayer that faces the notched portions **38**. Each bus bar **36** or **37** has a width slightly less than that of the notched portion so that its outer edge is recessed within the outer edge surface of the portion of the glass sheet **32** that faces the notched portion **38** adjacent thereto.

A lead-in wire **39** similar to lead-in wire **24** is soldered to bus bar **36** within the notched portion **38** along the upper edge of the windshield **30**, while a lead-in wire **40** similar to lead-in wire **26** is soldered to the bus bar **37** within the notched portion **38** along the lower longitudinal edge of the windshield **30**. The lead-in wires **39** and **40** are encased with insulation except for their free inner ends. The uninsulated free ends are soldered to the bus bars **36** and **37**, respectively. The electroconductive wires **35** have their ends in electrical contact with the bus bars **36** and **37**. Therefore, the bus bars **36** and **37** serve as means to connect the lead-in wires **39** and **40** to the antenna or heating wires **35**.

The chamber, defined by the notched portion **38**, is filled with a filler **42** of moisture-resistant, electrically insulating material. This may be a preformed member of an insulation material such as a fiber glass reinforced resin coated with a pressure sensitive adhesive, for example. However, such a preformed member must conform exactly in shape to that of the notched portion **38** containing the lead-in wire to bus bar connection. The technique to be described immediately below has been found to be most suitable for insulating the exposed wires and their connecting means from electrical contact with the metal frame during a test simulating mass production.

With particular emphasis on FIGS. 6 and 7, the apertured slotted wall **46** is provided with a centrally disposed slot **54** of just sufficient width to provide clearance to enable the angle member **41** to fit over the lead-in wire **39** or **40** when the angle member is applied against the central portion of one of the edges of the windshield to encompass the notched-out portion **38** of the notched glass sheet. In addition, apertures **56** and **58** are provided in the apertured slotted wall **46**. One of the apertures is used for injection molding a rapidly setting resin of electrical insulation material, while the other aperture and the slot **54** permit air to escape from the chamber when the resin is injected.

The article described above is made in the following manner. A pair of glass sheets **32** and **33** are mounted in superimposed relation with a suitable parting material disposed between the sheets. Sheet **33** having the notched-out portions **38** is disposed below sheet **32**. The two glass sheets are usually made of plate glass or float glass of commercial soda-lime-silica composition. The two sheets are superimposed in the manner recited in bending relation to a glass bending mold having an upward facing outline shaping surface of concave contour in elevation. The glass laden mold is exposed to sufficient heat to cause the glass sheets to conform to the upward facing shaping surface of the bending mold.

After the sheets have bent to the desired curvature and cooled according to a controlled pattern of cooling, they are removed from the bending mold and are assembled to form a sandwich with a sheet of plasticized polyvinyl butyral having the antenna wires embedded therein with excess wire extending from the plastic. The wires are embedded in the plastic sheet **16** by a battery of hot needles. A typical technique for sewing a thin wire into a sheet of insulating material, such as the plastic interlayer sheet **34**, is shown in U.S. Patent No. 2,813,960 to Egle and Bethge. While the wires **35** are shown as extending in straight lines, they may be sewn in sinuous configuration to reduce any diffraction patterns if desired.

After the glass-plastic sandwich has been assembled with the bent glass sheets on opposite sides of the wire-containing plastic interlayer, the assembly is subjected to a commercial laminating operation. A suitable operation is described and claimed in U.S. Patent No. 2,948,645 to Laurence A. Keim, assigned to PPG Industries, Inc. This laminating method comprises first enclosing the periphery and margin only of the assembly within a flexible, channel-shaped member made of a fluid-impervious material to form a conduit adjacent the periphery of the interfaces between the interlayer and the bent glass sheets, evacuating air from the conduit to remove air from between the interlayer and the glass sheets, continuing the evacuation while heating the enclosed assembly in a furnace at a temperature between about 150 degrees Fahrenheit and 350 degrees Fahrenheit with the furnace at substantially atmospheric pressure, removing the channel-shaped member when the marginal portion is bonded, and subjecting the assembly to a final lamination at a pressure of between about 100 and 250 pounds per square inch at a temperature between about 190 and 325 degrees Fahrenheit until the entire area of the assembly is clear.

After the assembly is laminated, it is cleaned with particular care being taken to remove oil from the notched portion of the assembly in case the final laminating step is performed in an oil autoclave. Any excess plastic is trimmed and the plastic edge sealed more intimately to the glass surfaces by edge rolling. U.S. Patent No. 2,999,779 to John W. Morris shows a typical edge rolling process and apparatus. Then, the lead-in wire **39** or **40** is carefully soldered to the exposed surface of bus bar **37**.

The angle member **41** is then adhered by the pressure sensitive adhesive **48** to abut against the windshield **11** and completely cover the notched portion **38**. In doing so, the slot **54** slides around the lead-in wire **39** or **40** to form the chamber defined by the notched portion **38**. Suitable adhesives include plasticized polyvinyl butyral, and any of the following commercially available materials sold under the following trade names by the following corporations: Poly EM sold by Gulf Oil Corporation of Pittsburgh, Pennsylvania; Eastman 910 sold by Eastman Kodak Corporation of Rochester, N.Y.; and Tackmaster 1477 sold by PPG Industries, Inc. of Pittsburgh, Pa.

The angle member **41** is preferably formed of any material that is moisture impervious. Thin aluminum sheeting has been found to be quite suitable. For a typical notched portion 2 inches long and about 0.4 inch wide, a partially tempered, flat aluminum sheet 3½ inches long and ¾ inch wide is perforated to form the apertures **56** and **58** and the slot **54** and then bent along an axis extending lengthwise of the sheet to form a slotted, apertured wall **46** having a width of ¼ inch and a solid wall **44** having a width of ½ inch. Other suitable materials are lead foil tape, copper sheeting, and the like.

After the windshield has passed an optical inspection and the angle member **41** has been secured to the windshield **30** to convert the notched portion **38** into an enclosed chamber, the windshield is oriented with holes **56** and **58** of the angle member **41** facing upward and the filler **42** of electrical insulator material is injection molded through one of the apertures **56** or **58** of the angle member **41**. A rapidly curing, water-resistant reisn is used, such as polysulfide resin called Thiokol sold by the Thiokol Chemical Corporation, Bristol, Pa., or a room temperature vulcanizable silicone, such as 615 RTV silicone supplied by General Electrical Company, Schenectady, N.Y., or Scotchcast 225 electrical resin sold by Minnesota Mining and Manufacturing Company, St. Paul, Minn. Any filler material having the ability to set within 24 hours is termed a "rapid setting" material for the purposes of filling the chamber with insulation.

When excess resin flows out through the other aperture **58** and the centrally disposed slot **54**, the chamber enclosed by the walls **44** and **46** of the angle member **41** is completely filled with resin **42**. Any excess resin that is inserted in a chamber oriented with its apertures facing upward forms small mushroom-shaped domes that mechanically lock the angle member in place. The resin provides sufficient insulation to insulate the free uninsulated end of the insulated lead-in wire **39** or **40** as well as the connecting means comprising the bus bar and the heating wires from any electric connection with the metal of the automobile body in which the windshield is to be installed.

A second injection molding operation is preferably conducted to fill the opposite notched portion after soldering the other lead-in wire **40** or **39** to bus bar **36** or **37**, respectively and after the laminated windshields have been mounted on a shipping pallet for shipping with the windshields oriented so that the opposite notched portion **38** to be filled with resin faces upward. The materials suitable for the filler have a short pot life on the order of a few hours, subject to variation depending on the choice and quantity of accelerator used as explained in the literature of the suppliers of these materials. After 24 hours, these materials are sufficiently set so that the windshields can be transported without danger of the system losing its moisture-resistant characteristics. It is necessary that the racks be stored for sufficient time for the resin to set before the windshields in the pallet are installed. To be on the safe side, each rack containing a number of windshields is permitted to stand overnight after the injection molding operations take place to ensure that the resin is set before the rack of windshields is shipped.

In a typical circuit for an AM and/or FM radio conforming to the present invention using a 12 volt system for an automobile and a heating area about 24 inches by 48 inches, wherein the bus bar to bus bar resistance is about 0.8 ohms, coils **14** and **15** are radio frequency chokes composed of air wound coils of insulated varnished coated number 15 copper wire wound in 2 layers having about 150 turns along a length of about 6 inches.

In automobiles provided with FM radios only, it has been found that the heating circuits **11** behave as antennas for the FM radios even in the absence of the coils **14** and **15**. The wiring in the system can provide sufficient inductance to isolate the FM radio antenna circuit from ground sufficiently to receive signals from FM stations.

Since many automobiles are provided with AM-FM radios, in order to provide a complete disclosure, FIG. 8 shows an alternative embodiment of a circuit that incorporates a combination heater and antenna for AM-FM radios for automobiles. According to the present invention, FIG. 8 represents an electrical circuit that isolates the radio antenna circuit from the ground while allowing the antenna to serve as a heater when subjected to direct current, as in the first embodiment, and incorporates means to switch wave bands.

The heating and antenna circuit **11** of FIG. 8 comprises elongated electroconductive elements **16** connected in parallel between bus bars **18** and **19** as in FIG. 1. The antenna lead wire **17** connects the elements **16** to an AM-FM radio antenna circuit **120** through the bus bar **18** and is isolated from ground by a slightly different arrangement than that depicted in FIG. 1.

The grounded battery **12** has its positive terminal coupled through an AM-FM switching circuit **61** to bus bar **18**, which also is connected to the antenna lead wire **17**, while the grounded terminal of battery **12** is coupled to bus bar **19** through another AM-FM switching circuit **62** and the grounded connections to the body of the automobile.

Switching circuit **61** comprises a tuner **T3** permanently tuned broadly to the middle of the AM band in one parallel branch **64** and another tuner **T4** permanently tuned broadly to the middle of the FM band in another parallel branch **66**. Switching circuit **62** comprises a tuner **T1** permanently tuned broadly to the middle of the AM band in one parallel branch **67** and another tuner **T2** tuned broadly to the middle of the FM band in another parallel branch **68**.

Each of the tuners **T1** through **T4** comprises an inductance and a capacitance of selected size for the tuning desired arranged in parallel. For example, tuners **T1** and **T3** for AM tuning tuned for 1000 kilocycles per second may comprise a capacitor of 51 micromicrofarads of capacitance in parallel with a coil having 500 microhenries of inductance while the FM tuner circuits **T-2** and **T-4** tuned for 100 megacycles per second may comprise a capacitor of 12.7 micromicrofarads capacity in parallel with a coil having an inductance of 0.2 microhenries or may consist of a wire having the requisite inductance at the desired frequency.

Switch SW–1 has a contact **77** for connecting tuner circuit T–1 in branch **67** to bus bar **19** and a contact **78** to connect tuner circuit T–2 in branch **68** to bus bar **19**. Switch SW–2 has a contact **74** for connecting tuner circuit T–3 in branch **64** to bus bar **18** and another contact **76** to connect tuner circuit T–4 in branch **66** to bus bar **18**. The two switches SW–1 and SW–2 are mechanically coupled to simultaneously connect both of the AM tuning circuits T–1 and T–3 to bus bars **19** and **18**, respectively, through contacts **77** and **74**, respectively, in one position when the radio **120** is tuned to an AM wavelength. When the switches SW–1 and SW–2 are switched to contacts **78** and **76**, respectively, the FM tuning circuits T–2 and T–4 in branches **68** and **66**, respectively, replace the AM tuning circuits T–1 and T–3 in the circuits that connect to the bus bars. The tuning circuit arrangement thus isolates from ground the radio antenna circuit regardless of whether the radio **120** is tuned to the AM or FM broadcast band.

In this embodiment, each pair of tuning circuits, either the one comprising AM tuning circuits T–1 and T–3 or the one comprising FM tuning circuits T–2 and T–4, serve the same function as the coils **14** and **15** in the FIG. 1 embodiment. Switching the switches SW–1 and SW–2 in unison enables the radio to receive signals in either the AM broadcast band or the FM broadcast band through the electroconductive circuit **11** which is effectively isolated from the ground.

While the tuner circuits of the FIG. 8 embodiments have been described as having fixed tuning, it would be a simple matter to make use of adjustable inductances and/or adjustable capacitors capable of tuning to the exact frequency to which the radio is tuned. Under such circumstances, the radio listener adjusts the tuning circuits T–1 and T–3 or T–2 and T–4 in unison to obtain maximum impedance which results in maximum strength of signal received. More specifically, branches **67** and **64** may contain adjustable tuning devices T–1 and T–3 suitable for the AM band, while branches **68** and **66** contain adjustable tuning devices T–2 and T–4 suitable for the FM band. This adjustable tuning enables the antenna to receive a strong signal for the radio receiver at any frequency in its respective wave band as long as the tuning devices are properly tuned and the switching devices SW–1 and SW–2 are suitably switched to the proper band (AM or FM) desired.

In most locations, coils **14** and **15** are suitable for AM reception without any adjustment. The FIG. 8 embodiment is usually sufficient to obtain a signal that is equivalent to that received by a typical pole antenna in its retracted position. The FIG. 8 embodiment, when properly tuned using adjustable reactances and/or capitances in the respective tuning circuits, develops a signal equivalent to that obtained by partially extending the pole-type antenna presently used.

While the devices described above disclose the use of a pair of fixed impedance chokes, tuned chokes and tuned circuits for isolating the radio antenna circuit from the source of potential for the heater circuit, it is understood that other systems are also possible to enable an electroconductive element to serve as both an antenna at radio frequencies and an electroresistant heating element of a direct current circuit. For example, the 12 volt battery operated system may be grounded by a separate bus bar that is insulated from the metal vehicle body which serves as a ground for the antenna or if the automobile body is a non-conductor electrically, such as one made of fiber glass, a wire radio antenna ground may be insulated electrically from a separate wire ground for the battery-operated direct current system.

The form of the invention shown and described in this disclosure represents certain preferred illustrative embodments thereof. It is understood that various changes may be made, such as using a glass sheet surface rather than the interlayer to support the electroconductive elements in a laminated glass unit or orienting the electroconductive elements in any orientation desired regardless of the monolithic or laminated nature of the window, for example, without departing from the spirit of the invention as defined and claimed in the subject matter which follows.

What is claimed is:

1. In combination, a transparent window having an area to be heated, an electroconductive circuit comprising a pair of spaced bus bars extending adjacent a spaced pair of opposite side edges of said area, and an electroconductive element interconnecting said bus bars, a lead-in wire connected to each of said bus bars, and electrical isolating means having high impedance to alternating current at radio frequencies and small resistance to direct current coupled to each of said lead-in wires, said combination serving as a combination antenna and window heater when one of said electrical isolating means is grounded and the other of said electrical isolating means is coupled to a D.C. source, and a radio antenna circuit is electrically connected in parallel to a circuit comprising said electroconductive circuit and said grounded isolating means.

2. The combination as in claim **1**, wherein said electroconductive element interconnecting said bus bars comprises a series of substantially parallel lines of electroconductive material.

3. The combination as in claim **1**, wherein said bus bars and said lines of electroconductive material are attached to a surface of said window.

4. The combination as in claim **3**, wherein said window is composed of a monolithic glass sheet.

5. The combination as in claim **2**, wherein said window comprises a pair of glass sheets laminated to opposite sides of a transparent, thermoplastic interlayer and said lines of electroconductive material are supported by said interlayer.

6. The combination as in claim **2**, wherein said bus bars extend in directions transverse to the length of said area along the opposite longitudinal edges of the area and said lines of electroconductive material extend substantially lengthwise of said area.

7. The combination as in claim **2**, wherein said bus bars extend substantially lengthwise of said area along the opposite lateral edges of the area and said lines of electroconductive material extend transversely of said area.

8. The combination as in claim **1**, further including means to adjust said high impedance means in response to the wave length at which said radio is tuned.

9. The combination as in claim **1**, each of said isolating means including parallel branches tuned to the AM and FM frequency band, respectively, and means for simultaneously switching from one of said parallel branches to the other of said parallel branches of each of said isolating means so that one branch of each of said isolating means is simultaneously tuned to the same frequency band as a corresponding branch of the other of said isolating means.

10. In combination, a transparent window having an area to be heated, an electroconductive circuit comprising an electroconductive element facing said area, and a source of potential of sufficient magnitude to defog said area when connected to said electroconductive circuit, a pair of electrical isolating means comprising an isolating means connected to each side of said electroconductive element, electrically conductive means to connect said electroconductive element in series to said source through said pair of electrical isolating means to form a heating circuit, electrically conductive means to connect said electroconductive element to a radio antenna circuit in such a manner that said radio antenna circuit is in parallel to said electroconductive element and one of said electrical isolating means, said electrical isolating means electrically isolating said radio antenna circuit from said source of potential to enable said electroconductive element to serve simultaneously as a heater and as an antenna.

References Cited

UNITED STATES PATENTS

2,787,696	4/1957	Karp et al.	219—203
2,806,118	9/1957	Peterson	219—203
2,947,841	8/1960	Pickles et al.	343—704 X
2,992,313	7/1961	Taylor	343—704 X
3,409,759	11/1968	Boicey et al.	219—522

FOREIGN PATENTS

730,131	1/1943	Germany.	

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