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LAMINATED WINDSHIELD WITH RADIO ANTENNA

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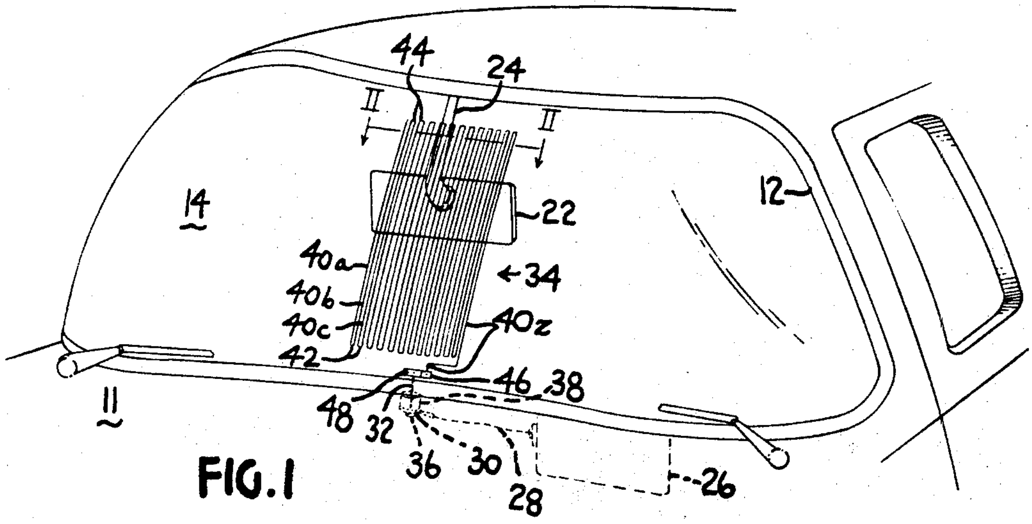
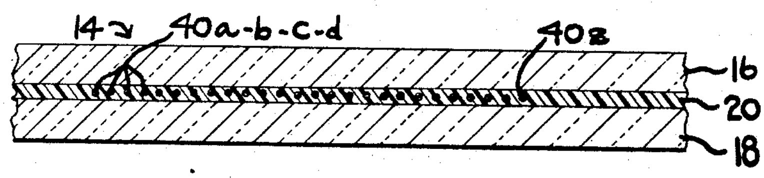


FIG. 1

FIG. 2



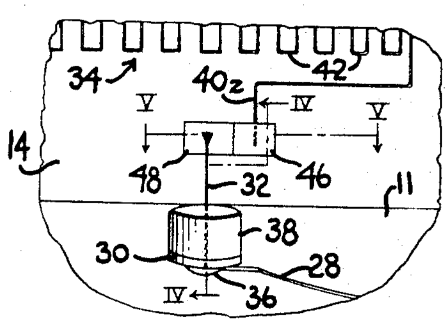


FIG. 3

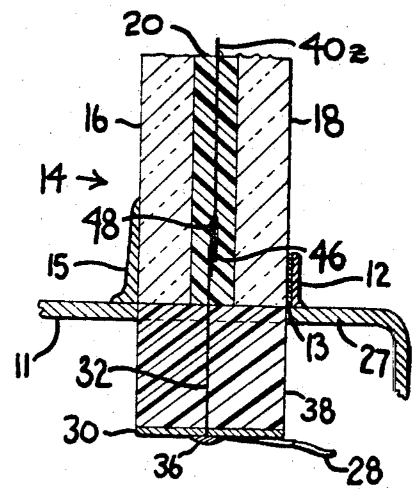


FIG. 4

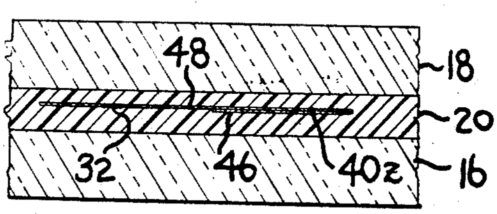


FIG. 5

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LAMINATED WINDSHIELD WITH RADIO ANTENNA

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ABSTRACT OF THE DISCLOSURE

An automobile windshield carrying an antenna comprising electroconductive wire occuping an area having a substantially larger vertical dimension than a horizontal dimension. The antenna is arranged as a plurality of parallel wire elements constituting a major portion of the length of said wire and extending in substantially vertical planes. The area is centrally located so that it is spaced from the windshield margin by sufficient distance to minimize any capacitance effect between the antenna and the metal of an automobile body in which said windshield may be installed.

This invention relates to a combination automobile window and radio antenna. While the embodiment described herein refers to a receiving radio antenna mounted in an automobile windshield, the principles of the present invention are equally adapted for employment as a transmitting or receiving radio antenna for any laminated window or monolithic sheet in an automobile. Windows which may be revised to produce combination antenna windows according to this invention include backlights, side lights, vent panes and combination windows and roof panels having sufficient vertical extent to carry the novel antenna of the present invention.

A specific embodiment illustrating the present invention comprises a laminated automobile window that includes two glass sheets and an interlayer of electrically nonconductive thermoplastic material bonded to one another to provide a transparent window and an antenna carried by the interlayer between the glass sheets. The radio antenna of the illustrative embodiment is preferably a continuous length of electroconductive material (wire or printed circuit) having substantially its entire length arranged vertically in such a manner that it provides sufficient reception or transmission of radio signals in all directions.

For some time automobile stylists have been interested in eliminating the conventional telescoping radio antenna employed for many years in radio equipped automobiles. However, past attempts to make antennas by incorporating coatings or wires as part of the windshield of an automobile have not been successful. The reason for this lack of success was the failure of the prior art to comply with one or more of the requirements for a good antenna enumerated below.

In order to provide sufficient reception or transmission of radio signals, a radio antenna should comprise an electrically conducting material of sufficient length to constitute about one-fourth of the wave length being received. Commercial radio stations broadcast at frequencies of 550 to 1600 kilocycles. To receive frequencies at the lower end of this range efficiently, theoretically an antenna more than 100 feet long should be employed. However, an antenna of such length is impractical for automotive use.

The theoretical length mentioned above is not necessary if a capacitor is connected in series with the automobile antenna and electrically coupled to the radio in properly tuned relation. Such capacitor connection increases the effective electrical length of a conventional antenna to

such an extent that telescoping antennas presently used provide satisfactory reception in lengths ranging from a minimum of about two feet to a maximum of about 4 feet 8 inches. Most automobile radios operating in metropolitan areas receive radio signals efficiently over the full range of commercial broadcasting frequencies when the conventional antenna connected in series with a capacitor is extended to a length of between 30 and 40 inches.

A recent attempt to provide a combination laminated windshield and antenna is found in U.S. Patent No. 3,208,070 to James Boicey, which issued on Sept. 21, 1965. The radio antenna element of this windshield comprises a plurality of parallel wires extending horizontally in the upper portion of the windshield where the interlayer is shaded to minimize any obstruction to the vision of an occupant of the automobile. Unfortunately, there are several drawbacks to this construction which precludes its efficient operation.

One drawback is that this type of antenna is incapable of receiving radio signals with equal efficiency when the windshield is turned to different orientations with respect to the direction from which the radio signal is received. When automobiles containing windshields of this type are oriented so that the horizontal wires are disposed in a direction normal to the direction from which the radio signals are approaching, reception is excellent. However, when the antenna wires are oriented in a direction parallel to the direction from which the signals are received, an unsatisfactory signal results.

Another drawback to the patent antenna windshield combination described above is that the wires forming the antenna are located sufficiently close to the body of the automobile so that the large mass of metal constituting the body of the automobile, which serves as the ground for the radio as well as other electrical circuits within the automobile, causes the metal of the automobile body to shield the antenna wires electrically and thus prevents the wires from functioning efficiently as an antenna.

According to the present invention, the wire constituting the antenna is located a sufficient distance from the metal of the automobile body to preclude the possibility of the antenna and the automobile metal from acting as a capacitor and thus interfering with reception or transmission of the radio signal. The lead from the antenna to the radio must be suitably insulated from the metal of the automobile body to prevent grounding of the antenna.

The wire constituting the electroconducting element of the antenna according to the illustrative embodiment of the present invention is arranged as a plurality of parallel wire elements constituting the major portion of the length of the wire. The wire elements extend in substantially vertical planes from an upper extremity spaced inward of an upper edge of the window to a lower extremity spaced inward of the lower edge of the window. A lead wire of electroconductive material is connected at one end to the antenna and extends from within the window to outside the window. An electrode is connected to the other end of the lead wire. The lead wire and the electrode are insulated electrically from the metal of an automobile body in which the window is installed.

More specifically, the antenna wire consists essentially of a plurality of parallel wire of filamentary elements electrically connected in series by interconnecting adjacent elements to one another at alternate extremities thereof to provide a square wave pattern elongated in its vertical dimension. The wire elements are considerably longer than their spacing from their neighboring elements. The spacing is considerably greater than the thickness of the wire. The wire is sufficiently thin to be essentially invisible to an automobile occupant when the antenna is installed in an automobile window. The wire elements occupy an area having a substantially larger vertical dimension than horizontal dimension. A substantial portion of the area occupied by the wire elements is aligned with a rear view mirror of the automobile when the window is installed as a windshield for the automobile.

For the purpose of definition, the term "wire" as used in this specification includes any electroconductive material applied in the form of a filament such as metallic paint and the like. The "wire" is located between the glass sheets and may be either embedded within the plastic or applied to any of the interfacial surfaces between the plastic and the glass.

In case of antennas formed on monolithic windows, the "wire" is applied directly to the glass surface in the manner conventionally employed to produce ceramic silver or ceramic gold bus bars for transparent electroconductive coatings for aircraft windows. Such bus bars and their method of application are disclosed in U.S. Patent No. 2,648,754 to William O. Lytle. The "wire" of the present invention is, of course, considerably thinner than the conventional bus bar of this patent.

The invention will be readily understood in the light of a description of an illustrative embodiment 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 perspective view of a combination windshield and antenna constructed according to the present invention shown mounted in an automobile with the decorative outer trim removed to show an element of the illustrative embodiment;

FIG. 2 is a fragmentary sectional view taken along the lines II—II of FIG. 1;

FIG. 3 is an enlarged view of the element of the device shown in FIG. 1;

FIG. 4 is an enlarged section along the lines IV—IV of FIG. 3, and

FIG. 5 is an enlarged section along the lines V—V of FIG. 3.

Referring to the drawings and particularly to FIG. 1, reference number **11** refers to a metal automobile body having a windshield frame **12** into which a windshield **14** is installed and secured into place by an adhesive layer **13** (FIG. 4). A decorative strip **15** of metal trim extends around the margin of the outer surface of the windshield. The drawings other than FIG. 4 omit this decorative strip to facilitate the showing of features of the antenna that must be described for a complete understanding of the present invention.

The windshield **14** is of the laminated type and comprises a pair of glass sheets **16** and **18** and an interlayer **20** of electrically nonconductive thermoplastic material, such as plasticized polyvinyl butyral. A rear view mirror **22** is mounted on a mounting bracket **24** suspended from the roof of the automobile directly behind the central portion of the windshield **14**.

A radio **26** is mounted in the automobile in the usual position below the dash board **27**. An insulated cable **28** connects the radio to an electrode **30**. The latter in turn is electrically connected to a lead wire **32**, which is preferably of braided copper wire. The other end of lead wire **32** is connected to a wire antenna **34** in a manner to be described later.

Solder connections **36** are provided between the insulated cable **28** and the electrode **30** and also between the electrode **30** and the end of the lead wire **32**. However, the exact manner of connection is not an element of the present invention and other types of connections, such as a plug and socket joint may be used to electrically connect insulated cable **28** with lead wire **32**.

In order to insulate lead wire **32** from the automobile metal, the lead wire **32** is surrounded by a sleeve **38** of electrically non-conductive material, such as polyvinyl butyral, in the portion of the wire that extends outward

from the edge of the window **14** through the metal body **11** of the automobile.

The wire antenna **34** comprises a plurality of parallel wire elements **40***a*, **40***b*, **40***c*, etc., which extend in substantially vertical planes from an upper extremity spaced inward of the upper edge of the window **14** to a lower extremity spaced inward of the lower edge of the window. The wire antenna **34** is preferably of fine electroconductive copper wire having a diameter not exceeding .002 inch. This thickness renders the wire essentially invisible to an automobile occupant when installed in an automobile.

The wire elements are electrically connected in series by interconnecting adjacent wire elements to one another at alternate extremities thereof. For example, connecting element **42** interconnects the lower ends of wire elements **40***a* and **40***b*, connecting element **44** interconnects the upper ends of wire elements **40***b* and **40***c*, and this alternation of lower and upper connections is repeated across the antenna.

In this manner, the wire elements form an elongated continuous wire or filament having the shape of an elongated squared sine wave. The wire element **40***z* at the opposite longitudinal extremity of the wire from that occupied by the free end wire element **40***a* extends beyond the rectangular area occupied by the wire elements and terminates between ¼ inch and ½ inch from the bottom edge of the windshield. The extremity of the wire element **40***z* is sandwiched between a pair of thin sheets **46** and **48**, made of tin foil .003 inch thick, for example. Sheet **48** is larger than sheet **46** and overlaps the latter.

The lead wire **32** of fine wire braid is soldered to a portion of the tin foil sheet **48** that extends beyond the smaller sheet **46**. The ends of the individual filaments of the braided wire **32** are unwound to improve their electrical connection to the plate **48**.

It is preferred that the ends of the wire elements **40** be spaced from the automobile metal by at least 2 inches so as to prevent a capacitance effect between the wire antenna **34** and the metal automobile body **11** or frame **12**. In a typical example of an antenna windshield that has provided excellent reception, the free or connected ends of the wire elements for a windshield 20 inches high were spaced 3 inches from the top and bottom edges of the windshield. A single continuous filament of copper wire .002 inch in diameter and 28 feet long was wound in the form of an elongated square wave of the type described above.

The continuous wire was embedded in the central region of the interlayer. The antenna was so mounted in place in the final product that when the interlayer was laminated between two matching sheets of glass to produce a laminated automobile windshield, a substantial portion occupied by the spaced, parallel, wire elements of the antenna was aligned with the rear view mirror of the automobile.

The wire elements of the preferred embodiment occupied an area 14 inches high and 3 inches wide. This provided the antenna with a substantially larger vertical dimension than horizontal dimension. The individual wire elements were only .002 inch thick and the parallel elements were spaced ⅛ inch from one another. Each wire element was 14 inches long.

Thus, the structure recited above had the following features characteristic of the present invention:

(1) The wire elements extended in spaced vertical planes between upper and lower limits.

(2) All parts of the wire elements were spaced from any metal of the vehicle.

(3) The wire elements were considerably longer than their spacing from adjacent elements.

(4) The spacing between elements was considerably greater than the thickness of the wire.

(5) The antenna and its lead wire were electrically insulated from the automobile metal.

The plastic interlayer was .030 inch thick and the two glass sheets were ⅛ inch thick. Since glass is electrically non-conductive at temperatures at which automobiles are operated, the antenna **34** was effectively insulated from the metal of the automobile frame. The sleeve **38** of polyvinyl butyral served to insulate the 6 inch length of lead wire of fine braid from the metal framework of the automobile.

The antenna described above was tuned at a radio frequency in the middle of the broadcast band to receive a station transmitting a relatively weak signal. A variable capacitor in series with the radio antenna was adjusted until the signal received at this intermediate frequency was at maximum volume. This provided optimum tuning for the entire broadcast range and sufficient but not optimum reception at the extremities of the broadcast range of frequencies without requiring any change in antenna tuning on changing stations.

The above structure operated as well as a conventional antenna mounted in telescoping relationship to an automobile body and extended to a height of 34 inches.

The particular embodiment described hereinabove is merely illustrative of the present invention. For a higher windshield, the antenna wires can be placed in the upper portion of the windshield so as to have the major portion of their wires behind the rear view mirror which is normally mounted in the upper center portion of the windshield. If the individual wire elements are made longer, generally less total length of wire is needed.

It is also contemplated that the windshield can also be provided with a wire antenna having a series of antenna elements that are connected in parallel rather than in series or in a series-parallel arrangement. It is also known that a grid or mesh of wires can be used as an antenna. However, it is necessary to employ a greater amount of wire for these other wire antenna configurations than is necessary in the simple series-connected wire antenna illustrated.

The antenna windshield described above was produced in a series of steps. The first step involved sewing the wire into a sheet of polyvinyl butyral. A hot needle travelling in the square wave pattern described above momentarily melted successive increments of the interlayer along the square wave path pattern described and deposited the filament into each interlayer increment before the increment could harden. The hot needle travelled at a substantially uniform speed while embedding the continuous filament.

The free end of the wire was not embedded into the plastic initially and was soldered between the metal foil sheets **46** and **48**. The end of the braided wire **32** was flattened and soldered to sheet **48** and placed on top of the interlayer sheet.

The interlayer with the wire braid **32**, metal foils **46** and **48** and the free end **40***z* of the filament stamped between the foil sheets was assembled between two matched sheets of glass and the sleeve **38** inserted over the wire braid extension until the sleeve was flush with the end of the assembly. The assembly was then ready for lamination. During lamination, the sheets **46** and **48**, the end of wire element **40***z* and the end of wire braid **32** became embedded in the interlayer and the glass sheets and plastic interlayer became a transparent unitary structure.

Laminating was done in the conventional manner. This comprised preliminarily pressing the assembly of the filament containing plastic sandwiched between two glass sheets by enclosing the marginal portion only of the assembly in an exacuation channel and applying heat while evacuating the marginal channel, then removing the channel and completing the lamination in an autoclave at elevated pressure (200 pounds per square inch) and elevated temperature (275 degrees Fahrenheit) for thirty minutes.

Alternatively, if the moisture content of the plastic is less than 2 parts per thousand by weight, the whole autoclave operation can be eliminated. The final lamination can take place at atmospheric pressure and elevated temperature. As another alternative, the wire can be tack welded to the plastic interlayer at spaced points before its assembly to form a composite interlayer to be assembled between the glass sheets.

Another manner of forming the antenna of the present invention is by spraying an electroconductive metal alloy of gold or silver or copper through a mask, thus forming a printed electrical circuit on the plastic sheet or the plastic facing surface of either glass sheet.

It is also within the purview of the present invention to paint or apply by spraying a printed circuit directly onto a surface of a monolithic glass sheet and attach an insulated lead wire to one end of the printed circuit for electrical coupling to a radio provided all five characteristics of the antenna enumerated above are met.

It is also understood that the antenna and its coupling lead wire and metal foil connectors may be incorporated in the surface of the plastic that is in direct contact with the inner surface of one of the glass sheets **16** or **18** of a laminated window.

While the form of the invention shown and described in this disclosure represents an illustrative preferred embodiment and certain modifications thereof, it is understood that various other changes may be made without departing from the spirit of the invention as defined in the claimed subject matter which follows.

What is claimed is:

1. A combination automobile window and radio antenna comprising a transparent window and an antenna carried by said window, said antenna comprising electroconductive wire of sufficient thinness to be essentially invisible to an automobile occupant when installed in an automobile and arranged as a plurality of parallel wire elements constituting a major portion of the length of said wire, said wire elements extending in substantially vertical planes from an upper extremity spaced downward of an upper edge of said window to a lower extremity spaced upward of a lower edge of said window, said wire elements occupying an area having a substantially larger vertical dimension that horizontal dimension, said area being spaced from the windshield margin sufficient distance to minimize any capacitance effect between the antenna and the metal of an automobile body in which said windshield may be installed, said wire elements being considerably longer than their spacing from their neighboring elements and said spacing being considerably greater than the thickness of said wire, said area being located in the central portion of said windshield; and a lead-in wire connected to one end of said antenna wire.

2. A combination automobile window and radio antenna as in claim **1**, in which said antenna wire is sinuous and consists essentially of a plurality of parallel wire elements electrically connected in series by interconnecting adjacent wire elements to one another at alternate extremities thereof.

3. A combination automobile window and radio antenna as in claim **1**, wherein said window comprises two glass sheets and an interlayer of electrically non-conductive thermoplastic material bonded to one another and said wire is carried between said glass sheets.

4. A combination automobile window and radio antenna as in claim **3**, wherein said wire is carried by said interlayer.

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