

[54] **INCONSPICUOUS VEHICLE MOUNTED
RADIO ANTENNA**

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[51] Int. Cl. **H01q 1/32**

[58] Field of Search..... 343/711, 712, 713,
343/716, 862

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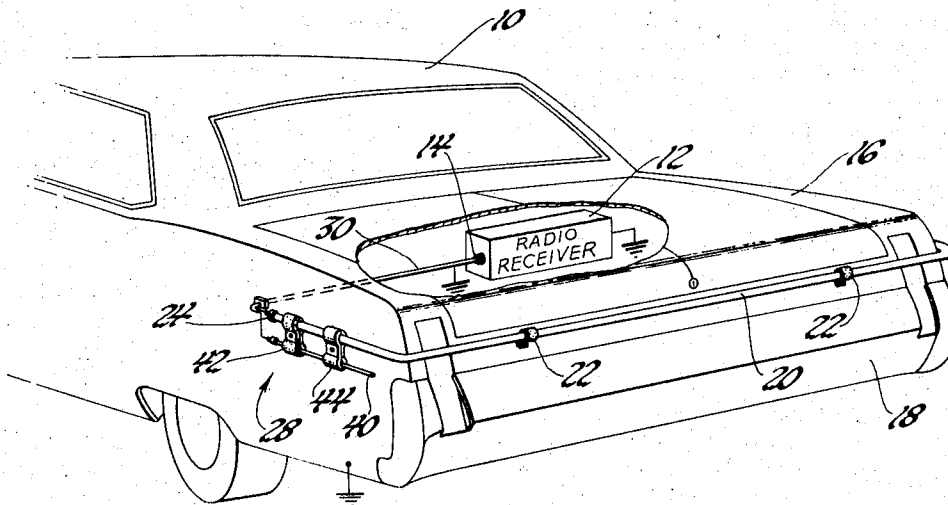
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[57] **ABSTRACT**

A conductive rod is mounted in spaced relationship to the outer body of an automotive vehicle to provide a decorative ornament for the vehicle and to provide an inconspicuous antenna for a radio receiver contained within the vehicle. The capacitance developed between the conductive rod and the vehicle body tunes the rod to act as a quarter wavelength antenna. An adjustable connector assembly couples the conductive rod to the radio receiver so as to match the output impedance of the antenna to the input impedance of the radio receiver.

1 Claim, 6 Drawing Figures



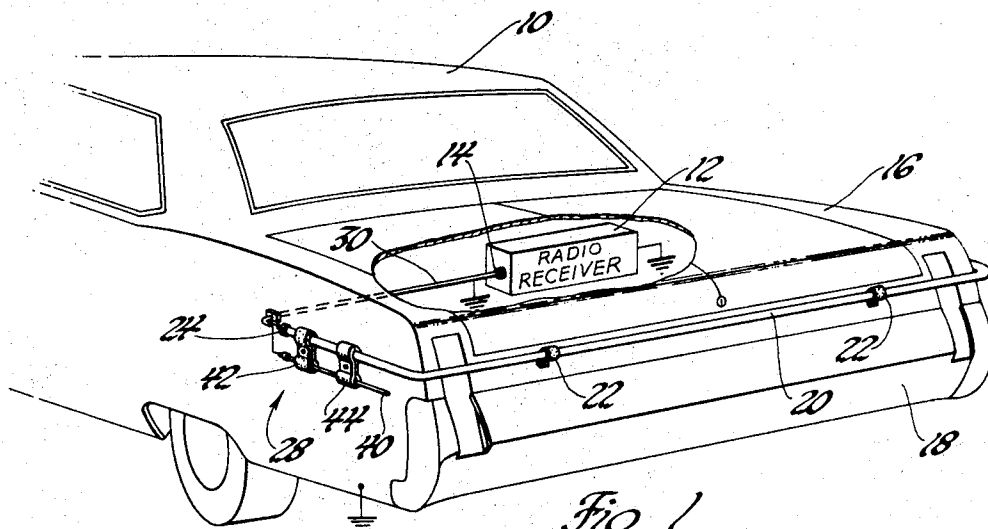


Fig. 1

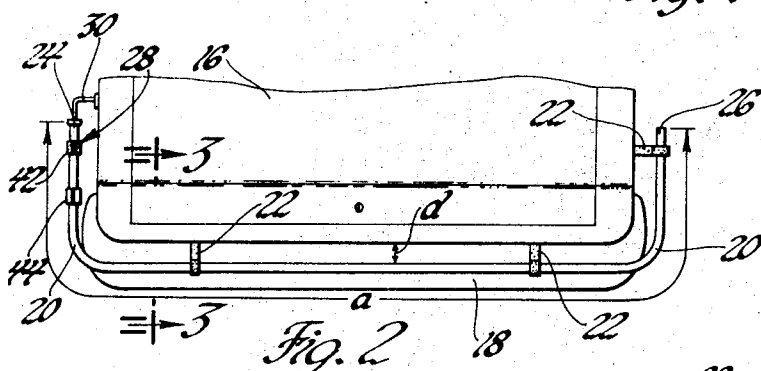


Fig. 2

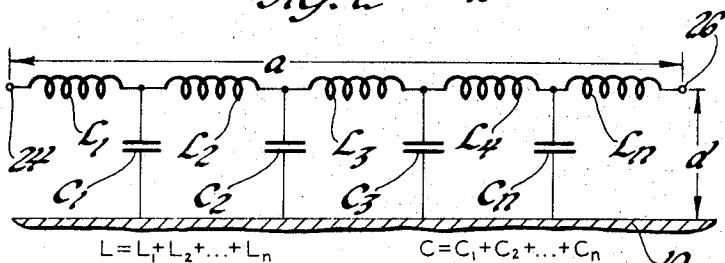


Fig. 4

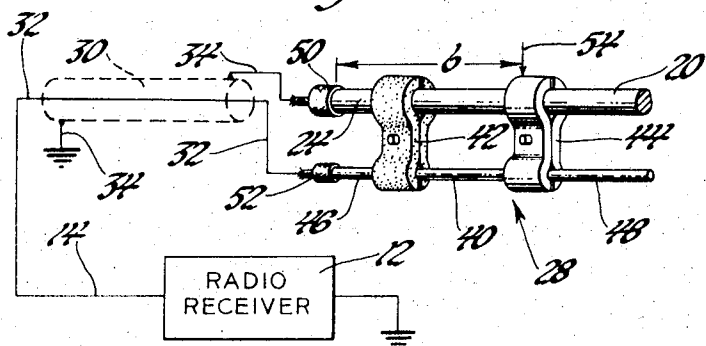


Fig. 6

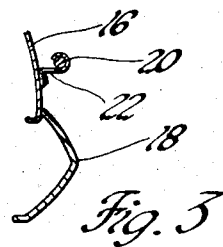


Fig. 3

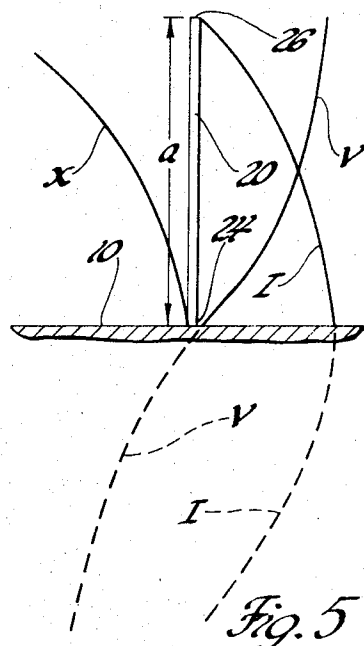


Fig. 5

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INCONSPICUOUS VEHICLE MOUNTED RADIO ANTENNA

This invention relates to an inconspicuous radio antenna for an automotive vehicle. More particularly, the invention relates to an automobile radio antenna which also serves as a decorative ornament for the vehicle.

According to one aspect of the invention, a conductive rod is mounted in physically spaced relationship from and in electrically isolated relationship from the outer body of an automotive vehicle to provide a decorative ornament for the vehicle and to provide an antenna for a radio receiver carried by the vehicle. The capacitance developed between the antenna rod and the vehicle body tunes the rod to a resonant frequency within the reception frequency band of the radio receiver. Preferably, the radio receiver is adapted to operate over the Citizen's Band.

In another aspect of the invention, the physical length of the antenna rod is less than the electrical length necessary to resonate the antenna at a desired frequency within the reception frequency band of the radio receiver. That is, the physical length of the antenna rod is less than a quarter wavelength of the desired frequency. However, the distributed capacitance along the length of the antenna rod with respect to the vehicle body effectively extends the electrical length of the antenna rod to approximately a quarter wavelength of the desired frequency. As a result, the antenna rod resonates at the desired frequency.

As contemplated by a further aspect of the invention, the radio receiver is connected to the antenna rod via a transmission line having a pair of conductors across which an input impedance is developed. An adjustable connector assembly couples the antenna rod to the conductors of the transmission line so as to match the output impedance of the antenna to the input impedance of the transmission line and the radio receiver. Preferably, the transmission line is provided by a coaxial cable having inner and outer conductors.

In yet another aspect of the invention, the antenna rod exhibits a distributed impedance which increases from a minimum impedance at a terminal end of the rod to a maximum impedance at an open end of the rod. The adjustable connector assembly connects the outer conductor of the coaxial cable to the terminal end of the antenna rod and connects the inner conductor of the coaxial cable to a tap point on the antenna rod. The tap point is spaced from the terminal end of the rod so as to define an antenna output impedance between the tap point and the terminal end which is approximately equal to the input impedance of the radio receiver and the coaxial cable.

According to a still different aspect of the invention, the connector assembly includes a connector rod which is mounted in physically spaced relationship to the antenna rod adjacent the terminal end of the antenna rod. The inner conductor of the coaxial cable is connected to a terminal end of the connector rod. Further, a conductive clamp electrically connects the connector rod to the antenna rod at the tap point thereby to match the output impedance of the antenna to the input impedance of the coaxial cable and the radio receiver.

As contemplated by a yet further aspect of the invention, the shape of the antenna rod generally conforms to the outer contour around the rear end of the vehicle body within the outer profile of the rear bumper of the

vehicle. Consequently, the rear bumper protects the antenna rod from damage due to inadvertent contact with extraneous objects.

These and other aspects and advantages of the invention may be best understood by reference to the following detailed description of a preferred embodiment when considered in conjunction with the accompanying drawing.

In the Drawing:

FIG. 1 is a perspective view of a vehicle mounted radio antenna incorporating the principles of the invention.

FIG. 2 is a partial top view of FIG. 1.

FIG. 3 is a cross-sectional view along the line 3—3 of

FIG. 2.

FIGS. 4 and 5 are schematic diagrams of a radio antenna incorporating the principles of the invention.

FIG. 6 is an enlarged view of a portion of FIG. 1 illustrating a connector assembly incorporated within the invention.

Referring to FIGS. 1, 2 and 3, a conventional automobile includes a vehicle body 10 which houses a radio receiver 12 for receiving radio signals in a reception frequency band. Preferably, the reception frequency band of the radio receiver 12 is the Citizen's Band which extends from 26.985 MHz to 27.255 MHz. However, it will be appreciated that the radio receiver 12 may have a reception frequency band which is above or below the Citizen's Band. Incoming radio signals are applied to the radio receiver 12 between an input 14 and ground as represented by the vehicle body 10.

The vehicle body 10 includes a rear portion 16 having a rear bumper 18. A conductive rod or tube 20 is disposed about the rear portion 16 of the vehicle body 10 to provide a decorative ornament or molding for the vehicle body 10 and to provide an inconspicuous antenna for the radio receiver 12. Specifically, a plurality of nonconductive struts 22 mount the antenna rod 20 in physically spaced relationship and in electrically isolated relationship at a general distance d from the vehicle body 10. The outer profile of the antenna rod 20 is disposed within the outer profile of the rear bumper 18 so that the bumper 18 protects the rod 20 from damage due to inadvertent contact with extraneous objects.

The physical length a of the antenna rod 20 extends from a terminal end 24 to an open end 26. The antenna rod 20 is connected to the input 14 of the radio receiver 12 through a connector assembly 28 and through a radio frequency transmission line 30 as best shown in FIG. 6. In general, the antenna rod 20 intercepts and applies radio signals through the connector assembly 28 and the transmission line 30 to the radio receiver 12 which amplifies and demodulates the radio signals to recover the transmitted information. Preferably, the transmission line 30 is provided by a coaxial cable including an inner conductor 32 and an outer conductor 34. The inner conductor 32 is connected between the connector assembly 28 and the input 14 of the radio receiver 12. The outer conductor 34 is connected between the terminal end 24 of the antenna rod 20 and the vehicle body 10. In a manner to be more fully described, the connector assembly 28 matches the output impedance of the antenna rod 20 to the input impedance of the radio receiver 12 and the transmission line 30.

FIG. 4 illustrates the equivalent circuit for the antenna 20 as mounted to the vehicle body 10. In particu-

lar, the antenna 20 exhibits a total distributed inductance L along its length a as represented by a plurality of discrete inductors $L_1 - L_n$. Further, the antenna 20 exhibits a total distributed capacitance C along its length a with respect to the vehicle body 10 as represented by a plurality of discrete capacitors $C_1 - C_n$. The distributed inductance L and the distributed capacitance C form an equivalent tuned circuit having a resonant frequency dependent upon the relative values of the distributed inductance L and the distributed capacitance C . The total distributed inductance L and the total distributed capacitance C is directly related to the length a of the antenna 20. Therefore, the length a of the antenna 20 determines the resonant frequency of the antenna 20.

Due to the inherent amplification produced by the resonance of the antenna 20, the magnitude of the intercepted radio signals is a maximum when the resonant frequency of the antenna 20 is equal to the carrier frequency of the received radio signals. Since the antenna 20 is to receive radio signals from across the reception frequency band of the radio receiver 12, it is desirable that the antenna 20 resonate at the center frequency of the reception frequency band in order to provide the greatest amplification across the entire reception frequency band. In the Citizen's Band, the desired center frequency is 27 MHz.

In order to resonate the antenna 20 at the desired frequency, the length of the antenna 20 must be a multiple of the wavelength of a radio signal having the desired frequency. The wavelength of a radio signal having a frequency of 27 MHz is approximately 11.2 meters. Hence, due to the practical size limitations involved in mounting the antenna 20 to the vehicle body 10, the antenna 20 is constructed to operate as a quarter wavelength antenna. That is, the length a of the antenna 20 is nominally one-quarter of the wavelength of a radio signal having the desired frequency. A quarter wavelength antenna is commonly known as a Marconi antenna.

Referring to FIG. 5, the antenna 20 exhibits a distributed voltage V over its length a which increases from a minimum at the terminal end 24 to a maximum at the open end 26. Conversely, the antenna 20 exhibits a distributed current I which decreases from a maximum at the terminal end 24 to a minimum at the open end 26. In actuality, the system ground, as represented by the vehicle body 10, provides a reflection of the distributed voltage V and the distributed current I in the antenna 20. As a result, the antenna 20 effectively operates as a half wavelength antenna even though it is physically a quarter wavelength antenna. Further, in keeping with the distributed voltage V and the distributed current I , the antenna 18 exhibits a distributed impedance X along its length a which increases from a minimum at the terminal end 24 to a maximum at the open end 26. The significance of the distributed impedance X will become more apparent later.

So far, it has been assumed that the physical length a of the antenna 20 is the same as its electrical length. This assumption is correct only if the antenna 20 were perfectly isolated in space. However, since the antenna 20 is mounted in relatively close proximity to the vehicle body 10, the effects of the vehicle body 10 on the electrical length of the antenna 20 cannot be ignored. As shown in FIG. 4, the antenna 20 exhibits a distributed capacitance C along its length a with respect to

the vehicle body 10. The distributed capacitance C between the antenna 20 and the vehicle body 10 causes the velocity of the radio signals along the antenna 20 to be less than the velocity of radio signals in free space. As a result, the wavelength of a radio signal having a particular frequency along the antenna 20 is shorter than the wavelength of a radio signal having the same frequency in free space. Thus, the distributed capacitance C effectively extends the electrical length of the antenna 20 beyond the physical length a of the antenna 20. Accordingly, the physical length a of the antenna 20 is made less than a quarter wavelength of the desired frequency to such an extent that the resultant electrical length of the antenna 20 is approximately equal to a quarter wavelength of the desired frequency. In other words, the distributed capacitance C between the antenna 20 and the vehicle body 10 is used to tune the antenna 20 to resonate at the desired frequency within the reception frequency band of the radio receiver 12.

For maximum power transfer from the antenna 20 through the transmission line 30 to the radio receiver 12, the output impedance of the antenna 20 must be matched to the input impedance of the radio receiver 12 and the transmission line 30. If the output impedance of the antenna 20 does not match the input impedance of the radio receiver 12 and the coaxial cable 30, part of the electrical energy transmitted from the antenna 20 is reflected by the radio receiver 12. This results in a disadvantageous loss of power. Conversely, when the output impedance of the antenna 20 matches the input impedance of the radio receiver 12 and the coaxial cable 30, all of the electrical energy transmitted from the antenna 20 is absorbed by the radio receiver 12. However, this is true only where the output impedance of the antenna 20 and the input impedance of the radio receiver 12 and the coaxial cable 30 are purely resistive and not reactive.

As previously described, the capacitance between the antenna 20 and the vehicle body 10 tunes the antenna 20 to make it resonant at the desired frequency. Therefore, the output impedance of the antenna 20 is purely resistive at the desired frequency and is almost purely resistive at all other frequencies within the reception frequency band of the radio receiver 12. Similarly, the input impedance provided by the radio receiver 12 and the coaxial cable 30 is made substantially purely resistive. Consequently, maximum power transfer from the antenna 20 to the radio receiver 12 may be accomplished by matching the output impedance of the antenna 20 to the input impedance of the radio receiver 12 and the coaxial cable 30.

The input impedance provided by the radio receiver 12 and the coaxial cable 30 appears across the inner and outer conductors 32 and 34 of the coaxial cable 30. The distributed impedance X between the terminal end 24 and the open end 26 of the antenna 20 is shown in FIG. 5. Referring to FIG. 6, the connector assembly 28 is connected between the terminal end 24 of the antenna 20 and the inner and outer conductors 32 and 34 of the coaxial cable 30 for matching the output impedance of the antenna 20 to the input impedance of the radio receiver 12 and the coaxial cable 30. Specifically, the connector assembly 28 includes a connector rod 40 which is mounted in parallel spaced relationship to the antenna rod 20 adjacent the terminal end 24 by a pair of clamps 42 and 44. The connector rod 40 includes a

terminal end 46 and an open end 48. The clamp 42 is nonconductive while the clamp 44 is conductive. Preferably, the clamps 42 and 44 each include a pair of complementary gripping arms having oppositely matched semicircular end portions which are drawn together around the antenna rod 20 and the connector rod 40 by the fastening action of a pair of adjusting screws threaded through the central portions of the clamps 42 and 44 substantially as shown.

A terminal device 50 connects the outer conductor 34 of the coaxial cable 30 to the terminal end 24 of the antenna rod 18. Similarly, a terminal device 52 connects the inner conductor 32 of the coaxial cable 30 to the terminal end 46 of the connector rod 40. Since the clamp 44 is conductive, it not only supports the connector rod 40 with respect to the antenna rod 20, it also effectively connects the inner conductor 32 of the coaxial cable 30 through the connector rod 40 to a tap point 54 on the antenna rod 20. The distributed impedance along the antenna rod 20 between the terminal end 24 and the tap point 54 defines the output impedance of the antenna 20. In particular, the tap point 54 is spaced at a distance *b* from the terminal end 24 of the antenna rod 20 so that the output impedance of the antenna 20 matches the input impedance of the radio receiver 12 and the coaxial cable 30. The optimum location of the tap point 54 on the antenna rod 20 may be empirically determined by moving the clamp 44 along the antenna rod 20 and the connector rod 40 while monitoring the magnitude of the radio signals applied at the input 14 of the radio receiver 12. When the magnitude of the applied radio signals is at a maximum, the clamp 44 is located at the optimum tap point 54.

In an antenna constructed in accordance with the invention for operation with a Citizen's Band radio receiver, the following values and parameters were found to yield satisfactory results:

Desired Frequency	27.0 mHz
Input Impedance (Radio Receiver 12) (Coaxial Cable 30)	50.0 ohms
Antenna Rod 20	0.5 inches O.D. (C.R. steel tube)
Length <i>a</i>	105.0 inches
Distance <i>b</i>	4.0 inches
Distance <i>d</i>	4.0 inches

It will now be readily apparent that the present invention provides an inconspicuous vehicle mounted radio antenna which is especially suited for application to a radio receiver operating over the Citizen's Band. However, it is to be noted that the illustrated embodiment

of the invention is shown for demonstrative purposes only. Therefore, various alterations and modifications may be made to the illustrated embodiment without departing from the spirit and scope of the invention.

What is claimed is:

1. In an automotive vehicle including a body structure having a contoured outer portion and a radio receiver adapted to receive radio signals in a particular frequency band over a coaxial cable including inner and outer conductors across which an input impedance is developed, the combination comprising: a conductive antenna rod having a terminal end and an open end, the antenna rod having a physical length less than a quarter wavelength of a desired frequency to provide an antenna which resonates at the desired frequency when mounted to the outer portion of the vehicle body structure, and the antenna rod having a shape generally conforming to the contour of the outer portion of the vehicle body structure to provide a decorative ornament when mounted to the outer portion of the vehicle body structure; support means for mounting the antenna rod in physically spaced relationship from and in electrically isolated relationship from the outer portion of the vehicle body structure so that the rod exhibits a distributed capacitance along its physical length with respect to the vehicle body structure thereby to increase the electrical length of the rod to approximately a quarter wavelength of the desired frequency to resonate the antenna rod at the desired frequency; terminal means for electrically connecting the outer conductor of the coaxial cable to the terminal end of the antenna rod so that the rod exhibits a distributed impedance along its length which increases from a low impedance at the terminal end to a high impedance at the open end; and connector means including a conductive connector rod having a terminal end and an open end, support means for mounting the connector rod in physically spaced relationship from and electrically isolated relationship from the antenna rod adjacent the terminal end, terminal means for connecting the inner conductor of the coaxial cable to the terminal end of the connector rod, and conductor means mounted between the connector rod and the antenna rod for effectively connecting the inner conductor of the coaxial cable through the connector rod to a tap point on the antenna rod so as to define an output impedance between the tap point and the terminal end of the antenna rod which matches the input impedance developed across the inner and outer conductors of the coaxial cable.

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