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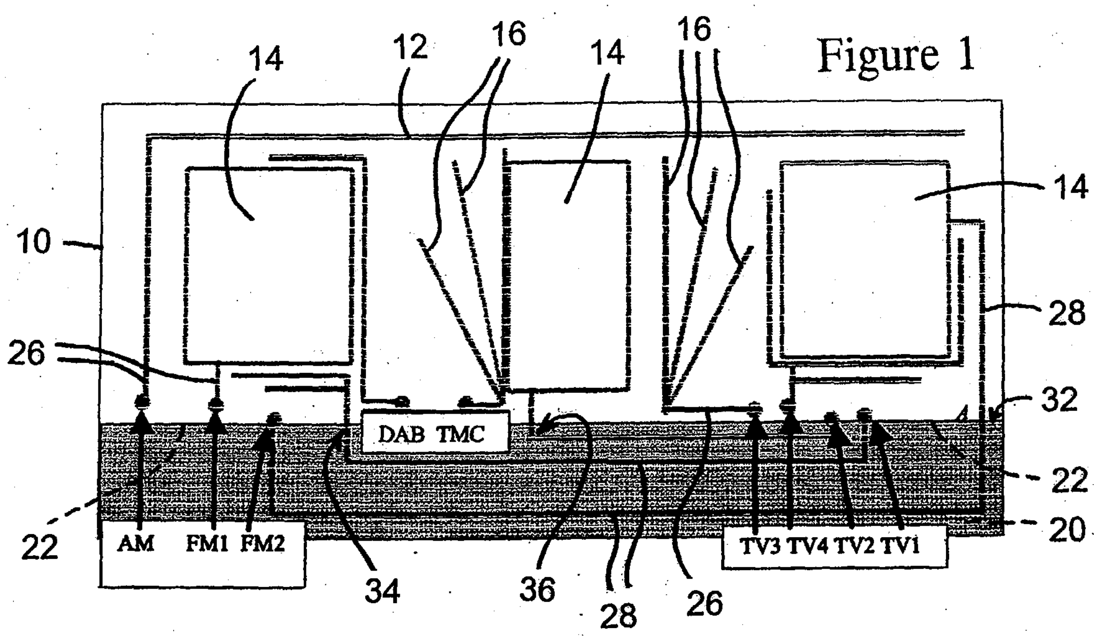
(54) **Integrated vehicular antenna system with selectable feedline positioning**

(57) An integrated vehicular antenna system utilizes a dielectric panel with printed metallic regions on one or both sides thereof. In the form of the antenna in which the metallic regions are on both sides, on one side is formed a series of antenna elements as well as a series of transmission lines each extending from a respective antenna element to one of several signal connection points. A conductive layer is formed on the other side of the panel and extends from one edge of the panel, being positioned such that none of the antenna elements are within a projection it forms on the one side of the panel. However, some of the transmission lines are extended within the projection of the conductive layer in their passage from respective antenna elements to the signal connection points. This arrangement allows an antenna element on one end of the panel to be connected to a signal connection point on the other end of the panel while also allowing control to be maintained over the radiation pattern formed by that antenna element. Another form of the antenna has the conductive layer on the same side of the panel as the transmission lines. In that case, each transmission line extends in a respective channel formed in the conductive layer.



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Description

[0001] The present invention relates to a vehicular antenna system, and more particularly, to an antenna system that includes a dielectric panel having antenna elements whose radiation patterns vary with positioning of a conductive layer on the panel. Although reference is made to radiation patterns and radiating elements, it will be understood that this is for conveniance of terminology only. The invention is equally appliable to transmitting and receiving antennas. Reference to transmission and radiation encompass reception and absorption, and vice versa.

[0002] Some recent communications systems for vehicles have been designed with antenna systems that are fitted within a surface cavity of a vehicle, for instance, within a roof cavity or trunk cavity of the vehicle. Although the vehicular antenna system of this invention is primarily intended to be fitted in that manner, i.e. within a surface cavity of a vehicle, it might alternatively be mounted so as itself to be a panel of the vehicle, or possibly an external attachment.

[0003] The vehicular antenna system of this invention has been designed using a multifunctional antenna system concept, in which a series of antenna elements exist on one side of the same dielectric panel, with each antenna element configured to carry communication signals of one or more frequency bands. Those frequency bands might be, for instance, AM (140 to 1607KHz), FM (76 to 108MHz), TMC, DAB (170 to 240MHz, and 1450 to 1492MHz), and TV (47 to 890MHz) bands. Here, "TMC" relates to the traffic management system band, and "DAB" relates to the digital audio band. One antenna element might, for instance, be capable of carrying signals only in the FM band, while another might be capable of carrying signals in the FM, TV and DAB bands.

[0004] In one form of the vehicular antenna system of the subject invention, a conductive region is formed on the other side of the dielectric panel at a location where a projection of its shape through the panel does not overlap any antenna element on the one side. (The word 'projection' is used here in the geometrical sense of a shape on one side of the panel being transposed through the panel.) However, a transmission line extending from that antenna element to a transmission-feed connection point on the panel partially overlaps such projection. The transmission line within a projection of the conductive region is inactive as a radiating element, so the radiation pattern of the connected antenna element does not vary with the path or length of the transmission line within that projection. This effect allows separation of the design of the antenna-element portion of the panel from a portion in which transmission lines connect to one or more connectors. Varying the point at which a transmission line enters within the projection of the conductive region also provides a means to fine-tune the radiation pattern of the antenna element connected to that transmission line.

[0005] The conductive region may alternatively be formed on the one side of the panel, and have channels extending through it providing pathways for the transmission lines. The word "overlap" is used in both forms of the invention to connote a region in which a transmission line either passes through a projection of the conductive region (when the line is on an opposite side of the panel from the conductive region) or passes through channels in the conductive region (when the line is on the same side of the panel as the conductive region).

[0006] The subject invention is a vehicular antenna system that includes a dielectric panel having at least one antenna elements in an antenna region on one side of the panel. The panel also has a grounded conductive region which does not overlap the antenna region. The or each antenna element has a respective connected transmission line which extends on the one side of the panel to a respective termination and which has a portion overlapping the grounded conductive region. The position relative to the conductive region of a portion of each transmission line that does not overlap the grounded conductive region is chosen to determine a radiation pattern associated with the antenna element connected to that transmission line.

[0007] Preferably, there are a plurality of said antenna elements for transmitting and receiving different types of signals, and the terminations of the respective connected transmission lines of the antenna elements are grouped together.

[0008] The grounded conductive region may be formed on the other side of the panel, with the transmission lines overlapping the conductive region when the transmission lines extend across a projection of the conductive region onto the one side of the panel.

[0009] Alternatively, the grounded conductive region may be formed on the one side of the panel and have a series of channels extending through the conductive region, each channel being sized to allow a respective transmission line to pass therethrough in close proximity to the sides of the channel.

[0010] The at least one antenna element, the respective transmission line connected thereto, and the conductive region may each be formed by patterning a metal layer on the panel or by depositing a layer of printed conducting ink onto the panel.

[0011] The conductive region may preferably be defined by a unitary conductive area. Alternatively, the conductive region may be defined by a series of parallel conductive strips.

[0012] The conductive region may extend as a band across the panel, and have an inner edge and an outer edge, with the outer edge of the conductive region being more proximate a closest edge of the panel. Preferably, the outer edge of the conductive region is co-extensive with the closest edge of the panel.

[0013] The inner edge of the conductive region may extend across the panel as an unstepped linear line, or alternatively, may extend across the panel as a stepped linear line. In either case, the radiation pattern associated with each antenna element preferably varies with the distance between the antenna element and the inner edge of the conductive region.

[0014] The transmission lines of two or more antenna elements may extend to at least one transmission-feed common location on the dielectric panel.

[0015] The vehicular antenna system may also include at least one additional antenna element having a respective connected transmission line extending on the one side of the panel without having any portion overlapping the conductive region. In such case, the transmission lines of two or more of the antenna elements and/or additional antenna elements may extend to at least one transmission-feed common location on the dielectric panel.

[0016] The vehicular antenna system may have two transmission-feed common locations, and each transmission-feed common location on the panel may be a portion of the panel configured for receiving a connector.

[0017] Each antenna element or additional antenna element may be configured to function in one of the AM, FM, TMC (traffic management system), DAB (digital audio) and TV frequency bands, or to function in more than one of those bands.

[0018] The dielectric panel may be enlarged at one end, with one of the antenna elements or additional antenna elements that functions in the AM frequency band being positioned at the one end of the panel. In such case, the antenna element or additional antenna element positioned at the one end of the panel may be formed as either a solid conductor or as a conductive mesh.

[0019] The vehicular antenna system of the invention may be fitted within a roof cavity or trunk cavity of a vehicle and to be protectively covered.

[0020] Preferred features of the present invention will now be described, by way of example only, with reference to the accompanying drawings, in which:-

Figure 1 is a plan view of a first embodiment of the antenna system of the invention, illustrating a series of antenna elements with their respective connected transmission lines on one side of an antenna panel, and also illustrating (as the shaded area) a projection onto the one side of the panel of a conductive region that extends on the other side of the panel;

Figure 2 is a plan view of a second embodiment of the antenna system of the invention, the second embodiment being similar to the first embodiment but also illustrating the transmission lines extending to transmission-line common locations;

Figure 3 is a perspective view of a third embodiment of the antenna system of the invention, the third embodiment being similar to the second embodiment but also having an AM extension antenna element extending from one end of the panel; and,

Figure 4 is a plan view of a fourth embodiment of the antenna system of the invention, the fourth embodiment being the same as the first embodiment of Figure 1 except that the conductive region on the opposite side of the antenna panel has a stepped outer edge.

[0021] With reference to Figure 1, a dielectric antenna panel 10 has a series of antenna elements formed on one side, i.e. a front side, by a shaped metal layer. The antenna elements are of various types, as illustrated. For receiving signals in the 1MHz range, AM antenna element 12 is a metal track extending from end to end of panel 10. Signals in the FM, DAB, TMC and TV bands are each receivable by an antenna element formed as a concertina-shaped metal track, schematically shown as the rectangular box 14, or by an antenna element formed from a series of diverging metal tracks 16.

[0022] On the other side, i.e. a back side, of the dielectric panel 10 extends a shaped metallic conductive layer 20 that forms a ground region (also referred to as a conductive region). The conductive layer 20 has an outer edge that is co-extensive with one edge of the panel 10, and an inner edge 22 that extends generally parallel to the one edge of the panel 10. Some of the transmission lines (those designated 26) do not extend within a projection of the inner edge 22 of the conductive layer 20, while other transmission lines (those designated 28) do extend within that projection. With respect to the transmission line 28 that extends from the right-hand side of panel 10 to the left-hand-side connection point marked FM2, the effect of that transmission line passing through the projection of conductive layer 20 is that the point 32, i.e. the point at which that transmission line 28 first crosses the projection of conductive layer 20, acts effectively the same electrically as the connection point FM2. This property allows the connection point FM2 to be placed close to the connection points marked AM and FM1, thus allowing all three connection points to be connected to a multi-way connector (not shown) carrying a grouping of feed signals to antenna panel 10. This property also allows the length of the transmission line from the antenna to the point of crossing the projection of conductive layer 20 to be varied so as to match the antenna impedance to the load or source, i.e. the length of the transmission line determines the impedance transformation of the antenna to which it is connected.

[0023] Although the conductive layer 20 has been described in this embodiment as being on the back side of the dielectric panel 10, it might be placed on the front side of the panel 10 but in such case would require narrow channels extending through it each acting as a pathway for a respective transmission line. The conductive layer 20, whether on the back side or front side of the dielectric panel 10, might also be formed as a series of connected parallel strips rather than as a solid conductor.

[0024] With further regard to Figure 1, the televisionsignal connection points TV1, TV2, TV3 and TV4 are placed close together, allowing all to be simultaneously connected to a second multi-way connector (also not shown) closer to the other end of the panel 10. It can be seen that the effect is equivalent to the second multi-way connector being able to simultaneously connect to three positions on the panel 10: a first position 34 (where the transmission line carrying the TV1 signal crosses into the projection of conductive layer 20), a second position 36 (where the transmission line carrying the TV2 signal crosses into the projection of conductive layer 20), and a third position at which are the TV3 and TV4 connection points.

[0025] The connection points marked DAB and TMC are positioned in close proximity to each other for connection to a third multi-way connector (also not shown) at a central position on the panel 10. The transmission lines that extend to connection points DAB and TMC originate from proximate antenna elements and neither needs to be extended into the projection of the conductive layer 20.

[0026] The path of the inner edge 22 of the conductive layer 20 is created according to the radiation pattern that is desired for each of the antenna elements. The inner edge 22 in Figure 1 is an unstepped straight line extending from one end to the other of panel 10 on the opposite side of the panel 10, and the radiation patterns of the antenna elements are therefore determined and fixed on that basis. As shown in Figure 4, however, it is possible to preselect radiation patterns that are required for the antenna elements and to then create a stepped inner edge 22 that will produce those patterns.

[0027] Figure 2 illustrates a dielectric antenna panel 38 similar to the panel 10 of Figure 1, but having arcuately-formed ends and also having two transmission-line male connection sockets 40 and 42 defined by an outer contour of the panel 38. The socket 40 is shaped to receive a connector carrying feed signals for the AM antenna element, the FM1/TV1 antenna element, and the FM2/TV4 antenna element. The FM2/TV4 antenna element sits on an opposite end of the panel 38 from the connection socket 40, and the presence of the conductive layer 44 on the opposite side of panel 38 allows the transmission line 46 to connect with the socket 40 while at the same time allowing a predictable radiation pattern to be maintained for the antenna element FM2/TV4. The socket 42 is shaped to receive a connector carrying feed signals for the TMC, TV2, TV3 and DAB antenna elements, which are all centrally positioned on the panel 38. The transmission lines extending to the TMC, TV2, TV3 and DAB antenna elements all extend over a projection of conductive layer 44, and the radiation pattern to each of those antenna elements can be adjusted by suitable stepping of the inner edge 48 of conductive layer 44.

[0028] Figure 3 shows an antenna panel 50 of generally similar shape to the antenna panel 38 of Figure 2, but having an AM extension antenna pad 52 at its one end. Since the antenna system of this invention is likely to be placed close to the metal bodywork of a vehicle, the pad 52 improves AM performance. The pad has two effects. It increases the area of the AM antenna element, but more importantly, it increases the capacitive coupling to the vehicle bodywork and thereby improves antenna performance by several decibels. The pad 52 may be formed as a solid conductor or may be meshed (as illustrated). Antenna panel 50 has a socket 54 to which a multi-way connector (not shown) may be connected.

[0029] The antenna elements, transmission lines and conductive layer may result from patterning a layer of metal plated onto one or both sides of a dielectric panel. Alternatively, a printed conducting ink might be placed onto the one or both sides of the panel to form the shape of the required patterns. In either case, the resulting transmission lines are in the form of microstrips. In place of such microstrip transmission lines, coaxial cables and other forms of transmission line might alternatively be used in this invention.

[0030] While the present invention has been described in its preferred embodiments, it is to be understood that the words which have been used are words of description rather than limitation, and that changes may be made to the invention without departing from its scope as defined by the appended claims.

[0031] Each feature disclosed in this specification (which term includes the claims) and/or shown in the drawings may be incorporated in the invention independently of other disclosed and/or illustrated features.

[0032] The text of the abstract filed herewith is repeated here as part of the specification.

[0033] An integrated vehicular antenna system utilizes a dielectric panel with printed metallic regions on one or both sides thereof. In the form of the antenna in which the metallic regions are on both sides, on one side is formed a series of antenna elements as well as a series of transmission lines each extending from a respective antenna element to one of several signal connection points. A conductive layer is formed on the other side of the panel and extends from one edge of the panel, being positioned such that none of the antenna elements are within a projection it forms on the one side of the panel. However, some of the transmission lines are extended within the projection of the conductive layer in their passage from respective antenna elements to the signal connection points. This arrangement allows an antenna element on one end of the panel to be connected to a signal connection point on the other end of the panel while also allowing control to be maintained over the radiation pattern formed by that antenna element. Another form of the antenna has the conductive layer on the same side of the panel as the transmission lines. In that case, each transmission line extends in a respective channel formed in the conductive layer.

Claims

1. A vehicular antenna system comprising a dielectric panel having at least one antenna element in an antenna region on one side of the panel, the panel also having a grounded conductive region which does not overlap the antenna region, the or each antenna element having a respective connected transmission line which extends on the one side of the panel to a respective termination and which has a portion overlapping the grounded conductive region, the position relative to the conductive region of a portion of each transmission line that does not overlap the grounded conductive region being chosen to determine a radiation pattern associated with the antenna element connected to that transmission line.

2. A vehicular antenna system as in claim 1, wherein there are a plurality of said antenna elements for transmitting and receiving different types of signals, and wherein the terminations of the respective connected transmission lines of the antenna elements are grouped together.

3. A vehicular antenna system as in claim 2, wherein the grounded conductive region is formed on the other side of the panel, and wherein the transmission lines overlap the conductive region when the transmission lines extend across a projection of the conductive region onto the one side of the panel.

4. A vehicular antenna system as in claim 2, wherein the grounded conductive region is formed on the one side of the panel, and wherein a series of channels extends through the conductive region, each channel being sized to allow a respective transmission line to pass therethrough in close proximity to the sides of the channel.

5. A vehicular antenna system as in any preceding claim, wherein the at least one antenna element, the respective transmission line connected thereto, and the conductive region are each formed by patterning a metal layer on the panel or by depositing a layer of printed conducting ink onto the panel.

6. A vehicular antenna system as in any one of claims 1 to 5, wherein the conductive region is defined by a unitary conductive area.

7. A vehicular antenna system as in any one of claims 1 to 5, wherein the conductive region is defined by a series of parallel conductive strips.

8. A vehicular antenna system as in any preceding claim, wherein the conductive region extends as a band across the panel, the conductive region having an inner edge and an outer edge, the outer edge of the conductive region being more proximate a closest edge of the panel.

9. A vehicular antenna system as in claim 8, wherein the outer edge of the conductive area is co-extensive with the closest edge of the panel.

10. A vehicular antenna system as in claim 8 or 9, wherein the inner edge of the conductive region extends across the panel as an unstepped linear line.

11. A vehicular antenna system as in claim 8 or 9, wherein the inner edge of the conductive region extends across the panel as a stepped linear line.

12. A vehicular antenna system as in claim 10 or 11, wherein the radiation pattern associated with each antenna element varies with the distance between that antenna element and the inner edge of the conductive region.

13. A vehicular antenna system as in any preceding claim, wherein the signal feedlines of two or more antenna elements extend to at least one transmission-feed common location on the dielectric panel.

14. A vehicular antenna system as in any preceding claim, and also comprising at least one additional antenna element having a respective connected transmission line extending on the one side of the panel without having any part overlapping the conductive region.

15. A vehicular antenna system as in claim 14, wherein the signal feedlines of two or more of the antenna elements and/or additional antenna elements extend to at least one transmission-feed common location on the dielectric panel.

16. A vehicular antenna system as in claim 13 or 15, wherein the antenna has transmission-feed common locations.

17. A vehicular antenna system as in claim 13, 15 or 16, wherein each transmission-feed common location on the dielectric panel is a portion of the panel that is configured for receiving a connector.

18. A vehicular antenna system as in any preceding claim, wherein each antenna element or additional antenna element is configured to function in one of the AM, FM, TMC (traffic management system), DAB (digital audio) and TV frequency bands, or to function in more than one of those bands.

19. A vehicular antenna system as in claim 18, wherein the dielectric panel is enlarged at one end, and wherein one of the antenna elements or additional

antenna elements that functions in the AM frequency band is positioned at the one end of the panel.

20. A vehicular antenna system as in claim 19, wherein the antenna element or additional antenna element positioned at the one end of the antenna is formed as a solid conductor.

21. A vehicular antenna system as in claim 19, wherein the antenna element or additional antenna element positioned at the one end of the antenna 'is formed as a conductive mesh.

22. A vehicular antenna system as in any preceding claim, wherein the antenna is adapted to be fitted within a roof cavity or trunk cavity of a vehicle and to be protectively covered.

Figure 1

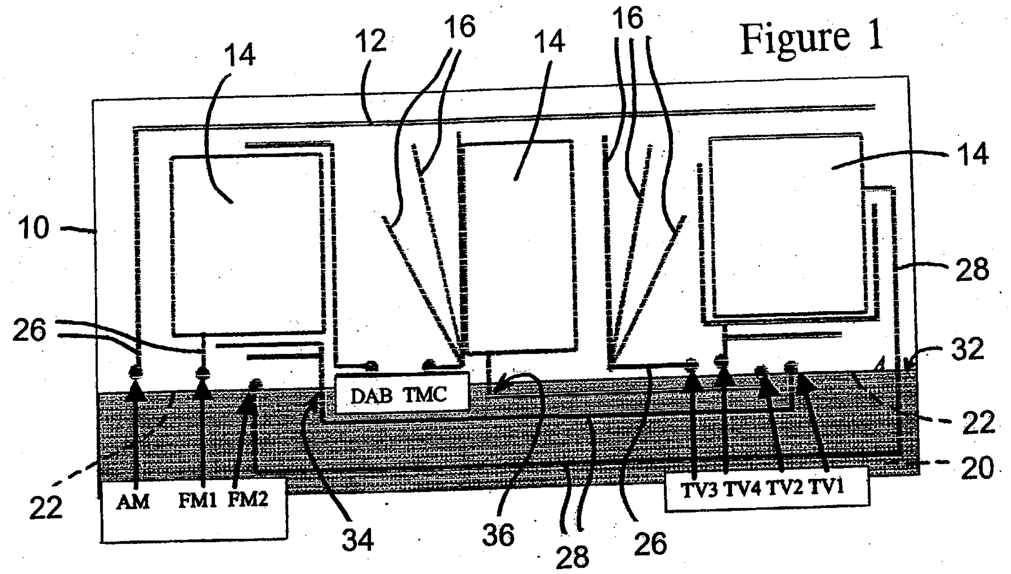


Figure 2

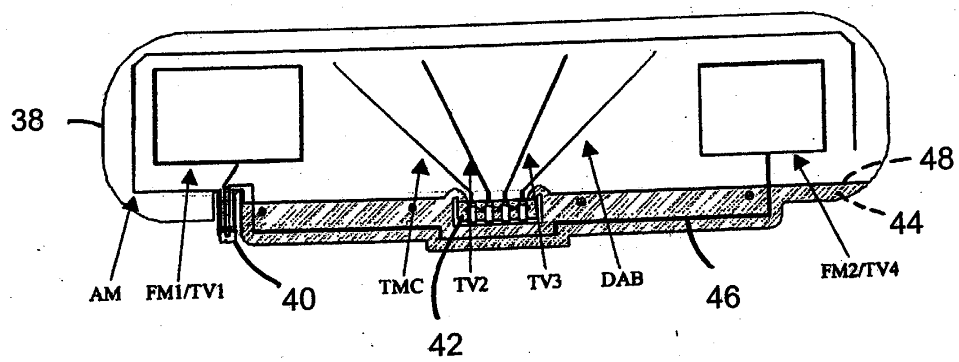
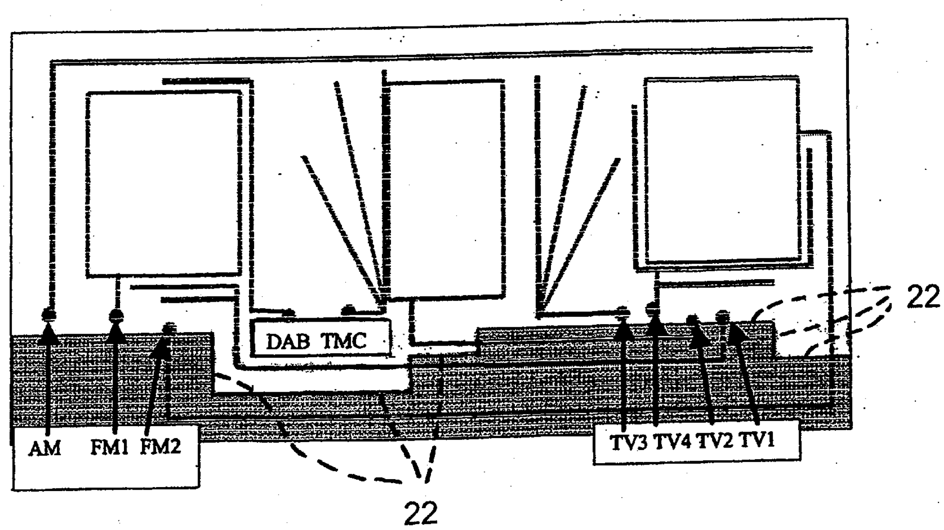


Figure 4



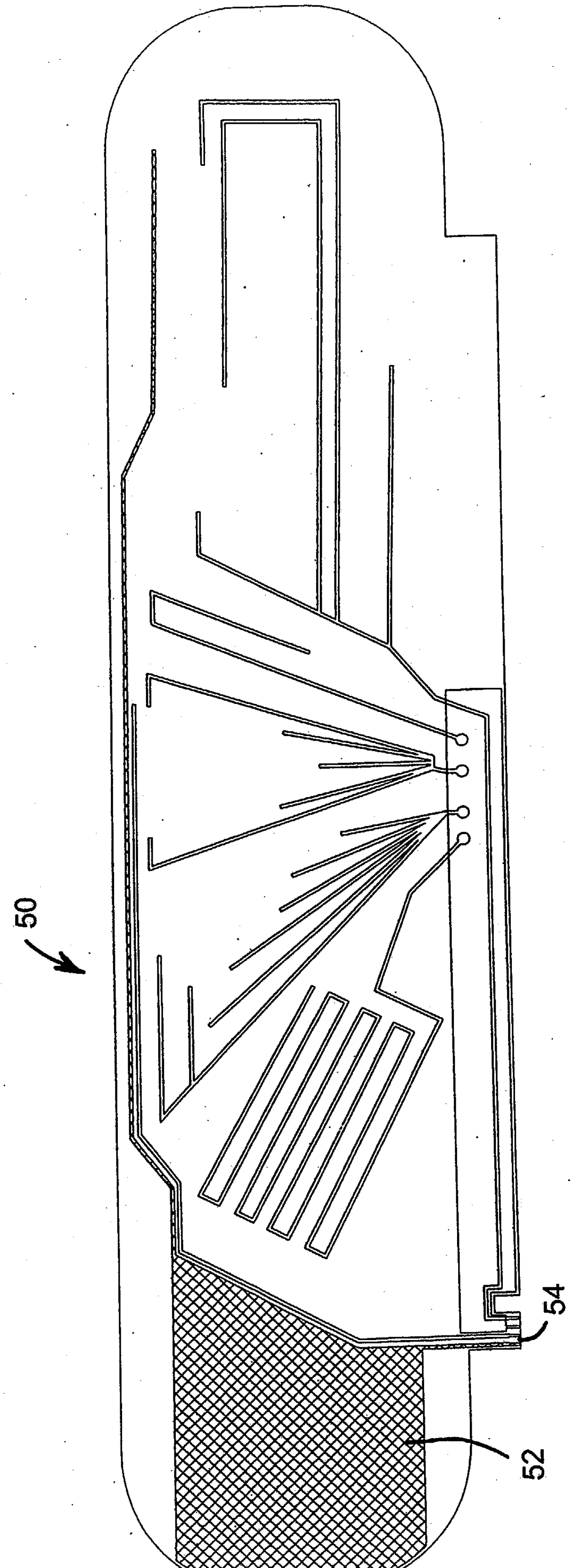


Figure 3