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Klopach et al.

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[54] BROADBAND CIRCULARLY POLARIZED OMNIDIRECTIONAL ANTENNA

[72] Inventors: **Robert T. Klopach; Joseph Bohar,** both of Lansdale, Pa.

[73] Assignee: **American Electronic Laboratories, Inc.,** Colmar, Pa.

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[52] **U.S. Cl.**.....**343/756,** 343/773, 343/872

[51] **Int. Cl.**.....**H01q 19/00**

[58] **Field of Search**.....343/756, 773, 774, 775, 872

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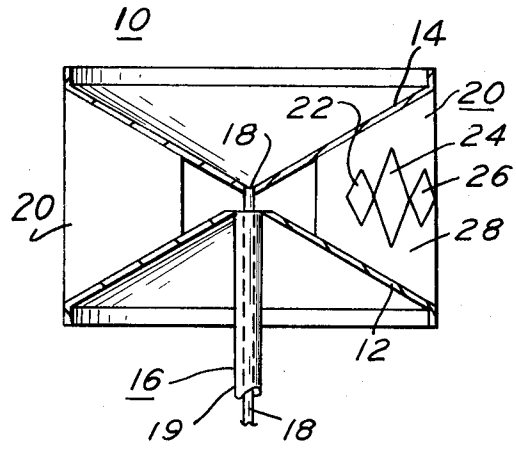
Primary Examiner—Eli Lieberman

Attorney—Jacob Trachtman

[57] **ABSTRACT**

An omnidirectional, circular polarized antenna which includes a biconical dipole and a plurality of passive numbers mounted around the axis of the dipole within a boundary formed by a cylinder enclosing the biconical dipole. Each of the passive members includes three diamond shaped metal elements in side-by-side relation and laying in the same plane. The plane of each of the passive members is at an angle with respect to the axis of the biconical dipole.

14 Claims, 9 Drawing Figures



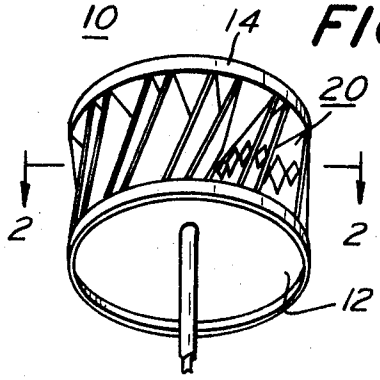


FIG.1

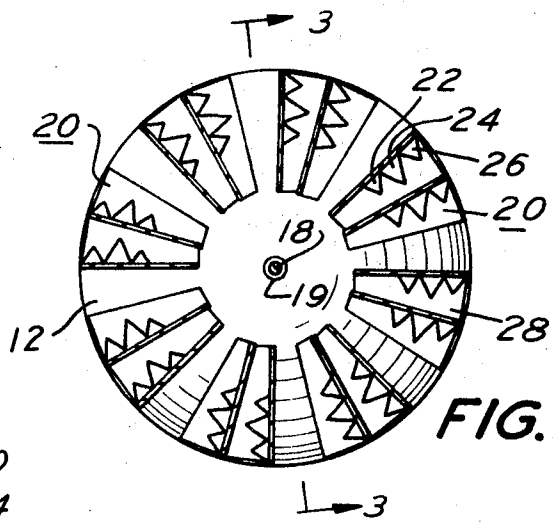


FIG.2

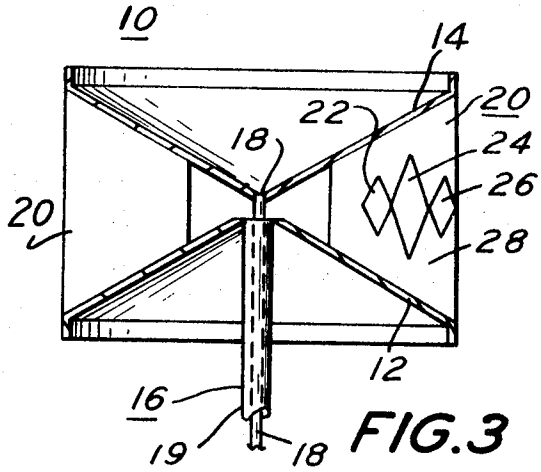


FIG.3

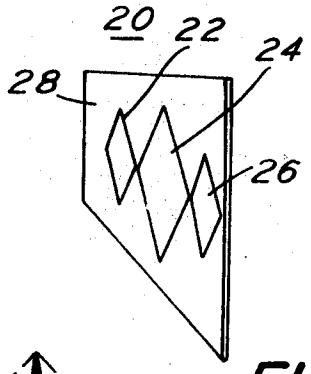
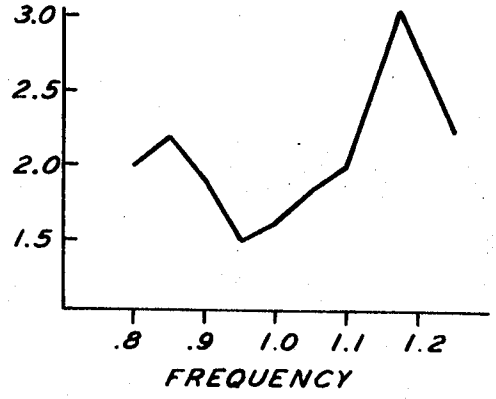


FIG.4

FIG.6



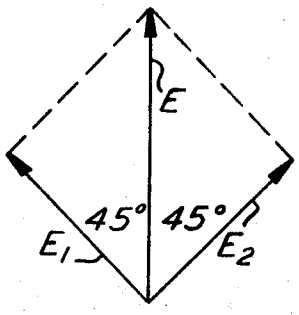


FIG.5

INVENTORS
ROBERT KLOPACH
JOSEPH BOHAR
BY
Jacob Trachtman
ATTORNEY

FIG.8

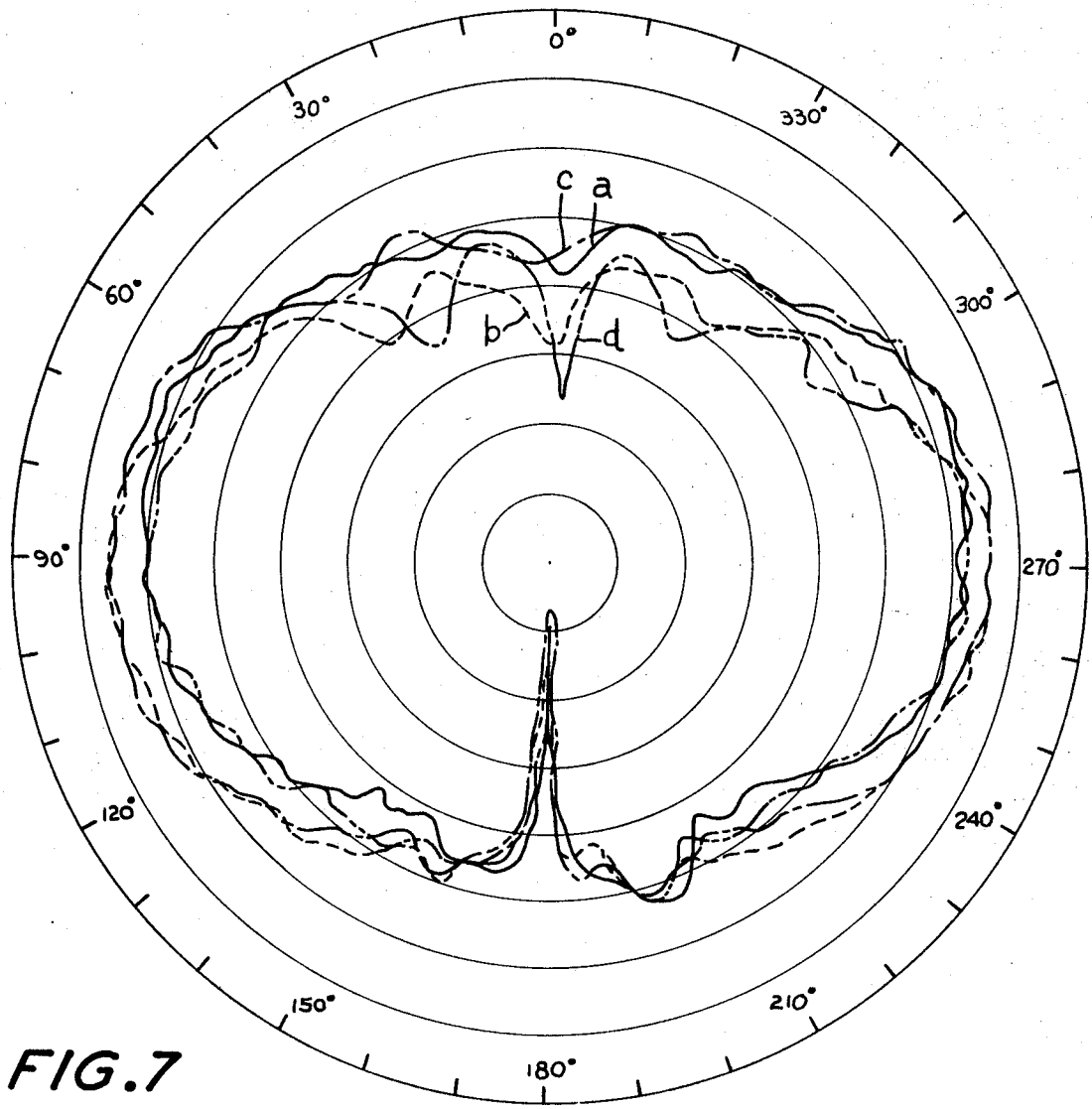
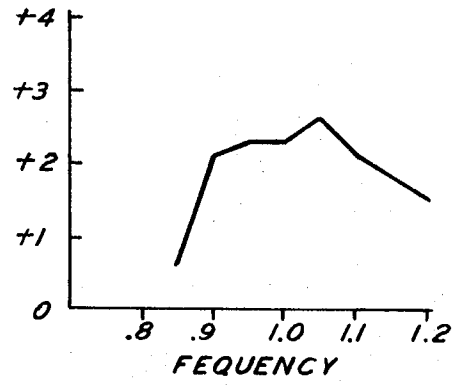
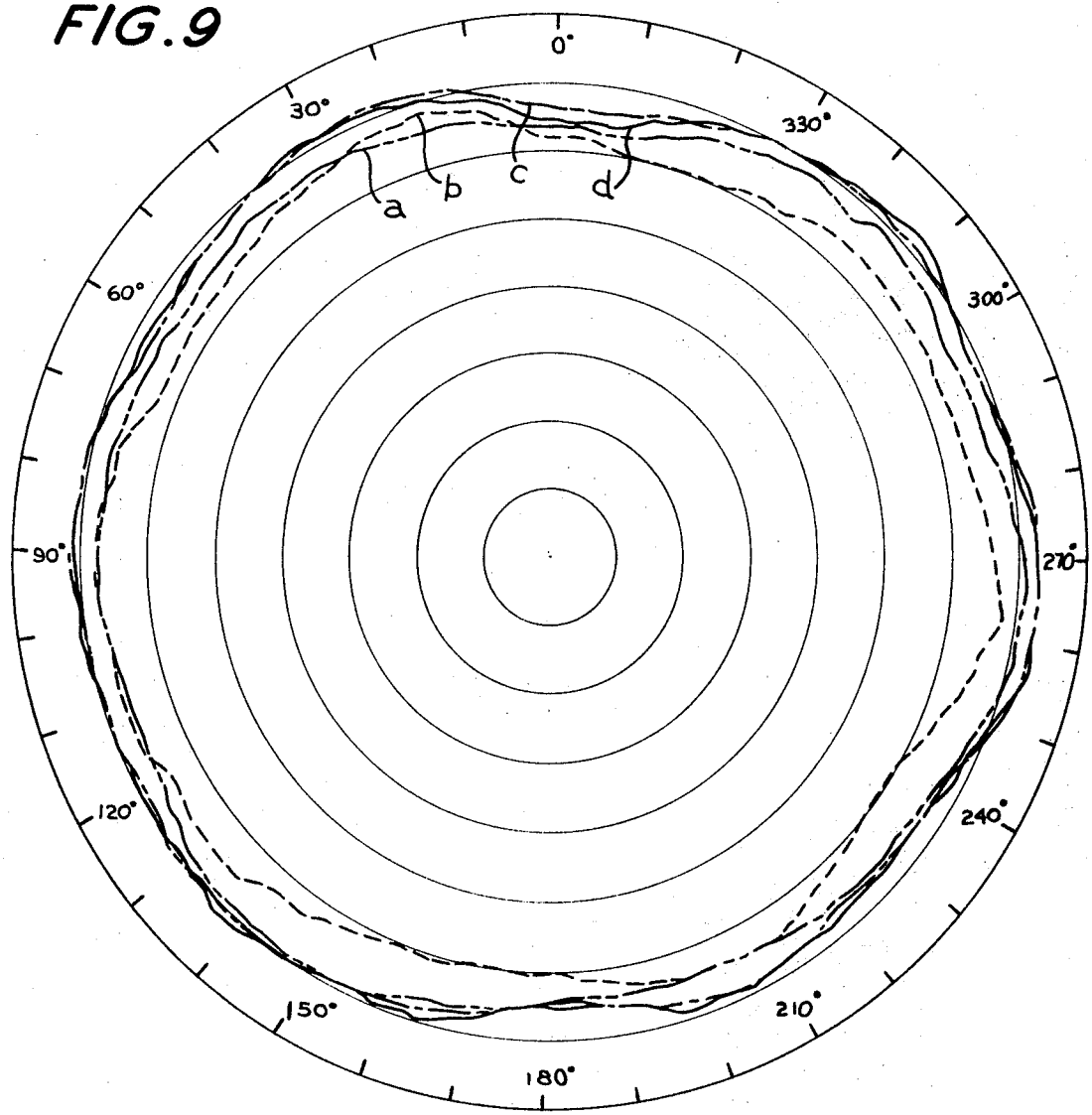


FIG.7



INVENTORS
ROBERT KLOPACH
JOSEPH BOHAR
BY Jacob Trachtman
ATTORNEY

FIG. 9



INVENTORS
ROBERT KLOPACH
JOSEPH BOHAR
BY
Jacob Trachtman
ATTORNEY

BROADBAND CIRCULARLY POLARIZED OMNIDIRECTIONAL ANTENNA

The present invention relates to an antenna, and more particularly to a circularly polarized omnidirectional antenna.

There are a number of applications for a circularly polarized omnidirectional antenna. Such an antenna is especially required for transmission through the ionosphere at frequencies where the ionosphere may produce rotation of the wave polarization. Thus, such antennae are useful in communications between the earth and an artificial satellite or other spacecraft. The antennae heretofore used for this purpose are arrays which use phase cables or power dividers. Such antennae are not only complex in structure but are also limited in frequency band.

It is therefore an object of the present invention to provide a novel circularly polarized omnidirectional antenna.

It is another object of the present invention to provide a circularly polarized omnidirectional antenna which is simple in design, has increased efficiency and reliability and is essentially maintenance free.

It is still another object of the present invention to provide a circularly polarized omnidirectional antenna which will operate over a range of frequencies, and can be easily built to operate at a desired range of frequencies.

These objects are achieved by an antenna which includes a biconical dipole, and means within the near field of the antenna to couple a portion of the energy of the biconical dipole into the means and re-radiate the energy at a retarded phase with respect to the energy radiated or received by the biconical dipole to achieve circular polarization. The coupling means are a plurality of passive members each of which includes three diamond shaped metal elements.

For the purpose of illustrating the invention there is shown in the drawings a form which is presently preferred; it being understood, however, that this invention is not limited to the precise arrangements and instrumentalities shown.

FIG. **1** is a perspective view of the antenna of the present invention.

FIG. **2** is a sectional view taken along line **2**—**2** of FIG. **1**.

FIG. **3** is a sectional view taken along line **3**—**3** of FIG. **2**.

FIG. **4** is a perspective view of one of the passive members of the antenna.

FIG. **5** is a vector diagram of the mode of operation of the antenna.

FIGS. **6**–**9** are graphs showing various characteristics of the antenna of the present invention.

Referring to the drawing, the antenna of the present invention is generally designated as **10**. Antenna **10** comprises a pair of identical metal, conical members **12** and **14** connected together at their apices with their axes being collinear so as to form a biconical dipole. The conical members **12** and **14** are mounted on an elongated supporting member **16** which is in the form of a coaxial feed line. The supporting member **16** comprises a center rod **18** extending through and electrically insulated from an outer tubular rod **19**. The supporting member **16** extends along the axis of the conical member **12** with the end of the outer rod **19** being mechanically and electrically connected to the apex of the conical member **12**. The end of the inner rod **18** extends through an opening in the apex of the conical member **12** and is mechanically and electrically connected to the apex of the conical member **14**.

A plurality of parallel passive coupling members **20** are mounted between the outer surfaces of the conical members **12** and **14**, and are within the boundary formed by a cylinder enclosing the biconical dipole. The passive members **20** are spaced around the periphery of the conical members **12** and **14**, and are at an angle with respect to the axes of the conical member. As shown in FIG. **4**, each of the passive members **20** comprises three thin, flat, diamond shaped metal elements **22**, **24** and **26** mounted on one side of a sheet **28** of a dielectric material, such as mica or a plastic. The diamond shaped elements **22**, **24** and **26** are mounted in side-by-side, spaced relation on the same surface of the sheet **28** with the minor diagonals of the elements being in alignment, and the major diagonals being parallel. The end elements **22** and **26** are of the same size, and the center element **24** is larger than the end elements **22** and **26**. The passive elements **20** are mounted between the conical members **12** and **14** with the minor diagonals of the diamond shaped elements **22**, **24** and **26** being perpendicular to the axes of the conical members and the major diagonals of the elements being at an angle to the axes of the conical members. Although the diamond shaped elements **22**, **24** and **26** of each of the passive members are shown as being mounted on a dielectric sheet, the elements can be mounted between the conical members **12** and **14** by other means, such as by strings, tapes or, for large models, dielectric rods.

The antenna **10** operates in the transverse-electric, TE_{10}, mode. The TE_{10} mode may be represented as two vectors oriented at 90° as shown in FIG. **5**. The biconical dipole formed by the conical members **12** and **14** radiates or receives the TE_{10} mode polarized such that the E vector of the electromagnetic wave is parallel to the axes of the conical members. A portion of the energy is coupled into the diamond shaped elements **22**, **24** and **26** of the passive member **20** and is re-radiated at a retarded phase with respect to the energy radiated or received by the biconical dipole. Only the portion of the E field which is parallel to the diamond shaped elements is coupled into the elements. Therefore, at a point far removed from the antenna there appears to be two E vectors, one generated (for the transmit operation) by the biconical dipole, and one generated by the diamond shaped elements. When the passive members **20** are arranged so that the amplitude of the E vectors are equal and differ in phase by 90°, circular polarization is obtained. When the passive members **20** are oriented in the biconical dipole parallel to the E_1 vector, right hand circular polarization is obtained, and when parallel to the E_2 vector, left hand circular polarization is obtained.

To achieve omnidirectional, circular polarization, the total height of the two conical members **12** and **14**, i.e. the height of the biconical dipole, is equal to the geometric wavelength of the desired frequency band, hereinafter referred to as λm, and the diameter of the base of each of the conical members is equal to $2\lambda m$. Each of the end diamond shaped elements **22** and **26** has its minor diagonal equal to $0.11\lambda m$ and its major diagonal equal to $0.34\lambda m$. The center diamond shaped elements **24** have their minor diagonals equal to $0.14\lambda m$ and their major diagonals equal to $0.43\lambda m$. The spacing between the apices of adjacent diamond shaped elements of each passive member **20** is less than $0.05\lambda m$. The passive members **20** are arranged in pairs around the conical members **12** and **14** with the spacing between the passive members of each pair being less than the spacing between adjacent pairs. The spacing between the passive members of each pair is $0.28\lambda m$ and the spacing between adjacent pairs is $0.05\lambda m$. The optimum number of the passive members **20** is 16.

An antenna **10** of the present invention was made with the diamond shaped members **22** and **26** having a minor diagonal of 0.33 inch and major diagonal of 0.98 inch, and the center diamond shaped element having a minor diagonal of 0.40 inch and major diagonal of 1.2 inches. The diamond shaped elements were mounted on dielectric sheets having an inside edge 1.25 inches long, an outside edge 3.75 inches long, and top and bottom edges 2 inches long. Sixteen passive members **20** were mounted between the biconical dipole with the spacing between the passive members of each pair of passive members being 0.8 inch and the spacing between the pairs being 1.5 inches. This antenna was found to provide omnidirectional circular polarization from 3.5 to 4.7 GH_z and omnidirectional circular or slant **45** degree linear polarization from 2.8 to 4.7 GH_z. FIGS. **6** through **9** show the characteristics of this antenna. FIG. **6** is a graph showing the voltage standing wave ratio at various frequencies, and FIG. **7** is a graph showing the gain at various frequencies. FIG. **8** is a graph showing the vertical plane pattern of the antenna, and FIG. **9** is a graph showing the horizontal plane pattern. In each of FIGS. **8** and **9**, line *a* is

the pattern with the E vector being horizontal, i.e. perpendicular to the axis of the biconical dipole, line *b* is the pattern with the E vector being vertical, i.e. extending along the axis of the biconical dipole, and lines *c* and *d* are the patterns with the E vector extending along opposite sides of the biconical dipole.

The present invention may be embodied in other specific forms without departing from the spirit or essential attributes thereof and, accordingly, reference should be made to the appended claims rather than to the foregoing specification as indicating the scope of the invention.

What is claimed is:

1. An antenna comprising a biconical dipole, and means within the near field of the antenna to couple a portion of the energy of the biconical dipole into the means and re-radiate the energy at a retarded phase with respect to the energy radiated or received by the biconical dipole to achieve circular polarization, said means comprising a plurality of passive members each including at least three substantially diamond shaped elements lying in the same plane, said members being at least partially within the boundary formed by a cylinder enclosing the biconical dipole.

2. An antenna in accordance with claim **1** in which the passive members are within the boundary formed by a cylinder enclosing the biconical dipole.

3. An antenna in accordance with claim **2** in which each of the passive members includes a thin flat diamond shaped metal element.

4. An antenna in accordance with claim **3** in which each of the passive members includes three diamond shaped metal elements with the elements lying in the same plane.

5. An antenna in accordance with claim **4** in which the plane of each passive member is at an angle with respect to the longitudinal axis of the biconical dipole.

6. An antenna in accordance with claim **5** in which the diamond shaped elements of each passive member are positioned in side-by-side relation with their minor diagonals being in alignment and their major diagonals being parallel.

7. An antenna in accordance with claim **6** in which the passive elements are arranged with the minor diagonals of the diamond shaped elements being perpendicular to and the major diagonals of the diamond shaped elements being at an angle to the axis of the biconical dipole.

8. An antenna in accordance with claim **7** in which the end diamond shaped elements of each passive member are of the same size, and the center diamond shaped element is larger than the end elements.

9. An antenna in accordance with claim **8** in which the passive members are arranged around the axis of the biconical dipole in pairs with the spacing between the passive members of each pair being less than the spacing between the pairs of the passive members.

10. An antenna in accordance with claim **9** in which the height of the biconical dipole is equal to λm and the diameter of the base of each conical member of the biconical dipole is equal to $2\lambda m$, where λm is the geometric wavelength of the desired frequency band.

11. An antenna in accordance with claim **10** in which each of the end diamond shaped elements of each of the passive members has its minor diagonal equal to $0.11\lambda m$ and its major diagonal equal to $0.34\lambda m$, and the center diamond shaped element has its minor diagonal equal to $0.14\lambda m$ and its major diagonal equal to $0.43\lambda m$.

12. An antenna in accordance with claim **11** in which the spacing between the apices of the adjacent diamond shaped elements of each of the passive members is less than $0.05\lambda m$.

13. An antenna in accordance with claim **12** in which the spacing between the passive members of each pair is equal to $0.28\lambda m$, and the spacing between the pairs is $0.5\lambda m$.

14. An antenna in accordance with claim **13** in which there are sixteen passive members around the biconical dipole.

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