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CIRCULAR DIPOLE ANTENNA ARRAY

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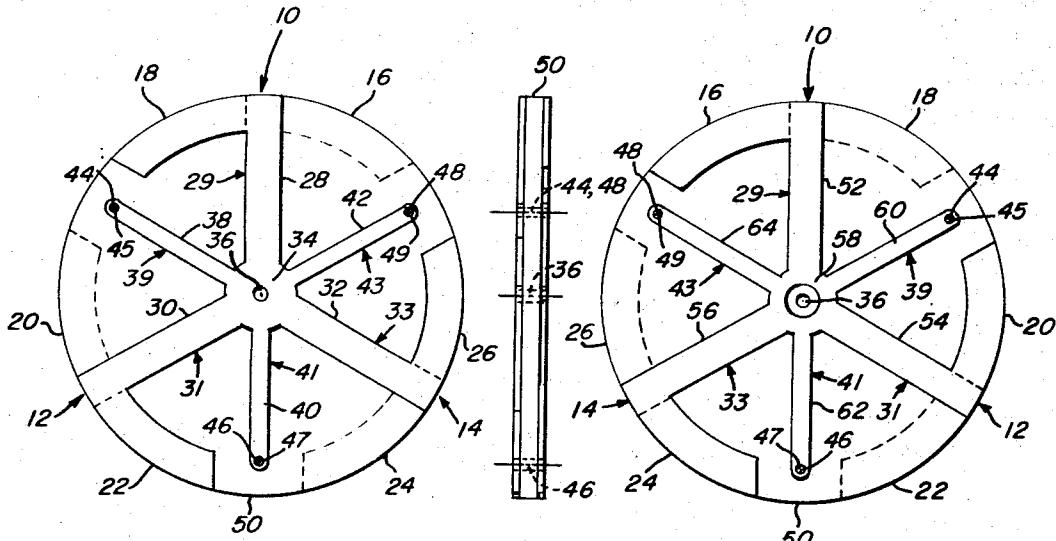


FIG. 1A

FIG. 1B

FIG. 1C

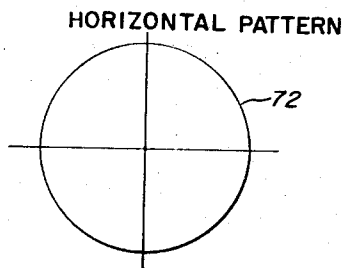


FIG. 3A

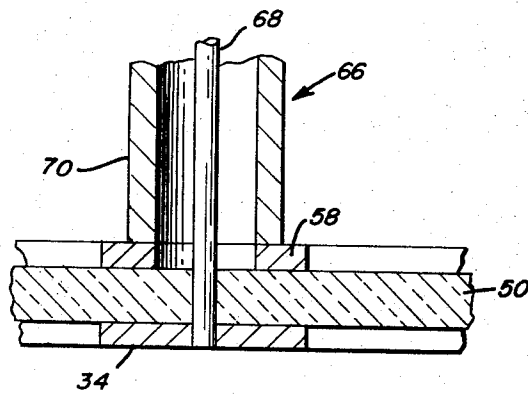


FIG. 2

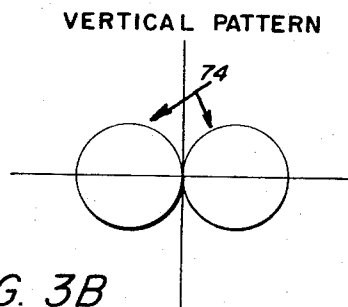


FIG. 3B

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CIRCULAR DIPOLE ANTENNA ARRAY

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 6 Claims. (Cl. 343-799)

This invention is concerned with antenna devices for communication systems and, more particularly, with those of the dipole type.

Hitherto, such antennas have been extremely complicated and difficult to manufacture, causing them to be quite costly. One example of such a dipole antenna may be found in U.S. Patent No. 2,639,382 by G. A. Jarvis, entitled, "Antenna," which issued on May 19, 1953. Briefly, that patent discloses a dipole antenna comprising a solid metal radiating element adapted to be mounted directly upon a feeder transmission line of the enclosed type. The radiating element includes three dipoles which are both excited and supported by solid metal members extending outwardly from the associated transmission line to the dipoles. Each half or section of the three dipoles is located in the same horizontal plane perpendicular to the longitudinal axis of the transmission line, and the two halves of each dipole are spaced-apart in that plane. Such an antenna is very difficult to fabricate, requiring extremely close tolerances. Additionally, it is of the utmost importance in a dipole antenna to maintain a constant distance between the dipole halves and their exciting means in order to achieve proper impedance matching; however, it would be almost impossible to maintain this distance to any significant degree using the above-referenced antenna since the dipole sections are floating and hence subject to rotate. This would, of course, hinder the proper operation of that antenna.

Co-pending patent application, Ser. No. 430,636, entitled, "Transponder," which was filed on Feb. 5, 1965, by John T. Zimmer, and is also assigned to the assignee of this application, discloses a compact, lightweight transponder which does not require most of the heavy microwave components utilized by prior art transponders. In brief, that transponder comprises a semiconductor diode mixer which immediately upon receipt of an interrogation signal from an antenna mixes that signal with one from a variable frequency oscillator, the output signal frequency of the antenna being a single-valued function of the data to be transmitted. Hence, the mixer provides signals which are offset from the interrogation signal by an amount proportional to the frequency of the oscillator signal and, thus, are readily distinguishable from accompanying clutter. Such a transponder is quite compact, with the only possible element of any size being the antenna. While some antennas available today may be used by that transponder, it is desirable to have one which is easily manufactured, non-complex, cheap, and yet highly reliable.

Accordingly, a primary object of the present invention is to provide an improved antenna, and, more particularly, one which is reliable, relatively non-complex, and easily fabricated.

Another object is to provide an improved dipole antenna, and one wherein the two dipole halves and their exciting means are maintained at a constant spacing.

A still further object is to provide an antenna which is very low in cost and lends itself to mass production techniques.

These and related objects are accomplished in one embodiment of the invention by a tri-dipole antenna comprising a circular disc being made of a plastic material having a high dielectric constant, and three dipoles, one half of each dipole being printed on one side of the

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disc and the other half on the reverse side. The three dipoles are uniformly spaced-apart and arranged close to the disc periphery. The excitation means for each dipole includes a short, quarter wavelength, parallel wire transmission line with one wire printed on each side of the disc and being connected to a coaxial transmission line at the center of the disc. Thus, the two lines of each dipole exciting means and the dipole sections themselves are spaced-apart in the vertical direction by a constant amount, that is, the width of the disc. Furthermore, three symmetrical direct current return paths are provided in order to achieve the desired antenna patterns.

Other objects, features, and embodiments of the invention will be readily apparent from the following description of a preferred embodiment and reference to the accompanying drawings, wherein:

FIGS. 1A-1C are diagrammatic representations of the top, side, and bottom views, respectively, of the antenna;

FIG. 2 is a sectional view of a coaxial line feeding the antenna of this invention; and,

FIGS. 3A and 3B are diagrammatic representations of the antenna horizontal and vertical plane patterns, respectively.

The antenna of the invention is shown in three views, i.e., top, side, and bottom in FIGS. 1A-1C, respectively, and comprises three dipoles 10, 12, and 14 and three excitation means 29, 31, and 33 which are printed upon a circular disc 50 of plastic material having a high dielectric constant as compared to air, by using well-known printed circuit techniques. However, it should be appreciated that other depositing techniques could readily be employed in place of printing. Dipole 10 includes two halves or sections 16 and 18, which may be made of a suitable metal such as .003 inch copper for example. Similarly, dipole 12 includes two halves 20 and 22, and dipole 14 also includes two halves 24 and 26. As is shown in FIGS. 1A and 1C, one section of each dipole is printed on one side of disc 50 along its periphery, and the other section is printed upon the other side. Thus, dipole halves 18, 22, and 26 are located on the top of disc 50, whereas dipole halves 16, 20, and 24 are located on the bottom. The means for exciting dipoles 10, 12, and 14 are parallel wire transmission lines 29, 31, and 33, respectively, each having wires printed on either side of disc 50. Consequently, wires 28 and 52 of line 29 are connected to dipole 10; wires 30 and 54 of line 31 are connected to dipole 12; and, wires 32 and 56 of line 33 are connected to dipole 14. Wires 28, 30, and 32 are printed upon the top of disc 50, whereas wires 52, 54, and 56 are printed upon the bottom. Transmission lines 39, 41, and 43 each comprise a shorted pair of parallel wires providing a direct current return path. Circles 36, 44, 46, and 48 represent holes passing through the copper printing and plastic disc 50, while circles 34 and 58 are printed copper rings. The purpose of these various circles will be explained below in detail.

FIG. 2 depicts part of the subject antenna connected to a transmission line 66 which may be of the well-known coaxial conductor type having a central conductor 68 and an outer conductor 70. Coaxial transmission line 66 feeds the antenna at the center of disc 50 and is connected thereto in the following manner. Outer conductor 70 is connected to printed ring 58 of FIG. 1C by soldering for instance, thus forming an electrical contact therewith. Inner conductor 68, on the other hand, passes through hole 36 and is soldered to printed ring 34 of FIG. 1A.

Circular disc 50 may be any width desired and can be as thin as the structural strength of the plastic material permits it to be. The radius of disc 50 is substantially equal to $\lambda/4\sqrt{\epsilon}$ where λ is the wavelength of the input

signal from transmission line 66 and ϵ is the dielectric constant of the plastic material being used in disc 50. Thus it is apparent that much shorter printed transmission lines 29, 31, and 33 may be used for activating dipoles 10, 12, and 14, respectively, than would be possible in air, when material having a high dielectric constant occupies the space between the two wires thereof. Each printed transmission line 29, 31, and 33 provides a good impedance match when looking into coaxial transmission line 66, and acts as a quarter-wave transformer between transmission line 66 and the associated dipole 10, 12, or 14. The quarter-wavelength transmission lines 29, 31, and 33 eliminate the necessity for a balun, and consequently coaxial transmission line 66 is directly connected to the antenna. In addition to allowing the use of much shorter or fractional quarter-wavelength transmission lines 29, 31, and 33 than could be used if air filled these lines, circular disc 50 provides a constant width support along the vertical axis between the printed wires forming these transmission lines, thus assuring proper impedance matching.

Transmission lines 39, 41, and 43 are short-circuited and provide a direct current return for the antenna. Transmission line 39 comprises two fractional quarter wavelength, printed wires 38 and 60, which are spaced apart along the vertical axis by an amount equal to the width of circular disc 50, and are connected by soldering them to wire 45 passing through hole 44, thus shorting out transmission line 39. Similarly, equivalent transmission line 41 includes two parallel wires 40 and 62, both being connected to wire 47 which passes through hole 46. Transmission line 43 likewise comprises wires 42 and 64 which are spaced apart and connected to wire 49 passing through hole 48. The purpose of transmission lines 39, 41, and 43 is essentially to provide symmetrical direct current return paths and thus assure the generation of the proper antenna patterns shown in FIGS. 3A and 3B.

The principal plane patterns produced by the horizontally polarized antenna upon receipt of energy from coaxial transmission line 66 are depicted in FIGS. 3A and 3B. The horizontal or azimuth plane pattern of FIG. 3A is an omnidirectional or circular pattern 72, while the vertical plane radiation pattern 74 has two circles and is similar to that of a half-wave dipole, with a null directly above and below the antenna center. As was mentioned previously, the three direct current return transmission lines 39, 41, and 43 aid in maintaining antenna symmetry and, thus, producing the desired circular omnidirectional patterns. Transmission lines 39, 41, and 43 are each fractional, quarter wavelength sections which are shorted at their far ends by being soldered to wires 45, 47, and 49, respectively. Consequently, these lines 39, 41, and 43 have no detrimental effect upon antenna performance since they appear to be open-circuited at radio frequencies. It should be noted, however, that although three direct current return paths 39, 41, and 43 are described herein, the invention is not limited to that number. Three paths, however, produce the most accurately shaped patterns with the least number of paths.

The invention is not limited to the specifics of the preceding description of a preferred embodiment, but embraces the full scope of the following claims.

What is claimed is:

1. An antenna device adapted for use with a coaxial transmission line providing electromagnetic energy thereto and having inner and outer conductors, comprising:
 a circular disc having a predetermined dielectric constant;
 first and second means, each being deposited on a different side of said disc around the center thereof and being adapted to be connected to a different one of said coaxial conductors;
 three curved dipoles uniformly spaced around the periphery of said disc, each of said dipoles including

a pair of dipole sections, one section being deposited on one side of said disc and the other section being deposited upon the other side of said disc; and,
 means for exciting each of said dipoles, each of said exciting means including a pair of lines, each of said lines extending from one of said first and second means to one of said dipole sections and being deposited upon a different side of said disc.

2. An antenna device adapted for use with a coaxial transmission line providing electromagnetic energy thereto and having inner and outer conductors, comprising:

a circular disc having a predetermined dielectric constant;

first and second means, each being deposited on a different side of said disc around the center thereof and being adapted to be connected to a different one of said coaxial conductors;

three curved dipoles uniformly spaced around the periphery of said disc, each of said dipoles including a pair of dipole sections, one section being deposited on one side of said disc and the other section being deposited upon the other side of said disc; and,

means for exciting each of said dipoles, each of said exciting means including a pair of lines, each of said lines extending from one of said first and second means to one of said dipole sections, having a length substantially equal to a quarter of the wavelength of said energy, and being deposited upon a different side of said disc.

3. An antenna device adapted for use with a coaxial transmission line providing electromagnetic energy thereto and having inner and outer conductors, comprising:

a circular disc having a higher dielectric constant than air;

first and second means, each being deposited on a different side of said disc around the center thereof and being adapted to be connected to a different one of said coaxial conductors;

three curved dipoles uniformly spaced around the periphery of said disc, each of said dipoles including a pair of dipole sections, one section being deposited on one side of said disc and the other section being deposited upon the other side of said disc; and,

means for exciting each of said dipoles, each of said exciting means including a pair of lines, each of said lines extending from one of said first and second means to one of said dipole sections and being deposited upon a different side of said disc.

4. An antenna device adapted for use with a coaxial transmission line providing electromagnetic energy thereto and having inner and outer conductors, comprising:

a circular disc having a higher dielectric constant than air;

first and second means, each being deposited on a different side of said disc around the center thereof and being adapted to be connected to a different one of said coaxial conductors;

three curved dipoles uniformly spaced around the periphery of said disc, each of said dipoles including a pair of dipole sections, one section being deposited on one side of said disc and the other section being deposited upon the other side of said disc; and,

means for exciting each of said dipoles, each of said exciting means including a pair of lines, each of said lines extending from one of said first and second means to one of said dipole sections, having a length substantially equal to a fractional quarter of the wavelength of said energy, and being deposited upon a different side of said disc.

5. An antenna device adapted for use with a coaxial transmission line providing electromagnetic energy thereto and having inner and outer conductors, comprising:

a circular disc having a predetermined dielectric constant;

first and second means, each being deposited on a differ-

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ent side of said disc around the center thereof and being adapted to be connected to a different one of said coaxial conductors;

three curved dipoles uniformly spaced around the periphery of said disc, each of said dipoles including a pair of dipole sections, one section being deposited on one side of said disc and the other section being deposited upon the other side of said disc; means for exciting each of said dipoles, each of said exciting means including a pair of lines, each of said lines extending from one of said first and second means to one of said dipole sections and being deposited upon a different side of said disc; and, three uniformly-spaced transmission lines, each including a pair of lines connected at one end, each of said lines being connected to one of said first and second means at the other end and being deposited upon a different side of said disc.

6. An antenna device adapted for use with a coaxial transmission line providing electromagnetic energy thereto and having inner and outer conductors, comprising:

a circular plastic disc having a higher dielectric constant than air, a first hole passing through the center thereof for passing said inner conductor, and three uniformly-spaced holes near the periphery thereof; first and second different width metallic rings, each being deposited on a different side of said disc around said first hole and being adapted to be connected to a different one of said coaxial conductors; three curved metallic dipoles uniformly spaced around the periphery of said disc, each of said dipoles including a pair of dipole sections, one section being deposited on one side of said disc and the other section being deposited upon the other side of said disc;

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metallic means for exciting each of said dipoles, each of said exciting means including a pair of lines, each of said lines extending from one of said rings to one of said dipole sections, having a length substantially equal to a fractional quarter of the wavelength of said energy, and being deposited upon a different side of said disc; and,

three uniformly-spaced metallic transmission lines, each including a pair of lines having a length substantially equal to a fractional quarter of the wavelength of said energy and means passing through one of said three holes for connecting said pair of lines together, each of said lines being connected to one of said rings and deposited upon a different side of said disc.

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