Sept. 13, 1966 J. C. HOLLOWAY 3,273,159

LOG PERIODIC ANTENNA COMPRISED OF PARALLEL FED QUAD ELEMENTS

Filed June 23, 1964 3 Sheets-Sheet 1

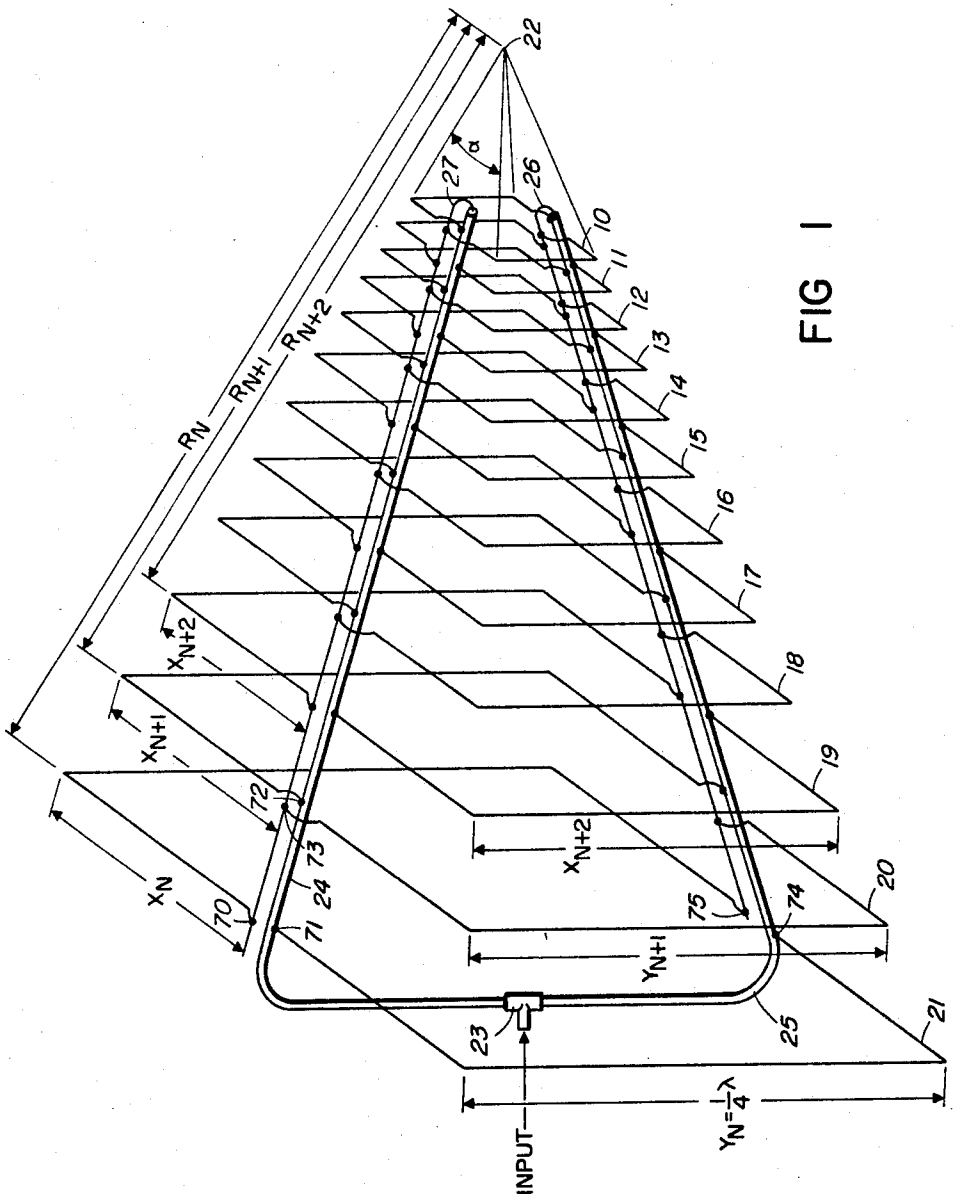



FIG 1

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LOG PERIODIC ANTENNA COMPRISED OF PARALLEL FED QUAD ELEMENTS

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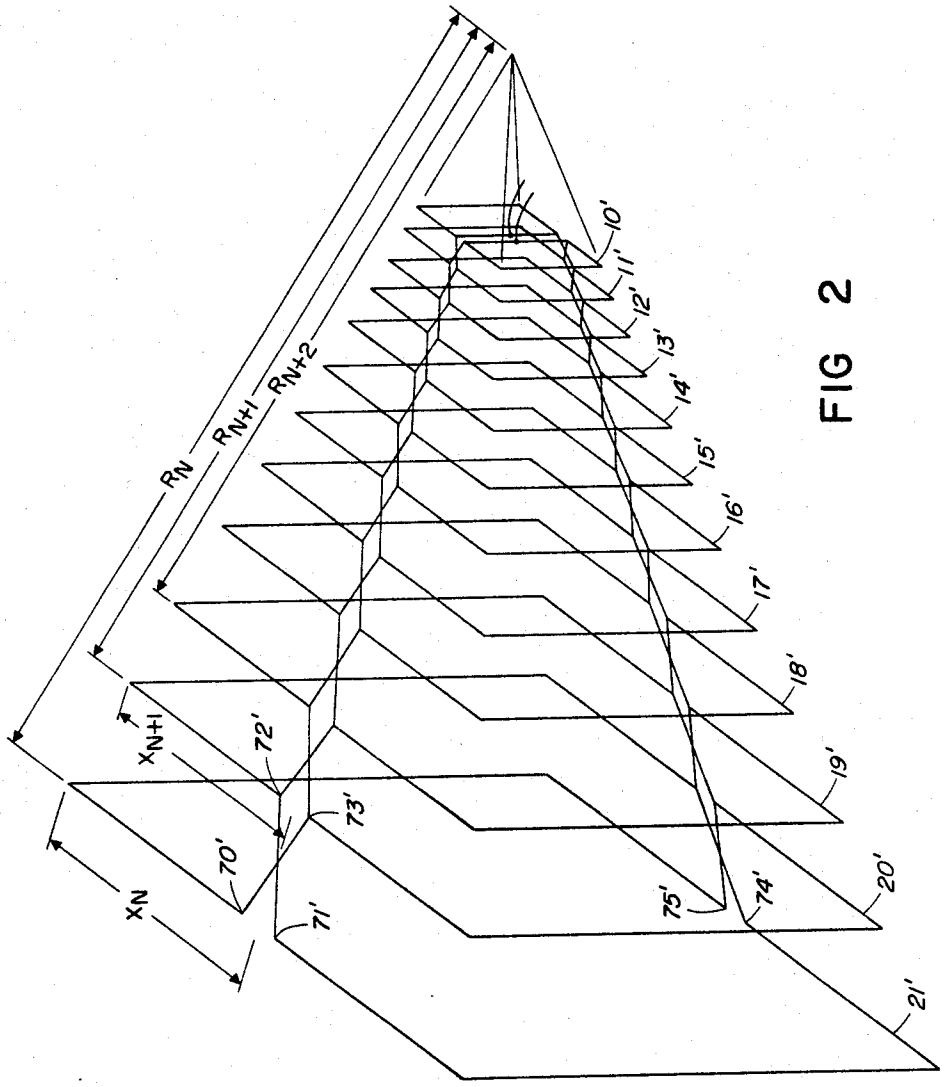



FIG 2

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LOG PERIODIC ANTENNA COMPRISED OF PARALLEL FED QUAD ELEMENTS

Filed June 23, 1964 3 Sheets-Sheet 3

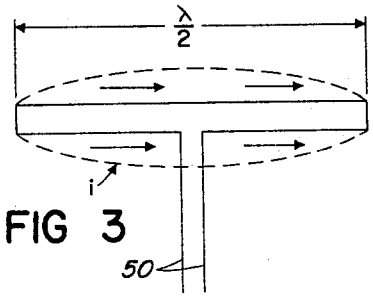



FIG 3

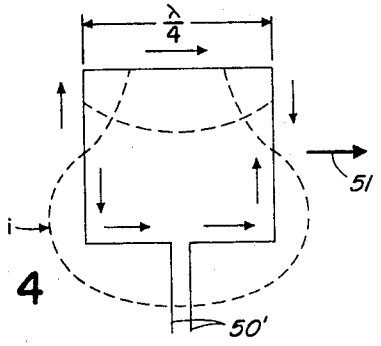



FIG 4

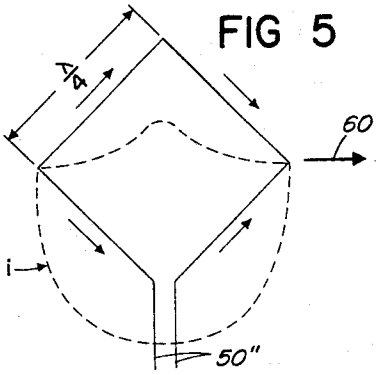



FIG 5

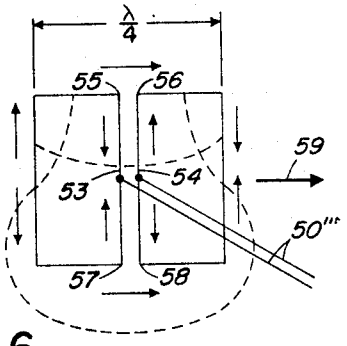



FIG 6

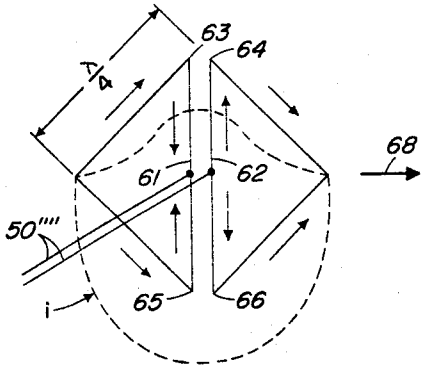



FIG 7

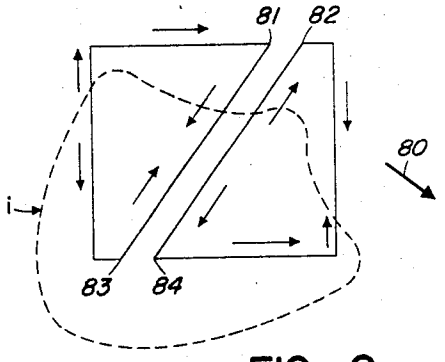



FIG 8

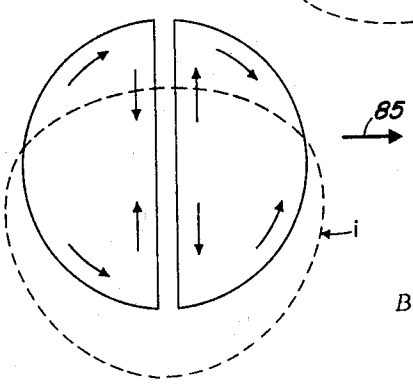



FIG 9

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3,273,159

# LOG PERIODIC ANTENNA COMPRISED OF PARALLEL FED QUAD ELEMENTS

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12 Claims. (Cl. 343—792.5)

This invention relates generally to logarithmically periodic antennas (log periodic antennas) and more particularly to log periodic antennas employing individual quad antennas.

Log periodic antennas are a recent development in the antenna art. The most important feature of log periodic antennas is their ability to maintain both a constant radiation pattern and a constant impedance over a large frequency band. Such antenna systems generally consist of individual antenna elements, each antenna element being generally triangular in shape and lying in a single plane, having a vertex, and having side elements defined by an angle $\alpha$ extending from the vertex. In more detail, each antenna element is comprised of at least two radial sections defined on one side by the center line of the antenna element and on the other side by a radial line extending from the vertex of an angle $\alpha/2$ with respect to said center line. Each radial section has a plurality of teeth comprised of rod-like elements positioned generally transverse to said center line. The said teeth are all similar to one another in shape, but become progressively longer and spaced progressively farther apart as their distance from the vertex increases. The above relationship may be expressed mathematically by stating that the radial distance measured from said vertex to a point on any given tooth in a given radial section bears a constant ratio $\tau$ to the radial distance of a corresponding point on the adjacent tooth next farther removed from said vertex. In the most general case, where each element employs two radial sections, the teeth of one of the radial sections are usually positioned opposite the gaps between the teeth of the other radial section. For a more complete discussion of log periodic principles, reference is made to U.S. Patent 3,059,234 issued Oct. 16, 1962 to R. H. Du Hamel et al. and entitled "Logarithmically Periodic Antenna Array" and incorporated herein by reference.

The frequency of operation of the log periodic antenna is determined by the shortest tooth (a tooth is sometimes refered to as a dipole) and the longest tooth, with the shortest tooth representing approximately a quarter wavelength of the highest frequency and the longest tooth representing approximately a quarter wavelength of the lowest frequency. Since two sections are used in an element, the entire distance across the angle $\alpha$ of the log periodic antenna would represent an electrical length of approximately a half wavelength of a particular frequency of operation.

One difficulty with log periodic antennas lies in the fact that construction thereof is sometimes difficult. The antennas frequently are large, and because of their ladder-like construction are subject to large strains and stresses produced by wind and ice formation thereon. More specifically, the long length of the antenna teeth offers considerable leverage at the bases thereof when snow, wind, or sleet is present.

An object of the present invention is to provide a log



periodic antenna in which the long teeth forming the transverse dipoles of prior art log periodic antennas are not required.

A further object of the invention is a log periodic antenna employing quad antenna elements in lieu of the transverse dipole elements which have been conventionally employed in the log periodic antennas.

A third object of the invention is to simplify the cost and the construction ease of log periodic antennas.

A fourth object is improvement of log periodic antennas, generally.

In accordance with the invention, there is provided a log periodic antenna consisting of a plurality of quad antenna elements lying in planes parallel to one another and having their perimeters lying in four planes which form a pyramidal configuration. Each of the planes in which a quad antenna element lies is normal to the center line of the pyramid and is spaced a radial distance from the apex of said pyramid which bears a constant ratio $\tau$ to the radial distance of the plane containing the quad antenna element next farthest removed from the apex of said pyramid. Feeding of the antenna is accomplished by supplying the signal to two points on each quad, said points being positioned diametrically opposite on each quad. The phase of the signal supplied to each quad is alternated with successive quads. More specifically, the supplied signal is supplied in a first phase to a first quad, then in the opposite phase to the next quad, then in the first phase to the following quad, and so on.

In accordance with a feature of the invention, the electrical distance around the perimeter of each quad is equal to approximately one wavelength of the particular frequency at which that quad is most active. Thus, each side of the quad, in the case where all four sides are equal, is substantially one-quarter wavelength as opposed to the one-half wavelength radiators (teeth) of prior log periodic antennas.

In accordance with another feature of the invention, double feeding at diametrically opposed positions in each quad is necessary in order to prevent the signals of lower frequencies being shorted out by the shorter front elements of the antenna, which shorting might occur if a single feed were employed. The phenomena of the shorting of the lower frequency signals by the higher frequency front elements in the instance of a single feed is much the same phenomena which occurs when folded dipoles are employed in an array. The electrical length of the short front elements is so small with respect to the lower frequency signals that a standing current wave cannot exist as it usually does if the shorted conductor is about one-quarter wavelength long.

In accordance with another feature of the invention, each of the quads may have a configuration different from that of a square. More specifically, each of the quads may be rectangular, circular, or oval in shape. Unless taken to extremes, considered in more detail hereinafter in the specification, each of the various configurations of the quad element will produce a resultant polarized electric field, capable of radiation.

The above-mentioned and other objects and features of the invention will be more fully understood from the following detailed description thereof when read in conjunction with the drawings in which:

FIG. 1 shows a perspective view of the invention;

FIG. 2 shows another perspective view of the invention

with an illustration of a means for feeding the input signal to the antenna; and

FIGS. 3 through 9 are illustrations of different quad configurations and different means for feeding the signals to each of the quad elements.

Referring now to FIG. 1 the quad elements **10** through **21**, inclusively, are positioned parallel to one another at increasing radial distances from the vertex of **22** of the pyramidal shape formed by the quad-like elements. More specifically, the radial distance of any given quad from the vertex **22** bears a constant relationship $\tau$ to the radial distance of the plane of the quad next farthest removed from the vertex **22**. Thus, the radial distance

$$\frac{R_{N+1}}{R_N}=\frac{R_{N+2}}{R_{N+1}}=\tau$$

Each of the quad elements in the embodiment of FIG. 1 has an electrical distance of about one-quarter wavelength. The foregoing may be better understood by a brief additional consideration of the operation of a log periodic antenna.

The lowest frequency of the operating bandwidth of a log periodic antenna is usually determined by the length of the longest dipole element (tooth), and the highest frequency of the operating bandwidth is determined by the length of the shortest dipole elements. The length of a dipole element of prior art log periodic antenna elements is about one-half wavelength in length. Any given frequency, either radiated from or intercepted by the log periodic antenna, will undergo its greatest activity in that area of the log periodic antenna where the width of the antenna is substantially one-half wavelength of the signal being radiated or received. The foregoing statement is an extremely simplified statement of the function of the various radiators in a long periodic antenna element, since some radiation will occur from each of the dipole elements thereon at any given frequency. The magnitude and phase of the radiated energy, however, will vary considerably over the different dipoles of the antenna. In point of fact, in most log periodic antennas there is very little activity beyond that point on the log periodic antenna wherein the electrical length of the dipole elements is substantially one-half the wavelength of the signal being transmitted.

In the configuration of FIG. 1, however, the conventional transverse dipole elements have been replaced by the quad-like elements which have an electrical length of one wavelength around their entire perimeter.

In order to understand the operation of the antenna in FIG. 1, a brief discussion of the operation of a quad antenna element will follow.

In FIG. 3 there is shown a simple folded dipole antenna having a length of one-half wavelength. The current distribution is shown by the dotted line marked with a small (*i*) and the direction of the current is shown by the arrows. By bending the dipole of FIG. 3 in the proper manner, the quad antenna of FIG. 4 can be obtained, with each side being a quarter wavelength long, and with the input signal being supplied through feed line **50'**. The dotted line (*i*) shows the current distribution and the small arrows show the direction of the current in the various parts of the quad antenna. The resultant current flow is represented by the vector **51** at the right of FIG. 4. It is to be noted that the quad antenna element of FIG. 4 has only one feed point.

In FIG. 6 the quad antenna has two feed points at diametrically opposed positions on the quad antenna element, similar to the arrangement shown in FIG. 1. More specifically, the lines **53** and **54** of FIG. 6 represent the transmission line which is connected to both the upper and the lower sides of the quad element. In more detail, the transmission lines **50''** are connected to terminals **55** and **56** at the top of the quad elements and also to terminals **57** and **58** at the bottom of the quad element. Such connections correspond to the connections of the structure of



FIG. 1. In FIG. 1, however, there is a plurality of quad elements, each being fed in a parallel manner with each other, with respect to the transmission feed lines **24**, **25**, **26**, and **27**. The current distribution and the direction of the current in various parts of the antenna element, as well as in the transmission line, are shown respectively by the dotted line identified by the small letter (*i*). At the right of FIG. 6 is a vector **59** which represents the overall resultant direction of current flow in the antenna. It will be observed that the vector **59** corresponds in direction to that of the vector **51** of the structure of FIG. 4.

Although the dual feed connections to the quad elements of FIG. 1 are shown in FIG. 6, it is possible to supply the dual feed input connection at points other than as shown in FIGS. 1 and 6. For example, FIG. 7 shows dual feed connections at the corners of the quad elements. However, before discussing FIG. 7, reference is made to FIG. 5 which may also be formed from the simple folded dipole antenna element of FIG. 2. The folded dipole of FIG. 3 is bent in such a manner so as to form the diamond-shaped configuration of FIG. 5, with each side thereof being a quarter wavelength long. The current direction and distribution is shown, respectively, by the arrows and the dotted line of FIG. 5 and is in response to a driving signal supplied to input feed lead lines **50''**. The resultant over-all direction of current is as shown by the vector **60** positioned at the right of FIG. 5.

The configuration of FIG. 7 is similar to that of FIG. 5 but with two feed inputs. One feed input is at the top of the structure of FIG. 7 and the other at the bottom. More specifically, the transmission lines, represented by leads **61** and **62**, are connected to the terminals **63** and **64**, and also to the second pair of terminals **65** and **66**. The current distribution and instantaneous direction of flow are shown, respectively, by the dotted line (*i*) and the small arrows. The large vector **68** at the right of FIG. 7 represents the over-all resultant current flow.

Returning again to the structure of FIG. 1, the input signal is fed into a T connector **23** which then supplies the input signal in parallel to the two coaxial transmission lines **24** and **25**. The outer conductors of the coaxial lines **24** and **25** terminate at the lower or small end of the antenna, and the inner conductors **27** and **26** thereof continue and are folded back to extend parallel to the outer conductor to the large end of the antenna. Thus, there are provided two transmission lines in parallel to corresponding pairs of terminals on diametrically opposed sides of each of the quad antenna elements. Since the system is balanced, the signal supplied to opposite sides of any given quad should be identical so that for practical purposes the corresponding terminals of each of the two pairs of terminals on a given quad are effectively shorted together as shown in FIGS 6 and 7.

To obtain a proper phasing, successive quad elements are connected to alternate ones of the inner and outer conductors of the coaxial transmission line. Thus, the terminal **70** of quad element **21** is connected to the inner (extended) conductor **27** of coax line **24** and the associated input terminal **71** is connected to the outer conductor of the coaxial cable. The next quad element, however, has the corresponding pair of input terminals **72** and **73** reversed so that the input terminal **72**, which correspond to input terminal **70** of quad element **21**, is connected to the outer conductor of coaxial cable **24**, and the input terminal **73** is connected to the inner conductor (extended) of the coaxial cable **24**.

It is to be noted that the upper and lower pair of input terminals of any given quad are connected in a similar manner. Thus, both terminals **70** and **75** of quad **21** are connected to the inner conductor (extended) of the associated coaxial cable and the terminals **71** and **74** are connected to the outer conductor of the associated coaxial transmission line.

The connections of the feed in transmission lines of FIG. 1 are more clearly shown in FIG. 2, particularly the

alternate phasing of the input signal with successive quad elements.

Since the structure of FIG. 2 is substantially electrically identical with the structure of FIG. 1, no detailed description thereof will be given. Corresponding elements of the structure of FIG. 2 are identified by the same reference characters as the corresponding elements of FIG. 1, although such reference characters are primed in FIG. 2.

In FIG. 8 and FIG. 9, there are shown two additional means for feeding a quad antenna. Also shown is a circular configuration for a quad antenna.

In FIG. 8 the feed points are shifted so as to form a diagonal relationship with the quad element. The two feed points are balanced in that the lengths of the perimeter between corresponding terminals of the two pairs of terminals are equal; i.e., the perimetric distance from the terminal **82** to the terminal **84** is equal to the perimetric distance between the terminals **81** and **83**. The vector **70** represents the resultant current.

In FIG. 9 there is shown a circular configuration for a quad element. Here, again, the dotted line (*i*) represents the current distribution in the quad element and the small arrows represent the direction of the current at various points in the quad element. The large vector **85** to the right of the figure represents the resultant current flow in the element.

Radiation from the antenna occurs off the small end or apex of the antenna of FIGS. 1 and 2, and is polarized in the manner described in connection with the polarization of the quad elements of FIGS. 6, 7, 8, and 9. Such polarization is represented by vectors **59**, **68**, **80**, and **85**.

It is to be understood that the forms of the invention shown and described herein are but preferred embodiments thereof and that various changes in configuration can be made without departing from the spirit or scope of the invention.

I claim:

**1.** Logarithmically periodic antenna means comprising a plurality of at least four quad antenna elements constructed to form a frustum with each quad lying in a plane substantially perpendicular to the axis of said frustum,

the radial distance of the plane of any quad antenna element measured from the apex of the frustum, bearing a constant ratio $\tau$ to the radial distance of the plane of the quad antenna next farthest removed from said apex,

said apex being defined as the point of convergence of the frustum when extended,

and feed means for supplying an input signal to each of said quad antenna elements in a parallel manner.

**2.** Log periodic antenna in accordance with claim **1** in which each quad antenna element is opened at diametrically opposed points thereon to form two pairs of open ends,

said feed means for feeding quad antenna elements comprising first and second transmission line means, one transmission line means being connected to the open ends of each of the quad antenna element on one side thereof, and the other transmission line means being connected to the open ends of each of the quad antenna elements on the other side thereof,

and third transmission line means for supplying the input signal to said two transmission line means in parallel.

**3.** Logarithmically periodical antenna means in accordance with claim **2** in which,

said first and second transmission line means each comprises two conductors,

in which each of said quad antennas is divided into two sections by said openings at diametrically opposed positions,

and in which the two sections of alternate quad antenna elements are connected to alternate conductors of the first and second transmission line means.

**4.** A logarithmically periodic antenna in accordance with claim **2** in which said first and second transmission line means each comprises:

coaxial cable means positioned along the open ends on one side of the quad antenna elements,

the outer conductor of said coaxial cable means terminating near the small end of said frustum,

and the inner conductor of said coaxial cable being folded back and extending alongside the said outer conductor,

the outer conductor and the inner conductor forming the said conductors of each of said first and second transmission line means.

**5.** A logarithmically periodic antenna in accordance with claim **1** in which each of said quad antenna elements is substantially square in shape with the electrical length of the complete perimeter being substantially equal to one wavelength at the frequency at which the most radiation occurs from said each quad antenna element.

**6.** Log periodic antenna in accordance with claim **5** in which each quad antenna element is opened at diametrically opposed points thereon to form two pairs of open ends,

said feed means for feeding quad antenna elements comprising first and second transmission line means, one transmission line means being connected to the open ends of each of the quad antenna elements on one side thereof, and the other transmission line means being connected to the open ends of each of the quad antenna elements on the other side thereof,

and third transmission line means for supplying the input signal to said two transmission line means in parallel.

**7.** Logarithmically periodical antenna means in accordance with claim **6** in which,

said first and second transmission line means each comprises two conductors,

in which each of said quad antennas is divided into two sections by said openings at diametrically opposed positions,

and in which the two sections of alternate quad antenna elements are connected to alternate conductors of the first and second transmission line means.

**8.** A logarithmically periodic antenna in accordance with claim **6** in which said first and second transmission line means each comprises:

coaxial cable means positioned along the open ends on one side of the quad antenna elements,

the outer conductor of said coaxial cable means terminating near the small end of said frustum,

and the inner conductor of said coaxial cable being folded back and extending alongside the said outer conductor,

the outer conductor and the inner conductor forming the said conductors of each of said first and second transmission line means.

**9.** A logarithmically periodic antenna in accordance with claim **1** in which each of said quad antenna elements is substantially rectangular in shape with the electrical length of the complete perimeter being substantially equal to one wavelength at the frequency which produces the greatest radiation from said each quad antenna element.

**10.** Log periodic antenna in accordance with claim **9** in which each quad antenna element is opened at diametrically opposed points thereon to form two pairs of open ends,

said feed means for feeding quad antenna elements comprising first and second transmission line means, one transmission line means being connected to the open ends of each of the quad antenna elements on one side thereof, and the other transmission line means being connected to the open ends of each of the quad antenna elements on the other side thereof,

and third transmission line means for supplying the

input signal to said two transmission line means in parallel.

**11.** Logarithmically periodical antenna means in accordance with claim **10** in which,

said first and second transmission line means each comprises two conductors,

in which each of said quad antennas is divided into two sections by said openings at diametrically opposed positions,

and in which the two sections of alternate quad antenna elements are connected to alternate conductors of the first and second transmission line means.

**12.** A logarithmically periodic antenna in accordance with claim **10** in which said first and second transmission line means each comprises:

coaxial cable means positioned along the open ends on one side of the quad antenna elements,

the outer conductor of said coaxial cable means terminating near the small end of said frustum,



and the inner conductor of said coaxial cable being folded back and extending alongside the said outer conductor,

the outer conductor and the inner conductor forming the said conductors of each of said first and second transmission line means.

**References Cited by the Examiner**

UNITED STATES PATENTS

| | | | |
|---|---|---|---|
| 1,347,440 | 7/1920 | Callaghan | 343—867 X |
| 2,246,151 | 6/1941 | Vrooman | 343—874 X |

OTHER REFERENCES

"The A.R.R.L. Antenna Book," The American Radio Relay League, Inc., West Hartford, Conn., 1960, p. 275.

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