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Oct. 5, 1965 E. HUDOCK ETAL 3,210,768

LOG PERIODIC ANTENNA FED BY SINGLE ZIGZAG CONDUCTOR WHICH REDUCES CAPACITIVE LOADING ON THE MONOPOLE RADIATORS AND REDUCES CROSS POLARIZATION

Filed Feb. 23, 1962 5 Sheets-Sheet 1

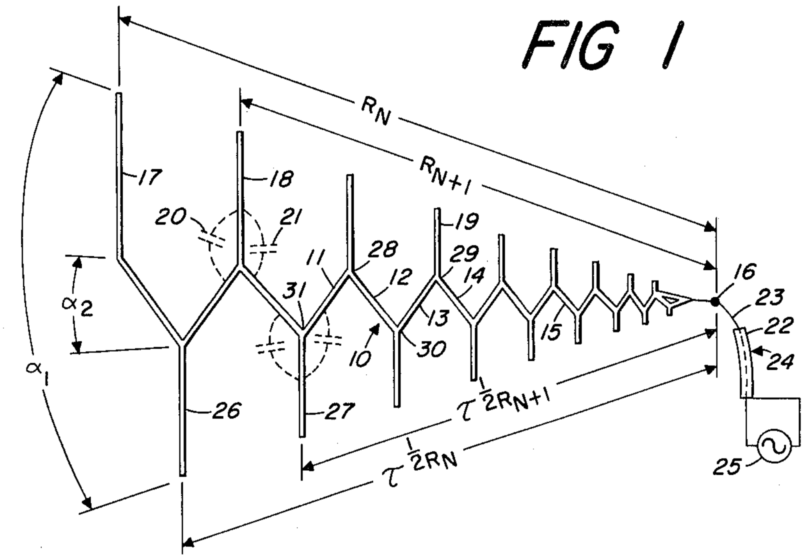

FIG 1

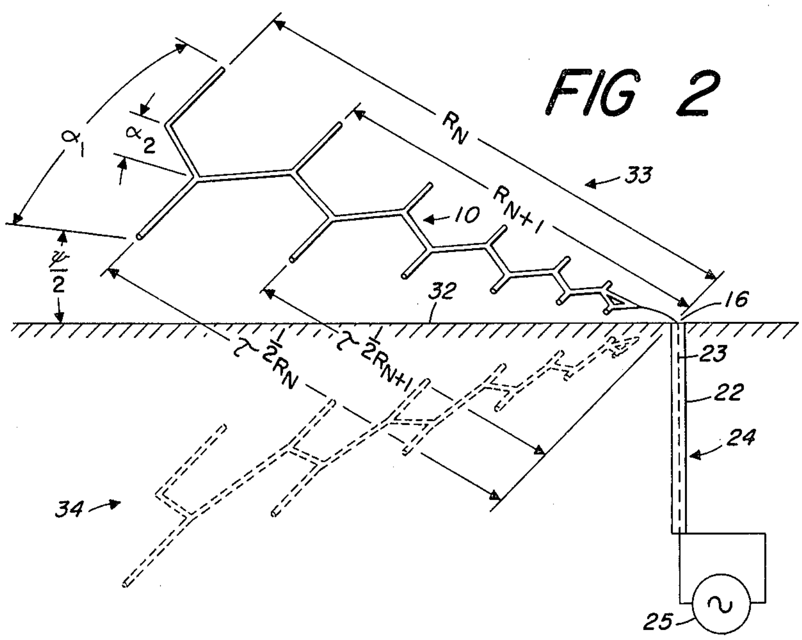

FIG 2

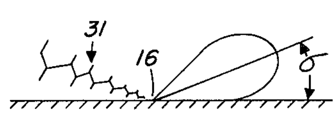

FIG 2a

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Filed Feb. 23, 1962 5 Sheets-Sheet 2

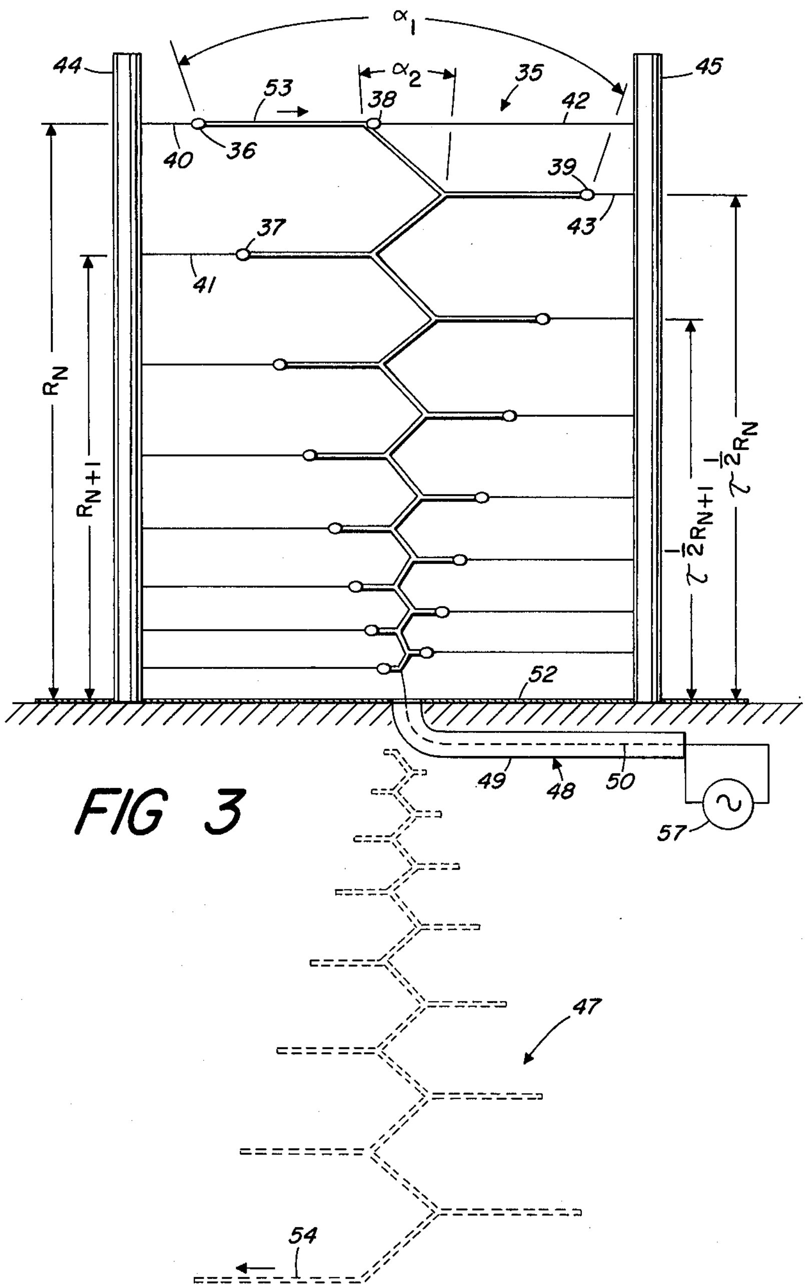

FIG 3

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Filed Feb. 23, 1962 5 Sheets-Sheet 3

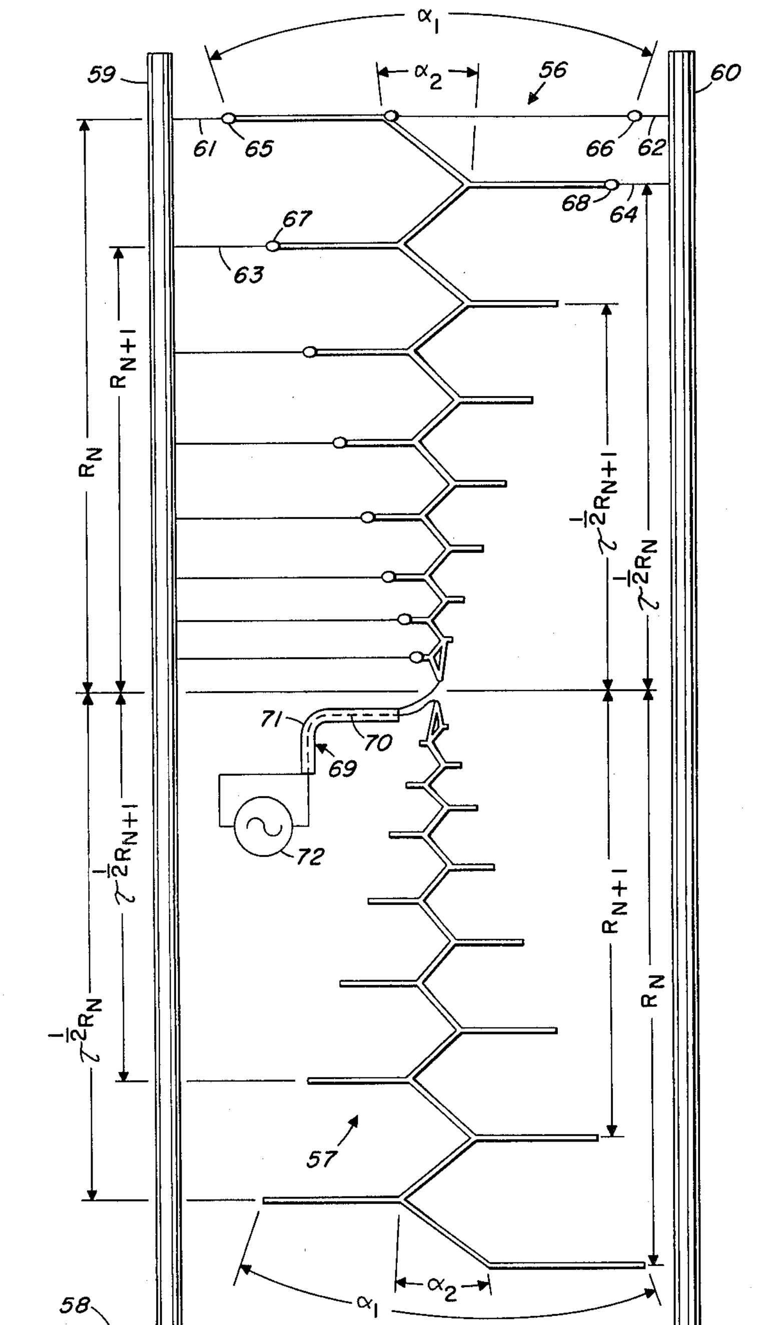

FIG 4

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Filed Feb. 23, 1962 5 Sheets-Sheet 4

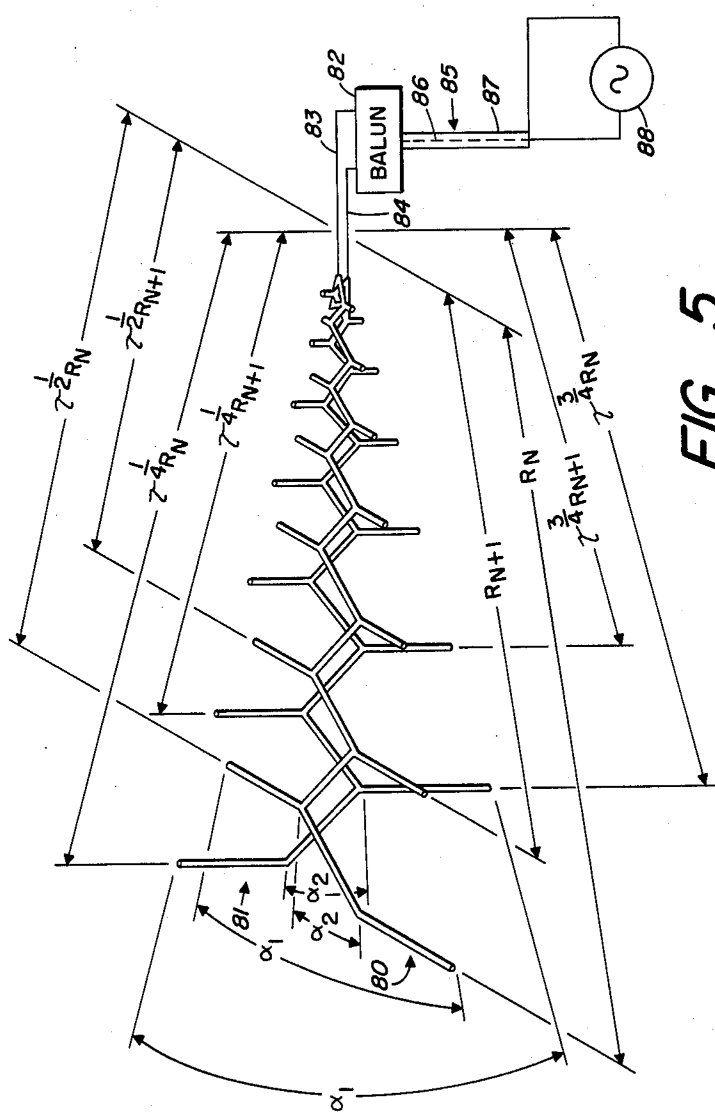

FIG 5

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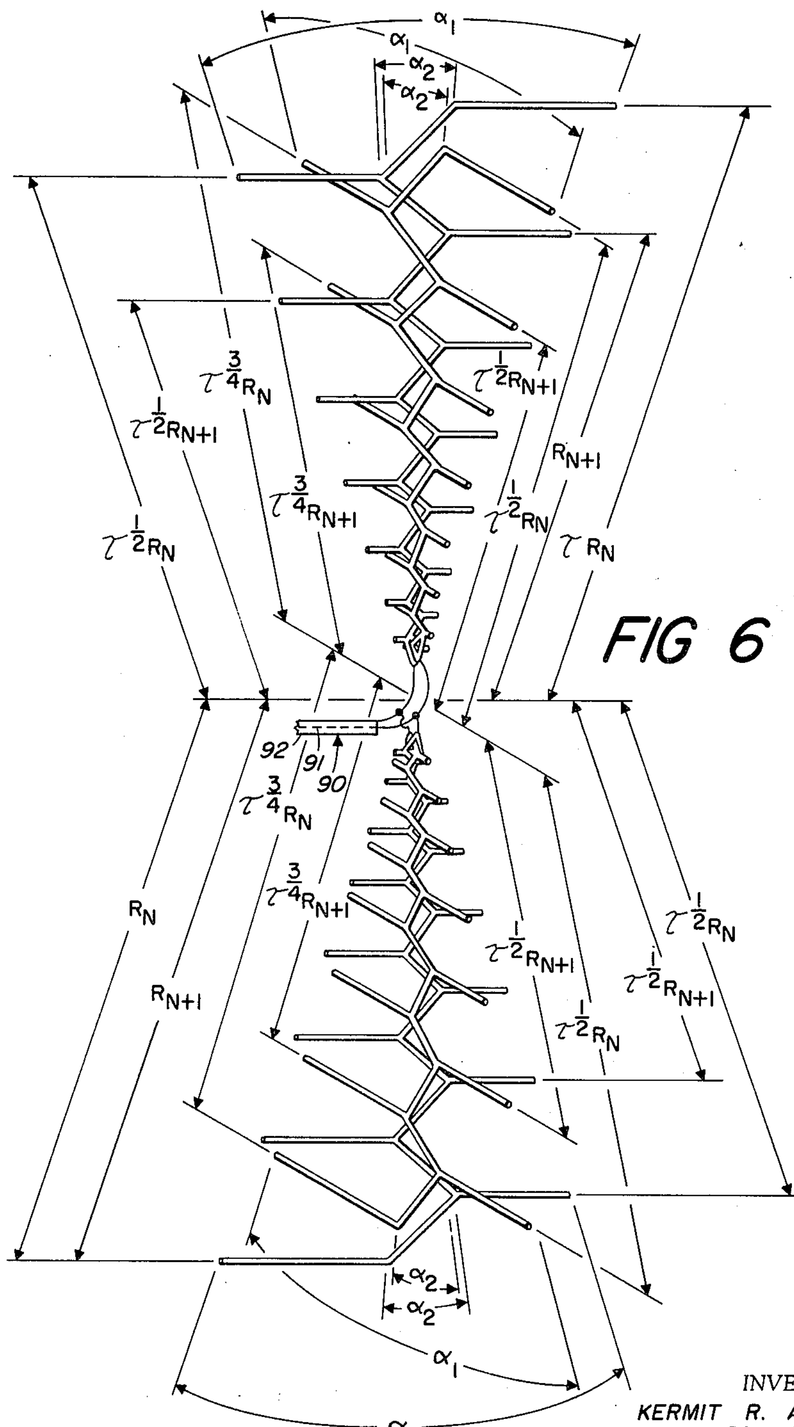

FIG 6

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LOG PERIODIC ANTENNA FED BY SINGLE ZIG-ZAG CONDUCTOR WHICH REDUCES CAPACITIVE LOADING ON THE MONOPOLE RADIATORS AND REDUCES CROSS POLARIZATION

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Filed Feb. 23, 1962, Ser. No. 175,132
8 Claims. (Cl. 343—792.5)

This invention relates generally to logarithmically periodic antenna structures and, more particularly, to an improved logarithmic periodic antenna configuration which for one principal intended application (i.e., fixed point-to-point high-frequency communication) is simpler in electrical and mechanical design than previous log periodic antennas having similar performance characteristics. Specifically, the means by which the antenna radiating elements are coupled to the input to the antenna (or output when receiving) allows for simplifications in design. Furthermore, such signal feed-in technique yields less cross polarization and, also, permits an unbalanced feed, thus requiring no balun (balancing to unbalancing device).

In the following introduction a general description of a logarithmic periodic antenna (also referred to herein as a log periodic antenna) will be given to supply the reader with background to better understand the invention. Subsequently, particular problems existing in present logarithmic periodic antennas, which the present invention solves, will be pointed out.

Log periodic antennas are a fairly recent development in the art. Perhaps the most important feature of log periodic antennas lies in their ability to maintain a substantially constant radiation pattern and a substantially constant input impedance over large frequency ranges of the order of 10 or 20 to 1, or even greater. Such antenna systems are usually comprised of a plurality of individual antenna elements, each antenna element being generally triangular in shape, having a vertex, and being confined within an angle α extending from the vertex. A line or boom of conductive material ordinarily is positioned along the bisector of the angle α and functions to couple the electromagnetic energy to the antenna elements, as well as to support said elements. Each antenna element is comprised of at least two radial sections, each section being generally triangular in shape with a common vertex and a common side, said common side consisting of the boom referred to above. The outer side of each triangularly shaped radial section is defined by a radial line extending from the vertex at an angle $\alpha/2$ formed with respect to said center line or boom of the antenna element. Further, each radial section has a plurality of teeth comprised of elements which are positioned in a generally transverse manner with respect to the center line of the antenna element. Such teeth are all similar to one another in shape, but become progressively larger and spaced progressively farther apart as the distance from the common vertex increases. The above-mentioned size and spacing relationships may be expressed by stating that in a given radial section the radial distance from the vertex to a given point on any given tooth bears a constant ratio τ to the radial distance to a corresponding point on the adjacent tooth next farthest removed from the vertex than said given tooth. In the most general case, where each antenna element employs two radial sections lying in the same plane, the teeth of one of the radial sections are positioned opposite the gaps between the teeth of the other radial section. It is to be noted that throughout this specification a single tooth of an antenna radial section will sometimes be referred to as a monopole.

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The log periodic antenna elements described in the preceding paragraphs may be arranged in many different combinations to perform desired functions. Usually, the antenna elements are employed in multiples of two, i.e., in pairs. For example, a pair of log periodic antenna elements may be arranged in such a manner that the vertices are near each other (but not quite touching), and positioned with respect to each other as opposite sides of a pyramid. Such an arrangement is known in the art as a nonoplanar array of log periodic antenna elements. For a more detailed description of such structure, the reader's attention is directed to the following patent applications which are hereby incorporated by reference into the present specification: United States patent application, Serial No. 721,408, filed March 14, 1958, now Patent No. 3,079,602, by Raymond H. Du Hamel and Fred R. Ore, and entitled, "Logarithmically Periodic Antenna;" United States patent application, Serial No. 804,-357, filed April 6, 1959, now Patent No. 2,989,749, by Raymond H. Du Hamel and David G. Berry, entitled, "Unidirectional Frequency Independent Coplanar Antenna"; United States patent application, Serial No. 841,-391, filed September 21, 1959, now Patent No. 3,059,234, by Raymond H. Du Hamel et al., entitled, "Antenna Arrays"; United States patent application, Serial No. 841,-400, filed September 21, 1959, now Patent No. 2,983,835, by Raymond H. Du Hamel et al., entitled, "Broadside Antenna Arrays"; and United States patent application, Serial No. 31,068, filed May 23, 1960, now Patent No. 3,113,316 by David G. Berry, entitled, "Unidirectional Circularly Polarized Antena."

It has been found that the cost of construction of the antenna arrays described in the preceding paragraphs, and in the applications incorporated herein by reference, has been quite high, especially in the lower frequency ranges. Such high cost is due primarily to the fact that the log periodic antenna arrays require a number of large antenna elements which are mounted in the air, usually many feet above the ground, on large masts. Structural difficulties are encountered in that the antenna element usually consist of rather long dipole elements mounted on suitable booms. In the presence of wind or sleet the dipole elements function as cantilever arms and provide rather serious stresses and strains at the point of connection to the boom elements.

It is to be noted that there has been developed a form of log periodic antenna structure which obviates many of the structural difficulties pointed out above. Such a log periodic structure comprises a single log periodic antenna element mounted overground with the vertex at the ground plane and with the remainder of the antenna sloping upwards so that the teeth or monopoles at the rear end of the antenna are well above the ground plane and, of course, parallel to said ground plane. The entire antenna forms an angle $\psi/2$ with the ground plane and feeds against its reflection in the ground plane. However, even with such a structure the problems presented by sleet, wind, and snow are still not completely solved. As will be shown hereinafter, such problems are appreciably lessened with respect to one form of the invention employing a log periodic antenna element mounted over ground.

Another difficulty with some forms of log periodic antenna structures, including horizontally polarized structures mounted over ground, is the presence of a vertical component of radiation emanating from the vertical component of the center conductor or boom, which is normally positioned between the two radial sections of the horizontally polarized antenna element.

It is a primary object of the invention to provide a horizontally polarized antenna structure over ground for high-frequency point-to-point communication (i.e., constant vertical plane pattern) which is simpler in electrical and mechanical design than any structure known heretofore and which exhibits less vertical polarization than other log periodic antenna structures having similar operating capabilities.

Another object of the invention is a less expensive and easier-to-construct horizontally polarized antenna structure over ground than has heretofore been known.

A third aim of the invention is to provide a relatively simple log periodic antenna structure which is less frequency sensitive with respect to impedance and pattern than other log periodic antenna configurations.

A fourth purpose of the invention is the improvement of log periodic structures, generally.

In accordance with the invention there is provided a log periodic antenna element having a center conductor which consists of a zigzag shaped conductive element which replaces the straight center conductor discussed above. The peak-to-peak amplitude of said zigzag element increases as the distance from the vertex of the antenna element increases. Further, the said peaks of the zigzag center element are defined by an angle α_2 which is measured from the vertex of the antenna element and which has a center line which coincides with the center line of the antenna element, i.e., of α_1. In accordance with log periodic principles the radial distance to any given peak on one side of said zigzag center conductor bears a constant ratio τ to the radial distance of the next farthest peak removed from said vertex on the same side of said zigzag center conductor member. Individual monopoles, or teeth, extend out in a transverse manner from each peak of said zigzag central conductive member with the radial distance from the vertex of the antenna element to any given monopole element bearing a constant ratio τ to the radial distance of the transverse monopole element next farthest removed from said vertex and on the same side of said central conductive member.

In accordance with one theory of the invention, the interwire capacitance existing between any given transverse monopole and the central conductive member is less than in the case where the central conductive member is straight as in prior art log periodic antenna configurations. Consequently, the electrical length of a given transverse monopole element appears smaller in the present invention than in those configurations where the central supporting member is straight. Such lessening of the effective electrical length of the transverse monopole elements results in the moving of the phase center (i.e., the apparent point of radiation of a signal having a given frequency) farther out along the antenna element from the vertex thereof, as compared to the structure having a straight center support member.

It is characteristic of log periodic antenna elements that as the phase center is moved back from the vertex, a smaller angle is required between the elements of a nonplanar array, or an element and ground in a horizontally polarized antenna over ground structure. Thus, construction is simplified.

In accordance with another feature of the invention, the zigzag configuration of the center support member functions to lessen the radiation caused by the vertical component of the center support member. Although the reasons for this lessening of radiation from such vertical component are not well understood at the present time, experimental data supports such a conclusion.

In accordance with other features of the invention, the log periodic configuration of the present invention can be employed in applications other than the horizontally polarized antenna overground configuration. More specifically, the configuration of the present invention may be applied to structures for producing horizontally or vertically polarized bidirectional radiation patterns, circularly or elliptically polarized radiation patterns, or omidirectional radiation patterns.

The above 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 plan view of the basic antenna element of the present invention;

FIG. 2 shows the application of the basic antenna element to a horizontally polarized structure positioned over ground;

FIG. 2*a* shows the vertical angle of radiation change with the change of phase center;

FIG. 3 shows another application to a horizontally polarized structure positioned over ground capable of producing a bidirectional radiation pattern;

FIG. 4 shows a structure employing two antenna elements of the present invention arranged in a plane vertical to ground and capable of producing a bidirectional radiation pattern;

FIG. 5 shows an application of the present invention employing two antenna elements arranged at right angles to each other along a common center line to produce a circularly polarized radiation pattern; and

FIG. 6 shows two structures each similar to the one of FIG. 5 and positioned along a common center line, with the vertices pointing in opposite directions and substantially coincident with each other; such structure is capable of producing a rotating omnidirectional radiation pattern.

Referring now to FIG. 1, there is shown the basic antenna element of the invention. It will be observed that the general shape of the antenna element is triangular with a vertex **16** and with its outer edges defined by the angle α_1. It will be noted that the antenna element of FIG. 1 has no straight conductive center support means positioned along the bisector of the angle α_1. Instead the center support means consists of short conductive sections, such as sections **11, 12, 13, 14,** and **15** arranged to form the zigzag configuration identified generally by the reference character **10**. Each short section functions as an electrical connection between successive teeth which are located at the peaks of the zigzag configuration; with no teeth or branches between the zigzag peaks. It will be observed that the peaks of the zigzag configuration, such as peaks **28, 29, 30,** and **31** have a larger amplitude swing as the distance from the vertex **16** of the antenna element increases. More specifically, the said peaks, such as **28** through **31**, are defined by the angle α_2 whose bisector coincides with the bisector of angle α_1. Furthermore, the radial distances of the peaks of the zigzag-shaped central supporting member **10** are in accordance with the log periodic principle; that is to say, the radial distance from the vertex **16** to any given peak, such as peak **29**, bears a constant ratio τ to the radial distance from the vertex **16** to the adjacent peak **28** next farthest removed from the vertex **16**. Similarly, the radial distance of the peak **20** would bear the ratio τ to the radial distance of the peak **31**.

From each peak there extends outwardly from the center line of the antenna element a tooth, or transverse monopole member, such as monopole members **17, 18, 19, 26,** and **27**. The outer ends of these teeth are defined by the angle α_1 which is measured from the vertex **16** of the antenna element shown in FIG. 1. The relationship of the radial distance of adjacent teeth is the same as that for adjacent peaks of the zigzag center supporting member. More specifically, the following relationships are true:

$$\frac{R_{n+1}}{R_n}=\tau=\frac{\tau^{1/2}R_{n+1}}{\tau^{1/2}R_n}$$

It will be noted that the radial distances of the teeth on the lower half of the antenna element bear a relationship $\tau^{1/2}$ to the radial distances of the teeth of the top half of the antenna element. Such relationship $\tau^{1/2}$ is in accordance with the log periodic principle and assures that any signal within the bandwidth of the antenna, will always see substantially the same environment.

An input signal is supplied to the antenna structure of FIG. 1 via a coaxial cable means **24** which has an outer conductor **22** and an inner conductor **23**. The said inner conductor **23** is electrically connected to the central supporting member of the antenna element and the outer conductor **22** can be connected to ground potential, as will be shown subsequently in connection with the discussion of FIG. 2. The signal source **25** represents the input signal source. The angle α_2 is of the order of 3 to 7 degrees.

It will be seen from FIG. 1 that the interwire capacitance, such as capacitances **20** and **21**, will be less with the zigzag-shaped center supporting member than a straight center supporting member due to the greater distances between the teeth and the center supporting member in the case of the zigzag configuration. Consequently, the electrical length of each of the transverse monopoles of the structure of FIG. 1 will be less than if the center conductive member were straight, since a decrease in capacitive loading, such as produced by the interwire capacitances **20** and **21**, functions to increase the resonant frequency. An increase in resonant frequency means, of course, that the corresponding wavelength is shorter. Since the electrical length of the structure of FIG. 1 is shorter than in a corresponding structure having a straight center support member, the phase center of the radiated signal will appear to be farther out along the antenna element from the vertex **16** than in the case where the center support means were straight.

The moving of the phase center, i.e., apparent source of radiation, farther from the vertex **16** of the log periodic antenna element has the following advantageous result. The vertical angle of radiation from a log periodic antenna mounted over ground, is determined chiefly by the height of the phase center above ground. More specifically, referring to FIG. 2*a*, as the phase center moves farther back along the antenna element **31** the vertical angle σ of radiation decreases. The advantage obtained from the moving of the phase center farther back from the vertex can be utilized in decreasing the angle that the antenna makes with the ground plane, such as the angle $\psi/2$ in FIG. 2, for example. Such decrease in the angle $\psi/2$ results in a reduction of construction costs as compared to the case where the angle $\psi/2$ were larger. As discussed in the introduction hereinbefore, log periodic antennas are sometimes very large and any reduction possible in the angle $\psi/2$ helps to alleviate the construction problems which are presented.

In FIG. 2 the antenna element **33**, similar to that shown in FIG. 1, is mounted over ground in such a manner as to produce a horizontally polarized radiation pattern. The vertex **16** thereof is near ground level, although it is to be understood that the vertex of the antenna does not actually touch the ground plane. The antenna slopes upward over the ground plane **32** to form an angle $\psi/2$ with said ground plane. A mirror image of the antenna element **33** is formed underground and is identified generally by the reference character **34**. The radiation pattern **46** occurs off the vertex **16**, as shown in FIG. 2*a*. Feeding of the input signal to the antenna element is accomplished by the coaxial cable **24** comprised of an outer conductive sheath **22** and an inner conductor **23**. The outer sheath **22** is connected to one terminal of a signal source **25** and the inner conductor **23** is connected to the other terminal of said signal source **25**. The other end of the inner conductor **23** is connected to the center support member **10** of antenna element **33** and the other end of the outer sheath **22** is connected to the ground plane **32**. It is to be noted that the ground plane **32** may consist of a conductive screen laid over a flat area prepared therefor on the earth's surface.

The antenna **33** of FIG. 2, which can be supported in the position shown in the figure by means of appropriate supporting posts and guy wires (not shown), may be constructed of conductive wire or rods, either of a solid or cylindrical cross section.

Referring now to FIG. 3, there is shown another form of the invention which employs the antenna element of FIG. 1 mounted vertically over ground with the vertex substantially at the ground plane, although not electrically connected thereto. The antenna is identified, generally, by the reference character **35** and is supported between supporting posts **44** and **45** by means of insulators, such as insulators **36**, **37**, **38**, and **39**, and tie wires **40**, **41**, **42**, and **43**. Each insulator may have holes therein through which the associated tie wire and transverse monopole means are affixed. As in the case of FIG. 2, the antenna element **35** produces a mirror image thereof in the ground plane; said mirror image being identified generally by the reference character **47**. The input signal is supplied to the antenna by means of a coaxial cable **48** comprised of an inner conductor **50** and an outer sheath **49**, with the inner conductor **50** being connected at one end to the antenna element **35** and at the other end to the signal source **57**. The outer sheath **49** of the coaxial cable is connected at one end to the ground plane **52** and at the other end to the other terminal of the signal source **51**. Radial distances of the various teeth of the antenna element **35** bear the relationship τ to each other as was described in connection with the antenna element of FIG. 1. Since the real and image antennas are mirrored images of each other and, further, since the signals supplied to the real and the image antenna element are 180° out of phase, the instantaneous current in corresponding teeth of the real and the virtual antenna element will be opposed, as shown by the arrows in the transverse monopole element, or teeth **53** and **54**, of the real and the virtual antenna elements. Such phasing of the currents would result, if both antenna elements were real, in a bidirectional radiation pattern with two lobes in the vertical plane in each direction. However, due to the presence of the boundary formed by the ground plane only one lobe will appear and that lobe will, of course, be above ground.

Referring now to FIG. 4, there is shown a configuration employing two of the antenna elements of FIG. 1 arranged in a single plane with the vertices pointing at each other and being substantially coincident. These two antenna elements are nonimages of each other, and are identified generally by the reference characters **56** and **57**. As can be seen from FIG. 4, they are supported in their particular position above the ground plane **58** by two upright posts **59** and **60**. Tie wires, such as tie wires **61**, **62**, **63**, and **64** in cooperation with insulators, such as insulators **65**, **66**, **67**, and **68** function to hold the antenna elements in their proper position. To simplify the drawing, all of the insulators and tie wires are not shown, although it is to be understood that an insulator and a tie wire is needed ordinarily for each tooth.

Since the two antenna elements **56** and **57** are nonmirror images of each other, there will be produced a bidirectional radiation pattern with a single lobe in the vertical plane in each of the two directions. The input signal to the antenna system is supplied by means of a coaxial cable **69** comprised of an inner conductor **70** and an outer sheath **71**. One end of the inner conductor **70** is connected to the center supporting member of the antenna element **57** and the other end thereof is connected to a terminal of the signal source **72**. The outer sheath **71** has one end thereof connected to the center supporting member of the antenna element **56** and the other end thereof connected to the other terminal of the signal source **72**.

Referring now to FIG. 5, there is shown a pair of antenna elements sharing a common center line and having their vertices pointing in the same direction and positioned substantially coincident in space. These two antenna elements lie in planes perpendicular to one another and are capable of producing a circularly polarized radiation pattern. For purposes of identification, the said two antenna elements are identified generally by the reference characters **80** and **81**.

It will be observed that the antenna element **80** lying in the plane vertical to the plane of the drawing has its radial dimensions defined in the same manner as the antenna element of FIG. 1. However, in order to obtain a circularly polarized radiation pattern, that is, a rotating radiation pattern, two conditions are necesary. A first of these two conditions is that the radiated signals are generated in space quadrature, i.e., the polarization of the signals at the source of generation should be 90° apart. This first condition is met by having the two antenna elements **80** and **81** positioned mutually perpendicular to each other. The second condition is that the two signals radiated by the two antenna elements be phased 90° apart in time. This latter condition is met by shrinking or stretching the antenna elements **80** or **81** by 90° in accordance with the principles set out in the above-mentioned co-pending application, Serial No. 841,391. In the particular structure shown in FIG. 5, the antenna element **81** lying in the plane of the drawing has been shrunk by 90°. Therefore, all of its dimensions are reduced by a factor $\tau^{1/4}$.

It will be observed that the relationship of the radial distances of the various teeth remain the same in FIG. 5 as they are in FIG. 1. More specifically

$$\frac{\tau^{3/4}R_{n+1}}{\tau^{3/4}R_n}=\tau=\frac{\tau^{1/4}R_{n+1}}{\tau^{1/4}R_n}$$

The signal is supplied to the structure of FIG. 5 by means of a coaxial cable **85** comprised of an inner conductor **86** and outer conductor **87** which are connected at one end across the signal source **88**. A balun **82** is provided to change the unbalanced coaxial conductor into a balanced two-wire conductor consisting of wires **83** and **84** which are connected to the center conductors of the two antenna elements **80** and **81**. It is to be noted that baluns can also be employed with the structures of FIGS. 4 and 6 in a manner similar to that shown in FIG. 5.

Referring now to FIG. 6, there is shown a form of the invention employing two of the structures shown in FIG. 5 which share a common center line, with their vertices pointed at each other, and being positioned substantially coincident in space. The upper half of the structure in FIG. 6 is a non-mirror image of the lower half of the structure of FIG. 6 and, with the connections shown, will function to produce a rotating omnidirectional radiation pattern. The signal is supplied to the structure through a coaxial cable **90** having an inner conductor **91** and an outer conductor **92**. The inner conductor **91** is connected to one of the antenna elements in the upper half of the structure of FIG. 6 and also to the antenna element lying in a plane perpendicular thereto in the lower half of the structure of FIG. 6. The outer sheath **92** of the coaxial cable is connected to the remaining two antenna elements of FIG. 6. An omnidirectional radiation pattern can also be obtained by rotating the lower half of the structure of FIG. 6 about its center line by 180° and then switching the connections to the two antenna elements forming said lower half.

It is to be understood that the forms of the invention shown and described herein are but preferred embodiments thereof and that various other combinations of log periodic configurations shown and described herein may be employed without departing from the spirit or the scope of the invention.

We claim:

1. A log periodic antenna structure comprising at least a first antenna element generally triangular in shape and having a vertex pointing generally in the direction of radiation from said antenna, the sides of said antenna element being defined by an angle α_1 measured from said vertex, central support means having a zigzag shape and consisting of a series of straight, conductive elements joined end-to-end without branches between said ends and lying in the plane of said antenna element, the peak-to-peak amplitude of said zigzag shape increasing linearly with the distance from said vertex with the position of said peaks being defined by an angle α_2 which is less than the angle α_1, and of the order of 3 to 7 degrees, and whose bisector coincides with the bisector of said angle α_1, the radial distance measured from said vertex to any peak on said zigzag center support means bearing a constant ratio τ to the radial distance to the peak of the adjacent peak next farthest removed from said vertex and on the same side of the bisector of angle α_2, the radial distance to a given peak on one side of said bisectors bearing a constant ratio $\tau^{1/2}$ to the radial distance to the peak next farthest removed from said vertex, but on the other side of said bisectors, and teeth comprised of substantially straight, conductive rods extending transversely out from each of said peaks on either side of said center support means, all of the teeth on each side of said center support means being substantially parallel with each other, the outer ends of all of said teeth being terminated on the lines forming said angle α_1.

2. A log periodic antenna structure in accordance with claim **1** comprising a ground plane and in which said antenna element is mounted over said ground plane with vertex near, but not connected to said ground plane, and with the bisector of the angle α_2 forming an angle $\psi/2$ with said ground plane, the said antenna element being positioned in such a manner that the plane in which it lies intercepts the ground plane in a line perpendicular to said bisector, and comprising means for supplying a signal to said antenna element including a coaxial line with the outer sheath connected to said ground plane and with the inner conductor connected to said center support means.

3. A log periodic antenna structure in accordance with claim **2** in which said angle $\psi/2$ is equal to 90°.

4. A log periodic antenna structure in accordance with claim **1** comprising a second antenna element constructed to be similar to said first antenna element, the said first and second antenna elements being positioned in the same plane which is perpendicular to the ground and with the bisectors of the angle α_1 lying in the same straight line, the said first and second antenna elements being further positioned with their vertices pointed toward each other and in juxtaposition with each other, and a pair of conductor means for supplying a signal to said first and second antenna elements, the first of said conductor means being connected to the first antenna element and the second of said conductor means being connected to the second antenna element.

5. A log periodic antenna structure in accordance with claim **1** comprising a second antenna element generally similar to the first antenna element, said first and second antenna elements being positioned in space such that the bisectors of the angle α_1 of said first and second antenna elements coincide and, further, with the vertices of said first and second antenna elements pointing in the same direction and positioned in juxtaposition with each other although not electrically connected to one another, the planes in which said first and second antenna elements lie in being at right angles with one another, the radial distances of said second antenna element bearing a ratio $\tau^{1/4}$ to corresponding radial distances of said first antenna element, and means including a pair of conductor means for supplying an input signal to said antenna elements, the first of said two conductor means being connected to said first antenna element and the second of said two conductor means being connected to said second antenna element.

6. A log periodic antenna structure in accordance with claim **5** comprising third and fourth antenna elements which are similar to said first and second antenna elements, respectively, and located in the same plane as said first and second antenna elements, respectively, said third and fourth antenna elements having their vertices pointing in a direction opposite to that of the vertices of said first and second antenna elements but positioned in juxtaposition with each other, one of said conductor means being connected to said third antenna element and the other of said conductor means being connected to said fourth antenna element.

7. A log periodic antenna structure in accordance with claim **6** in which said third antenna element is a mirror image of said first antenna element, in which said fourth antenna element is a mirror image of said second antenna element, in which said first conductor means is connected to said third antenna element and in which said second conductor means is connected to said fourth antenna element.

8. A log periodic antenna structure in accordance with claim **6** in which said third antenna element is a non-

mirror image of said first antenna element, in which said fourth antenna element is a non-mirror image of said second antenna element, in which said first conductor means is connected to said fourth antenna element, and in which said second conductor means is connected to said third antenna element.

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HERMAN KARL SAALBACH, *Primary Examiner.*