United States Patent

Cory et al.

[15] **3,683,390**

[45] **Aug. 8, 1972**

[54] **HF BROADBAND OMNIDIRECTIONAL ANTENNA**

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[73] Assignee: **Collins Radio Company,** Dallas, Tex.

[22] Filed: **April 26, 1971**

[21] Appl. No.: **137,371**

[52] **U.S. Cl.** **343/792.5,** 343/798, 343/809, 343/891

[51] **Int. Cl.** **H01q 11/10**

[58] **Field of Search**...343/792.5, 796, 797, 798, 809, 343/878, 891

[56] **References Cited**

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Primary Examiner—Eli Lieberman

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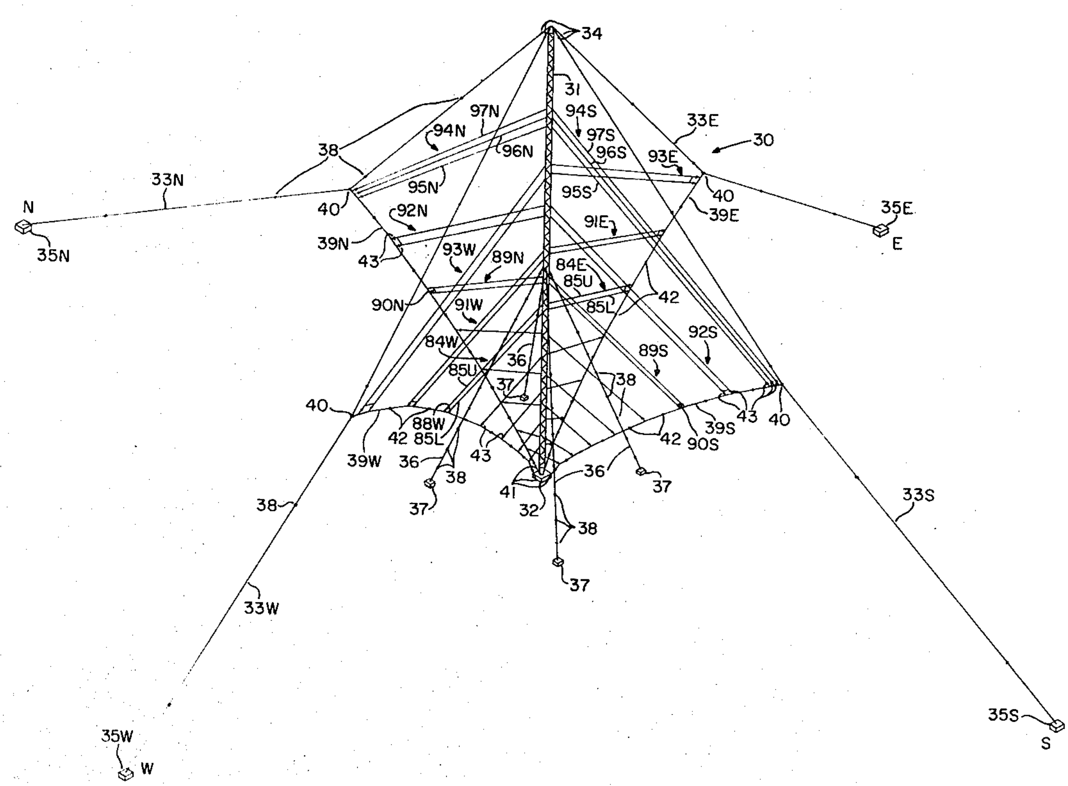
[57] **ABSTRACT**

An HF antenna providing high-angle skywave radiation at the lower end of the 2 MHz to 30 MHz band and low-angle skywave radiation at the upper frequencies with substantially gapless coverage in range from 0 to 1,000 miles with pattern characteristics optimized for propagation conditions. It utilizes predominantly horizontal polarization in minimizing ground losses in a log-periodic dipole array with elements lying in two orthogonal vertical planes with the apex substantially at ground level. It is an array with the phase center approximately a quarter-wavelength above ground at the lower frequencies and thereby near-vertical radiation for the short path circuits. Then as the frequency increases from 2 MHz to 6 MHz, the phase center increases from a quarter-wavelength above ground to near a half-wavelength above ground, providing lower angle radiation with omnidirectional characteristics. Antenna input impedance is from 50 ohms unbalanced coax line through an impedance transforming balun to 200 ohms balanced having VSWR with respect to the 50 ohm input line of less than 2.5 to 1. A single supporting tower occupying a near-minimum space volume is employed with phase controlled not only between orthogonal element bays but also between elements in each bay with one quarter phase spacing of elements so as to attain a desired elliptical polarization propagation characteristic.

16 Claims, 20 Drawing Figures



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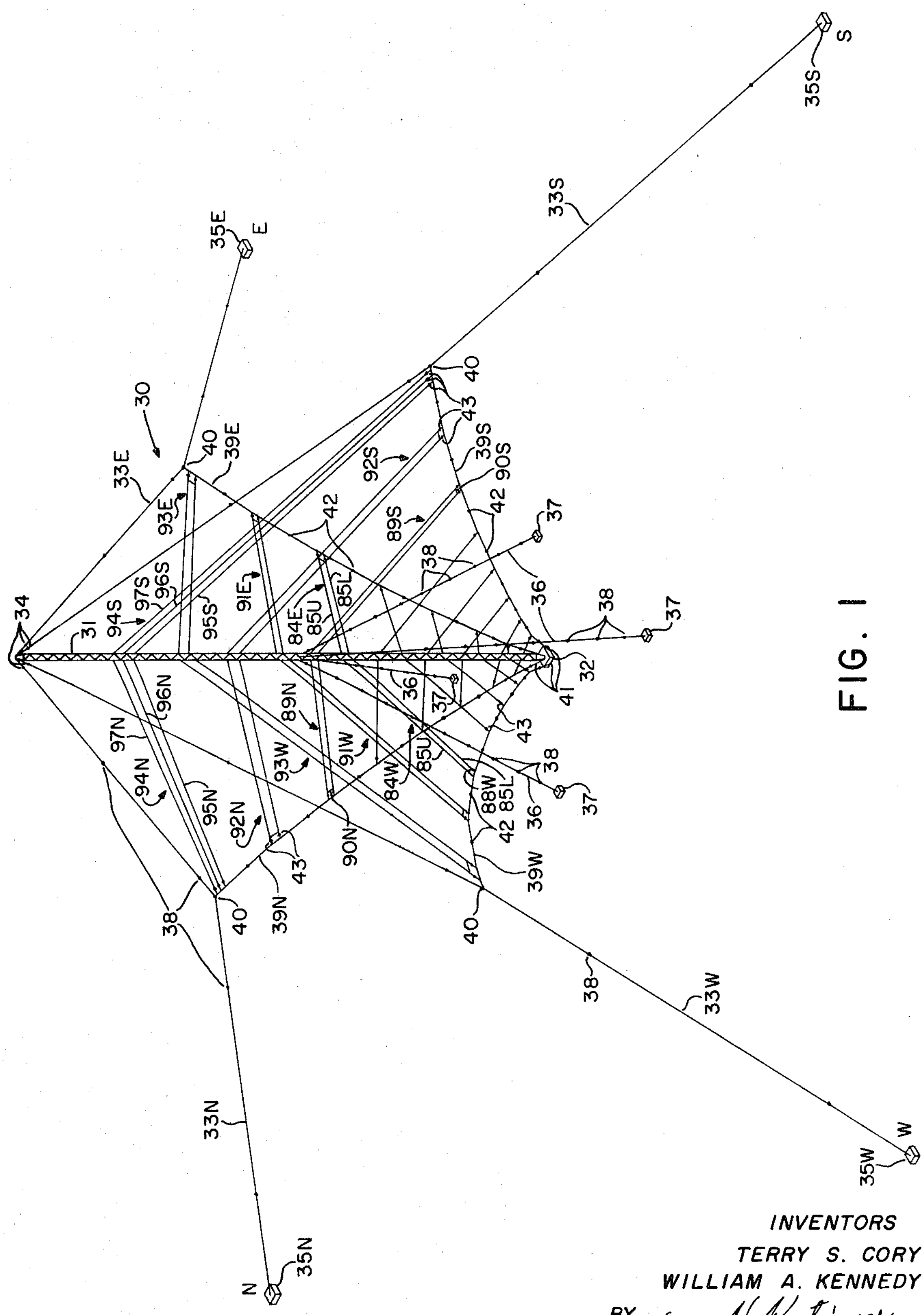

FIG. 1

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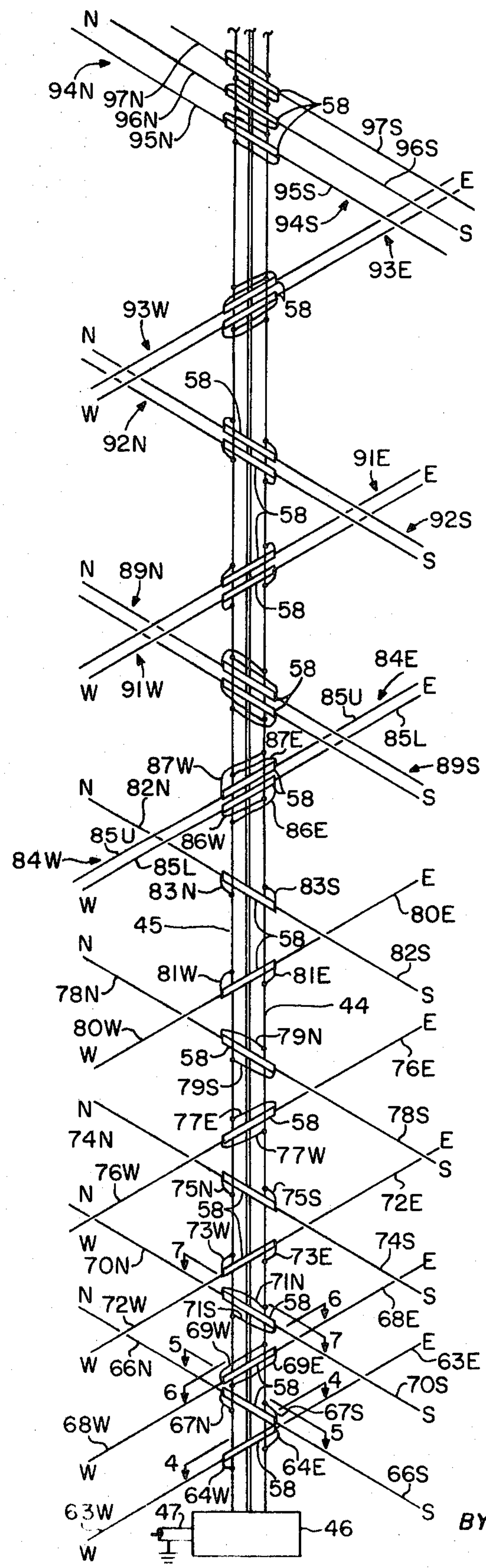

FIG. 2

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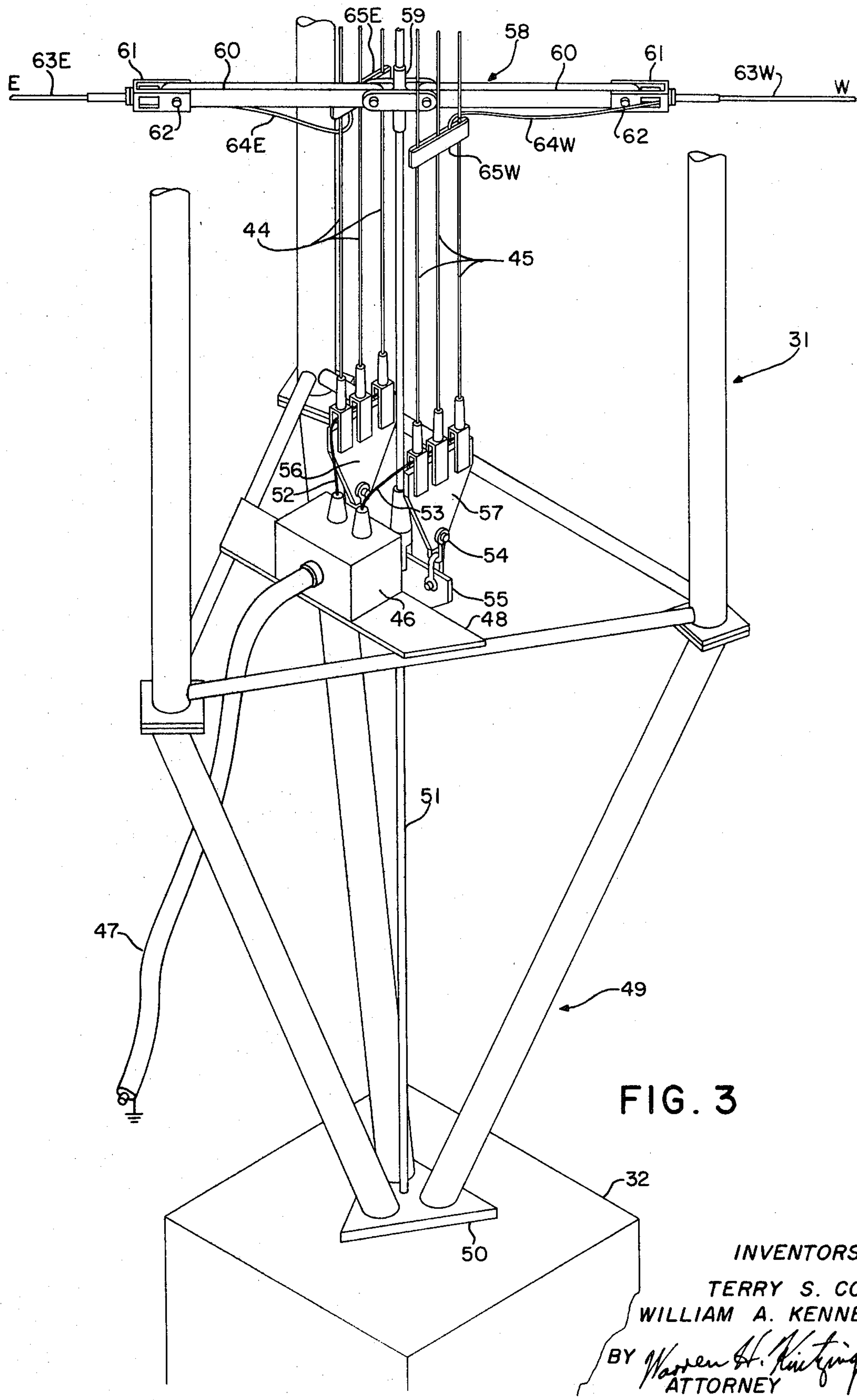

FIG. 3

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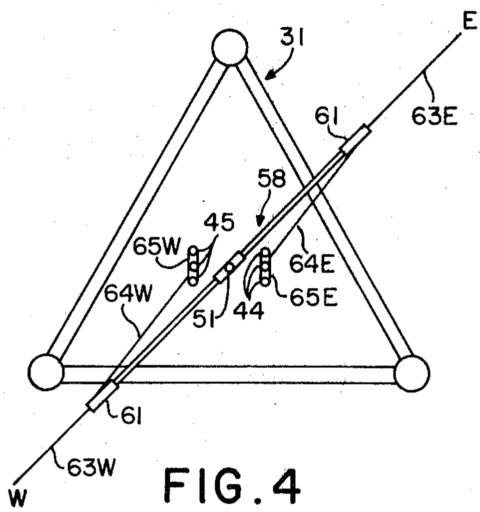

FIG. 4

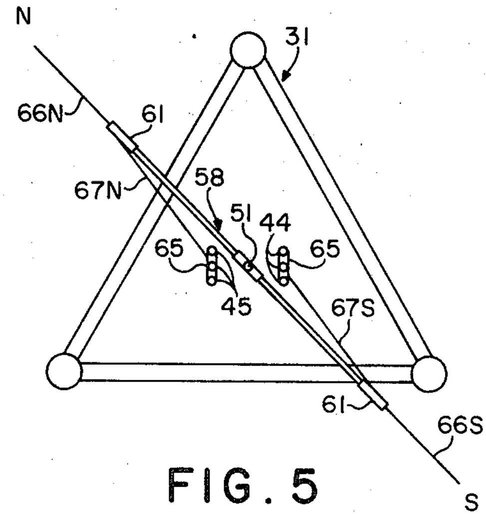

FIG. 5

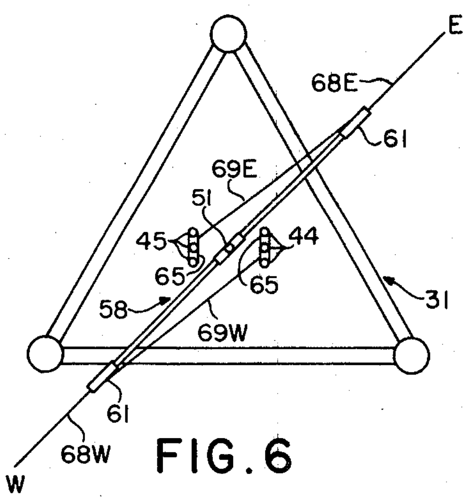

FIG. 6

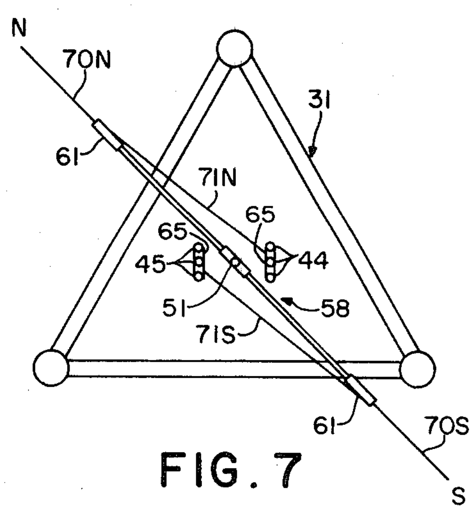

FIG. 7

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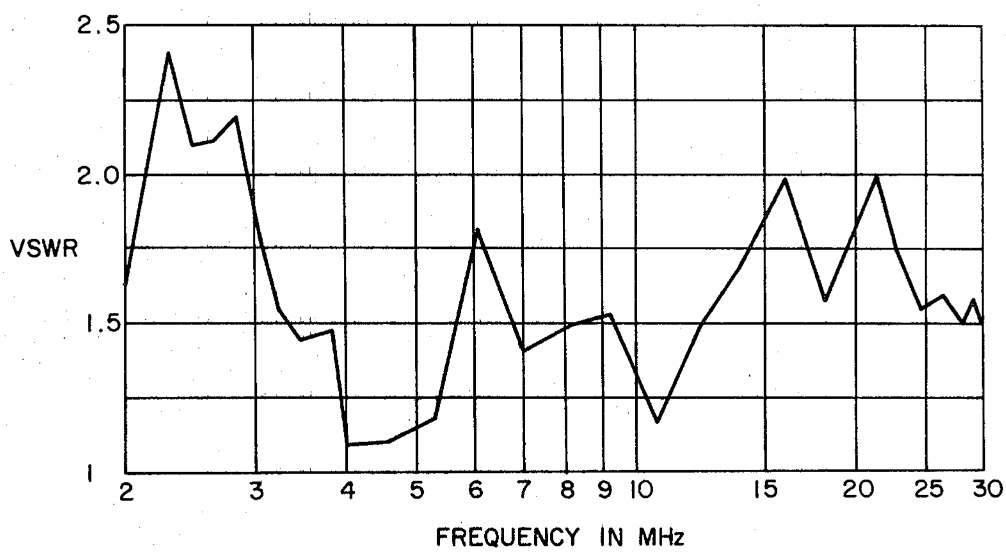

FIG. 8

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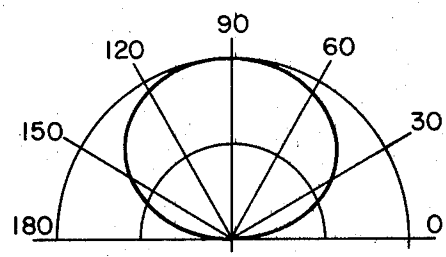
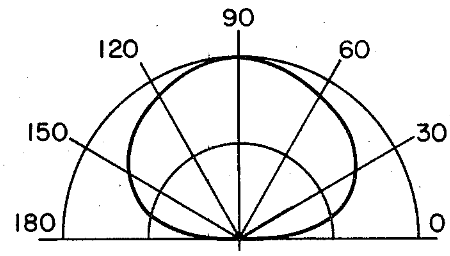


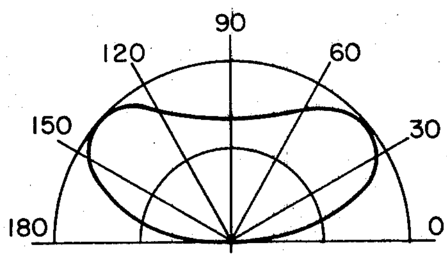
2 MHz

FIG. 9



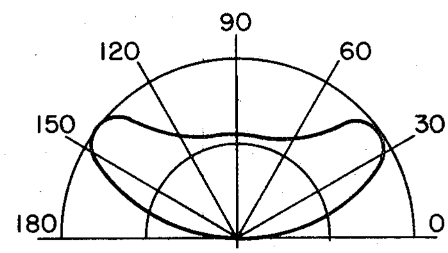
4 MHz

FIG. 10



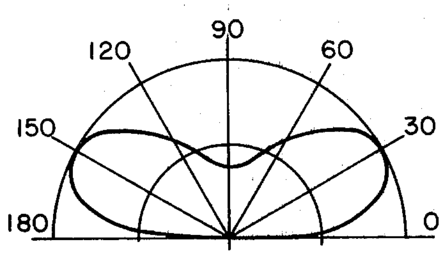
6 MHz

FIG. 11



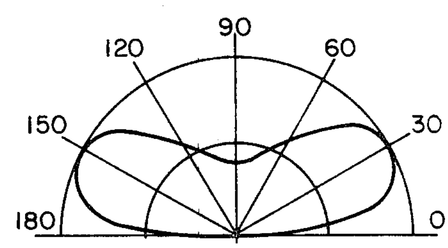
12 MHz

FIG. 12



20 MHz

FIG. 13



30 MHz

FIG. 14

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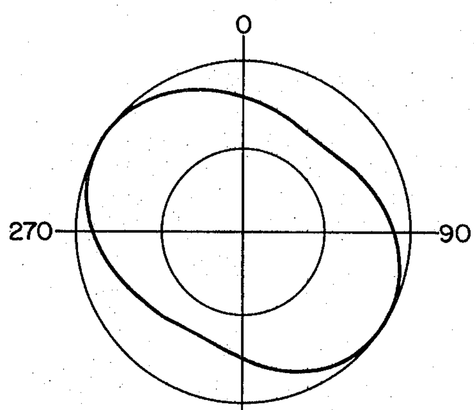

FIG. 15

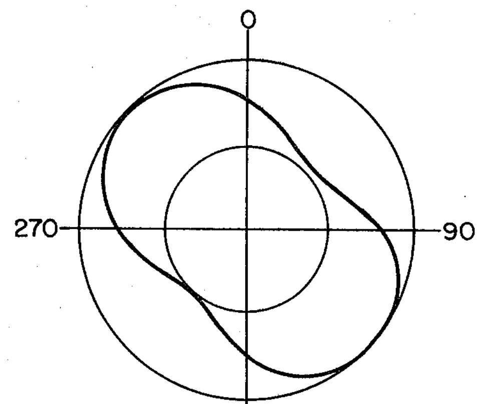

FIG. 16

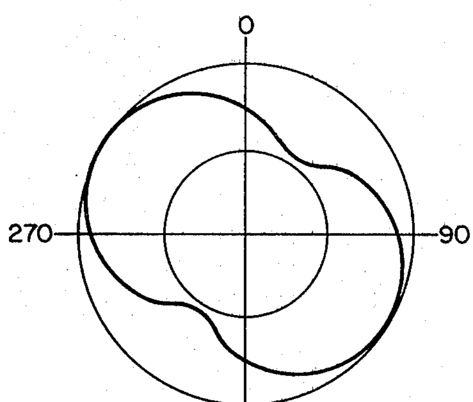

FIG. 17

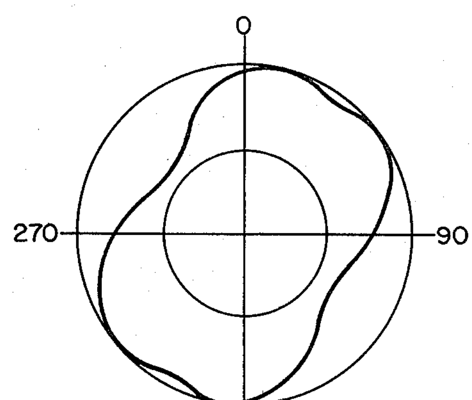

FIG. 18

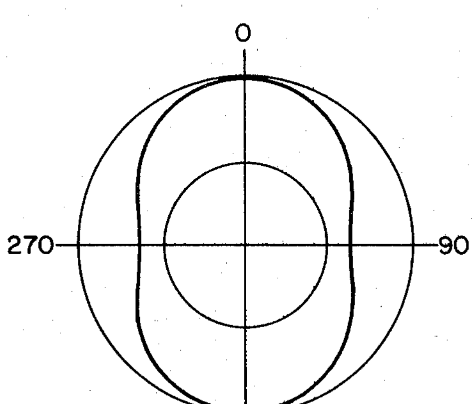

FIG. 19

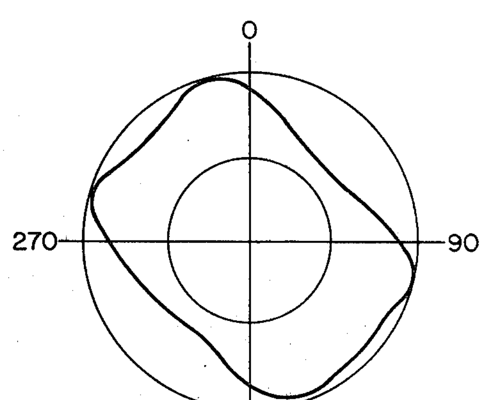

FIG. 20

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HF BROADBAND OMNIDIRECTIONAL ANTENNA

This invention relates in general to antenna systems and, in particular, to a horizontally polarized, omnidirectional, log-periodic array antenna providing high-angle skywave radiation at the lower end of the frequency range of operation and low-angle skywave radiation at the upper frequencies.

There has been a long time need for antenna structures having the ability to communicate with mobile stations such as ships and planes at variable ranges from 0 to approximately 1,000 miles. The needed antenna structures must have broad beams in azimuth (wider than a dipole beam width) and be preferably omnidirectional. In order that their propagation characteristics be optimum, the antenna structure must have radiation patterns that in elevation launch waves at angles that are compatible with the ionosphere for a given lineal range away from the transmitter. A normal station using broad beam vertically polarized antennas, such as a whip in its simplest form or a vertically polarized log periodic antenna, provides radiation generally restricted to the lower 45° in elevation with little or no ability for control of radiation pattern shape. Such antennas simply cannot provide satisfactory service with the high radiation angles characteristic of short range communications. This is particularly so since these antennas must be fed against a ground plane or set of wires extending through a considerable area obviously requiring a large installation area. There are other problems with such installations such as arise with antenna proximity to imperfectly conducting ground causing losses in the launching of the radiations. Furthermore, the vertically polarized waves radiated from such antennas are particularly susceptible to distortion due to terrain objects in the direction of propagation. The wave launching efficiency curve is accentuated disadvantageously with the propensity of location choice with installations in typical military and other service sites seeming many times to present combinations of the problems outlined.

Horizontal polarization in signal radiations is much more conducive to the efficient launching of signal waves without having to rely on critical ground systems and is such as to permit desired control of elevation plane radiation pattern by virtue of allowing discrete locations of horizontal elements or substantially horizontal elements in height above ground. Dipoles in an antenna structure comprising a horizontal polarization design are individually directional, however, and thus quadrature sets of elements properly phased are required to produce a broad beam. The inherent phasing of quadrature horizontal elements has a tendency to produce high angle circular polarization at some frequency for a broad band antenna. For short range communications, however, this circular polarization is undesirable because, while in temperate latitudes a single characteristic wave in the ionosphere is launched, the possibility exists of the antenna not functioning as a receptor of high angle waves by virtue of being cross polarized to the incoming waves. Thus, a short range communication requirement is to preclude circular polarization at high angles, and also to preclude linear polarization in order to mitigate against polarization fading. Thus, a design requirement that must be met is to provide a high angle radiator antenna structure that is always elliptically polarized.

A practical manifestation of a horizontally polarized omnidirectional antenna using a single tower supporting structure is that at least the uppermost elements must be tilted down toward ground. Thus, design objectives include the use of a single tower antenna supporting structure with quadrature radiating elements that achieve elliptical polarization overhead, and with the elements arranged in a manner to simultaneously tailor the elevation plane radiation patterns to a prescribed shape while maintaining the omnidirectionality within prescribed limits.

It is, therefore, a principal object of this invention to provide an HF broadband omnidirectional antenna capable of providing substantially gapless coverage in range from 0 to approximately 1,000 miles.

Another object is to provide such an antenna that is operational through approximately a frequency band of from 2 MHz to 30 MHz utilizing predominantly horizontal polarization.

A further object is to attain optimized antenna signal propagation through high-angle skywave radiation at the lower end of the 2 MHz to 30 MHz frequency range of operation and low-angle skywave radiation at the upper frequencies.

Still a further object is to provide an antenna array with the phase center approximately a quarter-wavelength above ground at the lower frequencies increasing, with frequency increase from 2 MHz to 6 MHz, to near a half-wavelength above ground.

Features of the invention useful in accomplishing the above objects include, in a high frequency broadband omnidirectional antenna, a log periodic antenna operating through the 2 MHz to 30 MHz frequency range and providing gapless communication between 0 and 1,000 miles. This is with two right angle vertical radiating element planes each containing log periodic related radiating elements all supported in the overall antenna structure by guys anchored to and from a center single fabricated triangularly cross sectioned tower mast and extended to ground anchors. Further, the highest frequency shortest dipole elements are adjacent the lower apex center end of the tower mast, and then the radiating elements becoming progressively longer in log periodic relation with successively higher elements in each of the two right angle radiating element vertical planes. This is continued serially successively through a series of single radiating element to broader radiating elements composed of two spaced generally parallel wires with outer ends electrically interconnected, and ultimately, in one of the planes, a broad three wire radiating broadband element on each side in that plane where the three wires of the opposite radiating sides are of sufficient length and so spaced as to have effectively an induced interconnect toward the outer ends without requiring actual wire interconnect at the outer ends thereof. The feed for the antenna is through a coaxial unbalanced 50 ohm feedline transformed through a balun jumper lead connected to the two sides of a balanced 200 ohm characteristic impedance transmission line that extends vertically through the triangular cross sectioned vertical center mast. The 200 ohm balanced transmission line is structurally supported within the antenna mast with each of the two sides of the balanced 200 ohm balanced transmission line having three wires as an aid to attaining the desired balanced 200 ohm characteristic impedance. It is important to note that as an additional feature of this high frequency antenna that the feed from the 200 ohm balanced transmission line is first from the two line sides directly to the lowest highest frequency pair of radiating elements and then from the two line sides to the next higher pair of radiating elements that are the lowest pair of elements in the other vertical plane. Then the next successively higher feed connections to a pair of elements in crossover feed from the opposite sides of the 200 ohm transmission line with this pair of elements again in the original plane of radiating elements. This same type crossover feed is used with the next successive higher radiating pair of elements that happen to be in the other plane. These direct and crossover feed system connections are continued with alternated pairs of radiating elements from vertical plane to plane at right angles to each other to in effect accomplish a spiral feed with the radiating element pair feed connection locations being successively spaced at approximately 90° phase angles up the balanced transmission line as related to the respective operational frequencies involved. Stated more simply this is with each of the radiating element planes containing a set of increasingly sloped single wire dipole elements and more highly located longer trapezoidal shaped multiwire radiating elements. The elements of each plane are feed connection staggered on the transmission line with respect to the three wire sides thereof so that at any one feed location there is only one pair of elements attached to the transmission line and these are in the same plane. This structure provides an antenna giving gapless skywave coverage from 0 to 1,000 miles over the HF band of 2–30 MHz. Please note, however, that this is not to be interpreted to mean that the coverage from 0 to 1,000 miles can be covered with any single one or two frequencies. The range covered depends on the propagation conditions (time of day and season of year), angle of maximum radiation above the horizon (take off angle) and the frequency of transmission. The antenna radiation elements are predominantly horizontally polarized and use the ground to form the radiation pattern that varies in take off angle from overhead to 30°. Higher angle patterns are formed for the frequencies from 2 MHz to approximately 6 MHz with this done to provide short range coverage of frequencies that do not penetrate the ionosphere at near perpendicular incidence. As the angle of incidence with the ionosphere is decreased (that is the take off angle is also decreased), the maximum frequency is increased before the energy penetrates the ionosphere. This is precisely the sort of action that the antenna gives during operation with take off angle getting lower as frequency is increased with it thereby being advantageously useful in attaining longer ranges with such frequency increase.

Specific embodiments representing what are presently regarded as the best modes of carrying out the invention are illustrated in the accompanying drawings.

In the drawings:

FIG. **1** represents an HF broadband omnidirectional antenna with a single antenna mast;

FIG. **2**, a partial schematic and antenna element feed system for the antenna;

FIG. **3**, a perspective of the unbalanced coaxial line input to two line balanced 200 ohm output balun with corrections from each of the balanced sides to respective three-line leads in the antenna structure;

FIGS. **4**, **5**, **6** and **7**, respectively, partial detailed showings of two-wire balanced line feed connections to respective radiation elements as seen looking down thereon from lines **4—4**, **5—5**, **6—6** and **7—7**, of FIG. **2**, respectively;

FIG. **8**, a VSWR to frequency in MHz diagram for the antenna;

FIGS. **9** through **14**, elevation voltage patterns for the antenna at 2 MHz, 4 MHz, 6 MHz, 12 MHz, 20 MHz and 30 MHz respectively; and

FIGS. **15** through **20**, azimuth voltage patterns through elevation beam maximum at 2 MHz, 4 MHz, 6 MHz, 12 MHz, 20 MHz and 30 MHz respectively.

Referring to the drawings:

The horizontally polarized, omnidirectional, log periodic array antenna **30** of FIG. **1** is shown to be supported by a single galvanized steel fabricated tower mast **31** of triangular cross section at the antenna center. The tower **31** is supported at its base by a concrete tower pad **32** partially buried in the ground so as to adequately support the weight of the tower **31** and antenna **30** structure. The tower mast **31** is laterally supported by four top guy wire or cable assemblies **33N**, **33E**, **33S** and **33W** that are individually fastened to the top of antenna mast tower **31** by four individual guy insulating and fastening units **34**. The guys **33N**, **33E**, **33S** and **33W** extend from their upper end fastenings to the top of the tower mast **31** to connections with individual concrete anchor pads **35N**, **35E**, **35S** and **35W** that are partially buried in soil so as to adequately support tension pull of the respective guys in their support of the center tower mast **31** and radiating elements supported in the antenna structure **30**. Four lower guys **36** are fastened at their upper ends to the antenna mast **31** in the mid region up the antenna mast and at their ground anchor ends in concrete anchor pads **37**. This is with the lower guys **36** substantially equally spaced about the antenna mast and individually located approximately midway in the four quadrants between the north, east, south and west orientations of the **33N**, **33E**, **33S**, and **33W** guys. Please note that the guy wire or cables **33N**, **33E**, **33S**, and **33W** and the four guys **36** while generally made of conductive metal wire cable, are individually assembled of a plurality of conductive metal lengths with interspersed insulators **38**. The insulators are provided with each guy cable assembly to break up electrically conductive lengths in the guy assemblies and minimize any tendency to induced reactive resonance thereof at any antenna operational frequency that would possibly be harmful in the attainment of antenna signal propagation operational objectives.

Four catenary wire rope assemblies **39N**, **39E**, **39S**, and **39W** are connected at their upper ends by individual insulator connectors **40** to the mid-regions of the top guys **33N**, **33E**, **33S**, and **33W**, respectively. The catenary wire rope assemblies **39N**, **39E**, **39S**, and **39W** extend from their top connections to connections with individual anchor rods **41** either right at or closely adjacent to tower mast mounting pad **32**. Further, each of the catenary ropes **39N**, **39E**, **39S**, and **39W** is properly tensioned between the respective top and anchor connections to give proper outer support to radiating elements connected at their outer ends thereto, respectively, as evidenced by the respective top guys 33N, 33E, 33S, and 33W being drawn down at the respective catenary connections thereto. Further, the catenary metal wire rope assemblies 39N, 39E, 39S, and 39W are provided with insulators 42 interrupting the electrical conductivity of each of the catenary ropes between the outer supporting connection of the rope with respective radiating elements of the antenna structure. Again, this is to minimize the chance of undesired resonant conditions being induced in conductive metal lengths of the catenary ropes, and further to prevent any undesired cross signal conductive paths between the outer ends of radiating elements.

The antenna radiating elements extend from outer end connections, via insulator assemblies 43 with respective catenary wire ropes, inward to electrical signal connection with a side of a two sided 44 and 45 balanced 200 ohm signal feed transmission line extended vertically within the tower mast 31 from adjacent balun structure 46 as shown in FIG. 2. Referring also to FIG. 3, in addition to FIGS. 1 and 2, the feed from radio equipment (not shown) is provided to balun 46 through an unbalanced coax line 47. This is with balun 46 mounted on a mounting plate 48 above the bottom triangular mounting section 49 of antenna mast 31 that includes a bottom triangular plate 50 resting directly on the top of concrete tower mounting pad 32. A tautly tensioned structural supporting cable 51 is extended from an anchor connection with bottom plate 50 upward through the center of the triangularly cross-sectioned antenna mast 31 to a top connection adjacent to the top of the tower mast 31 in a conventional manner (detail not shown), and this is with this top connection of cable 51 being above both the structural support interconnect and the electrical feed connections with the top radiating elements of the antenna structure. In any event, the 50 ohm unbalanced impedance of coaxial transmission line 47 is converted to a 200 ohm balanced output through the balun structure 46 with the two outputs being passed through connective lines 52 and 53 to three-wire balanced transmission line sides 44 and 45.

The three-wire sides 44 and 45 of two-sided balanced 200 ohm transmission line are provided with a bottom anchor yoke structure 54 having a cross member 55 anchored to the center structural supporting cable 51 and dual predominantly insulating material anchor connector assemblies 56 and 57 for the respective three-wire sides 44 and 45 of the balanced transmission line. Please note that there is an upper yoke assembly structure (not shown in detail) much the same as the lower yoke structure 54 to mount and support the two-sided 44 and 45 balanced transmission line from structural support cable 51 in the upper portion of the tower structure above feed connection to the top pair of radiating elements in the antenna. The two opposite transmission line upper and lower yoke assemblies 54 so mounted on the supporting cable 41 within the tower mast 31 that the three-wire side 44 and 45 of the balanced transmission line are tautly tensioned and supported in place to avoid any undesired shorting contact with any structural element of the tower through the extremes of any environmental conditions to be encountered. This is with feed connections to respective pairs of radiating elements of the antenna being supported in proper locations along the balanced transmission line.

The center structural supporting cable 51 mounts a plurality of radiating element wire inner end mounting connective assemblies 58 with each fixed in place on the cable 51 as by tight friction crimping fit of a collar 59 on cable 51. Each structural assembly 58 is provided with two opposite side inward end pivotably mounted dielectric arms 60 that are equipped with outer end feedline connective conductive clamps 61 pivotably pinned 62 thereto. The clamps 61, of the structural connective assembly 58 shown in FIG. 3, anchor the inner ends of the lowest vertically positioned shortest length highest frequency dipole elements 63E and 63W of the east-west oriented planar array. This is with clamps 61 also acting as conductive clamps electrically connecting feed jumper lines 64E and 64W to radiating elements 63E and 63W, respectively, to directly connect via the jumper feed lines 64E and 64W and conductive clamps 65E and 65W on the three-wire sides 44 and 45, respectively, of the 200 ohms balanced transmission line.

Please note that the lower portion of the antenna tower mast 31 appearing in FIG. 3 is turned around so as to better illustrate the balun 46 structure mounting and electrical lines 52 and 53 interconnect to the two sides 44 and 45 of the balanced transmission line in the tower structure. This is with what is really an east radiating element 63E appearing to the left and a west radiating element 63W shown extending to the right in FIG. 3. With reference to the showing of FIG. 1 and particularly to FIG. 2 with more normal north, east, south, and west orientation of radiation elements continuing vertically up the tower, the next radiation element structural interconnect and feed jumper connection is via another duplicate interconnect assembly 58 structurally mounting the inner ends of radiating elements 66N and 66S as the highest frequency shortest radiating elements in the bottom of the north-south oriented vertical planar array. This is with attendant feed jumper interconnect lines 67N and 67S similar to jumper feed lines 64E and 64W with attendant duplicate interconnecting clamps 65 on the transmission line three wire line sides 44 and 45 and clamps 61 of the respective pivoted opposite side arms 60 of the respective radiating element inner end mounting structure 58. The next pair of radiating elements up the antenna structure are radiating elements 68E and 68W again in the east-west oriented vertical plane with inner ends supported from structure supporting cable 51 by another element pair inner end interconnect structural assembly 58. However, in this instance the jumper feed lines 69E and 69W are long crossover jumper lines to opposite sides 45 and 44, respectively, of the two sided 200 ohm balanced transmission line. The next higher pair radiating elements in the antenna are radiating elements 70N and 70S that also use transmission line feed long crossover jumper lines 71N and 71S just as with the jumper feed lines 69E and 69W for the next lower set of radiating elements in the antenna structure. In like manner the remaining dipole radiating elements successively up the antenna have the same order successively jumper line feed alternating to successive pairs between vertical planes with through repetitive sequences resulting in a spiral-like feed with the feed to successively higher elements being vertically spaced approximately 90° in phase successively one from another up the antenna in the spiral like feed successively serially provided therefor. Reference also to the vertical plane section FIGS. **4**, **5**, **6** and **7** is helpful in understanding the spiral like phased feed arrangement serially up the antenna with respect to successively, respectively, the lowest radiating pair of elements **63E** and **63W**, the next higher pair **66N** and **66S**, the next pair **68E** and **68W**, and the next higher pair **70N** and **70S**. The same phase spacing feeding relationship exists with respect to the successively higher pairs of radiating elements **72E** and **72W**, **74N** and **74S**, **76E** and **76W**, **78N** and **78S**, **80E** and **80W** and **82N** and **82S** and the respective jumper feed lines **73E**, **73W**, **75N**, **75S**, **77E**, **77W**, **79N**, **79S**, **81E**, **81W**, **83N**, and **83S** that alternate between vertical planes. However, it should be noted that the next successively higher radiating elements are fatter two-wire radiating elements. This is with, for example, the next higher radiating element pair being an east-west vertical plane oriented pair with the east broad radiating element **84E** and west broad radiating element **84W** each having a lower wire **85L** and an upper wire **85U** in generally vertically spaced parallel relation. The inner ends of wires **85L** and wires **85U** are respectively connected to two likewise spaced radiating element inner end structural mounting assemblies **58**. Two long crossover jumper leads **86E** and **87E** connect transmission line side **45** with the broad radiating element **84E** lower and upper wires **85L** and **85U** interconnected at the outer end thereof by electrically conductive wire **88E**, and two long crossover jumper leads **86W** and **87W** connect transmission line side **44** with lower and upper wires **85L** and **85U** interconnected at the outer end by electrically conductive wire **88W**. Obviously the radiating interconnect structures **58** are balanced particularly with broad radiating element **84W** having correspondingly identified elements as with the east broad radiating element **84E**. The next higher radiating element pair has opposite broad two wire radiating pair elements **89N** and **89S** in the north-south vertical plane with outer end wire interconnects **90N** and **90S** with other components duplicating similar components mounting and feeding the broad element pair **84E** and **84W**. The next higher radiating element pairs are successively in order alternating between planes the broad element pairs **91E** and **91W**, **92N** and **92S**, and **93E** and **93N**, and then the next higher longest and lowest frequency range broad radiating element pair **94N** and **94S** are three-wire broad radiating elements in the north-south vertical plane. With this top radiating element pair the three wires **95N**, **96N**, **97N** and **95S**, **96S** and **97S**, respectively, are interconnected by three of the wire element inner end interconnect structural assemblies **58**. Further, with the longer length of the three wires in each radiating element pair and their relatively close spacing relative to the lower frequency band of operation thereof results in such inductive coupling therebetween as to eliminate any requirement for outer end interconnect conductive wires therefor.

It is of significant interest to note that in order that a reasonably compact relatively inexpensive single mast **31** antenna **30** of rugged construction be provided radiating elements are sloped at varying degrees of slope from the highest degree of slope at the topmost broad radiating element pair **94N** and **94S**. Then down through the antenna the slope of radiating elements is progressively lessened until at the lowermost shortest high frequency radiating element dipole pairs there is little, if any, slope downward from their respective center mast interconnect. The pivotal inner end interconnection mounting of dielectric material arms **60** advantageously permits the respective interconnect assemblies **58** to readily adjust to the required slope of the radiating element wire ends they, respectively, interconnect.

The orthogonal antenna **31** with the antenna radiating elements making up a log periodic dipole array lying in two vertical orthogonal planes depends upon ground reflection in developing the desired radiation patterns. It is an antenna having VSWR to frequency in MHz characteristics from the 50 ohm unbalanced coaxial cable input line through the balun to 200 ohm balanced transmission line extending vertically up within the antenna tower mast **31** such as shown in FIG. **8** and not exceeding 2.5 to 1 at any place over the frequency range. The antenna **30** with its horizontally polarized propagation characteristics uses ground relection in forming the radiation patterns that vary in takeoff angle from overhead to 30° such as would be in accord the elevation plane radiation patterns shown for 2 MHz, 4 MHz, 6 MHz, 12 MHz, 20 MHz, and 30 MHz in FIGS. **9** through **14**, respectively. Further, with the horizontal component of radiating elements in the two orthogonal planes and the spacing of the radiating elements on the feedline so that phase between the planes is approximately 90° results in omnidirectional azimuth patterns varied to some degree from patterns obtained with true circular polarization with, however, the deviation therefrom being highly desired. If two antennas were truly circularly polarized and were at both ends of a signal path there would be instances where excessive transmission loss would occur with decoupling where the incident received wave would possess one sense of circular polarization while the antenna would be receptive to the opposite sense. In any event it is of interest to refer to the azimuth planed radiation patterns that are generally semielliptical with these azimuth plane radiation patterns shown for 2 MHz, 4 MHz, 6 MHz, 12 MHz, 20 MHz, and 30 MHz in FIGS. **15** through **20**, respectively. Thus, it is particularly advantageous that the radiating elements are spaced on the transmission line feed system of the antenna so that the phase between planes is approximately 90° thereby resulting in omnidirectional azimuth patterns. This combined with the shift of the phase center of the antenna toward the apex of feed point as the frequency is increased with, for example, the phase center being about one-fourth wavelength above ground at the lower frequencies with a gradual change to one-half wavelength at higher frequencies is quite useful in providing high angle elevation patterns at low frequencies that shifts to approximately 30° at frequencies above 6 MHz.

Whereas this invention is herein illustrated and described with respect to a single specific embodiment thereof, it should be realized that various changes may be made without departing from the essential contributions to the art made by the teachings hereof.

We claim:

1. In an HF antenna operational through a substantial portion of a 2 MHz to 30 MHz frequency range; a log-periodic dipole array with elements lying in orthogonal vertical planes with the apex approaching ground; a single structural fabricated mast tower vertically mounted over a ground plane with the tower base resting on a tower mounting pad at the ground; four equally spaced guy assemblies connected to an upper portion of the tower and extended to and tensioned to four individual outer guy anchor means in the ground; four individual catenary rope assemblies one connected to each of said guy assemblies and connected to individual catenary rope anchor means adjacent said tower mounting pad; signal feed means for said antenna including a vertically extended two sided balanced transmission line mounted by said tower mast; log periodic radiating elements mounted in pairs with inner ends mounted by individual interconnect means at the tower center and extended to outer end connection with oppositely extended catenary rope assemblies; with said pairs of log periodic radiating elements being alternated between vertical orthogonal planes defined generally by said opposite guy assemblies and opposite catenary rope assemblies and the radiating elements connected to the opposite pairs of catenary rope assemblies; and with feed connection from the two sides of said balanced transmission line being a 180° phase related feed to the opposite sides of each pair of radiating elements and with the feed spacing along said balanced transmission line of successively higher radiating element pairs in the antenna being approximately a 90° phase shift successively resulting in a spiral feed up the antenna to successively higher and higher element pairs in the antenna.

2. The HF antenna of claim 1, wherein the antenna radiation elements are predominantly horizontally polarized and use the ground to form the radiation patterns that vary in take off angle from overhead high-angle skywave radiation at the lower end of the 2 MHz to 30 MHz frequency range of operation to low-angle skywave radiation at the upper frequencies.

3. The HF antenna of claim 2, wherein the log periodic radiating elements are positioned by pairs with the highest frequency shortest radiating element pair the lowest element pair adjacent the antenna lower apex ground end with the radiating element pairs progressively being longer in their successive spacings higher and higher through the antenna to the lowest frequency longest radiating element pair as the top radiating element pair in the antenna.

4. The HF antenna of claim 3, wherein the log periodic radiating element pairs are proportioned and positioned to insure phase center shift from approximately a quarter-wavelength above ground at the lower frequencies to a half-wavelength above ground with frequency increase from approximately 2 MHz to approximately 6 MHz.

5. The HF antenna of claim 4, wherein said log periodic radiating element pairs include a plurality of said radiating element pairs with single wire radiating elements extended to outer end connection with insulating interconnect means at their outer ends mounted on respective catenary rope assemblies.

6. The HF antenna of claim 5, wherein said log periodic radiating element pairs also include a plurality of broad radiating elements with a plurality of radiating element wires included in each broad radiating element; said broad radiating element pairs being larger lower frequency radiating elements than the longest single wire radiating element; and with said broad radiating element pairs positioned above the highest single wire radiating element in the antenna.

7. The HF antenna of claim 6, wherein the topmost pair of radiating elements, as the longest, lowest frequency pair of radiating elements, are canted at a downward angle from their common interconnect at the antenna center to outer end connection with respective catenary rope assemblies closely adjacent the connection of said catenary rope assemblies with the respective guy assemblies; and with the catenary rope assembly to guy assembly interconnect connections being at the mid region of the respective guy assemblies.

8. The HF antenna of claim 7, wherein the pairs of radiating elements vary in the rate of downward canted angle from a maximum with the topmost pair progressively less and less successively from radiating element pair to pair down the antenna to substantially horizontal radiating elements as the lowermost highest frequency radiating element pair is approached.

9. The HF antenna of claim 6, wherein outer ends of radiating element wires in individual units of a plurality of said broad radiating elements are electrically interconnected by conductive material means.

10. The HF antenna of claim 9, wherein a plurality of said broad radiating elements are two wire elements having said conductive material interconnect at their outer ends.

11. The HF antenna of claim 6, wherein the plurality of radiating element wires in each side of at least one pair of said broad radiating elements are sufficiently long and so spaced as to be so inductively coupled as to appear to have conductive material interconnect between element wire ends in each respective side.

12. The HF antenna of claim 11, wherein the pair of broad radiating elements having inductive interconnect between element wires in each respective side is the topmost pair of broad radiating elements in the antenna; and with each side having three inductively coupled element wires.

13. The HF antenna of claim 7, wherein said individual interconnect means is in the form of an interconnect structure having a center structure fastened to a structural support member vertically extended substantially along the vertical epicenter of the antenna, and opposite side insulating material arms pivotally connected by individual side pivot mount means to said interconnect means center structure; radiating element wire inner end fastening means mounted on the outer end of each of said insulating material arms; and said individual fastening means electrically interconnecting jumper feed lines from respective sides of said balanced transmission line and the inner ends of respective radiating wires structurally supported by said wire

inner end fastening means on the outer ends of said insulating material arms.

14. The HF antenna of claim 13, wherein the said structural support member is a support cable tautly vertically extended through the antenna mast from a mast bottom plate through the position range of said radiating elements from bottom to top to connection in the top portion of the antenna mast.

15. The HF antenna of claim 14, wherein each side of said balanced transmission line is a three parallel wire side with conductive electrical interconnect through a feed jumper lead connective clamp in the

transmission line to radiating element wire inner end jumper interconnect feed for all radiating elements up and down the antenna.

16. The HF antenna of claim 15, wherein said two three wire sides of the balanced transmission line are supported in vertical spaced apart relation extended between an upper yoke assembly and a lower yoke assembly; and a balun fed by an unbalanced coaxial transmission line, and with the balun having a balanced two wire output electrically connected respectively to opposite sides of said balanced transmission line.

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