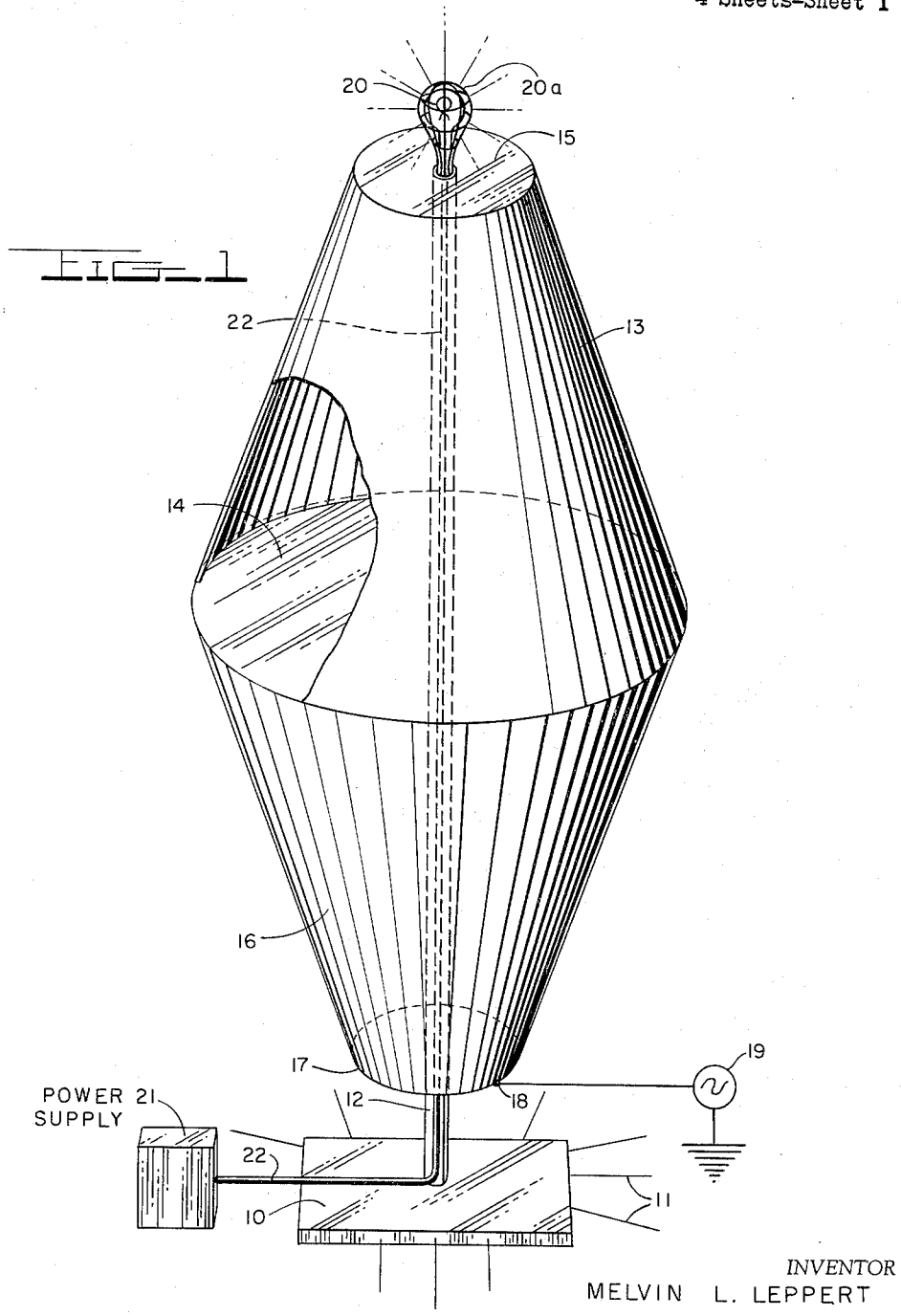
Sept. 19, 1961 M. L. LEPPERT 3,001,194

BROADBAND DISCAGE ANTENNA

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FIG. 1



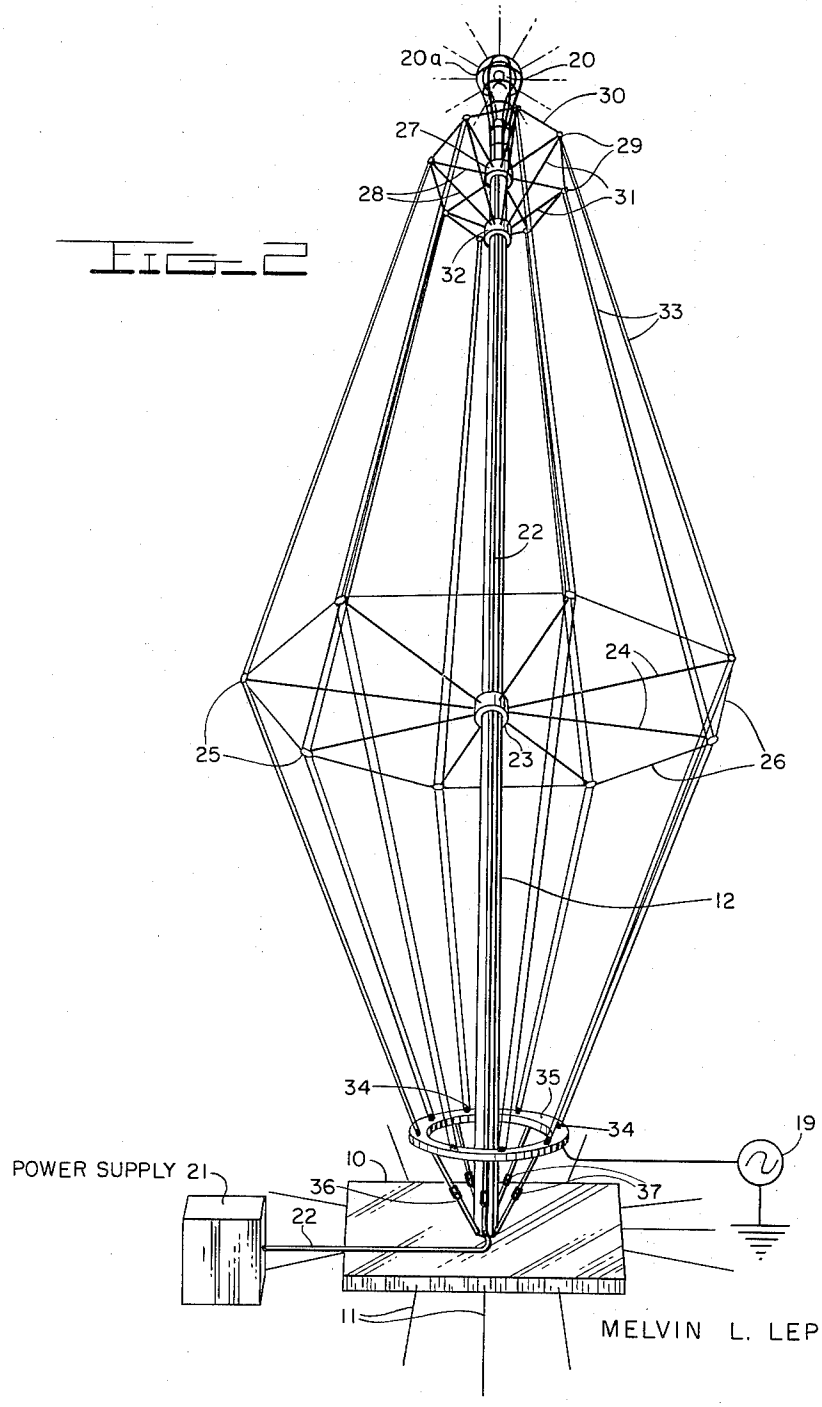
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FIG. 2



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FIG. 3

COMPARISON OF VSWR OF BROADBAND ANTENNAS

A. THE PRESENT ANTENNA

B. A TYPICAL SLEEVE ANTENNA (WITH TRANSFORMING SECTION OF TRANSMISSION LINE)

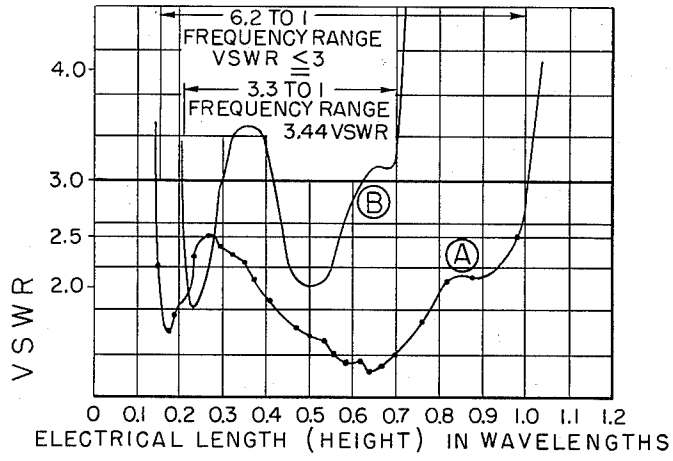
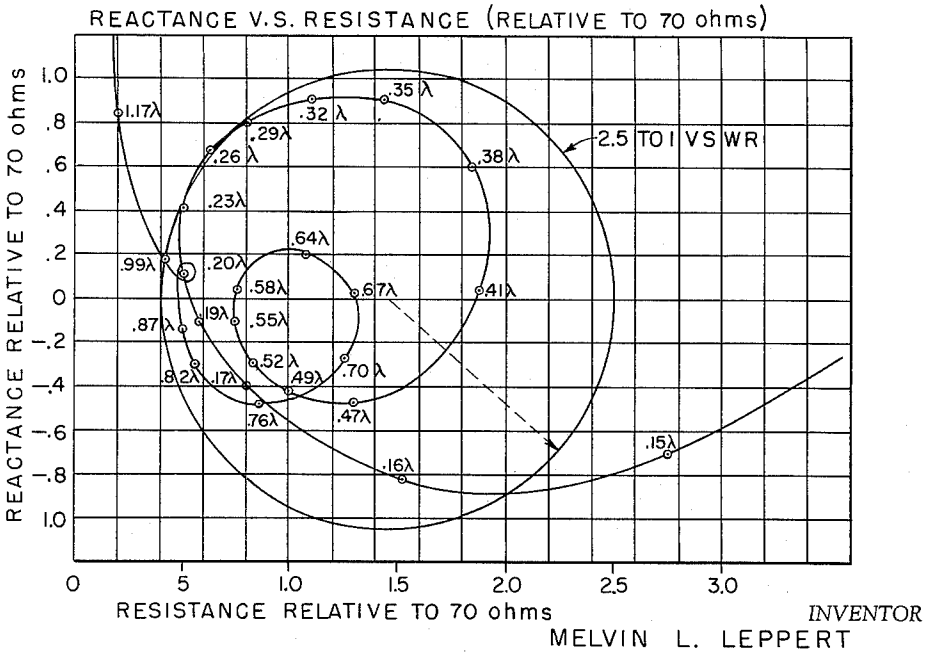


FIG. 4



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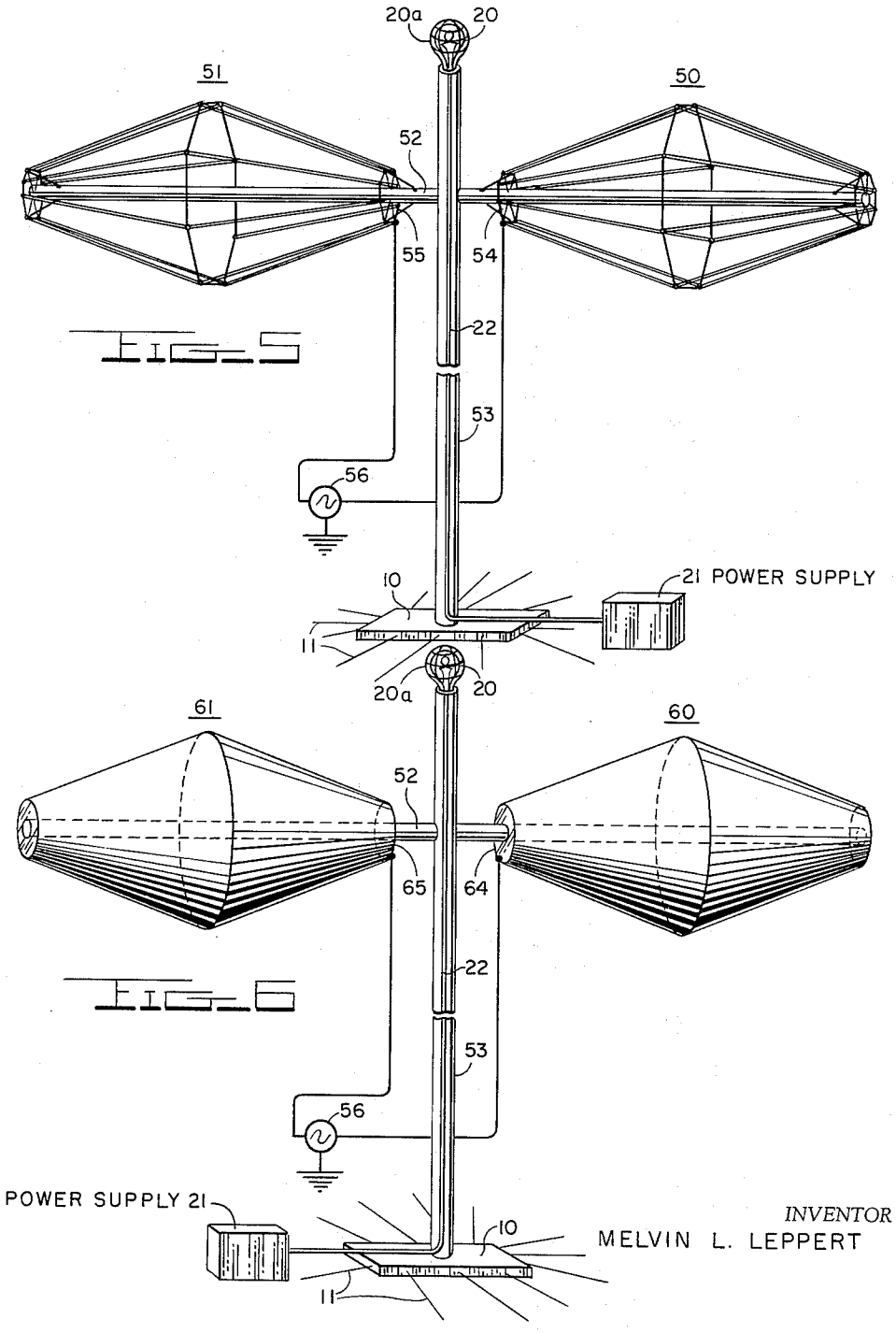


FIG. 5

FIG. 6

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3,001,194

BROADBAND DISCAGE ANTENNA

Melvin L. Leppert, 4012 1st Place SW., Washington 24, D.C.

Filed Sept. 8, 1958, Ser. No. 759,832
17 Claims. (Cl. 343—792)
(Granted under Title 35, U.S. Code (1952), sec. 266)

The invention described herein may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

This invention relates in general to means for radiating electromagnetic energy and in particular to an improved broadband antenna.

In the field of communications, it is often desired to employ an antenna that will transmit a wide band of frequencies from the low to and beyond the ultra high frequency range. It is also desired to transmit in all of these frequency ranges using antennas of different height but having a similar configuration. The few antennas in the prior art capable of transmitting such a broad band of frequencies at an acceptable radiation efficiency require matching transformers to transmit a selected frequency within a desired range of frequencies. Some of the prior antennas require the use of guy wires which cause undesirable variations in the antenna pattern as well as power losses in the guy wire insulators, while others produce undesirable lobing in frequencies close to the wave length for which the antenna is one-fourth wave resonant. Some prior antennas have a matching impedance for only one frequency, and some have conductors closely assembled at the top of the mast thereby causing low capacitance and high capacitive reactance. Others have their masts insulated from ground thereby aiding the formation of corona which, when started, dissipates power and limits the maximum power that can be radiated. A few of the prior antennas having heights approaching one-fourth wave length at the lowest frequency of the selected frequencies to be transmitted require obstruction lights on the top which, because of the necessary metallic conduits and wires, materially affect the impedance and radiation patterns of the antenna. Virtually all of the prior antennas lack adequate protection from lightning such as can be furnished by providing a path through the mast to ground.

Accordingly, it is an object of the present invention to provide a broadband antenna that may be used in frequency ranges from the low to and beyond the ultra high by varying the height thereof but retaining the basic configuration of the antenna.

Another object of this invention is to provide an antenna of short physical height relative to the lowest frequency of a band of frequencies to be radiated.

A further object of the present invention is to provide an antenna having an impedance that will match or substantially match the impedance of the transmission line over a selected band of frequencies.

A further object of the present invention is to provide an antenna on which obstruction lights or other relatively small electrical devices may be mounted without affecting the impedance or pattern of the antenna.

A further object of this invention is to provide an antenna that does not require insulators at high voltage points on the antenna.

A further object of the present invention is to provide an antenna in which capacitive reactance is reduced by having the radiating elements terminate in a ring around the flat top of the antenna.

A further object of this invention is to provide an antenna whose structure includes means for protection against lightning.

Other objects and advantages of this invention will become apparent upon a careful consideration of the following description when read in conjunction with the accompanying drawings in which like reference numerals designate like parts throughout the figures thereof and wherein:

FIG. 1 shows an isometric view of a first embodiment of the invention.

FIG. 2 is an isometric view of a second embodiment of the present invention.

FIG. 3 is a graphical representation of VSWR vs. height for the antenna shown in FIG. 2 and a standard sleeve antenna.

FIG. 4 is a graphical representation of reactance vs. resistance for the antenna shown in FIG. 2.

FIG. 5 shows an isometric view of a third embodiment of the invention.

FIG. 6 illustrates an isometric view of a fourth embodiment of the invention.

It is well known in the art that an inverted cone is an ideal radiator that will transmit a wide band of frequencies at a maximum efficiency without the use of matching transformers. In practice, however, it is impossible to attain the efficiency and radiation pattern of the inverted cone since it is necessary to support the cone by steadying poles which require obstruction lights and wiring with the result that the supporting structure and its attachments appreciably reduce the radiating efficiency and adversely affect the radiation pattern of the cone.

In accordance with the teachings of the present invention, an antenna is provided having a pattern similar to and a radiation efficiency approaching that of an inverted cone. This is accomplished in one embodiment by assembling two hollow cones together on a common base and mounting the assembled cones symmetrically along a center pole which in turn is mounted on a grounded, conductive base plate. The hollow cones have truncated ends both of which are parallel to the plane of the base plate and one of which is open and nearest the base plate. When energized, current flows upward along both the outer and inner surfaces of the lower hollow cone, the outer current continuing to the top of the antenna and the inner current flowing across the common base to the center pole which is grounded. The outer current effects the radiation of electromagnetic waves into space while the inner current flows through a path having an impedance which combines with the impedance of the antenna radiating elements to provide an impedance that matches or substantially matches the impedance of a standard transmission line over a broad band of frequencies. Since guy wires are not required to steady the center pole, energy is not lost by absorption and the radiation pattern is not adversely affected as it is where guy wires are installed.

In a second embodiment, the continuous surfaces of the cones are replaced by a wire cage formed of cables and supporting structure, and the conductive center pole is replaced by a wooden pole having metal strips attached along its length. A number of symmetrically spaced cables may be used to form the periphery of the wire cage, the greater the number used the more nearly will performance approach that of a continuous surface.

The first and second embodiments discussed above can be utilized to radiate energy from the low to and beyond the ultra high frequency ranges by varying the height of the antenna while maintaining proportional to height the diameters of the truncated ends and the common base, and the distance from the base support to the common base. Thus, the present invention teaches an antenna configuration that may be used to provide an antenna that will transmit in any of the several frequency ranges from low to ultra high and beyond.

Referring to FIG. 1, base plate 10 has conductors 11 extending radially therefrom into the ground. Center pole 12, which is made of conductive material, is mounted on and connected to the base plate by conventional connecting means so as to form a continuous conductor from the top of the center pole to ground. Hollow cone 13 has a base 14 and a truncated top 15 and is mounted symmetrically on the center pole 12 with the base 14 facing base plate 10. Conical surface 16 is open at both ends and is formed and mounted symmetrically on base 14 so that the periphery of base 14 and the periphery of the larger opening of conical surface 16 are identical. The embodiment is energized at point 18 on the periphery of the smaller opening, which is designated as base ring 17, by power source 19 and has a source of luminous energy 20, e.g. a light, mounted on the top of the center pole 12, shielded by screen 20*a*, and connected across power supply 21 by wires 22. The wires 22 are positioned adjacent to and along the length of center pole 12 to a point below base ring 17 where they diverge to power supply 21 which is located outside the volume enclosed by the radiating structure. As indicated below in connection with FIGS. 2, 5 and 6, the second, third and fourth embodiments may have a source of luminous energy mounted and shielded in the manner shown in FIG. 1.

Since the base plate in either embodiment is grounded, the center pole is at ground potential and electrical devices, e.g. lights, may be mounted thereon without changing the impedance or disturbing the radiation pattern of the antenna. This desired result is obtained because the grounded center pole does not carry radiating currents and is not in the radiation field of the antenna. Mechanical attachments such as a flag staff may also be mounted on the center pole without disturbing the radiation efficiency of the antenna.

The grounded center pole has the additional advantage of completing a circuit to ground which lightning may follow from any point on the antenna. Thus, the adverse effects on the radiation pattern of an antenna of an independent lightning arrestor and conductor to ground are avoided.

Since the electrical height of an embodiment of the antenna is substantially less than one-fourth of the fundamental wave length of the lowest frequency of a band of frequencies to be transmitted, undesirable lobing is avoided for a wider band of frequencies than is usual.

Referring to FIG. 2, band 23 is attached to the center pole 12 at a selected point between base plate 10 and the top of the center pole. Fittings 25 connect waist ring 26 to a plurality of arms 24 which extend radially from band 23 in a plane parallel to base plate 10. Band 27, having a plurality of radially extending arms 28 connected thereto, is mounted at the top of center pole 12. Fttings 29 connect top ring 30 to both arms 28 and supports 31, the supports in turn being connected to band 32 which is attached to the center pole 12. Radiating conductors 33 extend from fittings 29, pass through and are attached to fittings 25, and terminate in fittings 34 forming a radiating structure conical in shape. Fittings 34 support base ring 35 in space, the base ring being positioned symmetrically about the center pole 12 by cables 36 having insulators 37 inserted therein.

In a typical construction of the embodiment in FIG. 2, base plate 10, conductors 11, center pole 12, bands 23, 27, and 32, arms 24 and 28, fittings 25, 29, and 34, supports 31, waist ring 26 and top ring 30 are of conductive material. Base ring 35 is bronze and radiating conductors 33 are bronze wires preferably ⅜ inch in diameter but not less than ⅛ inch in diameter. In the embodiment in FIG. 2, a pole having a diameter of 1.25 feet is used.

The wide, flat top of the embodiment in FIG. 2, formed by ring 30, provides a greater capacitance than would be obtained with the radiating conductors 33 terminating more closely together at the top of the center pole. Increasing the number of radiating conductors 33 increases the capacitance of the upper portion of the antenna, reducing the capacitive reactance thereof, until minimum reactance is reached when a continuous surface is formed. Lowering the reactance of the upper portion of the antenna by providing a wide, flat top brings the impedance of the antenna within a region where it can be combined with the impedance of the radiating structure from the waist ring to the base ring to produce a low voltage standing wave ratio (VSWR) for the combined upper and lower portions of the antenna. VSWR with respect to an antenna constructed according to the embodiment in FIG. 2 is discussed in the description of FIG. 3.

When the embodiment shown in FIG. 1 is energized by power source 19, current flows around base ring 17 and upward along the inner and outer surfaces of conical surface 16 to the periphery of base 14, the inner surface current, or stub current, continuing across the lower surface of base 14 to grounded center pole 12 and the outer current, called radiating current, continuing upward along the outer surface of hollow cone 13 to the periphery of the truncated top 15 where it diminishes to zero. The path followed by the stub current has an impedance which combines with the impedance of the wide, flat top of the antenna to provide an impedance which enables the antenna to have a low VSWR. The radiating current effects radiation of electromagnetic energy into space.

Similarly, when the embodiment shown in FIG. 2 is energized by power source 19, current flows around base ring 35 and upward along the inner and outer surfaces of radiating conductors 33 to waist ring 26, the inner surface current, or stub current, continuing across the radial arms 24 to grounded center pole 12 and the outer surface current, or radiating current, continuing upward along the outer surface of radiating conductors 33 to top ring 30 where it diminishes to zero. The path of the stub current has an impedance that combines with the impedance of the antenna, and the radiating current effects the radiation of energy into space in the manner stated above in connection with the first embodiment.

In constructing the embodiments of the antenna shown in FIGS. 1 and 2, certain proportions have been found to be critical. These proportions relate to the wave length of the lowest frequency of the band of frequencies desired to be transmitted, and have been determined as 0.16 of that wave length for the height of the center pole, 0.066 for the distance from the base plate to the plane of the waist ring, 0.073 for the diameter of the waist ring, and 0.023 for the diameter of the top ring. Other proportions were determined as approximately 0.014 for the diameter of the base ring and 0.006 for the distance from the base plate to the plane of base ring. The foregoing proportions may be varied two or three percent without changing the effectiveness of the antenna.

If it is desired to transmit in the high frequency range, an antenna height of 57.3 feet will radiate efficiently a band from 2.75 to 17 megacycles. Using the proportions given above, such an antenna will have a waist ring 26.14 feet in diameter, a top ring 8.24 feet in diameter, and a distance from the base support to the plane of the waist ring of 23.64 feet. To transmit in the ultra high, the medium and the low frequency ranges, heights of 1.89 inches, 385 feet and 800 feet, respectively, will radiate effectively bands from 1,000 mc. to 6,000 mc., from 410 kilocycles to 1500 kilocycles and from 190 kilocycles to 680 kilocycles. Thus it is seen that an antenna can be constructed using the same configuration but with different heights to transmit in frequency ranges from the low to the ultra high and beyond.

Since VSWR is defined as the ratio of the effective voltage at a loop to the effective voltage at a node, a high

VSWR is undesirable and results in the following detriments: The power-handling capacity of the line is reduced because at some points the voltage is greater than at others, the efficiency of the line is lowered because of the excessive current and accompanying I^2R loss, and the effective resistance of the line is increased by the introduction of standing waves. VSWR, therefore, is a measure of efficiency, and at unity indicates that maximum transmission of power is being obtained. VSWR losses are not considered excessive below a value of 3.0.

Referring to FIG. 3, curves A and B represent voltage standing wave ratio vs. electrical height in wave lengths for an antenna having a height of 57.3 feet constructed in accordance with the second embodiment, and for a standard sleeve antenna with transforming section, respectively. It is noted that the transmission efficiency of antenna A is within acceptable losses, i.e. below a value of 3.0, for all the frequencies in a range 6.2 times the wave length of the lowest frequency to be transmitted, while antenna B radiates within acceptable losses for less than one-half the frequencies of a band 3.3 times the wave length of the lowest frequency to be transmitted. Antenna A radiates a wider band of frequencies with greater efficiency because the impedance of the stub current path and the impedance of the remainder of the antenna combine to form an antenna impedance that matches or nearly matches the impedance of a standard transmission line. The steep slope at each end of the curves indicates mismatch between the antenna and the transmission line.

FIG. 4 presents a plot of reactance vs. resistance, relative to 70 ohms, for an antenna having a height of 57.3 feet and constructed as in FIG. 2. Since 70 ohms is the resistance of a standard transmission line, the plot portrays how nearly the antenna matches the impedance of a standard transmission line. The circle enclosing VSWR ratios up to 2.5 to 1 defines, as does the 2.5 line in FIG. 3, the area in which there is a desirable impedance match between the antenna and the standard transmission line. Thus, in the frequency range between 2.75 megacycles and 17 megacycles an impedance match is provided which enables the antenna to radiate with acceptable efficiency. The plotted points are expressed in wave length for ease of interpretation as well as ready reference to FIG. 3. It is understood that transforming sections of coaxial line common to the art may be installed to modify the impedance characteristics of the antenna to a limited extent.

In summary it is seen from FIGS. 3 and 4 that an antenna constructed in accordance with the present invention will transmit all frequencies from 2.75 megacycles to 17 megacycles at 2.5 VSWR or less whereas a standard sleeve antenna will, at 2.5 VSWR or less, transmit only from 3.4 megacycles to 4.6 megacycles and from 7.5 megacycles to 9.8 megacycles. Thus an antenna constructed in accordance with the teachings of the second embodiment will efficiently transmit a band of frequencies having a span of 14.25 megacycles whereas a standard sleeve antenna will transmit efficiently a band having an interrupted span of but 3.5 megacycles.

FIG. 5 shows a dipole arrangement in which two radiating structures **50** and **51**, each identical to the structure shown in FIG. 2 excluding the base plate, light and center pole, are mounted symmetrically about crossarm **52**. The crossarm is attached perpendicular to center pole **53** which is mounted on base plate **10** from which conductors **11** extend. The center pole **53** may be mounted other than vertically, however, crossarm **52** preferably should be mounted perpendicular to the center pole. Power source **56** energizes base rings **54** and **55**, each of which are mounted a distance from the center line of center pole **53** equal to 0.006 of the wave length of the lowest frequency to be transmitted.

FIG. 6 shows a fourth embodiment similar to the dipole arrangement in FIG. 5 but having conical surfaces such as those shown in the first embodiment in FIG. 1. In FIG. 6, two radiating structures **60** and **61**, each identical to the structure shown in FIG. 1 excluding the base plate, light and center pole, are mounted symmetrically about crossarm **52**. The crossarm is attached perpendicular to center pole **53** which is mounted on base plate **10** from which conductors **11** extend. The center pole **53** may be mounted other than vertically, however, crossarm **52** preferably should be mounted perpendicular to the center pole. Power source **56** energizes base rings **64** and **65** each of which are mounted a distance from the center line of center pole **53** equal to 0.006 of the wave length of the lowest frequency to be transmitted.

The third and fourth embodiments shown in FIGS. 5 and 6, respectively, have characteristics similar to those of the embodiments illustrated in FIGS. 2 and 1, respectively, but with twice the impedance. The proportions stated as critical for the embodiments shown in FIGS. 1 and 2 are, of course, critical for the dipole embodiments of FIGS. 5 and 6. These embodiments can also be constructed to transmit in frequency ranges from low to ultra high and beyond by the same method used to adapt the embodiments in FIGS. 1 and 2 to so transmit.

Many modifications and variations of the present invention are possible pursuant to the above teachings. It is therefore to be understood that within the scope of the appended claims the invention may be practiced otherwise than as specifically described.

What is claimed is:

1. Means for radiating electromagnetic energy comprising a grounded base plate of conductive material, a center pole of conductive material mounted on said base plate, at least one first radiating means having a conical shape with a base of conductive material and a truncated top of conductive material, at least one second radiating means having a conical shape with an open base and an open truncated end, means connected between said first radiating means and said second radiating means for mounting the periphery of said open base on the periphery of said base, means for mounting said first radiating means and said second radiating means on said center pole with said open truncated end nearest said base plate, and energizing means attached at the periphery of said open truncated end for energizing said means for radiating electromagnetic energy.

2. Means for radiating electromagnetic energy comprising a grounded base plate of conductive material, a center pole of conductive material mounted on said base plate, at least one first radiating means having a conical shape with a base of conductive material and a truncated top of conductive material, at least one second radiating means having a conical shape with an open base and an open truncated end, means connected between said first radiating means and said second radiating means for mounting the periphery of said open base on the periphery of said base, means for mounting said first radiating means and said second radiating means on said center pole with said open truncated end nearest said base plate, the diameter of said base, the diameter of said truncated top, and the distance from said base plate to said base being 9/20, 3/20 and 2/5 of the length of said center pole, respectively, and energizing means attached at the periphery of said open truncated end for energizing said means for radiating electromagnetic energy.

3. Means for radiating electromagnetic energy comprising a grounded base support of conductive material, a center pole of conductive material mounted on said base support, at least one first radiating means having a conical shape with a base of conductive material and a truncated top of conductive material, at least one second radiating means having a conical shape with an open base and an open truncated end, means connected between said first radiating means and said second radiating means for mounting the periphery of said open base on the periphery of said base thereby forming a radiating structure, means for mounting said radiating structure on said center pole

with said open truncated end nearest said base plate, a source of luminous energy mounted on said center pole, a power source positioned outside the volume enclosed by said radiating structure, means for connecting said power source to said source of luminous energy, the portion of said last mentioned means located within the volume enclosed by said radiating structure being positioned adjacent to and along the length of said center pole, and energizing means attached at the periphery of said open truncated end for energizing said means for radiating electromagnetic energy.

4. Means for radiating electromagnetic energy comprising a grounded base plate of conductive material, a center pole of conductive material mounted on said base plate, a first hollow cone of conductive material having a base and a truncated top, means connected between said center pole and said hollow cone for mounting the first hollow cone symmetrically on said center pole with the base facing said base plate and electrically and physically connected therewith, a second hollow cone of conductive material having an open base and a circular opening opposite the open base in a plane parallel thereto, said open base having the same diameter as the base of the first hollow cone, means connected between the first hollow cone and the second hollow cone for mounting the periphery of said open base on the periphery of said base thereby forming a radiating structure, and energizing means attached at the periphery of said circular opening for energizing said means for radiating electromagnetic energy.

5. Means for radiating electromagnetic energy comprising a grounded base plate of conductive material, a center pole of conductive material mounted on said base plate, a first hollow cone of conductive material having a base and a truncated top, means connected between said center pole and said hollow cone for mounting the first hollow cone symmetrically on said center pole with the base facing said base plate, a second hollow cone of conductive material having an open base and a circular opening opposite the open base in a plane parallel thereto, means connected between the first hollow cone and the second hollow cone for mounting the periphery of said open base on the periphery of said base thereby forming a radiating structure, a source of luminous energy mounted on said center pole, a power source positioned outside the volume enclosed by said radiating structure, means for connecting said power source to said source of luminous energy, the portion of said last mentioned means located within the volume enclosed by said radiating structure being positioned adjacent to and along the length of said center pole, and energizing means attached at the periphery of said circular opening for energizing said means for radiating electromagnetic energy.

6. Means for radiating electromagnetic energy comprising a grounded base plate of conductive material, a center pole of conductive material mounted on said base plate, a first ring of conductive material, a plurality of conductive first supporting means for supporting said first ring symmetrically about the portion of said center pole furthest from and in a plane parallel to the base plate, a second ring of conductive material, means for positioning said second ring about the portion of said center pole nearest and in a plane parallel to the base plate, a third ring of conductive material, a plurality of conductive second supporting means for supporting said third ring between said second ring and said first ring in a plane parallel to the base plate, the third ring having a greater diameter than the first ring and the second ring, a plurality of conductors connected to the first ring, the second ring and the third ring, each of said conductors positioned coplanar with the longitudinal axis of the center pole, each of said conductors connected to said first ring at the same point as a respective one of said plurality of first supporting means and to said third ring at the same point as a respective one of said plurality of second supporting means, and energizing means attached at said second ring for energizing said means for radiating electromagnetic energy.

7. Means for radiating electromagnetic energy comprising a grounded base plate of conductive material, a center pole of conductive material mounted on said base plate, a first ring of conductive material, a plurality of conductive first supporting means for supporting said first ring symmetrically about the portion of said center pole furthest from and in a plane parallel to the base plate, a second ring of conductive material, means for positioning said second ring about the portion of said center pole nearest and in a plane parallel to the base plate, a third ring of conductive material, a plurality of conductive second supporting means for supporting said third ring between said second ring and said first ring in a plane parallel to the base plate, the third ring having a greater diameter than the first ring and the second ring, a plurality of conductors connected to the first ring, the second ring and the third ring, each of said conductors positioned coplanar with the longitudinal axis of the center pole, each of said conductors connected to said first ring at the same point as a respective one of said plurality of first supporting means and to said third ring at the same point as a respective one of said plurality of second supporting means, a source of luminous energy mounted on said center pole, a power source positioned outside the volume enclosed by said conductors, means for connecting said power source to said source of luminous energy, the portion of said last mentioned means located within the volume enclosed by said conductors being positioned adjacent to and along the length of said center pole, and energizing means attached at said second ring for energizing said means for radiating electromagnetic energy.

8. Means for radiating electromagnetic energy comprising a grounded base plate of conductive material, a center pole of conductive material mounted on said base plate, a crossarm of conductive material mounted symmetrically on said center pole, at least two first rings of conductive material, a plurality of first supporting means for supporting each of said first rings symmetrically about a respective portion of said crossarm furthest from said center pole in a plane perpendicular to the longitudinal axis of the crossarm, at least two second rings of conductive material, a plurality of means for positioning each of said second rings about a respective portion of said crossarm nearest said center pole in a plane parallel to the plane of a respective first ring, at least two third rings of conductive material, a plurality of conductive second supporting means for supporting each of said third rings between a respective second ring and first in a plane parallel to the plane of the respective first ring to form a set of rings, the third rings having a greater diameter than the first rings and the second rings, a plurality of conductors connected to the first ring and the second ring and third ring in each set of rings, each of said conductors positioned coplanar with the longitudinal axis of the crossarm, each of said conductors connected to a first ring at the same point as a respective one of said plurality of first supporting means and to a respective third ring at the same point as a respective one of said plurality of second supporting means, and energizing means attached at said second rings for energizing said means for radiating electromagnetic energy.

9. Means for radiating electromagnetic energy in a selected band of wave lengths comprising a grounded base plate of conductive material, a center pole of conductive material mounted on said base plate, a crossarm of conductive material mounted symmetrically on said center pole, at least two first rings of conductive material, a plurality of conductive first supporting means for supporting each of said first rings symmetrically about a respective portion of said crossarm furthest from said center pole in a plane perpendicular to the longitudinal

axis of the crossarm, at least two second rings of conductive material, a plurality of means for positioning each of said second rings about a respective portion of said crossarm nearest said center pole in a plane parallel to the plane of a respective first ring, at least two third rings of conductive material, a plurality of second conductive supporting means for supporting each of said third rings between a respective second ring and first ring in a plane parallel to the plane of the respective first ring to form a set of rings, the third rings having a greater diameter than the first rings and the second rings, a plurality of conductors connected to the first ring and the second ring and third ring in each set of rings, each of said conductors positioned coplanar with the longitudinal axis of the crossarm, each of said conductors connected to a first ring at the same point as a respective one of said plurality of first supporting means and to a respective third ring at the same point as a respective one of said plurality of second supporting means, a source of luminous energy mounted on said center pole, a power source positioned outside the volumes enclosed by said conductors, and means for connecting said power source to said source of luminous energy, the last mentioned means being positioned adjacent to and along the length of said center pole.

10. Means for radiating electromagnetic energy comprising a grounded base plate of conductive material, a center pole of conductive material mounted on said base plate, at least two first conductive hollow cones each having a base and a truncated top, at least two second conductive hollow cones each having an open base and a circular opening opposite the open base in a plane parallel thereto, means connected between each of said first hollow cones and a respective one of said second hollow cones for mounting the periphery of the open base of a second hollow cone on the periphery of the base of a first hollow cone such that each first hollow cone and the second hollow cone associated therewith forms a radiating structure, a crossarm connected to said center pole, means for mounting each radiating structure on said crossarm equidistant from and with the circular openings nearest the center pole, a source of luminous energy mounted on the top of the center pole, a power source positioned outside the volume enclosed by said radiating structures and means for connecting said power source to said source of luminous energy, the portion of said last mentioned means located within the volume enclosed by said radiating structures being positioned adjacent to and along the length of said center pole and energizing means attached at said circular openings for energizing said means for radiating electromagnetic energy.

11. Means for radiating electromagnetic energy in a selected band of wave lengths comprising a grounded base plate of conductive material, a center pole of conductive material mounted on said base plate, at least one first radiating means having a conical shape with a base of conductive material and a truncated top of conductive material, at least one second radiating means having a conical shape with an open base and an open truncated end, means connected between said first radiating means and said second radiating means for mounting the periphery of said open base on the periphery of said base, the distance from said base plate to the plane of said open base being substantially $41/100$ of the height of said center pole, the diameter of said open base being substantially $46/100$ of said height the diameter of said truncated top being substantially $15/100$ of said height, the diameter of said open truncated end being substantially $9/100$ of said height, the distance from said base plate to the plane of said open truncated end being substantially $4/100$ of said height, the said distances and diameters producing current paths whose combined impedance substantially matches the impedance of a 70-ohm transmission line, means for mounting said first radiating means and said second radiating means on said center pole with said open truncated end nearest said base plate, and energizing means attached at the periphery of said open truncated end for energizing said means for radiating electromagnetic energy.

12. Means for radiating electromagnetic energy in a selected band of wave lengths comprising a grounded base plate of conductive material, a center pole of conductive material mounted on said base plate, a first hollow cone of conductive material having a base and a truncated top, means connected between said center pole and said hollow cone for mounting the first hollow cone symmetrically on said center pole with the base facing said base plate, a second hollow cone of conductive material having an open base and a circular opening opposite the open base in a plane parallel thereto, means connected between the first hollow cone and the second hollow cone for mounting the periphery of said open base on the periphery of said base thereby forming a radiating structure, the distance from said base plate to the plane of said base being substantially $41/100$ of the height of said center pole, the diameter of said base being substantially $46/100$ of said height, the diameter of said truncated top being substantially $15/100$ of said height, the diameter of said circular opening being substantially $9/100$ of said height, the distance from said base plate to the plane of said circular opening being substantially $4/100$ of said height, the said distances and diameters producing current paths whose combined impedance substantially matches the impedance of a 70-ohm transmission line, and energizing means attached at the periphery of said circular opening for energizing said means for radiating electromagnetic energy.

13. Means for radiating electromagnetic energy in a selected band of wave lengths comprising a grounded base plate of conductive material, a center pole of conductive material mounted on said base plate, a first ring of conductive material, a plurality of first supporting means for supporting said first ring symmetrically about the portion of said center pole furthest from and in a plane parallel to the base plate, a second ring of conductive material, means for positioning said second ring about the portion of said center pole nearest and in a plane parallel to the base plate, a third ring of conductive material, a plurality of second supporting means for supporting said third ring between said second ring and said first ring in a plane parallel to the base plate, the third ring having a greater diameter than the first ring and the second ring, a plurality of conductors connected to the first ring, the second ring and the third ring, each of said conductors positioned coplanar with the longitudinal axis of the center pole, each of said conductors connected to said first ring at the same point as a respective one of said plurality of first supporting means and to said third ring at the same point as a respective one of said plurality of second supporting means, the distance from said base plate to the plane of said third ring being substantially $41/100$ of the height of said center pole, the diameter of said third ring being substantially $46/100$ of said height, the diameter of said first ring being substantially $15/100$ of said height, the diameter of said second ring being substantially $9/100$ of said height, the distance from said base plate to the plane of said second ring being substantially $4/100$ of said height, the said distances and diameters producing current paths whose combined impedance substantially matches the impedance of a 70-ohm transmission line, and energizing means attached at said second ring for energizing said means for radiating electromagnetic energy.

14. Means for radiating electromagnetic energy in a selected band of wave lengths comprising a grounded base plate of conductive material, a center pole of conductive material mounted on said base plate, a crossarm of conductive material mounted symmetrically on said center pole, at least two first rings of conductive material, a plurality of first supporting means for supporting each

of said first rings symmetrically about a respective portion of said crossarm furthest from said center pole in a plane perpendicular to the longitudinal axis of the crossarm, at least two second rings, a plurality of means for positioning each of said second rings about a respective portion of said crossarm nearest said center pole in a plane parallel to the plane of a respective first ring, at least two third rings, a plurality of second supporting means for supporting each of said third rings between a respective second ring and first ring in a plane parallel to the plane of the respective first ring to form a set of rings, the third rings having a greater diameter than the first rings and the second rings, a plurality of conductors connected to the first ring and the second ring and third ring in each set of rings, each of said conductors positioned coplanar with the longitudinal axis of the crossarm, each of said conductors connected to a first ring at the same point as a respective one of said plurality of first supporting means and to a respective third ring at the same point as a respective one of said plurality of second supporting means, the distance from said center pole to each of said third rings being substantially 41/100 of the span of said crossarm from the center pole to each end of the crossarm, the diameters of said third rings, said first rings and said second rings being, respectively, substantially 46/100, 15/100 and 9/100 of said span, the distance from said center pole to the planes of said second rings being substantially 4/100 of said span, the said distances and diameters producing current paths whose combined impedance substantially matches the impedance of 70-ohm transmission lines, and energizing means attached at said second rings for energizing said means for radiating electromagnetic energy.

15. Means for radiating electromagnetic energy in a selected band of wave lengths comprising a grounded base plate of conductive material, a center pole of conductive material mounted on said base plate, at least two first hollow cones each having a hose and a truncated top, at least two second hollow cones each having an open base and a circular opening opposite the open base in a plane parallel thereto, means connected between each of said first hollow cones and a respective one of said second hollow cones for mounting the periphery of the open base of a second hollow cone on the periphery of the base of a first hollow cone such that each first hollow cone and the second hollow cone associated therewith forms a radiating structure, a crossarm connected to said center pole, the distance from said center pole to each of said open bases being substantially 41/100 of the span of said crossarm from the center pole to each end of the crossarm, the diameters of said open bases, said truncated tops and said circular openings being, respectively, substantially 46/100, 15/100 and 9/100 of said span, the distance from said center pole to the planes of said circular openings being substantially 4/100 of said span, the said distances and diameters producing current paths whose combined impedances substantially match the impedance of 70-ohm transmission lines, and energizing means attached at said circular openings for energizing said means for radiating electromagnetic energy.

16. Means for radiating electromagnetic energy comprising a conductive center support mounted on a conductive base, radiating means substantially enclosing said support and extending from the end of said support remote from the base substantially to the base, electrically conductive supporting means connecting said radiating means and said support at the end of said support and at a point intermediate said end and said base, said radiating means having an enlarged waist portion at said intermediate point, said radiating means being electrically interconnected at said end of said support, at said intermediate point, and at a base portion displaced from and substantially parallel to said base so as to provide preselected antenna impedances, and energizing means attached at said base portion for energizing said means for radiating electromagnetic energy.

17. Means for radiating electromagnetic energy comprising a conductive center support mounted on a conductive base, radiating means substantially enclosing said support and extending from the end of said support remote from the base substantially to the base, electrically conductive supporting means connecting said radiating means and said support at the end of said support and at a point intermediate said end and said base, said radiating means having an enlarged waist portion at said intermediate point, said radiating means being electrically connected peripherally about said support at the end thereof, at said intermediate point, and at a base portion displaced from and substantially parallel to said base, and energizing means attached at said base portion for energizing said means for radiating electromagnetic energy, said radiating means providing at least two current paths having differing impedances, the combination of which substantially matches the impedance of a 70-ohm transmission line.

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