

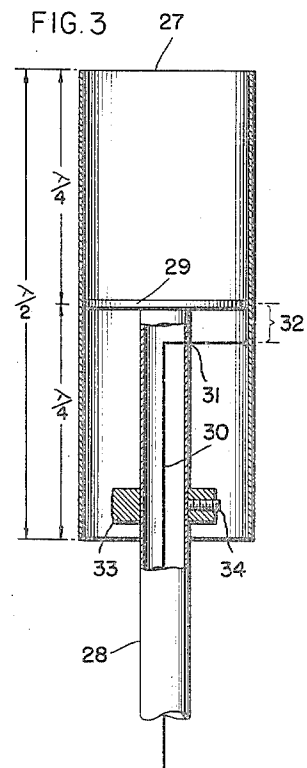
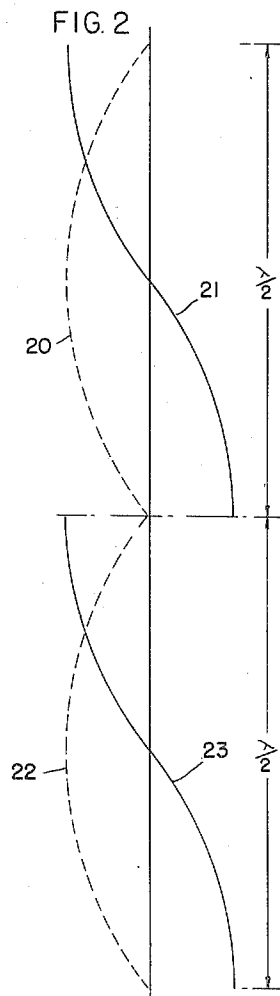
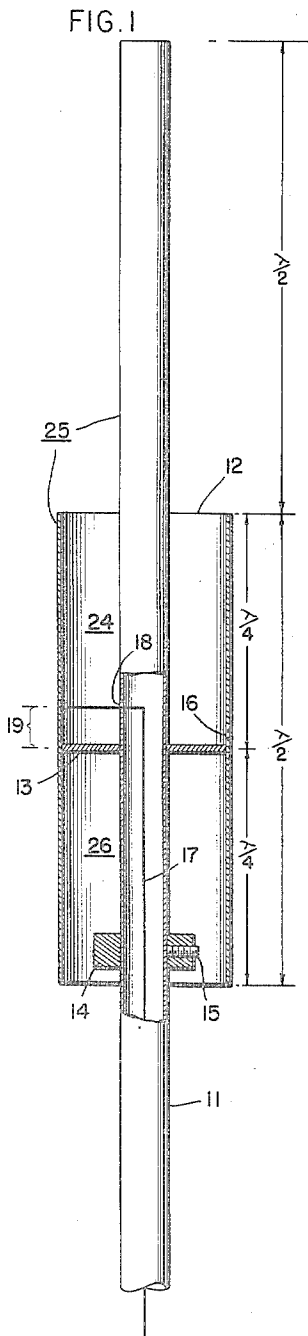
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VERTICAL ANTENNA ARRAY

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VERTICAL ANTENNA ARRAY

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This invention refers to antennas in general and more particularly relates to a vertical coaxial antenna for transmitting and receiving radiant energy at ultra-high frequencies.

The rapid growth and application of two-way radio communication with respect to railroad operations, police, fire and other emergency services has created the need for antenna, particularly one for central station use, which is capable of rendering continuous and efficient service over long periods of time without adjustment or maintenance irrespective of the weather or elements. Such an antenna should necessarily embody certain requirements, such as, ease of installation and adjustment and structural and electrical stability.

The efficiency of certain of the prior art antennas and associated feeder systems is greatly affected by adverse weather conditions. It has been found necessary, in many cases, to take special precautionary measures, such as, the incorporation of ice melting circuits and weather-proof antenna housings in order to minimize the detrimental effects or losses due to accumulation of ice, snow or sleet upon the antenna or feeder elements.

Another problem affecting antenna installation and operation is that of matching impedances between the radiating elements and the feeder system. An effort has been made to solve this problem by means of special impedance matching devices, such as, matching transformers, matching stubs, delta connections and the like. A device such as a matching stub very often is a bulky and unwieldy item necessitating special mounting provisions and usually requiring a resonating or tuning adjustment at the time of installation. Wind stresses and vibrations often incur mechanical breakage or electrical leakage in the matching device thereby necessitating further adjustment or maintenance in order to restore the functioning of the antenna to its highest efficiency.

It is further recognized that certain types of high frequency antennas require that the radiating elements be "floated" or insulated from ground. In this manner, a complicated system of supporting structures and insulators is required to maintain the radiating elements at a predetermined height above ground. These radiating elements then constitute a hazard inasmuch as they are not at a direct current ground potential and, as such, are subject to possible danger from atmospheric discharges, such as,

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lightning. Installations of this type usually employ special lightning protective apparatus.

Therefore, it is an object of this invention to provide a self-supporting vertical antenna array especially adapted to high frequency communication operation.

Another object of the invention is to provide an antenna, the input impedance of which may be adjusted during manufacture over a wide range of impedances, and thereby to permit the efficient matching of the impedance of the radiating elements to the impedance of the antenna feeder system prior to the installation and without recourse to external or supplementary impedance matching devices.

A further object of this invention is to provide a rigid and durable antenna system having simplicity of structure, the electrical efficiency of which will not be affected by accumulations of ice, snow or moisture and which, at the same time, will provide weatherproof protection to the antenna feeder elements contained within the structure.

Another and different object of the invention is to provide an antenna structure having its uppermost point at a direct current ground potential thereby providing protection against lightning or electrical storms.

In accordance with the present invention, there is provided a self-supporting coaxial antenna array comprising two metallic cylinders, namely, a supporting mast and an outer sleeve. The supporting mast is concentrically arranged within the outer sleeve and by means of a metallic plug, the outer sleeve is fixedly held upon the mast. The metallic plug also serves to establish resonant electrical circuits upon the inner surfaces within the confines of the outer sleeve. These resonant circuits provide means for antenna excitation. The entire antenna structure is of metallic substance and by means of a direct electrical connection between the mast section and the ground, the device may then function in the manner of a lightning rod, thereby reducing the hazard with respect to lightning or electrical storms.

A section of the mast, in conjunction with a center conductor, provides an antenna feeder system in the form of a concentric transmission line. The center conductor of this transmission line is terminated at a predetermined point upon the outer sleeve. The antenna impedance at the point of feeder line termination may be correlated with the impedance value of the transmission line. Means are also provided whereby the

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antenna structure may be tuned or resonated. Due to the structural form of the antenna and the distribution of impedances thereon, accumulations of ice, snow or sleet which may be deposited within the structure will not be detrimental to the operation or efficiency of the radiating elements because of the relatively low value of antenna impedance which is present where these accumulations may occur. Weatherproofing is provided for the antenna feeder system, the feeder connections and the antenna tuning element by the outer sleeve which forms a protective skirt.

In one embodiment of the present invention, the supporting mast is coaxially extended through and above the outer sleeve. This upper portion of the mast projects above the outer sleeve for a predetermined electrical distance to become an integral part of the radiating structure. The external surface of the outer sleeve also is dimensioned so as to provide a resonant structure which, in conjunction with the aforementioned projecting portion of the mast constitutes a complete antenna array for signal radiation purposes.

For a better understanding of the invention together with other and further objects thereof, reference is made to the following description taken in connection with the accompanying drawing, and its scope will be pointed out in the appended claims.

In the accompanying drawing:

Fig. 1 is a cross sectional view of a cylindrical antenna embodying the invention and having two half-wavelength radiating sections;

Fig. 2 illustrates the distribution of the voltages and currents on the radiating sections of the antenna structure of Fig. 1; and

Fig. 3 illustrates in cross section a cylindrical antenna embodying the invention in another form and having a single half-wavelength radiating section.

Referring now more particularly to Fig. 1 of the drawings, there is shown a cross sectional view of a vertical antenna array embodying one form of the present invention. The antenna comprises a pair of hollow metallic cylinders concentrically arranged so that the inner cylinder or mast 11 projects through and beyond the outer cylinder or sleeve 12. The projecting portion of the mast 11 and the overall length of the sleeve 12 are dimensioned so that each represents an electrical half-wavelength section. The mid-section of sleeve 12 is directly connected to the mast 11 by means of a metallic shorting disc 13. Shorting disc 13 provides fastening and mounting means whereby the sleeve 12 is fixedly held in position upon, and grounded to the mast 11. The disc 13, being located at the electrical center of sleeve 12, also serves to divide the inner surfaces of the sleeve into two resonant sections, each section being an electrical quarter-wavelength. A tuning slug 14 is adjustably mounted by means of a set screw 15 upon the mast 11 and may be slidably positioned, so as to exert a capacitive tuning effect within the interior of the lower section of sleeve 12. The lower section of sleeve 12 also serves as a protective skirt and weatherproofing enclosure to the components contained therein. For the purpose of draining off excess moisture deposits which may accumulate in the upper section of sleeve 12 there may be provided in the side wall thereof a drainage opening 16.

Mast 11 extending downwardly also serves as a support for the antenna array and may have

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its lower extremity grounded to provide lightning protection. At the same time, the lower section of mast 11 functions, in part, as the outer conductor of a coaxial feed line. The inner conductor of this feed line is a conductor 17 which is concentrically arranged within the mast 11. For antenna excitation purposes, the center conductor 17 is passed through an aperture 18 formed in the side wall structure of mast 11 and is terminated in a direct electrical connection to a predetermined point on the inner surface of the upper resonant section of the sleeve 12. Due to being shorted or grounded at its mid-section, the sleeve 12 provides an area or zone 19 adjacent to the shorting disc 13, for effecting an efficient impedance match with the antenna feeder system. The impedance of the antenna system will be of a reduced value at a point in zone 19 which is close to the shorting disc 13. This antenna impedance value is higher at greater distances from the shorting disc 13. Thus, if a 50 ohm feeder connection is made to a predetermined position in zone 19, where there exists an impedance value of approximately 50 ohms, a satisfactory impedance match is effected, thereby resulting in the efficient transfer of energy from the transmission line to the antenna proper. Thus, by taking advantage of zone 19, feeder systems of different impedance values may be employed. Antenna excitation energy is provided, for transmission, by the application of radio frequency energy to the remote end of the coaxial transmission line comprising the lower section of mast 11 and center conductor 17.

The described antenna array comprises two half-wave antennas which are driven in phase and the over-all voltage and current distribution, with respect to the propagating surfaces of the complete antenna, is diagrammatically illustrated in Fig. 2. The broken line curve 20 represents the current distribution, and the full line curve 21 indicates the voltage distribution with respect to the top section of mast 11. Curves 22 and 23 likewise illustrate the distribution of current and voltage, respectively as applied to the outer surface of sleeve 12.

An analysis of the operation of this type of antenna reveals that it is mainly composed of three resonant circuits 24, 25 and 26 which are coupled in a manner to be described. The first circuit 24 is a self-resonant circuit comprising the surface areas contained within the upper portion of sleeve 12. The second circuit 25 which is coupled to the circuit 24 is the self-resonant antenna comprising the upper-section of mast 11 extending beyond the outer sleeve 12 and the complete outer surface of this sleeve. The third circuit 26 which is coupled to the circuit 25 is the self-resonant circuit formed by the surface areas contained within the lower section of sleeve 12.

The radio frequency excitation or energy, applied to the sleeve 12 by means of the transmission line, does not directly induce a current on its outer surface but rather induces an initial current in circuit 24 upon the surfaces contained within the interior of the upper quarter-wavelength section. Referring to Fig. 2, it will be noted that a voltage maximum exists upon the topmost edge of sleeve 12, thereby electrostatically coupling circuits 24 and 25. Thus, circuit 25 is excited and causes the half-wavelength topmost section of the mast 11 and the half-wavelength external surface of the sleeve 12 to radiate signal energy. The excitation energy existent upon the external surface of sleeve 12 travels downwardly

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to its lower edge where electrostatic coupling again takes place to transfer the energy to circuit 26.

Circuit 26 is normally inductive, and by reason of the capacitive properties of the tuning slug 14, this section may be resonated to the operating frequency by varying the physical position of the tuning slug and to thereby establish a resonant condition. At resonance, circuit 26 is operating at a high value of impedance and due to coupling a resonant condition is likewise created in circuit 25. Referring to Fig. 2, there is illustrated the instantaneous values of the voltages and currents which are distributed, at resonance, over the radiating surfaces comprising circuit 25.

Fig. 3 illustrates a modified form of an antenna embodying the present invention. There is shown a single half-wavelength radiating section in the form of a metallic sleeve 27 which is mounted atop of a mast 28. Sleeve 27 indicated as being dimensioned to an electrical half-wavelength, is fastened to the top portion of mast 28 by means of a metallic shorting disc 29. The mast 28, which may be maintained at a direct current ground potential, is employed to support the antenna structure and, at the same time, serves as the outer conductor for a coaxial transmission line in conjunction with a center conductor 30. The center conductor 30 is coaxially arranged within the mast 28. The side wall structure of mast 28 contains an aperture 31 through which the center conductor 30 is passed to be terminated at a specific point of impedance, within zone 32, on the sleeve 27. This method of terminating the antenna feeder system has been previously shown and described in Fig. 1. An adjustable metallic tuning slug 33 is shown positioned within the lower quarter-wavelength section of sleeve 27 and is held in place upon mast 28 by means of a set screw 34.

Radio frequency excitation applied to the remote end of the coaxial transmission line results in the application of energy to the self-resonant section contained within the lower quarter-wavelength portion of sleeve 27. The tuning slug 33, normally capacitive, is employed for resonating or tuning the inductive sleeve 27.

The voltage maximum existant upon the lower edge of sleeve 27 effects electrostatic coupling between the resonant circuit within the lower section of sleeve 27 and a resonant circuit comprising the external radiating surface of the sleeve 27. There being no tuned circuit or elements within the top quarter-wavelength section of sleeve 27, no excitation effect will take place within this area. Signal radiation due to the applied excitation is the result of the functioning of the outer surface of sleeve 27.

Referring again to Fig. 2, the curves 22 and 23 illustrate respectively the current and voltage distribution over the outer radiating surface of sleeve 27 during operation.

If desired, the antenna of Fig. 3 may be provided with an opening in the upper section of the sleeve 27 similar to the hole 16 in the structure of Fig. 1 for draining off excess accumulations of moisture, water and the like. However, inasmuch as any such deposits will be made on the shorting disc 29, the impedance of the sleeve at this point necessarily is low and, in accordance with one of the features of the present invention, any such deposits at this point will have no appreciable detrimental effect upon the operation of the antenna. For that matter, the top of the sleeve 27 may be closed, since in this form of the

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invention the upper quarter-wavelength section of the sleeve is not used in operating the antenna.

It should be apparent that antenna arrays in accordance with this invention have numerous advantages. Such an antenna is a relatively simple structure and therefore is easy to fabricate and install. It also is self-supporting and is a particularly rugged device. The entire structure is completely metallic and consequently no insulation from ground or other supporting structure is required. Being entirely metallic and susceptible of being directly connected electrically to ground for direct currents, it requires no additional protection from lightning or other atmospheric electrical discharges. In operation such an antenna array is capable of propagating signal energy at a low angle of radiation. Furthermore, by reason of its symmetrical character, the signal radiation therefrom is substantially nondirectional. Consequently, there is produced a uniform field of distribution.

While there have been described two illustrative embodiments of the invention, it will be obvious to those skilled in the art that various changes and modifications may be made therein without departing from the invention, and it is, therefore desired that the appended claims be not limited to these two embodiments.

What is claimed is:

1. An antenna array comprising, a relatively large diameter hollow cylindrical outer sleeve having a longitudinal dimension substantially equal to a half-wavelength at a predetermined operating frequency, a metallic disc mechanically and electrically attached at its peripheral edge to the inner wall of said outer sleeve approximately midway between its upper and lower ends, thereby dividing the interior of said outer sleeve into upper and lower chambers each having longitudinal dimensions equal substantially to a quarter-wavelength at said operating frequency, a relatively small diameter hollow cylindrical inner sleeve extending concentrically within said outer sleeve and being mechanically and electrically connected to said metallic disc, said inner sleeve having an aperture formed in the wall thereof in the region within one of the chambers of said outer sleeve, a center conductor extending concentrically upwardly through said inner sleeve to form a coaxial transmission line with said sleeve, said center conductor being connected electrically through said aperture to said outer sleeve at a point in said one chamber spaced suitably from said metallic disc to have substantially the same impedance as the characteristic impedance of said coaxial transmission line, and a metallic annular member slidably mounted on said inner sleeve in the region of one of said quarter-wavelength chambers for adjusting the reactance of said antenna array to produce resonance at the predetermined operating frequency.

2. An antenna array comprising, a hollow metallic cylindrical member having a longitudinal dimension substantially equal to a half-wavelength at a predetermined operating frequency, a smaller cylindrical member mounted concentrically with said hollow cylindrical member and having a portion extending upwardly from the top of said hollow cylindrical member for a distance substantially equal to a half-wavelength at said operating frequency, said smaller cylindrical member being electrically connected to the inner surface of said hollow cylindrical member at its mid-section, and a concentric transmission line

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having an outer conductor of substantially the same diameter as that of said smaller cylindrical member and connected to said hollow cylindrical member at its mid-section in alignment with said smaller cylindrical member, said transmission line also having a center conductor connected to one of the resonant sections of said hollow cylindrical member.

3. An antenna array comprising, a relatively large diameter hollow cylindrical outer sleeve having a longitudinal dimension substantially equal to a half-wavelength at a predetermined operating frequency, a centrally apertured metallic disc attached at its peripheral edge to the inner wall of said outer sleeve approximately midway between its upper and lower ends, thereby dividing the inner surface of said outer sleeve into upper and lower chambers each having longitudinal dimensions equal substantially to a quarter-wavelength at said operating frequency, a relatively small diameter hollow cylindrical inner sleeve extending concentrically through said outer sleeve and the aperture of said metallic disc and beyond the upper end of said outer sleeve for a distance equal substantially to a half-wavelength at said operating frequency, said inner sleeve being mechanically and electrically connected to said metallic disc, a concentric center conductor extending upwardly through the lower portion of said inner sleeve into the region of the upper quarter-wavelength chamber of said outer sleeve, said center conductor being connected electrically to said outer sleeve at a point in the upper chamber thereof spaced suitably from said metallic disc to have substantially the same impedance as the characteristic impedance of the coaxial transmission line formed by said center conductor and the lower portion of said inner sleeve, and a metallic tuning device slidably mounted on said inner sleeve in the region of the lower quarter-wavelength chamber of said outer sleeve for adjusting

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said array for resonance at the predetermined operating frequency.

4. An antenna array comprising, a cylindrical radiating element having a longitudinal dimension substantially equal to a half-wavelength at a predetermined operating frequency and divided internally at its mid-section into two quarter-wavelength sections, a transmission line having concentrically arranged outer and inner conductors extending coaxially through one of said quarter-wavelength sections, said outer conductor being mechanically and electrically connected to said radiating element at its mid-section and forming with the internal surface of said one quarter-wavelength section a resonant circuit at said predetermined operating frequency, said inner conductor being connected to said radiating element at a point in said quarter-wavelength resonant section spaced suitably from said mid-section to have substantially the same impedance as the characteristic impedance of said coaxial transmission line, and a tuning device slidably mounted on said outer transmission line conductor in the region of said quarter-wavelength resonant section for adjusting said array for resonance at the predetermined operating frequency.

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