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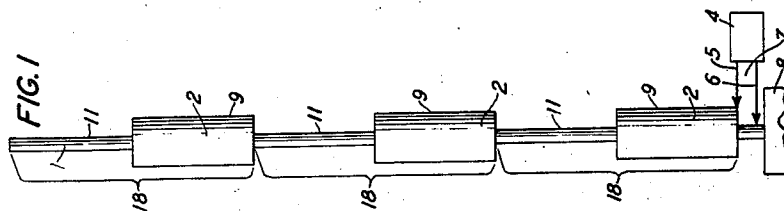
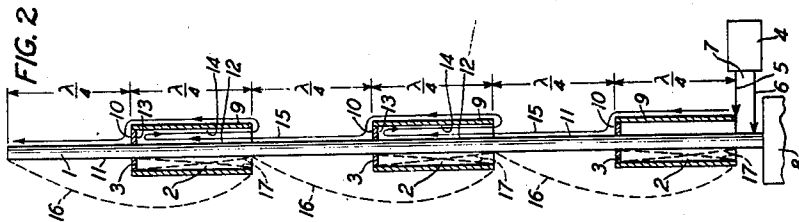
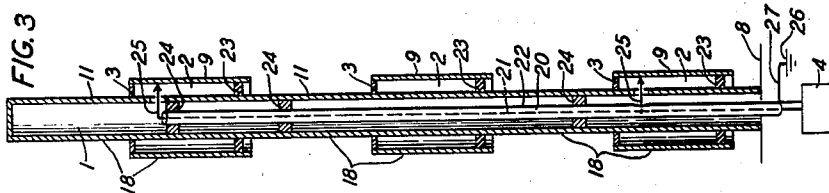
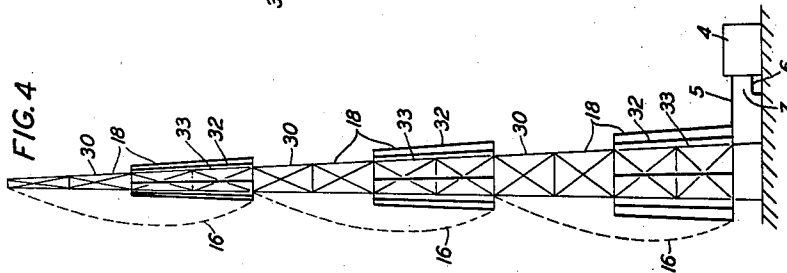
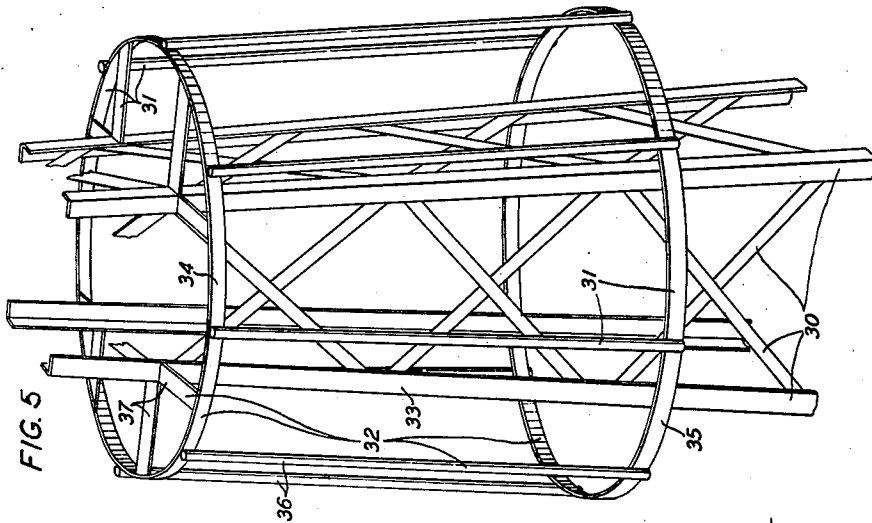
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2,323,641

ANTENNA SYSTEM

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2 Sheets-Sheet 1

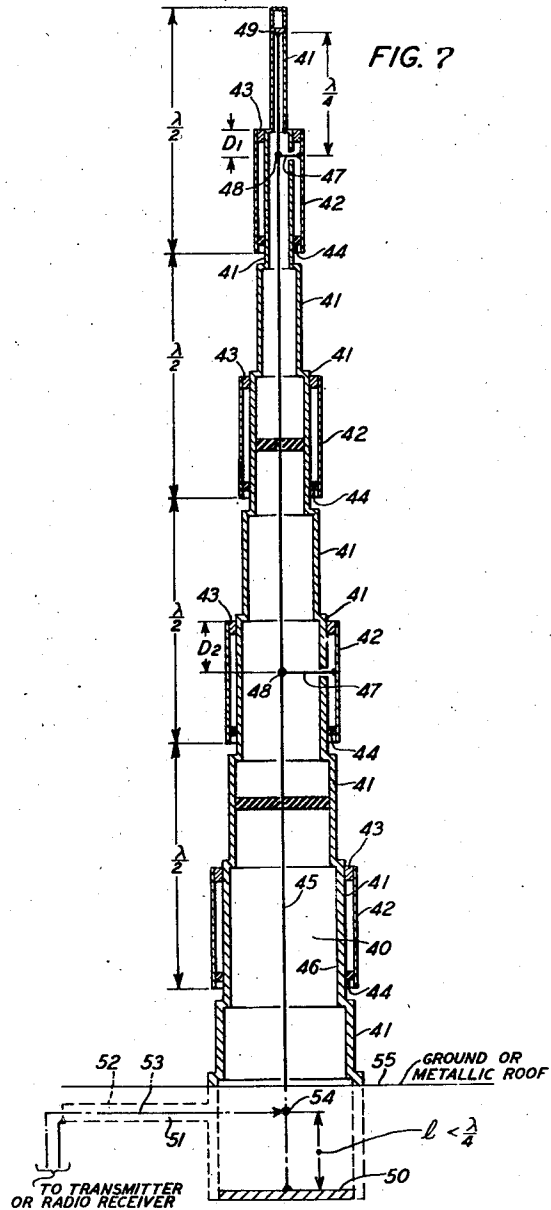


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2 Sheets-Sheet 2



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UNITED STATES PATENT OFFICE

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ANTENNA SYSTEM

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Application January 26, 1940, Serial No. 315,632

7 Claims. (Cl. 250—33)

This invention relates to antenna systems and more particularly to an array especially suitable for use with ultra-short waves.

One antenna array in common use today comprises several half wave radiators colinearly arranged in a vertical or horizontal plane and energized in phase, and means such as a half wave coil or a quarter wave line loop included between the adjacent radiators for suppressing the radiant action produced by standing wave alternations or loops having a phase opposite to that of the effective radiating alternations. Since the radiators, or collectors, are ordinarily connected in series, the total attenuation is relatively high and, as a result, the amplitudes of the outgoing and return traveling waves, and of the resultant standing wave, are not as large as desired. Moreover, the half wave suppressors and the associated supporting structure usually employed are such as to necessitate an undesired physical separation between the adjacent radiators or collectors whereby a highly concentrated low fire beam or maximum directive lobe is not fully realized. Again, in arrays of this type the radiation or absorption by the line and, in some systems, the radiant action of supporting structures such as guide wires, often materially distort the array directive characteristic and unfavorably affect the array efficiency.

It is one object of this invention to secure maximum radiant action in a desired direction.

It is another object of this invention to secure uniform maximum radiant action in all directions included in a given plane.

It is still another object of this invention to secure a highly concentrated radio beam and to avoid distortion thereof by line radiation.

It is a further object of this invention to secure a highly directional, compact self-supporting antenna array.

According to one embodiment of this invention the array comprises a vertical tubular member a plurality of half wave-lengths long, a plurality of quarter wave-length cylindrical sleeves of greater diameter, the sleeves being coaxially related to the tubular member and spaced thereon a quarter wave-length apart and means, such as bushings, connecting the inner circumference at the upper end of each sleeve to the rigid vertical member. Preferably, the diameters of the linear tubular member and associated sleeves are graduated or stepped in a direction toward the top of the structure. A transmission line inner conductor is included within and coaxially related to the tubular member; and the inner line

conductor and the inside surface of the tubular member constitute a coaxial line. In operation, the outer surface of each quarter wave-length sleeve and the one-quarter wave-length exposed portion of the tubular member immediately above constitute a dipole; and the inner surface of each sleeve and the portion of the outer surface of the tubular member enclosed thereby function as a radiation suppressor. Thus, the radiation produced by one set of standing wave alternations is canceled and since the adjacent in-phase alternations on the radiating portions of the structure are very closely positioned a highly concentrated beam is produced. Preferably individual branch line conductors are provided from the enclosed inner line conductor to several sleeve members whereby in effect the radiating elements are connected in parallel and a strong standing wave is established on the radiating portions of the structure. In one practical embodiment, branch line conductors are associated with alternate sleeve members, beginning with the top sleeve, the point of connection on the sleeve being critically selected and such that the branch line and antenna impedances are matched. The connection to the top sleeve is approximately a quarter wave-length from the apex of the tubular mast and the top extremity of the inner conductor is connected through a metallic cap or top end-piece to a point near the uppermost extremity of the tubular member, whereby the portion of the line above the last branch conductor constituted by the inner line conductor and the inner surface of the mast forms a high impedance short-circuited quarter wave transformer and functions as if removed. The lowest extremity of the inner line conductor is similarly connected through a metallic plate or bottom end-piece to the other extremity of the mast and the inner conductor of the main low impedance coaxial line from the transmitter or receiver is adjustably connected to the inner conductor at a distance slightly less than a quarter wave-length from the plate whereby the line section comprising the lower portion of the inner conductor and the associated inner surface of the mast functions as an impedance transformer to match the impedances of the two coaxial lines.

The invention will be more fully understood from a perusal of the following discussion taken in connection with the drawings on which like reference characters denote elements of similar function and on which:

Figs. 1 and 2 illustrate, respectively, eleva-

tional and sectional views of a simple embodiment of the invention;

Fig. 3 illustrates a sectional view of another embodiment;

Fig. 4 illustrates a tower antenna array constructed in accordance with the invention and Fig. 5 is a perspective view of a half wave suppressor included in the system of Fig. 4;

Figs. 6 and 7 illustrate, respectively, perspective and sectional views of a preferred embodiment of the invention.

Referring to Figs. 1 and 2, reference numeral 1 denotes a rigid solid cylindrical antenna member a plurality of one-half wave-lengths long and positioned in a desired plane of wave polarization as, for example, the vertical plane. Reference numerals 2 designate sleeve type metallic half wave suppressors each one-quarter wave-length long and supported by member 1 through metallic bushings 3. The tubular sleeves 2 and the linear member 1 are coaxially related and the sleeves are spaced one-quarter wave-length apart along the member 1, the uppermost quarter wave-length section of the member 1 being exposed. A translation device 4, such as a transmitter or receiver, is connected by conductors 5 and 6 of line 7 between the lowest sleeve and the adjacent portion of member 1. The linear array may be supported on a ground plate or on top of a structure or pole 8 and while the linear array is a plurality of half wave-lengths long the supporting pole or structure may, of course, have any height or length. Since in operation the velocity of the current on metallic members 1 and 2 is slightly less than that of a wave in space, that is, less than the theoretical velocity of wave propagation, the length of each sleeve and the sleeve spacing are each slightly less than a theoretical quarter wave-length.

In operation, assuming the device 4 is a transmitter, current flows along the outer surfaces 9 of sleeve 2, exposed surface 10 of bushing 3, exposed surface 11 of member 1, concealed surface 12 of member 1 and inner surfaces 13 and 14, respectively, of bushing 3 and sleeve 4, as indicated by the line 15 in Fig. 2. As is known, the current on the exposed surface 9 of sleeve 2 and the current on the inner surface 14 are separate and distinct, as explained in Patent 2,258,953 to W. H. C. Higgins, granted October 14, 1941. Thus a standing wave having similarly phased alternations 16 is established on the exposed radiating surfaces of members 1 and 2 and the oppositely phased alternations 17 are rendered ineffective in so far as radiant action is concerned. The conducting surfaces 12, 13 and 14 constituting the half wave suppressor is electrically similar to a half wave-length conductor folded at the center and back on itself; and the exposed colinear radiating surfaces 9 and 11 form a plurality of in-phase dipole radiators 18. It will be noted that the construction and design of the phase suppressors are such as not to necessitate a physical separation between adjacent in-phase dipoles. Consequently, the effective alternations are closely adjacent and their nodal points are in effect superimposed whereby a highly concentrated field is emitted and, at a given distant receiving point, the field components corresponding to the several dipoles are more nearly in phase agreement than in the case of the prior art system mentioned above wherein the dipoles are physically separated. Theoretically, the current at each nodal point has zero amplitude but it has been found in practice that at the intermediate

nodal points waves of small amplitude are established.

Referring to Fig. 3, the member 1 is hollow and encloses a low impedance coaxial line 20 having an inner conductor 21 and an outer conductor 22, the line 20 and the member 1 being coaxially related. Reference numerals 23 denote stand-off insulators for maintaining the sleeves 2 in position and numerals 24 designate metal bushings for supporting line 20, one bushing 24 being included between the top extremity of conductor 22 and the member 1. The inner conductor 21 of line 20 is directly connected by separate branch line conductors 25 to alternate sleeves 2. Preferably the outer conductor 22 and one terminal of device 4 are connected to ground 26 by conductor 27.

The radiant operation of the system of Fig. 3 is substantially the same as that of Fig. 1. The effective or radiant standing wave alternations established on each dipole 18 are relatively strong and have intensities comparable to those established on the structure of Fig. 1 since the dipoles are similarly energized in parallel, each through a path of low impedance. In the system of Fig. 1 the dipoles are energized in series, and the standing wave on the top dipole 18 which receives its energy through the high impedance lower dipoles is considerably weaker than that, for example, on the lowest dipole directly connected to the low impedance line 7. By positioning the line 20 within the member 1 and placing the short branch line conductors 25 inside sleeves 2, the formation of undesired standing waves on the outer surface of conductor 22 and the consequent distortion of the array directive characteristic by line radiation are substantially prevented. Hence, in accordance with one feature of the invention, in an array comprising a plurality of antenna elements connected in parallel, all transmission line conductors adjacent the structure are effectively shielded by the array elements. The arrays of Figs. 1, 2 and 3 are, of course, equally suitable for receiving and transmitting and may comprise any practical number of dipole elements. Also, these arrays may be oriented for any desired polarization and they are each suitable for use in stationary or mobile radio systems.

Referring to Figs. 4 and 5, the member 30 is a conventional tapered mast or tower type antenna element a plurality of wave-lengths long, and the phase suppressors each comprise the inner conductor surface 31 of the cage 32 and the associated enclosed surface 33 of the tower antenna 30. The cage radiator-suppressor 32 comprises a top annular member or hoop 34, bottom annular member 35, longitudinal members 36 and transverse members 37. The transverse members 37 correspond in function to the bushings 3 of the systems of Figs. 1, 2 and 3 and are rigidly fastened to the tower 30. The cages 32 are placed a quarter wave-length apart and since the tower or mast 30 is tapered they have different diameters as shown by Fig. 4. As in Fig. 1 the line 7 from the translation device 4 is connected to the bottom cage 32 although, alternatively, the line may extend inside the tower and parallel connections to the several cages may be used as in the system of Fig. 3. The operation of the system of Fig. 4 is similar to that of the systems of Figs. 1, 2 or Fig. 3 and in view of the above discussion is believed to be apparent.

Referring to Figs. 6 and 7 reference numeral 40 denotes a flagpole type radiator comprising the iron pipe sections 41, each approximately a

quarter wave-length long and having different diameters. The sections are arranged so that the diameter of the mast decreases toward the top in steps. The junctions of the adjacent sections are telescoped and calked to prevent moisture from entering the tubular iron conductor and, preferably, the arrangement or construction at each junction is such that if necessary, as upon a change in assigned operating frequency, the length in meters of each section 41 and the overall height of the structure may be altered. Reference numerals 42 designate light-weight metallic sleeve members which are spaced a quarter wave-length apart and supported on the member 40 by metallic bushings 43 and stand-off insulators 44. The diameters of the sleeves are graduated or stepped in accordance with the different diameters of the member 40. As in the systems described above, the uppermost quarter wave-length portion of member 40 is exposed and constitutes one-half of the top dipole 18. While Fig. 6 illustrates certain electrical and mechanical features of a preferred embodiment, in practice, the structure would usually be more slender than that indicated by this figure. In one practical embodiment the dipoles 18 are each sixteen feet long, the diameter of the top portion of radiator 1 is two inches, the sleeve diameter is one inch greater than the diameter of the associated portion of member 1, and the sleeve thickness is approximately one thirty-secondths of an inch.

A single line conductor 45 extends, coaxially, within member 40 and the inside surface 46 of member 40 constitutes a return line conductor. Branch conductors 47 are utilized to connect the line conductor 45 directly to alternate sleeve members including the top sleeve. The inner conductor 45 extends a quarter wave-length above the point 48 at which it is joined to the top branch line conductor 47 and it is conductively connected to a point near the top extremity of member 40 and supported by the top piece or cap 49. The lower terminal of the inner conductor 45 is electrically connected through the plate or bottom piece 50 to the lower extremity of the member 40. Numeral 51 denotes the main coaxial line from the translation device (not shown) the line having its outer conductor 52 connected to member 40 and its inner conductor 53 adjustably connected to the inner conductor 45 at a point 54 which is less than a quarter wave-length above the bottom end-piece 50. Preferably, the line 51 is positioned below the ground surface or the building roof 55. If desired, instead of insulators 44, the space between the sleeves 42 and member 40 may be filled with an insulating compound for the purpose of securing a solid aerial structure.

The radiant operation of the array of Figs. 6 and 7 is substantially the same as that of the system of Figs. 1, 2 or Fig. 3. The line section formed by the portion of the inner conductor 45, between junction point 54 and plate 50 and by the associated inside surface 46 of member 40, constitutes an impedance transformer for matching the low impedance line 51 to the high impedance line comprising the inner conductor 45 and the inside irregular surface 46 of member 40, the proper adjustment or position for the junction point 54 being determined by predetermined calculations or by experiment. At the upper end of the structure, the line section formed by the quarter wave-length portion of conductor 45 above junction point 48 and the associated inside surface of member 40 constitutes a high

impedance short-circuited quarter wave transformer whereby this line section functions as if removed. In other words, while the inner conductor 45 preferably extends for mechanical reasons to the top extremity of member 40 or to cap 49, the coaxial line comprising conductor 45 does not extend, from an electrical standpoint, beyond the point 48. This self-supporting structure, Figs. 6 and 7, is suitable for use in ground stations and since it is self-supporting, it is especially suitable for utilization on top of buildings. It functions to produce a concentrated low fire beam of uniform intensity in all horizontal directions and is highly efficient for emission or reception of ultra-short waves. As compared to prior art systems, it is easily manufactured and installed, and more easily maintained in operation.

Although the invention has been described in connection with certain embodiments it should be understood that it is not to be limited to the particular structures described inasmuch as other apparatus may be successfully employed without exceeding the scope of the invention.

What is claimed is:

1. In combination, a vertical tower antenna a plurality of half wave-lengths high, a plurality of cage sections each a quarter wave-length long enclosing alternate quarter wave-length portions of said tower including the second portion from the top, each section comprising a pair of spaced horizontal annular conductors and a plurality of substantially parallel linear conductors connected to and extending between said annular conductors, the upper extremities of said sections being conductively connected to said tower, and a line from a transmitter connected to the lowest section.

2. In combination, a vertical hollow self-supporting radiator a plurality of half wave-lengths long and having a circular cross-section, a plurality of hollow sleeve-like members each a quarter wave-length long substantially and having a diameter greater than that of said radiating member, a plurality of metallic bushing members each connecting the upper end of one of said members to said radiator, said bushings being attached to points on said radiator approximately a half wave-length apart, a line from a transmitter extending inside said radiator and separate connections from points on said line a wave-length apart to a plurality of said members.

3. In combination, a vertical self-supporting radiator a plurality of half wave-lengths long and comprising a plurality of sections having different diameters, a plurality of sleeve members, said sections and said sleeves each being approximately a quarter wave-length long, said members being spaced a quarter wave-length apart along said radiator and having diameters uniformly greater than the associated section, metallic bushings included between the uppermost portion of the sleeve member and the associated section, a high impedance coaxial line comprising the inner surface of said radiator and a conductor supported within said radiator, said conductor being connected to alternate sleeves, a transmitter, a low impedance line connecting said transmitter to the high impedance line, and an auxiliary coaxial line comprising a portion of said radiator and an extension of said conductor connected in shunt to said coaxial lines for matching said lines.

4. In an antenna system, a hollow vertical metallic element comprising a plurality of cylindrical one-quarter wave-length sections, having

different diameters, the diameters being stepped and the lowest section having the largest diameter, a separate one-quarter wave-length sleeve surrounding each of one set of alternate sections and conductively connected at its upper extremity to its respective section, a first line conductor extending coaxially within said element and being connected to at least two of said sleeves, and a second conductor connecting said first conductor to a translation device.

5. An antenna system in accordance with claim 4, said second conductor extending through the wall of the lowest section and being connected to the first conductor at a point a quarter wave-length approximately above the bottom extremity of said lowest section.

6. An antenna system in accordance with claim 4, the section adjacent the top section being included in the said set of alternate sections, said first conductor being connected to a point in the top section and to a point on the sleeve associated with the section adjacent the top section,

said points being electrically separated a quarter wave-length, whereby the upper extremity of said conductor is rigidly supported by said top section through a high impedance.

7. A rugged vertical coaxial antenna system comprising a hollow linear member a half wave-length long, a quarter wave-length cylindrical sleeve surrounding the bottom half of said member and attached at its upper extremity to the mid-point of said member, a line conductor extending coaxially within said member, said conductor being attached to an intermediate point in said sleeve and to an intermediate point in the upper half of said member, the conductive path connecting said points being a quarter wave-length long whereby the impedances of said conductor and antenna are matched, and the connection between the upper portion of said member and said conductor includes a high impedance.

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