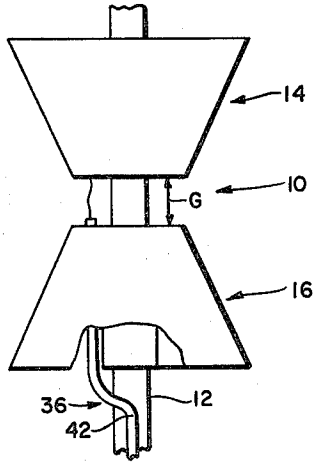
Dec. 1, 1964 F. B. FACCHINE 3,159,838

VERTICALLY STACKED HOLLOW DIPOLES CONDUCTIVELY SUPPORTED ON A MAST

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FIG. 1.



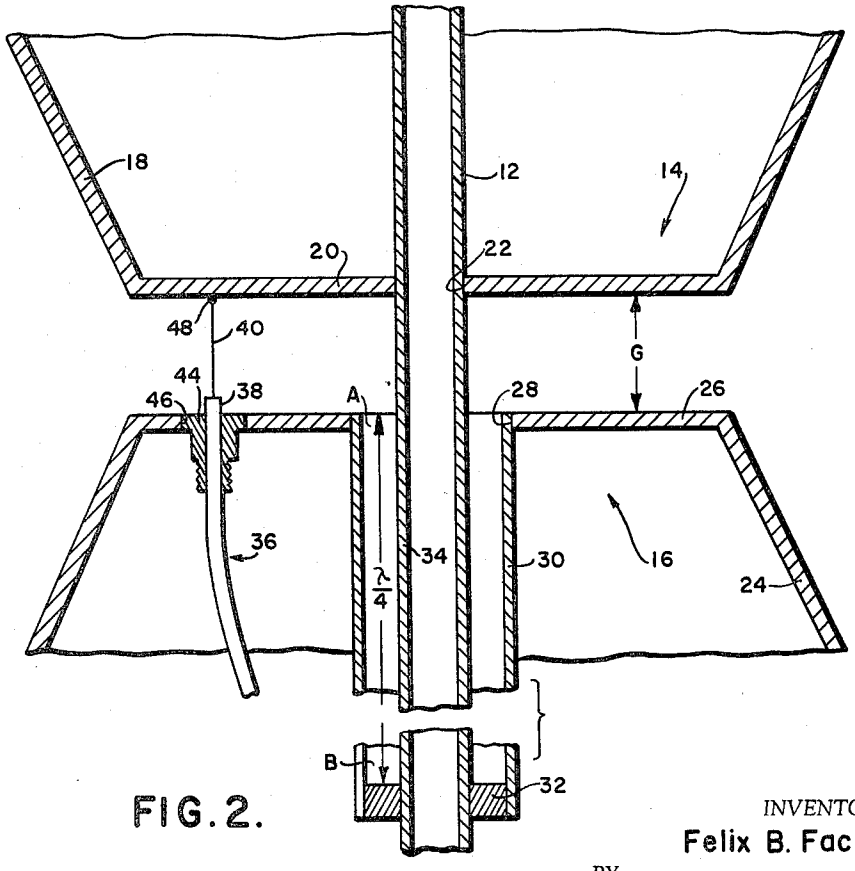


FIG. 2.

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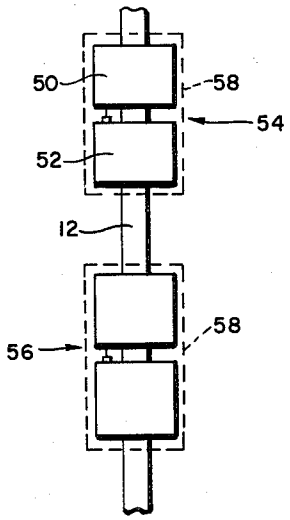
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FIG. 3.



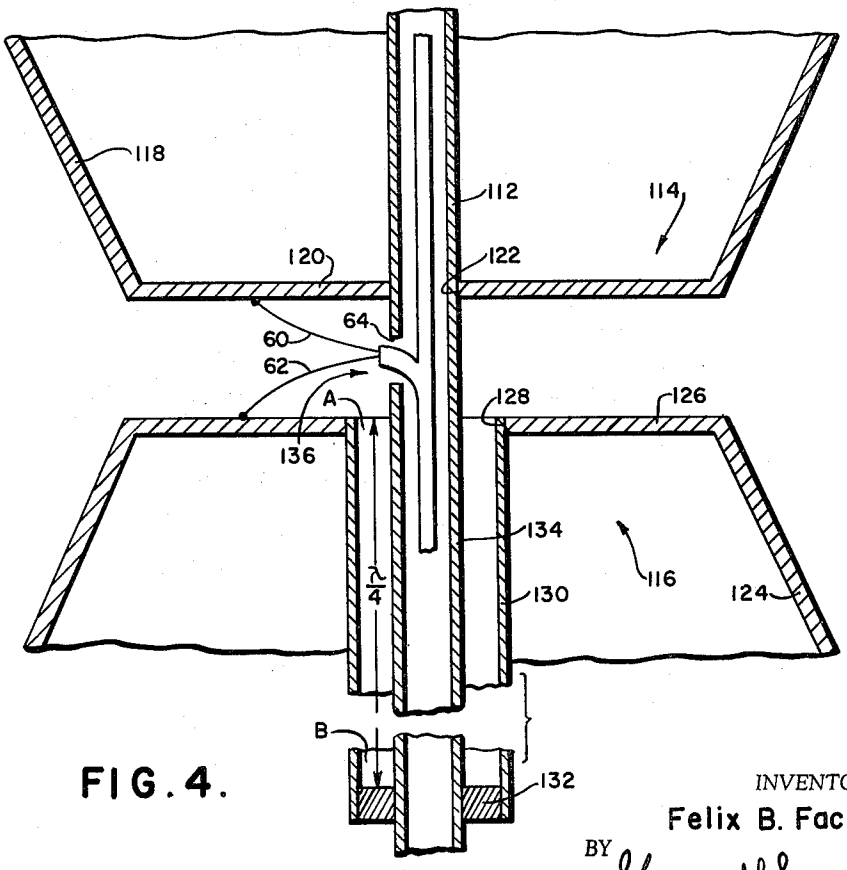


FIG. 4.

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United States Patent Office 3,159,838 Patented Dec. 1, 1964

3,159,838

VERTICALLY STACKED HOLLOW DIPOLES CONDUCTIVELY SUPPORTED ON A MAST

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Filed Jan. 19, 1962, Ser. No. 167,256
3 Claims. (Cl. 343—792)

The present invention relates generally to the microwave art, and more particularly to an antenna and antenna arrays, especially those suited for vertical stacking.

A particularly good ultra short wave antenna system which is efficient in radiation over a wide range of frequencies is the doublet antenna type, more specifically the bi-conical type of antenna taught by Schelkunoff, such as is disclosed in U.S. Patent No. 2,235,506. While the operating characteristics of such a system are favorable, there are, nevertheless, certain difficulties which are encountered, and therefore limitations, on previously known antennas of this type. For example, with the type of system disclosed in the aforementioned patent, it is extremely difficult to stack dipole arrays on a single mast, since in all of these systems the mast itself ends in a dipole element.

The only manner in which stacking could be accomplished with this type of antenna would be to provide a complicated mast structure in which the feed cable is led externally from one array to the other. However, the feed cable would dangle exteriorly adjacent each dipole antenna to feed the one next above. This causes problems in that there is cable blocking of the radiated waves. Further difficulties are encountered due to the external and freely swinging disposition of the feed cable. Also, the wind causes disastrous effects on such freely swinging cables which are open to the elements.

In an attempt to alleviate this problem, U.S. Patent No. 2,508,084 discloses an antenna system wherein a plurality of arrays could be stacked upon a vertical mast. However, the arrangement shown in that patent also presents certain drawbacks due to the fact that the dipole elements or discs must be a full wavelength in circumference and are therefore rather bulky, as well as being rather short and squat. Because of this construction, it is extremely difficult if not impossible to provide such structure with radomes; in addition, this structure presents a substantial wind load, and is very poor in operation under icy conditions. Furthermore, there is an external connection of the cable to the dipole elements which exposes the former to the elements and therefore creates further problems.

With these defects of the prior art in mind, it is a main object of the present invention to provide a dipole antenna which is so constructed that a plurality of them can be vertically stacked upon a simple mast.

Another object of this invention is to provide an antenna which is small in size in order to cut down the wind load which it presents.

Another object of this invention is to provide an antenna which may be very easily fitted with a protective radome.

Still a further object of this invention is to provide an antenna having an interior cable feed so as to eliminate cable blocking.

Yet a further object of the invention is to provide an antenna wherein a vertical mast is used as part of a distributed element circuit which improves element performance.

These objects and others ancillary thereto are accomplished according to preferred embodiments of the invention, wherein a vertical mast has a pair of dipole elements supported thereon and extending in opposite directions. Such dipole elements, for example, may be hollow truncated cones having facing end plates. The uppermost of these cones will have its end plate directly connected to the mast such as by welding or the like. The end plate of lower of the cones will not be directly connected to the mast, but will have a central opening provided therein through which the mast may extend. A sleeve, which is larger in cross sectional dimensions than the mast, will be connected to the end plate at this opening and will be of a length which is one quarter of the wavelength at which the antenna is to operate. At the end of this sleeve, a collar will provide a connection between the mast and the sleeve proper, so that a transmission line is provided from one end of the sleeve to the other, with the sleeve acting as the outer conductor of this transmission line and the underlying portion of the mast acting as the inner conductor thereof. A feed cable is provided and connected to the end plates of the cones with the outer conductor being connected to the lower dipole and the inner conductor being conencted to the upper dipole.

The feed cable extends upwardly through the mast and a small slot is provided therein through which the feed cable may pass so as to be connected to the cones. This slot will preferably be provided in the mast at a position which underlies the cone for protection purposes. When stacking is desired the feed cable may extend further upwardly through the mast.

It should be noted that other configurations of the dipole elements may be provided, such as cylindrical ones. Also, radomes may easily be provided for protection purposes.

Additional objects and advantages of the present invention will become apparent upon consideration of the following description when taken in conjunction with the accompanying drawings in which:

FIGURE 1 is a side elevational view of a bi-conical type of antenna which is constructed in accordance with the present invention with parts being broken away for purposes of clarity.

FIGURE 2 is a vertical sectional view taken through the feed section of the bi-conical antenna.

FIGURE 3 is an elevational view illustrating a stacked array of antennas, using cylindrical dipole elements.

FIGURE 4 is a vertical sectional view of the feed section for another embodiment wherein a balanced arrangement is used.

With more particular reference to the drawings, FIGURE 1 illustrates a bi-conical dipole 10 which is mounted upon a mast 12 with the upper and lower cones 14 and 16, respectively, being truncated and flaring in opposite directions. Also, there is a gap G between the ends of the cones.

As may be seen more clearly in FIGURE 2, the mast 12 is hollow and extends through the cones. The upper cone 14 comprises an outer conical radiation surface 18 and an end plate or transmission disc 20 which is provided with an opening 22 in the center thereof and through which the mast 12 extends. In this manner the upper cone 14 may be connected to the mast 12 such as by welding or the like. It will be apparent at this point that such a construction provides a rather rigid assembly since the upper cone 14 is directly connected to the mast 12 at its end plate 20.

The lower cone 16 is of more complex construction. The lower cone 16 is constructed having a conical outer radiating surface 24, and an end plate or transmission disc 26 connected in the feed point vicinity and slightly spaced from and facing plate 20 of the cone 14. This lower cone 16 is flared downwardly, whereas the upper cone is flared upwardly.

The disc 26 is provided with a central opening 28 of larger diameter than mast 12 so as to provide a clearance between the two. Thus, the mast 12 extends upwardly through the lower cone 16 and through its opening 28

without actually coming into contact with this cone. A sleeve 30 of larger diameter than mast 12 is disposed about the mast and of sufficiently larger diameter than the latter so that it does not touch the mast at all. This sleeve 30 is connected at its upper end with the portion of disc 26 in the vicinity of opening 28, this connection being accomplished in any suitable manner, such as welding or the like. At the lower end of disc 30, a collar 32 is provided which is disposed between the lower end of sleeve 30 and the mast 12, and which both structurally and electrically connects sleeve 30, and thus cone 16, with mast 12.

The connection, of course, must be sufficiently strong to provide a rigid mechanical connection capable of suitably supporting the lower cone 16. The length of sleeve 30 will be $\lambda/4$, where λ is equal to the wavelength at which the device is to operate, or the middle of the band of wavelengths in which the device is to operate. This length is clearly indicated as being equal to $\lambda/4$ in FIGURE 2 and is the distance between reference lines A and B. The portion of mast 12 which is disposed in this area is indicated at 34, and, together with the sleeve 30, defines a shorted length of coaxial transmission line in the center of the structure, with sleeve 30 being the outer conductor and mast portion 34 being the inner conductor. Collar 32 shorts the end thereof.

In order to feed the antenna, a feed cable 36 is provided and extends upwardly through mast 12 from below. A slot 42 is provided in mast 12 so that the feed cable 36 may exit from the interior of mast 12, or at least a parallel branch thereof may be taken off from the portion of the feed cable within mast 12. The latter will be the case when a stacked array is used whereby the cable 36 will extend upwardly to feed other ones of the antennas, with each antenna being fed directly by a parallel length of cable attached to the main feed cable. Preferably, the access opening 42 is disposed within the confines of lower cone 16 so that the cable is protected from the elements.

Cable 36 is held within a plug 44 disposed in an opening 46 in the end plate 26 of the lower cone 16. The outer conductor 38 of feed cable 36 is electrically connected with the plug 44 and thus with the plate 26. The inner conductor 40 of feed cable 36 extends upwardly and is connected at point 48, disposed directly above plug 44, to the end plate 20 of upper cone 14. Thus, the feed cable may feed energy either from a transmitter to the antenna, if the assembly is used as a transmitting device, or may feed energy received by the antenna down through cable 36 to receiving equipment, should a receiving arrangement be used. The distance of point 48 from the center of plate 20 will be preferably, but not necessarily, one-half to two-thirds of the radius from the axis of mast 12. Preferably, the feed point is not disposed at the edge of the disc 20, since in this event there is a possibility that some interference with proper radiation will be created.

Now, considering the arrangement of FIGURE 2, it may be noted that the horizontally disposed gap G between plates 20 and 26 provides for vertical polarization of waves which are radiated from the conical radiators 18 and 24. The feed point 48 of the feed cable 36 is short-circuited to the lower cone with respect to direct current, so that any direct current in the device is short-circuited and carried to ground via the mast 12. However, with respect to high frequency energy, there will be an infinite impedance or at least an extremely high impedance at the center of the gap which, when considered in parallel with the feed point, at the one-half or two-thirds radius point can be electrically neglected. That is, the transmission line formed by sleeve 30 and mast portion 34 which is a quarter wavelength long provides an infinite impedance, so that with respect to high frequency energy the path from point 48 along plate 20 down mast 12 through the coaxial line provided by sleeve 30 and mast portion 34, is an extremely high impedance and can therefore be neglected.

As illustrated in FIGURE 3, the upper and lower dipole elements may be cylinders 50 and 52, which in all features of construction will be identical to the structure illustrated in FIGURE 2, except that the conical radiating surfaces 18 and 24 will, in this case, be cylindrical. As shown, an upper antenna 54 is mounted on mast 12 and a lower antenna 56 is mounted thereon so that a stacked arrangement of the antennas is provided and a simple mast 12 may be used in the construction thereof. Furthermore, radomes 58 are provided about the structure for reinforcing purposes as well as for protecting the array from the elements.

The embodiment of FIGURE 4 illustrates the manner in which the present invention may be utilized to construct a bi-conical or cylindrical dipole using balanced rather than unbalanced feeding. In this embodiment, parts which are similar to those of FIGURE 2 are given the corresponding reference numerals with one hundred added. The feed cable 136 is a parallel conductor cable having two inner parallel conductors 60 and 62 which are connected to the end plates 120 and 126, respectively, of the radiators. The cable feeding line 136 is extended through the interior of mast 112 and is brought out of the mast 112 through a slot 64 which is formed in the mast in the vicinity of the feed gap, so that a portion of the feed line 136 may pass therethrough. If this is not to be the uppermost of the stacked antennas then the feed line 136 will continue upwardly through the interior of the mast 112 to feed the upper arrays.

Although other types of dipole elements may be used in connection with the present invention, cone antennas are preferable since they are broadband antennas which provide ease in construction and also provide desirable impedance characteristics. These antennas will behave like a transmission line of constant characteristic impedance and a change in the flare angle of the cones provides a change in impedance which may be such that it matches the feed line. Particularly favorable broadband characteristics are provided when bi-conical radiators are used having an angle between the cone axis and the cone surface which is between 30° and 60°. The angle will usually be chosen so that the characteristic impedance which is dependent upon this angle matches the characteristics of the feed line as close as possible.

The total circumference of the discs or plates 20, 120, and 26, 126, may have a value which may be as small as one-third wavelength in circumference so that the device may be extremely small.

In a typical construction where bi-conical radiators are used, and which is adapted for use in the range of 200 to 400 megacycles, the height of each cone would be 10" and the height of the gap between the end plates thereof would be 2". Moreover, in this typical construction the angle would be between 30 and 35 degrees using a 50 ohm feed cable, for example.

It will be understood that the above description of the present invention is susceptible to various modifications, changes, and adaptations, and the same are intended to be comprehended within the meaning and range of equivalents of the appended claims.

What is claimed is:

1. A microwave antenna for use over a predetermined band of frequencies comprising at least one plurality of first and second dipole paired elements, each of said elements of each dipole pair being a hollowed structure substantially defined by a selected surface of revolution, each hollowed structure having a uniform truncation in the vicinity of one end of the axis of revolution thereof with a substantially flat end plate section of selected surface area mechanically connected to said structure at said truncation thereof and adapted to cover said truncation thereof, each of said end plate sections having a central aperture therein of selected dimension and configuration; an antenna mast structure; said elements of each of said dipole pairs being disposed on said mast structure in axial alignment therewith and with respective end plate sec-

tions in parallel coadjacent relation with a predetermined spacing therebetween; first and second means electrically and mechanically connecting said end plate sections of said first and second dipole paired elements, respectively, to said mast structure, at least one of said first and second means being a metallic tubular section surrounding said mast structure such that said tubular section is coaxial with both said mast structure and its respective dipole element, said tubular section having a predetermined length substantially $n\lambda/4$ at the center frequency of said predetermnied band of frequencies where λ is the wavelength and n is an odd integer, said tubular section being electrically and mecahnically connected to said mast structure at one end and to its respective end plate section at the other end thereof; wave energy input means for energizing said first and second dipole elements at a location on their respective end plate section surfaces intermediate said central aperture and the outer edge of said end plate section surface, said location being in the vicinity of the outer edge thereof such that the antenna

wave energy radiation pattern is substantially free of feed discontinuity interference.

2. A microwave antenna as defined in claim 1 wherein said hollowed structure is a conical structure and said uniform truncation is in the vicinity of the smaller end thereof.

3. A microwave antenna as defined in claim 1 wherein said hollowed structure is a cylindrical structure.

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