May 22, 1962 E. HUDOCK 3,036,302

SHEET TYPE BALANCED DOUBLET ANTENNA STRUCTURE

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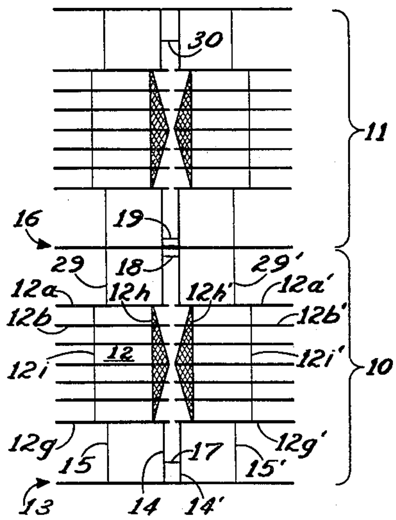

FIG 1

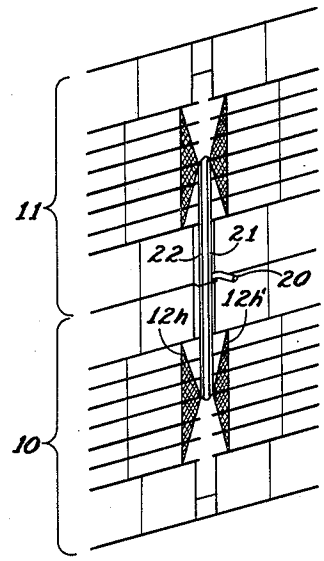

FIG 2

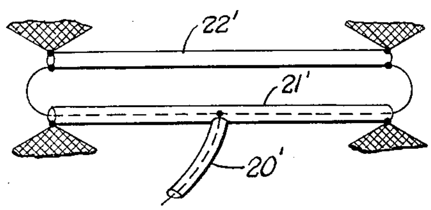

FIG.2a

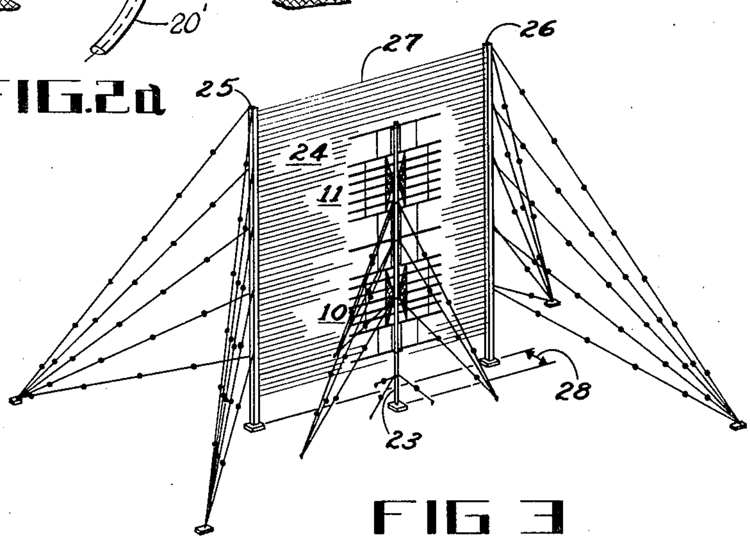

FIG 3

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SHEET TYPE BALANCED DOUBLET ANTENNA STRUCTURE

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This invention pertains to antennas and particularly to antennas that are operable over wide ranges of frequencies.

An object of this invention is to provide an improved antenna which has high gain and which has input impedance that is relatively constant over a wide range of frequencies so that the voltage standing-wave ratio on its transmission line at any frequency within this wide range does not exceed 2:1.

The following description and the appended claims may be more readily understood with reference to the accompanying drawings, in which:

FIGURE 1 is a layout drawing of the broadside of an array of two antennas according to this invention;

FIGURE 2 is an oblique side view of the array to show its connection to a transmission line through one type of balanced-to-unbalanced transformer;

FIGURE 2*a* is a blown-up view of a portion of the transmission line connections of FIG. 2; and

FIGURE 3 is an oblique broadside view of the array of antennas installed in front of a screen reflector.

An antenna of the instant invention simulates a conductive current sheet having a rectangular central fed portion and a pair of unfed portions spaced parallel to the side edges of the central portion. The central fed portion comprises a pair of coplanar sheets having inner ends spaced apart to form a relatively narrow transverse linear slot. This slot is extended by two pairs of parallel members that join the side edges of the central portion to the adjacent unfed portions. Adjustable shorting bars connected between each pair of parallel members determine the length of the slot so that when a transmission line is connected across the slot, the antenna combines the impedance characteristic of a folded wide dipole with that of a slot antenna. When the length of the slot is adjusted for resonance at approximately the mean frequency of the fed central elements, the input impedance of the antenna is sufficiently constant to prevent voltage standing-wave ratios in the connected transmission line from exceeding 2:1 over a frequency range of 3:1. Apparently the central narrow opening of the antenna operates as a slot for nullifying change in reactive impedance. It is well known that for the same direction of departure of frequency of signal from a center frequency, a change in reactive impedance for a dipole is opposite in sign to the change in reactance for a slot antenna.

The antenna array of FIGURE 1 comprises wideband dipole antennas **10** and **11** which, for horizontal polarization, are mounted on a vertical mast with antenna **11** being mounted directly above antenna **10**. Antenna **10** includes dipole **12** which comprises a plurality of parallel-spaced conductive elements **12*a*–12*g*** for one-half of the dipole and similar spaced opposite elements **12*a*′–12*g*′** for the other one-half of the dipole. At the frequencies at which the antenna is to be operated, the individual elements of the dipole have sufficiently small spacing so that each half of the dipole functions as a solid conductive sheet. The inner ends of the elements for each half of the dipole are connected together by a triangular shaped conductive mesh **12*h*** and **12*h*′** respectively. It is found through experimentation that the connection of a transmission line to the elements of the dipole by a triangular mesh that has its apex on the inner end of the central element, the apex being an angle of approximately 150°, aids in maintaining the relatively constant input impedance over a wide range of frequencies.

Although each half of the dipole usually operates as a single conductive sheet, at certain frequencies within the wide frequency range over which the antenna is to be operated, certain elements of the antenna tend to function independently of other elements and thereby to develop at points removed from the centers of the pairs of dipole elements undesirable voltages across corresponding points of adjacent conductive elements. In order to eliminate these differences in voltage, vertical short-circuiting conductors **12*i*** and **12*i*′** have been connected across the dipole elements at about two-thirds the distance from the center axis of the antenna. The exact positioning of the short-circuiting elements is not critical and so they are placed across the elements at points which provide the greatest rigidity for the elements of the dipole.

Parallel unfed adjustable elements **13** and **16** are positioned in the plane of the dipole directly below the dipole elements **12*g*** and **12*g*′** and above elements **12*a*–12*a*′** respectively. Each of the inner ends of elements **12*g*** and **12*g*′** are connected to unfed element **13** by one of the vertical parallel connecting elements **14** and **14′** that are normal to the elements, and likewise elements **12*a*** and **12*a*′** are connected to element **16**. Although an exact impedance match between the antenna and a connecting transmission line may be provided by adjusting the spacing between the ends of elements **13** and **16** and their respective adjacent relative dipole elements, the adjustment is made more conveniently by the adjustable short-circuiting transverse elements **15** and **15′** and elements **29** and **29′** that are connected between the unfed elements and their respective dipole elements. The short-circuiting elements are each slidably mounted to the elements across which they are connected so that they can be moved inwardly or outwardly for changing the impedance provided by the antenna at the transmission line terminals. The antenna section **11** that is mounted above antenna **10** is similar in construction to that of antenna **10**. The unfed adjustable element **16** that is equally spaced from both antennas **10** and **11** functions as an unfed element for both antennas.

The unfed elements are provided for increasing the impedance at the antenna terminals over that derived from the central fed portion alone. As the fed portion of the instant antenna is increased in width for providing operation over a wider band, the impedance at the antenna terminals is reduced below a desired value. The addition of the unfed elements and proper placement of short-circuiting elements provide impedance of the desired value, for example, 50 ohms for an array of two antennas connected in parallel.

A portion of the radiating slot for each antenna is formed by the space between the inner ends of the elements of the dipoles and the length of this space is extended at each end to the required length by the spaces between the vertical connecting elements that connect the dipole to the adjacent unfed adjustable elements. The exact length of a slot is determined by the positioning of horizontal short-circuiting bars, for example, bars **17** and **18** that are connected across respective pairs of the vertical connecting elements. The length of a slot is adjusted until the slot is resonant at approximately the mean resonant frequency of the respective dipole. The lower horizontal short-circuiting bar **19** of the upper antenna **11** and the upper short-circuiting bar of the lower antenna **10** that are positioned near the center of the array may, under certain conditions of operation, be combined into a single central short-circuiting element.

Radio equipment is connected to the antenna array through the unbalanced coaxial line 20 of FIGS. 2 and 2*a*. In FIG. 2*a*, which shows a blown-up view of a portion of FIG 2, line 20' is coupled to the antenna array through an unbalanced-to-balanced transformer which, for example, may comprise coaxial line section 21' and conductor 22' of equal outside diameters. The inner conductor of incoming line 20' is connected to the center of the inner conductor of coaxial line section 21'. In this type of transformer, the ends of the outer conductor of section 21' and the ends of conductor 22' are connected to the apexes of the triangular mesh conductors such that the antennas are fed in phase.

The azimuth field pattern of each antenna of FIGURES 1 and 2 is like that of a simple dipole but the gain in a vertical plane is much higher than that of a simple dipole because a large aperture is provided by the transverse dimension. One lobe of the FIGURE 8 azimuth field pattern is eliminated and the other lobe is reinforced by positioning the antenna array which is mounted on vertical mast 23 in front of a screen reflector 24 as shown in FIGURE 3. The reflector 24 that comprises closely spaced parallel conductors 27 mounted between vertical masts 25 and 26 functions in the usual manner. The plane of the reflector is parallel to the plane of the array, and the distance 28 between the planes is approximately 0.2 wavelength at the center frequency of the operating range of the antenna.

The dipole elements (12*a*, 12*a'*) of a typical antenna system of FIGURE 3 have an over-all length of 37 feet to provide required input impedance for a 50-ohm line over a frequency range of 9 megacycles to 27 megacycles. The vertical adjustable elements (15, 15') are approximately 10 feet from the vertical central mast. The horizontal short-circuiting bars 18 and 19 that are connected to the vertical connecting elements that extend between the dipoles are combined into a single bar that is positioned mid-way between the dipoles. The horizontal short-circuiting bar 30 is positioned 5 feet down from the upper unfed element, and the short-circuiting bar 17 is positioned 3 feet up from the lower unfed element. The vertical adjustable elements are adjusted to provide approximately 100 ohms impedance across the center terminals of each antenna. The balanced-to-unbalanced transformer connects the antennas in parallel for proper matching to a 50-ohm line. In comparison with an isotropic radiator, the array of two antennas, including the effect of ground, provides gain that varies between 14.2 decibels at 9 megacycles to 17.8 decibels at 27 megacycles.

Although this invention has been described with reference to a particular antenna for horizontal polarization, it can be rotated 90° for vertical polarization. The antenna of this invention which utilizes wide dipoles and transverse central slots may be modified in ways obvious to those skilled in the art and still be within the spirit and scope of the following claims.

What is claimed is:

1. An antenna with low standing-wave ratio over a wide range of frequencies comprising a wide dipole having a pair of coplanar sheets of conductive elements with the individual conductive elements of a first of said pair of sheets aligned end-to-end with the individual conductive elements of the second of said pair of sheets and spaced apart to form a central linear slot transverse said wide dipole, the width of said slot being small compared with the wavelength of any signal for which the antenna is being used, a second conductive element spaced on each side of said wide dipole in the plane thereof, said dipole and said second elements being spaced far enough apart to provide substantial phase difference therebetween at the wavelength of any operating signal, a pair of third conductive parallel elements for each side of said wide dipole, each of said third conductive elements on each side of the wide dipole being connected between an inner end of a respective one of said wide dipoles and the adjacent one of said second elements, said pairs of third conductive elements being in the direction required for extending linearly the length of said slot, and a transmission line connected to said first conductive elements across said slot.

2. An antenna as claimed in claim 1 having an adjustable connecting element normal to said dipole connected between each of said second conductive elements and the adjacent one of said first conductive elements of said dipole.

3. An antenna as claimed in claim 1 having a short-circuiting bar connected across each pair of said third conductive elements, said bars being positioned as required for adjusting the length of said slot.

4. A wideband antenna comprising a pair of coplanar wide dipole elements with a central linear transverse slot, each of said elements having a plurality of lengthwise coplanar parallel first conductors with small spacings therebetween compared with the wavelengths of the signals for which the antenna is to be used, said dipole elements being mounted linearly end-to-end separated by a distance that is small compared with said wavelengths to form said central transverse slot, a triangular conductive plane for each of said dipole elements for connecting together the inner ends of all conductors of the respective element, each of said planes having an obtuse apex positioned at the central point of the inner end of its respective dipole element, a second conductor spaced opposite each side of said dipole, said second conductors being coplanar and approximately parallel to said wide dipole, each of said second conductors being spaced a sufficient distance from a respective side of said dipole to provide substantial phase difference therebetween, a pair of third conductors connected to each side of said dipole elements, each of said third conductors on each side of said dipole being connected between an inner end of a respective one of said dipoles and the adjacent one of said second conductors, said pair of third conductors being in the direction of said slot for extending the length of said slot linearly and a two-conductor transmission line connected across the apexes of said conductive planes.

5. An antenna as claimed in claim 4 having an adjustable connecting element substantially normal to said dipole connected between each of the outer ones of said first conductors of said dipole element and the adjacent one of said second conductors.

6. An antenna as claimed in claim 4 having a short-circuiting conductor disposed transverse said first conductors of each wide dipole element to short-circuit said first conductors at points removed from said triangular conductive plane.

7. An array having a plurality of antennas according to claim 4, said antennas being coplanar side-by-side, said second conductors that are disposed between said antennas being combined into common conductors.

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