Aug. 30, 1949. R. W. MASTERS 2,480,153

ANTENNA

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Fig. 1.

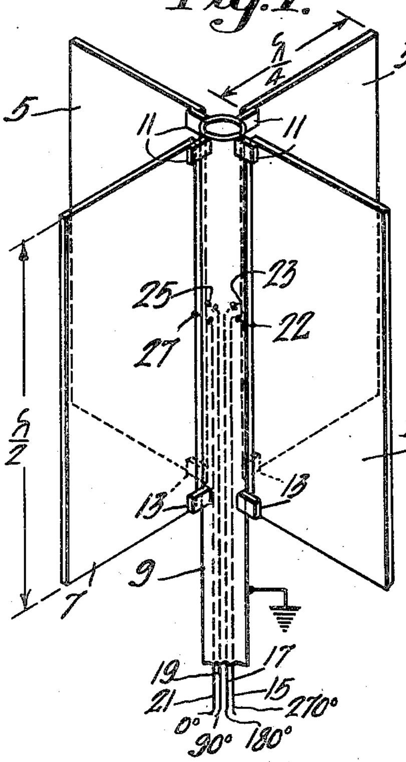



Fig. 2.

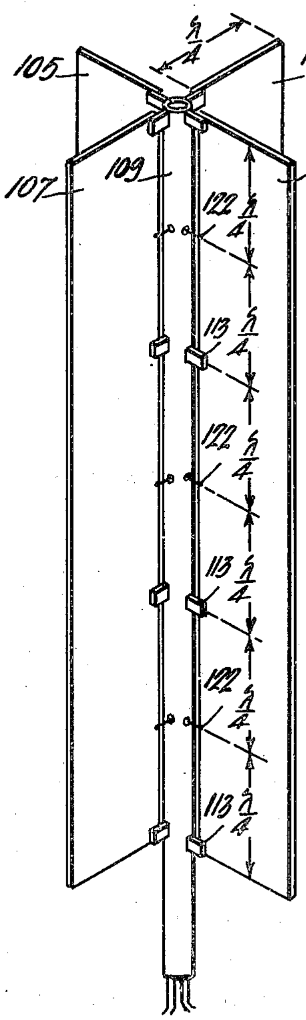
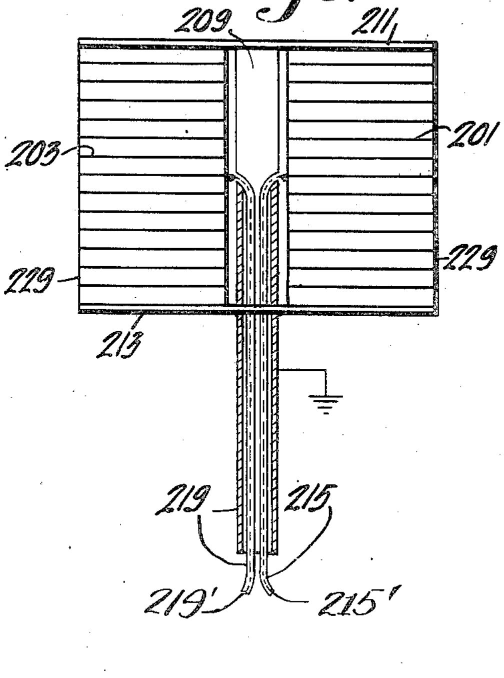



Fig. 3.

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2,480,153

## ANTENNA

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11 Claims. (Cl. 250—33.53)

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This invention relates to radio antennas, and more particularly to broad-band antenna systems having vertical directivity, whereby the principal radiation or response may be substantially confined to a horizontal plane. Such antennas are particularly useful in the transmission and reception of television signals, in blind-landing systems and other high frequency radio beacon systems for aircraft, and the like.

The principal object of the instant invention is to provide an improved type of antenna in which the radiator elements consist of flat sheets having dimensions of the order of the operating wavelength, grounded at certain points and fed at other points to produce such distribution of current therein as to provide the desired directive field patterns.

Another object is to provide antennas of the described type which are simple and rugged in structure while providing efficient operation throughout a relatively broad band of frequencies.

A further object is to provide antennas of the described type which have substantially uniform field patterns in the horizontal plane and may be designed readily to have substantially any desired vertical directivity.

Still another object of the present invention is to provide antennas of the described type suitable for radiation and reception of horizontally polarized radio waves.

These and other objects will become apparent to those skilled in the art upon consideration of the following description, with reference to the accompanying drawing, of which:

Figure 1 is a perspective view of one layer of a turnstile type antenna embodying the instant invention,

Figure 2 is a perspective view of a multilayer antenna of the type illustrated in Figure 1, wherein the radiators of the various layers are merged to form continuous sheets, and

Figure 3 is an elevation of a dipole type antenna embodying the invention.

Referring first to Figure 1, four flat plates or sheets 1, 3, 5 and 7 are disposed radially at 90° intervals around a tubular conductive mast 9. One edge of each sheet lies parallel and closely adjacent to the mast 1. This edge is in each case connected at its top and bottom to the mast 9, at the points 11 and 13. Each sheet is approximately one-half wavelength long, at the mean frequency at which the antenna is to operate, and extends approximately one-quarter wavelength in width radially outward from the mast 9.

Four wires or lines 15, 17, 19 and 21 extend up-

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wardly within the mast 9 as shown, or they may lie outside the mast. The lines 15, 17, 19 and 21 are connected to the sheets 1, 3, 5 and 7 respectively at the midpoints 22, 23, 25 and 27 respectively of their edges nearest the mast. The mast 9 is preferably grounded. The lines 15, 17, 19 and 21 are insulated from the mast itself and may, if desired, be surrounded with individual grounded coaxial sheaths shown in Figure 3 and described in more detail with reference to that figure. In this case, the mast 9 need not be of conductive material, but may be made of wood, for example.

In the operation of the system of Figure 1, the sheets 1 and 5 are energized as the elements of a dipole, i. e. while a current I flows up the line 15, an equal current flows down the line 19, and vice versa. Similarly, the sheets 3 and 7 are energized as the elements of another dipole, through the lines 17 and 21. The currents in the lines 17 and 21 are in quadrature phase with respect to those in the lines 15 and 19, to provide a rotating field which is substantially uniform in a horizontal plane about the antenna, as in the conventional turnstile structure. The lines 15, 17, 19 and 21 may be connected together and to the transmitter or receiver in any known way to provide the required current phase relationships. One suitable connection is shown and described in U. S. Patent 2,086,976, issued July 13, 1937 to G. H. Brown.

The current distribution in the sheet elements of the antenna of Figure 1 is such as to provide a vertical directivity approximating that of a single layer of a turnstile antenna of conventional design, such as that shown in the above-mentioned patent. Although the exact manner in which the current flows is not known at present, it has been found experimentally that the structure of Figure 1 has a relatively broad resonance characteristic, permitting efficient operation over a wide frequency band.

It is believed that the operation is somewhat as follows: Each of the sheets, for example, the sheet 1, cooperates with the opposite sheet and perhaps also the mast 9 to act as a parallel conductor transmission line one-half wavelength long, shorted at its ends 11 and 13 and fed at its center 22. This results in a standing wave, with maximum voltage at the point 22 and zero voltage at the shorted points 11 and 13. Each horizontal element of the sheet 1 constitutes a radiator connected to the line, with current flowing in it in a direction radial to the mast 9. The fields produced by these elements add together to produce a resultant field approximating that which would be provided by a single radiator of conventional form. However, it is probable that the voltage distribution along the parallel line varies with variation of the frequency from the resonant frequency, changing the currents in the elements of the sheet 1, with the result that the overall impedance remains relatively constant.

The vertical directivity may be increased as in the conventional turnstile antenna, by providing a series of layers of elements spaced vertically apart from each other along the mast 9. If the vertical spacing between centers of corresponding elements is made one-half wavelength, the sheets of each panel of radiators will merge to form a single sheet, as shown in Figure 2. In this arrangement, four sheets 101, 103, 105 and 107 are disposed around the mast 109 at 90° intervals, like the sheets of Figure 1. Each sheet is an integral number of half wavelengths long, and is connected to the mast at half wavelength intervals, beginning at the top, at points 113.

Each point 122 midway between two of the points 113 is connected to a feed line, as in the system of Figure 1. The arrangement is such that all of the points 113 in any one sheet are energized in phase with each other. The arrangement of Figure 2 will provide vertical directivity approximating that of a conventional turnstile of equivalent dimensions, retaining the broad resonance characteristics of the single layer system of Figure 1.

Referring to Figure 3, the invention is applied to a dipole type structure, comprising a pair of sheet radiators 201 and 203 supported in a common plane on opposite sides of a mast 209, and connected thereto at their upper and lower ends 211 and 213. Each sheet may comprise a screen or network of horizontal wires, supported between vertical conductors 229. The centers of the members 229 closest the mast 209 are connected to coaxial transmission lines having outer sheaths 215 and 219 and inner conductors 215′ and 219′. The inner conductors 215′ and 219′ are connected to the sheet radiators 201 and 203 while the outer sheaths 215 and 219 are connected at their upper ends to the supporting mast 209.

The operation of the system of Figure 3 is similar to that of one pair of radiators in the system of Figure 1. The directive characteristics are approximately those of conventional dipole, and the resonance characteristics are relatively broad. If desired, vertical layers of dipoles may be employed to provide increased vertical directivity as in the system of Figure 2.

It will be apparent without further illustration that the sheets in the structures of Figures 1 and 2 may be made in the form of screens, as in the structure of Figure 3, and that continuous sheets may be substituted for the screen radiators in the system of Figure 3. Although it has been stated throughout the above description that the sheet elements are fed at their midpoints, they may be energized at any other point along the edge adjacent the mast if a lower input impedance is desired. The maximum impedance appears at the midpoint.

The invention has been described as a broad band antenna structure including radiator elements in the form of flat sheets of conductive material, each disposed with one edge closely adjacent and parallel to a grounded support. The edge is connected to the support at intervals of substantially one-half wavelength, and fed at the point or points approximately midway between the connections to the support. This arrangement provides broad band characteristics, with the advantages of a simple and economical structure.

I claim as my invention:

1. An antenna system including a vertical mast of conductive material, a plurality of sheets of conductive material of generally rectangular shape and approximately one-half wavelength long and one-quarter wavelength wide, disposed in planes radially of said mast, each having one of its longer edges adjacent said mast, connections from the upper and lower ends of each of said edges to said mast, and means for applying radio frequency energy to said sheets at points substantially midway of said edges.

2. An antenna system including at least one radiator element comprising a plane sheet of conductive material approximately one-half wavelength long and one-quarter wavelength wide, a grounded conductive member disposed parallel to and adjacent one of the longer edges of said sheet, and connected to said edge at the ends of said sheet, and transmission line means including an outer conductor connected to said grounded member and an inner conductor connected to said sheet at a point on said edge displaced from said ends.

3. An antenna system including at least one radiator element comprising a plane sheet of conductive material of generally rectangular shape, a conductive supporting member disposed parallel to and adjacent one of the edges of said sheet, and connected to said edge at the ends of said sheet, and transmission line means including an outer conductor connected to said supporting member and an inner conductor connected to said sheet at substantially the midpoint of said edge.

4. An antenna system including a plurality of radiator elements, each comprising a plane sheet of conductive material approximately one-half wavelength long and one-quarter wavelength wide, a conductive supporting member disposed parallel to and adjacent one of the longer edges of said sheet, and connected to said edge at the ends of said sheet, and transmission line means including an outer conductor connected to said supporting member and an inner conductor connected to said sheet at substantially the midpoint of said edge.

5. An antenna system comprising a generally tubular conductive supporting member, at least one flat sheet of conductive material supported by and disposed radially of said supporting member, said sheet including one substantially linear edge disposed adjacent and parallel to said supporting member and connected thereto and grounded for radio frequency potential at the ends of said edge, a transmission line conductor extending within said support and insulated therefrom and connected to said sheet at a point on its said edge displaced from said ends.

6. An antenna system of the turnstile type, including at least one layer of four radiator elements, each of said elements comprising a vertically disposed flat sheet of generally rectangular shape, grounded at the ends of one of its vertical edges and fed at the center of said vertical edge.

7. An antenna system of the turnstile type, including a plurality of layers of four radiator elements, each of said elements comprising a

vertically disposed flat sheet of generally rectangular shape, grounded at the ends of one of its vertical edges and fed at the center of said vertical edge.

8. An antenna system comprising, as a radiating or receiving element a substantially plane sheet of conductive material and of a generally rectangular shape, said sheet having one lengthwise substantially straight edge and being grounded for radio frequency potential at the ends of said edge, a width substantially equal to a quarter wave length at the operating frequency, a length substantially equal to an integral number of half wave lengths at the operating frequency and points of voltage nodes substantially integral half wave lengths apart on said edge, said points including said grounded ends, a support for said sheet, and a transducer connected to said sheet.

9. An antenna system comprising, as a radiating or receiving element a substantially plane sheet of conductive material and of a generally rectangular shape, said sheet having one lengthwise substantially straight edge and being grounded for radio frequency potential at the ends of said edge, a width substantially equal to a quarter wave length at the operating frequency, a length substantially equal to a half wave length at the operating frequency, a support for said sheet, and a transducer connected to said sheet.

10. An antenna system comprising a plurality of radiating or receiving elements, each of said elements including a substantially plane conductive sheet of generally rectangular shape a quarter wavelength wide by an integral number of half wavelengths long at the operating frequency and disposed in a radial plane about a common axis and being substantially co-extensive axially with each of the other of said sheets, each of said sheets having one substantially linear lengthwise edge adjacent to and substantially parallel to said axis and closely spaced from the other said adjacent lengthwise edges, each of said sheets being grounded for radio frequency potential at the ends of said adjacent lenghwise edges, the radio frequency voltages at the operating frequency at those points on the said linear edges of any two sheets which points lie in the same plane normal to said axis being substantially equal in amplitude, a support for said elements, and a transducer connected to said sheets.



11. An antenna system comprising, as radiating or receiving elements, a pair of substantially plane sheets of conductive material each of a generally rectangular shape, each of said sheets having one lengthwise substantially straight edge and being grounded for radio frequency potential at the ends of said edge, a width substantially equal to a quarter wavelength at the operating frequency, a length substantially equal to an integral number of half wavelengths at the operating frequency and points of voltage nodes substantially integral half wavelengths apart on said edge, said points including said grounded ends, said sheets being disposed with said lengthwise edges closely adjacent and parallel to each other and in a common plane, a support for said sheets, and a transducer connected to said sheets.

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