

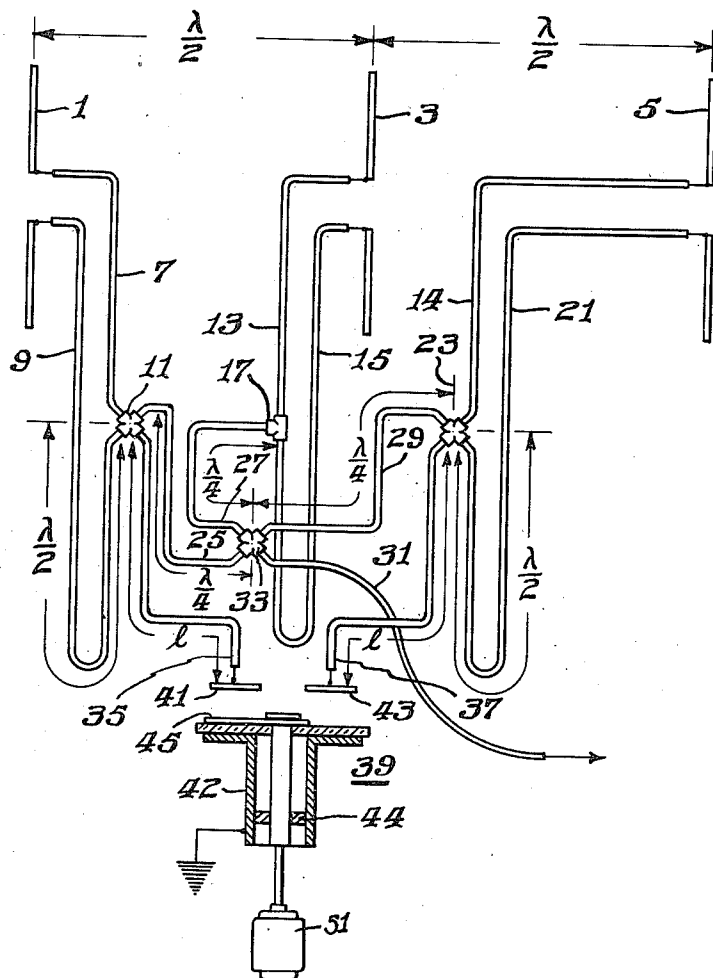
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ANTENNA SYSTEM

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2,415,932

ANTENNA SYSTEM

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1

This invention relates to directive antenna systems, and more particularly to improvements in the art of producing alternately overlapping directive radiation or field pattern lobes. Systems providing overlapping field patterns are employed in radio aircraft locators, object detectors, direction finders, and the like.

It is the principal object of the present invention to provide an improved method of and means for producing alternately overlapping radiation pattern lobes.

Another object is to provide an improved method of and means for controlling the energization of the several elements of an antenna array to provide alternately two discrete directive patterns.

A further object of this invention is to provide an improved antenna system of the above-mentioned type which is relatively simple in design and adjustment as compared with prior art systems, while providing equivalent performance.

These and other objects will become apparent to those skilled in the art upon consideration of the following description of a preferred embodiment of the invention, with reference to the accompanying drawing, which is a schematic diagram of an antenna system designed in accordance with the invention.

The antenna comprises an arrangement of three vertical dipoles, 1, 3 and 5. Each of the side radiators, 1 and 5, is spaced $\frac{1}{2}$ wave length from the central radiator 3. The upper and lower elements of the dipole 1 are connected through transmission lines 7 and 9 respectively to a junction point 11. The line 9 is $\frac{1}{2}$ wave length longer than the line 7 so that a voltage applied at the junction point 11 will reach the upper element $\frac{1}{2}$ cycle sooner than it will reach the lower element thus exciting the two elements 180° out of phase. The dipole 3 is similarly connected through lines 13 and 15 to a junction point 17, and the dipole 5 is connected through lines 19 and 21 to a junction point 23. The junctions 11, 17 and 23 are connected through lines 25, 27 and 29 to a main line 31 at a junction point 33. Each of the lines 25, 27 and 29 is $\frac{1}{4}$ wave length or an odd integral number of $\frac{1}{4}$ wave lengths long.

The points 11 and 23 are connected through lines 35 and 37 respectively to a rotatable capacitor 39. The capacitor 39 comprises a pair of stationary plates 41 and 43, which are connected to the lines 35 and 37 respectively, and a rotatable semi-circular plate 45 supported on a concentric line 42 and connected to the inner conductor thereof. The outer conductor of the

2

line 42 is grounded. An adjustable shorting plug 49 is provided within the line 42. A motor 51 is connected to the line 42 to rotate the line 42 and the plate 45 continuously. The structure of the capacitor 39 is described in more detail in copending application filed on February 27, 1943, Serial Number 477,482, filed by O. M. Woodward, and entitled "Improved capacitor switch."

The operation and adjustment of the above described system is as follows:

The central dipole 3 is energized continuously and the side radiators 1 and 5 are energized out of phase with the center radiator, one leading and the other lagging by the same amount. The phases of the side radiator are alternately interchanged to shift the axis of the directive pattern from one side to the other. The particular power and phase relationships which are required between the center and side radiators of an antenna system, such as that shown in the drawing, to provide the desired directive patterns may be determined experimentally or calculated in advance. For example, currents in the side radiators may be .707 of that in the central radiator and at phase angles of plus and minus 45° with respect to the current in the central radiator. The current in the radiator 5 lags and that in the radiator 1 leads when the axis of the total radiation pattern is directed to the right, looking into the sheet; and the current in the radiator 1 lags and that in the radiator 5 leads when the pattern is directed to the left.

The central radiator is energized continuously through the lines 31 and 27. The side radiators are constantly connected to the main line 37 through the lines 25 and 29 but are shunted with reactive elements to shift the phases of their currents with respect to that in the central radiator. Denoting the characteristic impedance of the transmission lines 7 and 9 as Z_c and assuming that the lines are matched with the respective radiator elements, the impedance presented at the point 11, looking into the lines 7 and 9, is $\frac{1}{2} Z_c$. Since the line 25 is $\frac{1}{4}$ wave length long, the impedance at the point 33, looking into the point 11 through the line 25, is $2 Z_c$. Similarly, the impedance at the point 33, looking toward the point 23 through the line 29, is $2 Z_c$. If an inductive reactance having a magnitude of $\frac{1}{2} Z_c$ is connected to the point 11 and a capacitor reactance having a magnitude of $\frac{1}{2} Z_c$ is connected to the point 23, the reactive components appearing at the point 33 will be equal and opposite, providing a total impedance of $2 Z_c$. The impedance at the point 33, looking into the line

27, is also $2 Z_c$. Thus the total impedance, looking into the point 33 from the main line 31, is Z_c . The current flowing into the line 27 is $\frac{1}{2}$ of the current in the line 31 and is in phase with the current in the line 31. The currents in the lines 25 and 29 lead and lag respectively the current in the line 31 and together are equal to $\frac{1}{2}$ of the current in the line 31. Since the currents of the lines 25 and 29 are each 45° out of phase with that in the line 27, they are each .707 of that in the line 27.

To produce the above phase relationships the lines 35 and 37 are made of such lengths that the maximum capacitance of the capacitor 39 is reflected as an inductive reactance $\frac{1}{2} Z_c$ ohms, and the minimum capacitance is reflected as a capacitive reactance of $\frac{1}{2} Z_c$ ohms. As described by the above-mentioned Woodward application, the maximum capacitance of the capacitor 39 may be adjusted to any desired value within very wide limits by altering the position of the shorting plug 44. The minimum capacitance is determined by the mechanical design of the capacitor. Thus the lengths of the lines 35 and 37 are determined in accordance with the minimum capacitance and the plug 44 is adjusted to provide the required maximum capacitance. As the motor 51 rotates the capacitor, the reactances presented at the points 11 and 23 are periodically interchanged, correspondingly changing the phases of the radiators 1 and 5 to provide alternately overlapping directive lobes.

Although the invention has been described in connection with a particular antenna array with specific phase and power relationships between the various elements, it will be apparent to those skilled in the art that the same principles are applicable to other and more complex lobes switching antenna systems wherein the desired variations in the directional characteristics may be produced by cyclical changes in the phases of the radiator elements.

I claim as my invention:

1. In an antenna system including at least one central radiator and at least two side radiators disposed on opposite sides of said center radiator, a distribution network including a main transmission line, branch lines connected between said main line and said radiators, reactance elements connected to said side radiators, the reactances of said elements being equal in magnitude and opposite in sign, and cyclically variable capacitance means connected to said reactance elements.

2. An antenna system including center radiator means, side radiator means disposed to the left

and to the right respectively of said center radiator means, a main transmission line, branch transmission lines, each an odd number of quarter wave lengths long, connected between said main line and said radiator means, and reactance elements connected to each of said side radiator means, said reactance elements each comprising variable capacitor means and a transmission line section connected thereto, the length of said line section and the maximum and minimum capacitances of said capacitor means being predetermined so as to present to said side radiator means reactances which are equal in magnitude and opposite in sign.

3. An antenna system comprising a center dipole and two side dipoles positioned $\frac{1}{2}$ wave length from said center dipole on opposite sides thereof, three transmission line means, each connected between the respective radiator elements of one of said dipoles, three branch transmission lines each connected respectively to one of said first transmission line means at a point $\frac{1}{4}$ wave length from the mid point thereof, each of said branch lines being $\frac{1}{4}$ wave length long, a main transmission line connected to all of said branch lines, reactance means connected to the two of said branch lines corresponding to said side dipoles, said reactance means comprising transmission lines shunted at their outer ends by variable capacitor means, said variable capacitor means comprising two stator plates, one connected to each of said last mentioned lines, a rotor plate and a short circuited concentric line stub connected to said rotor plate.

4. The invention as set forth in claim 2 including means for cyclically varying the capacitance of said variable capacitor means.

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REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
1,821,367	Usselman	Sept. 1, 1931
2,189,549	Hershberger	Feb. 6, 1940
2,198,025	Davies et al.	Apr. 23, 1940
2,244,756	Alford	June 10, 1941
2,285,851	Byrne	June 9, 1942
2,307,184	Alford	Jan. 5, 1943

FOREIGN PATENTS

Number	Country	Date
516,149	British	Dec. 22, 1939