Feb. 18, 1947. G. H. BROWN 2,415,933

ANTENNA SYSTEM

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Fig. 1.

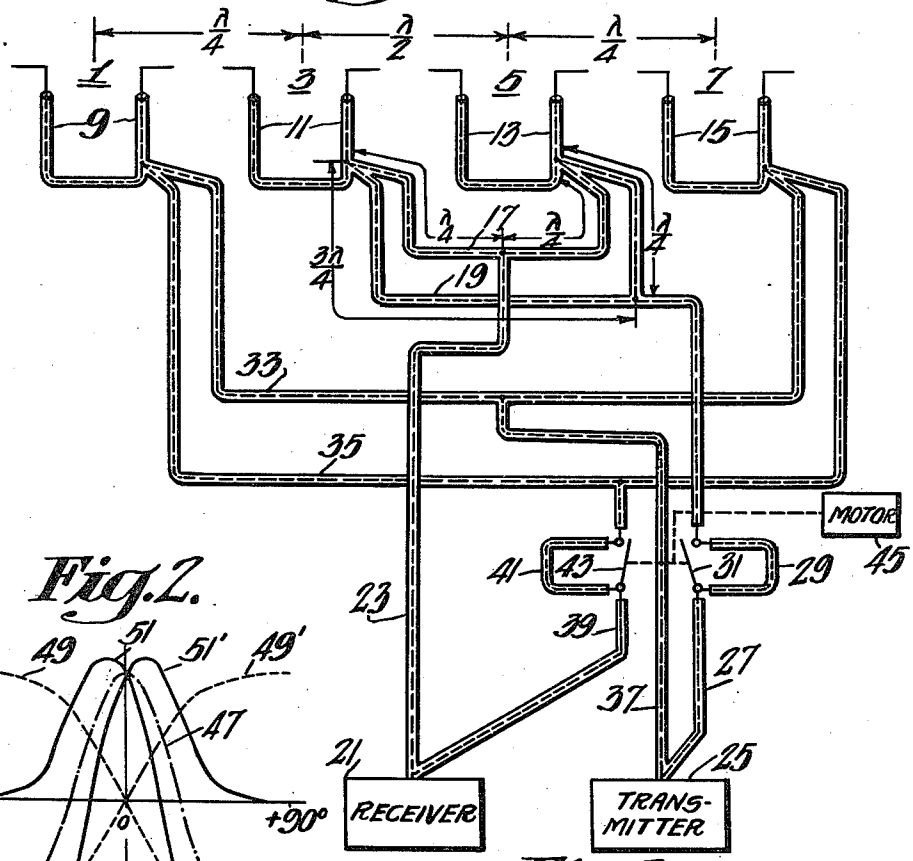


Fig. 2.

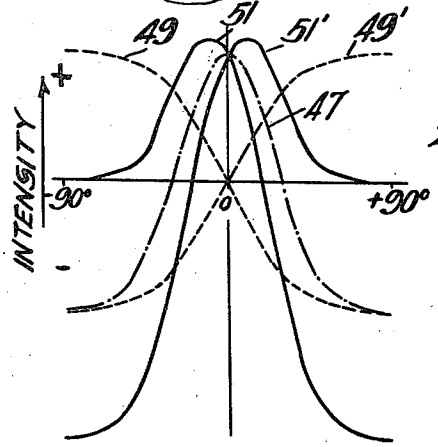
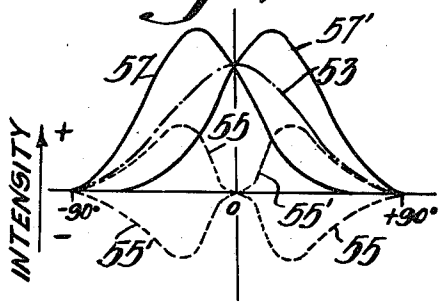


Fig. 3.



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ANTENNA SYSTEM

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4 Claims. (Cl. 250—13)

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This invention relates to directive antenna systems and more particularly to improvements in the art of producing alternately overlapping directive pattern lobes.

Systems providing overlapping field patterns are employed in radio aircraft locators, direction finders, and the like. In such applications it is frequently desirable to use the same antenna both for transmitting and for receiving. If this is done, it is necessary to provide some means for isolating electrically the receiver from the transmitter to prevent unnecessary dissipation of energy and to protect the receiver from the relatively high voltages produced by the transmitter. When the normal operation of the system involves relatively high peak power, switching systems employing make and break contact elements are impractical, owing to the probability of arcing. Also the parasitic inductive effects introduced by such switches are troublesome and must be minimized by careful design or by auxiliary compensation means. With pulse transmission, the period during which the transmitter is connected to the antenna is so short that a mechanical switch is normally incapable of sufficient rapid operation. For these reasons more or less elaborate networks involving gas discharge tubes and resonant line elements are ordinarily employed to isolate the transmitter and receiver from each other. These networks require critical adjustment and may cause damage to the equipment upon failure of a gas tube.

Accordingly, it is the principal object of the present invention to provide an improved method of and means for effecting radio transmission and reception alternately in overlapping, directive pattern lobes.

Another object is to provide an improved method of and means for operating a radio receiver and a radio transmitter with a common lobe switching antenna.

A further object is to provide an improved method of and means for controlling the phase relationships of the various elements of an antenna array to provide alternately two discrete, directive patterns.

A still further object of this invention is to provide an improved antenna system of the above mentioned type which is relatively simple in construction, design and adjustment, as compared with prior systems.

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:

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Fig. 1 is a schematic circuit diagram of an antenna system embodying the present invention, and

Figs. 2 and 3 are radiator pattern diagrams which are used in describing the operation of the transmission line network employed in the system of Fig. 1.

Referring to Fig. 1, a typical antenna array for providing overlapping field patterns comprises four dipoles, 1, 3, 5, and 7. The dipoles 3 and 5 constitute a center group and are spaced ½ wave length from each other. The dipoles 1 and 7 constitute side radiators and are located ¼ wave length to the left and to the right respectively of the dipoles 3 and 5. The two radiator elements of each dipole are connected together through coaxial transmission lines 9, 11, 13 and 15 respectively. Each of said lines is tapped at a point ¼ wave length from its midpoint for connection to the distribution system. Since the tapping point in each case is ½ wave length further from one radiator element than from the other, a voltage applied there will excite the two radiator elements 180° out of phase.

The dipoles 3 and 5 are interconnected through coaxial lines 17 and 19. The line 17 is ½ wave length long and the line 19 is 1 wave length long. A radio receiver 21 is connected directly through a coaxial line 23 to the midpoint of the line 17. A radio transmitter 25 is connected through a coaxial line 27 to a point on the line 19, ½ wave length closer to the dipole 5 than to the dipole 3. The line 27 includes a half wave section 29 shunted by a switch 31. The dipoles 1 and 7 are interconnected by lines 33 and 35. The line 35 is an even number of half wave lengths long and the line 33 is an odd number of half wave lengths long.

The transmitter 25 is connected through a line 37 to the midpoint of the line 33. The receiver 21 is connected through a line 39 to a point on the line 35 which is ½ wave length nearer the dipole 7 than it is to the dipole 1. The line 39 includes a half wave length section 41 shunted by a switch 43. The lines 27 and 39 including the half-way sections 29 and 41 are ¼ wave length longer than the lines 37 and 23 respectively. The switches 31 and 43 are mechanically interconnected and are arranged to be operated together by a motor 45.

The operation of the above described system is as follows:

Energy produced by the transmitter 25 is fed through line 37 to the midpoint of the line 33, energizing the dipoles 1 and 7 in phase with each other. This produces a radiation pattern like

that indicated by the dash line 47 in Fig. 2. At the same time, the dipoles 3 and 5 are energized out of phase with each other through the lines 27 and 19. The currents in the dipoles 3 and 5 are each 90° out of phase with those in the dipoles 1 and 7. When the switch 31 is closed the current in the dipole 3 leads the currents in the dipoles 1 and 7 and that in the dipole 5 lags, providing a radiation pattern like that indicated by the dotted line 49 in Fig. 2. The resultant of the radiation patterns 47 and 49 is indicated in Fig. 2 by the solid line 51. When the switch 31 is open, the half wave section 29 is included in the line 27 and the polarities of both of the two dipoles 3 and 5 are reversed, providing a radiation pattern as indicated by the dotted line 49' in Fig. 2 and a resultant radiation pattern shown by the solid line 51'. Thus by opening and closing the switch 31 energy may be radiated alternately in two overlapping lobes.

In the operation of the system for reception, voltages picked up by the two dipoles 3 and 5 are applied in phase with each other through the lines 17 and 23 to the receiver 21. The directive pattern of the two dipoles is indicated by the dash line 53 of Fig. 3. Voltages picked up by the side dipoles 1 and 7 are applied 180° out of phase with respect to each other to the receiver 21 through the lines 35 and 39. These voltages are each 90° with respect to the voltages derived from center dipoles, due to the quarter wave difference in the lengths of the lines 23 and 39. The resulting directive pattern is indicated by the dotted line 55 in Fig. 3. The resultant of the directive patterns 53 and 55 is indicated by the solid line 57 in Fig. 3.

When the switch 41 is closed, the polarities of the voltages derived from the dipoles 1 and 7 are reversed with respect to the polarities of these voltages when the switch 43 is open, reversing the polarity of the directive pattern 55, as indicated by the dotted line 55'. The resultant directive pattern is shown by the solid line 57'. Thus by opening and closing the switch 43, the directive pattern and reception is alternately shifted from one to the other of two overlapping lobes.

Isolation of the receiver and transmitter from each other is provided as follows:

In the operation of the transmitter, the dipoles 3 and 5 are energized 180° out of phase with each other. The line 17, being ½ wave length long, may be connected between these two points without altering the voltages because a standing wave will be produced having simultaneous maxima of opposite polarities at the opposite ends of the line. The midpoint of the line 17 is at zero potential and hence no energy flows through the line 23 to the receiver 21. Energy fed from the transmitter through the line 37 reaches the dipoles 1 and 7 in phase and a standing wave is produced on the line 35, providing voltages having simultaneous maxima of the same polarity at opposite ends of the line. The point of connection of the line 39 to the line 35 is at a voltage node so no energy is transmitted through the line 39 to the receiver 21.

Signal energy picked up by the antennas 1, 3, 5 and 7 will be divided equally between the receiver 21 and the transmitter 25. However, this energy will not harm the transmitter and, as a matter of fact, the energy reaching the receiver is the same as would be provided with an equivalent antenna array connected only to the receiver. The reason for this is that all of the energy derived from pickup in the desired directive pattern is applied to the receiver.

Although the invention has been described with reference to a specific antenna system, it will be apparent that the principles of the invention may be applied in many ways. For example, each of the dipoles 1, 3, 5 and 7 might be replaced by an array of dipoles or other radiator means. The spacings between the several radiator elements may be changed to meet different directive pattern requirements in accordance with design practice known to the art. The positions of the receiver and the transmitter in the circuit may be interchanged without substantially affecting the operation of the system. Although the switches 41 and 43 have been shown schematically as make and break contact devices, it should be understood that capacitor switches or any other suitable radio frequency switching means may be employed.

I claim as my invention:

1. An antenna system comprising at least two center radiator means and at least two side radiator means, first transmission line an odd number of half wave lengths long connected between said center radiator means, a second transmission line an even number of half wave lengths long connected between said center radiator means, a third transmission line connected to the midpoint of said first transmission line, a fourth transmission line connected to a point ¼ wave length distant from the midpoint of said second transmission line, a first switch means connected to short circuit a section ½ wave length long of said fourth transmission line, a fifth transmission line an odd number of half wave lengths long connected between said side radiator means, a sixth transmission line an even number of half wave lengths long connected between said side radiator means, a seventh transmission line connected between the midpoint of said fifth transmission line and the end of said fourth transmission line, an eighth transmission line connected between a point ¼ wave length distant from the midpoint of said sixth transmission line and the end of said third transmission line, a second switch means connected to short circuit a section ½ wave length long of said eighth transmission line, and a mechanical connection between said first and second switch means whereby said switch means are constrained to operate simultaneously.

2. A radio system including a receiver, a transmitter and an antenna array comprising two center groups of radiator elements and two side groups of radiator elements, a first transmission line connected between said center radiator elements, a second transmission line connected between the midpoint of said first transmission line and said receiver, a third transmission line connected between said center radiators and differing in length from said first transmission line by ½ wave length, a fourth transmission line connected between a point ¼ wave length from the midpoint of said third transmission line and said transmitter, a fifth transmission line connected between said side radiator elements, a sixth transmission line connected between the midpoint of said fifth transmission line and said transmitter, a seventh transmission line differing in length from said fifth transmission line by ½ wave length, and an eighth transmission line connected between a point ¼ wave length from the midpoint of said seventh transmission line and said receiver.

3. A radio system comprising a transmitter, a

receiver and an antenna array including center groups of radiator elements, a first transmission line ½ wave length long connected between said radiator elements, a second transmission line connected between the midpoint of said first transmission line and said receiver, a third transmission line 1 wave length long connected between said radiator elements, and a fourth transmission line connected between a point ¼ wave length distant from the midpoint of said third transmission line and said transmitter.

4. A radio system comprising a transmitter, a receiver and an antenna array including center groups of radiator elements, a first transmission line ½ wave length long connected between said radiator elements, a second transmission line connected between the midpoint of said first transmission line and said transmitter, a third transmission line 1 wave length long connected between said radiator elements, and a fourth transmission line connected between a point ¼ wave length distant from the midpoint of said third transmission line and said receiver.

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