May 8, 1945. H. O. PETERSON 2,375,580

DIRECTIVE ANTENNA

Filed June 25, 1942 2 Sheets-Sheet 1

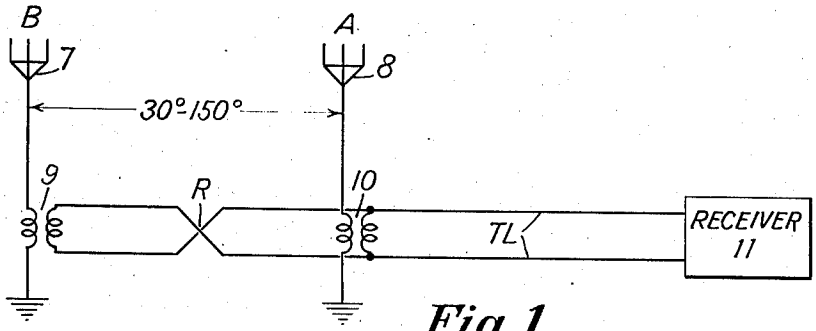

Fig. 1

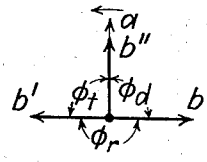

Fig. 2

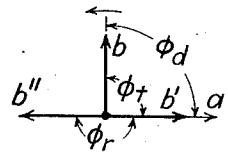

Fig. 3

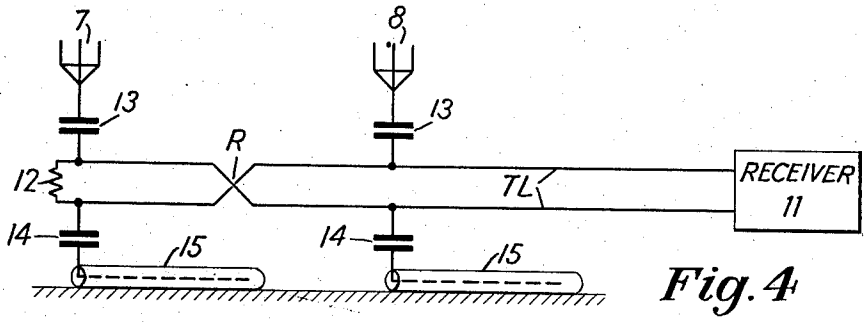

Fig. 4

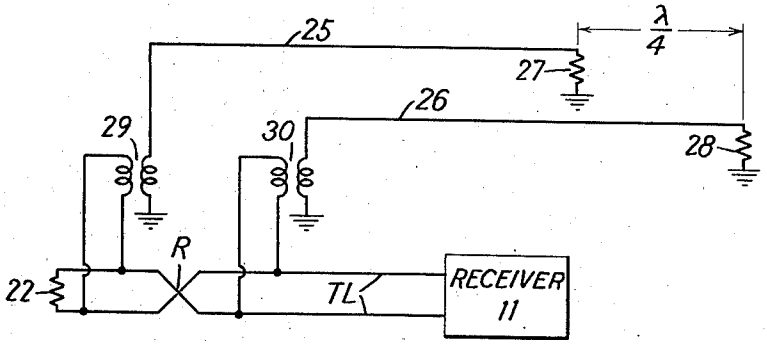

Fig. 5

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DIRECTIVE ANTENNA

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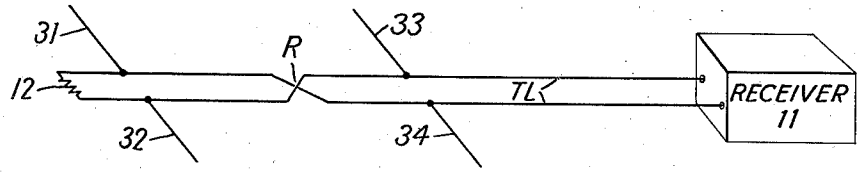

Fig. 6

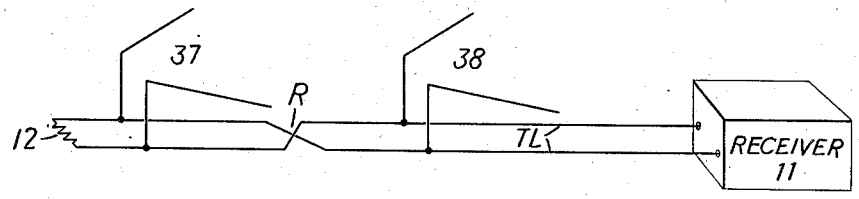

Fig. 7

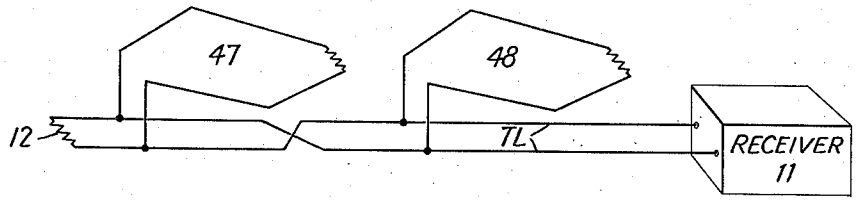

Fig. 8

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UNITED STATES PATENT OFFICE

2,375,580

DIRECTIVE ANTENNA

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Application June 25, 1942, Serial No. 448,341

16 Claims. (Cl. 250—11)

The present invention relates to directive antennas and, more particularly, to broad band directive antenna array systems.

An object of the present invention is the provision of a method of arranging two antennas to produce a unidirectional directivity pattern.

Another object of the present invention is to provide an antenna system giving a unilateral response over a broad band of frequencies.

Still another object is the provision of a unilaterally directive antenna system which is not critical as to frequency and which does not need readjustment when the operating frequency is changed. In systems heretofore used it has been possible to produce a unidirectional pattern but the effect has generally only occurred at one particular frequency for which the system was designed.

The foregoing objects are attained, in accordance with the principles of the present invention, by providing a plurality of antennas displaced along the line of signal travel. The antennas are connected through a transmission line to the receiver with phase reversing structure between the antennas. The spacing between the antennas and the length of transmission line are so related that signals arriving from the desired direction combine in additive relationship while signals from the opposite direction combine in an opposing phase relationship thus giving a directivity pattern which is substantially unidirectional in shape.

The present invention will be more fully understood by reference to the following detailed description, which is accompanied by drawings in which Figure 1 illustrates diagrammatically one form of the present invention, while Figures 2 and 3 are vector diagrams explanatory of the principle of operation of the present invention, while Figures 4 to 8, inclusive, diagrammatically illustrate modifications of the form of the invention shown in Figure 1.

In Figure 1 are shown two antennas 7 and 8 at locations A and B spaced from one another. Each antenna is coupled into a transmission line TL by means of coupling transformers 9 and 10. Receiving equipment, conventionally indicated by box 11, is connected to the end of the transmission line nearest the source of the desired signals. Phase reversing structure R is inserted in the transmission line between the points of coupling of antennas 7 and 8. Antennas 7 and 8 are spaced along the line of travel of the desired signal by a distance ranging from somewhat less than 30 electrical degrees to approximately 150 electrical degrees, 360 electrical degrees being one wavelength. Thus the desired unidirectional effect may readily be obtained over a frequency range of greater than 5 to 1.

The vector diagrams shown in Figures 2 and 3, explaining the principle of operation of the antenna of Figure 1, are for the sake of convenience, drawn for the condition where the distance between antennas 7 and 8 is 90 electrical degrees or one quarter wavelength.

Figure 2 shows the condition for a signal travelling in the direction from A to B. The signal first reaches antenna 8 at location A inducing a voltage represented by a in Figure 2. 90 degrees later the wave front reaches antenna B inducing a voltage b 90 degrees behind that induced in antenna A, as indicated by angle ϕ_d. The voltage indicated by b is further changed 180 degrees in phase, as indicated by the angle ϕ_r due to the reversal in the coupling system and is indicated by vector b'. This voltage suffers a further 90 degree lag in travelling back over the transmission line from location B to location A, as indicated by the angle ϕ_t, making a total phase change of 360 degrees which places the voltages from antennas 7 and 8 in phase at location A. This is represented by the coincidence of vectors a and b''. The voltage represented by the addition of vectors a and b'' consequently is transmitted over transmission line TL to receiver 11.

In Figure 3 is shown the condition for a signal travelling in the direction from location B to location A. The wave front first induces a voltage in antenna 7 indicated by vector b and 90 degrees later, as indicated by angle ϕ_d, a voltage represented by vector a in the antenna 8. The voltage represented by vector b originally induced in antenna 7 at location B loses 90 degrees in travelling along the transmission line TL over the distance from B to A, as indicated by the angle ϕ_t and is identified by vector b'. Another 180 degrees of phase change, indicated by the angle ϕ_r, is caused by the phase reverser R. Consequently, the voltage b'', which was induced in antenna B, is exactly 180 degrees out of phase with the voltage a contributed by the antenna at location A when it arrives at that position and, therefore, the two cancel each other and no signal is received at receiver 11. If the velocity of propogation along the transmission line is substantially equal to that of light, signals received in the direction from B to A will always cancel each other due to the reversal in the coupling system within the range of spacings I have indicated, whereas the additive effect for signals travelling in the other direction, that is, from A to B will generally amount to an appreciable value

depending, to some extent, upon the distance between locations A and B.

In Figure 4 I have shown another arrangement of antennas based on the same principle as Figure 1. In this case, the antennas 7 and 8 are coupled to the transmission line through coupling condenser 13, while balancing condensers 14 are connected between the transmission line and artificial lines 15. Condensers 14, together with the artificial lines 15, are so arranged as to balance the reactance of the antenna loading of the other side of the line. The artificial line sections 15 may have an electrical length equivalent to the electrical length of antennas 7 and 8 and include resistance components such as to perfectly match the impedances of antennas 7 and 8. In some cases it may not be necessary to actually use artificial line sections 15 but the condensers 14 may be directly connected to ground. In this figure I have shown the transmission line TL as being terminated by a damping resistance 12 having a value equal to the surge impedance of the transmission line.

Figure 5 shows the principle of the present invention as applied to a pair of wave antennas 25 and 26 which, by virtue of their damping impedances 27 and 28, are, in themselves, relatively unidirectional. The wave antennas are several wavelengths long and may be built on pole lines spaced 15 to 50 feet apart. The end-on displacement between the two antennas may be of the order of a quarter wavelength for the most generally used frequency. The wave antennas 25 and 26 are coupled to transmission line TL through coupling transformers 29 and 30. The damping resistance 22 is connected across the short end of the transmission line for the same purpose as damping resistance 12 in Figure 4.

The system of the present invention may also, as shown in Figure 6, be applied to balanced antenna systems. In Figure 6 the balanced antennas consist of doublets 31, 32 and 33, 34. While they are indicated in perspective as being horizontally arranged they may, of course, for vertically polarized waves, be vertically arranged.

Except for the difference in types of antennas shown, the operation of the modification of Figure 6 is the same as that of Figure 1.

Furthermore, the system of the present invention may be applied to a pair of V antennas 37, 38 of Figure 7 and, as before, the antennas connected to a transmission line TL having a phase reversing arrangement R between the two antennas.

Similarly, as shown in Figure 8, the system may be applied to a pair of rhombic antennas 47 and 48.

While the system of the present invention has been described particularly with reference to receiving antennas it may, of course, be equally well applied to transmitting antennas. Furthermore, a combination of two antennas set up according to the principles heretofore described may be duplicated by another group of similar antennas displaced from the first group and the two groups in turn combined according to the principles above set forth.

While I have shown and particularly described several embodiments of my invention, it is to be distinctly understood that my invention is not limited thereto but that modifications within the scope of my invention may be made.

I claim:

1. A unilaterally directive antenna system including transducer equipment, a transmission line extending from said equipment along a line away from the direction of maximum response, a plurality of antennas located at spaced points along said line and coupled to said transmission line, and phase reversing means in said transmission line between said antennas, the distance between said antennas and the length of transmission line therebetween being so related that said system has a maximum response to signals from only one direction.

2. A unilaterally directive antenna system including transducer equipment, a transmission line extending from said equipment along a line away from the direction of maximum response, a plurality of antennas located at spaced points along said line and coupled to said transmission line, and phase reversing means in said transmission line between said antennas, the distance between said antennas and the length of transmission line therebetween being so related that said system has substantially no response to signals travelling in the direction from the free end of said transmission line toward said transducer equipment.

3. A unilaterally directive antenna system including transducer equipment, a transmission line extending from said equipment along a line away from the direction of maximum response, a plurality of antennas located at spaced points along said line and coupled to said transmission line, and phase reversing means in said transmission line between said antennas, the distance between said antennas and the length of transmission line therebetween being between 30 and 150 electrical degrees.

4. A unilaterally directive antenna system including transducer equipment, a transmission line extending from said equipment along a line away from the direction of maximum response, a pair of antennas located at spaced points along said line and coupled to said transmission line, and phase reversing means in said transmission line between said antennas, the distance between said antennas and the length of transmission line therebetween being between 30 and 150 electrical degrees.

5. A system, as set forth in claim 4, wherein said transmission line is terminated at its other end by a resistor having a resistance equal to the surge impedance of said line.

6. A system, as set forth in claim 4, wherein each of said antennas is a long wire antenna having its free end in the direction of maximum response.

7. A system, as set forth in claim 4, wherein each of said antennas is a long wire antenna having its free end in the direction of maximum response, each of said free ends being connected to ground through a resistor having a resistance equal to the characteristic impedance of said antenna.

8. A system, as set forth in claim 4, wherein each of said antennas is a horizontally disposed dipole.

9. A system, as set forth in claim 4, wherein each of said antennas is a vertically disposed dipole.

10. A system, as set forth in claim 4, wherein each of said antennas is a V antenna.

11. A system, as set forth in claim 4, wherein each of said antennas is a rhombic antenna having its end remote from its coupling to said transmission line directed in the direction of maximum response.

12. A unilaterally directive antenna system in-

cluding transducer equipment, a transmission line extending from said equipment along a line away from the direction of maximum response, a plurality of antennas located at spaced points along said line and coupled to said transmission line, and phase reversing means in said transmission line between said antennas, the distance between said antennas and the length of transmission line therebetween being of the order of a quarter wavelength whereby said system has substantially no response to signals travelling in the direction from the free end of said transmission line toward said transducer equipment.

13. A unilaterally directive antenna system including transducer equipment, a transmission line extending from said equipment along a line away from the direction of maximum response, a plurality of antennas located at spaced points along said line and coupled to said transmission line, and phase reversing means in said transmission line between said antennas, the distance between said antennas and the length of transmission line therebetween being of the order of a quarter wavelength.

14. A system, as set forth in claim 12, wherein said transmission line is terminated at its other end by a resistor having a resistance equal to the surge impedance of said line.

15. A system, as set forth in claim 12, wherein each of said antennas is a long wire antenna having its free end in the direction of maximum response.

16. A system, as set forth in claim 12, wherein each of said antennas is a long wire antenna having its free end in the direction of maximum response, each of said free ends being connected to ground through a resistor having a resistance equal to the characteristic impedance of said antenna.

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