Jan. 7, 1941. DE WITT R. GODDARD 2,227,929

PANTOGRAPH ANTENNA

Filed June 29, 1939

Fig. 1.

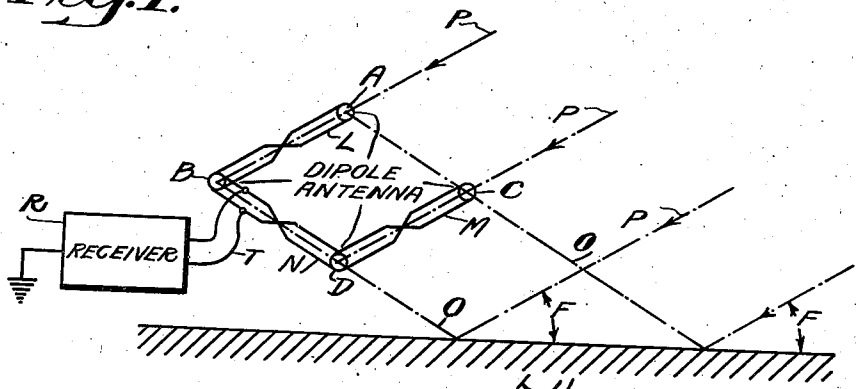
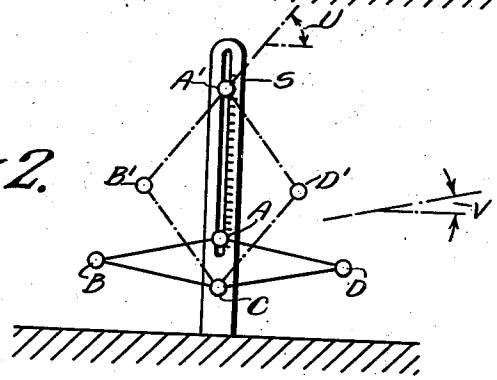


Fig. 2.



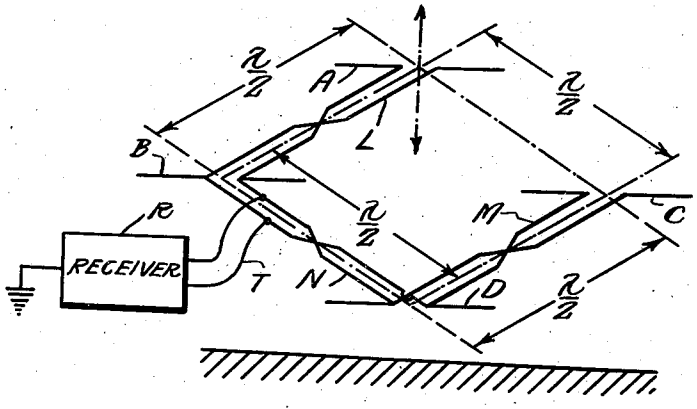


Fig. 3.

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PANTOGRAPH ANTENNA

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5 Claims. (Cl. 250—11)

This invention relates to a directional antenna system which is particularly adapted to measure the vertical arrival angle of short wave radiations.

In the past the measurement of the vertical angle of arrival of radio signals has been accomplished with considerable difficulty and has necessitated the use of complicated receiving equipment. In addition, the actual angle of arrival was obtained only after considerable computations had been made. It is therefore an object of this invention to provide a directive antenna system by means of which the vertical angle of arrival of radiated waves may be measured directly. Further objects of this invention include the provision of an improved directional antenna system; the provision of a readily adjustable directional antenna; the provision of a directional antenna which is not adversely affected by waves which are reflected from the surface of the earth; and the provision of a directional antenna system which may be used to provide an inclined plane of zero signal which may be used to guide aircrafts to blind landings.

This invention will be better understood from the following description when considered in connection with the accompanying drawing, in which Figure 1 illustrates the electrical connections of an antenna system in accordance with this invention; Figure 2 is a plan view of a mechanical arrangement suitable for adjusting the angle of reception of the directive antenna system; and Figure 3 is a perspective view illustrating the general arrangement and connection of the antennas used in the directive system herein proposed.

Referring to the drawing, the antenna system comprises four mutually parallel dipole antennas A, B, C and D which are supported at the four corners of a parallelogram, the sides of which are substantially a half wave length long at the operating frequency, the diagonals of which lie, respectively, in vertical and horizontal planes.

Referring particularly to Figures 1 and 3, dipole antennas A and B are connected by a transmission line L that contains one reversal, that is, the right hand portion of dipole A is connected to the left hand portion of dipole B, and vice versa. Dipoles C and D are connected in the same fashion, and dipoles C and B are likewise similarly connected. At any convenient point, adjacent dipole B, for example, a transmission line T is connected between the antenna system and a receiver R.

The arrangement shown produces a null or point of zero reception for signals arriving at the angle a line through antennas A and B makes to the ground. The voltage at antenna B which is produced by a signal whose wave front is proceeding in the direction of the arrows P parallel to a line drawn through antennas A and B is zero, as will now be explained. The voltage at antenna B is the resultant of the voltage picked up by all the antennas. That produced by antenna A is in phase opposition to that produced by antenna B due to the reversal of the connection in transmission line L. Likewise, the voltage produced by antenna C is in phase opposition to the voltage produced by antenna D due to the reversal of transmission line M. Consequently, there is no voltage present at antennas B or D, and the transmission line N connecting the latter antennas transfers no energy and the receiver R receives no signals.

Consideration will now be given to the effect of the energy which is reflected from the ground and which impinges on the dipole antennas. The reflected energy will have the same angle to the ground as the directly received energy but the wave front will proceed in a direction indicated by the arrows O, since the angle of incidence is equal to the angle of reflection. The reflected energy travels in a direction which is parallel to a line passing through antennas C and A, which is also parallel to a line passing through antenna B and D. The reflected energy will therefore induce a voltage in antenna C which will travel through transmission lines M, N and L and will arrive at antenna A at a time which is equal to three half wave lengths later. This voltage will also suffer three phase reversals while traversing this path. Each half wave length of transmission line and each phase reversal, respectively, provide 180° phase shift, so that the total phase shift experienced by the induced voltage in the three sections is equal to 1080°, or three complete revolutions. In other words, the voltage that appears at dipole antenna A due to the voltage induced in antenna C is in phase with the voltage at antenna C. However, the voltage picked up by dipole A is in phase opposition to that picked up by dipole C due to the half wave spacing between C and A. Therefore, the voltage at A is bucked out by the voltage induced in antenna C. This combination of voltages is, of course, true for any point on the transmission lines N, M or L, and is therefore true at the point at which transmission line T is connected to the system. The receiver R, therefore, receives no signal from voltages which are induced in antennas A and C. An-

tennas B and D are likewise in line with the reflected signal wave front, are likewise spaced a half wave length apart, and the induced voltages are likewise in phase opposition so that no signal will be reproduced in the receiver due to voltages induced in antennas B and D. It is apparent, therefore, that the antenna arrangement illustrated is not receptive to signals arriving from the directions indicated by the arrows O and P. Signals arriving from directions other than O and P, however, are not completely balanced out since the effective distance between the various dipole antennas is not equal to a half wave length at any other angle of approach.

In order to provide a directive antenna system which is readily adapted to be used for the measurement of signals arriving at an unknown angle, an arrangement similar to that illustrated in Fig. 2 is proposed. Each of the four dipole antennas is held at a fixed distance from each adjacent antenna by any suitable insulating means the length of which is preferably adjustable. For example, the transmission lines themselves may be rigid telescopic conductors. The lengths of the dipole antennas are also preferably adjustable to permit operation over a range of frequencies. The lower dipole C is held in fixed position, while the upper dipole A is arranged to be moved vertically in a rigid insulated support S so that the angle of reception may be adjusted. The arrangement is similar to a pantograph, the insulating spacers having flexible couplings at the respective antennas. By moving antenna A in a vertical direction the angle of minimum reception is varied, and the actual angle may be determined by means of a calibration which is provided along the vertical supporting member S. The angle of approach is therefore directly indicated, and computations are not necessary. In Figure 2, the antenna is illustrated in two positions. When extended, antennas A', B', and D' produce a null at the receiver for a signal which arrives at an angle U while in its lower position the antenna produces a null indication for signals arriving at an angle V.

While I have illustrated this antenna in connection with a receiver it is also adapted to be used in connection with a transmitter. In such an application it will provide a radiation pattern which has a plane of zero signal which makes an angle with the ground. This angle is readily adjustable, as will be seen, and may be used to direct the flight of an aircraft, for example, to permit blind landings.

I claim:

1. A directional antenna system comprising four mutually parallel horizontal dipole antennas having oppositely extending arms, said antennas being positioned so as to define the corners of a parallelogram the diagonals of which are, respectively, horizontal and vertical, and conducting means connected between said oppositely extending arms so that currents induced in said conducting means by one of said antennas are in phase opposition to currents induced in said conducting means by another of said antennas.

2. A directional antenna system comprising a plurality of mutually parallel dipole antennas having oppositely extending arms, means for supporting said dipole antennas at the four corners of a parallelogram the diagonals of which are, respectively, horizontal and vertical, a pair of conductors for connecting alternate arms of said antennas in parallel so that currents induced in said conductors by one of said antennas are in phase opposition to currents simultaneously induced in an adjacent antenna, and means for varying the relative positions of said dipole antennas to change the vertical angle of minimum response.

3. A directional antenna system comprising a plurality of mutually parallel dipole antennas, means for supporting said antennas at the four corners of a parallelogram, the sides of which are substantially a half wave length long at the operating frequency, means connected between adjacent dipole antennas for connecting said dipole antennas in parallel, the polarity of said connecting means being reversed between adjacent antennas, and means for varying the position of one of said antennas with respect to a diagonally positioned antenna to adjust said system to indicate the horizontal angle of approach of radio waves impinging on said system.

4. A directional antenna system comprising a plurality of mutually parallel dipole antennas, means for supporting said antennas at the four corners of a parallelogram, the sides of which are substantially a half wave length long at the operating frequency and the diagonals of which lie respectively in vertical and horizontal planes, means connected between adjacent dipole antennas for connecting said dipole antennas in parallel, the polarity of said connecting means being reversed between adjacent antennas, and means for varying the position of one of said antennas with respect to a diagonally positioned antenna to adjust said system to indicate the horizontal angle of approach of radio waves impinging on said system.

5. A device of the character described in claim 4 which includes indexing means associated with said one antenna for indicating the vertical angle of minimum reception of said system.

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