June 9, 1942. E. BRUCE 2,285,565

DIRECTIVE ANTENNA

Filed Feb. 3, 1931

FIG. 1

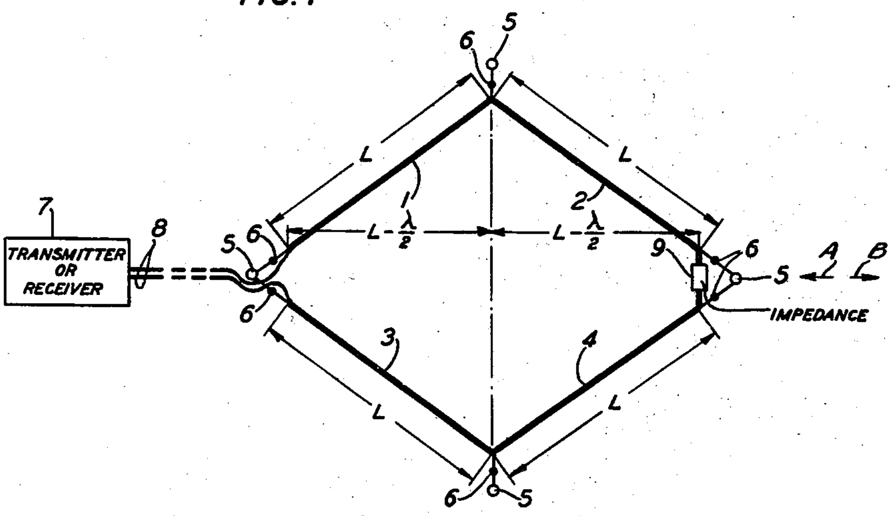
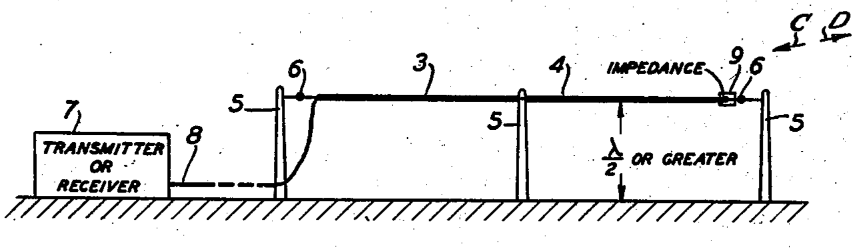


FIG. 2



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Patented June 9, 1942

2,285,565

UNITED STATES PATENT OFFICE

2,285,565

DIRECTIVE ANTENNA

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Application February 3, 1931, Serial No. 513,063

14 Claims. (Cl. 250—33)

This invention relates to aerial systems and more particularly to directive antennae for use in such systems.

An object of the invention is to render directive antennae capable of effective operation over a considerable range of wave lengths.

Another object is to secure a relatively high angle of reception or emanation.

An additional object of the invention is to enable an antenna to have a sharp selectivity.

A further object is to economize in the cost of supporting structures as compared with that of previous antennae of similar directional characteristics.

A still further object of the invention is to discriminate against undesired horizontally projected energy.

In accordance with the invention an antenna is constructed by positioning a V-shaped conductor so that its plane lies substantially parallel with the earth and with a spacing above it at least as great as one-half the wave length of the wave which is to be absorbed or radiated. A similar V-shaped structure with its terminals closely adjacent those of the active antenna and lying in the same plane may be suitably connected thereto as a counterpoise. The terminals of each V-shaped conductor are included substantially in the vertical plane of desired wave reception or emanation.

Additional features and objects of the invention will be apparent from a perusal of the following specification taken in connection with the accompanying drawing in which Fig. 1 is a plan view and Fig. 2 a view in elevation of an antenna constructed in accordance with this invention. In both figures like reference numerals designate elements of similar function.

Reference numerals 1 and 2 designate the conducting members of the horizontal antenna proper each of which has a length equal substantially to one-half wave length plus the projection of the conductor on the vertical plane path of wave propagation. Antenna conductors 1 and 2 are therefore each positioned at an angle greater than zero degree with respect to the plane of wave polarization, this plane being, of course, perpendicularly related to the direction or path of propagation. The distant cooperating station is assumed to be included in the vertical plane containing arrows A and B, which represent the direction of desired reception or emanation, respectively, so that conductor 1 extends away from and conductor 2 extends toward the distant cooperating station. In practice the maximum transmission and/or reception often occurs at a slight angle to the directions A and B. Reference numerals 3 and 4 designate conducting members of a counterpoise system, the length of each of which also equals substantially a half-wave length of the desired wave plus the projection of the conductor on the vertical plane of wave propagation. The V antenna and counterpoise each resemble in structure, although having certain distinctive functional attributes, the inverted V antenna described in my Patent 1,899,410 granted February 28, 1933. The length of the antenna members, and the angles formed by these members with the vertical plane of propagation, are shown equal in the figure but they may differ without affecting the result obtained provided that the relation mentioned above between the length of the member and its projection is maintained. Similarly the counterpoise members may differ in length. By making the length of the antenna-counterpoise members each equal to several, as for example, five or more, wave lengths effective operation is secured over a band of frequencies inasmuch as the ratio of the projection of the member to its length for all such long antennae may be considered substantially equal to each other. In such multi-wave length systems if the antenna members are equal in length and if the counterpoise members are equal in length the slight inaccuracy in angle tilt for the different frequencies in the band is compensated.

The antenna-counterpoise system is supported by means of wooden poles 5 and insulated therefrom by means of insulators 6. The translation device 7, which may be either a transmitter or a receiver, is connected by means of transmission line 8 to the terminal of the antenna and the adjacent terminal of the counterpoise, which terminals are positioned nearer to the distant cooperating station than the remaining antenna and counterpoise terminals. The remaining or "back" terminals of the antenna and counterpoise are connected together through a terminating impedance 9. As shown in Fig. 2 the horizontal antenna-counterpoise system is spaced preferably a half-wave length or more above the ground. Such spacing improves the discrimination against received horizontally propagated waves.

Any type of high frequency transmission line may be suitably employed with the antenna-counterpoise system disclosed in the drawing. In practice it has been found that the form of transmission line most suitably employed depends upon whether the antenna is used as a transmitting or a receiving system. For example, when the antenna is used for transmitting purposes, a matched line which may include impedance transformers such as disclosed in Patent 1,963,723 granted June 19, 1934, to E. J. Sterba, gives very satisfactory results; and when employed for receiving purposes a concentric line including a balanced coupling transformer such as is disclosed in my Patent 1,947,247 granted February 13, 1934, is a suitable form. The balanced line such as is used in connection with receiving systems suppresses reradiation from the line and also to a great extent cancels interfering waves absorbed by the vertical portion of the line.

The basic theory underlying the operation of the antenna system as shown in Figs. 1 and 2 is set forth in my Patent 1,899,410 mentioned above, the reception or transmission of the horizontally polarized component being assumed instead of the vertically polarized component. The counterpoise comprising conductors 3 and 4 in a sense simulates the ground associated with the vertical V-type antenna. Because of the compensatory effect of ground reflection substantially no reception or transmission occurs in a horizontal plane and maximum reception, as shown by arrow C, and maximum transmission, as shown by arrow D, each occur at a high angle to the plane of the antenna and the ground. Maximum reception occurs in the vertical plane including arrow A and maximum transmission similarly occurs in the vertical plane including arrow B. This compensatory effect is related to the fact that the horizontally polarized component with which this invention is concerned undergoes a phase reversal on reflection. This is not true of the vertically polarized component that is made use of in the operation of the otherwise similar vertical antenna of my copending application, supra. This accounts for the difference in the angles of fire between the horizontal and vertical antennae, a difference which would not result merely from applying the theory of my said copending application assuming a 90° rotation of the antenna.

The terminating impedance 9 may be a pure resistance or a tuned circuit comprising capacity and inductance, lumped or distributed. If the length of each member of the antenna and counterpoise is equal to an odd multiple greater than one of a quarter-wave length, a terminating impedance equal substantially to the antenna surge impedance will produce uni-directivity; and, if the length of each of these members equals an even multiple greater than two of one-quarter wave length a terminating impedance equal to the product of the antenna surge impedance and the cosine of the angle whose sides are formed by the member and its projection on the vertical plane of propagation will render the system unilateral. For antennae comprising members each having a length differing from those just mentioned a terminating impedance comprising a resistance and either a capacitive or an inductive reactance, as conditions may require, may be employed to produce a uni-lateral effect. It has been found in practice that in transmitting antennae an iron wire open-ended or short-circuited line is suitable for dissipating the large amount of energy which would otherwise be radiated in a direction opposite to the desired direction; and in receiving systems a carbon resistance is suitable for dissipating the relatively small amount of energy received from the rear or undesired direction.

The horizontal V-type antenna described herein possesses distinct advantages over other types of antennae commonly employed. First of all, as is well known in long distant radio communication, the horizontally polarized component of a radiated wave is much stronger at the receiving point than the vertically polarized component and from this viewpoint the horizontal antenna, which absorbs horizontally polarized components, absorbs a greater amount of energy than a vertical type antenna. Moreover, since very little energy is absorbed by the horizontal antenna of the invention from horizontally propagated waves, undesired pick-up from automobiles and other interfering sources positioned at points relatively near to the receiving antenna is greatly reduced. This feature does not affect the efficiency of the antenna for receiving the desired wave since, as pointed out before, the desired wave is received at a relatively high angle with respect to the ground. If it is desired to receive or radiate horizontal waves the antenna may be positioned on the slope of a hill parallel to the ground. In this connection it should be noted that in the case of the vertical V-type antenna maximum radiation and reception occur in a horizontal plane, that is, at a zero angle with respect to earth. The high angle obtained in the horizontal V is particularly useful in long distance transmission and reception. Still another advantage of the horizontal over the vertical type of antenna is that the horizontal type may be cheaply constructed in view of the fact that the supporting poles are relatively small.

It should be understood that the invention is not to be limited to the specific embodiment described herein. The configuration of the system may be other than the diamond-shaped disclosed, and the members comprising the antenna and counterpoise may have different lengths provided that the relation between the length and the projection referred to herein is that described heretofore. Moreover, the V-shaped antenna and V-shaped counterpoise may be positioned in different planes without exceeding the scope of the invention, and the terminating impedance employed to produce unidirectivity may, of course, have any value including zero and infinity.

What is claimed is:

1. An antenna comprising two oblique conductors of equal length positioned in a horizontal plane, said length being greater than a half wave length and substantially equal to one half wave length of the desired wave plus the projection of the conductor on a vertical plane including the distant cooperating station and said antenna, one terminal of each conductor being positioned in a plane perpendicularly related to said vertical plane and the remaining terminals of said conductors being superposed.

2. An antenna-counterpoise system comprising an antenna member and a counterpoise member, the length of each member being greater than one-half wave length of the desired wave and substantially equal to its projection on the vertical plane of wave propagation plus one half wave length of the desired wave, said members being arranged in V formation and the bisector of the angle between said members being included in the vertical plane of wave propagation.

3. In combination, an antenna-counterpoise

system comprising an antenna member and a counterpoise member each positioned at an angle greater than zero degrees to the plane of wave polarization, the length of each member being equal to its projection on the vertical plane of wave propagation plus one half wave length of the desired wave, the bisector of an angle formed by said members being included in the vertical plane of wave propagation, and a translation device included between said members.

4. A substantially horizontal diamond-shaped antenna comprising two V-shaped conductors, each conductor comprising two members each having a length substantially equal to one-half wave length of the desired wave plus the projection of the member on the vertical plane of wave propagation.

5. An antenna comprising two similar V-shaped conducting members with their open angles directed toward each other, said V-shaped members both lying in the same general horizontal plane, a transmission circuit connected to a terminal of one V-shaped member and to the adjacent terminal of the second V-shaped member and a terminating impedance connected to the other terminals of the V-shaped members.

6. In combination, an antenna and a counterpoise each comprising a V-shaped conductor horizontally positioned and having their open angles opposite each other, a translation device connected to one terminal of the antenna and to the adjacent terminal of the counterpoise, and a terminating impedance connected between the other terminal of the antenna and the other terminal of the counterpoise.

7. In a radio system, a directive antenna section for utilization of horizontally polarized wave components comprising two angularly related metallic conductors of equal length, a translation device connected between corresponding and relatively closely positioned points on said conductors, said conductor length being of the order of five to ten wave-lengths of the desired wave, and a substantially flat ground reflecting surface, said conductors being positioned in a plane parallel to the ground reflecting surface whereby the effective direction of maximum radiant action for said system comprising said section and said surface is angularly related to said plane, said conductors forming equal angles each of the order of eighteen to twenty-five degrees with a given or chosen direction of radiant action whereby the maximum direction of action of the system substantially coincides with said given or chosen direction.

8. A diamond-shaped antenna array comprising a pair of V-shaped antennas having their angles facing each other, the angle between the path of desired wave propagation and each leg or side element of each antenna being a function of the length of the side and the widely separated terminals of the V-shaped antennas being superimposed.

9. A diamond-shaped array comprising a pair of V-shaped antennas having their angles facing each other, the angle between the desired path of radio action and each leg or side of each V-shaped antenna being critically related to the length of the side, and the widely separated terminals of said antenna being conductively connected, and a translation device connected to said array.

10. A diamond-shaped antenna array comprising a pair of V-shaped antennas having their angles facing each other, the angle between the path of maximum radio action and each side element of each V-shaped antenna being a function of the individual length of each side, a translation device connected to the vertex of one antenna and a reflective passive impedance connected to the vertex of the other V-shaped antenna.

11. A radio system for effecting propagation including transmission and reception of radio waves comprising a substantially flat surface for reflecting radio waves and a V-shaped aerial structure comprising a pair of angularly related conductors, the angle between each conductor and the maximum direction of radio action being a function of the conductor length and the planes of said surface and said structure being substantially parallel, whereby the angle between said path and each of said planes is greater than zero.

12. A system in accordance with claim 11, the distance between said planes being at least one-half wave-length.

13. A system for effecting transmission or reception of radio waves comprising a conductive reflective portion of the earth's surface and a rhombic aerial structure comprising two conductively connected pairs of angularly related conductors, the angle between each conductor of each pair and the direction of maximum radio action for the entire system being dependent upon the individual length of the conductors, the planes of said surface portion and said structure being substantially parallel, and a translation device connected to said structure, whereby in reception and transmission radio action resulting from the interaction of the wave component traveling directly to or from said rhombic structure and the wave component traveling indirectly via said surface to or from said structure is of maximum intensity when the direction or path followed by said components makes an angle greater than zero with said planes.

14. A system in accordance with claim 13, the distance between said structure and said surface being at least one-half wave-length.

EDMOND BRUCE.