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ANTENNA FOR RADIO COMMUNICATION

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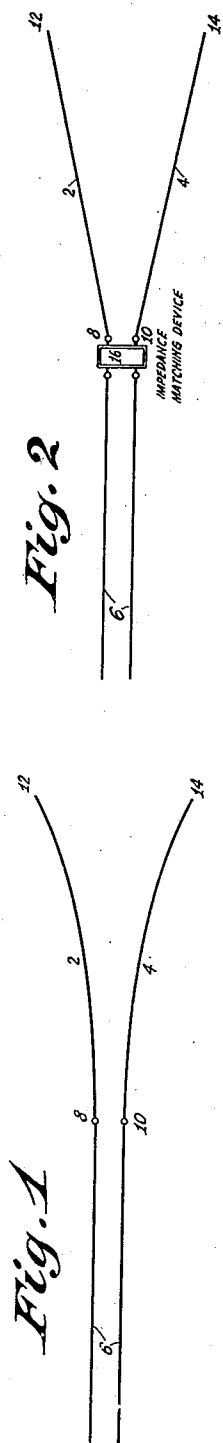


Fig. 2

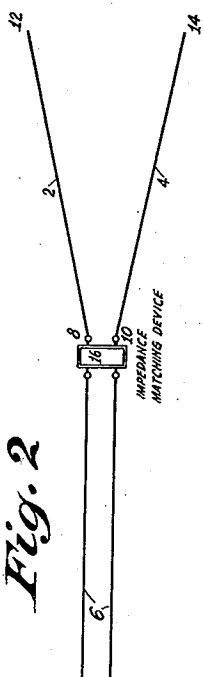


Fig. 3

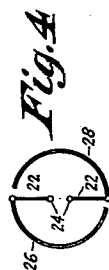
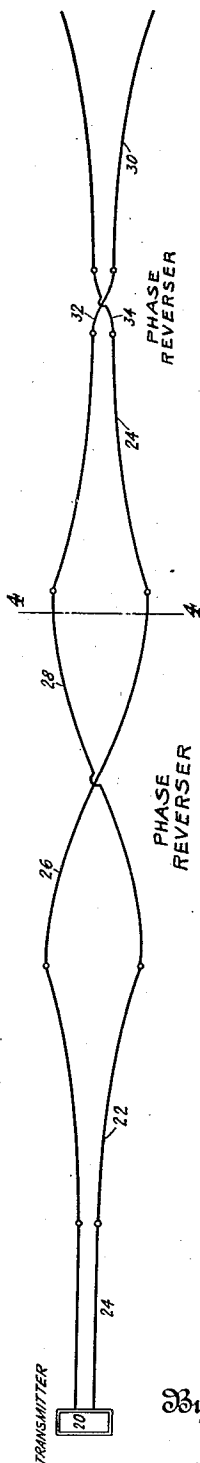
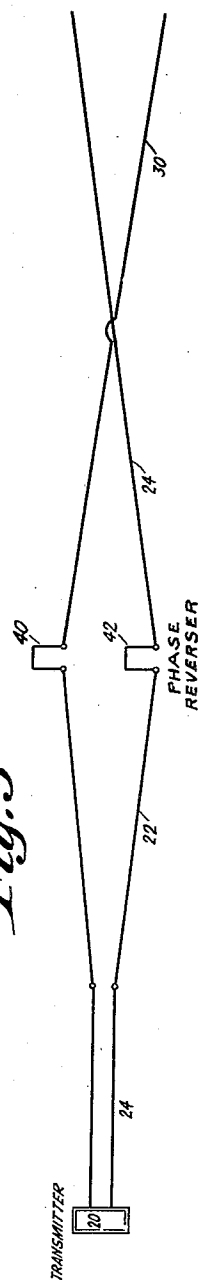


Fig. 5



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UNITED STATES PATENT OFFICE

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ANTENNA FOR RADIO COMMUNICATION

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24 Claims. (Cl. 250—33)

This invention relates to antennas for radio communication.

Short wave antennas suffer from the disadvantage of having to be rather critically tuned to the working frequency, and from the further disadvantage of necessitating the use of some kind of an impedance matching device between the antenna and the transmission line connecting the antenna with the radio equipment. It is an object of my invention to provide an exceedingly simple form of short wave antenna which will operate over a considerable range of frequency, and a further object of my invention is to provide an antenna with which a transmission line may be coupled without the use of intermediate impedance matching devices.

My antenna consists simply of a pair of conductors which at one end are spaced at the spacing of the transmission line, and are coupled thereto, and which gradually diverge to a much wider spacing at their other ends. In effect, therefore, the antenna consists merely of a gradually diverging extension of the conductors of the transmission line, and, in one aspect, the invention resides in the discovery that radiation may be obtained from a transmission line by gradually increasing the spacing between the wires of the line.

The desired radiation takes place in the direction of the axis of the pair of conductors, and is caused by the expansion of the current or the travelling wave of energy in the conductors. Reflection will cause a standing wave, instead of a travelling wave, and result in radiation sideways from the antenna. Despite this, the radiation in the direction of the antenna is still considerably greater than that obtainable from a simple doublet. However, as a refinement the harmonic radiation may be lessened by reducing the standing waves, and to so do is a further object of my invention. It is not feasible, in the case of a transmitting antenna, to avoid standing waves by closing the end of the antenna with a surge resistance, because of the excessive losses which would take place therein.

To lessen the standing wave I reduce the reflected energy by radiating as much of the energy fed to the antenna as possible. To merely increase the dimensions of the antenna is not practicable, for to increase the length without increasing the spacing, that is, to decrease the angle of divergence, does not increase the radiation, and on the other hand, to keep the same angle of divergence necessitates so wide a spacing as to make the antenna structurally inconvenient. To overcome this I employ a plurality of antennas or pairs of diverging conductors, arranged end to end, so as to radiate cumulatively.

I have also found that a pair of converging conductors, like a pair of diverging conductors,

will radiate energy, but this radiation is in opposite phase. The antenna may therefore comprise a plurality of pairs of conductors which successively diverge and converge, with means coupling the antennas which reverse the phase of the energy fed thereto.

While the terminology employed in the foregoing description may apply more particularly to a transmitting antenna the structure set forth is equally useful as a receiving antenna.

The invention is further described in the following specification, which is accompanied by a drawing in which

Figure 1 represents one form of my invention; Figure 2 is a modification employing straight conductors;

Figure 3 shows the use of a plurality of diverging and converging antennas;

Figure 4 is a section of Figure 3 taken on the line 4—4; and

Figure 5 is a modification of Figure 3 showing an alternative form of phase reversing coupling means between the successive antennas.

Referring to Figure 1 it will be seen that the antenna consists of a pair of conductors 2, 4, which are connected to a transmission line 6 at points 8 and 10, which are spaced at the spacing of the transmission line. From the points 8 and 10 the conductors 2 and 4 gradually diverge to a much wider spacing at the ends 12 and 14. The extension of the conductors may be curved, as shown, and one form which is quite successful in operation is an expansion according to an exponential law.

However, in actual practice I find that the refinement of an exponential curve is not essential, and that the conductors 2 and 4 may be straight conductors strung between the points 8 and 12, and the points 10 and 14, under direct tension, and without the use of intermediate shaping or guy wires, and such an arrangement has been indicated in Figure 2.

No impedance matching device is necessary with this antenna, so that in actual practice the antenna is exceedingly simple to erect, it being necessary merely to provide a pair of supporting points 12 and 14 at a desired distance from the termination of the transmission line, and then to continue the conductors of the transmission line directly to the spaced points 12 and 14.

Whatever amount of energy has not been radiated when the travelling wave reaches the end of the antenna is reflected, and thus causes a partial standing wave, which will extend back along the transmission line 6. If the transmission line is short, this may be neglected, but if the transmission line is long, and the antenna is relatively small, so that only a small portion of the energy is radiated, it may prove desir-

able to employ an impedance matching device between the transmission line and the antenna, as is indicated by the impedance matching unit 16, shown in Figure 2.

- 5 If, instead, the antenna is made to radiate more energy, the standing wave will incidentally be reduced, and the impedance matching device may be dispensed with. To merely make the antenna much longer, while keeping the same
10 spacing at its open end, does not help, because such a procedure merely slows up the rate of spread of the energy, and does not increase the quantity of energy radiated. On the other hand it ordinarily is not structurally possible to make
15 the antenna considerably longer while maintaining the same angle of divergence of the conductors, owing to the great spacing which would be needed at the open end of the antenna. The same result may be accomplished without these
20 disadvantages by using a plurality of antenna sections arranged end to end. Since a converging antenna is similar in operation to a diverging antenna, except for a reversal in phase, it becomes especially convenient to use a plurality
25 of antenna sections which are successively diverging and converging, and such antennas have been indicated in Figures 3 and 5.

- Referring to Figure 3 it will be seen that a transmitter 20 is coupled to a diverging antenna
30 22 by a transmission line 24. The diverging antenna 22 is followed by a converging antenna 24, which is coupled to the diverging antenna 22 by a pair of conductors 26 and 28. The spacing between these conductors is kept constant,
35 so that practically no radiation takes place therefrom, but at the same time the conductors are electrically crossed in order to reverse the phase of the energy being fed from antenna 22 to antenna 24. For this purpose each of the con-
40 ductors is supported, at least approximately, in the form of a helix, a feature which is more clearly indicated in the section taken on the line 4-4, and constituting Figure 4. The pitch of the helices should be sufficiently great that
45 the physical distance in space between the antennas 22 and 24 is substantially equal to the distance along the conductors 26 and 28, so that the phase displacement of the wave travelling in space will coincide with that of the energy wave travelling on the conductors 26 and
50 28. The converging antenna 24 is followed by a diverging antenna 30, and the adjacent ends of the antennas 24 and 30 are coupled by phase reversing coupling conductors 32 and 34.

- 55 A modification of the arrangement shown in Figure 3 is indicated in Figure 5, in which a transmitter 20 is coupled by a transmission line 24 to a diverging antenna 22, followed by a converging antenna 24, which in turn is followed by
60 a diverging antenna 30, much as in Figure 3. However, in this case the antennas 22 and 24 are coupled by conductors 40 and 42, which are a half wave in length, in order to reverse the phase of the energy flowing therethrough, and
65 which are bent back upon themselves so as to be substantially nonradiating. The connection between the antennas 24 and 30 is made simply by crossing the conductors, as shown, the conductors being separated slightly at the cross-
70 ing point by an insulator in order to prevent a short circuit between the conductors. In the arrangements shown in Figures 3 and 5 any desired number of antenna sections may be employed.

- 75 The plane of polarization of the radiated

energy coincides with the plane of the conductors, so that if the conductors are positioned in a horizontal plane the energy is radiated with horizontal polarization, and if the conductors are positioned in a vertical plane the energy is radiated with vertical polarization. 80

With the conductors in a horizontal plane a standing wave tends to cause side radiation. By locating the conductors in a vertical plane the directivity in azimuth may be maintained regardless of the presence of standing waves, but even in such case it is desirable to prevent waste of the energy radiated thereby, and it is therefore desirable to make the length of the conductors or the number of antenna sections sufficiently great, in accordance with the foregoing instruction, to reduce the standing wave. 85 90

In connection with Figures 3 and 5, the desired radiation will, of course, take place in the direction of the axis of the transmission line 24 and the diverging conductors. Taken from another point of view, we can consider merely the upper half of Figures 3 and 5 as being in a vertical plane with its image in the ground; we will then have two serially connected conductors (conductor 26 and the upper antenna leading to transmission line 24 in Figure 3). Radiation will occur substantially in the direction of a line perpendicular to the bisector of the angle between these two conductors. 95 100 105

It will be understood by those skilled in the art that if improved directivity is desired a plurality of these antennas may be employed abreast or in broadside, that is to say, collaterally spaced apart in parallel formation along a line at right angles to the desired direction of communication. 110

Since the preferred radiation is from the travelling wave, and is due to the expansion of the lines of force between the current charges travelling along the conductors, the divergence should preferably be fairly gradual, and the spacing at the open end, while variable over a great range, should be in the neighborhood of a fifth of the length, and the length of each antenna section should be of the order of magnitude of five to ten waves long. 115 120

The antenna is equally suitable both for transmission and reception, the energy in the latter case being collected and converged into the transmission line without the necessity of an impedance matching device. 125

I claim:

1. The method of directly radiating or collecting high frequency electrical energy which includes directing energy of opposite polarity in a plurality of gradually diverging paths diverging and extending longitudinally in the desired direction of radiant action. 130

2. The method of unidirectionally radiating or collecting high frequency electrical energy which includes directing energy of opposite polarity in a plurality of gradually converging paths converging and extending longitudinally in the desired direction of radiant action. 135

3. The method of radiating or collecting high frequency electrical energy which includes directing energy of opposite polarity successively in a plurality of gradually diverging and converging paths and phase reversing the energy as it is directed from one path into another. 140 145

4. A uni-directional antenna comprising a gradually diverging pair of conductors excited in phase opposition, diverging and extending longitudinally only in the desired direction of radiant action. 150

5. A uni-directional antenna comprising a gradually converging pair of conductors excited in phase opposition, converging and extending longitudinally only in the desired direction of radiant action.
6. A uni-directional antenna comprising a pair of conductors excited in phase opposition, extending longitudinally in the desired direction of radiant action, the effective portions of which gradually diverge and converge successively.
7. A uni-directional transmitting antenna comprising a pair of conductors excited in phase opposition, extending longitudinally in the direction of desired transmission, the radiating portions of which gradually diverge and converge successively in the direction of desired transmission.
8. In combination, a two conductor transmission line excited in phase opposition, and an antenna connected thereto extending longitudinally in the direction of transmission, comprising a gradually diverging extension of the conductors of the transmission line at their remote open ends.
9. In combination, a two conductor transmission line excited in phase opposition, and an antenna extending longitudinally in the direction of desired radiant action comprising an open ended pair of conductors which at one end are spaced at the spacing of the transmission line and are coupled thereto, and which gradually diverge to a much wider spacing at their open ends.
10. In combination, a transmission line, and an antenna extending longitudinally in the direction of desired radiant action connected thereto comprising a pair of open ended conductors of the order of magnitude of a number of wave lengths long which are widely spaced at the ends remote from the transmission line and energized with energy of opposite polarity, and spaced at the spacing of the transmission line at their junction therewith.
11. A uni-directional antenna comprising a plurality of pairs of gradually diverging conductors extending longitudinally in the direction of desired transmission and energized in phase opposition.
12. In combination, a transmission line, an antenna connected thereto comprising a pair of conductors a number of wave lengths long which are spaced at the spacing of the transmission line at their junction therewith, and which gradually diverge to a much wider spacing at their remote ends, a second antenna comprising a pair of conductors a number of wave lengths long arranged in extension of the first antenna, and widely spaced at their near ends and closely spaced at their remote ends, another diverging antenna arranged in extension of the converging antenna, and phase reversing means for coupling said antennas together.
13. A uni-directional antenna comprising a diverging pair of conductors excited in phase opposition, diverging only in the desired direction of radiant action.
14. A uni-directional antenna comprising a converging pair of conductors excited in phase opposition, converging only in the desired direction of radiant action.
15. A uni-directional antenna comprising a pair of conductors excited in phase opposition, extending longitudinally in the desired direction of radiant action, the effective portions of which diverge and converge successively.
16. A highly directional antenna system comprising wires which are long relative to the length of the communication wave excited in phase opposition, which first diverge from the excitation end and then converge successively, whereby radiant action occurs predominantly in a direction substantially through the opposite apices of the wires.
17. A system in accordance with claim 16, characterized in this, that said wires are in a single vertical plane.
18. A highly directional antenna system comprising a pair of conductors excited in phase opposition, said wires being long relative to the length of the communication wave and extending in the desired direction of radiant action, the effective portions of which diverge and converge successively.
19. A highly directional antenna system comprising a pair of conductors angularly disposed with respect to each other, said conductors being long relative to the length of the communication wave and open-ended, and means for exciting the conductors in phase opposition whereby radiant action occurs predominantly along the direction of the axis of the conductor system.
20. A unidirectional antenna system comprising a diverging pair of conductors, the said conductors being long relative to the length of the communication wave, and means for producing traveling waves thereon whereby radiation is predominantly along the approximate direction of the length of the conductor system.
21. A system in accordance with claim 20 characterized in this, that said conductors are open-ended and disposed in the same vertical plane.
22. A directional antenna comprising a diverging pair of conductors which are long relative to the working wave length, and means at adjacent ends of said conductors for energizing same in phase opposition, said conductors being arranged to be on the same side of said energizing means and to extend away from said energizing means whereby radiant action occurs predominantly along the approximate direction of the length of the conductor system.
23. A directional antenna comprising a pair of open-ended, diverging conductors which are long relative to the working wave length, and means at adjacent ends of said conductors for energizing same in phase opposition, said conductors being arranged to be on the same side of and to extend away from said energizing means whereby radiant action occurs predominantly in a direction making equal angles greater than zero degrees with reference to said conductors.
24. A highly directional antenna system comprising a pair of electrical conductors which are disposed at an angle with respect to each other and serially connected together, said conductors having an overall length which is long relative to the operating wave length, high frequency apparatus, and means for connecting said apparatus to one end of one of said conductors, the other end of said connected conductor being connected to one end of the second conductor of said pair whereby high frequency energy flows through the entire length of one conductor and continues serially through the entire length of the other conductor, the conductors being adjusted in length and impedance so that radiant action occurs principally in the direction of a line perpendicular to the bisector of the angle between said conductors.

DISCLAIMER

1,927,522.—*Nils E. Lindenblad*, Port Jefferson, N. Y. ANTENNA FOR RADIO COMMUNICATION. Patent dated September 19, 1933. Disclaimer filed September 24, 1940, by the assignee, *Radio Corporation of America*.

Hereby enters this disclaimer to claim 24 of said Letters Patent and to lines 96 to 105 of page 2 of the specification.

[*Official Gazette October 22, 1940.*]