July 9, 1940. O. BÖHM 2,207,504

AERIAL SYSTEM

Filed Dec. 21, 1938

Fig. 1

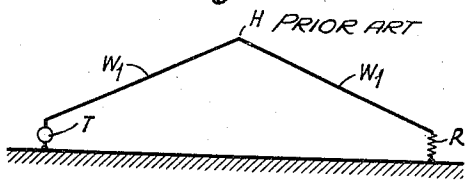


Fig. 1a

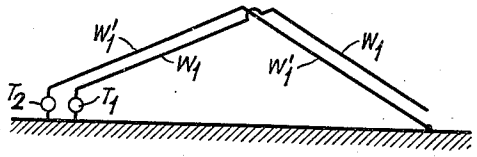


Fig. 2

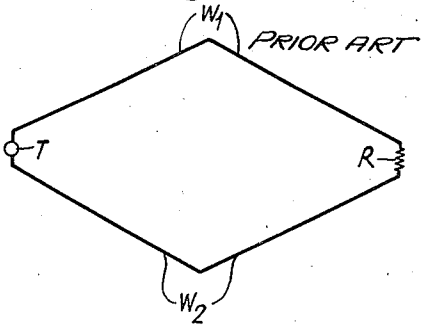


Fig. 2a

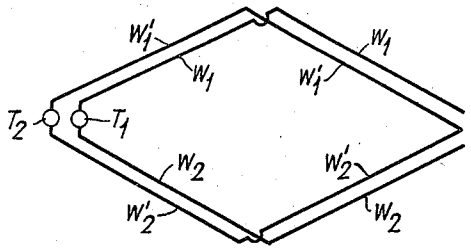


Fig. 3

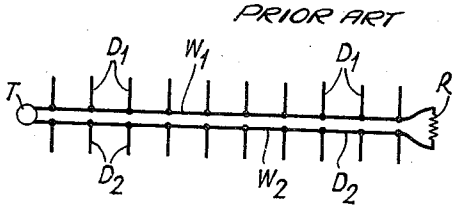
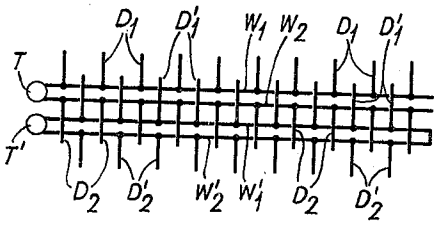


Fig. 3a



INVENTOR
OTTO BÖHM
BY
ATTORNEY

Patented July 9, 1940 2,207,504

UNITED STATES PATENT OFFICE

2,207,504

AERIAL SYSTEM

Otto Böhm, Hutton, Brentwood, England, assignor to Radio Corporation of America, a corporation of Delaware

Application December 21, 1938, Serial No. 247,004
In Great Britain December 24, 1937

10 Claims. (Cl. 250—11)

It is well known to obtain directional effects in aerial systems by providing at the end of an aerial conductor system a terminating resistance which is equal to the surge impedance of said system so that the current in the system is in one direction only. Aerial systems of this kind are well known and in general fall into one or other of two classes, namely, that in which the conductor system is essentially of the single conductor type and is earthed at the far end through a resistance equal to the surge impedance and that in which the conductor system is essentially of the two conductor type, the two conductors being connected together at the far end through a resistance equal to the surge impedance. In either class the aerial system may consist of the conductor system alone or the said conductor system may be provided at suitable intervals, with short, usually transverse radiators in respect of which it acts as a feeder system.

Three typical known aerial systems of the kind in question will now be described and, with reference to Figures 1, 2 and 3 of the accompanying drawing, the manner in which these systems may be modified to be in accordance with this invention will be described with reference to Figures 1A, 2A and 3A of the drawing, Figure 1A showing the antenna of Figure 1 modified according to the invention and similarly with respect to Figures 2A and 3A. In the first of these systems, which is illustrated by Figure 1, there is employed simply a single wire W_1 which, in the case of a transmitter aerial, is energized at one end by a transmitter T and is earthed at the other through a resistance R equal to the surge impedance. This wire W starts as shown at a little above ground level, slopes up for half its length to a point H of maximum height, and then slopes down to a little above ground level at its earthed end. In the second of these systems which is illustrated by Figure 2 two similar wires W_1, W_2 are employed, these wires being arranged so that, in plan view, they together embrace a diamond shape except for the acute angled ends. The transmitter T is connected between the wires at one end i. e. at one acute angled end of the diamond, and a resistance R equal to the surge impedance is connected between the wires at the other end of the diamond. In the third of these systems, illustrated by Figure 3, two straight, closely adjacent parallel wires W_1, W_2, are provided with suitably spaced short transverse radiators D_1, D_2, those (D_1) connected to one wire (W_1) projecting to one side and those (D_2) connected to the other (W_2) projecting to the other. Each radiator wire D_1 connected to one wire W_1 is opposite to and in the same straight line with a radiator wire D_2 connected to W_2. The transmitter T is connected between the wires W_1, W_2, at one end and a resistance R equal to the surge impedance is connected between the wires at the other end. Any of the systems of Figures 1, 2 and 3 may be used for reception by replacing the transmitter T by a receiver.

Known aerial systems of the kind referred to and of which the above three known systems are examples, suffer from the defect that there is a considerable loss of energy in the terminating ohmic resistance. This defect is serious both in the case of transmission and in the case of reception and the present invention seeks to overcome this defect by eliminating the ohmic resistance in question.

According to this invention an aerial system comprises two conductor systems arranged close together so as to be tightly radiation coupled, one of said systems being directly earthed or short circuited at the far end and the other being left open circuited at the far end, and means are provided for building up on said conductor systems stationary waves of the same amplitude but with a mutual phase displacement of 90°.

The easiest way to appreciate the underlying theory of the invention is to consider what is probably the simplest embodiment thereof, namely the case (not illustrated) where there are two simple parallel straight wires run closely adjacent to one another, one being directly earthed at the far end and the other being left open at the far end. The wires are energized at the near ends by currents of the same amplitude but in phase quadrature. There will be a current node at the far end of one wire and a current anti-node at the far end of the other. The current I_1 at the end of the earthed conductor is given by the expression

$$I_1 = I \cos\left[\frac{2\pi x}{\lambda}\right] \sin \omega t$$

where λ is the wave length and x the distance from the end.

The current I_2 at the end of the open conductor is given by

$$I_2 = I \sin\left[\frac{2\pi x}{\lambda}\right] \cos \omega t$$

Since the conductors are in close proximity and thus tightly coupled by radiation, the resultant effect is equivalent to that of a single conductor fed with the algebraic sum of the two currents I_1 and I_2. In other words, the resultant current I_R may be written in the form

$$I_R = I \sin\left[\frac{2\pi x}{\lambda} + \omega t\right]$$

The first of the three known systems (that of Figure 1), hereinbefore described, may be modified as shown in Figure 1A to be in accordance with this invention by dispensing with the earth-

ing resistance R of Figure 1 (leaving the wire W_1 open at the far end) and providing a second, similar, conductor W_1' closely adjacent the first conductor, and directly earthed at the far end. Both conductors are energized, in the case of a transmitter, at their near end by currents of the same amplitude but in phase quadrature. This energization is represented by two circles representing transmitters T_1, T_2 though in practice, of course, there would probably be only one transmitter giving the required two quadrature outputs.

The second of the three known systems hereinbefore described (that of Figure 2) may be as shown in Figure 2A modified to be in accordance with this invention by dispensing with the resistance R between the two wires at one end of the diamond and providing another diamond arrangement of two wires W_1', W_2', adjacent the first wires W_1 and W_2 and similar thereto except that the two wires W_1', W_2' of the second diamond are directly connected together at the end where the wires W_1, W_2 of the first diamond are left open. The two diamond arrangements are energized at their near ends by currents of the same amplitude but in phase quadrature.

The third of the three known systems hereinbefore described (that of Figure 3) may be modified as shown in Figure 3A to be in accordance with this invention by dispensing with the resistance R at the ends of the two wires and providing a second two wire feeder and associated radiator system closely adjacent the first. The second system is marked with the same references as the first with prime marks affixed thereto. The two two-wire feeder and associated radiator systems are alike except that, in the second system the two wires of the feeder are directly connected together at the far end while the radiators thereof are arranged to come midway between the radiators of the first system. The two systems are fed in phase quadrature by currents of the same amplitude.

Any of the embodiments of this invention may be used for reception. In the case of a transmitter both systems in any embodiment may be energized from the same source via any suitable amplitude and phase determining circuits as known per se, while, in the case of reception, the desired conditions can be realized by suitable coupling of the two systems to a common receiver.

Having now particularly described and ascertained the nature of my said invention and in what manner the same is to be performed, I declare that what I claim is:

1. An aerial system comprising two conductor systems arranged close together so as to be tightly radiation coupled, one of said systems being directly earthed at the far end and the other being left open circuited at the far end, and means for building up on said conductor systems stationary waves of the same amplitude but with a mutual phase displacement of 90°.

2. An aerial system comprising two conductor systems arranged close together so a sto be tightly radiation coupled, one of said systems being short circuited at the far end and the other being left open circuited at the far end, and means for building up on said conductor systems stationary waves of the same amplitude but with a mutual phase displacement of 90°.

3. A system as claimed in claim 1 wherein there are two simple parallel straight wires run closely adjacent to one another, one being directly earthed at the far end and the other being left open at the far end.

4. A system as claimed in claim 1 wherein each conductor system comprises a wire which starts at a little above ground level, slopes up for half its length to a point of maximum height, and then slopes down to a little above ground level.

5. A system as claimed in claim 2 wherein each conductor system comprises two similar wires so arranged as, in plan view, to lie along the outline of a diamond shape.

6. A system as claimed in claim 2 wherein each conductor system comprises two straight, closely adjacent parallel wires provided with suitably spaced short transverse radiators, those connected to one wire projecting to one side and those connected to the other projecting to the other, each radiator connected to one wire being opposite and in the same straight line with one connected to the other.

7. An aerial system comprising a pair of parallel straight wires closely adjacent one another, whereby said wires are tightly radiation coupled, means connected to one end of said wires for energizing said wires with stationary waves of the same amplitude but with a mutual phase displacement of 90°, one of said wires being earthed at its other end.

8. An aerial system comprising a pair of parallel wires arranged in a vertical half diamond, said wires being closely adjacent one another, whereby said wires are tightly radiation coupled, means connected to one end of said wires for energizing said wires with stationary waves of the same amplitude but with a mutual phase displacement of 90°, one of said wires being earthed at its other end.

9. An aerial system comprising a pair of conductor systems arranged in a horizontal plane with their ends adjacent and their mid points separated, whereby a rhombic plan is formed, each of said conductor systems comprising a pair of closely adjacent parallel wires, means connected to one end of said wires for energizing the wires of each conductor system with stationary waves of the same amplitude, the energy in one wire of each conductor system having a phase displacement of 90° from the energy in the other wire, one wire of one conductor system being connected to a wire of the other system carrying energy of the same phase.

10. An aerial system comprising a pair of conductor systems arranged in a horizontal plane with their ends adjacent and their mid points separated, whereby a horizontal diamond antenna is formed, each of said conductor systems comprising a pair of so closely adjacent parallel wires that said wires are tightly radiation coupled, means connected to one end of said wires for energizing the wires of each conductor system with stationary waves of the same amplitude, the energy in one wire of each conductor system having a phase displacement of 90° from the energy in the other wire, one wire of one conductor system being connected to a wire of the other system carrying energy of the same phase.

OTTO BÖHM.