

July 1, 1941.

W. JACHNOW

2,247,757

ANTENNA FOR UNIDIRECTIONAL RADIATION OF RADIO WAVES

Filed May 31, 1939

Fig. 1

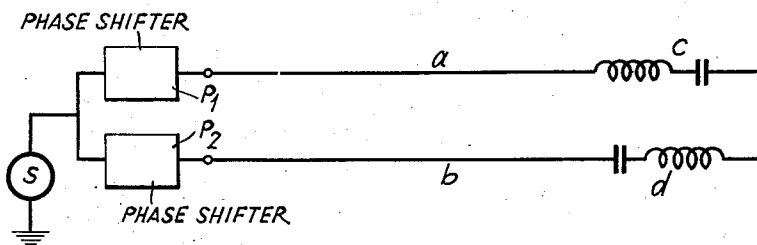


Fig. 2

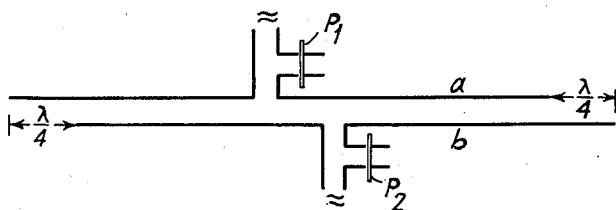
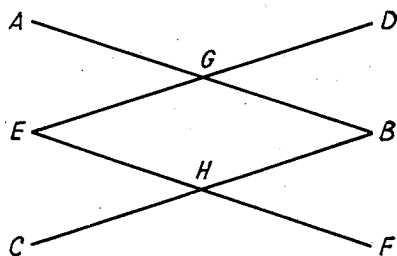


Fig. 3



INVENTOR
WALTER JACHNOW

BY

H. S. Snover
ATTORNEY

UNITED STATES PATENT OFFICE

2,247,757

ANTENNA FOR UNIDIRECTIONAL RADIATION OF RADIO WAVES

Walter Jachnow, Berlin, Germany, assignor to
Telefunken Gesellschaft für Drahtlose Tele-
graphie m. b. H., Berlin, Germany, a corpora-
tion of Germany

Application May 31, 1939, Serial No. 276,508
In Germany June 20, 1938

7 Claims. (Cl. 250—33)

For the production of unilateral directional characteristics quite a number of antenna forms have been disclosed in the art. Among these may be mentioned the Christmas tree antenna which comprises a plurality of individual radiators operated on standing waves and provided with a reflector. Antennae of this kind are rather voluminous so that for the production of very narrow beams recourse has been had to so-called "long-wire" or Beverage antennae which are fed with progressive waves. Antennae of this kind have been built in V or rhombic form.

In order to produce progressing waves upon long-wire aeriels terminating means are required which consist, for instance, of a resistance which is equal to the surge impedance of the aerial and in which such energy as reaches the end of the wire is destroyed so that no standing waves caused by reflection are able to arise. However, because of the said dissipation of energy occasioned in the termination of the aerial, the latter operates at low efficiency. Another disadvantage of long-wire aeriels is that because of the direction of propagation of the waves along the radiator which constitutes a significant direction, all of the radiators which are united to form an antenna assembly must be fed from the same end, in order that the waves in the predetermined direction may propagate over the antenna wires. In other words, contradistinct from what holds good for antennae working with standing waves, the feed point may not be placed at any desired point along the antennae. In order that radiating of the feed wires may be avoided—for this would appreciably vitiate and disturb the directional characteristic—a good many antenna arrangements, which, per se, would exhibit a satisfactory radiation diagram are impracticable because their feed points would be spaced far apart. Both these drawbacks appear to be inherent in the nature of antennae working with progressive waves.

Now, the invention discloses ways and means adapted to avoid the said shortcomings, for it is designed so as to obtain directional characteristics of a type heretofore apparently securable only with aeriels fed with progressive waves. The invention is predicated upon the notion that a progressing wave may be conceived as a superposition of two standing waves which are shifted both as regards space and time an amount equal to $\pi/2$ in relation to each other. The production of a progressive wave through the superposition of two standing waves in a phase relation of 90° as regards space and time, can be de-

duced in a very simple manner as follows: A standing wave may be identified by the expression

$$e^{j k x + j \omega t} + e^{-j k x + j \omega t} \quad (1)$$

- 5 The first quantity of this sum signifies, for instance, a wave travelling towards the right, the second quantity therefore signifies a wave travelling towards the left since the negative sign is applied to the space exponent $j k x$. In these formulae a phase displacement of 90° simply denotes a multiplication with j and $-j$ respectively, depending on whether the displacement takes place in the direction of the propagation of the wave, or in the direction opposite thereto. A wave which is displaced towards the right by 90° as regards space, hence, is given by the expression:

$$j e^{j k x + j \omega t} - j e^{-j k x + j \omega t} \quad (2)$$

- 20 A phase displacement by 90° as regards time in the positive direction of the time likewise denotes a multiplication with j . Hence, when multiplying the Expression 2 with j , a wave is obtained which is displaced in phase by 90° as regards space as well as time. The expression is:

$$-e^{j k x + j \omega t} + e^{-j k x + j \omega t} \quad (3)$$

In adding the Expressions 1 and 3, i. e., therefore, the original standing wave and the wave displaced in phase as regards space and time by 90° there will be:

$$e^{j k x + j \omega t} + e^{-j k x + j \omega t} + (-e^{j k x + j \omega t} + e^{-j k x + j \omega t}) \quad (4)$$

- 35 This is a travelling wave as can be readily seen. Hence, according to the invention a long-wire radiator is replaced by two parallel radiators placed in close proximity to each other and fed with standing waves. The currents on the two radiators are displaced in space an angle $\pi/2$ in reference to each other. This space shift preferably is insured by suitable impedances at the line end, thus shifting the current of one of the radiators an amount equal to $\lambda/8$ to the left and that of the other radiator by $\lambda/8$ to the right, as compared with a joint reference point. The time phase is insured by phase shifters of which quite a number of types are known in the prior art.

The invention will be more fully understood by reference to the following detailed description in which Figure 1 illustrates one form of the present invention; Figure 2 illustrates another form and Figure 3 an application of the invention to V antennae.

Figure 1 fundamentally shows the arrange-

ment of an individual radiator according to the invention. It comprises two wires *a* and *b* stretched out adjacent to each other. They are fed from a joint source *S* by way of the two phase shifter means *P*₁ and *P*₂. The phase shifters are so adjusted that there results a time phase shift equal to $\pi/2$ in the two wires *a* and *b*. At the ends of the wires *a* and *b* are means *c* and *d* which, for instance, may consist of suitable combinations of inductances and capacities. As a result the space phase on the two wires is shifted an amount equal to $\pi/2$ in relation to each other. The same effect is also obtained if one wire is made $\lambda/4$ longer than the other wire.

There is no need to feed the radiators from the end. In fact, they may be fed also at will in the middle or at some other suitable terminating point. An instance is shown in Figure 2. The two individual wires *a* and *b* are here staggered in relation to each other a distance $\lambda/4$. They are fed in their centers. For adjustment of the time phase shift by-pass leads *P*₁ and *P*₂ are here provided. By suitable adjustment of *P*₁ and *P*₂ the two wires *a* and *b* can be so fed that on the whole there will be set up on the arrangement at will a wave progressing from right to left or from left to right.

Individual radiators of the kind hereinbefore disclosed are eminently suited for the building of directional antennae fed with progressing waves of a form shown, for instance, in Figure 3 by two inter-crossing V-antennae.

An arrangement shown in Figure 3 exhibits, for progressing waves, a directional diagram which is superior to that of the plain rhombus aerial. However, attempts to carry such an antenna arrangement into practice heretofore have been defeated by the problem of feeding. Inasmuch as for the production of the desired directional characteristics the direction of propagation of the waves in all wires must be the same, it would be necessary to feed one of the V-antennae from its two outer ends, and in this case the feeder leads would vitiate the directional characteristic because of their radiation. If one of the V-aerials, say, ABC is fed at point B, then the other V-aerial DEF must be fed at the two points marked D and F. This is impracticable. But if double wires fed with standing waves according to the invention are substituted for the individual or unitary wires of the V-aerial then the antennae may be fed at any desired points at all, for example, at points E and B, or at points G and H. The lead brought to the feeder points may consist of symmetric double wires so that stray radiation of the feeder leads is avoided. A special advantage of an antenna thus built is that by variation of the phase relation between the long wires forming the individual radiators, the directional characteristic can be altered. Hence, an antenna as shown in Figure 3 is adapted to radiate both to the right as well as the left-hand side. Another merit is that different wavelengths may be used for the antenna without the directional diagram undergoing any substantial changes, if a suitable change is made in the phase shifters.

It will be understood that the invention is not limited to the exemplified embodiments here shown; in fact, a great many other antenna forms are conceivable which, when fed with progressing waves have not been practicable because of the difficulties attendant upon the feeding as before pointed out. Neither is the invention restricted to sending aerials, for it could

just as readily be employed to practical advantage for receiving aerials.

I claim:

1. Antenna for unilateral radiation of radio waves, with the characteristic feature that the individual radiators consist of two long parallel wires, said wires being axially displaced with respect to one another a distance equal to a quarter of the length of the operating wave, each wire being separately fed with standing waves of like amplitude, the current in both wires being shifted in time phase relative to each other an amount equal to $\pi/2$, said wires being so closely spaced as to radiate as a single wire.

2. A wave antenna comprising a pair of long wires arranged closely adjacent one another, said wires being axially displaced with respect to one another a distance equal to a quarter of the length of the operating wave, and means for energizing said wires with high frequency energy, the current in said wires being shifted in time phase 90 degrees in relation to each other, said wires being so closely spaced as to radiate as a single wire.

3. A wave antenna comprising a pair of long wires arranged closely adjacent one another, said wires being axially displaced with respect to one another a distance equal to a quarter of the length of the operating wave, and means for energizing said wires with high frequency energy, the current in said wires being shifted in time phase 90 degrees in relation to each other, said means for energizing said wires being connected thereto at points intermediate their ends, said wires being so closely spaced as to radiate as a single wire.

4. A V antenna comprising a plurality of long radiating elements disposed in a horizontal plane and at an angle to each other, each of said elements comprising a pair of long wires arranged closely adjacent one another, said wires being axially displaced with respect to one another a distance equal to a quarter of the length of the operating wave, and means for energizing said wires with high frequency energy, the current in said wires being shifted in time phase 90 degrees in relation to each other, said wires being so closely spaced as to radiate as a single wire.

5. A double V antenna comprising a plurality of pairs of radiating elements arranged in adjacent horizontal planes, the elements of said pairs forming an angle with respect to each other, each of said elements comprising a pair of long wires arranged closely adjacent one another, said wires being axially displaced with respect to one another a distance equal to a quarter of the length of the operating wave, and means for energizing said wires with high frequency energy, the current in said wires being shifted in time phase 90 degrees in relation to each other, said wires being so closely spaced as to radiate as a single wire, the means for energizing said wires being connected at the apex of one of said angles and at the open end of the other of said angles.

6. A wave antenna comprising a pair of long wires arranged closely adjacent one another, said wires being axially displaced with respect to one another a distance equal to a quarter of the length of the operating wave, a transmission line connected to each of said wires at points intermediate their ends, each of said transmission lines having means therein for separately adjusting the phase of energy supplied to said wires to a mutual phase quadrature relationship, said

wires being so closely spaced as to radiate as a single wire.

7. A wave antenna comprising a pair of long wires arranged closely adjacent one another, said wires being axially displaced with respect to one another a distance equal to a quarter of the length of the operating wave, and means for energizing said wires with high frequency energy,

the current in said wires being shifted in time phase relative to each other 90 degrees, said means for energizing said wires being connected thereto at points near their centers, said wires being so closely spaced as to radiate as a single wire.

WALTER JACHNOW.