Sept. 1, 1931.

H. O. PETERSON

1,821,402

ANTENNA

Filed Nov. 8, 1927

2 Sheets-Sheet 1

Fig. 1

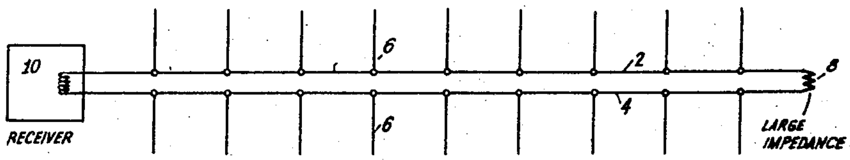

Fig. 2

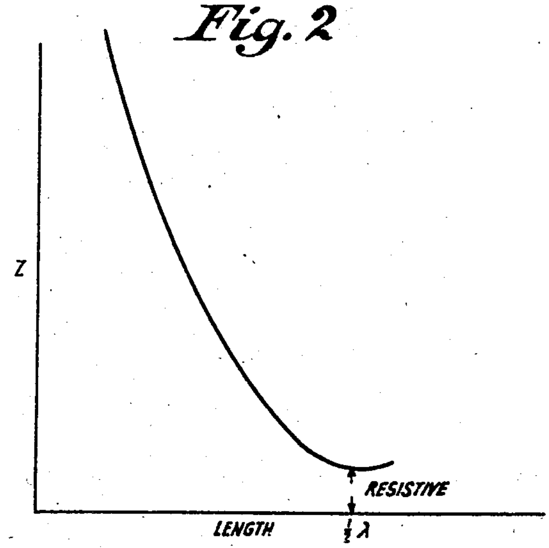

Fig. 3

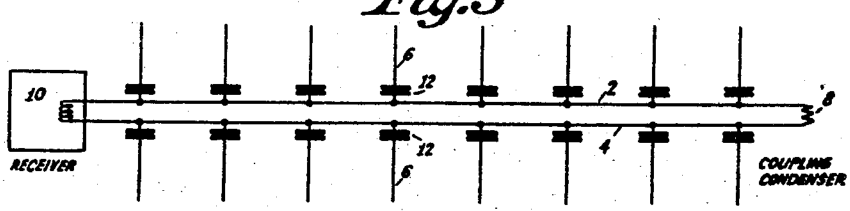

Fig. 4

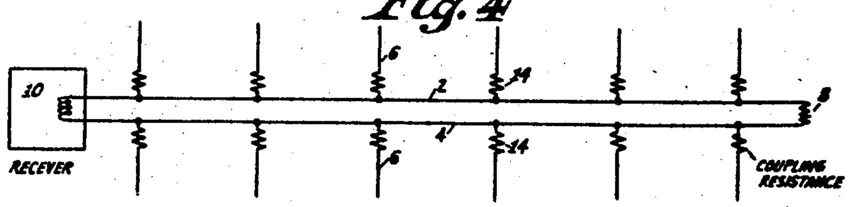

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Fig. 5

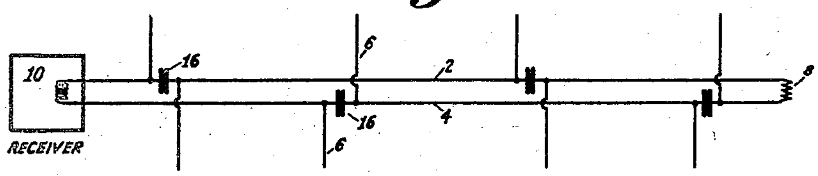


Fig. 6

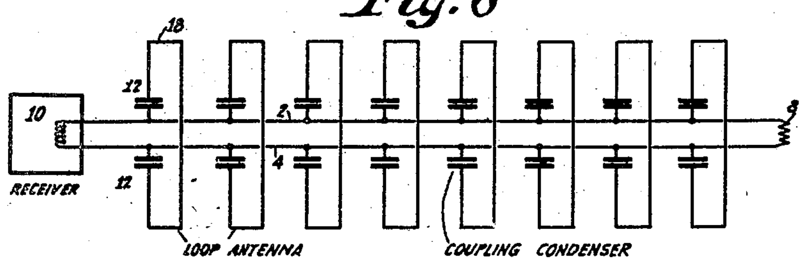


Fig. 7

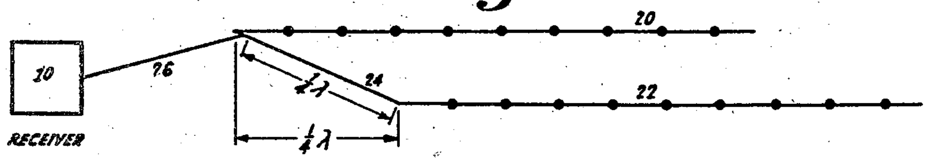
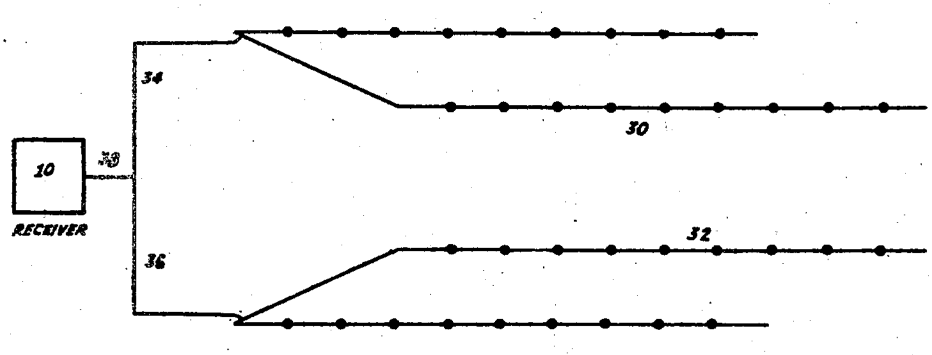


Fig. 8



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Patented Sept. 1, 1931 **1,821,402**

UNITED STATES PATENT OFFICE

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ANTENNA

Application filed November 8, 1927. Serial No. 231,804.

This invention relates to antennæ for the reception of radiant energy, and more particularly to directive antennæ for the reception of signals transmitted on very short waves.

A favored type of directive receiving antenna is the wave antenna invented by H. H. Beverage, but the ordinary wave antenna is not suitable for the reception of short wave energy. The difficulty seems to be that the great reduction in the horizontal length of the antenna at short wave lengths, makes the horizontal length become comparable with the vertical height above ground, as a result of which the ordinary nondirectional antenna effect becomes comparable with the directive or cumulative antenna effect, and thereby greatly distorts the directive characteristics of the antenna.

To overcome this difficulty Clarence W. Hansell, in a copending application Serial Number 161,171, filed Jan. 18, 1927, suggested the use of a special form of wave antenna comprising two wires a plurality of waves long, spaced about a half wave apart, and extending in the direction of desired reception, with a large number of doublets or half wave antennæ coupled transversely between the longitudinal wires or feeder members. I have found that by a simple change in construction I can greatly improve the operation of such an antenna, and to so do is one object of my invention.

The energy in the transverse pickup units is applied to the feeder members at phase displacements approximating those of the wave travelling in space, and therefore in order that the energy shall add cumulatively in proper phase, it is necessary that the velocity on the feeder members be substantially equal to that of the wave in space. An ordinary transmission line will transfer energy at a velocity very closely approximating that of a wave in space, but the addition of distributed transverse impedance to such a line will cause it to have a lower velocity. The transverse pickup units, if tuned, load the line as resistances of relatively small value, and therefore greatly lower the velocity on the loaded line relative to that of light.

In the application of Clarence W. Hansell already referred to, it was suggested to overcome this difficulty by suitably tuning the line for increased velocity. I find that a much simpler way to accomplish the same result is to use pickup units of high impedance, or to loosely couple the units to the feeder members through high impedances, and to employ relatively closely spaced feeder members. The impedance of the pickup wires may be increased by making them shorter than a half wave in length, so that they are not tuned, and they are coupled externally of the feeder members, rather than between them. With this arrangement an antenna only a wave in length is markedly directive, though antennæ two or three waves in length may be used conveniently, and give even better directivity and pickup.

The facts that the feeder members, being closely spaced, do not themselves pick up received energy, that the surge impedance later referred to is in the form of an ohmic resistance, and that the transverse pickup means are untuned, being different in length from a true half wave, result in that the antenna may efficiently receive an appreciable band of frequencies, that is, the antenna is not critically tuned. This result is desirable, and to make possible the reception of an even greater band of wave lengths is another object of my invention. For this purpose I find it desirable to limit the loading which the transverse pickup means apply to the feeder members by means other than the reduction in length of the transverse doublets, for the proportional reduction in length for a given transversal varies rapidly relative to a change in wave length. I therefore couple the pickup means to the feeder members through limiting impedances, which may preferably take the form of small series condensers. By loosely coupling the pickup wires to the feeder members in this manner they have less effect upon the line velocity, and their effect remains small in spite of appreciably large variations in the length of the received wave.

It is also an object of this invention to make the antenna unilateral in directivity, which I do by closing the end of the feed line nearest the desired transmission station with a resistance equal to the surge impedance of the line, which absorbs energy approaching from the opposite direction, and thereby prevents its reflection back to the receiver coupled to the other end of the feed line. The damping impedance is equal to the surge impedance of the transmission line as loaded by the pickup devices.

The surge resistance at the end of the feeder members fairly effectively prevents pickup of signals coming from a direction opposite to that desired, but back end residuals will nevertheless occur, just as in the case of a long wave wave antenna. To obviate these I use a plurality of antennæ located in broadside and displaced an odd number of quarter wave lengths, relative to the wave front of the approaching wave, so that the resulting phase opposition caused by unsymmetrical coupling neutralizes the undesired signals, as will be explained in more detail later.

A still further object of my invention is to increase the sharpness of directivity of such an antenna system, which I do by employing a plurality of end-on antennæ, or of staggered pairs of antennæ, such as have already been described, positioned relatively in broadside, and coupled together by symmetrically branched transmission lines.

The invention is more completely described in the following specification, accompanied by drawings in which

Figure 1 represents an antenna embodying my invention in a simple form;

Figure 2 is a curve showing the effect of the length of a transversal on its impedance;

Figure 3 illustrates the use of coupling condensers;

Figure 4 illustrates the use of coupling resistances;

Figure 5 is a modification in which the pickup means are connected in series, rather than in parallel;

Figure 6 shows loop antennæ instead of simple transverse wires for the pickup means.

Figure 7 shows a staggered pair of antennæ; and

Figure 8 shows a broadside combination of staggered pairs of antennæ.

Referring to Figure 1 it will be seen that there is a pair of linear feeder members 2 and 4, to which there are coupled transverse pickup wires 6. The feeder members alone would transfer energy at a velocity almost equal to that of light. However, with transverse impedances connected across the line the velocity is reduced.

In Figure 2 the impedance of a transversal is shown as a function of its length. It is seen that at a half wave length the impedance is low and is resistive, the transversal being tuned. This is a condition in which the transversals most greatly reduce the desired high feed line velocity. By shortening the doublets their impedance is greatly increased, and their effect on the line velocity may be brought within allowable limits. Hence in Figure 1 the length of each transverse wire is substantially less than a half wave length.

The feeder members need be only approximately a wave in length and a good directive pattern will be obtained. But a length of two or three waves adds to the directivity and the pickup, and therefore is preferable. However, this leads to the necessity for higher line velocities, for while a velocity of about 80 percent, relative to light, is sufficient when the feeder members are only one wave long, velocities of about 90 to 95 percent are respectively needed for antennæ, three to six waves long, if the energies of the pickup wires at the remote end of the antenna are to add, rather than oppose, the line energy.

The end towards the transmitter is closed by a resistance 8, equal to the surge impedance of the feeder members, considered as a loaded transmission line, while the end remote from the transmitter is coupled to a suitable receiver 10.

In Figure 3 the arrangement is similar to that shown in Figure 1 except that the transverse pickup wires 6 have been coupled to the feeder members 2 and 4 by small series coupling condensers 12. By their use the transversals are loosely coupled to the feeder members, so that the effective loading is reduced. For this reason the transversals need not be shortened so much, or from another and more practical view point, for a given length of transversal the antenna is suitable for a greater band of applied frequencies.

Figure 4 is similar to Figure 3 except that in place of the coupling condensers 12 there have been used coupling resistances 14.

In Figure 5 I have shown a modification designed to add the potential pickup of the various transversals in series, rather than in parallel, and for this purpose the two halves of the transversal are connected on either side of a series condenser 16 to one or the other of the feeder members. By this arrangement the coupling condensers are in series with the line, and tend to increase its velocity.

So far I have assumed that the pickup means are simple transverse wires, but the same principle, namely, the limiting or reduction of the effect of the individual pickup means on the velocity characteristics of the feeder members, may equally well be applied to other types of pickup means, exemplified by the loop antennæ 18 in Figure 5. These are loosely coupled to the feeder members 2 and 4 through small coupling condensers 12.

It has already been pointed out that in spite of the surge resistance 8 some residual back end pickup may be noted at the receiver. To completely obviate this I may resort to the arrangement shown in Figure 7 in which the pair of antennæ 20 and 22, arranged relatively in broadside but only about a tenth of a wave apart, are displaced a quarter wave length relative to the wave front of the approaching wave. The feeder members have negligible pickup, because of their close juxtaposition, and similarly the collecting transmission line 24 has negligible pickup, but there is a phase displacement in quadrature taking place across a quarter wave of its length, and therefore signals approaching from the desired direction combine in phase at the transmission line 26, for it is connected to the mid point of the remaining portion of the line 24, and the sum of the signals is applied to the receiver 10. However, energy travelling in the opposite direction reaches corresponding portions of the antennæ at a quarter wave apart in phase, and the energy from the antenna 22 experiences another quarter wave displacement in traversing the extra quarter wave length of the transmission line 24, hence the energies combine at a phase displacement of 180°, and neutralize one another. While the neutralization of residuals is perfect at only one wave length, the staggered pair of antennæ is equally good for desired signals over a full band of wave lengths, inasmuch as the signals are always combined in phase.

Figure 8 is a broadside array of staggered pairs of antennæ. The pair 30 and the pair 32 are each arranged as was the staggered pair in Figure 7, and their outputs are combined in phase by a symmetrically branched system of transmission lines comprising the lines 34, 36 and 38, the latter of which leads to a receiver 10.

I claim:

1. A directive receiving antenna for short waves comprising a pair of feeder members and a plurality of transverse pickup wires coupled to the feeder members, said pickup wires being substantially smaller than a half wave in length in order to detune them and to limit their effect on the velocity of energy transfer on the feeder members.

2. A directive receiving antenna for short waves comprising a pair of relatively closely spaced feeder members and a plurality of transverse pickup wires externally coupled to the feeder members, said pickup wires being substantially smaller than a half wave in length in order to detune them and to limit their effect on the velocity of energy transfer on the feeder members.

3. A directive receiving antenna for short waves comprising a pair of relatively closely spaced feeder members extending in the direction of desired reception and a plurality of transverse pickup wires externally coupled to the feeder members, said pickup wires being substantially smaller than a half wave in length in order to detune them and to limit their effect on the velocity of energy transfer on the feeder members.

4. A directive receiving antenna for short waves comprising a pair of relatively closely spaced feeder members extending in the direction of desired reception, a plurality of transverse pickup means arranged externally of the feeder members, and relatively high impedances loosely coupling the pickup wires to the feeder members in order to limit the effect of the impedance of the pickup means on the velocity of energy transfer on the feeder members.

5. A directive receiving antenna for short waves comprising a pair of relatively closely spaced feeder members extending in the direction of desired reception, a plurality of transverse pickup means arranged externally of the feeder members, and small condensers coupling the pickup means to the feeder members in order to limit the effect of the impedance of the pickup means on the velocity of energy transfer on the feeder members.

6. A directive receiving antenna for short waves comprising a pair of relatively closely spaced feeder members extending in the direction of desired reception, a plurality of transverse pickup means externally coupled to the feeder members, and a resistance equal to the surge impedance of the system connected across the end of the feeder members nearer the desired transmission station.

7. A directive receiving antenna for short waves comprising a pair of relatively closely spaced feeder members extending in the direction of desired reception, a plurality of pickup wires transversely and externally positioned relative to the feeder members, a plurality of impedances loosely coupling the pickup wires to the feeder members, and a resistance equal to the surge impedance of the system connected across the feeder members at the end nearer the desired transmission station.

8. A directive receiving antenna for short waves comprising a plurality of pairs of relatively closely spaced feeder members each extending in the direction of desired reception and located relatively in broadside, a plurality of transverse pickup means externally coupled to the feeder members, said pickup means being detuned to limit their effect on the velocity of energy transfer on the feeder members and a transmission line system interconnecting the feeder members in proper relation to combine their energies cophasially.

9. A unilaterally directive receiving antenna for the reception of short waves comprising a pair of relatively closely spaced feeder members each extending in the direction of desired reception and located relatively cosely in broadside but staggered an odd number of quarter wave lengths relative

to the wave front of an approaching wave, a plurality of transverse pickup means externally coupled to the feeder members, and means for combining the energies of the feeder members cophasially with respect to energy approaching from the desired direction, whereby reflected energy pickup from energy travelling in the opposite direction is combined in phase opposition.

10. A unilaterally directive receiving antenna for the reception of short waves comprising a pair of relatively closely spaced feeder members each extending in the direction of desired reception and located relatively in broadside but staggered a quarter wave length relative to the wave front of an approaching wave, a plurality of transverse pickup means externally coupled to the feeder members, a collecting transmission line connecting the ends of the feeder members remote from the desired transmission station, a receiver, and a transmission line unsymmetrically coupling the receiver to the collecting transmission line in order to introduce a quarter wave change in phase.

11. A unilaterally directive receiving antenna for the reception of short waves comprising a plurality of staggered pairs of antennæ located in broadside, each pair of antennæ comprising a plurality of pairs of relatively closely spaced feeder members extending in the direction of desired reception, and located relatively in broadside but staggered an odd number of quarter wave lengths relative to the wave front of an approaching wave, a plurality of transverse pickup means externally coupled to the feeder members, means for combining the energies of the feeder members in each pair of antennæ cophasially with respect to energy coming from the desired direction, whereby reflected energy pickup from energy travelling in the opposite direction is neutralized, and means for combining the energies from all of the pairs of antennæ in proper phase for utilization in a receiver.

12. An extensive antenna system for receiving electromagnetic waves comprising closely spaced, substantially linear feeder members and transverse pick-up conductors symmetrically coupled thereto through series resistances.

13. An extensive antenna system for receiving electromagnetic waves comprising closely spaced, substantially linear feeder members and a plurality of pick-up conductors transversely, externally and symmetrically coupled thereto through series resistances.

14. An extensive antenna receiving system comprising feeder members and a plurality of conductive pick-up elements transversely and externally coupled thereto through series limiting impedances.

15. A directive antenna system for receiving electromagnetic waves comprising a two conductor transmission line linear throughout its length, a plurality of linear pick-up elements parallel to each other arranged in one plane, a limiting impedance for connecting each of said elements externally to one of said conductors, another plurality of pick-up elements parallel to each other and arranged in the same plane as the plane of said first mentioned plurality of elements, and, an impedance, in series with each of said elements of said second mentioned plurality for connecting each of said elements to the other conductor of said line.

16. A directive receiving antenna for short waves comprising a pair of relatively closely spaced conductors linear and continuously conductive throughout their length forming a transmission line extending in the direction of desired reception, a plurality of linear pick-up elements externally coupled to one of said conductors, all of the said pick-up elements being parallel and lying in one plane, another plurality of linear pick-up elements parallel to each other lying in the same plane as said first mentioned plurality of elements, coupled to the other conductor of said line, and, an impedance, equal to the surge impedance of the system connected across the end of the transmission line nearer the desired transmission station.

17. A receiving system as defined in claim 16 characterized by the additional feature that each of the pick-up elements is coupled to its linear conductor through a series impedance.

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