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RADIO SIGNALING SYSTEM

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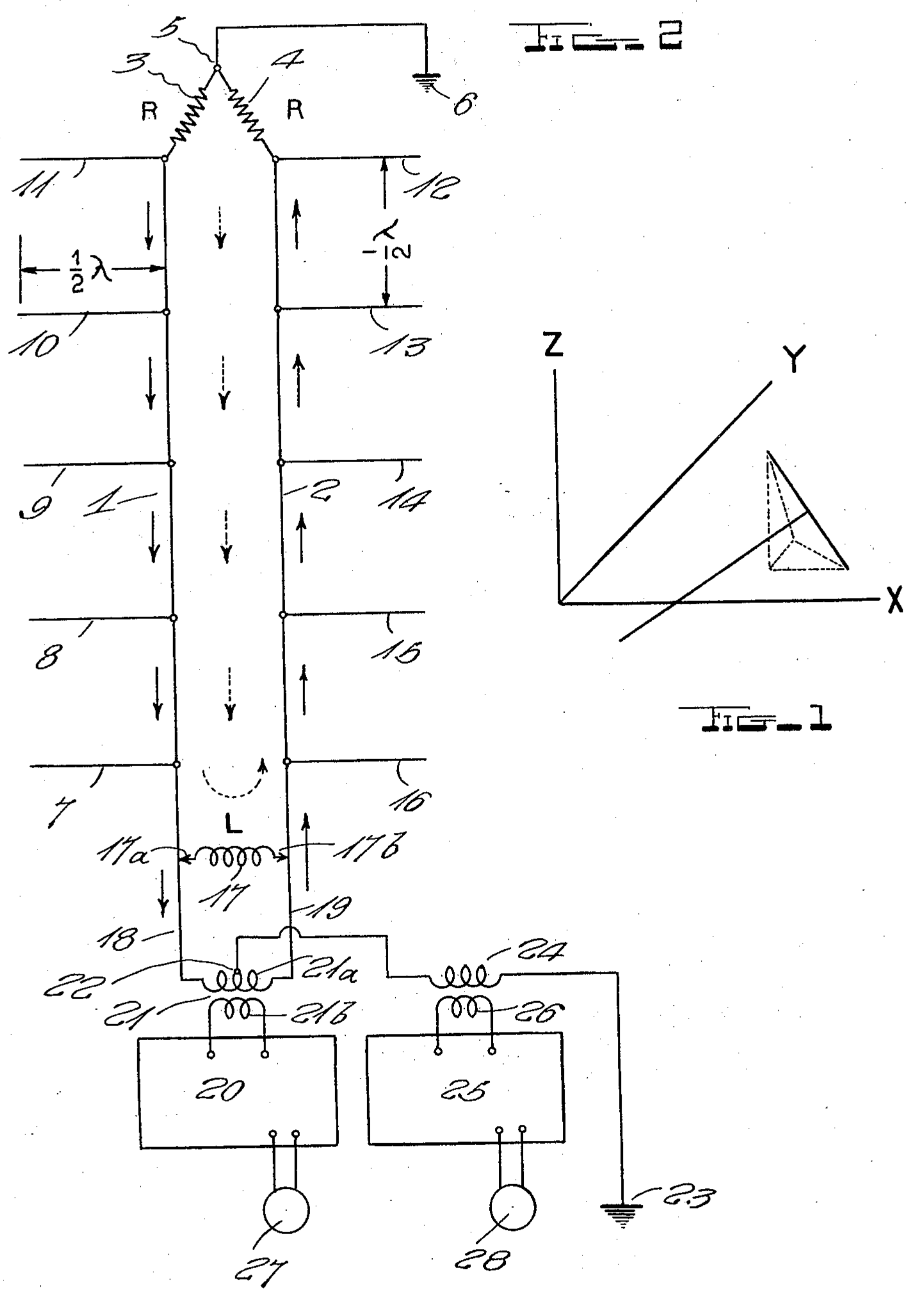


FIG. 2



FIG. 1

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# UNITED STATES PATENT OFFICE

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## RADIO SIGNALING SYSTEM

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My invention relates broadly to radio signaling systems and more particularly to a high frequency radio receiving system having means for reducing the effects of fading.

One of the objects of my invention is to provide a radio receiving circuit adapted to simultaneously receive signaling energy in a multiplicity of planes of polarization for avoiding the effects of fading in radio communication.

Another object of my invention is to provide a signal receiving system having means responsive to received signaling energy independently of the variation in receiving conditions under the effect of fadng for uniformly receiving the signaling energy.

A further object of my invention is to provide a receiving system having radio frequency energy collectors extending in a plurality of directions for intercepting the transmitted energy in differing planes of polarization and impressing the received energy upon a multiplicity of receiving circuits for the reception of signaling energy uniformly and without regard to the effects of fading.

A still further object of my invention is to provide an arrangement of receiving circuit for the simultaneous reception and integration of signaling energy received in shifting planes of polarization for rendering the resultant signaling energy effective upon a multiplicity of receiving circuits.

Other and further objects of my invention reside in the circuit arrangement for a receiving system for avoiding the effects of fading in radio communication as set forth more fully in the specification hereinafter following by reference to the accompanying drawing, in which:

Figure 1 is a space vector system illustrating the principles of my invention and Fig. 2 diagrammatically shows the circuit arrangement of the receiving system of my invention.

I have observed that signals received on nearby but differently arranged antennæ or on similarly arranged but somewhat separated antennæ do not fade in synchronism. There are three general causes of fading: first, a shifting of the plane of polarization of the received signal; second, a variation of interference pattern between differently refracted rays from the same station source when these rays arrive coincidently at the receiving antenna; and third, varying changes in absorption conditions. It is difficult to say which of these causes is the most important but it does seem likely that the first two are predominant and of about equal importance.

Heretofore a combination of differently spaced and arranged antennæ have been employed for the purpose of reducing fading effects. My invention employs a single network which is capable of receiving and isolating signals of two different types of polarization, which two types will not fade out synchronously.

Referring to Fig. 1, a space vector system is shown wherein the Z-axis extends in the vertical direction with the mutually perpendicular axes X and Y disposed in the horizontal direction with the X-axis pointing from the receiver towards the transmitting station. The electric force arriving at the receiving location at any instant of time may be represented by a vector which in general does not coincide with any axis and has projections shown by the dotted lines along all three of these axes. The direction of progress of the wave front is indicated by the solid line drawn perpendicular to the vector. This line will in general be inclined towards horizontal direction X but in the X Z plane. The reason this line is inclined is because in general high frequency signals are reflected from the Kennelly-Heaviside layer making an angle intermediate between vertical and horizontal. The higher the frequency the more likely the wave fronts of the signals are to be nearer the horizontal. It will be seen therefore that in general the electric force of the signal has components along all three of the principal directions X, Y and Z and that if the plane of polarization of the signal is continually shifted, the relative values of these three components will be correspondingly shifted.

Fig. 2 shows a system consisting of two parallel conductors 1 and 2 which may be several wave lengths in length connected through resistances 3 and 4 at the end towards the transmitting station, with the center 5 of these resistances grounded as shown at 6. At half wave length intervals along these two wires 1 and 2 are connected lateral wires 7, 8, 9, 10, 11, 12, 13, 14, 15 and 16 in the Y direction, which are adjusted to be one-half wave length in length, that is, one half of the wave length of the wave which is being received. The lateral conductors may also be spaced by odd multiples of half a wave length. The bridging inductance shown at 17 near the receiver is for the purpose of adjusting the impedance of the transmission line system indicated at 18 and 19. The inductance 17 is shiftable along the transmission line 18 and 19 by slidable taps shown at 17*a* and 17*b*. The transmission line then runs in the direction X while the lateral conductors will be considered as running in the direction Y. A receiver 20 is coupled to the end of the transmission line 18 and 19 by means of coupling transformer 21. Now the horizontal Y component of the downcoming wave will not work at all on the transmission lines 18 and 19 which run in the X direction but it will work on the half wave length lateral conductors 7–16 inclusive which feed their energy to the transmission lines 18 and 19, establishing waves thereon which will be built up or improved in value by consecutive pairs of half wave length elements. This results in a flow of high frequency wave currents in the transmission line system so that the receiver 20 receives and operates on the energy of this horizontal Y component of signal. For this method of operation the phases of the two sides in the transmission lines 18 and 19 are always opposite as indicated by the arrows adjacent each transmission line wire. The system is directive in the X direction. In the meantime, however, currents of similar phase are set up in the transmission wires 18 and 19 themselves due to the X component of the signal which will act equally on both wires. These currents are tapped off at the midpoint or nodal point 22 of the primary inductance 21*a* at the receiver end of the transmission lines 18 and 19 and brought to ground 23 through another inductance 24 which may be coupled to a second receiver 25.

It is clear then that the transmission lines 18 and 19 themselves will collect the X component and will deliver it to the receiver 25 on the way to the ground 23 through coupling coil 24 and that this system also will be directive in the direction X. It will be observed that since the center 22 of the inductance 21*a* across the receiver end of the transmission lines is a neutral point the wave energy due to the Y component will not be led into receiver 25. Also, since the surge currents in the direction X are of the same phase in each transmission wire 18 and 19, as indicated by the dotted arrows in the center, the X component signals will cancel out in the coupling 21*a*—21*b* to receiver 20. It may therefore be observed that the receiver 20 responds to the Y component and the receiver 25 to the X component of the signal. It has been definitely proved that these two components do not fade simultaneously, it more often being the case that as the plane of polarization rotates, so as to reduce the Y component, it at the same time increases the X component. The presence of the lateral conductors 7–16 is what makes it possible to receive the Y component at all, and the X component being at right angles to them does not set up currents therein but only in those wires which run in the X direction; namely, the transmission line itself. It is also clear that the system may be rotated 90° about the X axis. In other words, the lateral conductors may be made to run in the Z direction just as readily as in the Y direction. In this case the receiver 20 will respond to the vertical or Z component of the signal whereas the receiver 25 will still respond to the X component.

Operation of the system of my invention shows that there is quite a distinct gain as far as fading is concerned by the use of two such receivers, the operator wearing a single telephone 27 connected with the output of receiver 20 on the left ear and a single telephone 28 connected with the receiver 25 on the right ear. Of course an apparent binaural effect is present; that is, when differential fading occurs the signal seems to wander in front of the operator from right to left and vice versa but the signal does not fade out as frequently as it does with systems heretofore used whether receiving X, Y or Z component.

A still further benefit may be obtained as far as fading is concerned, by using one of these systems directive in the X or signal direction and responsive to the X and Z components, together with another system working on the vertical components, but this is only applicable to automatic recording and not to aural reception which is limited by the ability of the operator to listen to the output of only two telephones.

While I have described my invention in one of its preferred embodiments I desire that it be understood that modifications may be made and that no limitations upon my invention are intended other than are imposed by the scope of the appended claims.

What I claim as new and desire to secure by Letters Patent of the United States is as follows:

1. In a signal receiving system, a radio frequency energy collecting system comprising a pair of longitudinally extending conductors, a plurality of laterally extending conductors connected to each of said longitudinal conductors at spaced intervals along the length thereof and projecting normal thereto, said laterally projecting conductors being spaced a distance apart equal to substantially one-half of the received wave length, a primary inductance disposed in series with said longitudinally extending conductors, a receiving circuit coupled with said primary inductance, a connection between a nodal point in said primary inductance and through an independent primary inductance to ground, a separate receiving circuit coupled with said independent primary inductance, and means connected with each of said receiving circuits for integrating the effects of the received signaling energy of said conductors in shifting planes of polarization.

2. In a signal receiving system, a pair of longitudinally extending conductors, a primary inductance connected in series between said conductors, impedance elements connected to the opposite ends of said conductors and connected to ground, a multiplicity of laterally extending conductors connected at one-half wave length intervals along said longitudinally extending conductors, separate receiving circuits connected with said conductors and means connecting the outputs of said receiving circuits for integrating the effects of the received energy intercepted by said laterally and longitudinally extended conductors in shifting planes of polarization.

3. In a signal receiving system, an antenna comprising a pair of longitudinally extending conductors, a primary inductance connected in series between said conductors, impedance elements connected to the ends of said conductors and connected to ground, laterally extending conductors connected at one-half wave length intervals along said longitudinally extending conductors, a receiving circuit coupled to said primary inductance, a separate receiving circuit, means connecting said separate receiving circuit between a nodal point in said primary inductance and the ground, and means connected with the outputs of each of said receiving circuits for integrating the effects of signaling energy intercepted by each of said conductors in shifting planes of polarization.

4. In a signal receiving system, an antenna comprising a pair of parallel extending conductors, a primary inductance connected in series between said conductors and connected to ground, laterally extending conductors connected at one-half wave length intervals along said parallel extending conductors, a receiving circuit coupled to said primary inductance, a separate receiving circuit, means connecting said separate receiving circuit between a nodal point in said primary inductance and the ground, a bridging impedance adjustable to selected positions along said parallel extending conductors, and means connected with the outputs of each of said receiving circuits for integrating the effects of signaling energy intercepted by each of said conductors in shifting planes of polarization.

5. In a signal receiving system, a pair of substantially parallel primary conductors, a plurality of auxiliary conductors extending normally from each of said parallel primary conductors at spaced intervals equal to substantially half of the received wave length, the auxiliary conductors of one of said primary conductors extending from their primary conductor opposite to the direction in which the auxiliary conductors of the other of said primary conductors extend from their primary conductor, circuit elements connecting together the adjacent ends of said primary conductors, a pair of receiving units, means for electrically relating one of said receiving units with said primary conductors for actuation by the difference of the currents flowing in said parallel primary conductors in the same direction, means for electrically relating the other of said receiving units with said primary conductors for actuation by the sum of the currents in said parallel primary conductors flowing in the same direction, whereby one of said receiving units is actuated by energy absorbed by said auxiliary conductors and the other of said receiving units is actuated by energy absorbed by said primary conductors.

6. In a signal receiving system, a pair of substantially parallel primary conductors, a plurality of auxiliary conductors extending normally from each of said parallel primary conductors at spaced intervals equal to substantially half of the received wave length, the auxiliary conductors of one of said primary conductors extending from their primary conductor opposite to the direction in which the auxiliary conductors of the other of said primary conductors extend from their primary conductor, said auxiliary conductors being equal in length to substantially half of the wave length of the received wave, circuit elements connecting together the adjacent ends of said primary conductors, a pair of receiving units, means for electrically relating one of said receiving units with said primary conductors for actuation by the difference of the currents flowing in said parallel primary conductors in the same

direction, means for electrically relating the other of said receiving units with said primary conductors for actuation by the sum of the currents in said parallel primary conductors flowing in the same direction, whereby one of said receiving units is actuated by energy absorbed by said auxiliary conductors and the other of said receiving units is actuated by energy absorbed by said primary conductors.

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