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RADIO COMMUNICATION SYSTEM

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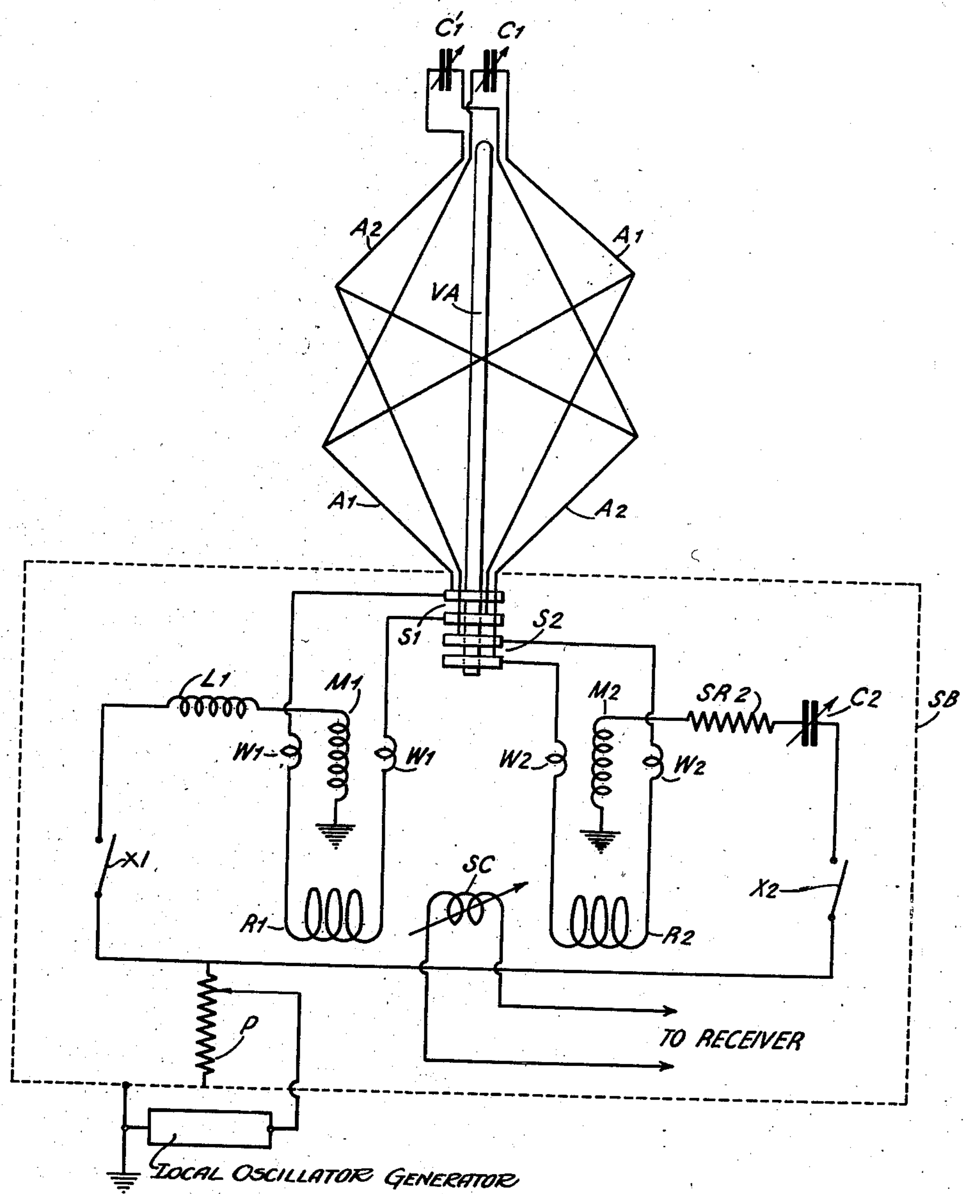

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RADIO COMMUNICATION SYSTEM

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This invention relates to radio communication systems and has for its object to provide apparatus whereby the effects commonly known as fading may be eliminated or at any rate reduced to a large extent.

Experiments appear to indicate that when a ray from a wireless transmitter, e. g., a broadcast transmitter, penetrates the so-called Kennelly-Heaviside layer, it is in effect divided into two rays which travel along different paths with different velocities and attenuations, the two rays into which the layer divides the incident ray being differently polarized, one being right hand elliptically or circularly polarized and the other being left hand elliptically or circularly polarized. There are theoretical and experimental reasons for supposing that the right hand polarized ray is much more attenuated than the left hand one so that, practically speaking, the latter may be regarded as the surviving reflected ray. The directions of polarization are reversed in the Southern Hemisphere. In addition to the rays which are reflected from the Kennelly-Heaviside layer there is, of course, the direct ray which, in the case of a normal transmitting aerial, such as is used for broadcasting purposes, is vertically polarized. Fading is largely, if not entirely, due to variations in received strength of energy which has reached the receiving point by reflection, i. e., not directly.

The principle of this invention, as applied to a receiving station, consists in picking up energy which has reached the receiving station from the transmitter directly and energy which has reached the said station by reflection by means of a double aerial system which is so arranged and connected with a receiver apparatus proper that the voltages from each aerial of the system and due to the incident right hand (or left hand) circularly or elliptically polarized rays substantially cancel one another, while the voltages due to the directly received rays do not.

A receiving station in accordance with this invention comprises a pair of directional receiving aerials which can be oriented in desired directions, means for adjusting the phase relation between current and voltage induced in said aerials differently for each aerial, and means for combining in a common receiving circuit the energy from the two aerials, the combining means being such that the relative intensities of the signals fed to the common receiving circuits from the two aerials may be adjusted to a desired ratio.

The invention is illustrated in the accompanying drawing which shows, diagrammatically, a portion of a receiver system in accordance with the invention, the said system comprising a pair of mutually perpendicular frame aerials A1, A2 which are mounted as a single structure so as to be rotatable together about a vertical axis VA. Connection to each aerial is made through a pair of slip rings S1 or S2 and means are provided for adjusting the phase relation between current and voltage in each aerial separately; for example, an adjustable condenser C1 or C1′ may be included in each aerial. Connection is taken from one pair S1 of slip rings to a radiogoniometer primary R1 and, in a similar manner, connection is taken from the other pair S2 of slip rings to the other radiogoniometer primary R2 a search coil SC connected to the receiving apparatus proper (not shown) being associated with the two primaries as in the ordinary radiogoniometer arrangement. Preferably the whole apparatus including the slip rings and radiogoniometer coils is enclosed in a shield box SB.

For reception the whole apparatus is tuned to the desired signal wave, as in the customary manner, and the tuning condenser in one of the aerials is increased in value and that in the other decreased so that the current in one aerial is caused to lag by 45° and that in the other is caused to lead by 45° on the E. M. F.'s induced therein. When the reflected ray is circularly polarized the aerials can be oriented in any direction, but preferably the orientation is such that the direction of the transmitting station bisects the angle between the two aerials, i. e. the line of the transmitter is at 45° to each aerial. With this adjustment the direct ray which is vertically polarized will produce a rotating field in the radiogoniometer, and as regards the signals due to this ray there is no balance position of the radiogoniometer, but as regards elliptically polarized rays or circularly polarized rays there is a balance position, and the radiogoniometer search coil is adjusted until this balance position is reached.

Obviously, any convenient means for phase adjustment of the oscillations, other than the "mistuning" means above described, may be employed.

In order to assist the adjustment the following additional apparatus is provided:—

A local oscillation generator is connected to set up voltage in any suitable circuit, such as a potentiometer resistance and means are provided for superimposing voltage from this resistance in the radiogoniometer primary circuits. For example, in the arrangement shown in the figure one terminal of a potentiometer resistance P across which the local generator is connected to the screen box SB which may be grounded in any suitable manner and the other terminal is connected through a first switch X1 and an inductance L1 to a coil M1 coupled to coils W1 in the circuit of the frame aerial A1 which circuit includes, of course, the aerial A1 and the associated radiogoniometer primary R1. The last mentioned terminal of the potentiometer resistance P is also connected through a second switch X2, an adjustable condenser C2 and a resistance SR2 all in series to a coil M2 similarly inductively coupled to coils W2, W2 in the circuit of the second frame aerial A2, i. e., the circuit including the said frame aerial A2, and its associated radiogoniometer primary R2. To effect adjustment, first one of the two switches X1 or X2 is closed and voltage thus induced into one aerial from the generator. The phasing condenser (e. g. C1) in that aerial is adjusted to give a maximum signal when the coupling to the local oscillation generator is at a given value, say m, and the said coupling is then increased to a value $\sqrt{2m}$ and the phasing condenser again adjusted until the receiver output is the same as it was before. With this adjustment, the aerial current in the aerial in question should lag 45° behind the induced E. M. F. The first switch X1 or X2 is now opened and the second switch X2 or X1 closed and a similar adjustment made except that for the second aerial the value of the phasing condenser is reduced instead of increased so that in the second aerial the adjustment made is such that the aerial current will lead 45° as respects the induced E. M. F.

A test of the correctness of the phasing as obtained by adjusting as set out above, may be made by means of an auxiliary oscillator (not shown) designed to provide two E. M. F.'s in quadrature. When these two E. M. F.'s are simultaneously applied across the potentiometer resistance and the two switches X1, X2 are closed, the currents induced in the two aerials will be in quadrature and if the adjustments are such that the said induced currents are equal in amplitude, the search coil can be adjusted so that there is zero E. M. F. set up therein in the +45° position and maximum E. M. F. in the −45° position. The aerials have been correctly phased if it is possible to obtain balance in the +45° position, i. e. with equal coupling of the search coil to the radiogoniometer primaries.

Consider apparatus adjusted and constructed as above set forth and employed to receive energy from a given transmitting station. The E. M. F. induced in the two aerials by circularly polarized rays will be 90° out of phase and as respects this circularly polarized energy there will be a balance position of the search coil, this balance position being either the +45° position or the −45° position, according as to whether the rays are left hand or right hand circularly polarized. This position will, however, not be a balance position as regards the plane polarized direct rays since the E. M. F.'s in the two aerials induced by these rays are in phase, and hence the corresponding currents in the radiogoniometer 90° out of phase. Where the reflected ray is circularly polarized, the orientation of the two frame aerials is immaterial as regards sense, since there is obvious symmetry about the vertical axis. Unfortunately, it is only in exceptional cases, or where the receiver is quite close to the transmitter that the rays are circularly polarized, elliptical polarization being the general condition. For elliptical polarization the aerials must, of course, be oriented correctly.

Suppose the resultant reflected signal is elliptically polarized so that it can be regarded vectorially as made up of two magnetic fields which are at right angles to one another, the representing vectors being along the major and minor axes of the ellipse. If the aerials be so oriented that their planes lie along the major and minor axes of the ellipse, then the E. M. F.'s induced in the two aerials will be 90° out of phase and a balance as regards the reflected rays will be obtained in some position of the radiogoniometer search coil. The correct position can be found approximately by calculation and then finally set by trial to the correct value. Once the apparatus is appropriately adjusted, the received signals should be substantially free from fading since only voltages due to the direct rays will be fed to the receiver proper.

Experimental tests with the invention have shown that on the shorter wave length ranges of, say, 40 to 100 meters, either the right hand or the left hand circularly polarized reflected pulses (but not both) from the Kennelly-Heaviside layer can be almost completely eliminated. For longer wave lengths (on the so-called shorter broadcast wave band) the results of experiments are not quite so conclusive, but very substantial reduction in fading has been effected on a wave length of 225 meters.

It will, of course, be appreciated that since receivers as above described are practically sensitive only to the direct rays they must be positioned within the "direct ray range" of the transmitter.

It will have been appreciated from the foregoing description, but may be again stated here, that a receiver arrangement in accordance with this invention does not eliminate both the right and left hand polarized rays, though it may be adjusted to eliminate either of them. However, the effects of fading are eliminated or greatly reduced by the invention by reason of the fact that (at any rate with frequencies in or near the present broadcast frequency band) only one of the reflected rays survives reflection to any substantial extent and reception of this ray can be practically eliminated by the invention. Such reduced and residual fading as remains after the present invention has been applied to a receiving system can easily be dealt with by providing the receiving apparatus proper (not shown in the figure) with any automatic gain control circuit arrangement as known, per se, and it will be appreciated that by reason of the application of the present invention the duty upon this gain control circuit arrangement will be relatively slight.

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. A radio receiving system comprising a pair of mutually perpendicular frame aerials rotatably mounted as a single structure about a vertical axis, a radiogoniometer having a primary coil electrically connected to each of said frame aerials, and a search coil electrically coupled to said primary coil, a plurality of coupling coil elements, said coupling coil elements being electrically in series with said primary coil and to said frame aerials, and capacitive means for adjusting the phase relationship between current and voltage in each frame aerial separately, said

means comprising a variable condenser symmetrically arranged at the apex of each frame aerial.

2. A radio receiving system comprising a pair of mutually perpendicular frame aerials rotatably mounted as a single structure about a vertical axis, a shielded box containing a radiogoniometer having a primary coil electrically connected with each of said frame aerials, and a search coil electrically coupled to said primary coil, a plurality of coupling coil elements, said coupling coil elements being electrically connected in series with said primary coil and to said frame aerials, and capacitive means for adjusting the phase relationship between current and voltage in each frame aerial separately, said means comprising a variable condenser symmetrically arranged at the apex of each frame aerial.

3. A radio receiving system comprising a pair of mutually perpendicular frame aerials rotatably mounted as a single structure about a vertical axis, a shielded box containing a radiogoniometer having a primary coil electrically connected with each of said frame aerials, and a search coil electrically coupled with said primary coil, a plurality of coupling coil elements, said coupling coil elements being electrically connected in series with said primary coil and to said frame aerials, and capacitive means for adjusting the phase relationship between current and voltage in each frame aerial separately, said means comprising a variable condenser symmetrically arranged at the apex of each frame aerial, a resistance connected to said shielded box, the other side of said resistance being connected to two switches, each switch being separately connected in series with each one of said coupling coil elements and said shielded box, and a local oscillator connected across said resistance.

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