Oct. 15, 1940. N. E. LINDENBLAD 2,217,911

RADIO COMMUNICATION

Filed Aug. 12, 1938 2 Sheets-Sheet 1

Fig. 1

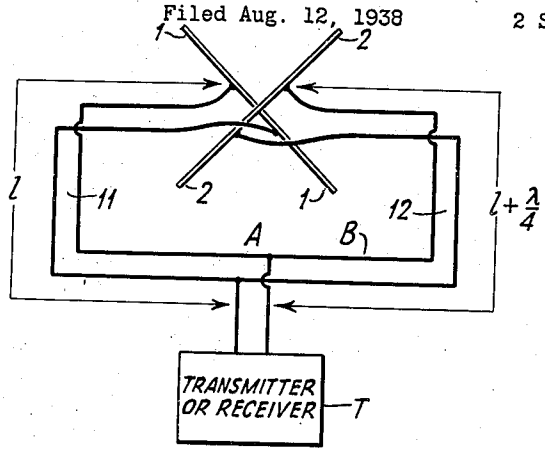


Fig. 2

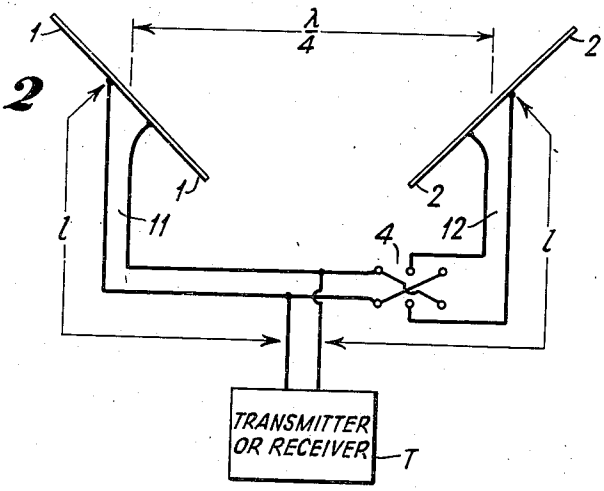
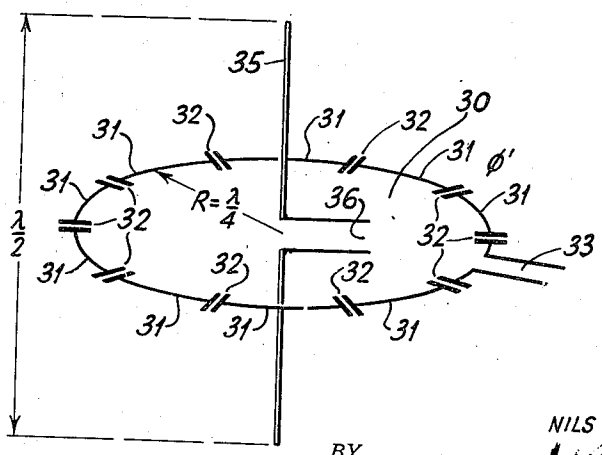


Fig. 3



INVENTOR.
NILS E. LINDENBLAD

BY

ATTORNEY.

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Filed Aug. 12, 1938 2 Sheets-Sheet 2

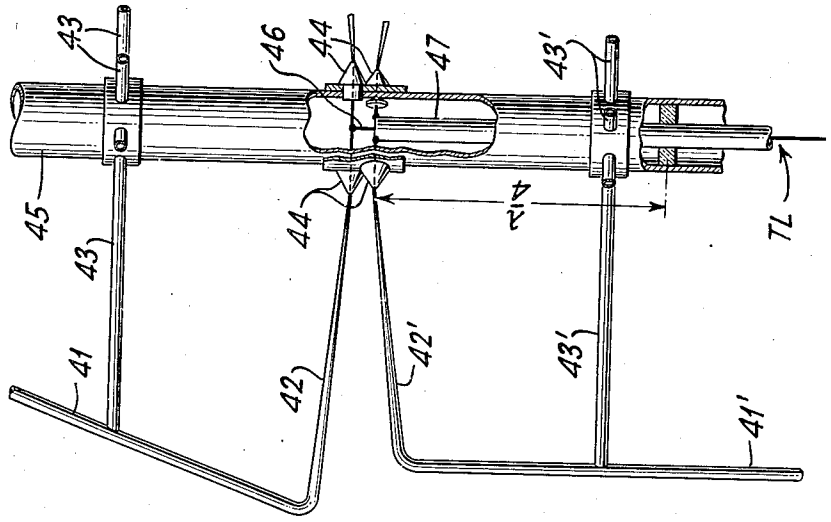


Fig. 5

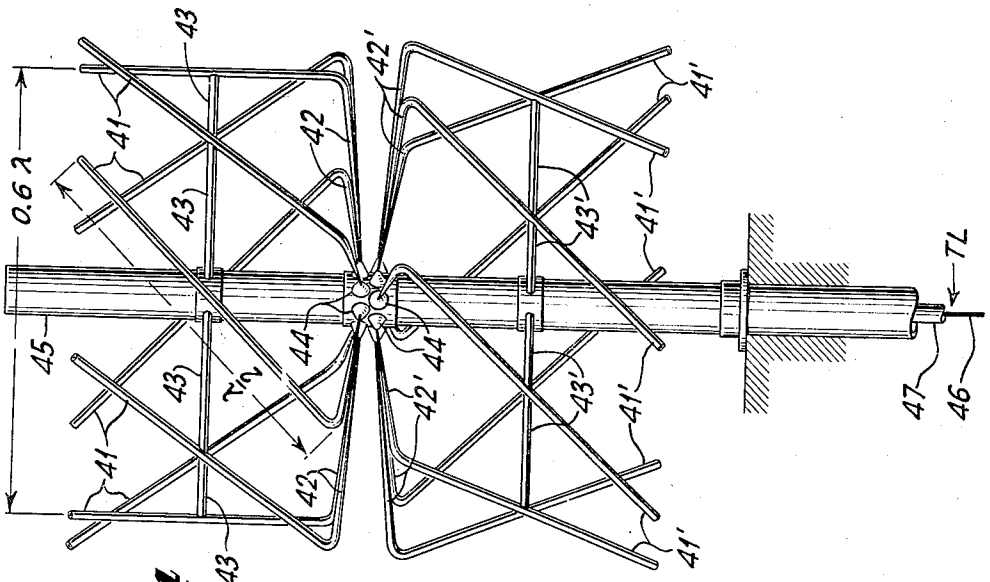


Fig. 4

INVENTOR.
NILS E. LINDENBLAD

BY

ATTORNEY.

Patented Oct. 15, 1940 2,217,911

UNITED STATES PATENT OFFICE

2,217,911

RADIO COMMUNICATION

Nils E. Lindenblad, Rocky Point, N. Y., assignor to Radio Corporation of America, a corporation of Delaware

Application August 12, 1938, Serial No. 224,425

12 Claims. (Cl. 250—11)

The present invention relates to radio antennas and, more particularly, to antenna systems for propagating electro-magnetic waves with a continuously variable plane of polarization. The plane of polarization may be varied by mechanical or electrical means. However, my present invention more specifically involves electrical means for obtaining a variable plane of polarization, that is, a structure that does not involve any motion of structural mass in order to obtain the variable polarization. In other words, the change of polarization is caused by combinations of the radiated components in certain specific phase and space relations.

The present invention is, furthermore, directly concerned with rotating planes of polarization having an intrinsic relationship to the frequency of the radiated waves, although it may also include the form in which the rotation of polarization is made independent of the frequency of the radiated wave. In either case a uniform intensity in all directions in a horizontal plane is obtained.

With the recent introduction of modulation frequencies which are high compared with the length of the propagation path, certain handicaps due to the complexity of the propagation have been encountered, such as the phenomena of multiple path transmission, selective fading and phase distortion of the received signals. An outstanding example of a condition where these phenomena are of overwhelming importance is in the problem of transmitting, by radio, television pictures through the chaotic propagation medium of a large American city. The well known result is, of course, that due to reflections from the sides of tall buildings and accompanying different lengths of paths and resulting time delay between the radiated components a short impulse may appear in multiple and a long impulse may be subject to a combination of phase distortions that will spoil its proper magnitude in relation to the general background. Furthermore, the large amount of "man-made" electrical interference tends to destroy the received picture.

An object, therefore, of my present invention is to provide a radio transmission system which will minimize the above mentioned difficulties.

A further object of my invention is to provide an efficient antenna for radiating electro-magnetic waves having a varying plane of polarization.

Still a further object is to provide an antenna for radiating circularly polarized radio waves which will be mechanically strong and entirely electrically grounded for protection against lightning.

Another object of my invention is to provide a means for radiating radio waves with a varying polarization which has no mechanically moving parts and which will give a substantially uniform intensity in the horizontal plane.

Of the many combinations and variations that may be considered when radiation travels over multiple paths, each of instable length, one of the most important causes of signal strength variation is due to the fact that each of the multiple paths may experience a different number of reflections.

An analysis of what happens when a wave is reflected from a conducting surface may be most readily made by reference to the so-called Kelvin's images of charges. The field set up by a body charged at a certain polarity to a certain magnitude and located in the vicinity of a flat conductive surface is such that the same field would be produced if the surface was replaced by the mirror image of the body charged to the same magnitude but at opposite potential. A radiator, say a doublet, located parallel with the surface would then have an image but of reversed polarity. The direct and the image radiation will then cancel one another at points on the surface since the polarization from the direct and the image radiators are opposing. If the doublet is perpendicular, no such reversal of polarization takes place since the real and the image radiators act as two doublets in series giving the same polarization. Without further discussion, it will now be understood that when a wave having a rotating polarization is subject to reflection the result of the reflection is that the direction of rotation of the polarization is reversed since only one component of the signal reverses its phase. Thus, a signal which has been reflected an odd number of times will have an opposite phase rotation to a signal which has been reflected an even number of times. Since a receiving antenna for rotary polarized waves is inherently selective as to the direction of phase rotation of the received signal, this effect provides a means by which half of all reflections may be cancelled or rejected. Therefore, the number of possible multiple paths by means of which the transmitted signal reaches the receiving antenna from the transmitting antenna will be cut in half, thus tending to reduce any multiple images or phase distortion.

Furthermore, it should also be borne in mind if noise interference or so called man-made static

is received, since the interference has a non-rotating, predominately vertical polarization, its components will not add up in line in the same way as the signal from the rotary polarized transmission antenna in the receiving system, but will instead add up in phase quadrature which will result in the signal to noise ratio being increased by a quantity equal to the square root of two.

My invention, which utilizes the above mentioned principles, involves a structure for radiating vertical and horizontal components of the radio wave of equal intensity in a phase quadrature relationship toward all points on the horizon whereby a circular polarization is obtained.

The preferred embodiment of the invention includes a number of half wave dipole antennae arranged at an angle of forty-five degrees to the vertical, cylindrically about a common vertical axis. The dipoles may be arranged in two bands spaced vertically a distance of a half the wave length of the operating wave and energized in a like phase relationship.

Referring, for a more complete understanding of my invention, to the following detailed description, which is accompanied by drawings in which Figures 1 and 2 show simple antenna structure for obtaining rotary polarization at the transmitting station; Figure 3 shows schematically a broadcast antenna for a rotary polarization of the elliptic type which may become circular if the vertical and horizontal components are adjusted to equal amplitude, while Figure 4 shows a simple feed system and utilizes space phasing only, and Figure 5 is the partial cross-section of the antenna shown in Figure 4.

In Figure 1 is shown a simple system of two doublet antennae **1**, **1** and **2**, **2** arranged in the same vertical plane and crossing one another at right angles at the mid or neutral point. The two doublets are fed from the transmitter T by means of transmission lines **11**, **12**, of which transmission line **12** is a quarter wave longer than transmission line **11**. Thus, the signal energies applied to the two doublets are in phase quadrature with each other and a rotary polarized signal is obtained. By applying the input from transmitter T at point B instead of at point A, the opposite transmission line becomes a quarter wave longer and the direction of rotation is reversed.

In Figure 2 is shown a system similar to that shown in Figure 1 in which one of the radiators has been moved parallel to itself along an axis perpendicular to its original plane of location to a new location a quarter of a wave length away. In this modification the two transmission lines **11**, **12** are of equal length but due to the spatial relationship between the two doublets, the resultant transmitted wave still has a circular polarization. The most convenient way of reversing the direction of rotation of the transmitted wave is by reversing one of the transmission lines which may be done by means of the reversing switch **4**. Obviously, of course, this reversing switch may also be used in Figure 1, instead of moving the point of connection of the transmitter from point A to point B. The antennas shown in Figures 1 and 2 are somewhat directive in effect and, as a consequence, are not suited to broadcast transmission, though either antenna may be used for receiving signals radiated from my improved antenna which will be later described.

As can be seen from an inspection of Figure 3, the vertical component of the transmitted wave is supplied by a vertical half wave doublet antenna **35**, which is fed from the transmitter by means of transmission line **36**. The horizontal component is supplied by a ring or loop element **30** which is composed of a plurality of short conducting sections **31** separated by series condensers **32**. These condensers compensate for the inductance of the ring sections and act to insure a uniform field distribution from the ring element. For the horizontal radiation any combination of doublets, such as a triangle or a square which will give uniform horizontal radiation, may replace the ring. The ring shown in Figure 3 is fed from a transmitter by means of transmission line **33**. The ring shown in Figure 3 may have a radius of an even number of quarter waves in length, in which case the phase relationship between the signals applied to the vertical dipole and the ring should be an odd number of quadratures out of phase with each other. The radius of the ring may, also, as in the specific example in Figure 3, be an odd multiple of a quarter wave in length, in which case the phase relation between the signals in the two transmission lines **33**, **36** should be of even number of quadratures.

In Figure 4 is shown an antenna for radiating a circularly polarized wave which provides a simple feed system and which utilizes space-phasing only. The antenna comprises a number of doublets **41**, which are cylindrically located around a vertical supporting mast **45**. Each of the doublets **41** is inclined at an angle of 45 degrees with a vertical axis. Each of the doublets is supported at its midpoint by a conductive support **43**. Below the first named series of doublets, a second series of doublets **41'** is provided. These, likewise, are supported at their midpoints by conducting supports **43'**. The distance between supports **43** and **43'** is a half the length of the operating wave. At the adjacent ends of the two series of doublets are connected tapered connecting sections **42** which pass through insulators **44** and connect to the transmission line from the transmitter. Each of the upper series of doublets **41** are connected together to the central conductor **46** of the transmission line, while all of the lower doublets **41'** are connected together to the shell **47** of the transmission line. Since the lower ends of the upper doublets and the upper ends of the lower doublets are fed in phase opposition, the currents of all the doublets are in phase. The general radiation characteristic of this combination is broad since each drum shaped combination is equivalent to a single large diameter radiator. Circular polarization is obtained in this modification as follows: The diameter of the radiator formed by the array of doublets is a little more than a half the length of the operating wave so that the centers of radiation of the two diametrically opposite drum sections becomes a half wave. Since the current in all radiators are in phase the combination of the opposite tilting radiators across the half wave diameter of the drum will combine to form a horizontal component and cancel one another vertically. The vertical component of the radiators half way between the diametrically located radiators is, however, not cancelled, but is additive in effect. Furthermore, by the time this component has advanced to the planes of the aforementioned diametrically opposite radiators it is in phase quadrature with the radiation at that instant from these radiators and a rotating

resultant is obtained. Since approximate equal energy is applied to all of the radiators, the vertical and horizontal components will be approximately equal and, therefore, practically circular polarization will be obtained.

If antennae of the types shown in Figures 1 and 2 are used for reception, the combined system will be selective as to the direction of rotation. If the receiving antenna is properly phased it will be responsive to the direct radiation and to that part of the reflected radiation which has been reflected an even number of times. The axis perpendicular to the receiving doublets is, of course, pointed towards the transmitting antenna, since they are somewhat directive. The trouble due to the multiple path phenomena heretofore discussed, therefore, with my invention is attacked by the combined effects of polarization selective radiation and directivity. The first reflection is conveniently eliminated by polarization selective reception and the second reflection will probably arrive from a direction so far from the direction of arrival of the direct signal that it will be eliminated by the directivity of the antenna. For reception, elements of any good directive antenna may, of course, be combined to form a pick up of good directive selectivity, provided it has broad tuning to conform with television wide band modulation.

If an aperiodic receiving antenna is desired, a receiving antenna of the long harmonic wire type may be used. With such a receiving antenna loaded at one end by a resistance equal to the surge impedance of the antenna, considerable directivity may be obtained while at the same time retaining the advantages of an aperiodic antenna.

While I have shown and particularly described several embodiments of my invention, it is to be distinctly understood that my invention is not limited thereto but that modifications within the scope of my invention may be made.

I claim:

1. An antenna system comprising a series of half wave dipole antennas arranged in a hyperbolic cylindrical formation about a common center, each of said antennas being inclined at an angle of 45 degrees with respect to the vertical, a second series of antennas similarly arranged about a center coaxial with said first center and spaced from said first series a distance equal to one half the length of the operating wave and means for cophasally supplying current to all of said antennas.

2. An antenna system comprising a series of half wave dipole antennas arranged in cylindrical formation about a common vertical center support, each of said dipoles being inclined at an angle of 45 degrees with respect to the vertical, a second series of dipoles similarly arranged about said vertical support and spaced from said first series a distance equal to one half the length of the operating wave and means for cophasally energizing all of said dipoles.

3. An antenna system comprising a plurality of radiating means arranged in a circle about a common center point, said means being so arranged that along any line passing through said point, radiation from the means at each point of intersection of said line with said circle adds to form a vertically polarized component of radiated energy and the radiation from the radiating means at points 90 degrees from said first mentioned points adds to form a horizontally polarized radiating component, the radius of said circle being such that any point along said line the phase relationship between said horizontally polarized and vertically polarized radiations is 90 degrees.

4. An antenna system comprising a first series of diametrically opposed pairs of radiating elements disposed about a common vertical axis, the elements of each pair disposed in parallel planes and inclined at an angle of 45 degrees with respect to the vertical, a second series of similarly disposed radiating elements adjacent thereto and arranged about the same vertical axis and means for cophasally energizing all of said elements.

5. An antenna system comprising a first series of diametrically opposed pairs of antennas disposed about a common vertical axis, the antennas of each pair disposed in parallel planes and inclined at mutually opposing angles of 45 degrees with respect to the vertical, a second series of similarly disposed antennas adjacent thereto and arranged about the same vertical axis and means for cophasally energizing all of said antennas.

6. An antenna system comprising a first series of diametrically opposed pairs of antennas disposed about a common vertical supporting mast, the antennas of each pair being disposed in parallel planes and inclined at an angle of 45 degrees with respect to the vertical, a second series of similarly disposed antennas adjacent thereto and arranged about the same vertical supporting mast and means for cophasally energizing all of said antennas of each series.

7. An antenna system comprising a first series of diametrically opposed pairs of half wave dipole antennas disposed about a common vertical supporting mast, the antennas of each pair being disposed in parallel planes and inclined at mutually opposing angles of 45 degrees with respect to the vertical, a second series of similarly disposed antennas adjacent thereto and arranged about the same vertical supporting mast and means for cophasally energizing all of said dipoles.

8. An antenna system comprising a first series of diametrically opposed pairs of half wave dipole antennas disposed about a common vertical axis the antennas of each pair being disposed in parallel planes and inclined at an angle of 45 degrees with respect to the vertical, a second series of similarly disposed antennas adjacent thereto and arranged about the same vertical axis, the adjacent ends of said two series of antennas being connected to opposite sides of a transmission line whereby all of said antennas are cophasally energized.

9. An antenna system comprising a first series of diametrically opposed pairs of half wave dipole antennas disposed about a common vertical axis the antennas of each pair being disposed in parallel planes and inclined at mutually opposing angles of 45 degrees with respect to the vertical, a second series of similarly disposed antennas adjacent thereto and arranged about the same vertical axis, the adjacent ends of said two series of antennas being connected to opposite sides of a transmission line whereby all of said antennas are cophasally energized.

10. An antenna system comprising a series of diametrically opposed pairs of radiating elements disposed about a common vertical axis, the elements of each pair being disposed in parallel planes and inclined at an angle of 45 degrees

with respect to the vertical and means for cophasally energizing all of said elements.

11. An antenna system comprising a series of diametrically opposed pairs of antennas disposed about a common vertical axis, the antennas of each pair being disposed in parallel planes and at right angles to each other and means for cophasally energizing all of said antennas.

12. An antenna system comprising a series of diametrically opposed pairs of half wave antennas disposed about a common vertical axis, the antennas of each pair being disposed in parallel planes and inclined at mutually opposing angles of 45 degrees with respect to the vertical and means for cophasally energizing all of said antennas.

NILS E. LINDENBLAD.