

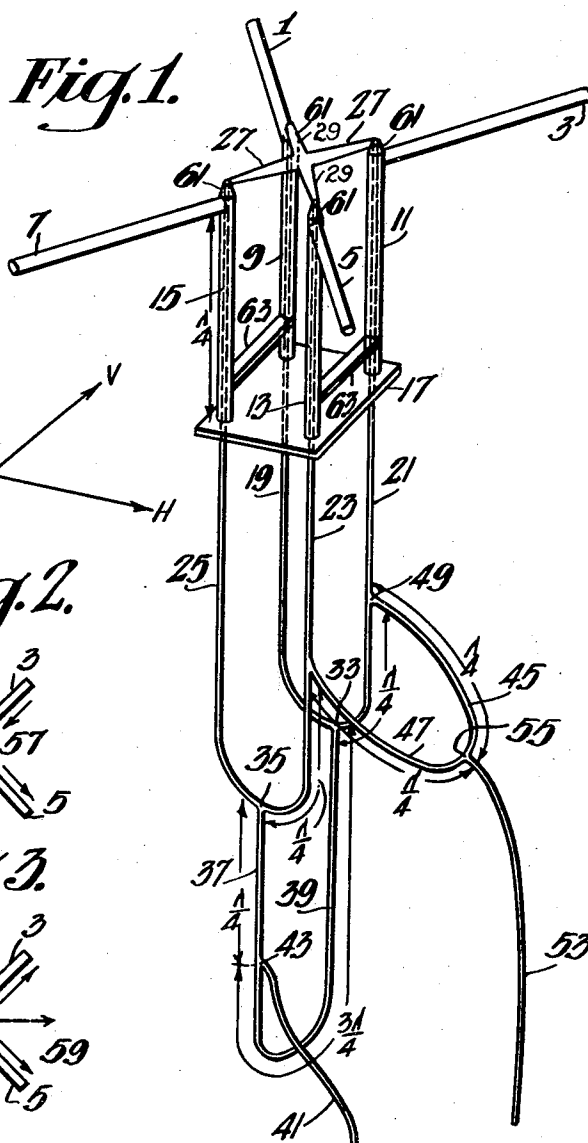
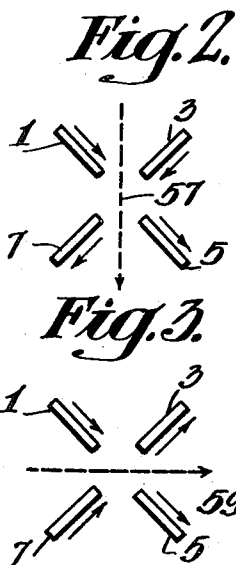
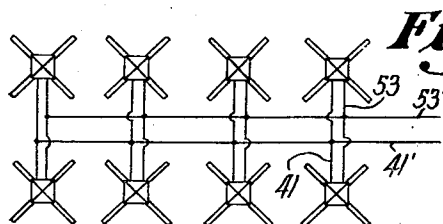
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ANTENNA SYSTEM

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ANTENNA SYSTEM

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This invention relates to antennas and more particularly to an improved method of and means for providing selectively radiation polarized in two orthogonal planes. This effect may be produced by means of physically rotatable linear antenna elements which may be moved to alter the planes of polarization, or by means of elements arranged at right angles to each other and energized selectively. The present invention contemplates the use of pairs of radiator elements supported at right angles to each other and energized simultaneously so as to simulate a single dipole. By reversing the polarity of the energization of certain of said elements, the plane of the simulated dipole is rotated through an angle of 90°.

The principal object of the present invention is to provide an improved antenna structure for radiating energy selectively in two planes of polarization.

Another object is to provide an improved method of and means for changing the energization of an antenna to alter the polarization of the energy radiated thereby.

A further object is to provide a system of the above mentioned type which is structurally rugged and of simple design.

A further object is to provide a system of the above described type wherein the necessary switching operation may be performed at any convenient point in the feed system.

These and other objects will become apparent to those skilled in the art upon consideration of the following description, with reference to the accompanying drawing, of which Fig. 1 is a schematic perspective view of an antenna system embodying the instant invention, Fig. 2 is a plan view of the radiator elements of the system of Fig. 1, illustrating the energization for vertical polarization, Fig. 3 is a plan view similar to that of Fig. 2, illustrating the energization for horizontal polarization, and Fig. 4 is a schematic plan view of an array of elements of the type illustrated in Fig. 1.

Referring to Fig. 1, four radiator elements 1, 3, 5 and 7 are arranged in the form of a cross, the elements 1 and 5 being collinear and at right angles to the elements 3 and 7 which are also collinear. The elements 1, 3, 5 and 7 may be made of steel tubing and are welded at their inner ends to parallel tubular supporting members 9, 11, 13 and 15 respectively. The supporting members are secured by welding or the like to a metallic base plate 17. Coaxial transmission lines 19, 21, 23 and 25 extend through the base plate and through

the tubular supporting members 9, 11, 13 and 15 respectively, and have the ends of their outer conductors soldered or otherwise connected thereto. The inner conductors of the lines 19, 21, 23 and 25 are connected together by a shorting member 27. The lines 19 and 21 are made of equal lengths and are connected together at a point 33. The lines 23 and 25 are similarly connected together at a point 35.

A line 37, $\frac{1}{4}$ wave length long is connected to the point 35, and a line 39, $\frac{3}{4}$ wave length long is connected to the point 33. The lines 37 and 39 are connected together and to a line 41 at point 43. Lines 45 and 47 are connected to the lines 21 and 23 respectively at the points 49 and 51. The point 49 is $\frac{1}{4}$ wave length nearer the radiator 3 than the point 33. Similarly the point 51 is $\frac{1}{4}$ wave length nearer the radiator 5 than the point 35. The lines 45 and 47 are each $\frac{1}{4}$ wave length long and are connected together to a line 53 at a point 55. The lines 41 and 53 extend over any convenient distance to a radio device, not shown. The radio device is connected to the line 41 to provide polarization in one plane and to the line 53 to provide polarization in a second plane at right angles to the first.

The operation is as follows:

Assuming that radio frequency voltages applied to the line 41, the resulting voltage at the point 35 leads that at the point 33 by 180°, since the line 37 is $\frac{1}{2}$ wave shorter than the line 39. Since the point 35 is equidistant from the radiator elements 5 and 7, these elements are excited in phase, that is when current is flowing outward on the radiator 5, current also flows outward on the radiator 7. The radiators 1 and 3 are likewise excited in phase with each other, but out of phase with the elements 5 and 7. Referring to Fig. 2, when the currents on the radiators 1 and 3 are flowing inward, the currents on the radiators 5 and 7 are flowing outward. This provides a resultant radiation substantially equivalent to that which would be produced by a radiator lying in a vertical line through the center of the system, with current flowing downward as indicated by the dotted arrow 57. Under the above described conditions, the points 49 and 51 on the lines 21 and 23 respectively are at equal and opposite potentials. The lines 45 and 47 from these points to the point 55 are each $\frac{1}{4}$ wave length long. Therefore there is no voltage produced at the point 55 as a result of the voltage applied to the line 41, and the impedance looking into the line 53 from the point 55 has no effect

upon the above described operation regardless of its magnitude.

If energy is supplied to the line 53, the voltages at the points 49 and 51 are in phase, and the radiators 3 and 5 are excited in phase. The radiators 1 and 7 are excited in phase with each other and out of phase with the radiators 3 and 5 because the points 49 and 51 are $\frac{1}{2}$ wave further from the elements 3 and 5. Referring to Fig. 3, the resultant field is directed along a horizontal line as indicated by the dotted arrow 59. The voltages at points 33 and 35 are equal and in phase. The total length of the lines 37 and 39 connecting the points 33 and 35 is one wave length long. There is a voltage node at the point 43, $\frac{1}{4}$ wave length distant from the point 35. Hence the above described operation is unaffected by the impedance presented at the point 43 by the line 41. Thus by energization of the system through either the line 41 or the line 53, energy may be radiated with polarization in either of the two orthogonal planes.

It should be noted that circular polarization may be produced by energizing the system through lines 41 and 53 simultaneously. Since voltage applied to the line 41 provides a vertically polarized wave, and voltage applied to the line 53 provides a horizontally polarized wave, both types of polarization will be present as both lines are energized. In order to provide circular polarization it is necessary that the horizontally polarized and the vertically polarized fields occur in quadrature. This condition is met if the lines 41 and 53 are made of equal length because the point of connection of the line 53 to the system is one-quarter wave length nearer the radiators than that of the line 41.

As pointed out above the presence of either of the main transmission lines has no effect upon the operation when the other line is energized. This fact may be utilized if it is desired to transmit independently two signals on substantially the same carrier frequency, using horizontal polarization for one signal and vertical polarization for the other. The same antenna array may be employed for reception selectively of horizontally, vertically or circularly polarized waves.

Although any desired arrangement for coupling the lines 19, 21, 23 and 25 to the respective radiator elements may be employed, the arrangement illustrated in Fig. 1 has several advantages over the more conventional systems. The upper ends of the tubular supporting members are provided with insulating bushings 61, through which the inner conductors of the respective transmission lines are connected to the shorting bars 27 and 29. This provides mechanical rigidity without the necessity for additional parts which are not required in the operation of the radiator system. The supporting members 9, 11, 13 and 15 are tuned by means of shorting bars 63 to parallel resonance, so that each pair of supports acts as a parallel $\frac{1}{4}$ wave line, presenting a high impedance between each pair of radiator elements. Current flowing up through one of the feed lines, for example the line 19, is balanced by an equal current flow through another of the feed lines, for example the line 21. In each case, there is a current in the outer line conductor which is equal to and opposite in direction to the current in the inner line conductor. Since the supports present substantially an open circuit at the terminals of the outer conductors, the current can flow only to the radiator elements. Thus the energy supplied to the feed lines is conveyed to the radiators. A

further advantage in the above described coupling arrangement accrues from the fact that very little parasitic inductance is introduced. This enables the antenna reactance to be substantially balanced out over a relatively wide range of frequencies by the action of the parallel resonant supporting members, providing a broad band radiation characteristic.

Although the invention has been described with reference to a single group of radiators, it will be apparent to those skilled in the art that an array of such groups may be employed to provide any desired directive pattern, in accordance with known design principles. Referring to Figure 4, an array is illustrated comprising six groups similar to that shown in Figure 1. The transmission lines 41 are connected in parallel to a main transmission line 41' and the lines 53 are similarly connected to a line 53'. The operation of the system in Figure 4 is identical with that of the system of Figure 1 except for the modified directive pattern.

I claim as my invention:

1. An antenna system comprising a base plate, four parallel tubular supporting members secured at their lower ends thereto, two pairs of coplanar orthogonally related radiator elements each secured at the upper end of a respective one of said supporting members and disposed in a plane perpendicular to said supporting members, a transmission line extending through two adjacent ones of said supporting members with the ends of the outer conductors thereof connected to the ends of said supporting members, a second transmission line similarly connected to the other two of said supporting members, all of the ends of the inner conductors of said lines being connected together adjacent the upper ends of said supporting member, a third transmission line one wavelength long connected between the midpoints of said first two transmission lines, a fourth transmission line connected to said third transmission line at a point $\frac{1}{4}$ wavelength distant from the midpoint thereof, a fifth transmission line $\frac{1}{2}$ wavelength long connected between said first two transmission lines at points $\frac{1}{4}$ wavelength distant from the midpoints thereof, and a sixth transmission line connected to the midpoint of said fifth transmission line.

2. An antenna system including groups of four orthogonally disposed radiator elements, one pair of the elements of each of said groups lying at right angles to each other in line with corresponding elements of the other pair, transmission line circuits interconnecting all of said groups and two main transmission lines, said transmission line circuits connecting one of said main transmission lines to the elements of each of said pairs in like polarities and connecting the other of said main transmission lines to the elements of each of said pairs in opposite polarities.

3. An antenna system comprising groups of four radiator elements, each of said groups comprising two pairs of collinear elements, two main transmission lines, transmission line circuits connecting one of said main transmission lines to each element of each of said collinear pairs in opposite polarities and connecting the other of said main transmission lines in the same polarity as said first main transmission line to all of said collinear pairs lying parallel to one plane, and in the opposite polarity to said first main transmission line to all of the collinear pairs lying parallel to another plane.

4. An antenna system comprising four radiator

elements directed in four orthogonal lines outward from a common center, a transmission line connected between two of said elements which lie at right angles to each other, a second transmission line connected between two others of said elements a third transmission line, an integral number of wave lengths long connected between points on said first and second lines such that voltage at each of said points reaches each of the elements of the respective pair in phase, a fourth transmission line, an odd integral number of half wave lengths long connected between points on said first and second transmission lines such that voltage at each of said latter points reaches the elements of the respective pair out of phase, a fifth transmission line connected to a point on said third transmission line, an odd number of $\frac{1}{4}$

wave lengths from the midpoint thereof, and a sixth transmission line connected to said fourth transmission line at a point such that a voltage at the junction thereof reaches the respective points of connections to said first and second transmission lines in phase.

5. An antenna system including two pairs of radiator elements, the elements of each pair lying at an angle to each other and in line with the corresponding elements of the other pair, and transmission line circuits including means for energizing the elements of each pair in phase with each other through one path and means for energizing the elements of each pair out of phase with each other through another path.

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