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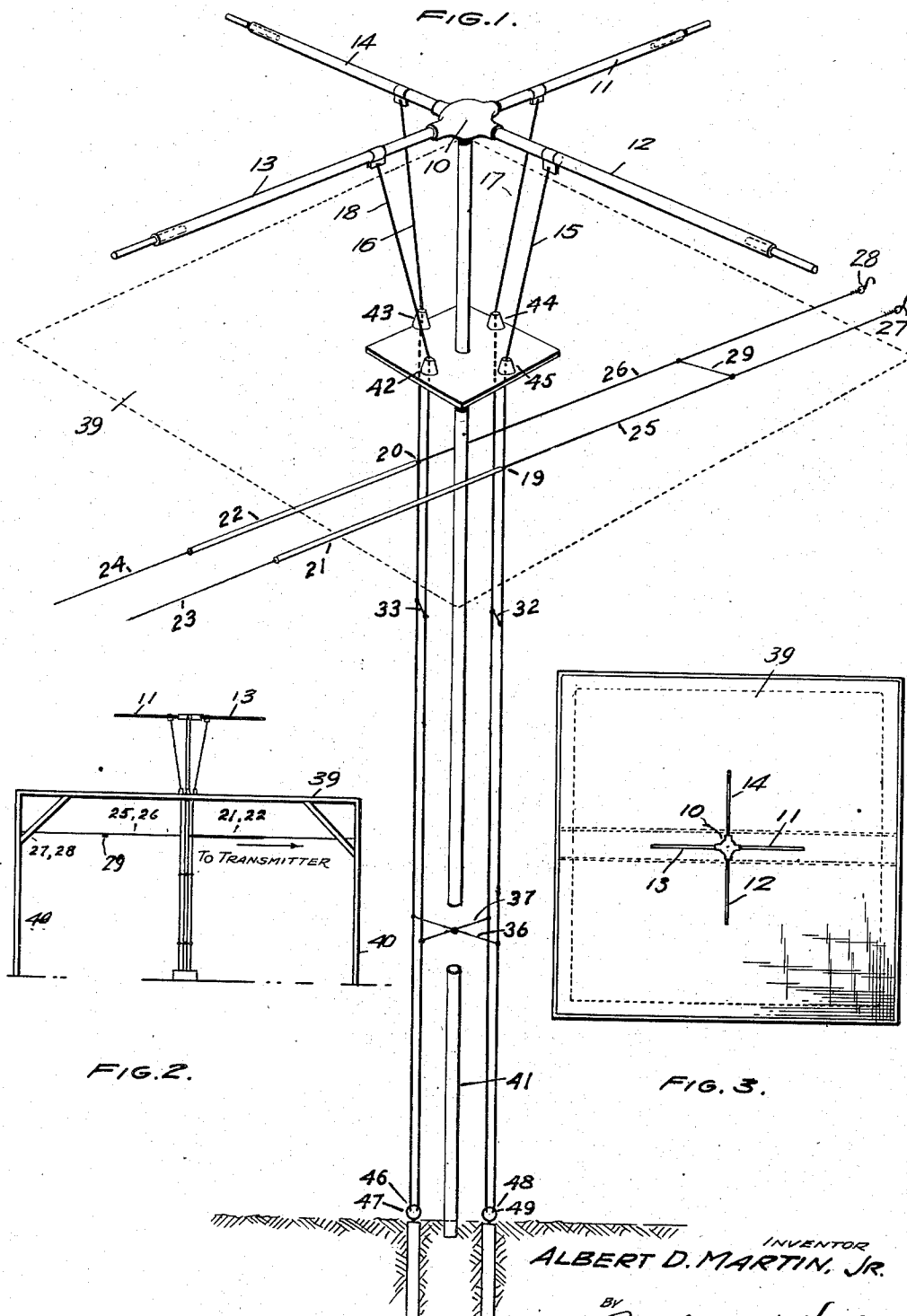
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2,364,084

DIRECTIVE ANTENNA SYSTEM

Filed Aug. 6, 1941

2 Sheets-Sheet 1



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2 Sheets-Sheet 2

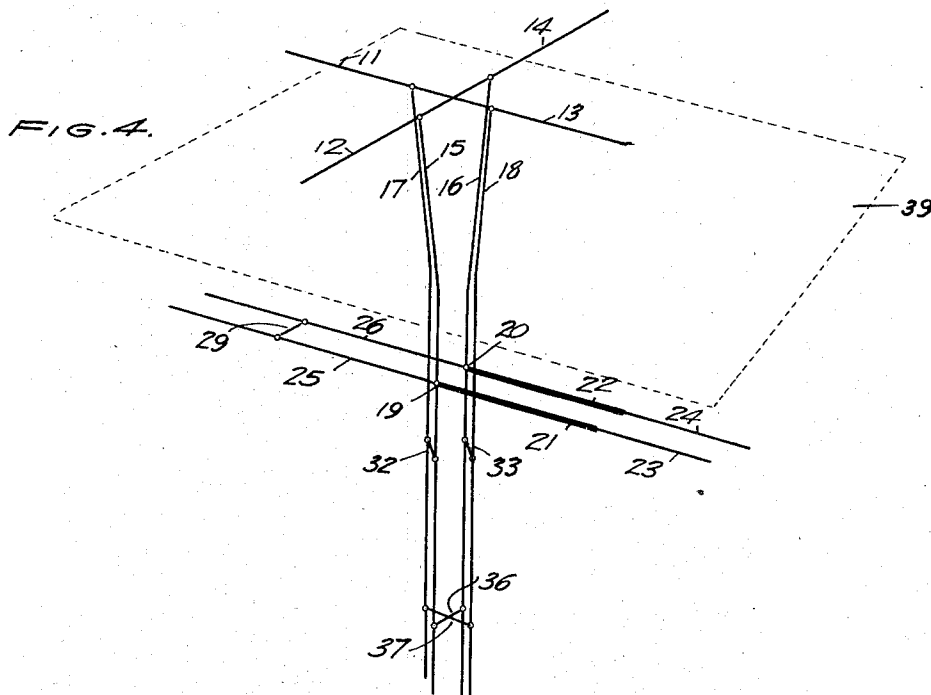
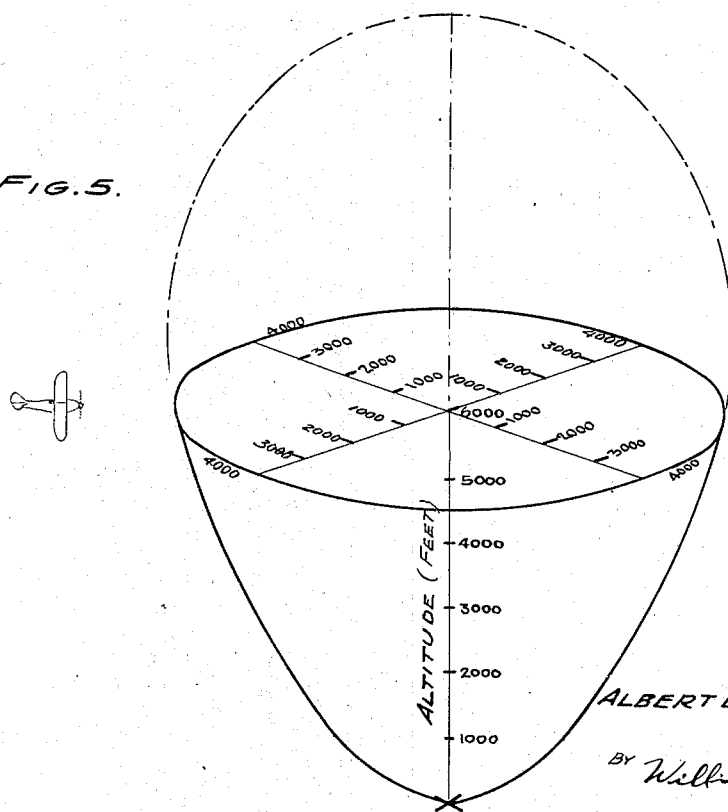


FIG. 5.



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DIRECTIVE ANTENNA SYSTEM

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12 Claims. (Cl. 250—11)

(Granted under the act of March 3, 1883, as amended April 30, 1928; 370 O. G. 757)

The invention described herein may be manufactured and used by or for the Government for governmental purposes, without the payment to me of any royalty thereon.

This invention relates to radio antennas and more particularly to directive transmitting antennas for radio marker facilities for air navigation. The invention has for its primary object the provision of an antenna that is more rugged in design, is simpler to adjust, is more efficient in operation and has a more confined field pattern than prior antennas of this general character.

Briefly speaking, the primary features of my invention comprise two half wavelength radiating elements mounted at right angles with common centers, in a plane parallel with and displaced from a reflecting plane surface by one quarter wavelength or less; the two elements furthermore being fed with a phase relationship of ninety electrical degrees by suitable matched impedance transmission lines. The performance is characterized by circular field polarization in a plane parallel to that of the antenna elements and maximum radiation along the normal to said plane from the center of the array, the radiation diminishing in an inverse relation with the angle from said normal. When the elements and reflecting plane are horizontal, the radiated field pattern is particularly well suited for use as a marker for the navigation of aircraft.

Other objects and features of construction will become apparent as this description proceeds.

With reference to the drawings, Fig. 1 is a perspective view of one form of the antenna system constituting my invention. Fig. 2 is a side view of the antenna system of Fig. 1, whereas Fig. 3 is a top view of the antenna system of Fig. 1. Fig. 4 is a schematic diagram of the electrical elements of Fig. 1. Fig. 5 illustrates a typical space contour of field strength produced by this form of antenna, when employed as a marker for air navigation.

Referring to the drawings in detail, 12 and 14 constitute a radiating element nominally one half wavelength overall, driven by feeders 15 and 16. Likewise, 11 and 13 constitute a second and similar element oriented ninety degrees from the first and driven by feeders 17 and 18. The two radiating elements are mechanically supported by a metallic hub 10 and a rod or pipe member 41. The lengths of the radiating elements and the points of connection of the feeders thereto are adjustable to facilitate the tuning operations. The horizontal reflecting plane 39 is parallel to and spaced preferably one quarter wavelength, or

less, from the plane of the radiating elements. It may comprise a sheet of metal or of wire mesh. The dimensions of the reflecting plane are relatively large in comparison with one wavelength. The feeders 15, 16, 17, and 18 are symmetrically located with respect to the supporting member 41, respectively converging slightly from the radiating elements to the insulating bushings 45, 43, 44, and 42 in the reflecting plane 39 and respectively extending thence with constant spacing to conveniently located anchors 48, 46, 49, and 47. Feeders 15 and 16 are respectively connected to feeders 17 and 18 by means of jumpers 32 and 33. Jumpers 36 and 37 are situated one quarter wavelength from jumpers 32 and 33. Radio frequency power is applied to the system at points 19 and 20 through feeders 23 and 24 and matching section 21 and 22 which are mechanically anchored at points 27 and 28 through conductors 25 and 26. Jumper 29 is situated one quarter wavelength from points 19 and 20.

Reference is made to Fig. 4 for a clear understanding of the operation of this antenna system. The transmission line comprising feeders 15 and 16 is terminated in its characteristic impedance in the radiating element 12, 14. Likewise the transmission line comprising feeders 17 and 18 is terminated in its characteristic impedance in the radiating element 11, 13. The two transmission lines are effectively connected in parallel at points 19 and 20; however, feeders 17 and 18 are each made longer than feeders 15 and 16 by one quarter wavelength by adjusting the position of jumpers 32 and 33. Consequently when radio frequency power is applied between points 19 and 20, the radiating elements 12, 14, and 11, 13 are excited with equal intensity but with a phase difference of ninety electrical degrees. The matching section 21, 22 consists of two conductors, each one quarter wavelength long and of such diameter and spacing that the characteristic impedance is the geometric mean of the impedance at points 19, 20 and the characteristic impedance of the transmission line comprising feeders 23, 24. This matching section therefore provides the correct termination for the transmission line 23, 24. The feeder system employs the high impedance characteristic of a folded half wave conductor for insulating purposes. Jumpers 36 and 37 are so located that their centers are one quarter wavelength from the ends of jumpers 32 and 33 thereby forming two folded half wave elements which effectively insulate jumpers 32 and 33 from the anchors 48, 47, 48, and 49 and that portion of the conductors be-

tween jumpers 36 and 37 and the anchors. Likewise, jumper 29 is so located that its center is one quarter wavelength from points 19 and 20, thereby forming with conductors 25 and 26 a folded half wave element which insulates points 19 and 20 from the anchors 27 and 28 and from that portion of the conductors between jumper 29 and the anchors. One feature of this antenna system is the symmetrical disposition of the elements which contributes to the electrical balance of the radiators and feeders, minimizes the electromagnetic coupling between elements, and permits mechanical support of the elements at points of zero voltage without the necessity of insulating material. Furthermore, the location of impedance matching and phasing elements being below the reflecting plane, any stray radiation therefrom is effectively prevented from distorting the principal field pattern.

Adjustment of the antenna system described herein is relatively simple. In the embodiment shown in the drawings wherein the feeders 23, 24 are physically and electrically similar, the following procedure is convenient. Matching section 21, 22 is removed and feeders 23, 24 connected directly to points 19 and 20. Jumpers 32, 33 are removed and jumpers 36, 37 raised to a point one quarter wavelength below points 19 and 20, thereby insulating feeders 17, 18 and radiator 11, 13 from the source of power. Feeders 23, 24 and 15, 16 then constitute a line of uniform characteristic impedance from the source of power to radiator 12, 14. The length of radiator 12, 14 and the spacing between taps of feeders 15, 16 are then adjusted to effect a termination of said line in its characteristic impedance as evidenced by a minimum of standing waves on the line. In the event feeders 23, 24 are different in characteristics from feeders 15, 16, an appropriate matching section is substituted for section 21, 22 during the above operation. Having completed the impedance matching of radiator 12, 14, the length of radiator 11, 13 and the spacing of its feeders are made identical with respective dimensions on radiator 12, 14 so that the characteristics of the second radiator are identical with those of the first, and the matching section 21, 22 and jumpers 32, 33 restored to the positions indicated in the drawings. Proper phasing is obtained by adjusting the position of jumpers 32, 33 and 36, 37 until uniform response is obtained in a receiving antenna located above the array and rotated in a horizontal plane.

The antenna system described above is well suited for application as a marker for air navigation. When installed with the radiating elements and reflecting plane horizontal, the antenna provides a vertically directed field of relatively narrow limitation as compared with the fields obtained with more complex arrays. The circular polarization furthermore insures a uniform response in a horizontal aircraft receiving antenna regardless of the orientation of same.

The space contour of field intensity shown in Fig. 5 illustrates the radiation characteristics of this antenna system as determined by actual measurements. The dimensions shown define the region wherein a positive indication is obtained with the preferred receiver sensitivity and power input to the antenna.

I claim:

1. A radio transmitting antenna comprising two straight radiating elements disposed in angular relationship; means including matched im-

pedance transmission lines for feeding said elements with radio frequency currents electrically different in phase to effect a rotation of the resultant radiated field; and reflecting means positioned to confine said field primarily along the normal to said radiating elements.

2. A radio transmitting antenna comprising a reflecting plane; two crossed half wave elements electrically joined and supported at their centers parallel with and separated no greater than one quarter wavelength from said reflecting plane; and feeder means comprising two matched impedance transmission lines connecting said elements to a common source of power, said transmission lines being of different length thereby effecting a phase difference in the currents in said elements.

3. A radio transmitting antenna comprising a pair of crossed wires of equal length, physically at right angles to each other; two pairs of balanced feeder lines symmetrically disposed perpendicular to said wires, said feeder lines being connected to the respective wires equidistant from the centers thereof and so positioned as to effect the matching of impedances, one of said pair of feeder lines being one quarter wavelength longer than the other pair whereby to feed said wires with currents whose electrical difference of phase angle equals the physical angle of separation of said wires; and reflecting means, said reflecting means and said wires being located in parallel planes one quarter wavelength apart whereby the waves will be reflected away from the reflecting means in a direction primarily perpendicular thereto.

4. A marker beacon radio transmitting antenna system comprising reflective means that is substantially horizontal; a pair of similar straight horizontal doublet antennas which constitute all of the effective radiating elements of the system and are both located near each other and approximately one quarter wavelength above said reflecting means; said antennas being mechanically angularly separated; and means for energizing said antennas comprising matched impedance feeders that respectively energize said antennas with currents the electrical phase difference of which is the same as the mechanical angle of separation.

5. A radio antenna comprising a first straight continuous horizontal wire of n half wavelengths in length, where n is a whole number; a second straight continuous horizontal wire in substantially the same plane as the first and of m half wavelengths in length, where m is a whole number; a first pair of feeders for energizing the first of said wires, said first pair of feeders being respectively connected on opposite sides of the center of the first wire; a second pair of feeders for energizing the second wire and respectively connected on opposite sides of the center of the second wire, the second pair of feeders being sufficiently longer than the first pair that the phase difference between the energizing voltages of the wires equals the physical angle of separation of said wires; and grounded reflecting means located p quarter wavelengths below the plane of the wires, where p is an odd whole number.

6. A radio antenna system comprising a metallic supporting member; a plurality of quarter wave radiating elements extending radially from a common point on said supporting member with equal angular displacement; a plurality of feeders symmetrically disposed about and parallel with said supporting member, said feeders being equal

in number to said radiating elements and connected respectively thereto; electrical means for energizing said feeders from a common source of power so that said radiating elements are fed with electric currents differing in electrical phase by the same angles as their physical displacement; and reflecting means perpendicular to the supporting member and situated between the radiating elements and said electrical means to effect maximum radiation along the axis of the supporting member away from said reflecting means, and free from influence of said electrical means.

7. A marker beacon antenna for projecting a radio wave vertically upward comprising a central metal supporting post grounded at its base; a plurality of metal antenna elements extending from, connected electrically to, and mechanically supported by said post; said antenna elements extending from said post in the same horizontal plane and at different physical angles in such plane, a screen positioned in a horizontal plane not substantially greater than one quarter wavelength below said elements; feeder means extending from said antenna elements downward below said screen; and means located below said screen for energizing said feeders with currents having electrical phase difference angles corresponding to the physical angles of separation of the respective antenna elements whereby a symmetrical lobe of radio frequency energy is transmitted vertically upward.

8. A directive marker beacon antenna system and supporting structure therefor comprising a centrally located elongated metal supporting post rigidly fixed in the ground and extending vertically upward, first and second quarter wavelength antenna elements one end of each being mechanically supported by and electrically connected to the metal supporting post and extending perpendicularly from the post in opposite directions from each other, a horizontal reflecting screen located below said elements and positioned not substantially in excess of one quarter wavelength therefrom, symmetrically disposed matched impedance feeders respectively connected to said first and second elements, said feeders extending substantially vertically downwardly from the elements and parallel to said post and to a position below said screen, third and fourth quarter wavelength antenna elements one end of each being electrically connected to and mechanically supported by said post at substantially the same elevation as said first and second elements, said third and fourth elements extending horizontally from said post in opposite directions and at a physical angle to the first and second antenna elements, additional symmetrically disposed matched impedance feeders connected to the third and fourth antenna elements respectively and extending substantially vertically downwardly to a point below said screen, radio frequency feeding means for energizing the first mentioned feeders, and reactance means connecting the lower end

of the first mentioned feeders to the said additional feeders for thereby displacing the currents in the third and fourth antenna elements by the same electrical phase angle as the physical angle of separation of the antenna elements.

9. The device of claim 2 including in addition a central metal supporting post grounded at its base and electrically connected to and mechanically supporting both of said half wave elements at their common centers.

10. A marker beacon antenna comprising a horizontal reflecting plane, first and second substantially straight horizontal antennas positioned at a physical angle to each other and which are both located above said reflecting plane by a distance not substantially greater than one quarter wavelength whereby the energy of the antennas will be radiated primarily upward, first and second wires symmetrically connected a short distance off center of the first of said antennas and extending away from said first antenna to constitute a matched impedance feeder therefor, third and fourth wires symmetrically connected to the second of said antennas at points a short distance off center thereof and extending away from said second antenna to constitute a matched impedance feeder therefor, a first connection electrically joining the outer ends of said first and third wires, a second connection electrically joining the outer ends of the second and fourth wires, a pair of parallel feeders for supplying radio frequency energy to said first and second connections, and removable matching means cooperating with said pair of parallel feeders adjacent said connections, said first and second wires being sufficiently longer than the third and fourth to effectuate a phase displacement of the currents in said antennas corresponding to their physical angles.

11. A marker beacon antenna as set forth in claim 10 in which the two feeders extend from the antennas vertically downward below said reflecting plane; said first connection, said second connection, said pair of parallel feeders, and said removable matching means all being located below said reflecting plane.

12. A marker beacon antenna system comprising first and second straight horizontal radiating elements disposed at a physical angle to each other and which are continuous throughout their respective lengths, matched impedance feeder means including a first wire connected off center of the first of said elements, matched impedance feeder means for the second of said elements including a second wire connected off-center of the second element, the first wire being sufficiently longer than the second wire that the phase displacement of the energizing currents in the elements set up a rotating field, radio transmitting means for energizing said wires, and a reflecting plane located not greater than one quarter wavelength below the radiating elements and parallel thereto.

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