April 29, 1947. L. HIMMEL ET AL 2,419,552

RADIO ANTENNA

Filed June 12, 1943 2 Sheets-Sheet 1

Fig: 1.

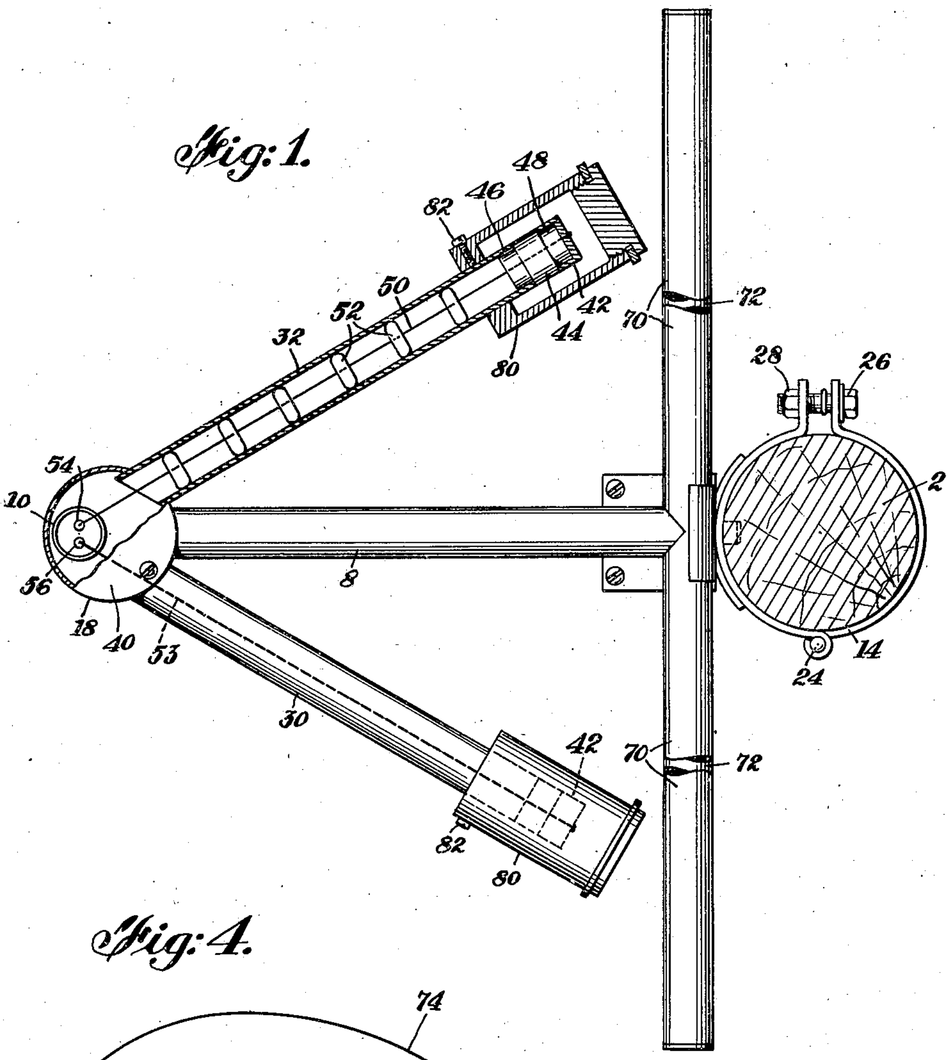
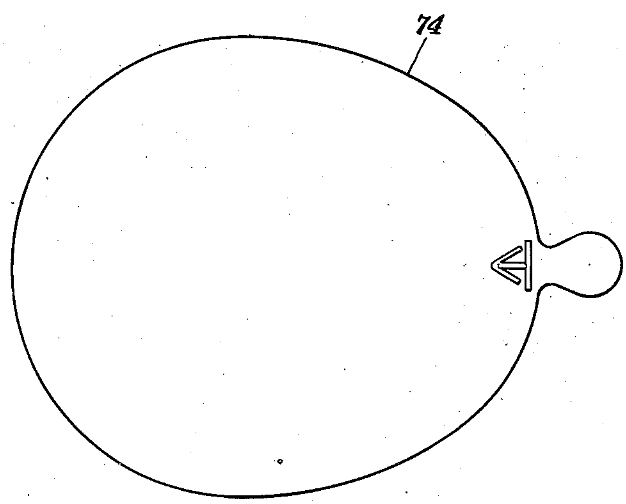


Fig: 4.



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RADIO ANTENNA

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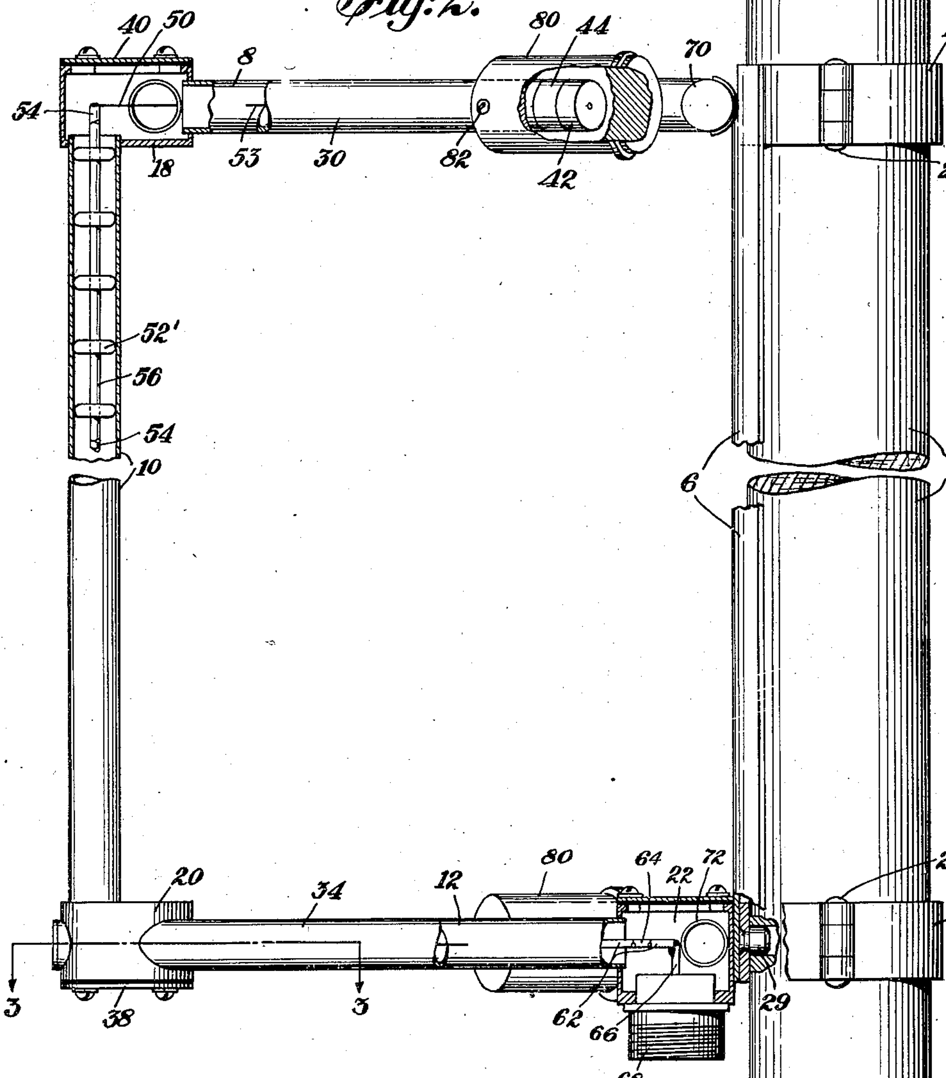
Fig:2.



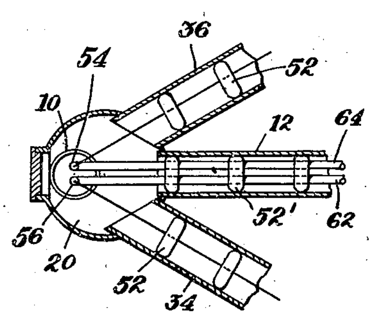


Fig:3.

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UNITED STATES PATENT OFFICE

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RADIO ANTENNA

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8 Claims. (Cl. 250—11)

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This invention relates to radio antennas and in particular to directive antenna systems for operation at ultra-high frequencies.

An object of the invention is to provide a rigid unitary antenna structure for operation on ultra-high frequency waves.

Another object of the invention is to provide a directional antenna structure for radiating predominantly horizontally polarized waves.

A further object of the invention is to provide a directional antenna structure for horizontally polarized waves having wave energy concentrated in a horizontal plane.

A still further object of the invention is to provide an antenna system suitable for operation with a portable glide path transmitter.

These and other objects and features of the invention will be best understood from the following description of an embodiment thereof and the illustrations in the accompanying drawings in which

Figs. 1 and 2 are partially sectionalized plan and elevational views respectively of the antenna system of our invention.

Fig. 3 is a sectional view of the antenna structure taken through the section 3—3 of Fig. 2 and

Fig. 4 illustrates a constant intensity field pattern in the horizontal plane resulting from radiation from our antenna structure.

The antenna structure of our invention is particularly useful in connection with portable instrument landing equipment such as is described in U. S. Alford Patent 2,294,882. This patent describes an antenna system for establishing a suitable glide path for the landing of aircraft in which two antennas are positioned one above the other in a manner such that the field patterns of the two antennas combine to produce the glide path. Both antennas operate on the same carrier frequency, but the radiation from each antenna is modulated at its own characteristic frequency and produces what is termed an equi-signal glide path. The antenna arrangement of our invention is particularly satisfactory for determining one of the field patterns of the glide path.

In the Alford patent above referred to, the radiation patterns resulting from each of the antennas disclosed therein are symmetrical, that is to say, the intensity of the radiated field is substantially equal in any two opposite directions from either antenna structure. However, the field pattern on one side only of the antenna system is employed for determining the glide path. The energy radiated from the opposite side of

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the antenna represents wasted energy, and furthermore, should there be any obstacles in the field of this energy, reflected radiation therefrom may produce deleterious effects such as undesired lobes of energy in the field of the desired glide path. This problem of reradiation is very important in connection with portable equipment since an otherwise suitable location for a landing runway may be rendered unsuitable due to the reflections from objects located on the far side of the transmitter with respect to the runway.

With the antenna structure of our invention, the field pattern which determines the glide path extends substantially from one side only of the antenna and since there is little or no radiation from the opposite side, the problem of undesired reflections from objects to the rear of the antenna does not exist.

Referring now to Figs. 1 and 2, the reference character 2 represents a wooden mast or other supporting means for our antenna structure. A rectangular frame member composed of a spacing member 6 and three tubular members 8, 10 and 12 is supported on the mast 2 by two clamping devices 14 and 16. A junction box 18 is positioned between members 8 and 10 and another similar junction box 20 is positioned between members 10 and 12. The third junction box 22 is positioned between the spacing member 6 and the tubular member 12. The spacing member 6, the tubular members 8, 10 and 12, the junction boxes 18, 20 and 22 together with the clamps 14 and 16 may all be welded or otherwise fastened together to form a very rigid structure. The clamping devices 14 and 16 are hinged at the points 24 and by operating the clamping screws 26 and nuts 28 the complete antenna structure may be readily fastened to or removed from the mast. The dowel 29 locates the antenna structure on the mast 2.

Two antenna arms 30 and 32 may be welded or otherwise fastened to the junction box 18 in such a manner that the two arms make an angle with each other to form a V having an apex substantially coinciding with the center line of the tubular member 10. Similar antenna arms 34 and 36 may be welded or otherwise fastened to the junction box 20 and these arms also are inclined at an angle to each other to form a V having an apex substantially coinciding to the tubular member 10. The arms 30 and 32 lie in a plane which is parallel to the plane formed by the arms 34 and 36. The arms 32 and 36 lie in a plane as do the arms 30 and 34 whereby the angle between the arms 30 and 32 is equal to the angle between the arms 34 and 36. This angle is not critical but in accordance with our invention is preferably of the order of 60°.

The cover plates 38 and 40 for the junction boxes 20 and 18 respectively are removable for the purpose of assembling sections of transmission lines within the tubular members. The transmission lines are employed for carrying radio frequency energy to the four antenna arms.

A capacitance element 42 is insulatingly mounted on the divergent end of each of the antenna arms. The detail of this construction is shown in Fig. 1 in connection with the antenna arm 32. An insulating spacing member 44 having two reduced portions 46 and 48 is pressed into the antenna arm 32 as illustrated. The insulating member may be composed of Dilectine or other low-loss material. The capacitance element 42 is pressed over the reduced portion 48 of the insulating member 44.

The antenna arm 32 also serves as the outer conductor of a concentric transmission line comprising said antenna arm and the inner conductor 50, the latter being suitably spaced from the walls of the antenna arm by insulating members 52. The conductor 50 is soldered or otherwise fastened to the capacitance element 42. Similar capacitance elements, insulating members, and inner conductors of transmission lines are mounted on and within all of the four antenna arms.

The antenna arms are energized through the capacitance coupling which exists between the capacitance elements and the antenna arms in accordance with principles disclosed in U. S. Alford Patent 2,287,220.

Within the tubular member 10 is a balanced transmission line composed of two conductors 54 and 56. Within the junction box 18 a connection is made between the conductor 54 and the inner conductor 50. The conductor 50 is very much smaller than the conductor 54. This is required for impedance matching purposes since it is desirable that the impedance of the coaxial line represented by the conductor 50 and the antenna arm 32 be substantially equal to twice the impedance of the balanced transmission line within the tubular member 10. The coaxial line operates as a quarter wave impedance transformer.

Within the junction box 18 a connection is also made between the conductor 56 and the transmission line 58, the latter forming the inner conductor of the coaxial line represented by said inner conductor and the antenna arm 30. Within the junction box 20 similar connections are made between the conductors of the balanced transmission line and the inner conductors of the transmission lines whose outer conductors are the antenna arms 34 and 36. A section of transmission line composed of conductors 62 and 64 also extends within the tubular member 12 as an extension of the transmission line within the tubular member 10. The other end of the conductors 62 and 64 meet and are connected to a pair of conductors 66 which terminate within a plug and jack arrangement (not shown) within the fitting 68. A flexible transmission line (not shown) connects with the conductors 66 and extends to a distant point where it is connected to an energy translator which may be either a transmitter or a receiver.

While we have illustrated the means for energizing the antenna arms 30, 32, 34, and 36 as comprising a capacitance coupling between said arms and the elements 42 other means of energization could be employed such as for example the inductive means illustrated in Fig. 5 of U. S. Alford Patent 2,287,220.

We have also shown four shielding members 80, mounted over the ends of the antenna arms. These shielding members prevent any accumulation of moisture, snow, dirt, or other foreign material from depositing on the insulating members 44 which might thereby impair the operation of the antenna system. The members 80 may be held in place by any suitable means such as set screws 82 for example.

Reflecting members 70 and 72 are welded or otherwise fastened to the spacing member 6 and to the tubular members 8 and 12 respectively. These reflecting members are parasitically excited from the antenna arms to which they are adjacent.

For a given wave length or frequency, the dimensions of the antenna system of our invention are substantially as follows: The length of each of the four antenna arms 30, 32, 34, and 36 is one-quarter wavelength. The length of each of the reflecting members 70 and 72 is one-half wavelength. The distance between the apex of the V formed by the antenna arms and the corresponding reflector element is one-quarter wavelength. These dimensions, given in terms of wavelength, are to be considered as electrical lengths and not necessarily as actual physical lengths. This is in accordance with known practice and theory.

The length of the transmission line within the hollow member 10 is one-half wavelength as determined by the velocity of wave propagation along the transmission line. This velocity of propagation is somewhat lower than the propagation of electro-magnetic waves in free space. Therefore the distance between the upper and lower V of the antenna arrangement is somewhat less than one-half wavelength. The criterion which determines the length of this transmission line is that the radiated energy from the upper V should be substantially in phase with the radiated energy from the lower V. This is desirable in order that radiated wave energy will be in phase in a horizontal plane. Since the transmission line is one-half wavelength long, a cross-over or transposition of the conductors 54 and 56 is required and this cross-over can be made at any point between the apexes of the two V's. One way of producing this transposition is to relatively oppositely rotate the two ends of the transmission line by 180°.

Since the wave radiation from the upper V is in phase with the radiation from the lower V and the two V's are separated substantially one-half wave length, radiation in the vertical direction is very low. This radiation would be zero were it not for the difference in wave propagation along the transmission line composed of conductors 54 and 56 and in free space. Due to lower downward radiation, wave reflections from the ground and other objects which may be located beneath the antenna structure are greatly reduced.

The radiation pattern of our antenna system is shown in Fig. 4 by the curve 74. This curve represents the locus of points of a given field intensity in a horizontal plane. It is recognized that due to reflections from the ground resulting from the so-called mirror image of the antenna there will generally be several lobes of radiation in a vertical plane. It is the lower lobe which is usually employed in determining the pattern for a glide path.

While we have described above the principles of our invention in connection with specific apparatus, it is to be clearly understood that this description is made only by way of example and not as a limitation on the scope of our invention as set forth in the objects of our invention and the following claims.

We claim:

1. A directive antenna system comprising two antenna arms inclined at an angle to each other to form a V, the length of each of said arms being substantially one-quarter wavelength, a linear reflecting element positioned adjacent the open end of said V and substantially one-quarter wavelength from the apex of said V, the length of said reflecting element being substantially one-half wavelength, all of said lengths being in terms of the operating wavelength of said antenna system, and means for energizing said antenna arms, said energizing means comprising capacitance elements, one capacitance element being mounted adjacent the open end of each of said antenna arms, and a transmission line extending through each of said arms and connected to said capacitance element.

2. A directive antenna system in accordance with claim 1 in combination with a substantially identical antenna structure as that recited in claim 1, said structure being positioned substantially one-half wavelength from said first named antenna, and a section of transmission line connecting together the transmission lines extending through the arms of each of said V's for energizing said antennas in phase coincidence, said transmission line section being substantially perpendicular to the planes of said V's.

3. A directive antenna system in accordance with claim 1 in combination with a substantially identical structure as that recited in claim 1, said structure being positioned substantially one-half wavelength from said first named antenna, the plane passing through said reflecting elements being substantially perpendicular to the planes passing through said V's, and means for energizing the antennas forming said V's in phase coincidence.

4. A directive antenna system in accordance with claim 1 in combination with a substantially identical antenna structure as that recited in claim 1, said substantially identical structure being positioned an even plurality of quarter wavelengths from the first named antenna, the plane passing through said reflecting elements being substantially perpendicular to the planes passing through said V's, and means for energizing the antennas forming said V's whereby radiation perpendicular to the planes of said antennas is substantially zero.

5. A directive antenna system comprising a support, said support defining a rectangle, two opposite sides of said rectangle being formed of linear members having lengths substantially equal to one quarter wavelength and having a

spacing substantially equal to an even plurality of quarter wavelengths, four antenna arms, each having a length substantially equal to one-quarter wavelength, two of said arms being connected to one of said sides to define substantially equal angles, therewith said arms forming a V shaped antenna, the two remaining arms being connected to the other of said sides to define with said other side angles equal to said equal angles, two parallel linear reflecting elements connected to said rectangle, said reflecting elements being perpendicular to said support and having lengths substantially equal to a half wavelength, all of said lengths being in terms of the operating wavelength of said antenna system, the plane of said rectangle bisecting said reflecting elements, and means for energizing said four antenna arms comprising a capacitance element positioned adjacent the diverging ends of said arms, and a transmission line passing through at least one of the members forming the sides of said rectangle and through said arms, said transmission line being connected to said capacitance elements.

6. A directive antenna system in accordance with claim 1 wherein the angle between said arms is substantially 60°.

7. A directive antenna system comprising two antenna arms inclined at an angle to each other to form a V, the length of each of said arms being substantially one-quarter wavelength, a linear reflecting element positioned adjacent the open end of said V and substantially one-quarter wavelength from the apex of said V, the length of said reflecting element being substantially one-half wavelength, all of said lengths being in terms of the operating wave length of said antenna system, and means coupled to said antenna arms for translating energy therewith.

8. A directive antenna system in accordance with claim 7 wherein said means for translating energy comprises a transmission line and two capacitance elements, one of said capacitance elements being positioned adjacent the open end of each of said antenna arms, and means for connecting said capacitance elements to said transmission line.

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