Dec. 10, 1946. P. S. CARTER 2,412,320

ANTENNA SYSTEM

Filed Nov. 12, 1941

Fig. 1

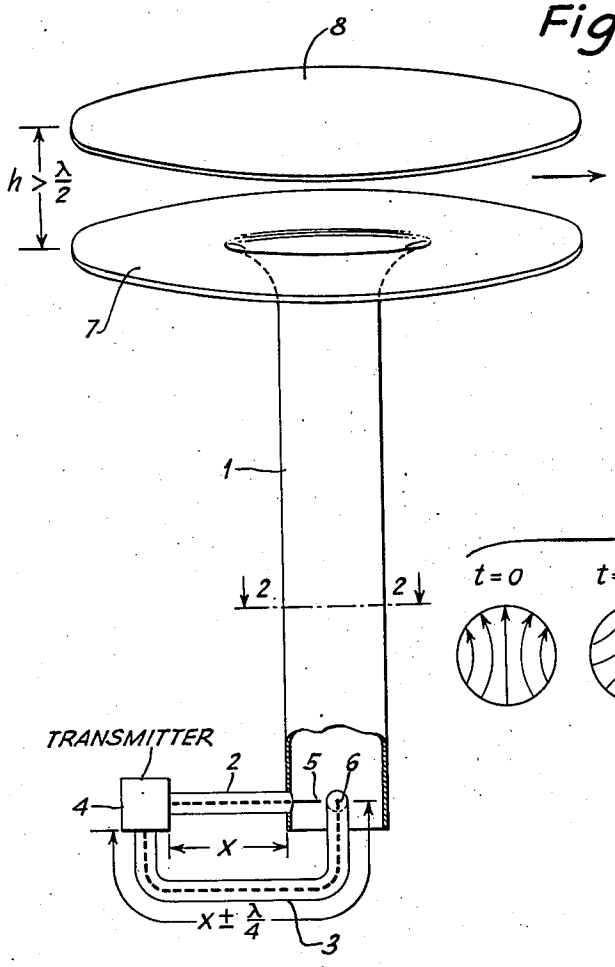
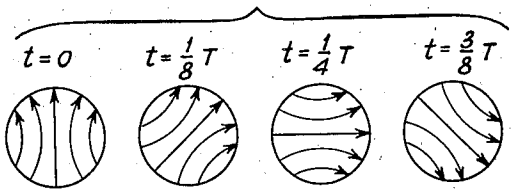


Fig. 3



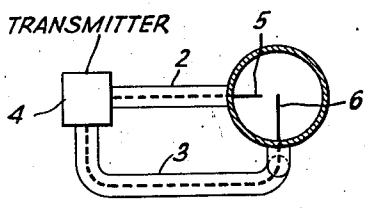


Fig. 2

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ANTENNA SYSTEM

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12 Claims. (Cl. 250—11)

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This invention relates to an antenna system for use particularly with ultra short waves.

An object of the present invention is to provide a simplified antenna system for radiating circularly polarized waves equally in all horizontal directions.

Another object is to provide an antenna system for broadcasting circularly polarized waves of the order of one meter, and particularly centimeter waves appreciably less than one meter.

A further object is to provide an antenna system having a broad frequency band characteristic for use with circularly polarized waves.

In the past it has been attempted to radiate centimeter waves of less than one meter in length in the same manner employed for much longer waves; namely, by means of elevated dipoles connected to the transmitter through transmission lines. At the ultra high frequencies corresponding to waves less than one meter, the losses in the ordinary transmission lines have been found to be very high.

The present invention avoids the use of connecting transmission lines between the radiating structure per se and the transmitter located appreciably below the radiating structure, as a consequence of which there are eliminated the customary losses in the lines of prior art structures. Further, the present invention eliminates the customary complicated radiating antenna systems of the prior art and provides a simplified arrangement.

In brief, the foregoing objects and advantages of the invention are achieved in the preferred embodiment of the invention, first, by using a wave guide to carry the extremely high frequency energy from the elevated radiating structure to the transmission line elements located below, and secondly, by employing as the radiating structure per se, the combination of a trumpet shaped element communicating with the free end of the wave guide and a circular plate horizontally positioned above and spaced from the flared sides of the trumpet shaped element. By making the space between the horizontal circular plate and the sides of the trumpet entirely open, I am able to obtain radiation equally in all horizontal directions.

A more detailed description of the invention follows in conjunction with a drawing, wherein:

Fig. 1 shows an elevation view of the combined wave guide and antenna system of the invention;

Fig. 2 is a plan view of the system of Fig. 1 along the line 2—2; and

Fig. 3 shows pictures of the electric field lines in the cross-section of the wave guide for different times of a cycle.

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Referring to the drawing in more detail, applicant's antenna system for radiating circularly polarized waves comprises a circular hollow conductor wave guide 1 having supplied thereto at one end energy in quarter phase relation from two concentric lines 2 and 3 extending to radio transmitter apparatus 4. Concentric lines 2 and 3 differ in length from one another by one-quarter of a wavelength at the operating frequency (as shown), the inner conductors of the lines 2 and 3 projecting into the interior of the wave guide 1 at 5 and 6, respectively, in the same horizontal plane but at right angles to each other. In effect, the extensions 5 and 6 of the center conductors of the two concentric transmission lines constitute dipoles or probes, each having a length of one-quarter wavelength or less at the operating frequency. If desired, the probes may be replaced by loops of wire or other exciting elements with equal effectiveness. Because of this method of feeding the dipoles 5 and 6 in quarter phase relation in the interior of the wave guide 1, there is produced in the guide 1 an electromagnetic wave with a transverse rotating electric field. Pictures of the electric field lines in the cross section of the guide 1 are shown in Fig. 3 for times equal to 0, ⅛, ¼, and ⅜ of a cycle.

In order to obtain relatively free propagation of the waves in the interior of the wave guide, the diameter of the circular pipe 1 forming the wave guide must be greater than 0.67 wavelength. This value of 0.67 wavelength for the diameter is substantially the critical value or cut-off point below which cut-off of propagation takes place, and may be obtained from the relation

$$\frac{2.01\times10^{10}\text{ cm.}}{\text{frequency}}$$

The upper end of the wave guide 1 is terminated by a trumpet-shaped affair 7, having a flat circular surface beyond the mouth. Above the trumpet 7 there is provided a circular plate 8 which must be spaced from the flat surface of the trumpet 7 by a distance greater than one-half wavelength at the operating frequency in order for free propagation to take place between the surface of the plate 8 and the flat surface of the trumpet 7. The wave guide 1, the flat surface of trumpet 7, and the confronting surface of plate 8, should all preferably be made of electrically conducting material, although the invention will work fairly well if plate 8 is of dielectric material having a high dielectric con-

stant. With the arrangement I have just described, I am able to radiate a circularly polarized wave equally in all horizontal directions from the space between plate 8 and trumpet 7. The lower end of the wave guide 4 is closed by a metallic plate to prevent escape of radiation from this end. This closure plate can, if desired, be replaced by an enclosure having good conducting walls for terminating the wave guide.

As an illustration of the dimensions which my antenna system may take, if it is desired to radiate a ten centimeter circularly polarized wave, then the diameter of the circular wave guide should be at least 6.7 centimeters and the distance between the plate 8 and the flared surface of the trumpet or horn should be at least five centimeters.

An exposition of the operation of the inention will now be given: Since the two excitations of the wave guide 4 produced by probes 5 and 6 are perpendicular to each other and in quarter phase relation, each may be considered separately for purposes of analysis. The wave in which the principal axis of the electric field is perpendicular to the plane of the paper remains horizontally polarized in the plane of the paper as it expands in the space between plate 8 and trumpet 7 and is radiated in the plane of the paper from the aperture at the edges of elements 8 and 7. The wave whose principal electric field axis lies in the plane of the paper, although horizontally polarized near the lower end of the wave guide 4, eventually becomes substantially vertically polarized in the plane of the paper at the aperture between the plate 8 and the ends of the flare of trumpet 7. When expanding in the flare in the plane of the paper, the electric field of the last mentioned wave is finally split so that its electric fields lie between the plate 8 and the side surfaces of the trumpet. Thus ,the electromagnetic field radiated into space in the plane of the paper consists of two waves of quarter phase relation, one having its electric field vertical and the other horizontal. The combined electromagnetic field is a circularly polarized wave. Similarly, in the plane perpendicular to the plane of the paper, the wave in which the principal axis of the electric field is perpendicular to the plane of the paper becomes vertically polarized as it expands and is radiated in the same plane from the aperture between the plane 8 and the ends of the flare. The other wave whose principal electric field remains in the plane of the paper remains horizontally polarized at the aperture as it is radiated in a direction perpendicular to the plane of the paper. Thus, the electromagnetic field radiated into space in the plane perpendicular to the plane of the paper also consists of two waves in quarter phase relation, one having its electric field vertical and the other horizontal, the combination of which is a circularly polarized wave. As for directions intermediate the plane of the paper and its perpendicular plane, the radiated field is also circularly polarized.

Although the foregoing description of the invention has been explained with particular reference to a transmitting system, it should be understood that if desired the same antenna system can be employed for receiving purposes. Further, the invention is not limited to the precise structure illustrated, since numerous modifications and substitutions of elements by equivalent features will readily appear to those skilled

in the art. For example, the concentric feeder lines can be replaced by two-wire feeders terminated either in probes, as shown, or in wire loops.

What is claimed is:

1. An electromagnetic wave radiator comprising a wave guide devoid of a central conductor throughout at least the major portion of its length, said guide having at its open end a metallic horn flaring therefrom and at its other end a pair of elements in the interior of said guide for producing therein a transverse electric rotating field, said elements being adapted to be energized in quarter phase relation, and a flat imperforate plate located externally of and facing the flared surface of said horn, said plate being spaced from said flared surface by a distance greater than one-half a wavelength at the operating frequency.

2. An electromagnetic wave radiator comprising a wave guide having at its open end a metallic horn flaring therefrom, and at its other end a pair of elements in the interior of said guide for producing therein a transverse rotating electric field, and a flat plate located externally of and facing the flared surface of said horn and spaced therefrom, said elements being adapted to be energized in quarter phase relation.

3. An electromagnetic wave radiating system comprising a circular wave guide having a diameter greater than 0.67 wavelength at the operating frequency, said guide being open at one end and closed at the other end, a metallic horn terminating the open end of said wave guide and having surfaces flaring from the open end of the guide, a pair of probes located in the interior of said wave guide at right angles to each other and in the same horizontal plane, leads exciting said probes in quarter phase relation, a plate facing the flared surface of said horn and spaced therefrom by a distance greater than one-half a wavelength at the operating frequency, the transverse dimensions of said plate being substantially coextensive with the transverse dimensions of the flared portion of the horn.

4. In combination, a wave guide comprising a pipe devoid of an inner conductor for assisting in the transfer of waves from a source to a load, means for launching ultra high frequency electromagnetic waves having a transverse rotating electric field within said pipe for transmission therethrough, one end of said pipe being open, a metallic horn at said open end of the pipe for the radiation of said waves, and a flat plate located externally of said horn at the mouth thereof, said plate being spaced from said mouth and arranged in a plane substantially perpendicular to the length of said pipe.

5. In combination, a wave guide comprising a pipe devoid of an inner conductor for assisting in the transfer of waves from a source to a load, means for launching ultra high frequency electromagnetic waves having a transverse rotating electric field within said pipe for transmission therethrough, one end of said pipe being open, and a metallic horn at said open end of the pipe for the radiation of said waves, and a flat plate extending across the mouth of said horn and spaced therefrom, whereby the waves emanating from said horn are radiated from the aperture between the plate and the flared portion of the horn.

6. An antenna system for broadcasting circularly polarized waves comprising a single wave guide of circular cross section having a diameter

greater than 0.67 wavelength at the operating frequency, the upper end of said pipe being open, a metallic horn terminating the open end of said pipe, and having a flared surface in a substantially horizontal plane, means for launching ultra high frequency electromagnetic waves having a transverse rotating electric field within said pipe at the lower end thereof for progressive transmission therethrough, and a plate positioned in the horizontal plane above the mouth of said horn and spaced therefrom by a distance greater than a half wavelength at the operating frequency, whereby the radiated field from the space between said plate and the flared surface of said horn is circularly polarized in all horizontal directions.

7. A system for broadcasting circularly polarized waves comprising a vertical wave guide having its upper end open and its lower end closed, a pair of exciting elements in the interior of said pipe near said closed end in the same horizontal plane at right angles to each other, a transmitter and connections from said transmitter to said exciting elements for exciting the same in quarter phase relation, a metallic horn terminating the open end of said guide, and a flat plate extending over the mouth of said horn but spaced from the flared surface of said horn by a minimum predetermined distance, whereby the waves transmitted through said wave guide by said exciting elements are radiated equally in all horizontal directions from the aperture between the plate and the flared surface of the horn.

8. An antenna system in accordance with claim 7, characterized in this that said excited elements are probes each of which is a quarter

wavelength or less at the operating frequency.

9. An electromagnetic wave radiator comprising a wave guide having at its open end a metallic horn flaring therefrom, and at its other end a pair of exciting elements in the interior of said guide for producing therein a transverse rotating electric field, and a flat circular metallic plate located externally of and facing the flared surface of said horn and spaced therefrom.

10. An electromagnetic wave radiator comprising a hollow wave guide open at one end and electrically closed at its other end, a horn flaring from said open end, a pair of exciting elements in the interior of said guide for producing therein a transverse rotating electric field, and a flat imperforate plate located externally of and facing the flared surface of said horn and spaced therefrom a distance not less than one-half wavelength at the operating frequency.

11. A radiator in accordance with claim 10, characterized in this that said plate is a dielectric material of high dielectric constant.

12. In combination, an electromagnetic radiator comprising a wave guide devoid of a central conductor throughout the major portion of its length, said guide having at its open end a metallic horn flaring therefrom and at or near its other end a pair of energy coupling elements at right angles to each other, a flat imperforate plate located externally of said horn and facing the flared surface of said horn and spaced therefrom, and ultra high frequency translating apparatus coupled to said elements in quarter phase relation.

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